THE IMPACT OF ECONOMIC GROWTH ON ENVIRONMENTAL QUALITY IN AFRICA: THE MODERATING ROLE OF INSTITUTIONAL QUALITY

A Thesis

Submitted to the Master's Study Program of Economics at the Faculty of Economics and Business in partial fulfillment of the requirements for the degree of

Master of Arts in Economics (M.A.)

by:

Ishiaka Adamu

03212420010

UNIVERSITAS ISLAM INTERNASIONAL INDONESIA (UIII)
DEPOK
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ABSTRACT

Ishiaka Adamu
03212420010
ishiaka.adamu@uiii.ac.id
Economics
Universitas Islam Internasional Indonesia

This thesis examines the impact of economic growth on environmental quality in Africa over the period from 2002 to 2023. It also investigates the moderating role of institutional quality in this relationship. The study employs the Two-Step System Generalized Method of Moment Estimators (GMM) on forty-three (43) African countries, yielding a total of 946 observations. The results show a positive relationship between economic growth (GDP) and CO2 emissions, suggesting that expanding economic activities increase environmental pressure. However, the negative relationship between economic growth (GDP^2) and CO2 emissions confirms an inverted U-shaped pattern, consistent with the Environmental Kuznets Curve (EKC) hypothesis, implying that emissions begin to decline after income reaches a certain level. Additionally, institutional quality is also found to have a negative impact on CO2 emissions, indicating that improvements in governance, regulatory effectiveness, and policy enforcement contribute to environmental sustainability by reducing carbon emissions. Furthermore, the results of the interaction term between institutional quality and economic growth indicate a positive and significant effect of economic growth (GDP) on CO2 emissions, indicating that institutional quality increases the adverse effect of economic growth on environmental degradation at early development, while the interactions between institutional quality and economic growth (GDP^2) show a negative and significant effect on CO2 emissions, suggesting that strong institutions can mitigate these effects by reducing the environmental impact of economic growth. This thesis contributes to the literature by providing empirical evidence of a nonlinear relationship between economic growth and environmental quality, thereby reaffirming the validity of the EKC hypothesis. It further enriches the literature by investigating the moderating role of institutional quality in the relationship between this macroeconomic variable and environmental quality. This study provides valuable insights for policymakers, regulators, and stakeholders by demonstrating how strong institutions can offset the environmental challenges associated with economic expansion.

Keywords: Economic Growth, Environmental Quality, Institutional Quality, Environmental Kuznets Curve, Africa

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Covid-19	: *Corona Virus Pandemic*
CSR	: *Corporate Social Responsibility*
EKC	: *Environmental Kuznets Curve Theory*
FDI	: *Foreign Direct Investment*
GDP	: *Gross Domestic Product*
GMM	: *Generalized Method of Moment estimator*
MNCs	: *Multinational Corporations*
NIE	: *New Institutional Economics Theory*
OECD	: *Organization for Economic Co-operation and Development*
PCA	: *Principal Component Analysis*
SDGs	: *Sustainable development goals*
SSA	: *Sub-Saharan African*
UNCTAD	: *United Nations Conference on Trade and Development*
UNEP	: *United Nations Environment Programme*
WDI	: *World Development Indicators*
WMO	: *World Meteorological Organization*
WTO	: *World Trade Organization*

CHAPTER I

INTRODUCTION

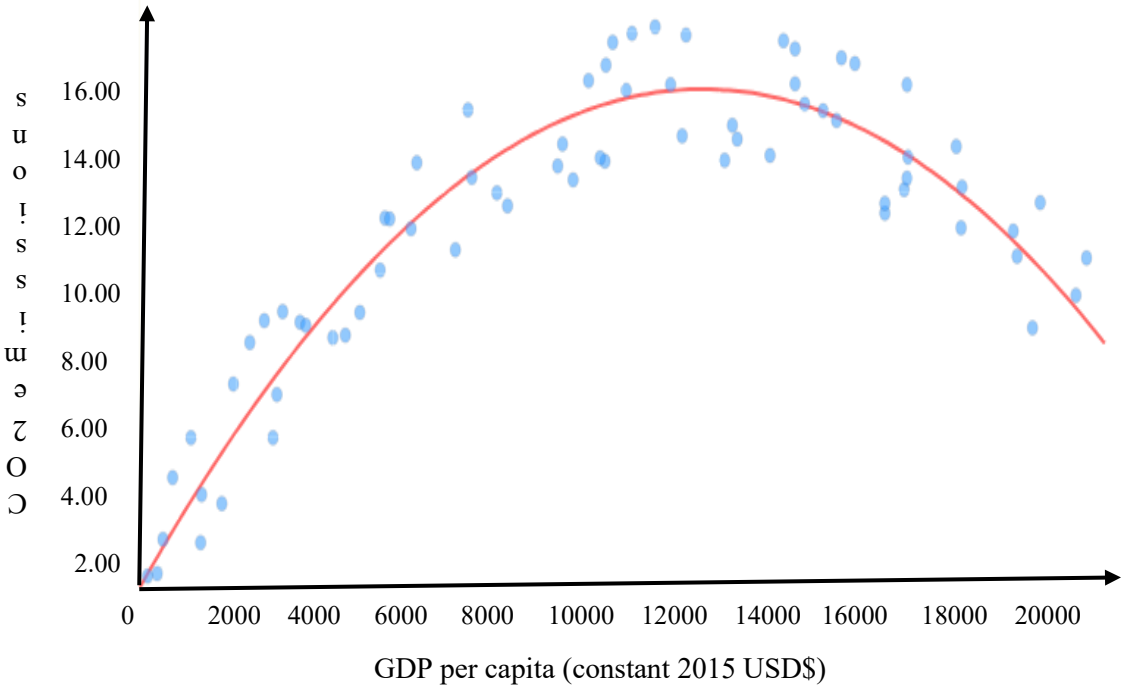
1.1 Background of the study

The interactions between economic growth, and institutional quality with environmental quality has emerged as a key discussed theme across environmental economics and development economics during the past decades. The global search for sustainable development has raised environmental concerns about the ecological impacts of rapid economic changes and globalization (Jickling & Wals, 2008). Economic growth has long been seen as a stimulating factor for greater welfare improvement and poverty alleviation (Škare & Družeta, 2016). Economic growth is essentially the driving force behind structural change. It ensures improvements in people's lives through better standards of living and job opportunities. However, this is normally coupled with a corresponding increase in emissions and environmental degradation if not carefully controlled. Environmental quality, which is proxied by CO2 emissions, is used interchangeably in the discussion of this study. According to Padhan et al. (2023), CO2 emissions through air pollution have continued to increase, and this has had a significant impact on sustainability. To illustrate this point, it can be mentioned that in 2017, member nations of Organization for Economic Co-operation and Development (OECD) contributed 37.2% of total global emissions of carbon dioxide (Padhan et al., 2023). In comparison, this is significantly greater than that contributed by European economies 10.6%, African economies 3.6%, Middle East economies 6.3%, and North America 18.3% (Padhan et al., 2023), as cited in BP Statistical Review of World Energy in 2020. As a consequence, reducing carbon emissions in economies all over the world has lately emerged as a serious concern for policymakers (World Energy, 2020). It is pertinent to mention that member nations of OECD are accountable for a total of 69% of trading in all economies around the globe and 72% of total global earnings, and they contribute around 40% of total energy in worldwide economies (Padhan et al., 2023). In addition, Indonesia, a country reach in natural resources with a large population facing the dilemma between economic growth and CO2 emission control, Indonesia's CO2 emission not only impact the national environment but also have significant implications for global climate change mitigation efforts. For instance, based on data from 2000 to 2023, Indonesia is recorded as the largest contributor to CO2 emissions in Southeast Asia with a cumulative total of $1.15*10^{10}$ tons (Aminy et al., 2025). The

distribution of CO2 emission sources in Indonesia from 1970 to 2023 was influenced by multiple factors, including coal, gas, cement production, flaring, and other sources.

Moreover, according to NDC (2023), greenhouse gas emission in Africa is largely dominated by the AFOLU (Agriculture, Forestry, and other Land Use) sector, which accounts for roughly 60% to 65% on the continent's total emissions. The energy sector is the second-largest contributor, making up about 30% to 35% of the total emissions in Africa.

Figure 1.1 CO2 emissions per capita and GDP per capita across African countries from 2002 to 2023



Source: Calculated from World Development Indicators

Figure 1.1 illustrates the relationship between GDP per capita and CO2 emissions per capita in Africa from 2002 to 2023. The scatter plot reveals a nonlinear (quadratic) relationship rather than a simple linear association. The fitted quadratic curve suggests that CO2 emissions initially rises slightly at lower income levels and then decreases as GDP per capita rises, indicating an inverted U-shaped curve in Africa. This pattern provides preliminary visual evidence that the relationship between economic growth and environmental quality is nonlinear, thereby justifying the inclusion of both GDP per capita and its squared term (GDP^2).

Moving further, Institutional quality is an essential tool in amplifying economic growth, it has the potential to display favorable or unfavorable effects on the environment (Abaidoo & Agyapong, 2025). The role of institutions, generally include political stability, rule of law, government effectiveness, voice and accountability, regulatory quality, and corruption control can create and enforce environment-related regulations that define people's economic and investment choices (Ali et al., 2019; Jianguo et al., 2022). Strong institution can help enforce environmental policies and regulations, that could lead to advanced technology, thereby offsetting negative consequences on economic growth and the environments (Amuakwa-mensah & Adom, 2017). Conversely, Weak institution is more likely to provide ineffective enforcement, and misallocation of natural resources, leading to adverse effects of economic growth and trade (Ji et al., 2013).

