Does democracy really improve environmental quality? Empirical contribution to the environmental politics debate

Alex O. Acheampong
Eric Evans Osei Opoku
Janet Dzator

October 2022

Users Working Paper
SERIES 2022:49
THE VARIETIES OF DEMOCRACY INSTITUTE

UNIVERSITY OF GOTHENBURG
DEPT OF POLITICAL SCIENCE

Varieties of Democracy (V-Dem) produces the largest global dataset on democracy with almost 30 million data points for 202 countries from 1789 to 2021. The V-Dem Institute at the University of Gothenburg comprises 20 staff members, and a project team across the world with 5 Principal Investigators, 19 Project Managers, 33 Regional Managers, 134 Country Coordinators, and 3700 Country Experts.

Please address comments and/or queries for information to:
V-Dem Institute
Department of Political Science
University of Gothenburg
Sprängkullsgatan 19, Box 711
SE 405 30 Gothenburg
Sweden
E-mail: contact@v-dem.net

V-Dem Working Papers are available in electronic format at www.v-dem.net.

Does democracy really improve environmental quality? Empirical contribution to the environmental politics debate

Alex O. Acheampong
Newcastle Business School, University of Newcastle, Australia
Bond Business School, Bond University, Gold Coast, Australia
Centre for African Research, Engagement and Partnerships (CARE-P), University of Newcastle, Australia

Eric Evans Osei Opoku
Nottingham University Business School China, University of Nottingham Ningbo China. 199 Taikang East Road Ningbo, 315100, China
Corresponding Author: Email: eric-evans-osei.opoku@nottingham.edu.cn

Janet Dzator
Newcastle Business School, University of Newcastle, Australia
Centre for African Research, Engagement and Partnerships (CARE-P), University of Newcastle, Australia

Abstract

The theoretical debate on democracy—environment remains contentious in the environmental politics literature. The existing empirical studies have attempted to explore the effect of democracy on environmental degradation. However, there are limitations in these studies regarding how democracy is measured. Also, the prior empirical studies have been silent on how democracy moderates the effect of economic growth and energy consumption on the environment. In this study, we employed dynamic and static econometric techniques to explore the effect of democracy on the environment using comprehensive data for 46 sub-Saharan African countries (SSA). As institutionalised democracy is a multi-faceted concept, we follow the political science literature to use high-level democracy indices such as electoral, liberal, participatory, deliberative, and egalitarian democracy to examine their respective effect on environmental degradation. Using the dynamic system-GMM and Lewbel two-stage least squares technique to control endogeneity, our empirical results indicate that the high-level democracy indicators drive CO_2 emissions in SSA. We also observed that the high-level democracy indicators moderate GDP per capita to reduce CO_2 emissions in SSA. The regional analysis reveals that the high-level democracy indicators spur CO_2 emissions in West Africa while reducing CO_2 emissions in Southern and Central-Eastern Africa. Further, the high-level democracy indicators moderate GDP per capita to reduce CO_2 emissions in West Africa while increasing CO_2 emissions in Southern and Central-Eastern Africa. The findings also indicate that the high-level democracy indicators moderate energy consumption to increase CO_2 emissions in West Africa and Central-Eastern Africa, not SSA and Southern Africa. These results are robust to using ecological footprint as a broader measure of environmental degradation. The policy implications of these findings for SSA and the sub-regions are discussed.

1. Introduction

Concerns about the environment and matters of sustainability have heightened since the inception of the United Nations (UN) led Sustainable Development Goals (SDGs) in 2015. The concerns escalate year on year, ever following drastic consequences of environmental degradation and climate change. The world is facing the consequences of climate change like never before. Many countries, including China, Germany, the Netherlands, and the United States, saw unprecedented flooding in 2021. The year 2021 saw wildfires in Algeria, South Africa, Cyprus, Turkey, Russia, Greece, and the United States. A period that many thought that the deadly Covid-19 would somehow spare the environment due to the reduced travelling and production activities that have led to the reduction in the emissions of greenhouse gases (GHG). What is even more striking is that a UN report released in October 2021 reveals that all countries fall short of their emissions and climate targets. The adverse consequence of environmental degradation calls for immediate policy to improve environmental quality.

For a very long-time, environmental quality has been hypothesised to be a simple function of income/economic growth (Binder & Neumayer, 2005). Grossman & Krueger (1991) postulated that the relationship between environmental quality and economic growth is not linear; environmental quality tends to deteriorate in the initial stages of growth and later improves after the income levels have reached a certain threshold. This nonlinear relationship-inverted 'U-shaped' relationship between income and environmental quality- is what has come to be known as the Environmental Kuznets Curve (EKC) (Grossman & Krueger, 1991). Many studies have followed that of Grossman & Krueger (1991) to ascertain the EKC for several countries; however, the outcomes have been mixed. For example, as Gill, Hassan & Viswanathan (2019) and Laegreid & Povitkina (2018) find the EKC evidence for ASEAN countries and 156 countries respectively, Al-Mulali et al. (2015) and Liu et al. (2017) find no evidence for Vietnam and a sample of 4 countries respectively.

To many, economic growth was the most important variable in explaining environmental quality, and concerns about policy (environmental policy) were relegated. Nevertheless, the inconclusive outcome of the EKC hypothesis gave room for further deliberations. Some economists even warned that the outcomes of the EKC hypothesis should not be taken on the face-value to mean that higher growth automatically leads to improvement in the environment (Binder & Neumayer, 2005). This leaves space to consider other mediating factors. Indeed, Grossman & Krueger (1996) proposed that policy, characterised by vigilance and advocacy, plays a crucial mediating role in the income-environment nexus. The concern of policy has particularly drawn in political scientists in quantitatively analysing the consequences of political variables on the environment (Deacon, 2009; Lake & Baum, 2001). Many have also argued that even the relationship between income and environmental quality is not formed independently of the political framework that drives environmental policy (Fredriksson & Wollscheid, 2007).

The UN and other international bodies have called that without immediate government commitment and actions against environmental degradation, the climate change situation would get out of hand. The decision to transition to low (and zero) carbon emissions follow political commitments and decisions. Barrett & Graddy (2000) have also argued that income/prosperity alone cannot explain the behaviour of environmental quality. The duo asserts that as countries become richer, attention on the improvement in non-material gains of citizens begins to escalate. Some of these non-material aspects of life include citizens acquisition of information about environmental quality and their rights to voice out about environmental and other issues (Gill et al., 2019; Neumayer, 2002). Governments would then have the incentive to change policy to accommodate their citizens' needs, depending on civil and political freedoms (Barrett & Graddy, 2000). Regarding this, Deacon (2009) opines that the political apparatus of a country, whether democratic or not, plays an essential role in the allocation of environmental resources. Congleton (1992) argues that countries' political and institutional frameworks are the crucial elements in environmental regulations. In jurisdictions where governments do not tend to represent the interest of the entire population but some selected groups, the provision of a public good as environmental quality may be underproduced or compromised (Gill et al., 2019).

The general argument follows that democracies protect the environment better (Arvin & Lew 2011). Fiorino (2018) argues that democracies have relatively better environmental performance than nondemocracies because they tend to invest more in environmental technologies and climate governance. Fredriksson & Wollscheid (2007) indicate that democracies set stricter environmental regulations than nondemocracies. In 1992, Albert Gore, President Clinton's running mate, said, "*an essential prerequisite for saving the environment is the spread of democratic government to more nations of the world*". In his 1992 presidential campaign, Clinton himself said democracies "*are more likely to protect the global environment*." Payne (1995) argues that in democracies, people are better informed about environmental issues due to free press and freedom of speech. People can easily express their grievances about the environment and mount pressure on the government through civil societies and the formation of associations. In autocracies, information might be restricted, and citizens might not be able to express themselves about environmental degradation.

Considering the importance of political factors in the environmental debate, this study examines the effect of democracy on environment degradation. Some studies have attempted to explore the environmental degradation effect of democracy. However, the outcome of the previous studies is mixed. For instance, while one strand of the empirical studies such as Neumayer (2003), Li and Reuveny (2006), Farzanegan and Markwardt (2018) have reported a negative effect, others such as Satrovic et al. (2021), Azam et al. (2021) and Akalin and Erdogan (2021) have reported positive effect. The previous studies are fraught with two major challenges/limitations. The first limitation has to do with how democracy is measured. A critical review of the literature reveals that most prior empirical studies have focused on democracy variables from databases such as the Polity II/IV Project, Freedom House, and the International Country Risk Guide. However, the democracy indices from these databases have been criticised based on their precision, coverage and source, aggregation, coding, validity, and reliability[1]. Accordingly, Coppedge et al. (2011, p. 252) argue that:

> Existing measures of democracy are especially inadequate for measuring small changes and differences in the quality of autocracy/democracy; empirically analysing relationships among various elements of democracy; and evaluating the effectiveness of targeted democracy promotion efforts. Polity, Freedom House, and their counterparts are overstretched insofar as they are applied for these sorts of tasks. At the same time, extant indices perform some important functions well. Sometimes, one needs to identify major regime changes, or gross differences in levels of democracy. Sometimes, one needs to measure trends in the average level of democracy at a global level. For these purposes, extant indices provide a rough empirical estimate of a complex and multivalent concept.

Coppedge et al. (2011) contend that these indices of democracy are not sensitive to the relevant span or quality of democracy across countries. Democracy is a multifaceted concept, and hence many variables have to be lumped to measure it, which poses a challenge to the accuracy and meaning of democracy (Coppedge et al., 2011). These indices of democracy are also narrow as they are usually based on the existence of elections. However, the idea of democracy supersedes elections (Coppedge et al., 2011). These criticisms suggest that valid, reliable, and precise democracy indices are needed for empirical research. Given that institutionalised democracy is a multidimensional concept, we follow the political science literature to use five (5) high-level democracy indices such as electoral, liberal, participatory, deliberative, and egalitarian democracy to examine their respective effect on the environment. These democracy indicators are obtained from the Varieties of Democracy (V-Dem) database constructed by Coppedge et al. (2018). This

[1] See Coppedge et al. (2011) for more discussions on the limitations of the existing democracy indices.

study relies on V-Dem because it provides a new approach to conceptualizing and measuring democracy and provide a multidimensional and disaggregated dataset that reflects the complexity of the concept of institutionalised democracy, which is beyond the simple presence of elections[2] (Coppedge et al., 2011; Coppedge et al., 2018). We believe that using variables that capture the present discourse and form of democracy are necessary, as it will enable us to ascertain a more constructive effect of democracy. To the best of the authors' knowledge, this study presents the first attempt of examining the effect of democracy (using the multidimensional measures of democracy by Coppedge et al.) on environmental degradation. The issue of environmental degradation is considered very important in all recent policy discourses due to its ravaging effect on the economy, health and livelihoods.

The second limitation of the existing studies concerns the narrow definition of environmental degradation that obscures the ascertainment of the effect of any variable on environmental degradation. Most empirical studies have used CO_2 emissions as the proxy for environmental degradation. However, environmental degradation transcends CO_2 emissions, as emissions are just an aspect. In addition to CO_2 emissions, this study broadly captures environmental degradation by employing ecological footprint. The ecological footprint is an encompassing measure of environmental degradation as it accounts for anthropogenic gas emissions as well as humans' consumption of the ecosystem for production to meet their demands and absorption of wastes in its computation (NFA, 2021). In essence, the ecological footprint represents human pressure on the environment (Opoku & Aluko, 2021). To better account for factors affecting the environment, the use of a comprehensive indicator to gauge the environment is prudent. To the best of the authors' knowledge, this study presents the first attempt to ascertain the effect of democracy (using the multidimensional measures of democracy by Coppedge et al.) on environmental degradation (using ecological footprint as a broader measure of the environment).

Examination of the existing democracy-environment literature reveals another loophole that has not been catered for yet. The environmental politics literature suggests that democracy interacts with economic growth to affect the environment. However, despite the argument for such interactive effect (Spilker, 2013), the existing empirical research have not tested such relationship (Laegreid & Povitkina, 2018). In addition, democracy is argued to influence energy transition and therefore, understanding the role of democracy on the energy consumption-environment relationship is crucial (Adams & Acheampong, 2019). In the same vein, the existing studies have not empirically examined the interactive effect of democracy and energy consumption

[2] https://www.v-dem.net/en/about/

on the environment. In this study, we account for these research gaps by examining how the high-level democracy indices moderate GDP per capita and energy consumption on the environment.

This study, therefore, addresses the research gaps identified and contributes to the literature by examining the direct and interactive effect of democracy on the environment in sub-Saharan Africa (SSA). To achieve the objective of this paper and contribute significantly to literature and policy, the following research questions are addressed by this study:

1. *Does institutionalised democracy contribute to environmental degradation in SSA?*
2. *Does democracy moderate economic growth to reduce environmental degradation in SSA?*
3. *Does democracy moderate the effect of energy to spur environmental degradation in SSA?*
4. *Does the direct and indirect effect of democracy on the environment differ among sub-regions within SSA?*

While the previous literature has mainly focused on other countries outside the sub-Saharan Africa countries (SSA) region, this study uses comprehensive panel data for 46 SSA to explore the environmental effect of democracy. Besides this knowledge gap on SSA, we focus on the SSA for several reasons. First, most countries in the SSA region are experimenting with democracy and are at different stages of democracy. Some have argued that young democracies, like those in SSA, lack the prerequisite institutional framework to enforce accountability, and hence the institutions fall prey to the dictates of a few political elites rather than serving the interests of the masses (Gill et al., 2019). In view of this, they have held that developing countries do not have the necessary supporting conditions to produce cleaner environments. Considering the SSA relatively young democratic and semi-democratic countries, will the improvement in democracy enhance environmental quality? A focus on SSA contributes to the effect and debate on democracy in the region. Besides, despite the fact that developing countries (particularly those in SSA) contribute the least to GHG emissions, they are believed to suffer the most from the consequences of climate change. The World Metropolitan Organization indicate that out of the about 11,000 natural disasters attributed to climate change between 1970-2019, developing countries accounted for about 91% of the nearly 2 million deaths that resulted from these disasters[3]. Existing studies have highlighted the disparity in environmental degradation and political institutions among the SSA sub-regions (Acheampong, Dzator, & Savage, 2021). With this argument, we avoid the assumption of homogeneity in our sample and examine the sub-regional effect of democracy on the environment. The study's findings will contribute to the debate on environmental sustainability and environmental politics, as the SDGs are keen on climate action, environmental degradation, and sustainability.

[3] World Metropolitan Organization

The remainder of the study is organised as follows. Section 2 presents a theoretical and empirical literature review on the topic. Section 3 describes the data and the methodology. Section 4 presents and discusses the empirical results. Section 5 concludes the study.

2. Literature Review

Regarding the democracy-environment nexus, the major standpoint of political scientists has been rooted in the theories of public goods provision (Deacon, 2002; Lake & Baum, 2001). This follows the argument that autocratic countries are probable to under provide public goods (Deacon, 2002). Environmental quality is considered a public good (Arvin & Lew 2011; Deacon, 2002; Winslow, 2005). Generally, public goods cannot be bought on the market, and it is provided mainly by the government; hence the provision and improvement in environmental quality require a coordinated government policy (Winslow, 2005). This is considered more important in democracies. However, in non-democratic countries where a few elites mainly own the productive resources, the government may care less about the provision of public goods compared to their private gains and would hence underproduce public goods (including the environment) (Deacon, 2003, 2009; Olson, 1993). The elites benefit from the environment, and the cost is spread to the masses. Therefore, strict environmental regulations can lower private gains, which would not sit down well with nondemocrats. Since the marginal gain of a better environment (public good) is the same for all in democratic countries, democrats are better motivated to produce and champion environmental quality.

Proponents of liberal democracies argue that there is no alternative system that assures people's basic human rights, including the right to environmental quality (Fredriksson & Wollscheid, 2007; Laegreid & Povitkina, 2018). Proponents of the positive effect of democracy on the environment have generally held that this is possible due to; i) people's rights are respected in democracies, so they are able to champion their environmental demands into legislation (Laegreid & Povitkina, 2018; Policardo, 2016; Winslow, 2005), ii) the quest for governments to be re-elected in democracies make them more responsive to the demands (including environmental demands) of their citizens (Li & Reuveny, 2006; Policardo, 2016; Popovic, 2020), iii) relative to non-democratic countries, governments are more likely to listen and work with scientists on the effect of environmental degradation (Policardo, 2016), iv) democratic countries are more likely to be subjected to international bodies like the UN and also to adhere to environmental rules and regulations from these bodies (Policardo, 2016). For example, parties to the Paris Agreement on climate change signed in 2015 must endeavour and work together to keep global temperature rise this century below 2 degrees Celsius. v) elected leaders are expected to be more accountable

(Winslow, 2005). This makes it difficult for them to personally benefit from environmental degradation and turn a blind eye to the situation. vi) in democracies, people have enormous access to information, which makes them aware of environmental problems and can heap pressure on the government. vii) the presence of non-governmental organisations/civil society organisations monitors government activities and actions (Popovic, 2020; Winslow, 2005).

Employing different measures of democracy, some studies have found evidence supporting the assertion that democracy promotes environmental quality. For example, using data from 21 OECD countries over the period 1980/1990-1999 and the fixed/random effects methods, Neumayer (2003) found left-wing party strength and corporation to negatively affect emissions (sulphur dioxide, nitrogen dioxide and carbon monoxide). Winslow (2005) used data from 107 cities in 46 countries from 1971-1992 and the random/fixed effects methods to reveal that democracy (Freedom House Index and Polity III) negatively affects sulphur dioxide, suspended particulate matter and smoke. Castiglione et al. (2012), using data from 28 countries over the period 1996-2008 and the Two-Stage Least Squares method, showed that rule of law has a negative effect on CO_2 emissions. You et al. (2015) also found that democracy (Polity IV) has a negative impact on CO_2 emissions based on data from developed and developing countries over the period 1985-2005 and Quantile regression methods. Using data from 17 Middle East and North Africa (MENA) countries over the period 1980-2005, the fixed effect, and the System GMM methods, Farzanegan and Markwardt (2018) found that democracy (Polity II) has a negative impact on sulphur dioxide and CO_2 emissions. Similarly, Chou et al. (2020) used data from 26 countries to investigate the effect of democracy (using variables from Freedom House and Polity IV) on CO_2 emissions. The quantile regression results indicated that democracy has a significant reduction effect on CO_2 emissions.

