

CAN INSTITUTIONAL QUALITY REDUCE GREENHOUSE GAS EMISSIONS IN SUB-SAHARAN AFRICA? A LESSON FOR CLIMATE CHANGE MITIGATION STRATEGY

¹Naseer Babangida Muazu, ²Sani Saidu, and ³Ibrahim Danladi Sule

¹Department of Geography and Sustainability Studies

Kaduna State University, Nigeria

²Department of Accountancy

Bauchi State University, Nigeria

³Department of Environmental Resource Management

Federal University Dutsin-Ma, Katsina State, Nigeria

idanladi@fudutsinma.edu.ng

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ABSTRACT

Quality institutions serve as a vehicle for balancing immediate economic growth imperatives with long-term, sustainable and environmentally friendly economic growth. In light of this, the present study examines institutional quality in 49 Sub-Saharan African countries to assess its strength in reducing greenhouse gas (GHG) emissions. Five (5) institutional factors, namely: Legal system, Rule-based Governance, Social Protection, Investor's Protection and Police Services, were used. The data were sourced from the World Bank Country Institutional Policy Assessment and World Economic Forum Global Competitiveness Index data during 2008-2018. We used descriptive statistics, Pearson's correlation statistics, and regression estimates to analyse the data. The results show that Sub-Saharan African countries have low institutional quality, which reduces GHG emissions. To confront the climate change crisis head-on, we recommend that Sub-Saharan African governments strengthen their democratic institutions.

Keywords: Institutional Policies, Climate Change Crisis, Net National Emissions, Energy policy, Sub-Saharan Africa

INTRODUCTION

Institutional quality has been emphasised as a panacea for environmental problems, especially in developing countries, where the energy transition is a serious concern because weak institutions hinder renewable energy uptake and environmental sustainability. Ibrahim and Law (2016) explained that environmental quality tends to worsen during the early stages of economic development and then improves after an economy reaches and surpasses a threshold income level. This means that environmental problems such as greenhouse gas (GHG) emissions are more of a problem for poor or developing countries than for developed countries. However, few studies in Sub-Saharan Africa consider the endogenous role of institutional quality in addressing environmental issues. It has been argued that institutional policies in developing countries have largely aimed to develop and support a carbon-based economy, and that consideration of greenhouse gas (GHG) emissions has not been featured prominently (Mahendhiran et al., 2020).

Human intervention has been established as the biggest contributor to climate change events due to the economic development agenda of many nations. Climate change remains an undeniable reality that has devastating impacts on the environment. Global GHG emissions are increasing, driving major changes in Earth's ecosystem services and fueling extreme weather events such as rising temperatures, extreme precipitation, and rising sea levels. These extremes have concomitant effects on the socioeconomic development of economies across the globe, especially the Sub-Saharan African countries. For example, Nigeria's total net GHG emissions for 2015, including removals, amounted to 712,638 Gg CO₂-eq from agriculture, forestry and other land uses

(AFOLU), energy, industrial processes and product use (IPPU), and waste. Agriculture, forestry and other land uses led the sectors with 476,949 Gg CO₂-eq (66.9%) of total aggregated emissions, followed by energy (28.2%), waste (3.0%), and the remaining 1.9% from industrial processes and product use. Regarding direct GHGs, CO₂ accounted for 82.3% of emissions, CH₄ for 12.4%, and N₂O for 5.3% (Climate Change Policy, 2020). In light of these developments, the Nigerian government developed the National Climate Change Policy to transform the country into a low-carbon economy, promote sustainable development and contribute to global efforts to reduce GHG emissions. To achieve this goal, and in line with the country's Nationally Determined Contribution, and within the context of the policy, some key options were identified for reducing GHG emissions that include; increasing the availability of carbon sinks (biological absorption of GHGs) or reducing the level of emissions released into the atmosphere, in sectors such as energy generation, oil and gas, use of renewable energy, particularly solar and wind, both on-grid and off-grid, facilitation of full transition to clean cooking fuel and provision of sustainable incentives as well as financial mechanisms to encourage and support the use of renewable sources of energy. However, because institutions are weak in governing and implementing the policy, about 70% of households in the northern part of the country still use biomass energy for cooking, which has the highest population (Ogujiuba & Muazu, 2022).