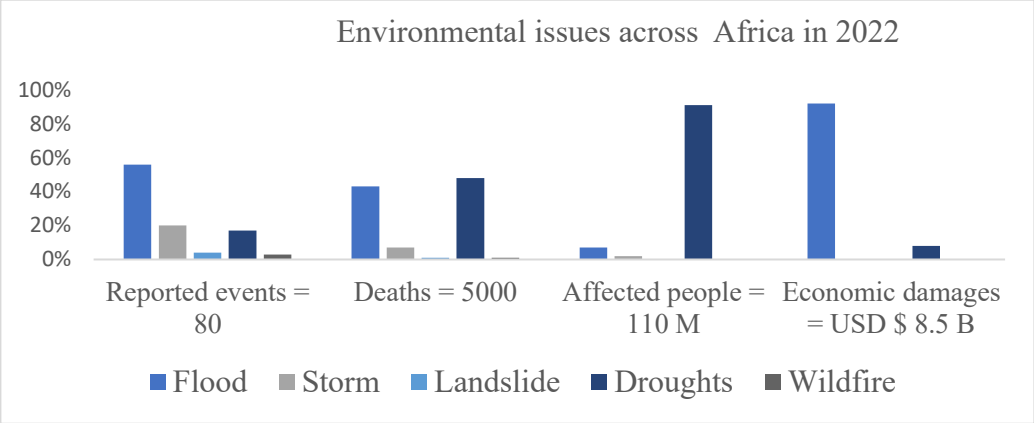
Africa is characterized by the challenges of balancing economic growth with environmental quality and institutional quality. As a consequence of these challenges, many Africa countries have remained deprived of robust infrastructure as well as lacked of proper capacity in environmental management and resource sectors (Kposowa & Kposowa, 2006). These challenges offer a compelling basis for examining the relationship between economic growth and environmental quality, as moderated by institutional quality. The economic system of many African countries depend on the extraction of natural resources such as diamonds, iron ore, golds, oils, uranium, and bauxite, making them vulnerable to the phenomenon of 'resource curse' (Jalloh et al., 2013), whereby reliance on natural resource exports leads to adverse effects on environmental sustainability and economic diversification.

Along this line, environmental challenges and sustainability have become an integral part of Africa’s development blueprint in recent years, influencing policies related to trade, transport, energy, agriculture, and investment, as well as associated practices across the continent and its populations. Both SDGs and Agenda 2063, initiated by African leaders, focus on ensuring that Africa develops sustainable and resilient environments and communities for both present and future generations of African citizens and peoples (AfDB, 2024). Africa’s environment is, however, not only characterized by inefficient and unsustainability, despite contributing the least to global carbon emissions, the continent is experiencing some of the worst impacts of climatic change, including water scarcity, heat stress, and noise pollution. Air pollution is one of the biggest threats to environment-related health on this continent. Household air pollution is most common, especially in rural and poor settings, where biofuels,

kerosene, and charcoal are used for cooking, heating, and generating power. Outdoor air pollution, especially due to urbanization, is caused by power plant emissions, industrial pollution, automobile exhaust, crop burning, and blown dust. Moreover, water pollution and water insecurity are critical issues that require urgent attention. Ensuring equitable access to safe and clean water remains a major concern, as it presents both environmental and developmental challenges. Achieving water security has been considered imperative under SDG Goal 6 and Agenda 2063 of the African Union as one of its visions of Africa in 2063 (AfDB, 2024). Climate change is an added risk for Africa and its environment. Africa has more than 60% of its population that is reliant on rain-fed agriculture, and this jeopardizes local markets and economic development because of irregular climate change. Additionally, by 2030, it is estimated that more than 100 million people in Africa living below the extreme poverty line will be exposed to adverse climatic conditions such as drought, floods, and heat waves. For instance, the Lake Chad Basin has shrunk by over 90%, resulting in migration, criminality, and social unrest (Williams et al., 2022).

Land degradation is yet another threat posing serious risks, as approximately two-thirds of Africa's productive land area has already been degraded and more than 45% of the continent is affected by desertification (Williams et al., 2022). This is driven by overgrazing, deforestation, unsustainable agricultural practices, and the clearance of forests for agricultural expansion. These factors have resulted in reduced crop productivity, food insecurity, and increased human conflict. Addressing Africa's environmental challenges therefore requires collective and integrated responses. The effects of air and water pollution, as well as land degradation and climate change, extend beyond borders and can be address through local, national, and regional cooperation, as well as on a continental scale. Africa's future can be made resilient and sustainable through improved governance, cooperation, and visionary policies that address developmental challenges without compromising environmental preservation.

Figure 1.2 Environmental issues across Africa in 2022



Source: WMO (2023)

The environmental issues affect African nations in 2022 are shown in Figure 1.2. The chat clearly indicates that many African countries continue to face significant environmental challenges. As reported by WMO (2023), over 110 million individuals across Africa experienced the effects of weather, land, water, and climate-based hazards in 2022, resulting in economic losses exceeding $8.5billion, these events led to about 5000 deaths, with drought accounting for 48% of the fatalities and floods responsible for 43% as shown in Figure 1.2.

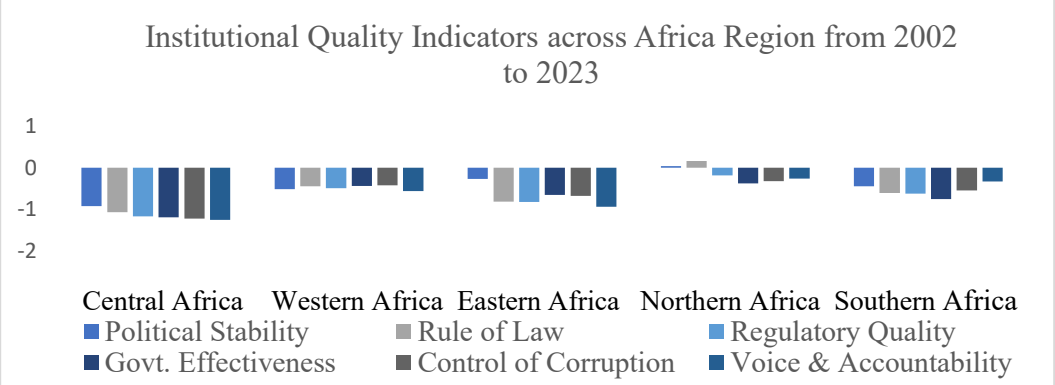
Nevertheless, the case of Africa fits into the broader literature on the Environmental Kuznets Curve hypothesis, which posits that an inverted U-shaped relationship between economic growth and environmental quality (Agras & Chapman, 1999). However, the continent's fragile economic structure and weak environmental governance make it uncertain whether this theoretical relationship holds in such a context., and it remains questionable whether the Environmental Kuznets Curve hypothesis is applicable to Africa's economic setting. The recurring experiences of environmental problems, such as deforestation, land degradation, water pollution, noise pollution, and air pollution has been due to artisanal mining and agricultural land clearing (Bangura et al., 2013; Mabey et al., 2020). Although many studies have been conducted globally, but limited empirical attention has been given to Africa-wide panel analyses examining the impact of economic growth on environmental quality across African countries, a continent characterized by highly divergent economic structures and production specializations. Therefore, examining the relationship between economic growth and environmental quality, with institutional quality as a moderating factor in Africa, is essential.

1.2 Problem Statement

The global era has been marked by a profound international analysis of the dynamic interconnection between economic advancement and environmental sustainability. Economic development is universally known as key determinants of economic transformation and globalization but have also been identified as key sources of environmental pressures and degradation (Doytch & Uctum, 2016; Kumar & Wu, 2025). As global economies intensify their engagement in trade, environmental related problems associated with these development trajectories have increasingly emerged. The dilemma has confronted both developed and developing nations, particularly Africa countries, on how to achieve sustainable economic development.

Moving further, Institutional quality is a significant determinant of environmental sustainability (Ogbuabor et al., 2023). Weak institutional setting can jeopardize effective governance and environmental quality (Katuka & Mudzingiri, 2023). Leading to political instability, poor legal systems, and corruption, which limit investment and growth (Wang et al., 2023a). The Worldwide Governance Indicator (WGI) represents varying institutional quality in Africa, with countries such as Botswana, Rwanda, and Seychelles are making significant governance improvements, while other nations like Burundi, Somalia, Libya, Equatorial Guinea, South Sudan, and Sudan are struggling with corruption and inefficient regulation.

Figure 1.3. Institutional quality indicators across Africa Region from 2002 to 2023



Source: WDI (2024)

A brief overview of the quality of institution ratings in various Africa region, as reported by WDI (2024) was graphically explored. Following this, the scores for each sub-regions across the six Worldwide Governance Indicators; political stability, government effectiveness, voice and accountability, regulatory quality, control of corruption, and rule of law were compared to those for all regions. As indicated in figure 1.3, Central Africa displays lower scores in terms of institutional quality, followed by Northern Africa and Western Africa when compared to Eastern Africa and Southern Africa, which present the highest scores. This divergence can be linked to the extensive corruption, political instability, ineffective regulatory quality, and poor rule of law in Central, Northern, and Western African nations. These weak governance outcomes may contribute to reduce investment, economic decline, uneven development, poor regulations, and ineffective public services potentially leading to environmental issues. Against this backdrop, this study seeks to assess the moderating role of institutional quality in the relationship between economic growth and environmental quality in Africa.

In recent years, a growing interest has arisen to investigate the determinants of environmental quality in Africa. Previous studies have stressed on economic growth, FDI, and urbanization as significant factors affecting environmental quality across different contexts. Galeotti (2007) sheds light on this issue, showing that the relationship between economic growth and environmental quality is heterogeneous, while some pollutants exhibit an Environmental Kuznets Curve pattern, others display a monotonically increasing trend. Additionally, Kindo & Pazisnewende (2023) conclude that FDI has negative effect on environmental quality in West Africa reflecting the existence of the pollution haven hypothesis in the area. While, Radoine et al. (2022) emphasize that urbanization contributes significantly to environmental degradation in Sub-Sahara Africa. Specifically, this thesis focus on the moderating role of institutional quality in examining the relationship between economic growth and environmental quality in Africa.