Koçak & Kızılkaya (2020) examined the impact of the institutional structure on environmental sustainability (CO_2 intensity) in China over the period 1973-2014. Measuring institutional structure with political rights and civil liberties and using cointegration techniques, they found that institutions reduce environmental pollution. Using 10 countries indexed as the most freedom of press countries over 1993-2016 and panel autoregressive distributed lag model/PMG, Riti et al. (2021) indicated that press freedom has a negative effect on CO_2 emissions. Using the pooled mean group (PMG) method and data from 9 countries over the period 1990-2014, Güngör, Olanipekun and Usman (2021) found that democratic accountability (how the government responds to its people) has a diminishing effect on CO_2 emissions in the long run. Also, using data from the top five CO_2 emitting countries from 1995–2015 and employing the Fully Modified Ordinary Least Squares (FMOLS) method, Haseeb and Azam (2021) found that democracy (Freedom House) reduces CO_2 emissions in high-income countries. Uzar (2021) finds that freedom of the press can contribute to a significant reduction in CO_2 emissions in 7 emerging countries (Turkey, Russia, Mexico, Indonesia, India, China, Brazil), using data from 1993–2016 and the panel autoregressive distributed lag (ARDL) method.

Critics, however, argue that democracy could rather make citizens more irresponsible to the environment if they so desire (Policardo, 2016). This is the case as they can argue and justify their actions more in democracies. Hence, the liberties associated with democracy could lead to environmental catastrophes (Policardo, 2016). This can, however, be curbed in democratic countries where the rule of law operates effectively. Besides, the positive effect of democracy on the environment cannot be ascertained ex-ante, and there is also the possibility of democracy leading to more pollution or degradation of the environment. Democracies with private property and individual rights would promote more business ownership and activities. This might exert more pressure on the environment from increased economic activities (Akalin & Erdogan, 2021; Li & Reuveny, 2006). Desai (1998) argues that as democracy is dependent on economic development, and since economic growth largely leads to increased environmental degradation, democracy will not be protective of the environment. Heilbronner (1974) argues that one of the critical drivers of environmental degradation is population growth. Autocratic countries can easily impose birth controls to curb population growth than democratic ones. Dryzek (1987) also asserts that the democratic regime relative to the non-democratic is a regime in which lobbying groups are prevalent and significantly impact political decisions. Hence, governments' decisions on the environment can be affected by lobbyists seeking to maximise their private gains (Akalin & Erdogan, 2021). Besides, political democracies might less protect the environment due to the long-term commitment to pollution abatement, considering that elected governments are short-lived and would commit scarce resources to short-term exigencies to ensure their re-election (Akalin & Erdogan, 202l; Bernauer & Koubi 2009).

Some empirical studies have found support for the stance of the critics of the democracy-environment nexus. For example, Farzin and Bond (2006) showed that democracy (Polity IV) positively affects sulphur dioxide using data from 45 countries over the 1972–1994 and the reduced-form parametric approach. Based on a sample of 163 countries and using the Propensity Score Matching method, Fredriksson et al. (2007) found that parliamentary democracies positively affect environmental policy stringency. Using spatial panel model with 41 Belt and Road Initiative countries over the period 1980–2016, You et al. (2020) indicated that high inequality in conjunction with democratic institutions (measured with freedom from Freedom House) are likely to increase pollution (CO_2 emissions). Also, Zhang and Chiu (2020) examined the non-linear effects of country risks (including political risks) on CO_2 emissions using a panel of 111 countries from 1985 to 2014. Applying the panel smooth transition regression model, they found that political risk indices have monotonically increasing effects on CO_2 emissions. Satrovic et al. (2021) also showed that democratic accountability (International Country Risk Guide) positively affects CO_2 emissions in the Gulf Cooperation Council region using data from 1990-2019 and the PMG technique. Azam, Liu and Ahmad (2021) examined the effect of institutional quality (i.e., government stability, investment profile of the country, control over corruption by the government, law and order and democratic accountability) on the environment for 66 developing countries over the period 1991-2017. Using the System GMM, they found that institutional quality positively affects CO_2 and methane emissions.

Some other studies have found insignificant or mixed results for the democracy-environment nexus. For example, using data from 141 developing countries from 1976–2003, Arvin and Lew (2011) found no significant relationship between democracy (Freedom House) and CO_2 emissions using the generalised least squares method. Using the dynamic OLS and data from Ghana over the period 1970-2014, Adom, Kwakwa and Amankwaa (2018) showed that the effect of democracy (Polity II) on CO_2 emissions (actual and potential) is statistically insignificant in the aggregate sample, statistically negative in the transport sector samples, and statistically positive in manufacturing and construction sector sample. Using data from South Africa and the FMOLS method, Usman et al. (2020) found that the effect of democracy (ranging from − 10 for worst autocracy and + 10 for perfect democracy) on environmental degradation (CO_2 emissions) is statistically insignificant. Yameogo, Omojolaibi and Dauda (2021) examined how institutions affect environmental quality (CO_2 and Nitrous Oxide emissions) for 20 Sub-Saharan African countries over 2002–2017. Using the system GMM, they revealed that regulatory quality positively impacts environmental degradation, control of corruption, and government effectiveness negatively affect environmental degradation.

Examination of the empirical papers above and others reveals two main things (see Table 1 for the summary of some of the empirical studies). The first has to do with the measurement of democracy. Most of these studies have used democracy measures based on the Polity II/III/IV projects, Freedom House Index and democratic accountability (International Country Risk Guide). The polity variables measure democracy and autocracy on a scale of -10 to 10, where -10 is a hereditary monarchy, and +10 is democracy; this is further sub-divided into "Autocracies" (-10 to -6), "Anocracies" (-5 to +5), and "Democracies" (+6 to +10). The Freedom House variables are based on political rights and civil liberties. Each variable follows a rating of one to seven, with lower values indicating freer societies. The International Country Risk Guide variables include variables such as; government stability, investment profile of a country, control of corruption, law and order, democratic accountability and bureaucracy quality. These democracy indices have been criticised for their precision, coverage and source, aggregation, coding, validity, and reliability (see Coppedge et al., 2011). Coppedge et al. (2011) argue that these indices of democracy are not sensitive to the relevant span or quality of democracy across countries or through time. The indices are also limited in temporal or country coverage. Considering the multidimensionality of the concept of democracy, many indices of democracy have to be aggregated, which poses challenges to the correctness and definition of democracy (Coppedge et al., 2011). These measures of democracy are also criticised for being narrow as they mainly follow from the existence of elections or not. The concept of democracy far surpasses elections (Coppedge et al., 2011).

Though there is no general agreement on what democracy at large means, the general notion has been "rule by the people". Coppedge et al. (2011) argue that there appears to be some agreement in the many likely conceptions of this mutable term. They, therefore, come up with six comprehensive indicators to capture the multifacetedness of democracy beyond the simple presence of elections. These democracy indices are electoral, liberal, majoritarian, participatory, deliberative, and egalitarian. Each indicator denotes a divergent manner of comprehending what "rule by the people" means. Coppedge et al. (2011) argue that these indicators come with improved specificity in measurement, making them more reliable, transparent, and valuable for evaluating policies. They capture many activities and actions surrounding the present discourse on democracy. In this study, we cater for the criticisms levelled against the measurement of democracy by employing the comprehensive indicators developed by Coppedge et al. (2011).

The second thing that can be observed from the literature is the measurement of the environment. Most of these studies have employed emissions/pollution (sulphur dioxide, nitrogen dioxide and carbon monoxide, methane, CO_2), with CO_2 as the major proxy for environmental degradation. However, emissions are just an aspect of environmental degradation and do not broadly capture the environment (Aluko et al., 2021; Opoku et al., 2022; Hassan et al., 2019). Hence, most previous studies on the democracy-environment nexus have not shown the effect of democracy on a broader measure of the environment. In this study, in addition to emissions (CO_2), we employ ecological footprint as an encompassing measure of environmental degradation. The ecological footprint represents human pressure on the environment captured by the collective effects of human activities on the environment emanating from the production and consumption of goods and services to satisfy human needs (NFA, 2021).

Scrutiny of the empirical literature also reveals that not many studies have focused on African countries, particularly SSA. However, SSA countries serve a good experiment of democracy following a series of historical political upheavals and some coups (including successful and attempted ones) that have occurred in recent years. At the 2021 United Nations Climate Change Conference (COP26), it was obvious that many SSA countries were torn between bettering the lots of their citizen by exploiting the environment and protecting the environment to mitigate the effects of climate change. Given the limitations in the existing literature as highlighted, our study contributes to the literature by examining the direct and interactive effect of electoral, liberal, participatory, deliberative, and egalitarian democracy on the environment (using measures of CO_2 emissions and ecological footprint) on a comprehensive panel data of 46 SSA countries. Based on the literature review, we hypothesize that:

Hypothesis 1: The effect of democracy variables on environmental degradation is positive.

Hypothesis 2: Democracy moderates the effect of economic growth to reduce environmental degradation.

Hypothesis 3: Democracy moderates the effect of energy to spur environmental degradation.

Table 1: Summary of empirical studies on democracy and the environment

Authors	Sample	Environment Variable	Democracy Variable	Estimation Methods	Results
Neumayer (2003)	21 OECD countries 1980 or 1990-1999	Sulphur dioxide, nitrogen dioxide, carbon monoxide	Left-wing party strength and corporatism	Fixed- and random-effects	Negative
Jahanger (2021)	74 developing countries 1990-2016	CO_2 emissions	Autocracy, democracy/ polity IV	System generalised method of moments (SYS-GMM)	Autocracy, Positive Democracy, Negative
Li & Reuveny (2006)	143 countries, 1961-1998	CO2 emissions, nitrogen dioxide, deforestation, land degradation, and organic pollution in water	Democracy/polity IV	Fixed effects	Negative
Farzin & Bond (2006)	45 countries, 1972–1994	Sulphur dioxide	Democracy, polity IV	Reduced-form parametric approach	Positive
You et al. (2015)	Developed and developing countries, 1985-2005	CO_2 emissions	Democracy/polity IV	Quantile regression methods	Negative
Fredriksson et al. (2007)	163 countries from the late 1990s.	Environmental policy stringency	Parliamentary democracies	Propensity Score Matching	Positive
Farzanegan & Markwardt (2018)	17 Middle East and North Africa (MENA) countries, 1980 to 2005	Sulphur dioxide, CO_2	Democracy/Polity 2	Fixed effect model, SYS-GMM	Negative
Akalin & Erdogan (2021)	26 OECD countries, 1990 -2015	Ecological footprint	Democracy/International Country Risk Guide	Augmented Mean Group (AMG) approach	Positive
Satrovic et al. (2021)	Gulf Cooperation Council, region 1990-2019	CO_2	Democratic/ International Country Risk Guide	FMOLS, LSDV, PMG	Positive
Azam et al. (2021)	66 developing countries, 1991-2017	CO_2, CH4 emissions, forest area, organic water pollutants	Democratic/International Country Risk Guide	SYS-GMM	Positive
Riti et al. (2021)	10 countries indexed as the most freedom of press countries, 1993-2016	CO_2 emissions	Freedom of press	Panel autoregressive distributed lag model/pooled mean group (PMG)	Negative
Policardo (2016)	47 transition countries 1950-2002	CO2 emissions and PM10 concentrations	Democracy	Interrupted time series (ITS)	Negative
Winslow (2005)	107 cities in 46 countries 1971-1992	Sulphur dioxide (SO2), suspended particulate matter (SPM) and smoke	Democracy/Freedom House Index and Polity III	Random effects, fixed effects model	Negative
Arvin & Lew (2011)	141 developing countries, 1976–2003	CO_2 emissions, water pollution and deforestation damage	Democracy/Freedom House	Generalized Least Squares	No Uniform Relationship

Farzanegan & Markwardt (2012)	17 MENA countries, 1980 -2005	Sulphur dioxide, CO_2	Democracy/polity 2	Pooled OLS	Negative
Castiglione et al. (2012)	28 countries, 1996 -2008	CO_2 emissions	Rule of law	Two-Stage Least Squares	Negative

3. Methodology and Data

3.1. Specification of the empirical model

This study examines the effect of democracy on the environment in SSA. We follow Adams & Acheampong (2019), Farzanegan & Markwardt (2018) and Acheampong (2019) to specify that environmental degradation depends on income, income squared, energy use, democracy and a set of covariates that affect the environment. Therefore, the reduced-form equation for the environmental degradation function is stated in Eq. (1) as:

$$lnEnv_{2_{it}} = \alpha_1 + \beta_1 lnY_{it} + \beta_2 lnY^2{}_{it} + \beta_3 lnE_{it} + \beta_4 DEMO_{it} + \delta_1 lnX_{it} + \varepsilon_{it} \quad (1)$$

The political economy literature suggests that democracy promotes economic growth by creating better investment opportunities, economic liberalization, and enhancing individual property rights protection (Peev & Murller, 2012). It further argued that democracy ensures fundamental human rights and creates social conditions that promote economic growth. In addition, the political and economic freedoms associated with democratic regimes provide competition and drive technological innovation, which in turn spurs economic growth (North, 1990; Olson, 2000). Given that economic growth plays a critical role in the environment, it is argued that democracy can moderate the effect of economic growth on environmental degradation. While it is argued that democracy can moderate the effect of democracy on the environment (Spilker, 2013), the existing empirical research have not tested such a relationship (Laegreid & Povitkina, 2018). We augment Eq. (1) with the interaction term for democracy and GDP per capita (income) to test this hypothesis. Therefore, Eq. (2) is used to examine the interactive effect of democracy and income on environmental degradation.

$$lnEnv_{2_{it}} = \alpha_1 + \beta_1 lnY_{it} + \beta_2 lnY^2{}_{it} + \beta_3 lnE_{it} + \beta_4 DEMO_{it} + \gamma_1 (DEMO \times lnY)_{it} + \delta_1 lnX_{it} + \varepsilon_{it} \quad (2)$$

Also, the literature suggests that democracy can moderate energy consumption to influence the environment (see, for instance, Adams & Acheampong, 2019). This stems from the argument that democracy can affect energy consumption by strengthening energy efficiency policies. It is also argued that democratic regimes protect private property rights and individual rights, promote business ownership and economic activities (Akalin & Erdogan, 2021; Li & Reuveny, 2006). Increasing business ownership and economic activities due to democracy can induce higher energy demand, hence promoting energy inefficiency. We include an interactive term of democracy and energy in our model to test this indirect effect. Eq. (3) examines the interactive effect of democracy and energy consumption on carbon emissions.

$$lnEnv_{2_{it}} = \alpha_1 + \beta_1 lnY_{it} + \beta_2 lnY^2{}_{it} + \beta_3 lnE_{it} + \beta_4 DEMO_{it} + \gamma_2 (DEMO \times lnE)_{it} + \delta_1 lnX_{it} + \varepsilon_{it} \quad (3)$$

Where:

$i = 1 — N;\ \ t = 1 — T$

$lnEnv =$ $natural\ logarithm\ of\ of\ dependent\ variable, the\ proxy\ for\ environmental\ degradation$

$lnY = natural\ logarithm\ of\ income$

$lnY^2 = natural\ logarithm\ of\ income\ squared$

$lnE = natural\ logarithm\ of\ energy\ consumption$

DEMO= *democracy variables (electoral, liberal, participatory, deliberative, and egalitarian democracy)*

$lnX = natural\ logarithm\ of\ control\ variables$

$\alpha_1 = constant\ paramter\ to\ be\ estimated$

$\beta_1 — \beta_4 = coefficients\ to\ be\ estimated$

$\gamma_1 — \gamma_2 = coefficients\ of\ the\ interactive\ terms\ to\ be\ estimated$

$\delta_1 = coefficients\ of\ the\ control\ covariates\ to\ be\ estimated$

$\varepsilon_{it} = error\ term$

3.2 Description of Data

In this study, we use comprehensive panel data for a total of 46 SSA countries[4] to explore the effect of democracy on carbon emissions from 2000 to 2015.

- ***The dependent variable:*** We employ CO_2 emissions, the most widely used proxy for environmental degradation/pollution in the literature (Acheampong, 2019; Laegreid & Povitkina, 2018; Zhu & Peng, 2012), as aa proxy of environmental degradation. It is measured in kiloton (kt). In addition to CO_2 emissions, we also employ ecological footprint (lnefcon), which presents a more encompassing measure of environmental degradation. Ecological footprint demonstrates the extent to which human-based activities such as crop and livestock production, grazing, fishing, mining, construction and absorption of wastes, particularly CO_2 emissions, affect the amount of biologically productive area of a country (NFA, 2021). Hence, the ecological footprint is considered to capture environmental degradation broadly compared to CO_2 emissions.

- ***The independent variables of interest*:** Five high-level democracy indices are used in this study. These are electoral, liberal, participatory, deliberative, and egalitarian democracy. For clarity purposes, these high-level democracy indicators, according to Coppedge et al. (2018), are defined as follows:

[4]See Appendix Table 1 for the list of SSA countries used in this study.

- Electoral democracy seeks to embody the core value of making rulers responsive to citizens, achieved through electoral competition for the electorate's approval under circumstances when suffrage is extensive; political and civil society organisations can operate freely; elections are clean and not marred by fraud or systematic irregularities; elections affect the composition of the chief executive of the country.
- Liberal democracy emphasises the importance of protecting individual and minority rights against the tyranny of the state and the tyranny of the majority.
- Participatory democracy emphasises active participation by citizens in all political processes, electoral and non-electoral.
- Deliberative democracy focuses on the process by which decisions are reached in a polity. A deliberative process is one in which public reasoning focused on the common good motivates political decisions—as contrasted with emotional appeals, solidary attachments, parochial interests, or coercion.
- Egalitarian democracy is achieved when the rights and freedoms of individuals are protected equally across all social groups; resources are distributed equally across all social groups; groups and individuals enjoy equal access to power.

- ***The control variables***: In this study, we control economic growth, energy consumption, population, international trade, foreign direct investment, and urbanisation in the empirical model.
  - ***Economic growth***: In the literature, income (economic growth) is considered to be one of the most significant factors driving environmental degradation. The Environmental Kuznets Curve (EKC) hypothesis postulates an inverted-U shaped relationship between economic growth and environmental degradation (Grossman & Krueger, 1991, 1996). This implies that the environment deteriorates at the initial stages of economic growth; however, after a certain threshold of economic growth or as economic growth increases, environmental quality sets in (Gill et al., 2019; Laegreid & Povitkina, 2018). The higher economic growth is represented in the literature as the squared of the variable representing economic growth or income (Y^2). Higher levels of economic growth come with the development of better (less polluting) technologies and stringent environmental regulations that help reduce environmental degradation (Stern, 2004).