Climate change has severely compromised the four components of food security (food availability, food accessibility, food utilisation and food stability) in many Sub-Saharan African countries, increasing the risks of hunger and disease (Muazu et al., 2022). The impact of climate change on Sub-Saharan Africa's development is enormous and difficult to address decisively because of weak democratic institutions. Evidently, these institutions pursue policies that optimise the extraction of cheap energy resources to increase economic growth, at the expense of environmental well-being. In developed countries, strong institutions are taking significant measures to reduce GHG emissions, decouple industrial development from a hydrocarbon-based economy, and shift to renewable energy. The institutions in developed countries have undertaken measures to ensure adherence to global environmental standards and practices, ensuring renewable energy is a core source of economic development, removal of impediments to investments in green energy sources, reallocation of subsidies to support meeting the carbon footprint targets, procurement to help support environmentally-friendly products and promotion of innovation in renewable energy sources, as well as adherence to good environmental practice in their international trade and multilateral agreements (Mahendhiran et al., 2020).

Currently, Sub-Saharan African countries face a development dilemma: choosing between economic development and environmental sustainability due to low institutional quality. Continued use of biomass and fossil fuels can be a double-edged sword: rising use for household and industrial activities increases greenhouse gas emissions, leading to negative outcomes such as environmental degradation and health hazards. It can also reduce economic productivity and long-term growth in the fragile economies of Sub-Saharan Africa. Hence, there must be a balance between immediate economic growth imperatives and long-term, sustainable, environmentally friendly economic growth. In light of this, the present paper examines the institutional strength of 49 Sub-Saharan African countries using the World Bank Country Institutional Policy Assessment (CPIA) and World Economic Forum Global Competitiveness Index data during 2008-2018 on institutional enforcement criteria, namely, Strength of the Legal System (LEGAL); Rule-Based Governance Rating (RBGR); Social Protection Ratings (SOCPR); Investor's Protection Rating (INVPR); and Police Services Rating (POLS) on greenhouse gas emissions reduction.

LITERATURE REVIEW

Establishing Institutional Quality and Greenhouse Gas Emission Nexus

Many scholars have argued that quality institutions provide effective policies, regulations, enforcement, incentives and management systems to galvanise stakeholders on environmental

sustainability, with the aim of protecting the planet from GHG emissions and preserving ecosystem services. Along this line of thought, researchers postulate a unidirectional causality running from institutional quality to CO₂ (the institutional quality-driven CO₂ emission hypothesis), since CO₂ accounts for a substantial share of GHG emissions. Therefore, strong institutions are linked to reduced GHG emissions. Quality institutions are believed to allocate resources prudently and efficiently to projects and initiatives such as renewable energy technologies to reduce GHG emissions. Quality institutions also provide effective monitoring to ensure compliance with greenhouse gas emission targets and use enforcement institutions to ensure compliance. Furthermore, quality institutions develop a culture of evaluation and improvement of methodologies used to reduce greenhouse gas emissions. Based on this, a negative causal relationship is established between greenhouse gas emissions and institutional quality. However, a positive causal relationship between GHG emissions and institutional quality may be established in developing countries, including Sub-Saharan Africa, where institutional development is devoted to supporting the utilisation of biomass and fossil fuels for household and industrial uses for economic development (Lau et al., 2014; Ibrahim & Law, 2016; Andersson, 2020; Mahendhiran et al., 2020).

Empirical Review

Over the years, researchers have investigated the nexus between institutional quality and GHG reduction. Zakaria and Bibi (2019) argue that higher institutional quality is strongly linked to reductions in per capita carbon emissions; as a result, stronger institutions improve environmental conditions. Bletsas (2022) found that institutional and bureaucratic quality, measured through government effectiveness and expansionary fiscal policies, as well as central bank independence and transparency, are ameliorating factors because they decrease GHG emissions. In the 19 Latin American countries. To support this position, Ulucak (2020) found that in Asia-Pacific Cooperation (APEC) countries, stronger institutional arrangements could help implement effective environmental regulation to address rising environmental challenges without sacrificing economic growth. Similarly, Baloch and Wang's (2019) investigation into the effects of governance under various determinants, including government effectiveness, in BRICS countries found that all determinants and government effectiveness significantly reduce CO₂ emissions.

Energy policy is an important factor in economic development in developing countries; it is a key part of the overall regulatory framework that shapes their global attractiveness and the incorporation of the private business sector (Ogujiuba & Muazu, 2022).