Moreover, African nations have struggled with environmental quality due to civil war, political instability, ineffective regulations, and corruptions (Asongu et al., 2021; Bellows et al., 2006), these nations have experienced an episode of economic growth, varying emphases on foreign direct investment, and gradual integration into global trade circuits. Macroeconomic shifts, however, have coexisted with persistence, and in some cases, highlighting environmental threats, deforestation, land degradation, water contamination associated with

mining activities, and poor air quality in urban centers, leading to a question of how economic growth affect environmental conditions in Africa, through effective governance structure. Uncontrolled development activities have immensely intensified the overexploitation of both terrestrial and marine ecosystems in these countries, leading to severe environmental degradation, extensive habitat and biodiversity loss, rising levels of air, and water pollution, all of which have profound social and public health consequences (UNDP, 2021). For example, as of December 2020, internal displacement affected an estimated 7.5 million individuals across West and Central Africa, including 824,000 displaced by environmental issues (IOM, 2023). Floods and windstorms were the leading causes, displacing approximately 276,000 people in Niger, 279,000 in Nigeria, and 20,000 in Burkina Faso, while in the Central African Republic, floods were the primary driver of displacement. Beyond these sudden events, environmental issues such as drought, deforestation, water pollution, air pollution, land degradation, rising sea levels, and coastal erosion have intensified, forcing many to migrate in regions where 80% of the population relies on natural resources for survival. These environmental shifts also put disrupt traditional patterns, as herders are compelled to alter or delay their routes due to bushfires and degraded pastures (IOM, 2023). Furthermore, it is reported that less than 5% of Sierra Leone's original forest cover in 1990 was still unaltered by 2020, with forest depletion continuing at an alarming rate of approximately 100,000 hectares per year (UNDP, 2021). This persistent decline is largely attributed to extensive agricultural expansion, both at commercial and subsistence levels, as well as to commercial logging and charcoal production for energy (UNDP, 2021). In addition, mining operations have exacerbated deforestation and land degradation, resulting in the destruction of farmland, insufficient availability of clean water, poor air quality, and increase noise pollution (UNDP, 2021). While, in South Africa, sources of pollution came from industrial combustion of fossil fuels, domestic burning of coal, wood for cooking and heating, and exhaust fumes from motor vehicles leading to high emissions (Ross, 2025).

Meanwhile, Africa continent face increasing threats from multiple stressors, including pollution, land degradation, overexploitation of natural resources, unplanned urban and infrastructural development, coastal erosion, and the growing impacts of climate change (EPA, 2020). The persistence and intensification of these environmental challenges stem from a fragile regulatory and legal framework, incoherent policy implementation, limited managerial capacity, insufficient coordination among agencies, inadequate financial and technical

resources, poor data management, and low levels of public awareness and environmental education.

Background studies of environmental Kuznets curve suggest that income-environment degradation relationship tends to display nonlinear patterns (Baloch et al., 2018). However, some studies suggest that institutional quality may achieve varying results on environmental quality, whereas trade holds a potential for spreading cleaner technologies, it also exposes countries to comparative advantage, and pollution intensive sectors (Pata et al., 2023). Besides, FDI may bring both modern, less-polluting production techniques as well as a growth of extraction-oriented activities harming local environments (Ning & Wang, 2018; Zugravu-Soilita, 2017). However, it remains unclear how macroeconomic factor such as economic growth affect environmental quality in Africa through institutional quality, given the simultaneous occurrence of economic gains and environmental deterioration.

Numerous studies have explored the relationship between economic growth and environmental quality, but the results are inconsistent across contexts. For example, this includes the works of (Ali et al., 2020; Fonchamnyo et al., 2021; Hakimi & Hamdi, 2016; Khan et al., 2022; Pham & Nguyen, 2024; Seker et al., 2015; Tiba & Belaid, 2020; Wasif et al., 2020). However, the relationship between economic growth and environmental quality, moderated by institutional quality, has received limited empirical attention in Africa-wide panel studies. Therefore, this study investigates how economic growth influences environmental quality through the moderating role of institutional quality in Africa countries.

Nevertheless, many countries in Africa have been in multiple initiatives for environmental protection, including the Paris Climate Agreement and country-level mitigation of carbon emissions and deforestation (UN, 2024). Despite these initiatives, the nation has continuously been dogged by issues of deforestation, land degradation, air pollution, and poor regulatory enforcement (UNCTAD, 2023). This contrast enables better understanding of how economic growth influence environmental quality in Africa through the moderating effect of institutional quality. By addressing the below research questions and objectives, this study seeks to enhance our understanding of the role that economic growth play in shaping environmental quality in Africa, with institutional quality acting as a moderating factor.

1.3. Research Questions

The below research questions are;

1. What is the impact of economic growth on environmental quality in Africa?
2. What is the impact of institutional quality on environmental quality in Africa?
3. Does institutional quality moderate the relationship between economic growth and environmental quality in Africa?

1.4. Objectives of the study

The research objectives are;

1. To examine the impact of economic growth on environmental quality in Africa
2. To investigate the impact of institutional quality on environmental quality in Africa
3. To examine the moderating role of institutional quality in the relationship between economic growth and environmental quality in Africa

1.5. Research Hypothesis

H1: Economic growth increases CO2 emission in the short-run but may decrease it in the long-run after reaching a certain income threshold in Africa.

H2: Institutional quality decreases CO2 emissions in Africa.

H3: Institutional quality significantly moderates the relationship between economic growth and environmental quality in Africa

1.6 Significance of the study

This study provides several contributions with practical implications for policymakers, government, regulators, stakeholders, environmental advocates, investors, civil society, and shareholders. The findings of this paper may also assist international organizations such as the World Bank, UNEP, and UNCTAD when designing regionally specific sustainability policies for emerging economies. For researchers and scholars, this study provides a comparative framework that can be replicated across countries and regions with similar developmental disparities. The main contributions of this study are as follows:

1. Contributing to the existing body of knowledge: This research contributes to the existing study by exploring the effects of economic growth on environmental quality in selected Africa countries. By focusing on a resource-rich, coups, and corruptions, the study offers important insights into how such structural and policy-related

challenges influence the link between growth and the quality of the environment. In addition, this research further extends prior research by explicitly demonstrates that the impact of economic growth on environmental quality is moderated by institutional quality. Most studies focus on environmental quality from different perspectives, such as how economic globalization impact it, the relation between it and human capital, and industrialization (Asamoah et al., 2019; Fonchamnyo et al., 2021; Padhan et al., 2023; Yameogo et al., 2021), whereas this research demonstrates how economic growth impacted environmental quality in Africa, a continent crawling from poverty and land degradation. This is essential, as it informs policymakers, government, and scholars about the unintended effects of these macroeconomic factors in improving environmental quality in Africa and the world at large.

2. Continent-specific analysis for Africa: This study provides new findings on what impact did the interaction term between institutional quality, and economic growth have on environmental quality in Africa, and did the capacity of the impact predict the level of environmental quality in the continent? By doing so, it inform regulators and stakeholders about whether the continent should enhance their governance system or not. Karaduman (2022) called for further research on how economic globalization and productivity is impacting environmental quality in continent's specific, and this study responds to that call for Africa, by providing more insight into the real effect of economic growth on environmental quality, as moderated by institutional quality.

3. Policy relevance to sustainable development goals (SDGs): This research touches on several SDGs of the United Nations, including the 6th Goal (Clean water and sanitation), the 8th Goal (Decent Work and Economic Growth), the 13th Goal (Climate Actions), and the 16th Goal (Peace, Justice, and Strong Institutions). The objective of this research serves as an evidence-based guide for other continents and developing countries on their path to achieving the SDGs.

4. Implications for environmental quality policies: Another key contribution of this study is its ability to facilitate policies that can promote environmental quality. A result supporting the view that environmental quality significantly contributes to improving the living standard would also underscore the importance of reducing CO2 emissions through effective regulation and government intervention in environmental protection.

Moreover, the results of this study would act as a practical guide for countries in enhancing effective environmental quality reform. In more specific terms, it can put forward strategies for reducing corruption, improving public resource management, enhance regulatory effectiveness, and fostering more transparent and accountable governance structures. This would serve as a valuable recommendation for governments, civil society groups, and international development organizations who advocate for environmental quality and better governance in Africa.

1.7 Research Outline

The remaining part of this study is structured as follows. Chapter 1 outlines the introduction which entails the background of the study, problem statement, research questions, research objectives, research hypotheses, and significance and contributions of the research. Chapter 2 outlines the literature review which encompasses theoretical framework, conceptual framework, and previous studies. Chapter 3 displays the methodology which include types of research, research approaches, data and data source, data collection methods, variable definition and measurement, research models, and data analysis techniques. Chapter 4 presents the results and discussions, while Chapter 5 discusses the conclusions, policy implications, recommendations, limitations of the study, and directions for future research.

CHAPTER II

LITERATURE REVIEW

In order to build on the background and problem statement of this study as presented in Chapter 1, it is important to situate the investigation within the broader theoretical and empirical landscape. The complex interactions between economic growth and environmental quality have been widely studied, yet the institutional quality context through which these factors operate remains insufficiently explored in the African Setting. Therefore, Chapter 2 provides a comprehensive review of relevant theories and previous studies that explain these relationships, highlighting existing knowledge gaps, and justify the need for incorporating institutional quality as a moderating variable. This review forms the analytical foundation for conceptual framework that guide the empirical analysis of this research.