- ***Energy consumption***: In this study, we also proxy for energy consumption as it is one of the essential sources of greenhouse gas emissions. The burning of fossil fuels is the major source of CO_2 emissions.
- ***Population size***: An increase in population is considered one of the major causes of environmental degradation. An increase in population is likely to increase energy consumption and deforestation due to the rise in resource utilisation, which puts pressure on the environment (Birdsall, 1992; Zhu & Peng, 2012). Moreover, Zhu & Peng (2012) argue that population size harms the environment by altering the scale and structure and composition of production and consumption in an economy. Hence, we expect the population to have a negative impact on the environment.
- ***International trade***: Trade openness measures the flow of goods between countries, and it is one of the major factors that is argued to degrade the environment. International trade is associated with increased production activities, resource use, and economic growth, affecting the environment (Dou et al., 2021; Ahmad et al., 2021). Antweiler, Copeland & Taylor (2001) contend that scale, composition and techniques effects are the theoretical channels through which trade affect the environment. The composition effect shows that based on comparative advantage, trade openness affects the environment by changing the composition of production. The technique effect proposes that trade openness could enable the transfer of environmentally friendly technologies and energy-efficient technologies, lowering carbon emissions. Contrarily, when the technological transfer associated with trade openness results in high production, it could equally increase carbon emissions. The scale effect posits that trade openness could boost economic growth, energy use, and production activities, thereby increasing carbon emissions.
- ***Foreign direct investment (FDI):*** FDI is expected to have an ambiguous effect (either positive or negative) on the environment. Following the pollution-haven hypothesis (PHH), FDI could have a negative effect on the environment. The PHH postulates that with strict environmental regulations, polluting firms in developed countries will relocate to developing countries with less stringent environmental regulations. This will increase pollution activities in developing countries and degrade the environment (Mahadevan & Sun, 2020; Tan et al., 2021; Zafar et al., 2020). However, the pollution halo hypothesis argues that

multinational firms possess superior technologies to protect the environment better; hence, the relocation of firms from developed countries will improve environmental quality in developing countries (Doytch & Uctum, 2016).

- ***Urbanisation***: Finally, we expect urbanisation to increase environmental degradation as urbanization increases resource utilisation. Urbanisation is associated with traffic congestion, overcrowding and excessive energy use (Poumanyvong & Kaneko, 2010).

The definition, sources and descriptive statistics[5] of the variables are provided in Table 2. It must be noted that except for the democracy variables, the remaining variables were estimated using their natural logarithm. Hence, "*ln*" before these variables represents logarithm. Before estimating the empirical equations, we estimate the bivariate relationship between the high-level democracy indicators and the environment (carbon emissions) and the results are presented in Appendix Figs. A1-A5. Observation from the scatterplots suggests a positive correlation between carbon emissions and the democracy indicators such as electoral, liberal, participatory, and deliberative democracy (see Appendix Figs. A1-A4), while a negative relationship exists between carbon emissions and egalitarian democracy (see Appendix Fig.A5). It is not robust to make conclusions and policy recommendations from these bivariate relationships. Therefore, to present robust results and conclusions to inform policy, we further employed various econometrics techniques to estimate the effect of the high-level democracy indices on the environmental degradation while accounting for other variables such as economic growth, energy consumption, population, international trade, foreign direct investment, and urbanisation that affect environment degradation. The next sub-section describes these techniques.

[5] See Appendix Table 2 for the descriptive statistics for the SSA sub-regions.

Table 2: Variables' descriptions

Variables	Description of variables	Mean	Std. Dev.	Min	Max	Sources
lnco2kt	carbon emissions measured in kiloton (kt).	7.625	1.628	3.864	13.129	WDI
lnefcon	Ecological footprint global hectares	16.242	1.286	13.331	19.150	NFA (2021)
lnY^2	GDP per capita (constant 2010 US$) squared	50.331	15.985	27.743	98.407	WDI
lnY	GDP per capita (constant 2010 US$)	7.013	1.071	5.267	9.920	WDI
lnpop	total population	15.729	1.595	11.304	19.015	WDI
lnE	kg of oil equivalent per capita	6.129	0.849	2.260	8.040	WDI
lntra	Trade (export +import) as a % of GDP	4.252	0.471	2.950	5.861	WDI
lnturpop	total urban population	3.536	0.454	2.110	4.468	WDI
lnfdi	net inflow as a % of GDP	0.998	1.362	-6.089	4.494	WDI
polyarchy	Electoral democracy indicator	0.440	0.191	0.085	0.844	Coppedge et al. (2018)
libdem	Liberal democracy indicator	0.302	0.190	0.011	0.770	Coppedge et al. (2018)
partipdem	Participatory democracy indicator	0.254	0.130	0.010	0.553	Coppedge et al. (2018)
delibdem	Deliberative democracy indicator	0.336	0.191	0.020	0.773	Coppedge et al. (2018)
egaldem	Egalitarian democracy indicator	0.299	0.157	0.041	0.711	Coppedge et al. (2018)

3.2. Econometric estimation techniques

In this study, we employ dynamic and static econometric techniques to estimate the above equations. The dynamic econometric technique utilised in this study is important for presenting the short-run elasticities. This study applied the Blundell and Bond (BB) (1998) dynamic system-generalised method of moment (System-GMM) to estimate the short-run elasticities. The BB (1998) dynamic system-GMM address the limitation of Arellano and Bond (1991) first difference GMM by using the lagged differences of the dependent variable as instruments for equations in levels and also includes the lagged levels of the dependent variable as instruments for equations in first differences. Therefore, applying the BB (1998) dynamic system-GMM helps address the issue of endogeneity. We applied the Windmeijer (2005) finite-sample correction for the covariance matrix to present consistent short-run estimates. We evaluate the validity of the dynamic system-GMM models using the post-estimation statistics such as the Sargan test and the first and second-order autocorrelation.[6] One major advantage of the GMM estimation is that it permits the generation of internal instruments for the instrumentation process.

Besides, we utilised the Lewbel (2012) two-stage least squares (TSLS) approach, which is a static model, to estimate the long run elasticities. The Lewbel (2012) two-stage least squares (TSLS) technique is mostly applied when the sources of identification, such as having appropriate external instruments, are not available or weak. The novelty of the Lewbel TSLS approach is that it internally generates heteroskedasticity-based instruments generated from the residuals of the auxiliary equation, which is multiplied by each of the included exogenous variables in mean-centred

[6] Note that since the System GMM is a dynamic model, in the estimations of Eqs. 1-3, the lag of the dependent variable is included in the right-hand side of the equations. For simplicity, we did not include the lags in specifying Eqs. 1-3.

form (Lewbel, 2012). Another advantage of the Lewbel TSLS is that when appropriate instruments are not available or weak for identifying structural parameters in the regression models with endogenous or mismeasured regressors, it is vital to apply the Lewbel TSLS. In applied research, the Lewbel instrumental variable approach does not rely on satisfying standard exclusion restrictions, and it is demonstrated that applying the Lewbel TSLS without any external instruments produces similar estimates to those obtained when external instruments are used (Lewbel, 2012). The Lewbel TSLS technique has been applied in existing research (Acheampong, Erdiaw-Kwasie, & Abunyewah, 2021; Mishra & Smyth, 2015; Saha, Mishra, & Smyth, 2021). In addition to the Lewbel TSLS, we also applied the Driscoll and Kraay (1998) estimator. Using the Driscoll and Kraay (1998) nonparametric estimator in this study is important. It produces robust results when both cross-sectional and temporal dependence are present and can handle missing data series, and works with both balanced, unbalanced panels (Hoechle, 2007).

4. Results and Discussions

4.1 Short-run results for SSA

Table 3 displays the dynamic system-GMM results for the total SSA sample. From Table 3, the dynamic system-GMM results estimates show that electoral, liberal, participatory, deliberative, and egalitarian democracy coefficients are positive and statistically significant at 5% or higher levels. Thus, a 1 standard deviation (SD) increase in electoral, liberal, participatory, deliberative, and egalitarian democracy is associated with 0.008, 0.078, 0.066, 0.098 and 0.082 SD increase in carbon emissions in the short run. This short-run result aligns with a strand of the theoretical literature/argument that democracy could be a bane for the environment. This strand of literature typically argues that democracy deteriorates environment quality since it is associated with laissez-faire economies (Dryzek, 1987; Q. Li & Reuveny, 2006). It is argued that democracy favours the capitalist, whose aim is to maximise profit at the expense of the environment. This suggests that democratic rulers accountable to capitalists that support their coming to power may not necessarily value environmental quality (Dryzek, 1987; Li & Reuveny, 2006). Similarly, Midlarsky (1998) argues that democracy worsens environmental quality since democratic leaders intend to please competing interest groups to win political votes and because of budget constraints may not be responsive to environmental challenges but to more pressing economic issues. These are very applicable in SSA since the democratic leaders are more likely to value improving macroeconomic indicators to win political votes rather than enhancing environmental quality. Empirically, our short-run estimates are inconsistent with previous studies such as Jahanger, Usman, and Balsalobre-Lorente (2021) and Farzanegan and Markwardt (2018) that use the same estimator to claim that democracy enhances environmental quality. Contrarily, our results add to Azam, Liu, and Ahmad (2021) empirical findings for developing countries. The difference in the results may be due to the different measurement of democracy.

Table 3: Dynamic Sys-GMM results for the full SSA sample (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
L.lnco2kt	0.917***	0.935***	0.933***	0.935***	0.935***	0.932***
	(0.023)	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)
$\ln Y^2$	-0.012	-0.005	-0.003	-0.006	-0.005	-0.006
	(0.011)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
lnY	0.209	0.102	0.075	0.123	0.105	0.124
	(0.174)	(0.117)	(0.124)	(0.116)	(0.121)	(0.122)
lnpop	0.079***	0.068***	0.072***	0.068***	0.069***	0.073***
	(0.020)	(0.012)	(0.013)	(0.013)	(0.012)	(0.013)
lnE	0.062**	0.029*	0.028	0.029*	0.028	0.029
	(0.028)	(0.017)	(0.018)	(0.017)	(0.018)	(0.018)
lntra	0.029	0.034	0.038*	0.036*	0.034	0.034
	(0.024)	(0.021)	(0.023)	(0.022)	(0.021)	(0.022)
lnturpop	0.013	0.009	0.015	0.011	0.011	0.010
	(0.027)	(0.020)	(0.020)	(0.021)	(0.020)	(0.020)
lnfdi	0.011	0.007	0.003	0.005	0.006	0.006
	(0.010)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
polyarchy		0.072**				
		(0.033)				
libdem			0.078**			
			(0.031)			
partipdem				0.097**		
				(0.048)		
delibdem					0.067**	
					(0.032)	
egaldem						0.100***
						(0.039)
Constant	-1.981**	-1.399***	-1.356***	-1.474***	-1.406***	-1.555***
	(0.792)	(0.504)	(0.511)	(0.491)	(0.530)	(0.529)
Observations	317	317	317	317	317	317
Sargan	216.748	270.336	270.010	268.281	270.260	270.958
P(Sargan)	0.360	0.601	0.590	0.619	0.569	0.558
AR(1)	0.000	0.000	0.000	0.000	0.000	0.000
AR(2)	0.563	0.549	0.538	0.553	0.553	0.545

Heteroscedasticity robust standard errors in parentheses. Sargan-test refers to the over-identification test for the restrictions in system-GMM estimation. The AR (1) and AR (2) tests are the Arellano–Bond tests for the first and second-order autocorrelation in first differences. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Regarding the control variables, the results show that the population and energy consumption coefficients are positive and statistically significant. The results show that GDP per capita and GDP per capita squared have an insignificant effect on carbon emissions, negating the Environmental Kuznets Curve in the short run. Also, our dynamic system-GMM estimates suggest that international trade, foreign direct investment, and urbanisation have an insignificant effect on carbon emissions. Thus, these variables do not play a significant role in carbon emissions in the short run. These observations contradict previous studies such as Acheampong (2019), Mehdi

Abid (2016), Abid (2017) and Twerefou, Danso-Mensah and Bokpin (2017), which have utilised dynamic system-GMM to demonstrate these variables play a significant role in carbon emissions, especially in SSA. Similar to Li and Reuveny (2006) and Joshi and Beck (2018) results, the coefficient on lagged carbon emissions is positive and statistically significant at 1%, suggesting that past emissions contribute to current emissions.

4.1.1 Short-run results for sub-regions within SSA

It is argued that there is a disparity in carbon emissions and institutional quality among the sub-regions within the SSA (Acheampong, 2019; Acheampong et al., 2021). In addition to Fig. 1, it can be observed that the democracy indices vary across the SSA sub-regions. Observation from Fig. 1 suggests that, on average, West Africa has the highest value for electoral, liberal, participatory, deliberative, and egalitarian democracy indices, followed by Southern Africa and then Central-Eastern Africa. This suggests that West Africa is more democratic while Central-Eastern Africa is the least democratic sub-region in SSA. Therefore, we follow this observation and argument to examine the contribution of the democracy variables to regional carbon emissions. We follow Acheampong (2019) and Acheampong et al. (2021) to group the SSA countries into West Africa, Southern Africa and Central-Eastern Africa. The results for West Africa and Southern Africa are presented in Table 4, while the estimates for Central-Eastern Africa are shown in Table 5.

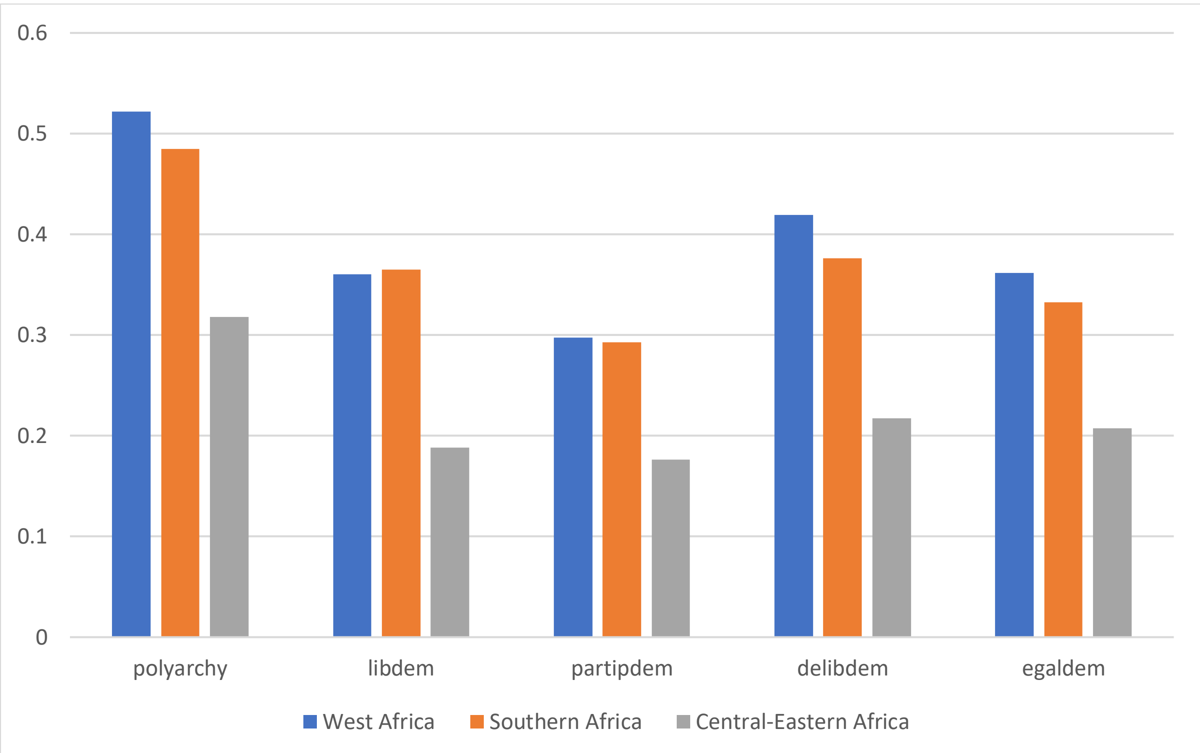


Fig.1: Averages of the democracy indicators across SSA sub-regions

For the regional analysis, the estimates suggest that for West Africa, electoral, liberal, participatory, deliberative, and egalitarian democracy coefficients are positive and statistically significant at a 5% level or better. Thus, 1 SD increase in electoral, liberal, participatory, deliberative, and egalitarian democracy increases emissions by 0.036, 0.034, 0.056, 0.029 and 0.037 SD, respectively. For the case of Southern Africa, the results show that the coefficient of electoral, liberal, participatory, deliberative, and egalitarian democracy coefficients are negative, but it is the only electoral and liberal democracy that is significant at 10%. This result suggests that a 1 SD increase in electoral and liberal democracy is associated with a 0.012 and 0.012 decrease in carbon emissions. For Central-Eastern Africa, the estimates show that electoral, liberal, participatory, and deliberative democracy coefficients are negative and statistically significant at 10% level or better, while egalitarian democracy has a neutral effect on carbon emissions. The estimate shows that a 1 SD increase in electoral, liberal, participatory, and deliberative democracy decreases carbon emissions by 0.019, 0.021, 0.028 and 0.031 SD.

Generally, the regional analysis suggests that democracy impedes environmental quality in West Africa while improving environmental quality in Southern Africa and Central-Eastern African countries. From Fig. 1, we argue that the democracy indicators worsen environmental pollution in West Africa because they are more democratic than Southern Africa and Central-Eastern Africa, where the democracy variables reduce emissions. The regional analysis further added to the literature that argues that highly democratic countries contribute more to environmental pollution than less democratic countries. Thus, high democratic regimes worsen environmental quality because Dryzek (1987) argue that the democratic regime relative to the non-democratic, is a regime in which lobbying groups are prevalent and have a significant impact on political decisions. Hence, governments decisions on the environment can be affected by lobbyists seeking to maximise their private gains (Akalin & Erdogan, 2021). Besides, political democracy might less protect the environment due to the long-term commitment to pollution abatement, considering that elected governments are short-lived and would commit scarce resources to short-term exigencies to ensure their re-election (Akalin & Erdogan, 202l; Bernauer & Koubi 2009). Conversely, less democratic regimes improve environmental quality because, in less democratic countries, policymakers implement actionable policies instead of deliberations to overcome the resistance of stakeholders who see environmental regulation as inimical to their short-term economic interest (Wurster, 2013). The regional analysis results affirm earlier studies such as Akalin and Erdogan (2021), Azam et al. (2021), Satrovic et al. (2021), Farzin and Bond (2006) and Zhang and Chiu (2020), which reported that highly democratic countries (in the case of West Africa countries) pollute the environment more than less democratic countries (in the case of Southern

Africa and Central-Eastern African countries). On the other hand, our regional analysis results are incongruent with earlier empirical studies (see Castiglione et al., 2012; Chou et al., 2020; Koçak & Kızılkaya, 2020) that claim that high democratic regimes improve environmental quality relative to less democratic countries.