The literature on institutional quality and climate change consistently highlights the crucial role of governance structures in shaping environmental outcomes, though findings vary across regions and institutional dimensions. A large body of studies demonstrates that stronger institutions, through mechanisms such as regulatory quality, corruption control, rule of law, and government effectiveness, tend to reduce greenhouse gas emissions. For example, Abbas et al. (2021), Adedoyin et al. (2022), Hassan et al. (2024), Karim et al. (2022), Kwakwa (2023), Saboori et al. (2024), Shabir et al. (2023), Zaman and Yu (2024), and Yaman and Cetin (2025) all report that improvements in institutional quality contribute to lower CO₂ emissions, often by enhancing regulatory enforcement, supporting technological innovation, or moderating the negative impacts of foreign direct investment. Similarly, studies such as Gregori et al. (2025) and Hamid et al. (2022) emphasise that reducing corruption and strengthening democracy are particularly effective in curbing emissions.

At the same time, several studies highlight the moderating role of institutional quality in shaping the effectiveness of other environmental policies. Asif et al. (2026) and Khan et al. (2022) show that high-quality institutions can offset the negative effects of climate policy uncertainty and guide FDI toward greener technologies. Kwakwa (2023) and Oyewo et al. (2026) further suggest

that institutional quality strengthens the impact of renewable energy adoption and private sector emission reductions, though Oyewo et al. note that regulatory quality may sometimes encourage emissions depending on the scope considered.

However, the evidence is not uniformly positive. Wenlong et al. (2023) report that institutional quality in some Asian economies has not significantly contributed to emission reductions, while Yaman and Cetin (2025) find that certain dimensions—such as government effectiveness, regulatory quality, and political stability—can be associated with increased emissions in developing countries. This divergence underscores that institutional quality is multidimensional, and its effects may vary by indicator, regional context, and level of economic development. For instance, Barra and Falcone (2024) show that institutional quality improves environmental efficiency in high-income European countries but has weaker or even negative effects in lower-income contexts.

Overall, the literature converges on the idea that institutional quality is a critical determinant of environmental outcomes, but its impact depends on the governance dimension examined and the socioeconomic context. Strong institutions generally reduce emissions, yet in some cases, particular institutional features or regional conditions may limit or even reverse these benefits. This suggests that policy design must account for both the strengths and weaknesses of institutional frameworks to effectively leverage governance for climate change mitigation.

Regional imbalance: Much of the evidence comes from Asia, Africa, and G7 countries, but findings are inconsistent across regions. For example, Abbas et al. (2021) and Karim et al. (2022) show strong positive effects in Asia and Sub-Saharan Africa, while Wenlong et al. (2023) report weak or even detrimental effects in Asian economies. This suggests a need for more comparative, cross-regional studies to explain why institutional quality works differently in similar contexts.

Barra and Falcone (2024) found institutional quality improves efficiency in high-income countries but not in lower-income ones. This gap points to the need for more nuanced research on how economic development stages interact with institutional quality.

Studies use different proxies for corruption control, rule of law, democracy and government effectiveness, but results vary. For instance, Yaman and Cetin (2025) show that while corruption control reduces emissions, government effectiveness and political stability may increase them. This inconsistency highlights the need for integrated frameworks that capture the trade-offs across institutional dimensions.

In addition, some studies (Asif et al., 2026; Khan et al., 2022) show institutions moderate the effects of FDI, renewable energy, or policy uncertainty, but few examine how multiple policies interact simultaneously under different institutional settings. While Karim et al. (2022) report two-way causality between CO₂ emissions and institutional quality, most other studies rely on correlation-based panel models. More causal inference approaches (e.g., natural experiments, instrumental variables) are needed to establish directionality.

Moreover, Oyewo et al. (2026) highlight differences across Scope 1, 2, and 3 emissions, but most studies treat emissions as a single aggregate measure. This gap suggests future research should disaggregate emissions to capture sectoral and firm-level dynamics. Asif et al. (2026) show institutions can offset climate policy uncertainty, but little is known about how institutions adapt under shocks like pandemics, geopolitical crises, or energy transitions. Oyewo et al. (2026) also begin to explore private-sector emissions, but most studies focus on national-level institutions. More research is needed on how institutional quality influences corporate governance and sustainability practices.

In short, while the literature confirms that institutional quality matters, gaps remain in regional coverage, multidimensional analysis, causal identification, and sector-specific impacts. Addressing these would deepen the understanding of how institutions can be leveraged for effective climate change mitigation.

MATERIALS AND METHODS

Description of the Study Area

Sub-Saharan Africa (SSA) refers to the vast part of the African continent located south of the Sahara Desert. It comprises about 46 countries, depending on the classification used, and extends from the Atlantic coast in the west to the Indian Ocean in the east, and from the Sahelian transition zone in the north to the southern tip of Africa (Figure 1).