2.1 Theoretical Framework

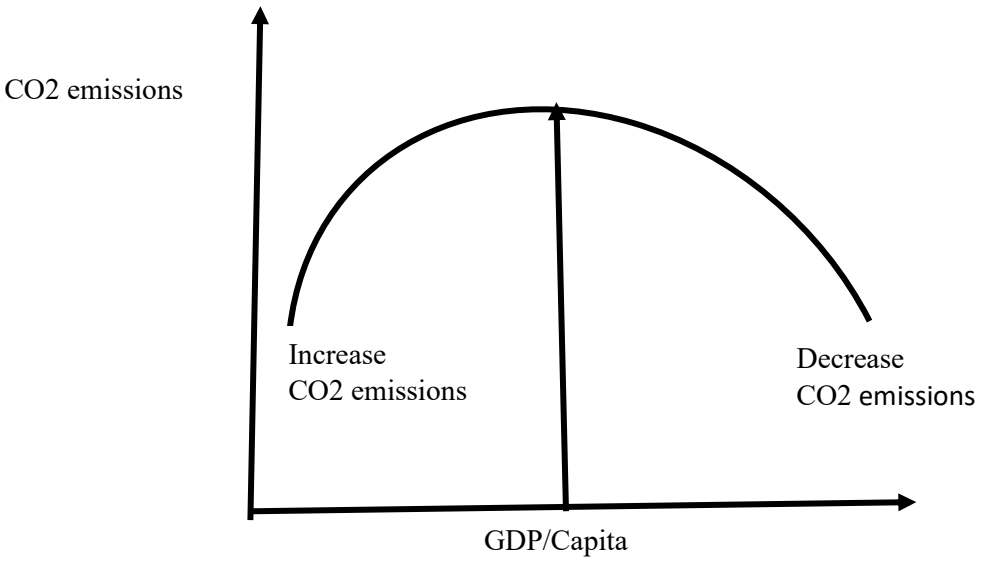
The economics literature on the effects of economic growth on environmental quality, moderated by institutional quality are drawn on three complementary strands of economic theory. The Environmental Kuznets Curve (EKC) hypothesis, and the New Institutional Economics (NIE) Theory. Collectively, these theories suggest that the environmental consequences of economic expansion and global integration depend not only on the scale and structure of economic activity but also on the governance structure that shape incentives, enforce regulations, and guide resource use. This integrated framework implies that growth may either degrade or enhance environmental quality depending on the strength, credibility, and effectiveness of institutional structure. By linking market dynamics with regulatory capacity, the framework emphasizes that institutions play a decisive role in conditioning how forces translate into environmental outcomes, thereby providing a coherent basis for assessing the moderating effect of institutional quality in empirical analysis.

2.1.1 Environmental Kuznets Curve (EKC) Hypothesis

The Environmental Kuznets curve was firstly introduced by Grossman and Krueger (1995) to describe a hypothesized relationship between environmental degradation and GDP per capita. Adopting the inverted U curved by Kuznets, EKC shows that in the early stage of economic growth, pollution increase along with increase in GDP per capital and at some point, beyond pollution and environment degradation decrease along with higher per capita income. The EKC applies this concept to the environment, proposing that in the early stages of development, economic growth contributes

to environmental pollution and subsequently declines once a specific income threshold is reached (Bibi & Jamil, 2021; Dogan & Inglesi-Lotz, 2020). The EKC hypothesis suggests that, at first, economic growth causes environmental degradation, yet a subsequent reduction takes place when a certain income level is reached due to technological advancements and raised environmental awareness (Mahmood & Houaneb, 2023; Rashid Gill et al., 2018). This framing has been the leading empirical and theoretical intuition on connections between growth and the environment, and has been thoroughly surveyed and formalized in recent reviews of syntheses of EKC findings.

Figure 2.1 The Kuznets Curve



Source: Author's computation

At lower income levels, the emerging economies prefer industrialization, job creation, and growth more than environmental sustainability (Sadorsky, 2014). However, as income rises, societies begin to demand cleaner environment, and government enact strict environmental regulations and cleaner technologies (Smulders et al., 2011). Economic growth increases environmental degradation through industries that consume resources such as mining and agriculture. As with the EKC hypothesis, however, long-term growth driven by environmental policy and green investment may ultimately enhance environmental quality (Zhao et al., 2023). This approach thus assumes that the impact of economic growth on the quality of the environment lies on the development stage of the nation as well as enforcement mechanisms for policies. There has been some studies emphasizing that the EKC is not a global

rule and that the income-pollution link is specific to a country and based on variables such as technology adoption, energy composition, urbanization, and green regulation (Udeagha & Breitenbach, 2023).

2.1.2 The New Institutional Economics (NIE) Theory

Well-functioning institutions constitute a cornerstone of sustainable economic improvement in every nation, and they are the core determinants of political and environmental development for nations across the globe. According to the New Institutional Economics (NIE) theory, institutions play major roles in the levels of economic development experienced by countries (Rafiqui et al., 2009). The core aspect that institutions bring to the attention of the world is the significance of development related to institutional quality (Rafiqui et al., 2009).

According to Huo et al. (2023), institutions are classified into three groups. These groups are economic institutions, political institutions, and legal institutions. To minimize uncertainty, the political institutions place emphasis on the evolution of laws, the enforcement of property rights, the generation of rules and regulations, and the enhancement of social benefits. However, the legal institutions provide approval for the rules, laws, and regulations introduced by the political institutions. Additionally, the economic institutions ensure efficient resource mobilization through advancement in technology and efficient human and physical capital (Mishra et al., 2007). There is an agreement that inefficient institutions act as a deterrent in the capacity of countries in gaining access to productive resources such as physical capital. Additionally, the use of new technology. This is because inefficient institutions in some countries are involved in judicial perversion. Such institutions are also involved in improper checks and balances. Other inefficiencies in the institutions involve bureaucratic inefficiencies.

Moreover, efficient institution in a nation can enable a nation to render the ability to reduce transaction costs to the least, very much involve in the aspect of international trade with the intention of benefiting from the same trade processes for a better future in terms of production levels for capital goods. Institutions play significant role in improving human development and economic advancement at different levels of economies (Chinonye et al., 2022). Macroeconomic stability and the ability for environmental quality are ensured by the aspects of good institutions through political stability, control of corruption, regulation quality, and the rule of law. Hence various researchers like Tinta (2022) conclude that the extent to which institutions are of good quality effectively captures the existence of discrepant variations

within the cross-country levels of income. Although low-quality institutions are experienced by developed countries together with developing countries, research shows that the topic-area issue has been noted to be more popular in the context of the latter (Xu et al., 2019).

2.2 Conceptual Framework

This research analyzes the impact of economic growth on environmental quality in Africa, while examining the moderating role of institutional quality. As discussed, existing theories and prior empirical literature provide the foundation for developing the conceptual framework of this research. The dependent variable of this study is Environmental quality, while the independent variable is economic growth, and to what extend does institutional quality moderates this relationship. According to Kuznets' theoretical model, environmental quality and economic growth have a non-linear relationship. The non-linearity of the relationship between the independent and dependent variables is thus indicated by GDP^2, another independent variable. Moreover, in order to moderate the relationship between the independent variable and environmental quality, institutional quality serves as a moderating element. In addition, this study also includes Trade openness, FDI inflows, population growth, and Covid-19 as control variables in order to enhance the robustness of our findings, this is because these control variables also have an impact on environmental quality according to previous research.

2.2.1 Environmental Quality

Environmental quality refers to the condition and potential for supporting human and environmental processes for development (Smulders et al., 2011). Jalloh et al. (2013) argue that environmental quality can be influenced negatively or positively depending on economic factors such as industrialization and technological advancement. In most industrialized countries, environmental conditions continue to worsen due to increasing industrialization and rising energy use (Zhao et al., 2023). Udeagha & Breitenbach (2023) state that when a nation develops economically, environmental performance often declines before improving. This phenomenon forms a curve called the Environmental Kuznets Curve. Furthermore, Galeotti (2007) consider effective environmental regulation framework and approaches critical for improving environmental performance instead. This approach becomes more important for a nation experiencing environmental transformation because of such factors as fast urbanization.

Climate-related factors such as forest destruction, and climate-related disasters affect environmental quality.

2.2.2. Economic Performances; (GDP)

The performance of economies is measured by their ability to register economic growth and stability (Mahmood & Houaneb, 2023). GDP growth has remained one of the important measures used to consider economic performance. Improvements in productivity and changes in economic structure are effectively measured using this indicator (Rashid Gill et al., 2018). Economic growth is a source for economic performance because of its contribution of capital, technology, and management. Economic growth indicates overall strength in sectors such as manufacturing. Accordingly, economic performance and open economy variables form a major part of analysis framework concerning policies and sustainability.

2.2.3. Institutional Quality

Institutional quality can be viewed as the strength and credibility of political and social framework that govern relationship between politics, society, and economies (Katuka & Mudzingiri, 2023). A quality institution is one that ensures that elements such as rule of law, protection of property rights, transparency, and accountability are entrenched (Rafiqui et al., 2009). The most critical factors driving institutional quality are political stability, voice and accountability, regulatory quality, effective government, control of corruption, and rule of law (Katuka & Mudzingiri, 2023). A strong institution can lower transaction costs, promote entrepreneurship, and optimize policy execution. Conversely, a poor institution may bring about inefficiencies and misallocation of resources (Chinonye et al., 2022). Institutional quality also influences a nation's preparedness for external shocks, environmental conditions, and demographic changes.

2.2.4 Open Economy and Pandemic Shock; (Trade openness, FDI, Population growth, and Covid-19)

Trade openness allows countries to tap benefits of global markets and efficiency gains based on a comparative advantage concept. But while trade openness can accelerate economic performance, economies are also vulnerable to external shocks such as trade restrictions and price variations (Amoah et al., 2024). Fonchamnyo et al. (2021) argue that a higher trade openness has a positive effect on economic growth due to specialization and efficiency gains.

Thus, economic performance is influenced by various parameters such as structures, finance, and external elements.