Focusing on the control variables, the results show that energy consumption is associated with higher carbon emissions in West Africa and Central-Eastern Africa, while energy consumption has a neutral effect on carbon emissions in Southern Africa. These findings suggest that increasing energy consumption will degrade West Africa and Central-Eastern Africa's environment and not Southern Africa's environment. These results affirm Acheampong (2019) for the sub-regions within SSA. Also, the population is associated with higher carbon emissions across all the sub-regions, which aligns with Acheampong, Adams, and Boateng (2019) and Acheampong (2019) findings for the same sub-regions. The estimate shows that while FDI is associated with increasing carbon emissions in Central-Eastern Africa, it has a neutral effect on carbon emissions in West Africa and Southern Africa. This result suggests that increasing FDI flow to Central-Eastern Africa leads to environmental pollution, confirming the pollution-haven hypothesis. The Central-Eastern Africa results align with Kivyiro and Arminen (2014) and Twerefou et al. (2017) empirical findings in SSA.

Also, for West Africa and Central-Eastern Africa, international trade has a statistically insignificant impact on carbon emissions while significantly increasing carbon emissions in Southern Africa. Thus, boosting international trade in Southern Africa would impede environmental quality, which can be attributed to international trade's scale and composition effect. The Southern African countries results align with Vural (2020) and Twerefou et al. (2017) findings that trade openness contributes substantially to environmental pollution. Also, our estimates indicate that urbanisation has a neutral effect on carbon emissions in West Africa. However, while urbanisation significantly lowers carbon emissions in Central-Eastern Africa, it drives carbon emissions in Southern Africa. This demonstrates that the environmental effect of urbanisation is heterogeneous and that increasing urbanisation in Southern Africa would lead to environmental pollution. In contrast, the opposite is observed for Central-Eastern Africa.

The estimate shows that both GDP per capita and GDP per capita squared are statistically insignificant in West Africa. Also, while GDP per capita has a statistically insignificant effect on carbon emissions for Southern Africa, the GDP per capita squared has a statistically significant positive effect. Contrarily, for Central-Eastern Africa, the results show that GDP per capita and GDP per capita squared has a statistically significant positive and negative effect on carbon emissions, respectively, indicating the presence of EKC. This shows that the EKC hypothesis is not valid for West Africa and Southern African countries but valid for Central-Eastern Africa. This result confirms Acheampong (2019) findings that the EKC hypothesis is invalid in West Africa and Southern Africa. Also, similar to Acheampong (2019) results, the coefficient on lagged carbon emissions is positive and statistically significant at 1% across all the sub-regions, suggesting that past emissions contribute to current emissions in SSA.

Table 4: Dynamic Sys-GMM results for West and Southern Africa (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	West Africa						**Southern Africa**					
L.lnco2kt	0.866***	0.804***	0.818***	0.785***	0.816***	0.793***	0.906***	0.890***	0.889***	0.895***	0.893***	0.894***
	(0.044)	(0.057)	(0.054)	(0.052)	(0.052)	(0.065)	(0.020)	(0.025)	(0.025)	(0.026)	(0.024)	(0.024)
$\ln Y^2$	-0.085	0.001	0.000	0.039	-0.016	0.003	0.016	0.028*	0.027*	0.024	0.026*	0.026
	(0.065)	(0.084)	(0.085)	(0.108)	(0.077)	(0.088)	(0.011)	(0.017)	(0.016)	(0.018)	(0.015)	(0.017)
lnY	1.289	0.048	0.046	-0.510	0.299	0.047	-0.155	-0.307	-0.289	-0.258	-0.277	-0.286
	(0.956)	(1.216)	(1.251)	(1.583)	(1.128)	(1.280)	(0.154)	(0.224)	(0.206)	(0.237)	(0.203)	(0.224)
lnpop	0.080**	0.157***	0.143***	0.194***	0.143***	0.178***	0.128***	0.142***	0.144***	0.139***	0.140***	0.138***
	(0.034)	(0.053)	(0.045)	(0.058)	(0.046)	(0.063)	(0.022)	(0.024)	(0.025)	(0.026)	(0.023)	(0.023)
lnE	0.095***	0.122***	0.117***	0.093***	0.104***	0.106***	0.005	-0.005	-0.003	-0.002	-0.001	-0.002
	(0.026)	(0.042)	(0.041)	(0.034)	(0.036)	(0.041)	(0.020)	(0.022)	(0.022)	(0.021)	(0.021)	(0.021)
lntra	-0.059	-0.062	-0.063	-0.004	-0.065	-0.059	0.178***	0.166***	0.169***	0.164***	0.164***	0.176***
	(0.046)	(0.048)	(0.054)	(0.058)	(0.049)	(0.053)	(0.038)	(0.041)	(0.040)	(0.045)	(0.041)	(0.039)
lnturpop	-0.039	-0.011	-0.011	-0.063	-0.016	-0.023	0.101*	0.144**	0.142**	0.122**	0.126**	0.132**
	(0.176)	(0.231)	(0.230)	(0.188)	(0.222)	(0.244)	(0.053)	(0.063)	(0.058)	(0.055)	(0.057)	(0.056)
lnfdi	-0.001	0.007	0.001	0.011	0.003	0.003	-0.012	-0.014	-0.014	-0.014	-0.014	-0.015
	(0.030)	(0.025)	(0.029)	(0.026)	(0.027)	(0.028)	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
polyarchy		0.336*						-0.109*				
		(0.182)						(0.064)				
libdem			0.284**						-0.118*			
			(0.144)						(0.066)			
partipdem				0.754**						-0.108		
				(0.363)						(0.113)		
delibdem					0.253*						-0.097	
					(0.134)						(0.060)	
egaldem						0.380**						-0.106
						(0.193)						(0.077)
Constant	-5.087	-1.843	-1.566	-0.165	-2.408	-1.994	-2.096***	-1.709**	-1.829***	-1.808**	-1.774***	-1.757**
	(3.101)	(3.231)	(3.497)	(4.445)	(3.079)	(3.371)	(0.539)	(0.710)	(0.638)	(0.768)	(0.671)	(0.714)
Observations	91	91	91	91	91	91	114	114	114	114	114	114
Sargan	80.224	79.992	80.278	80.948	79.800	81.102	99.774	100.460	100.434	100.151	100.390	100.199
P(Sargan)	0.535	0.511	0.502	0.481	0.517	0.476	0.626	0.580	0.581	0.589	0.582	0.587
AR(1)	0.032	0.023	0.025	0.028	0.025	0.023	0.033	0.035	0.035	0.035	0.035	0.035
AR(2)	0.238	0.353	0.300	0.311	0.273	0.308	0.755	0.757	0.767	0.751	0.755	0.758

Heteroscedasticity robust standard errors in parentheses. Sargan-test refers to the over-identification test for the restrictions in system-GMM estimation. The AR (1) and AR (2) tests are the Arellano–Bond tests for the first and second-order autocorrelation in first differences. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Dynamic Sys-GMM results for Central-Eastern Africa (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
L.lnco2kt	0.827***	0.818***	0.815***	0.815***	0.804***	0.826***
	(0.031)	(0.035)	(0.032)	(0.037)	(0.037)	(0.032)
$\ln Y^2$	-0.033***	-0.044***	-0.047***	-0.048***	-0.058***	-0.042***
	(0.008)	(0.013)	(0.015)	(0.014)	(0.017)	(0.014)
lnY	0.639***	0.809***	0.840***	0.853***	0.997***	0.753***
	(0.115)	(0.192)	(0.202)	(0.199)	(0.238)	(0.180)
lnpop	0.168***	0.184***	0.181***	0.186***	0.190***	0.164***
	(0.023)	(0.026)	(0.023)	(0.028)	(0.026)	(0.024)
lnE	0.113***	0.158***	0.173***	0.187***	0.218***	0.153***
	(0.031)	(0.049)	(0.057)	(0.058)	(0.067)	(0.056)
lntra	0.002	0.022	0.016	0.023	0.042	0.010
	(0.022)	(0.026)	(0.024)	(0.024)	(0.028)	(0.023)
lnturpop	-0.089***	-0.095***	-0.110***	-0.088***	-0.113***	-0.093***
	(0.031)	(0.032)	(0.035)	(0.030)	(0.035)	(0.033)
lnfdi	0.011*	0.009*	0.009	0.009	0.004	0.010*
	(0.006)	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)
polyarchy		-0.203*				
		(0.113)				
libdem			-0.222**			
			(0.112)			
partipdem				-0.410**		
				(0.160)		
delibdem					-0.342***	
					(0.122)	
egaldem						-0.184
						(0.130)
Constant	-4.537***	-5.598***	-5.657***	-5.924***	-6.590***	-5.027***
	(0.470)	(0.928)	(0.909)	(0.999)	(1.170)	(0.718)
Observations	112	112	112	112	112	112
Sargan	100.905	100.076	100.846	100.204	99.960	100.242
P(Sargan)	0.540	0.535	0.514	0.532	0.539	0.531
AR(1)	0.027	0.026	0.025	0.025	0.023	0.026
AR(2)	0.343	0.328	0.336	0.341	0.302	0.336

Heteroscedasticity robust standard errors in parentheses. Sargan-test refers to the over-identification test for the restrictions in system-GMM estimation. The AR (1) and AR (2) tests are the Arellano–Bond tests for the first and second-order autocorrelation in first differences. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2. Long-run results for SSA

Table 6 presents the long-run elasticities for SSA that were estimated using the Driscoll-Kray and Lewbel TSLS estimators. From Table 2, the Driscoll-Kray estimates show that electoral, liberal, participatory, deliberative, and egalitarian democracy coefficients are positive, but it is only egalitarian democracy that is statistically significant at the 10% level. However, the Lewbel TSLS estimates show that the coefficients of electoral, liberal, deliberative, and egalitarian democracy are positive and statistically significant at a 5% level or better, while participatory democracy has an insignificant effect. Thus, from the Lewbel TSLS estimator, 1 SD increase in electoral, liberal, deliberative, and egalitarian democracy is associated with 0.092, 0.130, 0.080, and 0.106 SD increase in carbon emissions in the long run. These results further strengthen our earlier results that democracy spurs environmental pollution in SSA. Generally, the static model results are inconsistent with previous studies such as Adams and Acheampong (2019), Neumayer (2003), Li & Reuveny (2006) and You et al. (2015), that use static econometric models to show that democracy reduces environmental pollution.

The dynamic model results showed that except for population and energy consumption variables, the remaining control variables have an insignificant effect on carbon emissions. However, our statistic models reveal otherwise. For instance, the static models estimate shows that the FDI coefficient is negative and statistically significant at a 1% level. This suggests that a larger flow of FDI into SSA would enhance environmental quality, and this contradicts the findings of Twerefou et al. (2017), Kivyiro and Arminen (2014) and Akinlo and Dada (2021). Also, the results indicate that the coefficient of urbanisation is negative but most significant in the Driscoll-Kray models. The estimates also show that the international trade coefficient is positive and statistically significant at 5% or better, indicating that increasing trade openness leads to more emissions in SSA. This result aligns with Adams and Opoku (2020) for SSA while being at odds with Twerefou et al. (2017) findings. It is also revealed that the estimated coefficients on energy consumption and population are positive and statistically significant at the 1% level. This implies that increasing population size and energy use leads to environmental pollution, affirming Adams and Opoku (2020) and Twerefou et al. (2017) empirical results for SSA. It is also observed that GDP per capita has a positive and statistically significant effect on carbon emissions while GDP per capita squared negatively affects carbon emissions but is most significant in the Driscoll-Kray models, indicating the presence of EKC in SSA. The validity of EKC in SSA aligns with the results of Ahmad et al. (2017) for Croatia, Apergis and Ozturk (2015) for 14 Asian countries and Lisciandra and Migliardo (2017) for a panel of 153 countries.

Table 6: Driscoll-Kray and Lewbel TSLS results for the full-sample (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Driscoll-Kray results						**Lewbel TSLS results**					
$\ln Y^2$	-0.079**	-0.069*	-0.068	-0.074*	-0.068*	-0.068*	-0.393**	-0.062	-0.051	-0.073	-0.062	-0.061
	(0.034)	(0.037)	(0.039)	(0.036)	(0.039)	(0.038)	(0.173)	(0.051)	(0.052)	(0.050)	(0.051)	(0.049)
lnY	2.081***	1.923***	1.901***	1.987***	1.909***	1.910***	6.614***	1.808**	1.603**	1.970***	1.814**	1.807***
	(0.496)	(0.549)	(0.581)	(0.536)	(0.570)	(0.554)	(2.525)	(0.713)	(0.730)	(0.710)	(0.717)	(0.685)
lnpop	0.944***	0.945***	0.946***	0.943***	0.945***	0.961***	0.818***	0.945***	0.950***	0.942***	0.945***	0.971***
	(0.015)	(0.019)	(0.018)	(0.019)	(0.018)	(0.015)	(0.064)	(0.042)	(0.042)	(0.041)	(0.042)	(0.044)
lnE	0.359***	0.365***	0.357***	0.360***	0.353***	0.356***	0.666***	0.369***	0.355***	0.361***	0.349***	0.355***
	(0.090)	(0.091)	(0.092)	(0.089)	(0.092)	(0.092)	(0.178)	(0.133)	(0.133)	(0.133)	(0.135)	(0.131)
lntra	0.275***	0.242***	0.250***	0.260***	0.238***	0.241***	0.158	0.219**	0.209**	0.257**	0.217**	0.221**
	(0.066)	(0.074)	(0.072)	(0.070)	(0.076)	(0.071)	(0.120)	(0.104)	(0.106)	(0.105)	(0.105)	(0.102)
lnturpop	-0.015	-0.066***	-0.034	-0.047**	-0.056**	-0.063***	-0.069	-0.103	-0.066	-0.053	-0.079	-0.092
	(0.031)	(0.022)	(0.028)	(0.022)	(0.023)	(0.021)	(0.135)	(0.117)	(0.105)	(0.108)	(0.112)	(0.109)
lnfdi	-0.148***	-0.144***	-0.147***	-0.145***	-0.142***	-0.141***	-0.109***	-0.140***	-0.146***	-0.144***	-0.139***	-0.137***
	(0.018)	(0.016)	(0.018)	(0.017)	(0.016)	(0.015)	(0.035)	(0.027)	(0.028)	(0.027)	(0.027)	(0.027)
polyarchy		0.455						0.786**				
		(0.262)						(0.344)				
libdem			0.419						1.111***			
			(0.265)						(0.302)			
partipdem				0.488						0.577		
				(0.327)						(0.446)		
delibdem					0.438						0.681**	
					(0.278)						(0.296)	
egaldem						0.685*						1.097***
						(0.346)						(0.375)
Constant	-20.843***	-20.136***	-20.094***	-20.359***	-19.989***	-20.351***	-36.067***	-19.623***	-18.857***	-20.271***	-19.514***	-20.055***
	(2.416)	(2.713)	(2.806)	(2.668)	(2.817)	(2.653)	(8.627)	(2.504)	(2.546)	(2.504)	(2.558)	(2.327)
Observations	337	337	337	337	337	337	337	337	337	337	337	337
R^2	0.889	0.892	0.892	0.891	0.892	0.894	0.860	0.890	0.885	0.891	0.891	0.892

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2.1. Long run results for sub-regions within SSA

In this section, we present the long-run estimates for the SSA sub-regions. Tables 7 and 8 display the long run estimates for West Africa and Southern Africa, while Table 9 shows the estimates for Central-Eastern Africa. From these tables, the Driscoll-Kray models and Lewbel TSLS estimates show that the coefficients of electoral, liberal, participatory, deliberative, and egalitarian democracy are positive and statistically significant for West Africa. Based on the Lewbel TSLS estimates, 1 SD increase in electoral, liberal, participatory, deliberative, and egalitarian democracy increases emissions by 0.092, 0.060, 0.201, 0.054 and 0.072 SD, respectively. Contrarily, the Driscoll-Kray models and Lewbel TSLS estimates show that the coefficients of electoral, liberal, participatory, deliberative, and egalitarian democracy are negative and statistically significant for Southern Africa and Central-Eastern Africa. Thus, based on the Lewbel TSLS estimates, a 1SD increase in electoral, liberal, participatory, deliberative, and egalitarian democracy decreases carbon emissions by 0.121, 0.126, 0.118, 0.099 and 0.102 SD, respectively in Southern Africa. Similarly, from the Lewbel TSLS estimates, a 1SD increase in electoral, liberal, deliberative, and egalitarian democracy decrease carbon emissions by 0.121, 0.059, 0.109 and 0.075 SD, respectively, in Central-Eastern Africa. These results from the static models consistently suggest that while democracy impedes environmental quality in West Africa, it improves environmental quality in Southern Africa and Central-Eastern Africa countries. These results from the static models also align with existing empirical studies that have established that highly democratic countries (for our case, West African countries) pollute the environment more than less democratic countries (for our case, Southern Africa and Central-Eastern African countries) (see, for instance, Akalin & Erdogan, 2021; Azam et al., 2021, Satrovic et al., 2021; Zhang & Chiu, 2020). On the other hand, the findings from the regional analysis are inconsistent with the earlier empirical studies (see, for instance, Castiglione et al., 2012; Chou et al., 2020; Koçak & Kızılkaya, 2020) that found that high democratic regimes improve environmental quality relative to less democratic countries.

Turning to the control variables, the static model estimates show that the coefficient on FDI is positive and statistically significant in West Africa. However, for Southern Africa and Central-Eastern Africa, the estimates show that the coefficient of FDI is negative and statistically significant. These findings imply that in the long run, increasing FDI flows would increase environmental pollution (carbon emissions) in West Africa while mitigating environmental degradation (carbon emissions) in Southern Africa and Central-Eastern Africa. The long run effect of FDI on emissions in West Africa confirms the pollution-haven hypothesis while confirming the pollution-halo hypothesis in Southern Africa and Central-Eastern Africa. This result confirms Acheampong's (2019) findings that FDI reduces environmental pollution in Southern Africa.

However, our result contradicts Acheampong's (2019) findings that FDI reduces environmental pollution in West Africa while reducing environmental pollution in Central-Eastern Africa. The estimates also show that urbanisation has a significant negative effect on carbon emissions in West Africa and Central-Eastern Africa while having a significant positive effect in Southern Africa. These results indicate increasing urbanisation in Southern Africa would lead to environmental pollution while improving environmental quality in West Africa and Central-Eastern Africa.