Sub-Saharan Africa has a highly diverse physical environment. The major geographical features include the Sahel, savanna grasslands, tropical rainforests, highlands and mountains, plateaus, and coastal plains. Major physical features include the Congo Basin, the East African Rift Valley, the Ethiopian Highlands, the Kalahari Basin, and the Drakensberg Mountains. Important rivers include the Nile, Congo, Niger, Zambezi, Orange and Senegal rivers (Iliffe, 2007; Coquery-Vidrovitch, 2012; UNEP, 2023; World Bank, 2024).

The region experiences a wide range of climates, from semi-arid and arid conditions in the Sahel and parts of southern Africa to humid tropical climates around the equatorial Congo Basin. Seasonal rainfall strongly influences agriculture, vegetation, water availability and settlement patterns (Iliffe, 2007; Coquery-Vidrovitch, 2012; UNEP, 2023; World Bank, 2024).

Vegetation ranges from desert and semi-desert vegetation to grasslands, woodlands and dense tropical forests. Sub-Saharan Africa is richly endowed with natural resources, including petroleum, natural gas, gold, diamonds, iron ore, copper, uranium, forests, fertile agricultural land and wildlife. These resources form an important foundation for many national economies.

The region has a large and rapidly growing population, with substantial concentrations around river valleys, agricultural zones, coastal areas and major urban centres. Important cities include Lagos, Nairobi, Johannesburg, Addis Ababa, Kinshasa, Accra and Dakar. The region is experiencing rapid urbanisation, although rural populations remain important, particularly in agricultural areas (Iliffe, 2007; Coquery-Vidrovitch, 2012; UNEP, 2023; World Bank, 2024).

Agriculture remains a major economic activity, supporting many people through both subsistence and commercial farming. Major crops include maize, millet, sorghum, cassava, rice, cocoa, coffee, cotton and groundnuts. Mining, manufacturing, trade, tourism and services are also significant. However, economic development is uneven, with considerable differences between countries and regions (Iliffe, 2007; Coquery-Vidrovitch, 2012; UNEP, 2023; World Bank, 2024).

Sub-Saharan Africa is characterised by great environmental, cultural, economic and geographical diversity. Climate variability, natural-resource distribution, population growth, urbanisation, environmental degradation and regional connectivity strongly influence its development. Consequently, the region is important for studying regional development, environmental management, natural-resource conservation, and human–environment relationships (Iliffe, 2007; Coquery-Vidrovitch, 2012; UNEP, 2023; World Bank, 2024).