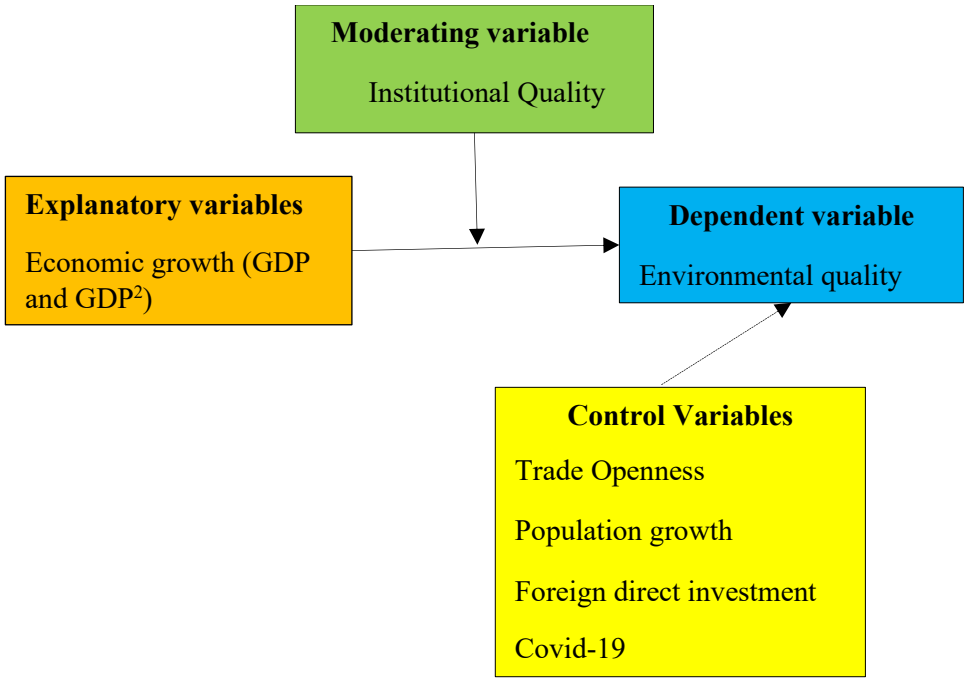
Demographic dynamics can be explained as changes in population composition and size that affect the supply of labor and economic development (Nasrollahi & Saeed, 2018). Population growth generates demographic dividend that leads to increased labor productivity and stimulates economic development when appropriate education and employment opportunities are available (Fonchamnyo et al., 2021).

FDI inflows accelerate capital accumulation. The literature in empirical studies clearly indicates that economies with appropriate open economy policies and environments along with strong macroeconomic conditions perform better in the long run (Hakimi & Hamdi, 2016; Khan et al., 2022; Tiba & Belaid, 2020).

Covid-19 pandemic has been a major economic shock with effects on labor market, public health infrastructure, and mobility (Chuan et al., 2022). Productivity and consumption behavior were impacted because of restriction associated with theCovid-19 pandemic (Anser et al., 2020). Shah (2021) shows that Covid-19 has impacted world trade, FDI, and economic performance. This explains how open economies are susceptible to external shocks.

The diagram below presents the independent variable, moderated by institutional quality, along with the control variables, in explaining their overall impact on environmental quality in Africa.

Figure 2.2 Conceptual framework



Source: Author's computation

2.3 Previous Studies

2.3.1 Economic growth and environmental quality

The relationship between economic growth and environmental quality has formed a core debate in environmental economics, with the notion from the EKC hypothesis that environmental degradation first increases with income before decreasing beyond a threshold level. For instance, recent evidence discovers a favorable relationship between GDP growth and CO_2 emissions, suggesting that West Africa may still be on the rising side of any EKC curve (Asumadu & Owusu, 2017). Sambodo & Lestari (2012) demonstrates that in the long run, an increase in per capita GDP will lead to much higher CO2 emissions per capita than in the run. Empirical findings also emphasize that cointegration techniques are most widely used to test such relationships in country studies because they provide reliable estimates in small samples as well as where variables are of mixed orders of integration (Jehangir et al., 2020; Sultanuzzaman et al., 2018).

Along this line, previous studies on economic growth and CO2 emissions display mixed findings. For instance, Cialani (2007) indicated that the peak level of CO2 per capita in Sub-Saharan would be achieved when GDP per capita reached a turning point. Furthermore, Wang (2019) found that tourism sector significantly encourages economic growth, however, degrades the quality of the environment, and also conclude that globalization has a long-term relationship with economic growth but an insignificant relationship with CO2 emissions. Salahuddin et al. (2019) examined time series data from Asia using ARDL model and found turning points for specific pollutants, indicating a certain level of income at which certain air quality measures improved. Moreover, Adejumo (2020) investigated time series data using Nigeria as a case study, and found that natural resources which depletes environmental quality, increases economic growth but reduces environmental quality. Cointegration analysis was used by Usman et al. (2022), who found a cointegrating linkage between per capita income and various outputs of pollution, some of which were positive and some negative, depending on the pollutant in question. Similarly, Charfeddine et al. (2018) analyzed whether it is feasible to achieve improvements in the quality of the environment without decreasing economic growth in North Africa, and found that energy conservation policy will have adverse effects on economic growth, but alternative measures must be undertaken to preserve the environment.

On the contrary, Xue et al. (2022) examined the determinants of CO2 emissions and found the prices of energy and policy incentives to be crucial for whether economic growth leads to a rise or a reduction in emissions. Similarly, Liu et al (2022) found that the pattern of growth associated with commodities was usually accompanied by higher levels of deforestation and water pollution, in the absence of compensatory action for the environment. Furthermore, Lee & Oh (2015) indicated the effects of urbanization associated with economic development, which often leads to local air and water pollution unless reinforced by infrastructure development expenditure.

Despite these insights, limited empirical attention in Africa-wide panel studies has been received on how economic growth affects environmental quality in Africa. Consequently, the current study examines the impact of economic growth on environmental quality in Africa. Understanding this relationship is crucial, particularly in light of emerging nations with specific characteristics, country norms, governance structure, and economic reforms initiatives.

2.3.2 Institutional quality and environmental quality

The relationship between institutional quality and environmental quality is complex and multi-dimensional. Existing studies generally show that institution can have either a positive or negative impact on the environment. For instance, Frutos-Bencze et al. (2017) suggest that weak institution can raise some measures of air quality but the finding is sensitive to identification and to whether or not trade openness causes changes in composition towards cleaner or dirtier production. Mishra et al. (2007) found that poor institutions increase the polluting effects of the country. Similarly, Amegavi et al. (2022) found that institutional quality has a decreasing effect on environmental quality, suggesting that the quality of institutions is essential for environmental quality. Similarly, Kamran & Kazak (2025) points out instances of per capita CO_2 emission growth being more closely associated with stronger institutions.

While, Githaiga & Wenani (2023) applied the GMM estimators on 34 countries from Sub Saharan African and revealed that the effect of remittances on the human capital development is determine by the quality of institutions, suggesting that it is necessary to investigate how much foreign capital flows through the development of human capital contribute to the socio-economic change of the region.. In addition, Xu et al. (2019) examined institutional quality, resource endowment, and economic growth in a cross-country data, and found that institutional quality affects both local and neighboring economies, with the relationship following a U-shaped pattern, and these nonlinear influences can be attributed to resource allocation impacts for the former and demonstration effects for the latter, suggesting that this influence stems from investment expansion effects. Nevertheless, Tinta (2022) also found regulatory quality very critical with regard to economic growth.

Hence, in line with the mixed findings of these arguments on the relationship between institutional quality and environmental quality, it is expected that institutional quality would have significant effects on environmental outcomes in Africa.

2.3.3 Institutional quality as a moderator of the growth-environment relationship

The ability of institutional quality to moderate the relationship between economic growth and environmental quality by (Wang et al., 2023a), is confirmed that government should embark on policies that promote sustainable power in order to reduce CO2 emissions and improving learning environments to encourage economic development. Further investigation of the role of institutional quality on the relationship among growth induced by

the effects of the growth of Nigeria on CO2 emissions revealed that a country with higher levels of institutions experience reduced increments (and even declines) of CO2 emissions due to the induced growth effects (Chinonye et al., 2022).

Studies on the intersection of institutions in studying the implications of the environment yield mix results. For instance, Kinuthia et al (2025) showed that economic growth augments CO_2 emission levels on average but the relationship depends on the quality of institutions; institutions mitigate the increase of CO_2 emission levels that result from economic growth and financial development. Similarly, Bokpin (2016) found that weak institution significantly increases environmental degradation, hence leading to a negative impact on sustainability of the environment, they suggest that for institution to have negative and favorable impact on environmental sustainability, there need to be a strong governance and quality institutions in place to check the conduct of businesses. Moreover, Huo et al. (2023) found that institutional quality moderates the effect of natural resources rent on finance, suggesting that policymakers should evaluate the significance of institutions in developing realistic estimates and policy inputs and support a robust role for institutional quality and natural resource exploration for rapid growth.

In line with the literature, this study posits that institutional quality moderates the relationship between economic growth and environmental quality. Countries with good governance are expected to adopt more stringent institutions strategies in response to the increased in industrial waste, environmental degradation, and increasing transportation related emissions, driven by the risk aversion and control motivations of poor institutions.

2.3.4 Previous studies on the control variables

The relationship between trade openness and environmental quality is complex and multi-dimensional. Existing studies generally show that trade openness can have either a positive or negative impact on the environment. For instance, Frutos-Bencze et al. (2017) suggest that trade openness can raise some measures of air quality but the finding is sensitive to identification and to whether or not trade openness causes changes in composition towards cleaner or dirtier production. Trade-theory models and empirical decompositions by Brack et al. (2013), render the channel through which trade can create pollution havens under asymmetric regulation but also show that factor-price and composition effects are able to counter simple predictions. Results have indicated that increased trade openness benefits the

environment of East Africa (Managi et al., 2009), they also found the impact s large in the long run, after the dynamic adjustment process, although it is small in the short term. Similarly, Le et al. (2016) reported that higher levels of trade openness led the industrial sector's carbon emissions to increase above certain levels. This meant that the increase in trade openness led to a deterioration in the potential emissions levels.

Recent empirical literature report that population growth remains a significant driver of environmental degradation, although the magnitude and direction vary by context and demographic structure. For instance, Nasrollahi & Saeed, (2018) examined environmental pollution, economic growth, and population in a weak and strong sustainability of nations using a STIRPAT model, and found that weak and strong sustainability is affected negatively by population, suggesting that policymakers in sustainability should develop preventive and qualitative strategies for population and industrial activities. Arnocky et al. (2012) indicated that environmental concern and pollution-related health concerns both predicted a less positive attitude towards population growth, suggesting that population growth can also mediate the negative link between pollution-related health concerns and personal fertility intentions.