Table 7: Driscoll-Kray and Lewbel TSLS results for West Africa (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Driscoll-Kray results						**Lewbel TSLS results**					
$\ln Y^2$	-0.495***	-0.218***	-0.229**	-0.090	-0.263***	-0.185**	-1.120***	-0.222*	-0.314***	0.050	-0.336***	-0.269**
	(0.053)	(0.066)	(0.081)	(0.090)	(0.065)	(0.080)	(0.189)	(0.126)	(0.106)	(0.136)	(0.116)	(0.110)
lnY	7.668***	3.599***	3.744***	1.673	4.264***	3.163**	16.514***	3.659**	4.994***	-0.386	5.345***	4.390***
	(0.713)	(0.930)	(1.189)	(1.269)	(0.912)	(1.158)	(2.694)	(1.829)	(1.532)	(1.979)	(1.679)	(1.583)
lnpop	0.798***	0.858***	0.855***	0.910***	0.851***	0.896***	0.662***	0.857***	0.837***	0.949***	0.835***	0.869***
	(0.063)	(0.045)	(0.040)	(0.035)	(0.047)	(0.036)	(0.051)	(0.033)	(0.028)	(0.041)	(0.031)	(0.032)
lnE	0.407***	0.427***	0.426***	0.340***	0.390***	0.370***	0.568***	0.427***	0.420***	0.317***	0.395***	0.380***
	(0.107)	(0.090)	(0.092)	(0.061)	(0.087)	(0.087)	(0.072)	(0.061)	(0.061)	(0.059)	(0.057)	(0.054)
lntra	-0.272**	-0.251***	-0.264***	-0.106*	-0.266***	-0.231***	-0.552***	-0.252***	-0.266***	-0.049	-0.268***	-0.242***
	(0.103)	(0.054)	(0.056)	(0.057)	(0.057)	(0.058)	(0.108)	(0.089)	(0.093)	(0.109)	(0.093)	(0.087)
lnturpop	-0.956***	-0.769***	-0.793***	-0.849***	-0.801***	-0.762***	-1.420***	-0.772***	-0.845***	-0.812***	-0.850***	-0.815***
	(0.180)	(0.110)	(0.100)	(0.092)	(0.102)	(0.084)	(0.329)	(0.252)	(0.234)	(0.231)	(0.242)	(0.234)
lnfdi	0.126***	0.124***	0.116***	0.131***	0.119***	0.111***	0.216***	0.124***	0.119***	0.133***	0.121***	0.115***
	(0.015)	(0.029)	(0.035)	(0.033)	(0.031)	(0.033)	(0.042)	(0.031)	(0.031)	(0.030)	(0.031)	(0.030)
polyarchy		0.859***						0.846**				
		(0.163)						(0.347)				
libdem			0.736***						0.501**			
			(0.174)						(0.217)			
partipdem				2.009***						2.700***		
				(0.148)						(0.463)		
delibdem					0.675***						0.460*	
					(0.117)						(0.259)	
egaldem						1.017***						0.740**
						(0.200)						(0.291)
Constant	-31.431***	-18.982***	-19.056***	-12.665**	-20.755***	-17.864***	-58.370***	-19.166***	-23.000***	-6.218	-24.146***	-21.560***
	(2.220)	(3.524)	(4.675)	(4.433)	(3.509)	(4.302)	(8.218)	(5.711)	(4.996)	(6.133)	(5.367)	(5.051)
Observations	96	96	96	96	96	96	96	96	96	96	96	96
R^2	0.982	0.986	0.985	0.987	0.985	0.986	0.976	0.986	0.985	0.986	0.985	0.986

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Further, the static models' estimates suggest that for West Africa, the international trade coefficient is negative and statistically significant. In contrast, the international trade coefficient is positive and statistically significant for Southern Africa while having a neutral effect on carbon emissions in Central-Eastern Africa. These findings suggest that in the long run, trade liberalisation policies would contribute to carbon emissions mitigation in West Africa while driving emissions in Southern Africa. Southern Africa's result is consistent with Acheampong, Adams and Boateng (2019) findings that trade openness improves environmental quality in the same region. However, the results for West Africa and Central-Eastern Africa are not consistent with Acheampong, Adams and Boateng (2019) findings for the same regions. Also, it is observed that the estimated coefficient on energy consumption is positive and statistically significant at the 1% level in West Africa and Central-Eastern Africa, while energy consumption has a neutral effect on carbon emissions in Southern Africa. These findings suggest that increasing energy use will continue to drive carbon emissions in West Africa and Central-Eastern Africa and not Southern Africa. These results are similar to Adams and Opoku (2020) and Twerefou et al. (2017) empirical results.

Across all the sub-regions, the estimated coefficient of the population is positive and statistically significant at a 1% level, indicating that population size is a major driver of carbon emissions. Also, the estimates suggest that GDP per capita has a positive and statistically significant effect on carbon emissions while GDP per capita squared has a statistically significant negative impact on carbon emissions in West Africa and Central-Eastern Africa, indicating the presence of EKC. Contrarily, the estimate shows that GDP per capita has a negative and statistically significant effect on carbon emissions while GDP per capita squared has a statistically significant positive impact on carbon emissions in Southern Africa, indicating the non-existence of EKC. This shows that the EKC hypothesis is valid for both West Africa and Central-Eastern Africa in the long run but invalid in Southern Africa. These results partially confirm the findings of Acheampong et al. (2019), Ahmad et al. (2017) and Apergis and Ozturk (2015).

Table 8: Driscoll-Kray and Lewbel TSLS results for Southern Africa (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Driscoll-Kray results						**Lewbel TSLS results**					
lnY^2	0.160***	0.270***	0.257***	0.266***	0.254***	0.260***	0.057	0.249***	0.238***	0.248***	0.228***	0.238***
	(0.046)	(0.052)	(0.052)	(0.048)	(0.046)	(0.051)	(0.064)	(0.064)	(0.060)	(0.069)	(0.066)	(0.066)
lnY	-1.413*	-2.950***	-2.736***	-2.837***	-2.680***	-2.839***	0.100	-2.649***	-2.476***	-2.593***	-2.333**	-2.520***
	(0.735)	(0.794)	(0.793)	(0.735)	(0.717)	(0.779)	(0.903)	(0.904)	(0.840)	(0.957)	(0.919)	(0.936)
lnpop	1.177***	1.120***	1.119***	1.141***	1.135***	1.114***	1.155***	1.131***	1.130***	1.148***	1.147***	1.128***
	(0.031)	(0.049)	(0.049)	(0.043)	(0.048)	(0.053)	(0.066)	(0.050)	(0.052)	(0.049)	(0.053)	(0.052)
lnE	0.134	-0.009	0.016	-0.015	0.045	0.028	0.185	0.019	0.039	0.010	0.070	0.052
	(0.133)	(0.157)	(0.157)	(0.162)	(0.163)	(0.161)	(0.241)	(0.242)	(0.240)	(0.251)	(0.243)	(0.245)
lntra	0.800***	0.524***	0.545***	0.433**	0.515**	0.673***	0.803***	0.578***	0.595***	0.496**	0.593***	0.702***
	(0.211)	(0.167)	(0.173)	(0.177)	(0.196)	(0.170)	(0.271)	(0.220)	(0.226)	(0.204)	(0.227)	(0.235)
lnturpop	0.617	1.048*	1.028**	0.885*	0.858	0.962*	0.710*	0.963**	0.947**	0.839**	0.792**	0.885**
	(0.374)	(0.496)	(0.478)	(0.416)	(0.504)	(0.522)	(0.370)	(0.408)	(0.395)	(0.385)	(0.392)	(0.407)
lnfdi	-0.301***	-0.261***	-0.250***	-0.262***	-0.262***	-0.281***	-0.292***	-0.269***	-0.260***	-0.268***	-0.273***	-0.285***
	(0.041)	(0.032)	(0.034)	(0.033)	(0.037)	(0.033)	(0.038)	(0.030)	(0.030)	(0.030)	(0.031)	(0.031)
polyarchy		-1.386***						-1.114***				
		(0.216)						(0.321)				
libdem			-1.527***						-1.227***			
			(0.234)						(0.331)			
partipdem				-1.918***						-1.588***		
				(0.421)						(0.577)		
delibdem					-1.279***						-0.929***	
					(0.344)						(0.359)	
egaldem						-1.427***						-1.108***
						(0.326)						(0.385)
Constant	-15.001***	-7.648***	-8.790***	-7.648***	-8.789***	-8.617***	-20.746***	-9.089***	-10.009***	-8.911***	-10.492***	-10.044***
	(2.144)	(2.211)	(2.317)	(1.771)	(1.836)	(2.254)	(3.256)	(3.138)	(2.874)	(3.390)	(3.244)	(3.160)
Observations	122	122	122	122	122	122	122	122	122	122	122	122
R^2	0.944	0.955	0.956	0.955	0.954	0.953	0.942	0.955	0.956	0.955	0.953	0.953

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Driscoll-Kray and Lewbel TSLS results for Central-Eastern Africa (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Driscoll-Kray results						**Lewbel TSLS results**					
$\ln Y^2$	-0.133***	-0.155***	-0.160***	-0.155***	-0.174***	-0.139***	-0.083**	-0.198***	-0.167***	-0.122***	-0.208***	-0.182***
	(0.017)	(0.022)	(0.021)	(0.017)	(0.024)	(0.024)	(0.042)	(0.035)	(0.033)	(0.038)	(0.038)	(0.036)
lnY	3.181***	3.478***	3.519***	3.453***	3.701***	3.251***	2.495***	4.056***	3.615***	3.038***	4.133***	3.776***
	(0.250)	(0.339)	(0.306)	(0.256)	(0.347)	(0.355)	(0.560)	(0.478)	(0.446)	(0.515)	(0.500)	(0.475)
lnpop	0.905***	0.922***	0.910***	0.917***	0.910***	0.902***	0.939***	0.955***	0.911***	0.898***	0.915***	0.878***
	(0.024)	(0.012)	(0.018)	(0.019)	(0.016)	(0.033)	(0.037)	(0.032)	(0.029)	(0.033)	(0.029)	(0.032)
lnE	0.415***	0.505***	0.534***	0.525***	0.595***	0.441***	0.309***	0.680***	0.568***	0.357***	0.746***	0.635***
	(0.066)	(0.116)	(0.122)	(0.096)	(0.142)	(0.123)	(0.091)	(0.122)	(0.098)	(0.118)	(0.130)	(0.126)
lntra	-0.101	-0.055	-0.066	-0.064	-0.017	-0.096	-0.110*	0.035	-0.056	-0.121	0.052	-0.054
	(0.095)	(0.076)	(0.083)	(0.084)	(0.078)	(0.085)	(0.063)	(0.073)	(0.068)	(0.086)	(0.077)	(0.071)
lnturpop	-0.782***	-0.783***	-0.806***	-0.767***	-0.793***	-0.785***	-0.772***	-0.783***	-0.813***	-0.790***	-0.803***	-0.806***
	(0.126)	(0.132)	(0.135)	(0.123)	(0.127)	(0.134)	(0.076)	(0.075)	(0.072)	(0.077)	(0.071)	(0.077)
lnfdi	-0.023**	-0.027***	-0.025***	-0.025***	-0.034***	-0.024**	-0.029*	-0.035**	-0.026	-0.021	-0.043**	-0.032*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.010)	(0.009)	(0.015)	(0.017)	(0.017)	(0.017)	(0.018)	(0.017)
polyarchy		-0.432						-1.276***				
		(0.313)						(0.366)				
libdem			-0.482						-0.620**			
			(0.291)						(0.264)			
partipdem				-0.664**						0.350		
				(0.273)						(0.731)		
delibdem					-0.654*						-1.197***	
					(0.339)						(0.398)	
egaldem						-0.123						-1.041***
						(0.363)						(0.395)
Constant	-21.673***	-23.529***	-23.513***	-23.476***	-24.619***	-21.973***	-19.339***	-27.146***	-24.038***	-20.722***	-27.067***	-24.220***
	(1.172)	(1.440)	(1.290)	(1.122)	(1.605)	(1.200)	(1.934)	(2.179)	(1.828)	(2.620)	(2.288)	(1.845)
Observations	119	119	119	119	119	119	119	119	119	119	119	119
R^2	0.949	0.950	0.950	0.950	0.952	0.949	0.947	0.946	0.950	0.947	0.950	0.945

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.3. Interactive effect results

In this section, we present the interactive results for SSA and the sub-regions. Tables 10 and 11, respectively, display the interactive results for SSA and West Africa, while Tables 12 and 13 show the interactive results for Southern Africa and Central-Eastern Africa. From Table 10, the results show that electoral, liberal, participatory, deliberative, and egalitarian democracy interacts with GDP per capita to reduce carbon emissions. The implication is that when there is an improvement in democracy, economic growth significantly leads to a decline in carbon emissions in SSA. This supports the political science argument that democracy conditions economic growth to reduce environmental pollution (Laegreid & Povitkina, 2018). It is argued that the economic growth effect of democracy increases the demand for environmental protection and generates the financial resource to meet such demand (Laegreid & Povitkina, 2018). Also, advancing economic growth due to democracy can lead to technological advancement and the implementation and enforcement of stringent environmental regulations, thereby reducing environmental pollution. This result aligns with Laegreid and Povitkina (2018) empirical findings. Our empirical results also suggest that electoral, liberal, participatory, deliberative, and egalitarian democracy interact with energy consumption to have an insignificant effect on carbon emissions. This implication is that democracy does not moderate the effect of energy use on carbon emissions in SSA, which affirms Adams and Acheampong (2019) result in the context of SSA.

For the regional analysis, the results presented in Table 11 suggest that electoral, liberal, participatory, deliberative, and egalitarian democracy interact with GDP per capita to have a negative effect on carbon emissions in West Africa, but it is only the interaction between electoral democracy and GDP per capita and participatory democracy and GDP per capita that is statistically significant. Thus, in West Africa, with higher electoral and participatory democracy, economic growth enhances environmental quality. On the other hand, the findings indicate that electoral, liberal, participatory, deliberative, and egalitarian democracy moderate energy consumption to significantly increase carbon emissions at a 1% level in West Africa. Thus, when democracy increase in West Africa, energy consumption significantly leads to higher carbon emissions.

Table 10: Lewbel TSLS interactive effect results for the full SSA sample (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
lnY	1.895***	1.805***	1.994***	1.771***	1.678***	1.948***	2.021***	2.066***	2.110***	1.827***
	(0.619)	(0.616)	(0.656)	(0.619)	(0.580)	(0.673)	(0.716)	(0.693)	(0.721)	(0.642)
lnE	0.369***	0.361***	0.360***	0.353***	0.365***	0.345**	0.257**	0.282**	0.209	0.511***
	(0.134)	(0.133)	(0.134)	(0.133)	(0.128)	(0.158)	(0.125)	(0.134)	(0.129)	(0.149)
polyarchy	2.535*					0.149				
	(1.336)					(1.992)				
polyarchy × lnY	-0.272									
	(0.167)									
libdem		2.492**					-1.645			
		(1.266)					(2.028)			
libdem × lnY		-0.267*								
		(0.159)								
partipdem			0.371					-1.476		
			(1.654)					(2.297)		
partipdem × lnY			0.011							
			(0.205)							
delibdem				3.313***					-2.319	
				(1.114)					(1.736)	
delibdem × lnY				-0.372***						
				(0.139)						
egaldem					7.599***					3.562
					(1.778)					(2.785)
egaldem × lnY					-0.890***					
					(0.226)					
polyarchy × lnE						0.042				
						(0.318)				
libdem × lnE							0.321			
							(0.321)			
partipdem × lnE								0.301		
								(0.359)		
delibdem × lnE									0.436	
									(0.276)	
egaldem × lnE										-0.467
										(0.444)
Controls	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Constant	-20.179***	-19.786***	-20.390***	-19.538***	-19.950***	-20.149***	-20.139***	-20.250***	-20.107***	-20.703***
	(2.146)	(2.118)	(2.261)	(2.127)	(2.006)	(2.240)	(2.346)	(2.284)	(2.357)	(2.122)
Observations	337	337	337	337	337	337	337	337	337	337
R^2	0.894	0.892	0.891	0.892	0.900	0.892	0.889	0.890	0.890	0.898

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Lewbel TSLS interactive effect results for West Africa (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
lnY	2.387	0.814	-1.911	3.094*	2.590	4.856***	4.095***	3.022*	6.560***	3.400**
	(1.515)	(2.851)	(2.238)	(1.799)	(1.598)	(1.274)	(1.350)	(1.604)	(1.267)	(1.352)
lnE	0.416***	0.408***	0.331***	0.344***	0.345***	-0.688***	-0.307*	-0.250	-0.292	-0.055
	(0.062)	(0.060)	(0.053)	(0.063)	(0.058)	(0.168)	(0.184)	(0.192)	(0.188)	(0.368)
polyarchy	8.738**					-12.975***				
	(3.983)					(1.937)				
polyarchy × lnY	-1.139**									
	(0.570)									
libdem		10.633					-15.051***			
		(7.161)					(3.510)			
libdem × lnY		-1.418								
		(1.020)								
partipdem			20.614***					-12.366***		
			(6.847)					(4.255)		
partipdem × lnY			-2.721***							
			(0.997)							
delibdem				7.303					-12.226***	
				(4.591)					(3.303)	
delibdem × lnY				-0.961						
				(0.659)						
egaldem					8.279					-6.669
					(7.066)					(6.497)
egaldem × lnY					-1.044					
					(1.007)					
polyarchy × lnE						2.457***				
						(0.347)				
libdem × lnE							2.824***			
							(0.628)			
partipdem × lnE								2.526***		
								(0.750)		
delibdem × lnE									2.319***	
									(0.591)	
egaldem × lnE										1.354
										(1.141)
Controls	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Constant	-16.872***	-10.807	-2.652	-17.987***	-17.044***	-13.224***	-12.551***	-11.937**	-21.496***	-15.192***
	(4.239)	(8.244)	(6.634)	(5.125)	(4.287)	(4.020)	(4.257)	(5.037)	(3.474)	(4.136)
Observations	96	96	96	96	96	96	96	96	96	96
R^2	0.987	0.986	0.987	0.986	0.987	0.990	0.987	0.986	0.989	0.988

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Lewbel TSLS interactive effect results for Southern Africa (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
lnY	-5.478***	-3.303***	-4.657***	-3.457***	-3.907***	-2.870***	-2.813***	-2.643***	-2.805***	-2.593***
	(0.831)	(0.533)	(0.846)	(0.625)	(0.640)	(0.702)	(0.733)	(0.715)	(0.796)	(0.698)
lnE	-0.228	-0.073	-0.164	-0.070	-0.105	0.306	0.197	0.402	0.227	0.479**
	(0.259)	(0.246)	(0.256)	(0.268)	(0.201)	(0.202)	(0.145)	(0.250)	(0.145)	(0.211)
polyarchy	-23.568***					2.754				
	(4.655)					(3.848)				
polyarchy × lnY	2.601***									
	(0.549)									
libdem		-18.283***					1.948			
		(5.908)					(4.404)			
libdem × lnY		1.987***								
		(0.702)								
partipdem			-26.746***					7.377		
			(7.395)					(7.219)		
partipdem × lnY			2.893***							
			(0.863)							
delibdem				-26.019***					2.252	
				(4.693)					(4.361)	
delibdem × lnY				2.922***						
				(0.556)						
egaldem					-15.162*					6.374
					(8.252)					(4.914)
egaldem × lnY					1.607*					
					(0.964)					
polyarchy × lnE						-0.598				
						(0.559)				
libdem × lnE							-0.506			
							(0.644)			
partipdem × lnE								-1.316		
								(1.026)		
delibdem × lnE									-0.516	
									(0.640)	
egaldem × lnE										-1.122
										(0.706)
Controls	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Constant	12.635**	-0.515	7.805	3.717	-0.251	-10.569***	-9.991***	-12.751***	-10.043***	-12.672***
	(5.030)	(3.458)	(5.424)	(3.297)	(5.365)	(3.638)	(2.790)	(4.667)	(3.028)	(3.707)
Observations	122	122	122	122	122	122	122	122	122	122
R^2	0.957	0.961	0.959	0.956	0.956	0.956	0.956	0.954	0.953	0.955