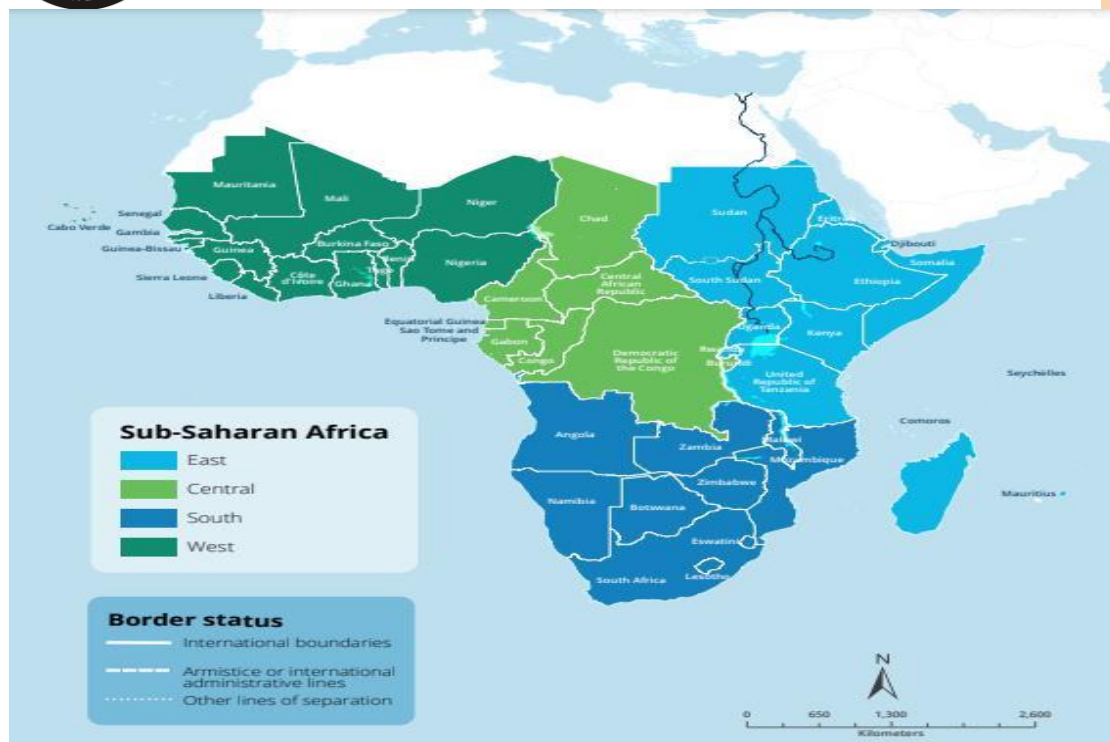


Figure 1: Map of Sub-Saharan Africa showing countries and national boundaries.
Source: World Bank, 2023 (IBRD 47255).

Research Design

This study investigates the role of institutional strength in reducing greenhouse gas emissions by Sub-Saharan African governments. The sample comprises all 49 Sub-Saharan countries, and the study drew data for analysis from all member countries. The study used data on greenhouse gas emissions and the strength of countries' legal systems from the World Bank database. The data on rule-based governance and social protection rating were obtained from the World Bank Country Policy and Institutional Assessment (CPIA). Also, the data on police service rating and investor protection rating were obtained from the World Economic Forum Global Competitiveness Index. The study covers the period from 2013 to 2023. This is because the World Economic Forum Global Competitiveness Index data for 2023 was available as of December 2025. The year 2025 is excluded from the dataset to reduce missing values, as many countries' 2025 data were unavailable.

Six variables were used, including change in total greenhouse gas emissions (DGHG) reduction, which indicates the mitigation of climate change, as the dependent variable in the study. The independent variables are the democratic institutions used to enforce climate change mitigation, which include the Strength of the Legal System (LEGAL); Rule-Based Governance Rating (RBGR); Social Protection Rating (SOCPR); Investor Protection Rating (INVPR); and Police Services Rating (POLR). Table 1 summarises the variables and their measurements.

Method of Data Collection

This study adopts a quantitative longitudinal research design based on secondary panel data covering selected countries in Sub-Saharan Africa. This design is appropriate because the study examines the relationship between institutional quality and greenhouse gas (GHG) emissions over time and across countries. A panel-data approach combines cross-sectional country characteristics with time-series observations, allowing the study to account for differences among countries and changes over time.

The study examines whether improvements in institutional quality reduce GHG emissions and what lessons it offers for climate-change mitigation strategies in Sub-Saharan Africa. Panel data are particularly suitable for the Generalised Method of Moments (GMM) estimator because GMM addresses dynamic relationships, unobserved country-specific effects, simultaneity and potential endogeneity among explanatory variables.

Sources of Data

The study relies primarily on secondary data from internationally recognised, publicly available databases. The major sources include the World Bank's World Development Indicators (WDI), the Worldwide Governance Indicators (WGI), and other relevant international databases where necessary.

The World Development Indicators (WDI) provide data on greenhouse gas emissions and major socioeconomic and environmental variables, including real GDP, energy consumption, urbanisation, trade openness and foreign direct investment. The Worldwide Governance Indicators (WGI) provide internationally comparable measures of institutional quality, including Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption, among others.

Additional data may be obtained from recognised sources such as the International Energy Agency (IEA), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), United Nations Population Division, and relevant national statistical agencies where a variable is unavailable or requires verification from an alternative source.

Period of Data Collection

The study will use annual observations for a sufficiently long period to capture changes in institutional quality, economic development and environmental performance. A proposed study period is 1996–2023, subject to the availability and consistency of data for all major variables.

The starting year is particularly relevant because internationally comparable Worldwide Governance Indicators become available from the mid-1990s. The terminal year should be determined by the most recent year for which sufficiently complete observations are available across the principal variables.

Where data are unavailable for individual years, the study will not arbitrarily substitute values without justification. The study will carefully identify missing observations and report their implications for the estimation sample.

Variables and Data Requirements

The data collection process will focus on the dependent variable, the principal explanatory variable and relevant control variables. The dependent variable, GHG emissions, represents the environmental outcome that the study seeks to explain. Depending on data availability and the researcher's theoretical preference, emissions may be expressed in metric tonnes per capita, total emissions, or another consistent GHG-emissions measure.