Empirical literature on FDI and environment has recorded divergent outcomes, studies indicate that the general effect of FDI on emissions is context-dependent, with some demonstrate environmental benefits in the form of technology spillovers while others have recorded increased emissions as FDI is agglomeration in pollution-intensive industries (Sanna-Randaccio et al., 2017; Zheng et al., 2025). Regional and national studies in Sub-Saharan Africa underscore this heterogeneity, for instance, studies in African countries find weak or nonexistent EKC relationships, and also found that FDI effects are conditional on whether or not economic growth is accompanied by structural change to cleaner sector, industries and environmental regulation investment (Kindo, & Kabore, 2023; Sarpong et al., 2024).

Previous studies on Sub-Saharan African (SSA) countries conducted by Jinapor et al. (2024), utilizing the Driscoll and kraal standard error estimation technique, and found that FDI presents favorable and harmful effect on the environment, suggesting that SSA authorities should strengthen institutional capacities to ensuring environmental quality while promoting industrialization and FDI inflows. Furthermore, Tsoy & Heshmati (2024) analyzed panel data of 100 countries from 2000 to 2020 and found non-linear and quantile-dependent effects of FDI on emissions per capita, such that the probability of positive FDI effects on environment

outcomes is greater in countries below to medium values of CO_2 emissions, but can be non-linear and negative above certain quantiles, suggesting that emissions per country and their position within emissions distribution affect both sign and magnitude of FDI effect on emissions.

Empirical studies on Covid-19 and environmental quality have reported mixed findings on air pollutants and other related indicators during lockdowns, leading to environmental issues with significant regional and methodological limitations exist in these findings. For instance, Chuan et al. (2022) examined global environmental impacts pandemic lockdown, and confirmed that the amount of pollution in the air, water, soil, and noise present a significant decline during the pandemic, indicating that Covid-19 pandemic lockdown also led to a world-wide decline in noise pollution. Moreover, Shah (2021) confirmed that despite the negative impact of Covid-19 on the globe, the pandemic crises brought a positive impact on the natural environment, suggesting that the Covid-19 induced lockdown decreased environmental pollution significantly worldwide leading to environmental quality. Similarly, Nilashi et al. (2020) examined Covid-19 and its natural environmental impacts, and found that Covid-19 lockdown hassled to an improving in air quality and a reduction in water pollution in many cities around the world, they also showed that Covid-19 has positively impacted the natural environment. In addition, Anser et al. (2020) found that there are some negative externalities associated with Covid-19 pandemic towards the environment leading to increasing death tolls and rising healthcare costs, which present the globe in a situation wherein they should understand how to direct high mass carbon emissions and population growth through acceptance of preventive measures. Furthermore, Broomandi et al. (2020) examined the impact of Covid-19 on the air quality in Iran from 2019 to 2020, and found that SO2 and NO2 decreases the air quality but AOD increased during the lockdown, indicating that even with the adverse weather conditions, a decrease in primary pollutant levels, confirms the possible improvement on the air quality in Africa. Nonetheless, Bashir et al. (2021) examined environmental quality and Covid-19 pandemic in the top most affected states in the USA, and confirmed that temperature, humidity, environmental quality index and rainfall are significant factors related to the Covid-19 pandemic in the top 10 most affected states in the USA leading to environmental issues.

Table 1 of the matrix table presents a concise summary of the empirical literature by comparing key characteristics of previous studies. It typically lists the author(s) and year,

variables used, expected signs, and research approach. This enables readers to quickly identify similarities, differences, research trends, and gaps in the existing literature, thereby providing a strong foundation and justification for the current study.

Table 2.1. Empirical summary of variables used in previous studies (Matrix)

Author(s)	Dependent Variable	Explanatory Variable	Expected Sign	Methods
Sambodo & Lestari (2012)	CO2 emissions	GDP per capita	+	Time-series econometric analysis
Usman et al. (2022)	Environmental pollution	GDP per capita	+	Cointegration Analysis
Xue et al. (2022)	CO2 emissions	GDP, Energy, Prices	GDP (+)	Panel Regression
Liu et al. (2022)	Environmental degradation	Economic growth	+	Panel Data Estimation
Kinuthia et al. (2025)	CO2 emissions	GDP * Institutional quality	Moderating effect	System GMM
Chinonye et al. (2022)	CO2 emissions	GDP * Institutional quality	-	Dynamic Panel Estimation
Le et al. (2016)	Air pollution	Trade openness	+	Threshold Regression
Jinapor et al. (2024)	Environmental quality	FDI	+/(-)	Driscoll-Kraay Estimator
Tsoy & Heshmati (2024)	CO2 emissions	FDI	+/(-)	Panel Quantile Regression
Shah (2021)	Environmental quality	Covid-19	-	Descriptive & Econometric Analysis
Chuan et al. (2022)	Air pollution	Covid-19	-	Comparative Environmental Analysis

CHAPTER 3

RESEARCH METHODOLOGY

To provide answer to the research questions and objectives outlined in Chapter 1, Chapter 2 presents a comprehensive review of relevant theories and previous studies that explain the relationship between economic growth and environmental quality, highlighting existing knowledge gaps, and justify the need for incorporating institutional quality as a moderating variable. It is important to place this investigation within a robust methodological approach in order to unravel the impact of economic growth on environmental quality in Africa, moderated by institutional quality. Chapter 3 provides a rigorous and comprehensive methodology designed to address the research problems by providing empirical evidence on the impact of economic growth on environmental quality in Africa, with institutional quality as a moderator. This methodological approach forms the analytical foundation for answering the research questions and achieving the study's objectives.

3.1 Types of Research

A quantitative research design with the Generalized Method of Moment (GMM) estimator is used in this study to empirically analyze the impact of economic growth on environmental quality in Africa, while moderated by institutional quality from 2002 to 2023. Africa was selected due to its widespread air and water pollution, deforestation, land degradation, economic activities, ineffective regulation, and limited environmental policy (Boubacar et al., 2025; Asongu et al., 2015). This study utilizes panel data to control for country and time-dynamic effects.

3.2 Research Approach

The main objective of this study is to identify the impact of economic growth on environmental quality in Africa, while examine the moderating role of institutional quality in this relationship. A quantitative panel approach is the most suitable for this research. Panel data has been widely used in many previous economic research, involves data containing several individual's time series observations (Bond, 2002). It incorporates a time series dimension (i) and a cross-sectional dimension (t) (Karabiyik et al., 2019).

The advantage of panel data over time-series and cross-sectional data have been identified by (Karabiyik et al., 2019). Firstly, panel data has the ability to control for time and country variables, while this cannot be achieved in a cross-sectional or time series study.

Secondly, in the control of heterogeneity, time series and cross-sectional analysis lead to biased results, while panel data analysis controls for it. Thirdly, researchers conducting panel studies come up with more informative data with a greater degree of freedom, more efficiency, less collinearity, and more variability among variables, leading to a more reliable parameter estimate. Fourthly, in the investigation of dynamic adjustment, the relative stability of cross-sectional distributions allows it to hide a lot of changing features. Lastly, in the case of panel data, their speed of adjustment makes them better suited for economic policy changes.

3.3 Data and Data Source

Panel data is used to capture long-term trends of economic and environmental policy reforms. The study utilizes secondary annual panel data of forty-three (43) African countries from 2002 to 2023 period with total observations of 946. These African countries are selected exclusively based on the data availability for each variable covering the study period 2002 to 2023. The selected countries are listed below in Table 3.1.

Table 3.1 List of selected African Countries and their income group

Income Group	Countries
Low-income	Burundi, Burkina Faso, Central African Republic, Chad, Congo DR (Democratic Republic of the Congo), Congo Rep (Republic of the Congo), Gambia, Guinea-Bissau, Guinea, Madagascar, Mali, Mozambique, Niger, Rwanda, Sierra Leone, Sudan, Togo, Uganda, and Zambia
Lower-Middle-income	Angola, Algeria, Cameroon, Comoros, Egypt, Kenya, Benin, Cabo Verde, Cote d'Ivoire, Ghana, Mauritania, Senegal, Morocco Tanzania, Tunisia, and Zimbabwe
Upper-Middle income	Equatorial Guinea, Gabon, Libya, Mauritius, Botswana, Namibia, Seychelles, and South Africa

Source: WDI (2024)

3.4 Data Collection Methods

The study used balanced panel data, which is obtained from the World Development Indicators (WDI) website. An explanation of the data description and their associated interactions is given below.

3.5 Variables definition and measurement

3.5.1 Dependent variable: Environmental Quality

Environmental quality is an indication of the health of the natural environment, generally estimated by a proxy to pollution or ecological sustainability (Padhan et al., 2023). Some of the measures across literature in economics used per capita CO_2 emissions (metric tons per person) as a proxy to measure environmental quality, while others use Ecological Footprint (gha per capita) as a broad measure of sustainability. These studies include, Padhan et al. (2023) who measured environmental quality as a proxy of CO2 emissions. Environmental quality is measured as a proxy by CO2 carbon dioxide emissions (metric tons per capita) (Lv & Xu, 2018). CO2 emissions (metric tons per capita is used as a proxy to measure environmental quality (Yameogo et al., 2021). Ecological footprint per capita is used as a proxy to measure environmental quality (Karaduman, 2022).

In the present study, environmental quality (EQY) is proxy by CO_2 emissions per capita (metric tons per capita). This study proxies environmental quality using CO2 emissions because CO2 emissions are a major indicator of environmental pollution and climate change, particularly in Africa, reflecting the extent of environmental degradation caused by economic and industrial activities, this captures only one dimension of environmental quality (Boubacar et al., 2025; Asongu et al., 2015).