Heteroscedasticity robust standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13: Lewbel TSLS interactive effect results for Central-Eastern Africa (Dependent variable: CO_2 emissions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
lnY	3.034***	2.896***	2.647***	2.909***	2.914***	3.345***	3.473***	2.977***	3.269***	3.380***
	(0.564)	(0.487)	(0.506)	(0.498)	(0.436)	(0.481)	(0.580)	(0.453)	(0.502)	(0.506)
lnE	0.386***	0.296**	0.283**	0.323**	0.272**	0.366	0.509*	0.131	0.242	0.617**
	(0.146)	(0.139)	(0.137)	(0.145)	(0.136)	(0.282)	(0.296)	(0.217)	(0.230)	(0.299)
polyarchy	-4.379					-2.292				
	(3.071)					(3.412)				
polyarchy × lnY	0.596									
	(0.464)									
libdem		-7.680***					-0.794			
		(2.666)					(5.149)			
libdem × lnY		1.090***								
		(0.404)								
partipdem			-9.603***					-9.600**		
			(3.092)					(4.764)		
partipdem × lnY			1.295***							
			(0.439)							
delibdem				-8.760***					-6.219**	
				(2.428)					(3.054)	
delibdem × lnY				1.168***						
				(0.345)						
egaldem					-5.665*					3.644
					(2.986)					(4.776)
egaldem × lnY					0.829*					
					(0.443)					
polyarchy × lnE						0.315				
						(0.563)				
libdem × lnE							0.058			
							(0.859)			
partipdem × lnE								1.453*		
								(0.763)		
delibdem × lnE									0.920*	
									(0.499)	
egaldem × lnE										-0.615
										(0.790)
Controls	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Constant	-21.863***	-21.334***	-21.345***	-22.591***	-20.578***	-22.862***	-23.300***	-22.170***	-23.131***	-22.825***
	(2.212)	(1.834)	(1.809)	(1.846)	(1.670)	(2.017)	(2.206)	(1.715)	(2.011)	(2.188)
Observations	119	119	119	119	119	119	119	119	119	119
R^2	0.951	0.955	0.951	0.952	0.952	0.951	0.951	0.954	0.955	0.948

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

For Southern Africa, the results presented in Table 12 show that electoral, liberal, participatory, deliberative, and egalitarian democracy interact with GDP per capita to increase carbon emissions. The implication is that when there is an improvement in democracy, economic growth significantly leads to higher carbon emissions in Southern Africa. On the other hand, the estimates suggest that electoral, liberal, participatory, deliberative, and egalitarian democracy interact with energy consumption to have an insignificant effect on carbon emissions. As indicated in Table 13, electoral, liberal, participatory, deliberative, and egalitarian democracy interact with GDP per capita to increase carbon emissions in Central-Eastern Africa. This suggests at higher levels of democracy, economic growth significantly generates higher carbon emissions in Central-Eastern Africa. Also, the findings indicate that the participatory and deliberative democracy interact with energy consumption to increase carbon emissions, while the interaction between electoral, liberal, and egalitarian democracy and energy consumption on carbon emissions is statistically insignificant. Thus, at higher participatory and deliberative democracy levels, energy consumption significantly generates higher carbon emissions in Central-Eastern Africa.

4.4 Further analysis using ecological footprint as an alternative measure of environmental degradation

To better account for factors affecting the environment, the use of a comprehensive indicator to gauge the environment is prudent. In this section, we conduct further analysis using ecological footprint as an alternative measure of environmental degradation. The ecological footprint, which is a comprehensive indicator of environmental degradation, accounts for anthropogenic gas emissions as well as humans' consumption of the ecosystem for production to meet their demands and absorption of wastes in its computation (NFA, 2021). In essence, the ecological footprint represents human pressure on the environment (Opoku & Aluko, 2021). From Tables 14-17, using ecological footprint as an alternative measure of environmental degradation does not qualitatively change our results presented above (see Tables 6-9). Thus, the results are consistent in terms of signs and significance level (in most cases). For instance, the results show that electoral, liberal, participatory, deliberative, and egalitarian democracy positively affects ecological footprint in the full sample (see Table 14). This result suggests that democracy degrade the SSA environment. For the sub-samples, the results indicate that electoral, liberal, participatory, deliberative, and egalitarian democracy has a positive effect on the ecological footprint in West Africa (see Table 15) while reducing ecological footprint in Southern Africa (see Table 16) and Central-Eastern Africa (see Table 17) countries. These results consistently suggest that democracy impedes environmental quality in West Africa while improving environmental quality in Southern Africa and Central-Eastern Africa countries.

Table 14: Driscoll-Kray and Lewbel TSLS results for the full-sample (Dependent variable: Ecological Footprint)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Driscoll-Kray results						**Lewbel TSLS results**					
Y^2	-0.095***	-0.086***	-0.086***	-0.093***	-0.089***	-0.090***	-0.164	-0.075	-0.075	-0.094*	-0.081	-0.077
	(0.022)	(0.021)	(0.020)	(0.022)	(0.022)	(0.023)	(0.186)	(0.054)	(0.053)	(0.054)	(0.054)	(0.053)
Y	1.397***	1.273***	1.261***	1.364***	1.313***	1.331***	2.379	1.116	1.092	1.384*	1.201*	1.151*
	(0.249)	(0.237)	(0.227)	(0.250)	(0.259)	(0.263)	(2.599)	(0.720)	(0.713)	(0.732)	(0.715)	(0.699)
lnpop	0.717***	0.719***	0.720***	0.716***	0.718***	0.722***	0.684***	0.722***	0.724***	0.716***	0.721***	0.737***
	(0.067)	(0.065)	(0.065)	(0.067)	(0.067)	(0.068)	(0.127)	(0.073)	(0.073)	(0.070)	(0.073)	(0.077)
lnE	0.528***	0.522***	0.520***	0.527***	0.520***	0.522***	0.609*	0.515***	0.510***	0.528***	0.508***	0.504***
	(0.135)	(0.131)	(0.129)	(0.134)	(0.133)	(0.133)	(0.314)	(0.173)	(0.174)	(0.177)	(0.178)	(0.175)
lntra	-0.069	-0.098	-0.094	-0.078	-0.089	-0.080	-0.092	-0.134	-0.125	-0.073	-0.114	-0.111
	(0.103)	(0.108)	(0.108)	(0.108)	(0.111)	(0.107)	(0.114)	(0.095)	(0.095)	(0.098)	(0.095)	(0.095)
lnturpop	-0.210*	-0.246**	-0.227**	-0.224**	-0.227**	-0.221*	-0.232	-0.292***	-0.248**	-0.215*	-0.250**	-0.251**
	(0.114)	(0.102)	(0.104)	(0.102)	(0.102)	(0.107)	(0.146)	(0.112)	(0.114)	(0.112)	(0.115)	(0.117)
lnfdi	0.072***	0.080***	0.077***	0.075***	0.077***	0.075***	0.080**	0.090***	0.085***	0.073***	0.085***	0.085***
	(0.014)	(0.014)	(0.014)	(0.013)	(0.013)	(0.013)	(0.038)	(0.028)	(0.028)	(0.027)	(0.028)	(0.028)
polyarchy		0.274***						0.622**				
		(0.064)						(0.314)				
libdem			0.272***						0.610**			
			(0.069)						(0.285)			
partipdem				0.167						0.063		
				(0.134)						(0.683)		
delibdem					0.158*						0.367	
					(0.084)						(0.262)	
egaldem						0.152						0.569**
						(0.087)						(0.283)
Constant	-2.401***	-1.845***	-1.819***	-2.215***	-1.995***	-2.192***	-5.633	-1.137	-1.098	-2.331	-1.457	-1.617
	(0.481)	(0.524)	(0.514)	(0.554)	(0.595)	(0.531)	(8.253)	(2.256)	(2.203)	(2.403)	(2.291)	(2.105)
Observations	290	290	290	290	290	290	290	290	290	290	290	290
R^2	0.857	0.858	0.858	0.857	0.857	0.857	0.855	0.856	0.856	0.857	0.856	0.855

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 15: Driscoll-Kray and Lewbel TSLS results for West Africa (Dependent variable: Ecological Footprint)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Driscoll-Kray results						**Lewbel TSLS results**					
Y^2	0.936***	1.050***	1.167***	1.073***	1.053***	0.997***	0.400*	2.246***	1.707***	1.359***	1.819***	1.739***
	(0.155)	(0.142)	(0.142)	(0.065)	(0.128)	(0.132)	(0.216)	(0.456)	(0.270)	(0.282)	(0.314)	(0.306)
Y	-13.506***	-15.176***	-16.909***	-15.524***	-15.212***	-14.392***	-5.916*	-32.710***	-24.874***	-19.753***	-26.412***	-25.157***
	(2.042)	(1.919)	(1.970)	(0.920)	(1.712)	(1.747)	(3.047)	(6.611)	(3.921)	(4.120)	(4.547)	(4.424)
lnpop	1.125***	1.149***	1.174***	1.162***	1.151***	1.144***	1.007***	1.404***	1.289***	1.241***	1.325***	1.376***
	(0.037)	(0.028)	(0.029)	(0.018)	(0.025)	(0.026)	(0.054)	(0.097)	(0.058)	(0.078)	(0.065)	(0.078)
lnE	0.128	0.136	0.143	0.105	0.119	0.120	0.265*	0.219	0.180	0.057	0.060	0.031
	(0.106)	(0.106)	(0.102)	(0.077)	(0.100)	(0.102)	(0.144)	(0.172)	(0.127)	(0.119)	(0.148)	(0.140)
lntra	0.382*	0.390**	0.389**	0.438***	0.385**	0.390*	0.142	0.478**	0.404***	0.555***	0.404***	0.488***
	(0.208)	(0.178)	(0.149)	(0.125)	(0.179)	(0.186)	(0.164)	(0.192)	(0.118)	(0.160)	(0.147)	(0.138)
lnturpop	1.419***	1.496***	1.560***	1.455***	1.497***	1.458***	1.021***	2.301***	1.890***	1.531***	2.005***	1.920***
	(0.344)	(0.418)	(0.445)	(0.413)	(0.426)	(0.399)	(0.374)	(0.682)	(0.474)	(0.434)	(0.573)	(0.545)
lnfdi	0.038	0.038	0.030	0.040	0.035	0.035	0.116*	0.031	0.009	0.044	0.012	-0.001
	(0.097)	(0.089)	(0.075)	(0.090)	(0.086)	(0.092)	(0.065)	(0.082)	(0.054)	(0.057)	(0.064)	(0.062)
polyarchy		0.352						4.052***				
		(0.331)						(0.875)				
libdem			0.638*						2.132***			
			(0.333)						(0.379)			
partipdem				0.676						2.094**		
				(0.721)						(0.969)		
delibdem					0.338						2.559***	
					(0.274)						(0.450)	
egaldem						0.200						2.630***
						(0.292)						(0.587)
Constant	38.752***	43.860***	49.485***	45.068***	44.104***	41.420***	15.636	97.506***	74.606***	58.308***	79.235***	73.839***
	(7.294)	(6.999)	(7.018)	(3.293)	(6.424)	(6.571)	(9.780)	(20.555)	(12.165)	(12.499)	(14.101)	(13.363)
Observations	96	96	96	96	96	96	96	96	96	96	96	96
R2	0.948	0.949	0.951	0.949	0.949	0.948	0.941	0.857	0.935	0.946	0.905	0.916

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 16: Driscoll-Kray and Lewbel TSLS results for Southern Africa (Dependent variable: Ecological Footprint)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Driscoll-Kray results						**Lewbel TSLS results**					
Y^2	0.059	0.470***	0.431***	0.409***	0.428**	0.434***	0.358	0.515***	0.436***	0.411***	0.436***	0.426***
	(0.141)	(0.128)	(0.129)	(0.120)	(0.152)	(0.145)	(0.220)	(0.115)	(0.125)	(0.120)	(0.131)	(0.124)
Y	-0.965	-6.925***	-6.319***	-5.947***	-6.236**	-6.391***	-5.237*	-7.577***	-6.387***	-5.967***	-6.350***	-6.277***
	(1.952)	(1.808)	(1.799)	(1.648)	(2.129)	(2.042)	(3.098)	(1.631)	(1.752)	(1.684)	(1.837)	(1.748)
lnpop	0.509***	0.495***	0.499***	0.516***	0.514***	0.473***	0.599***	0.493***	0.499***	0.516***	0.514***	0.474***
	(0.047)	(0.049)	(0.053)	(0.050)	(0.055)	(0.053)	(0.099)	(0.058)	(0.065)	(0.062)	(0.067)	(0.067)
lnE	0.596***	0.143	0.211	0.189	0.249	0.214	0.316	0.093	0.206	0.188	0.242	0.222
	(0.165)	(0.155)	(0.159)	(0.144)	(0.181)	(0.172)	(0.336)	(0.236)	(0.267)	(0.257)	(0.279)	(0.268)
lntra	0.351	0.543***	0.625***	0.273**	0.460**	0.637***	0.537*	0.564**	0.629**	0.272	0.462*	0.631**
	(0.356)	(0.146)	(0.161)	(0.094)	(0.176)	(0.167)	(0.321)	(0.246)	(0.259)	(0.232)	(0.256)	(0.262)
lnturpop	-0.040	1.180***	1.056***	0.768***	0.784***	0.868***	0.040	1.313***	1.070**	0.771*	0.802**	0.849**
	(0.301)	(0.179)	(0.137)	(0.101)	(0.213)	(0.185)	(0.560)	(0.389)	(0.419)	(0.426)	(0.403)	(0.404)
lnfdi	0.038	-0.010	-0.005	0.011	-0.006	-0.009	0.020	-0.015	-0.005	0.011	-0.007	-0.008
	(0.045)	(0.026)	(0.022)	(0.023)	(0.031)	(0.022)	(0.059)	(0.045)	(0.040)	(0.041)	(0.041)	(0.042)
polyarchy		-2.302***						-2.554***				
		(0.200)						(0.219)				
libdem			-2.377***						-2.407***			
			(0.194)						(0.219)			
partipdem				-3.036***						-3.049***		
				(0.242)						(0.287)		
delibdem					-2.195***						-2.243***	
					(0.208)						(0.211)	
egaldem						-2.417***						-2.366***
						(0.232)						(0.247)
Constant	6.741	26.703***	23.737***	24.720***	24.479***	25.057***	20.716**	28.887***	23.954***	24.792***	24.863***	24.671***
	(7.947)	(5.736)	(5.568)	(5.700)	(6.547)	(6.428)	(10.241)	(4.750)	(5.049)	(5.040)	(5.380)	(5.097)
Observations	75	75	75	75	75	75	75	75	75	75	75	75
R2	0.845	0.930	0.928	0.928	0.925	0.923	0.824	0.929	0.928	0.928	0.925	0.923

Heteroscedasticity robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 17: Driscoll-Kray and Lewbel TSLS results for Central-Eastern Africa (Dependent variable: Ecological Footprint)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Driscoll-Kray results						**Lewbel TSLS results**					
Y^2	0.074***	0.046**	0.045***	0.048**	0.036**	0.042**	0.073***	0.066***	0.061***	0.090***	0.046*	0.049**
	(0.016)	(0.017)	(0.015)	(0.018)	(0.014)	(0.019)	(0.024)	(0.021)	(0.020)	(0.027)	(0.026)	(0.020)
Y	-0.555**	-0.169	-0.175	-0.224	-0.066	-0.161	-0.536*	-0.447*	-0.389	-0.756**	-0.185	-0.248
	(0.207)	(0.224)	(0.186)	(0.227)	(0.180)	(0.237)	(0.309)	(0.264)	(0.256)	(0.338)	(0.329)	(0.248)
lnpop	1.220***	1.242***	1.226***	1.235***	1.225***	1.202***	1.219***	1.226***	1.222***	1.211***	1.224***	1.206***
	(0.016)	(0.017)	(0.016)	(0.015)	(0.015)	(0.016)	(0.025)	(0.025)	(0.024)	(0.023)	(0.023)	(0.024)
lnE	-0.016	0.101	0.118*	0.118	0.154**	0.130	-0.013	0.017	0.043	-0.098	0.112	0.098
	(0.052)	(0.073)	(0.064)	(0.074)	(0.065)	(0.082)	(0.059)	(0.063)	(0.065)	(0.100)	(0.098)	(0.066)
lntra	-0.226***	-0.166***	-0.187***	-0.181***	-0.147***	-0.195***	-0.226***	-0.209***	-0.209***	-0.254***	-0.166***	-0.202***
	(0.029)	(0.045)	(0.037)	(0.037)	(0.045)	(0.041)	(0.033)	(0.037)	(0.032)	(0.036)	(0.048)	(0.033)
lnturpop	-0.010	-0.010	-0.037	0.008	-0.020	-0.026	-0.010	-0.010	-0.022	-0.021	-0.018	-0.022
	(0.083)	(0.090)	(0.082)	(0.081)	(0.080)	(0.092)	(0.048)	(0.047)	(0.044)	(0.054)	(0.045)	(0.046)
lnfdi	0.034	0.029	0.031	0.031	0.024	0.028	0.034*	0.033	0.033	0.036	0.026	0.029
	(0.022)	(0.021)	(0.021)	(0.020)	(0.019)	(0.021)	(0.021)	(0.021)	(0.021)	(0.023)	(0.023)	(0.021)
polyarchy		-0.562***						-0.157				
		(0.065)						(0.262)				
libdem			-0.543***						-0.237			
			(0.057)						(0.219)			
partipdem				-0.810***						0.492		
				(0.144)						(0.429)		
delibdem					-0.615***						-0.465	
					(0.050)						(0.321)	
egaldem						-0.689***						-0.537*
						(0.123)						(0.277)
Constant	-2.382***	-4.794***	-4.453***	-4.582***	-5.154***	-4.068***	-2.445**	-3.055***	-3.288***	-1.046	-4.476***	-3.696***
	(0.799)	(1.068)	(0.843)	(1.046)	(0.947)	(0.993)	(1.109)	(1.135)	(0.990)	(1.560)	(1.488)	(0.896)
Observations	119	119	119	119	119	119	119	119	119	119	119	119
R2	0.989	0.990	0.990	0.990	0.990	0.990	0.989	0.989	0.990	0.987	0.990	0.990

Heteroscedasticity robust standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusion and Policy Recommendation

The debate on democracy—environment remains contentious and inconclusive in the environmental politics literature. The existing empirical studies have attempted to explore the effect of democracy on the environment. However, there are limitations in these studies with regards to how democracy was measured. Also, the prior empirical studies have been silent on how democracy moderates economic growth and energy consumption to influence the environment. This study, therefore, seeks to fill these gaps by following the political science literature to use high-level democracy indices such as electoral, liberal, participatory, deliberative, and egalitarian democracy to examine their respective effect on carbon emissions. Regarding methodology, we employed the dynamic system-GMM and Lewbel two-stage least squares technique to explore the direct and interactive effect of these democracy indicators on carbon emissions using comprehensive panel data for 46 SSA countries.