Table 1: Summary of the Variables and their Sources

Variable Names	Description	Main Source	Specific Source
Changes in Greenhouse Gas emissions (DGHG)	Measured as the reduction in the Country's Total greenhouse gas emissions in kilotons of CO ₂ equivalent, as reported by the World Bank.	World Bank	Boaitey, Goddard and Mohapatra (2019)
Rule-Based Governance Rating (RBGR)	Is measured by the Country Policy and Institutional Assessment property rights and rule-based governance rating (CPIA property rights and rule-based governance rating). Ranges from the lowest (1) to the highest (6).	World Bank	Namit (2016); Tzu-Yorn and Huang (2017)
Strength of the Legal System (LEGAL)	This measures the degree to which collateral and laws protect borrowers' and lenders' rights and facilitate lending. The index ranges from 0 to 12, with higher scores indicating that these laws are better designed to expand access to credit. Strength of the legal system (Strength of legal rights index (0=weak to 12=strong))	World Bank	Gani and Clemes (2016); Arslan (2020).
Social Security Rating (SOCPR)	This is based on the World Bank Country Policy and Institutional Assessment of social protection and labour market regulations that reduce poverty risk and help the poor manage risk. The CPIA social protection rating is from lowest (1) to highest (6).	World Bank	Alola, A., Avci, & Ozturen (2021). Osabohien, M., Aderounmu, & Olawande (2019). Osabohien, Olurinola, Matthew, and Ufua (2022).
Investor's Protection Rating INVPR	World Bank Global Competitiveness Index measuring the Strength of investor protection from 0 (lowest) to 10 (best)	World Economic Forum Global Competitiveness Index	Boğa-Avram (2013)
Police Service POLS	World Bank Global Competitiveness Index measuring the police services reliability from 0 (lowest) to 10 (best)	World Economic Forum Global Competitiveness Index	Gerell (2018)

Method of Data Analysis

This study employs the Generalised Method of Moments (GMM) to examine whether institutional quality can reduce greenhouse gas (GHG) emissions in Sub-Saharan Africa. The choice of GMM

is motivated by the dynamic nature of environmental outcomes, the possibility of reverse causality between institutional quality and environmental quality and potential endogeneity arising from omitted variables, measurement errors and simultaneity. Unlike conventional panel estimators, GMM provides a framework for controlling for unobserved country-specific effects while using appropriate internal instruments to address endogeneity. The software used for the analysis of descriptive statistics, the correlation matrix, panel unit-root tests, and system GMM is Stata, which is particularly suitable for panel-data GMM.

RESULT AND DISCUSSION

The study data are analysed using three analytical tools: descriptive statistics, correlation analysis and panel regression analysis. Descriptive statistics reveal key variable parameters, including the mean, standard deviation (SD), and maximum and minimum values in the dataset. In addition, the descriptive statistics include the number of observations for each variable. The correlation statistics measure the correlations between pairs of variables, while the regression analyses the extent to which the test variables affect changes in greenhouse gas emissions.

Table 2 summarises the descriptive statistics of the variables used to analyse the relationship between institutional factors and greenhouse gas emissions across all countries in sub-Saharan Africa. The table summarises the mean, maximum and minimum values for each variable. The table also highlights the standard deviation and the number of observations for all the variables in the dataset.

Table 2: Summary of descriptive statistics on the institutional factors and the greenhouse gas emission

Variables	Mean	Min	Max	SD	Number
DGHG	802.714	-29850	21840	4203.721	539
GHG	48230.30	130	532140	2580.10	539
RBGR	2.692	1	4	0.0245	539
LEGAL	4.654	0	11	2.403	539
SOCPR	2.920	1	4.5	0.648	539
INVPR	4.528	2	8	1.133	539
POLS	3.874	1	6	0.787	539

Note: GHG = Greenhouse Gas Emission (in kilo Ton): DGHG = Changes Greenhouse Gas Emission (in kilo Ton): RBGR = rule-based governance: LEGAL= strength of the Legal system: SOCPR= Social protection rating: INVPR= Investors protection rating: POLS = Police Service Reliability Score

The mean greenhouse gas emissions of sub-Saharan countries are 48230 kilotons of CO₂ equivalent. This shows that each country emits over forty-six thousand kilotons of carbon every year. This is relatively low compared to the carbon emissions in other regions such as Europe, North and South America and Asia (Yaya, 2017; Panait, 2022; Lee et al., 2018). To assess whether countries in sub-Saharan Africa engage in activities that reduce carbon emissions, this study analysed data on annual changes in carbon emissions, and the results are summarised in Table 2. The descriptive analysis shows a mean annual increase in total carbon emissions of 802.714 kilotons of carbon. Despite this average annual increase of more than 800 kilotons of carbon emissions, the figure is relatively low compared with Latin America, North America, Asia and Europe, as reported in Yaya (2017), Córdova, Zorio-Grima and Merello (2018) and a host of other studies.