3.5.2 Independent variables: Economic Growth

Economic growth is the increase in a country's productive capacity and output in the long run (Fonchamnyo et al 2021). Previous research such as, Asamoah et al (2019) measured economic growth by using GDP per capita as the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Fonchamnyo et al (2021) measured economic growth as GDP per capital growth rate as a proxy. Karaduman (2022) used GDP per capita (constant US$) as a proxy to measure Economic Growth. In order to establish the non-linearity argument of the Kuznets theory upon

which this study is based, another variable GDP^2 is generated through the GDP per capita. In the current study, GDP per capita (Constant 2015 US$) is used as a proxy to measure economic growth.

3.5.3 Moderating variable: Institutional quality

Institutional quality refers to how strong, effective, and reliable a country's institutions are, and how these institutions influence economic outcomes (Wang et al., 2023a). One of the objectives of this study is to uncover the moderating role of institutional quality on economic growth and environmental quality relationship. Institutional quality is described by (Ogbuabor et al., 2023), as a constraint associated with human made that affect societal interactions. It has been measured using varieties of parameters across different studies. One of the most popularly used parameters is Kaufman's six governance indicators, which include rule of law, government effectiveness, political stability, control of corruption, voice and accountability, and regulatory quality. The data for this study will be obtained from the World Development Indicators (WDI) with measures ranging from -2.5 (for weak institutions) to +2.5 (for strong institutions).

3.5.4 Control variables

3.5.4.1 Trade Openness

Trade openness represents the degree to which a country is integrated into the global economy (Keho, 2017). It is commonly approximated as the ratio of total trade (exports + imports) to GDP, indicating the degree of exposure to foreign markets (Musila & Yiheyis, 2015). Different proxies have been used to measure trade openness. For instance, a study done by (Fonchamnyo et al., 2021) measured trade openness by Trade (% of GDP). Ogbuabor et al. (2023) measured trade openness by Trade (% of GDP). Trade openness is measured as Trade (% of GDP) (Le et al., 2016). Trade openness is measured as the sum of real exports per capita and real imports per capita. Real import and real export is computed on the basis of their respective shares in GDP (Keho, 2017). In the present study, Trade (% of GDP) is used as a proxy to measure trade openness.

3.5.4.2 Population Growth

Population growth is a rate of change over a year in a country's population (Dimnwobi et al. 2021). It represents demographic pressure on natural resources and is normally included

in environmental models to allow for the scale effect (Weber & Sciubba, 2019). Several proxies have been used in previous literatures to capture population growth. For instance, Dimnwobi et al. (2021) measured population growth as annual percentage growth in population size. Fonchamnyo et al. (2021) used total population growth rate as a proxy to measure population growth. While Khan et al. (2021) used annual percentage, the total population-based on the de-facto definition as a proxy to measure population growth. In the current study, population growth is measured as population growth rate (annual %).

3.5.4.3 Foreign Direct Investment

Foreign Direct Investment refers to cross-border capital movements by foreign investors that produce long-term interest and management control within local businesses (Frutos-Bencze et al., 2017). It is often expressed as net FDI inflows (% of GDP) (Contractor et al., 2020). FDI have been measured by different proxies in previous studies. For example, Asamoah et al. (2019) used net inflow of foreign direct investment as share of GDP as a proxy to measure FDI. Fonchamnyo et al. (2021) measured FDI by net inflow as a percentage of GDP. FDI is measured by net FDI inflows for each country in year t (balance of payment, current USD$) (Frutos-Bencze et al., 2017). Accordingly, in the present study, FDI is measured as foreign direct investment, net inflows (% of GDP).

3.5.4.4 Covid-19 Pandemic

Covid-19, also known as Coronavirus Disease 2019, is “a very infectious respiratory disease caused by SARS-CoV-2, a new type of coronavirus, which emerged in late 2019 in Wuhan, China” (Chuan et al., 2022). Covid-19 quickly spread to become a global pandemic that greatly affected economic activity, movement, trades, manufacturing, and overall societal activity, as highlighted by (Shah, 2021). Nilashi et al (2020) observed that Covid-19 control policies, including lockdowns, border closures, travel bans, and factory closures, greatly reduced pollution, energy demand, and CO_2 emissions in many areas. Various authors have used different proxies to capture Covid-19 in previous literatures. For instance, Arat et al. (2023) measured Covid-19 using a binary variable, which takes the value of one (1) if trading occur during the normal market times, pre Covid-19, and zero (0) otherwise. Furthermore, Anser et al. (2020) measured Covid-19 by using the electric power consumption (denoted by EPC measured as kilowatt hour per capita) in carbon emissions modeling to analyze its environmental effects that are pertaining to Covid-19 measures in across the world. In addition, Rousseau & Deschacht (2020) measured Covid-19 by using a dummy variable, assigning a

value of one (1) for the treatment years 2020 and onward to capture the period affected by the Covid-19 pandemic, and a value of zero (0) for the years 2019 and earlier. In the present study, Covid-19 is measured by using a binary indicator for the year 2020 to 2023 is (1) if the observation belongs to either of those years and (0) otherwise. We control for Covid-19 based on the fact that Covid-19 controls for the exogenous shocks that significantly altered trade, and economic activity during 2019 to 2022 period.

3.6 Measurement of variables

Table 3.2 Measurement of variables

Abbr	Variables	Measurements	Source
	Dependent variable:		
EQY	Environmental quality	EQY is measured by Carbon dioxide (CO2) emissions (metric tons per capita)	WDI
	Independent variable:		
GDP & GDP^2	Economic growth	Economic growth is proxied by GDP per capita (Constant 2015 US$)	WDI
	Moderating variable:		
INQ	Institutional quality	Measures range from -2.5 (for weak institutions) to +2.5 (for strong institutions). Institutional quality is measured through Author's computational derivation using PCA from voice and accountability, political stability, rule of law, government effectiveness, regulatory quality, and corruption control	WDI
	Control variables:		
TOP	Trade openness	TOP is proxied by Trade (% of GDP)	WDI
PGR	Population growth	Population growth is proxied by population growth rate (annual %)	WDI
FDI	Foreign direct investment	FDI is measured as Foreign direct investment, net inflows as a % of GDP	WDI
COV	Covid-19	Covid-19 is measured by using a binary indicator for the year 2020 to 2023 is (1) if the observation belongs to either of those years and (0) otherwise	Author's computational derivation using excel

3.7 Research models

This study uses the System Generalized Method of Moment (GMM) estimator of (Blundell & Bond, 1998) to determine whether the independent variable has influence on the dependent variable, and also whether institutional quality moderates the relationship between economic growth and environmental quality in Africa. This approach has been found to produce reliable coefficient estimates in dynamic panel settings (Flannery & Hankins, 2012). The research models for this study are as follows;

3.7.1 Research model of the direct effect

$$EQY_{it} = \beta_o + \beta_1 EQY_{it-1} + \beta_2 GDP_{it} + \beta_3 GDP^2{}_{it} + \beta_4 INQ_{it} + \beta_5 TOP_{it} + \beta_6 PGR_{it} + \beta_7 FDI_{it} + \beta_8 COV_{it} + U_i + \lambda_t + \varepsilon\_it \quad \ldots\ldots (1)$$

3.7.2 Research models of the moderating effect

To address the research question concerning the interaction effects raised in this study, this study follow Brambor et al. (2006) by specifying the model for the moderating effects as presented below:

$$EQY_{it} = \beta_o + \beta_1 EQY_{it-1} + \beta_2 GDP_{it} + \beta_3 GDP^2{}_{it} + \beta_4 INQ_{it} + \beta_5 INQ * GDP_{it} + \beta_6 INQ * GDP^2{}_{it} + \beta_7 TOP_{it} + \beta_8 FDI_{it} + \beta_9 PGR_{it} + \beta_{10} COV_{it} + U_i + \lambda_t + \varepsilon\_it \quad \ldots\ldots (2)$$

The marginal effect of GDP on CO2 emissions for the moderating role is stated as:

$$\frac{\partial CO_2}{\partial GDP} = \beta_1 + 2\beta_2 GDP_{it} + \beta_4 INQ_{it} + 2\beta_5 (INQ \times GDP_{it}) \quad \ldots\ldots (3)$$

The effect of institutional quality depends on GDP:

$$\frac{\partial CO_2}{\partial INQ} = \beta_3 + \beta_4 GDP + \beta_5 GDP^2 \quad \ldots\ldots (4)$$

Where; EQY_{it-1} is the lagged of the dependent variable, EQY is environmental quality, GDP and GDP^2 represent economic growth, INQ is institutional quality, TOP is trade openness, PGR is population growth, FDI is foreign direct investment, COV is Covid-19, INQ * GDP and INQ * GDP^2 are the interplay between institutional quality and economic growth, U_i is country-specific effect, and λ_t is time-specific effect.

The dependent variable as an explanatory factor integrates lagged variable at t-1 for each model to assess the extent to which performance exhibits persistence over time within the

country. Previous studies also include lagged dependent as an explanatory variable in their model specifications (Ogbuabor et al., 2023; Wang et al., 2023a).

3.7.3 Functional form of the EKC

Following Grossman and Krueger (1995), the functional form of the EKC hypothesis is stated as;

$CO2 = f(GDP, GDP^2)$, which can be extended by incorporating the moderating and control variables;

$CO2 = f(GDP, GDP^2, INQ, GDP*INQ, GDP^2*INQ, TOP, FDI, PGR, COV)$

Using the direct model, the equation for the calculation of the turning point is stated below;

$$CO2_{it} = \beta_o + \beta_1 GDP_{it} + \beta_2 GDP^2{}_{it} + \varepsilon\_it \text{……………………..…(5)}$$

The mechanical turning point would be;

$$\frac{\partial CO2}{\partial GDP}$$

For the moderated model, the turning point is conditional on institutional quality:

$$GDP^*(INQ) = -\frac{\beta_1 + \beta_4 INQ}{2(\beta_2 + \beta_5 INQ)} \quad \text{……………………………………(6)}$$

3.7.4 Research models for testing linear, quadratic, and cubic GDP specifications for robustness

These diagnostic tests are conducted to know whether the correct functional form is linear, quadratic, or cubic.