Our findings are summarised in five (5) main parts. (1) The high-level democracy measures drive environmental degradation measured by increasing carbon emissions in SSA. (2) The high-level democracy measures moderate economic growth to reduce carbon emissions in SSA. (3) There is no evidence that the high-level democracy measures moderate energy use to influence carbon emissions in SSA. (4) The direct and interactive effect of high-level democracy measures on carbon emissions differs among the sub-regions within SSA. The democracy indicators degrade the environment in West Africa while improving environmental quality in Southern Africa and Central-Eastern Africa. (5) The results are robust to using ecological footprint as an alternative measure of environmental degradation.

From theoretical and policy perspectives, our empirical results generally contribute to a strand of the environmental politics literature, arguing that democracy is associated with higher environmental degradation since democratic rulers are often myopic and focus on short-run gains rather than a commitment to long-run gains projects as climate change mitigation. Conversely, less democratic regimes improve environmental quality because, in less democratic countries, policymakers implement actionable policies instead of deliberations to overcome the resistance of stakeholders who see environmental regulation as inimical to their short-term economic interest. Our findings highlight the existing "political syndrome" in SSA where democratic leaders value improving macroeconomic indicators such as GDP, inflation, unemployment etc., to win political votes rather than enhancing environmental quality. Our study, therefore, calls political leaders to prioritise the environment in their development plan since macroeconomic performance can be challenged by environmental degradation in the long term.

Commitment to environmental sustainability is a commitment to attaining sustainable development goals. Environmental degradation, particularly CO_2 emissions, is the major cause of climate change. The effect of climate change is ravaging lots of developing countries, including those in the SSA region. Many experts have warned that the future effect of climate change would surpass those of the COVID-19 pandemic if globally countries and governments do not take care. As a result, governments have to be seen at the forefront championing environmental sustainability. The call for renewed government effort and commitment to protecting the environment was emphasized at COP26. This follows the failure of almost all countries to meet the commitments made in 2015 at the COP21 (The Paris Agreement). The United Nations Secretary General has admonished at the COP26 that there is no longer time to waste in saving the planet and rather the time for action is now. Hence, governments should employ the tools of democracy in driving the environmentally sustainable development agenda since this is an issue of public policy.

Another policy implication of our findings is that democracy can indirectly improve environmental quality when it conditions economic growth. Therefore, with an improvement in democracy in SSA, economic growth would significantly lead to carbon emissions mitigation. This supports the political science argument that democracy can improve environmental quality when it conditions economic growth. It is argued that the economic growth effect of democracy increases the demand for environmental protection and generates the financial resource to meet such demand. Further, increasing economic growth due to democracy can lead to technological advancement and the implementation and enforcement of stringent environmental regulations, thereby limiting environmental pollution.

Most empirical studies have limitations, and the present study is no exception. The major limitation of our study was data availability, which limits the sample size. With greater access to data in the future, we suggest further studies be conducted on extended years and countries sample for a more constructive conclusion on the impact of democracy on the environment. With access to data, future studies can also measure environmental degradation more comprehensively to examine how democracy affects the environment. This study employs a panel methodology and hence pools the countries together. For a more constructive conclusion, future studies can consider performing a country-by-country level analysis to ascertain the effect of democracy on the environment.

Reference

Abid, M. (2016). Impact of economic, financial, and institutional factors on CO2 emissions: Evidence from Sub-Saharan Africa economies. *Utilities Policy, 41*, 85-94. doi:10.1016/j.jup.2016.06.009

Abid, M. (2017). Does economic, financial and institutional developments matter for environmental quality? A comparative analysis of EU and MEA countries. *J Environ Manage, 188*, 183-194. doi:10.1016/j.jenvman.2016.12.007

Acheampong, A. O. (2019). Modelling for insight: Does financial development improve environmental quality? *Energy Economics, 83*, 156-179. doi: https://doi.org/10.1016/j.eneco.2019.06.025

Acheampong, A. O., Adams, S., & Boateng, E. (2019). Do globalization and renewable energy contribute to carbon emissions mitigation in Sub-Saharan Africa? *Science of The Total Environment, 677*, 436-446. doi: https://doi.org/10.1016/j.scitotenv.2019.04.353

Acheampong, A. O., Dzator, J., & Savage, D. A. (2021). The role of economic institutions in electricity consumption, economic growth, and CO2 emissions linkages: evidence from sub-Saharan Africa. In P. Singh, P. Verma, D. Perrotti, & K. K. Srivastava (Eds.), *Environmental Sustainability and Economy* (pp. 61-83): Elsevier.

Acheampong, A. O., Erdiaw-Kwasie, M. O., & Abunyewah, M. (2021). Does energy accessibility improve human development? Evidence from energy-poor regions. *Energy Economics, 96*, 105165. doi: https://doi.org/10.1016/j.eneco.2021.105165

Adams, S., & Acheampong, A. O. (2019). Reducing carbon emissions: The role of renewable energy and democracy. *Journal of Cleaner Production, 240*, 118245. doi: https://doi.org/10.1016/j.jclepro.2019.118245

Adams, S., & Opoku, E. E. O. (2020). Trade and environmental pollution in Africa: accounting for consumption and territorial-based emissions. *Environmental Science and Pollution Research, 27*(35), 44230-44239. doi:10.1007/s11356-020-10328-8

Adom, P. K., Kwakwa, P. A., & Amankwaa, A. (2018). The long-run effects of economic, demographic, and political indices on actual and potential CO2 emissions. Journal of environmental management, 218, 516-526.

Ahmad, N., Du, L., Lu, J., Wang, J., Li, H.-Z., & Hashmi, M. Z. (2017). Modelling the CO 2 emissions and economic growth in Croatia: Is there any environmental Kuznets curve? Energy, 123, 164-172. doi:10.1016/j.energy.2016.12.106

Akalin, G., & Erdogan, S. (2021). Does democracy help reduce environmental degradation?. Environmental Science and Pollution Research, 28(6), 7226-7235.

Akinlo, T., & Dada, J. T. (2021). The moderating effect of foreign direct investment on environmental degradation-poverty reduction nexus: evidence from sub-Saharan African countries. *Environment, Development and Sustainability, 23*(11), 15764-15784. doi:10.1007/s10668-021-01315-1

Al-Mulali, U., Saboori, B., & Ozturk, I. (2015). Investigating the environmental Kuznets curve hypothesis in Vietnam. Energy policy, 76, 123-131.

Aluko, O. A., Opoku, E. E. O., & Ibrahim, M. (2021). Investigating the environmental effect of globalization: Insights from selected industrialized countries. Journal of Environmental Management, 281, 111892.

Antweiler, W., Copeland, B. R., & Taylor, M. S. (2001). Is free trade good for the environment?. American Economic Review, 91(4), 877-908.

Apergis, N., & Ozturk, I. (2015). Testing Environmental Kuznets Curve hypothesis in Asian countries. Ecological Indicators, 52(Supplement C), 16-22. doi: https://doi.org/10.1016/j.ecolind.2014.11.026

Arvin, M.B., & Lew, B. (2011). Does democracy affect environmental quality in developing countries?. Applied economics, 43(9), 1151-1160.

Azam, M., Liu, L., & Ahmad, N. (2021). Impact of institutional quality on environment and energy consumption: evidence from developing world. *Environment, Development and Sustainability, 23*(2), 1646-1667.

Barrett, S., & Graddy, K. (2000). Freedom, growth, and the environment. Environment and development economics, 5(4), 433-456.

Bernauer, T., & Koubi, V. (2009). Effects of political institutions on air quality. Ecological economics, 68(5), 1355-1365.

Binder, S., & Neumayer, E. (2005). Environmental pressure group strength and air pollution: An empirical analysis. Ecological economics, 55(4), 527-538.

Birdsall, N. (1992). *Another look at population and global warming* (Vol. 1020): World Bank Publications.

Chou, L. C., Zhang, W. H., Wang, M. Y., & Yang, F. M. (2020). The influence of democracy on emissions and energy efficiency in America: New evidence from quantile regression analysis. Energy & Environment, 31(8), 1318-1334.

Congleton, R. D. (1992). Political institutions and pollution control. The review of economics and statistics, 412-421.

Coppedge, M., Gerring, J., Altman, D., Bernhard, M., Fish, S., Hicken, A., . . . Teorell, J. (2011). Conceptualizing and Measuring Democracy: A New Approach. *Perspectives on Politics, 9*(2), 247-267. doi:10.1017/S1537592711000880

Coppedge, Michael, John Gerring, Carl Henrik Knutsen, Staffan I. Lindberg, Svend-Erik Skaaning, Jan Teorell, David Altman, Michael Bernhard, Agnes Cornell, M. Steven Fish, Haakon Gjerløw, Adam Glynn, Allen Hicken, Joshua Krusell, Anna Lührmann, Kyle L. Marquardt, Kelly McMann, Valeriya Mechkova, Moa Olin, Pamela Paxton, Daniel Pemstein, Brigitte Seim, Rachel Sigman, Jeffrey Staton, Aksel Sundtröm, Eitan Tzelgov, Luca Uberti, Yi-ting Wang, Tore Wig, and Daniel Ziblatt. 2018. "V-Dem Codebook v8" Varieties of Democracy (V-Dem) Project.

Coppedge, Michael, John Gerring, Carl Henrik Knutsen, Staffan I. Lindberg, Svend-Erik Skaaning, Jan Teorell, David Altman, Michael Bernhard, M. Steven Fish, Agnes Cornell, Sirianne Dahlum, Haakon Gjerløw, Adam Glynn, Allen Hicken, Joshua Krusell, Anna Lührmann, Kyle L.

Marquardt, Kelly McMann, Valeriya Mechkova, Juraj Medzihorsky, Moa Olin, Pamela Paxton, Daniel Pemstein, Josefine Pernes, Johannes von Römer, Brigitte Seim, Rachel Sigman, Jeffrey Staton, Natalia Stepanova, Aksel Sundström, Eitan Tzelgov, Yi-ting Wang, Tore Wig, Steven Wilson, and Daniel Ziblatt. 2018. "V-Dem [Country-Year/Country-Date] Dataset v8" Varieties of Democracy (V-Dem) Project.

Deacon, R. (2003). Dictatorship, Democracy, and the Provision of Public Goods. UC Santa Barbara: Department of Economics.

Deacon, R. T. (2002). Dictatorship, Democracy and the Provision of Public Goods. In Department of Economics, University of California at Santa Barbara, Working Paper.

Deacon, R. T. (2009). Public good provision under dictatorship and democracy. Public choice, 139(1-2), 241-262.

Desai, U. (1998). Environment, economic growth, and government, ecological policy and politics in developing countries. Albany, NY. State University Press of New York Press.

Dou, Y., Zhao, J., Malik, M. N., & Dong, K. (2021). Assessing the impact of trade openness on CO2 emissions: Evidence from China-Japan-ROK FTA countries. *Journal of Environmental Management, 296*, 113241.

Doytch, N., & Uctum, M. (2016). Globalization and the environmental impact of sectoral FDI. Economic Systems, 40(4), 582-594.

Driscoll, J. C., & Kraay, A. C. (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of economics and statistics, 80*(4), 549-560.

Dryzek JS (1987) Rational ecology: environment and political economy. Basil Blackwell, New York.

Dryzek, J. (1987). *Rational ecology: environment and political economy*: Basil Blackwell.

Farzanegan, M. R., & Markwardt, G. (2012). Pollution, economic development and democracy: evidence from the MENA countries (No. 27-2012). MAGKS Joint Discussion Paper Series in Economics.

Farzanegan, M. R., & Markwardt, G. (2018). Development and pollution in the Middle East and North Africa: Democracy matters. *Journal of Policy Modeling, 40*(2), 350-374. doi:https://doi.org/10.1016/j.jpolmod.2018.01.010

Farzin, Y. H., & Bond, C. A. (2006). Democracy and environmental quality. Journal of Development Economics, 81(1), 213-235.

Fiorino, D. J. (2018). Can democracy handle climate change?. John Wiley & Sons.

Fredriksson, P. G., & Wollscheid, J. R. (2007). Democratic institutions versus autocratic regimes: The case of environmental policy. Public choice, 130(3), 381-393.

Gill, A. R., Hassan, S., & Viswanathan, K. K. (2019). Is democracy enough to get early turn of the environmental Kuznets curve in ASEAN countries?. Energy & Environment, 30(8), 1491-1505.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement. NBER, WORKING PAPER 3914.

Grossman, G. M., & Krueger, A. B. (1996). The inverted-U: what does it mean?. Environment and Development Economics, 1(1), 119-122.

Güngör, H., Olanipekun, I. O., & Usman, O. (2021). Testing the environmental Kuznets curve hypothesis: the role of energy consumption and democratic accountability. Environmental Science and Pollution Research, 28(2), 1464-1478.

Haseeb, M., & Azam, M. (2021). Dynamic nexus among tourism, corruption, democracy and environmental degradation: a panel data investigation. Environment, development and sustainability, 23(4), 5557-5575.

Hassan, S. T., Baloch, M. A., Mahmood, N., & Zhang, J. (2019). Linking economic growth and ecological footprint through human capital and biocapacity. Sustainable Cities and Society, 47, 101516.

Heilbroner, R. L. (1991). An inquiry into the human prospect. WW Norton & Company.

Heo, U., & Tan, A. C. (2001). Democracy and economic growth: a causal analysis. Comparative politics, 463-473.

Hoechle, D. (2007). Robust standard errors for panel regressions with cross-sectional dependence. *The stata journal, 7*(3), 281-312.

Jahanger, A., Usman, M., & Balsalobre‐Lorente, D. (2021). Autocracy, democracy, globalization, and environmental pollution in developing world: fresh evidence from STIRPAT model. *Journal of Public Affairs*, e2753.

Joshi, P., & Beck, K. (2018). Democracy and carbon dioxide emissions: assessing the interactions of political and economic freedom and the environmental Kuznets curve. *Energy Research & Social Science, 39*, 46-54.

Kivyiro, P., & Arminen, H. (2014). Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: Causality analysis for Sub-Saharan Africa. *Energy, 74*, 595-606. doi:https://doi.org/10.1016/j.energy.2014.07.025

Kivyiro, P., & Arminen, H. (2014). Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: Causality analysis for Sub-Saharan Africa. Energy, 74, 595-606. doi: https://doi.org/10.1016/j.energy.2014.07.025

Koçak, E., & Kızılkaya, O. (2020). Towards sustainable development in China: do political rights and civil liberties matter for environmental quality?. Environmental Science and Pollution Research, 27(28), 35488-35500.

Laegreid, O. M., & Povitkina, M. (2018). Do political institutions moderate the GDP-CO2 relationship? *Ecological Economics, 145*, 441-450.

Lake, D. A., & Baum, M. A. (2001). The invisible hand of democracy: political control and the provision of public services. Comparative Political Studies, 34(6), 587-621.

Lewbel, A. (2012). Using heteroscedasticity to identify and estimate mismeasured and endogenous regressor models. *Journal of Business & Economic Statistics, 30*(1), 67-80.

Li, M., Ahmad, M., Fareed, Z., Hassan, T., & Kirikkaleli, D. (2021). Role of trade openness, export diversification, and renewable electricity output in realizing carbon neutrality dream of China. *Journal of Environmental Management, 297*, 113419. doi: https://doi.org/10.1016/j.jenvman.2021.113419

Li, Q., & Reuveny, R. (2006). Democracy and Environmental Degradation. *International Studies Quarterly, 50*(4), 935-956. doi:10.1111/j.1468-2478.2006.00432.x

Lisciandra, M., & Migliardo, C. (2017). An Empirical Study of the Impact of Corruption on Environmental Performance: Evidence from Panel Data. Environmental and Resource Economics, 68(2), 297-318. doi:10.1007/s10640-016-0019-1

Liu, X., Zhang, S., & Bae, J. (2017). The impact of renewable energy and agriculture on carbon dioxide emissions: investigating the environmental Kuznets curve in four selected ASEAN countries. Journal of cleaner production, 164, 1239-1247.

Mahadevan, R., & Sun, Y. (2020). Effects of foreign direct investment on carbon emissions: Evidence from China and its Belt and Road countries. *Journal of Environmental Management, 276*, 111321. doi: https://doi.org/10.1016/j.jenvman.2020.111321

Mak Arvin, B., & Lew, B. (2011). Does democracy affect environmental quality in developing countries? *Applied Economics, 43*(9), 1151-1160.

Midlarsky, M. I. (1998). Democracy and the environment: an empirical assessment. *Journal of Peace Research, 35*(3), 341-361.

Mishra, V., & Smyth, R. (2015). Estimating returns to schooling in urban China using conventional and heteroskedasticity-based instruments. *Economic Modelling, 47*, 166-173. doi: https://doi.org/10.1016/j.econmod.2015.02.002

Nathaniel, S. P., Yalçiner, K., & Bekun, F. V. (2021). Assessing the environmental sustainability corridor: Linking natural resources, renewable energy, human capital, and ecological footprint in BRICS. Resources Policy, 70, 101924.

Neumayer, E. (2002). Do democracies exhibit stronger international environmental commitment? A cross-country analysis. Journal of Peace Research, 39(2), 139-164.

Neumayer, E. (2003). Are left-wing party strength and corporatism good for the environment? Evidence from panel analysis of air pollution in OECD countries. Ecological economics, 45(2), 203-220.

NFA, 2021. York University Ecological Footprint Initiative & Global Footprint Network. National Footprint and Biocapacity Accounts, 2021 Edition. Produced for the Footprint Data Foundation and Distributed by Global Footprint Network. Available online at https://data.footprintnetwork.org.

North, Douglass C. (1990). Institutions, Institutional Change and Economic Performance. Cambridge: Cambridge University Press.