This study analysed the independent variables, and the descriptive statistics reported in Table 2 indicate that the rule-based governance rating (RBGR) for all the countries under study is 2.83,

with a standard deviation of 0.68 and a maximum of 4 and a minimum of 1, which is an indication that the average rule-based governance is relatively low on the scale of 1 to 6. The mean strength of the legal system (LEGAL) for sub-Saharan countries is 4.83, with a standard deviation of 2.4. The minimum and maximum LEGAL values are 0 and 11, respectively. Similarly, the social protection score (SOCPR) has an average of 2.86 and a standard deviation of 0.65. The maximum social protection score is 4.5, while the minimum is 1. The mean investor's protection rating (INVPR) for all sub-Saharan countries is 4.66, with a standard deviation of 1.13, a minimum of 2 and a maximum of 8. Scores range from 1 to 10 (worst to best). The mean police service reliability (POLS) score is 3.819 out of the maximum obtainable score of 10. The maximum value in the distribution is 6, while the minimum value is 1. Sub-Saharan African countries record relatively low institutional strength.

This study used Pearson's correlation statistics to analyse the extent of linear association between pairs of variables used in the study. Table 3 summarises the correlation statistics between the study variables, and the results show a statistically significant negative correlation between rule-based governance (RBGR) and GHG emissions. The relationship between police service rating (POLS) and GHG is also negative but not statistically significant. In contrast, social protection rating (SOCPR) and the strength of the legal system in the countries under study are positively associated with GHG emissions, and the results are statistically significant. In the same manner, there is a positive but statistically significant relationship between the investor's protection ratings (INVPR) and GHG emissions, but the result is not statistically significant.

Table 3: Results of Correlation Analysis between institutional factors and greenhouse gas emissions

	1	2	3	4	5	6
(1) GHG	1					
(2) INVPR	0.052 0.254	1				
(3) LEGAL	0.0524* 0.062	0.124*** 0.000	1			
(4) SOCPR	0.105*** 0.000	0.109** 0.023	0.177*** 0.000	1		
(5) POLS	-0.006 0.135	0.102 0.712	0.034 0.120	0.188*** 0.000	1	
(6) RBGR	-0.291 0.475	0.196*** 0.000	0.108* 0.064	0.255*** 0.000	0.235*** 0.000	1

Note: GHG = Greenhouse Gas Emission (in kilo Ton): DGHG = Changes Greenhouse Gas Emission (in kilo Ton): RBGR = rule based governance: LEGAL= strength of the Legal system: SOCPR= Social protection rating: INVPR= Investors protection rating: POLS = Police Service Reliability Score

Furthermore, Table 3 explains the correlations among the test variables to check for possible multicollinearity. The table shows that RBGR has a positive association with POLS, SOCPR, LEGAL and INVPR, and the relationships are significant. The relationship between POLS and SOCPR is also positive and statistically significant. In addition, SOCPR has a positive, statistically significant relationship with LEGAL and INVPR. The correlation between INVPR and LEGAL is also positive. Despite the significant correlations among the test variables, this does not indicate multicollinearity. Table 3 shows that the highest correlation coefficient is 0.467 between RBGR and SOCPR. This is below the 0.8 criterion for the likelihood of multicollinearity (Shrestha, 2020; Kim, 2019; Midi et al., 2010).

Estimation of Institutional Strength and the Changes in Greenhouse Gas Emissions

The study used regression estimation to empirically analyse the relationship between institutional strength and changes in greenhouse gas emissions. The pre-estimation test showed autocorrelation and heteroskedasticity, which could invalidate pooled OLS results. As a result, both panel-corrected standard error (PCSE) and Generalised Method of Moments (GMM) models are used to test the significance of the effect of institutional quality and greenhouse gas emissions.

Table 4 summarises the results of three regression estimations: the pooled ordinary least squares regression model, the Panel-Corrected Standard Error model, and the Generalised Method of Moments Model. The three models have 0% probability of F-statistics, indicating that the models are significant at the 99% confidence level. However, the Wooldridge test for serial correlation has accepted the null hypothesis that serial correlation is present in the panel. Similarly, the Breusch-Pagan test shows heteroskedasticity; as such, pooled OLS may not be the best or unbiased estimator, so panel-corrected standard errors and the Generalised Method of Moments are used for interpretation. The Arellano-Bond test accepts second-order autocorrelation in the GMM model. Similarly, the Hansen overidentification test does not invalidate the instruments used in the GMM.

Table 4: Regression Estimation of Institutional Strength and the Changes in Greenhouse Gas Emissions

Variables	POOL OLS		PCSE		GMM	
	Coef.	T-stat	Coef.	T-stat	Coef.	T-stat
Cons	-12.203	-0.88	-21.849**	9.892	-6.843	-0.59
L.DGHG	-0.182**	-2.01	-0.107	0.179	-0.010*	1.7
RBGR	-5.908*	-1.89	-5.956**	2.889	-0.909	-0.21
LEGAL	1.181	1.56	1.294*	0.690	0.809***	3.31
SOCPR	15.701***	4.92	15.868***	3.339	6.900*	1.75
POLS	-5.464**	-2.31	-5.424**	2.205	-7.051***	-3.36
INVPR	3.813**	2.32	3.741	2.508	6.458***	8.32
Year Dummy	Yes		Yes		Yes	
No. of Obs	441		441		441	
R2	0.19		0.356		-	
Pr (F-Stat)/(Chi2)	0.000		0.000		0.000	
No. Instruments/Lags	-		-		76	
AR1 Test (P-value)	-		-		0.111	
AR2 Test (P-value)	-		-		0.338	
Hansen's Test Over-identification	-		-		0.994	
Diff-in-Hansen tests of exogeneity	-		-		0.998	
Hansen test excluding group	-		-		0.372	

Note: GHG = Greenhouse Gas Emission (in kilo Ton); DGHG = Changes Greenhouse Gas Emission (in kilo Ton); RBGR = rule-based governance; LEGAL= strength of the Legal system; SOCPR= Social protection rating; INVPR= Investors protection rating; POLS = Police Service Reliability Score

The results, as presented in Table 4, indicate a negative relationship between rule-based governance and the reduction of greenhouse gas emissions in Sub-Saharan Africa, and the result is significant at 10%. Similarly, police service rating has a negative and statistically significant effect on the reduction of greenhouse gas emissions in Sub-Saharan Africa. The result is not surprising, given that democracy and rule-based governance in Africa are relatively growing

(Chen et al., 2022; McKay & Thorbecke, 2019; Davis, 2017). Tomkins (2017) noted that police services are key instruments for enforcement and for raising awareness of environmental laws.

Table 4 also shows that the strength of the legal system and social protection rating in the Sub-Saharan region positively affect greenhouse gas emissions. This indicates that higher ratings are associated with higher greenhouse gas emissions. This result suggests that the legal system and social protection in the region do not help reduce GHG emissions, a major contributor to global warming and climate change. The region has a less developed legal system to protect the environment (Bribena, 2019; Kohler & Schmithüsen, 2004; Bakibinga-Ibembe, Said & Mungai, 2011). Also, Osabohien et al. (2019) identified that the shortage and, in some cases, unavailability of the social protection programs, which are instrumental in worsening crop production through the undeterred effect of greenhouse gas emissions, as such, recommended insurance programmes to be put in place to provide cover for losses.

CONCLUSION

Greenhouse gas emissions from human economic activities have continued to threaten human existence in recent times. This study provides new evidence on how the strength of some democratic institutions influences climate change mitigation through greenhouse gas emissions in sub-Saharan Africa. These institutional factors have been found to contribute to reducing greenhouse gas emissions. Studies have also found that sub-Saharan countries' contribution to GHG build-up is relatively lower than global greenhouse gas emissions. Improving legal, social and democratic principles and ideals helps tackle the climate challenges the continent faces. One important contribution of this paper is that it provides empirical evidence on the role of police services in protecting the environment through enforcement. This suggests that political leaders in Sub-Saharan Africa must strengthen climate change mitigation institutions to address the crisis.

RECOMMENDATIONS

The study recommends the following:

- i. To confront the climate change crisis head-on, the Sub-Saharan African governments must strengthen their democratic institutions.
- ii. Institutional policies that would enhance mitigation of climate change and its crisis should be strengthened with commitment and patriotism.
- iii. Sub-Saharan African countries should pay attention to the transition to a low-carbon economy and development in order to cut down the level of greenhouse gas emissions.
- iv. The SSA countries and international communities should come together and provide a workable framework that will address green growth, economy and other initiatives aimed at climate change mitigation and adaptation.

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