Olson, M. (1993). Dictatorship, democracy, and development. American political science review, 87(3), 567-576.

Olson, Mancur (2000). Power and Prosperity: Outgrowing Communist and Capitalist Dictatorships. New York: Basic books.

Opoku, E. E. O., & Aluko, O. A. (2021). Heterogeneous effects of industrialization on the environment: Evidence from panel quantile regression. Structural Change and Economic Dynamics, 59, 174-184.

Opoku, E. E. O., Dogah, K. E., & Aluko, O. A. (2022). The contribution of human development towards environmental sustainability. Energy Economics, 106, 105782.

Payne, R. A. (1995). Freedom and the environment. Journal of Democracy, 6(3), 41-55.

Peev, Evgeni, and Dennis C. Mueller (2012). Democracy, economic freedom and growth in transition economics. Kyklos, vol. 65, No. 3 (August), p. 371 - 407.

Pemstein, Daniel, Kyle L. Marquardt, Eitan Tzelgov, Yi-ting Wang, Joshua Krusell and Farhad Miri. 2018. "The V-Dem Measurement Model: Latent Variable Analysis for Cross-National and Cross-Temporal Expert-Coded Data". University of Gothenburg, Varieties of Democracy Institute: Working Paper No. 21, 3d edition

Policardo, L. (2016). Is democracy good for the environment? Quasi-experimental evidence from regime transitions. Environmental and Resource Economics, 64(2), 275-300.

Popović, E. (2020). Advocacy groups in China's environmental policymaking: Pathways to influence. Journal of environmental management, 261, 109928.

Poumanyvong, P., & Kaneko, S. (2010). Does urbanization lead to less energy use and lower CO2 emissions? A cross-country analysis. *Ecological Economics, 70*(2), 434-444. doi:10.1016/j.ecolecon.2010.09.029

Riti, J. S., Shu, Y., & Kamah, M. (2021). Institutional quality and environmental sustainability: The role of freedom of press in most freedom of press countries. Environmental Impact Assessment Review, 91, 106656.

Saha, A. K., Mishra, V., & Smyth, R. (2021). Financial development and top income shares in OECD countries. *Southern Economic Journal, 87*(3), 952-978. doi: https://doi.org/10.1002/soej.12472

Satrovic, E., Ahmad, M., & Muslija, A. (2021). Does democracy improve environmental quality of GCC region? Analysis robust to cross-section dependence and slope heterogeneity. Environmental Science and Pollution Research, 1-16.

Spilker, G. (2013). *Globalization, political institutions and the environment in developing countries*: Routledge.

Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. World Development, 32(8), 1419-1439.

Tan, Z., Koondhar, M. A., Nawaz, K., Malik, M. N., Khan, Z. A., & Koondhar, M. A. (2021). Foreign direct investment, financial development, energy consumption, and air quality: A way for carbon neutrality in China. *Journal of Environmental Management, 299*, 113572. doi: https://doi.org/10.1016/j.jenvman.2021.113572

Twerefou, D. K., Danso-Mensah, K., & Bokpin, G. A. (2017). The environmental effects of economic growth and globalization in Sub-Saharan Africa: A panel general method of moments approach. Research in International Business and Finance, 42, 939-949.

Usman, O., Olanipekun, I. O., Iorember, P. T., & Abu-Goodman, M. (2020). Modelling environmental degradation in South Africa: the effects of energy consumption, democracy, and globalization using innovation accounting tests. Environmental Science and Pollution Research, 27(8), 8334-8349.

Uzar, U. (2021). The connection between freedom of the press and environmental quality: an investigation on emerging market countries. In Natural Resources Forum. Oxford, UK: Blackwell Publishing Ltd.

Vural, G. (2020). How do output, trade, renewable energy and non-renewable energy impact carbon emissions in selected Sub-Saharan African Countries? Resources Policy, 69, 101840. doi: https://doi.org/10.1016/j.resourpol.2020.101840

Winslow, M. (2005). Is democracy good for the environment?. Journal of Environmental Planning and Management, 48(5), 771-783.

Wurster, S. (2013). Comparing ecological sustainability in autocracies and democracies. *Contemporary Politics, 19*(1), 76-93.

WWF. (2019). Into the Wild: integrating nature into investment strategies. Retrieved from https://wwf.panda.org/our_work/finance/?346755/Into-the-Wild-integrating-nature-into-investment-strategies

Yameogo, C. E., Omojolaibi, J. A., & Dauda, R. O. (2021). Economic globalisation, institutions and environmental quality in sub-Saharan Africa. Research in Globalization, 3, 100035.

You, W. H., Zhu, H. M., Yu, K., & Peng, C. (2015). Democracy, financial openness, and global carbon dioxide emissions: heterogeneity across existing emission levels. World Development, 66, 189-207.

You, W., Li, Y., Guo, P., & Guo, Y. (2020). Income inequality and CO2 emissions in belt and road initiative countries: the role of democracy. Environmental Science and Pollution Research, 27(6), 6278-6299.

Zafar, M. W., Qin, Q., malik, M. N., & Zaidi, S. A. H. (2020). Foreign direct investment and education as determinants of environmental quality: The importance of post Paris Agreement (COP21). *Journal of Environmental Management, 270*, 110827. doi: https://doi.org/10.1016/j.jenvman.2020.110827

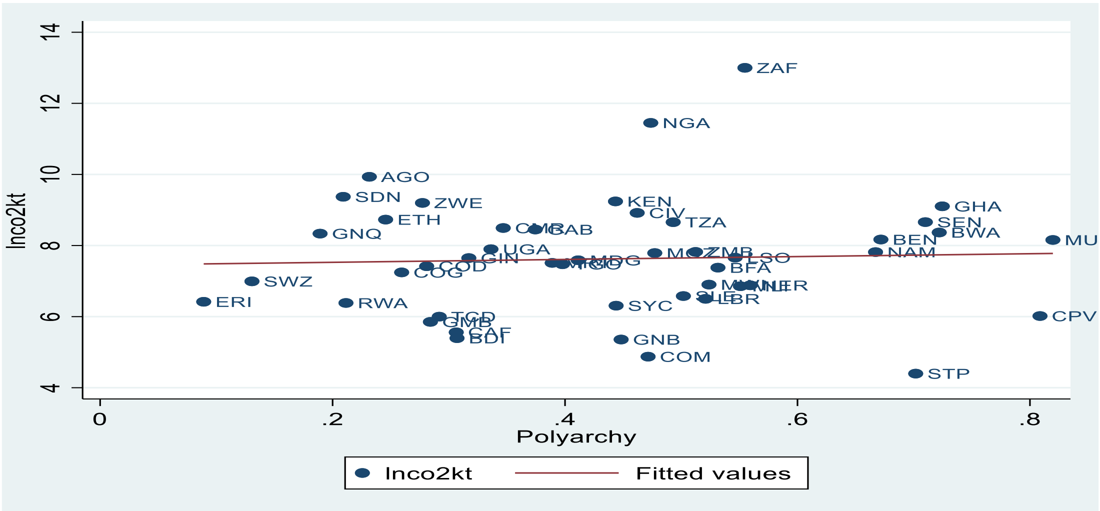
Zhang, W., & Chiu, Y. B. (2020). Do country risks influence carbon dioxide emissions? A non-linear perspective. Energy, 206, 118048.

Zhu, Q., & Peng, X. (2012). The impacts of population change on carbon emissions in China during 1978–2008. *Environmental Impact Assessment Review, 36*, 1-8. doi: https://doi.org/10.1016/j.eiar.2012.03.003

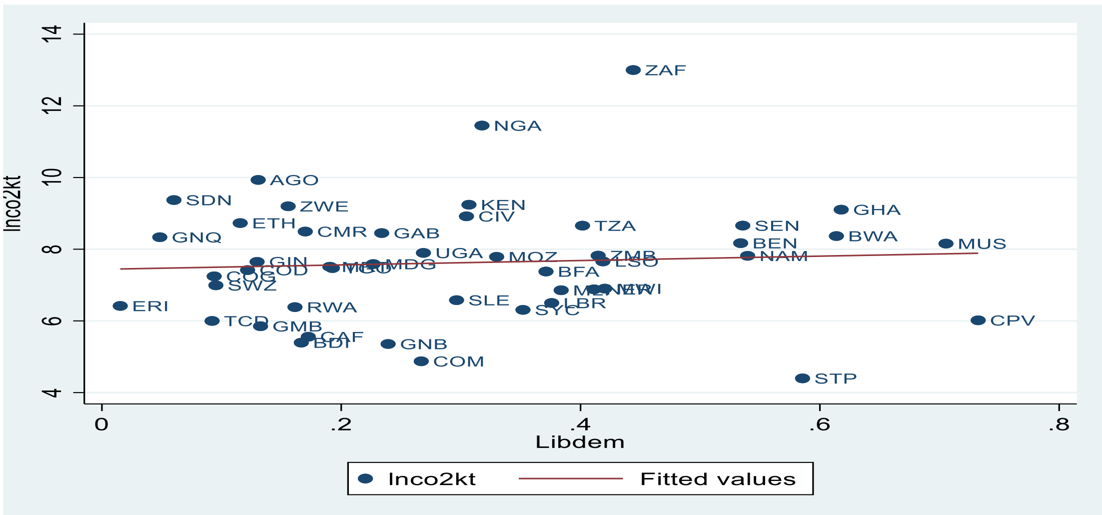
APPENDIX

Table A.1: List of SSA countries used for the study

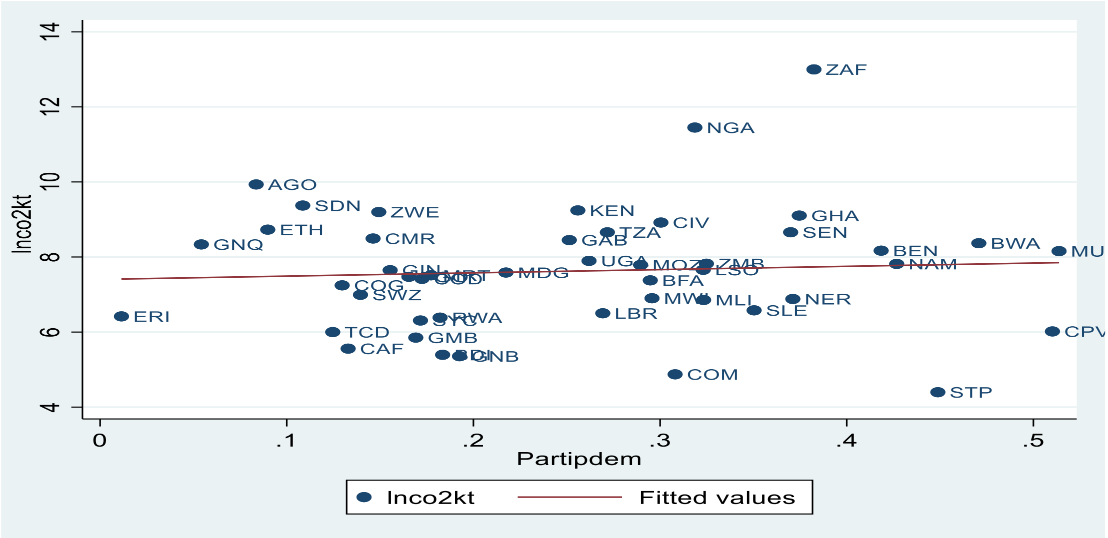
Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, The, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Swaziland (Eswatini), Tanzania, Togo, Uganda, Zambia, Zimbabwe



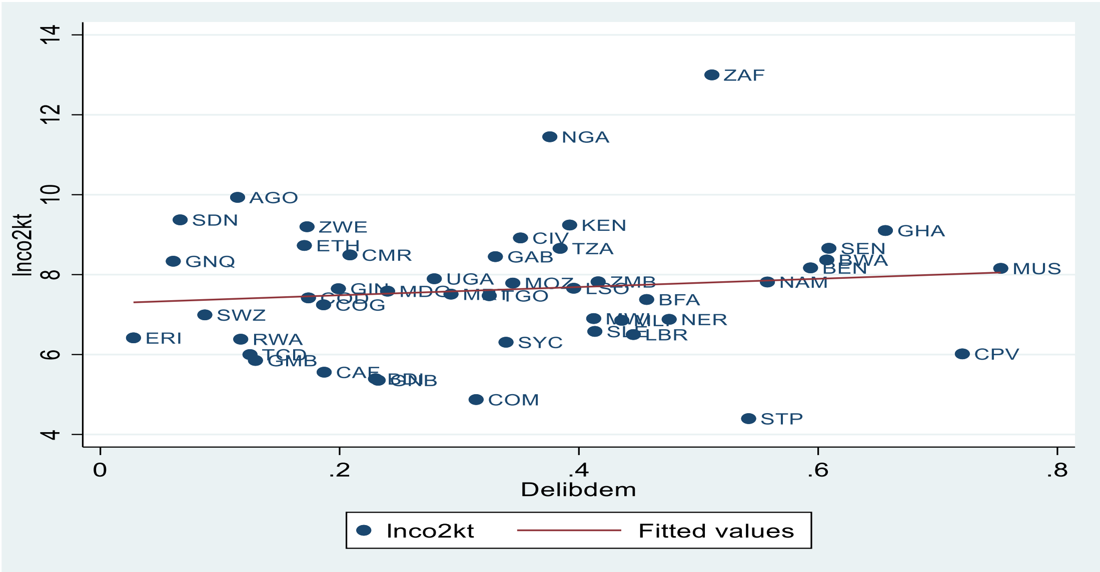
Appendix Fig. A1: Relationship between electoral democracy and CO_2 emissions



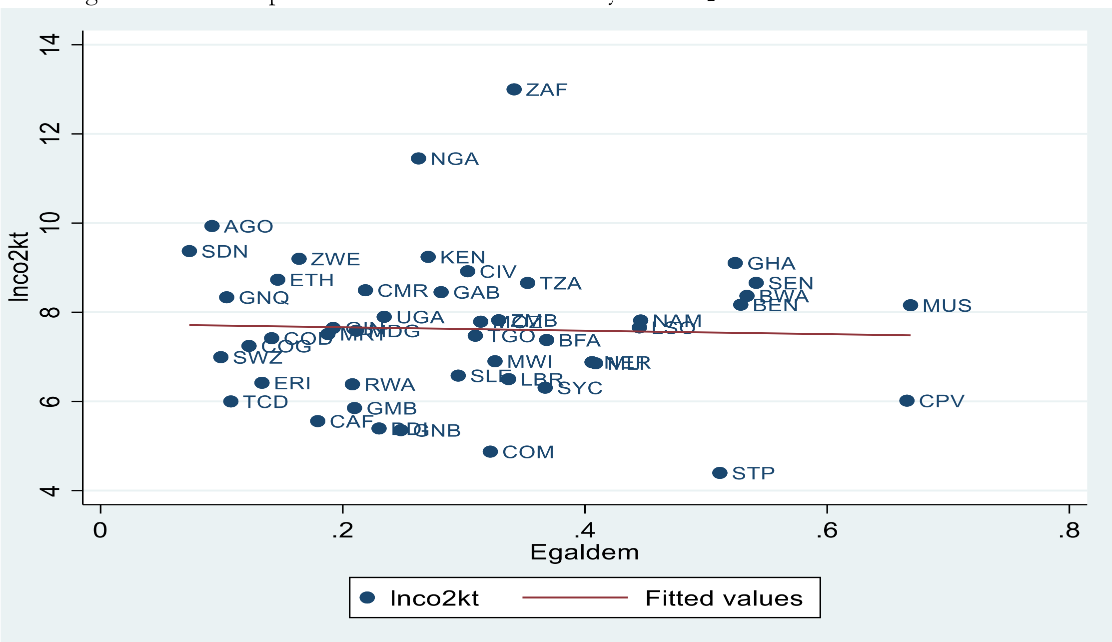
Appendix Fig. A2: Relationship between liberal democracy and CO_2 emissions



Appendix Fig. A3: Relationship between participatory democracy and CO_2 emissions



Appendix Fig. A4: Relationship between deliberative democracy and CO_2 emissions



Appendix Fig. A5: Relationship between egalitarian democracy and CO_2 emissions

Table A.2: Descriptive statistics for the SSA sub-regions

Variable	Mean	Std. Dev.	Min	Max
West Africa				
lnco2kt	7.521966	1.491513	4.988253	11.57184
lnefcon	16.334	1.439	13.351	19.149
lnY^2	44.92443	8.22126	31.38466	66.14943
lnY	6.675956	0.59794	5.602201	8.13323
lnpop	15.83235	1.297906	12.98328	19.01501
lnE	5.721748	0.640942	4.143218	6.682488
lntra	4.236577	0.390192	3.050426	5.740934
lnturpop	3.680052	0.318235	2.784147	4.182447
lnfdi	1.108292	1.248165	-6.08877	4.49397
polyarchy	0.521969	0.161868	0.193	0.844
libdem	0.360297	0.179508	0.069	0.77
partipdem	0.297555	0.110969	0.107	0.553
delibdem	0.419484	0.173509	0.114	0.771
egaldem	0.361719	0.14415	0.141	0.711
Southern Africa				
lnco2kt	8.028453	1.824742	4.631578	13.12857
lnefcon	15.920	1.146	13.339	18.239
lnY^2	58.4917	17.45248	30.77234	90.50797
lnY	7.560465	1.156305	5.547282	9.513568
lnpop	15.27679	1.726153	11.30382	17.82306
lnE	6.492655	1.009961	2.260188	8.040438
lntra	4.485923	0.373632	3.652792	5.416203
lnturpop	3.525788	0.37074	2.681706	4.171321
lnfdi	1.041214	1.249958	-3.08054	3.990134
polyarchy	0.484964	0.198738	0.118	0.837
libdem	0.365237	0.187722	0.085	0.73
partipdem	0.292603	0.135601	0.064	0.537
delibdem	0.376094	0.195339	0.075	0.773
egaldem	0.332763	0.167589	0.041	0.699
Central-Eastern Africa				
lnco2kt	7.374228	1.513212	3.864323	9.676615
lnefcon	16.366	1.178	13.331	18.506
lnY^2	48.22639	17.35026	27.7431	98.40733
lnY	6.848071	1.155686	5.267172	9.920047
lnpop	16.02588	1.66507	11.83939	18.41941
lnE	6.122446	0.661526	5.071073	8.038648
lntra	4.044739	0.530745	2.94973	5.861087
lnturpop	3.397938	0.579357	2.109728	4.4677
lnfdi	0.853838	1.543342	-5.9989	4.164867
polyarchy	0.317859	0.143257	0.085	0.727
libdem	0.188363	0.144024	0.011	0.621
partipdem	0.176586	0.104658	0.01	0.465
delibdem	0.217633	0.137759	0.02	0.615
egaldem	0.207129	0.109377	0.051	0.53