3.7.4.1 Linear specification model

$$CO2_{it} = \beta_o + \beta_1 GDP_{it} + \beta_2 TOP_{it} + \beta_3 PGR_{it} + \beta_4 FDI_{it} + \beta_5 COV_{it} + U_i + \lambda_t + \varepsilon\_it \text{………………………………………………………………………..……..(7)}$$

3.7.4.2 Quadratic specification model (EKC)

$$CO2_{it} = \beta_o + \beta_1 GDP_{it} + \beta_2 GDP^2{}_{it} + \beta_3 TOP_{it} + \beta_4 PGR_{it} + \beta_5 FDI_{it} + \beta_6 COV_{it} + U_i + \lambda_t + \varepsilon\_it \text{ ……………………………………………………………………...…….(8)}$$

3.7.4.3 Cubic specifications model

$$CO2_{it} = \beta_o + \beta_1 GDP_{it} + \beta_2 GDP^2{}_{it} + \beta_3 GDP^3{}_{it} + \beta_5 TOP_{it} + \beta_6 PGR_{it} + \beta_7 FDI_{it} + \beta_8 COV_{it} + U_i + \lambda_t + \varepsilon\_it \quad \text{..... (9)}$$

3.8 Data analysis

This section outlines the overall panel data framework employed to examine the relationship between the explanatory variable and environmental quality, moderated by institutional quality. The data analysis including robustness check that will be done in this study are as follows, (1) Serial correlation, (2) Multicollinearity, and (3) The generalized method of moment (GMM) estimator.

3.8.1 Serial correlation

The serial correlation test examines whether the residuals (errors) of a regression model are correlated across time or observations (Born, 2016). It is determine using the Wooldridge test for autocorrelation in panel data. Gujarati and Porter, (2009) conclude that when a p-value is less than 0.05 indicates the presence of serial correlation, but if the t-statistics are insignificant, that is, greater than 0.5, it suggests no autocorrelation. This diagnostic test is essential in this study because autocorrelation can bias standard errors and lead to misleading significance levels. Previous studies such as (Coad, 2007; Hong & Kao, 2000; Bond, 2002) have also addressed serial correlation in their research.

3.8.2 Multicollinearity

This test assesses whether the independent variables in a regression model are highly correlated with each other (Lindner et al., 2020). Variance Inflation Factors (VIF) is computed to ensure that the variables such as; economic growth, and institutional quality are not highly collinear. Gujarati and Porter (2009) suggests that when the VIF is less than 5, it shows low or no multicollinearity issues and the reliability of regression estimates, but if the VIF is greater or equal to 10 it indicates a high level of multicollinearity. Multicollinearity can distort coefficient estimates, especially when introducing interaction terms such as the moderating effect of institutional quality, ensuring these issues address the accuracy, reliability, and robustness of the empirical findings (Wang et al., 2023a).

3.8.3 Generalized Method of Moment (GMM) Estimators

This study adopts a quantitative research approach and applies panel data analysis of System Generalized Method of Moment (GMM) estimator to investigate the impact of economic growth on environmental quality, while examine the moderating role of institutional quality. The data of 946 observations is analyzed. Panel data analysis is well suited for this study due to its ability to control for unobserved heterogeneity, increase the efficiency of estimators, and capture dynamic relationships (Phillips & Moon, 2000). Such features are necessary in order to identify the effect of economic growth, and institutional quality, a policy change that impacts nation's ability to enhance the environment.

The Two-Step System Generalized Method of Moment (GMM) estimator is a suitable estimator in this research since it is able to handle panel data with potential endogeneity by considering the possible correlations between explanatory variables and the error terms (Ullah et al., 2018). It also integrate the lagged dependent variable as explanatory factor while accounting for unobserved heterogeneity, dynamic panel bias, country-specific effects, and time specific effects across panels (Ullah et al., 2018; Wooldridge, 2001), which is akin to the complexity of environmental policy and economic growth. To check for the existence of serial correlation in the dynamic panel data models, we used the Arellano Bond (AR) test for autocorrelation. While, the Hansen test of overidentifying restrictions will be used to test for the validity of the instruments.

Moreover, there is a potential endogeneity problem between economic growth, institutional quality, and environmental quality because environmental quality can influence economic growth and institutional quality, while economic growth and institutional quality can also influence environmental quality, resulting in reverse causality (Chakravarty & Mandal, 2020). To address this problem, the study used lagged values of the endogenous variables as internal instruments to obtain consistent and efficient estimates (Chakravarty & Mandal, 2020; Roodman, 2009).

In addition, in order to further assess the suitability of the system GMM estimator, we consider the Hansen test, Arellano Bond AR(1) and Arellano Bond AR(2) tests, the number of instruments, and the number of groups. If the Hansen test p-value > 0.05, the AR(1) p-value is < 0.05, the AR(2) p-value > 0.05, and the number of instruments is lower than the number of

groups, it indicates that the model is valid and that the system GMM estimator is the most appropriate method for this study (Wooldridge, 2001).

Furthermore, system GMM is appropriate when variables exhibit dynamic behavior and highly persistent over time, unlike difference GMM (Wooldridge, 2001). Since the variables in this study are dynamic and highly persistent, then system GMM estimator is therefore the most suitable method (Chakravarty & Mandal, 2020; Roodman, 2009). A variable is highly persistent over time if it can change slowly over time (Asongu et al., 2021; Ogbuabor et al., 2023). For example, CO2 emissions are highly persistent overtime due to the slow adjustment of energy systems and production structures. Previous studies such as (Asongu et al., 2021; Ogbuabor et al., 2023; Wang et al., 2023a) have used similar method in examining environmental quality in their research. Finally, this study employs the two-step system GMM because it provides more efficient and robust estimates by using an optimal weighting matrix, especial in dynamic panel models with potential endogeneity, while one-step system GMM uses a simpler weighting matrix, making it less efficient (Roodman, 2009).

3.8.3.1 Reasons for choosing two-step system GMM over Panel Linear Regression Model (random effect/ fixed effect)

This study choose the two-step system GMM over Panel Linear Regression Model (random effect/ fixed effect, because it effectively addresses endogeneity, and dynamic persistence by using lag values and internal instruments (Roodman, 2009). Whereas fixed and random effects models cannot adequately address reverse causality, and they are appropriate when there is no serious endogeneity problem (Bell et al., 2019). Additionally, GMM is used when a data set has short time dimension (T) and large cross-sectional dimension (N) (Roodman, 2009), unlike panel linear regression that is useful when the data structure and assumptions are relatively simple (Bell et al., 2019).

CHAPTER IV

RESULTS AND DISCUSSION

The primary objective of this research is to examine the impact of economic growth on environmental quality in Africa, and to also investigate how institutional quality moderates this relationship. In order to provide empirical answer to the research objective as outlined in Chapter 1, Chapter 2 shows a comprehensive review of relevant theories and previous studies that explain the relationship between economic growth and environmental quality, highlighting existing knowledge gaps, and justify the need for incorporating institutional quality as a moderating variable.

In addition, Chapter 3 provides a rigorous and comprehensive methodology designed to address the research problems by providing empirical evidence on the impact of economic growth on environmental quality in Africa, with institutional quality as a moderator. This methodological approach forms the analytical foundation for answering the research questions and achieving the study's objectives. Building on this foundation, Chapter 4 presents and discuss the empirical results derived from the specified GMM models. It provides a detailed analysis and interpretation of the findings in relation to the study objectives and existing literature, highlighting key patterns, statistical significance, and important policy insights. This investigation is essential for identifying the influence of economic growth in shaping the environment of Africa, and provide insights into how it can be optimized to better support the health of the environment. To achieve this objective, secondary data was collected from the World Development Indicator (WDI) website and analyzed. A total sample of 946 observations was collected from 2002 to 2023 from forty-three (43) Africa countries. This chapter ultimately links the empirical evidence to the research questions, thereby providing concrete answers and supports the overall study's conclusions.

4.1 Descriptive statistics

The results of the descriptive statistics presented in **Table 4.1** indicate substantial heterogeneity across the sampled African countries. CO2 emissions have a mean value of 1.473, suggesting that, on average, African countries exert a relatively low level of pressure on the environment, as the continent remains less industrialized, while GDP records a mean of 2635.93, reflecting considerable variability in economic growth across the sample. Furthermore, a variation is also observed in FDI (mean = 3.814), trade openness (mean =

67.155), and institutional quality (mean = 0.021), indicating differing levels of external integration and institutional development that may exert heterogeneous effects on environmental outcomes. These variations reflect the diverse levels of development, institutional capacity, resource endowments, and policy environments across Africa countries.

Table 4.1. Descriptive statistics results

Variable	Obs	Mean	Std. Dev.	Min	Max	Unit. M.
CO2	946	1.473	2.423	0.024	12.863	Metric tons per capita
GDP	946	2635.93	3149.75	250.879	19481.64	GDP per capita (C. US$)
FDI	946	3.814	5.499	-17.292	56.288	Net inflows % of GDP
TOP	946	67.155	32.181	2.474	222.178	Trade % of GDP
INQ	946	0.021	2.151	-1.714	2.135	VA, PS, RL, GE, RQ, CC
PGR	946	2.393	1.011	-2.629	8.645	Pop. growth rate annual %
COV	946	0.182	0.386	0	1	Binary indicator

Notes: Obs denotes number of observations, Std. Dev signifies standard deviation,
Min means Minimum, Max represents Maximum, Unit. M is Unit of measurement,
VA is voice and accountability, PS is political stability, RL is rule of law, GE is government effectiveness, RQ is regulatory quality, CC is corruption control, and C. US$ is constant US$

Table 4.2. Descriptive summary of income group, region, resource dependence, and emission profile in Africa

Characteristic	Category	No. of countries	Percentage (%)
Income group	Low income	19	44.2
	Lower-middle income	16	37.2
	Upper-middle income	8	18.6
Region	Eastern Africa	13	30.2
	Western Africa	14	32.6
	Central Africa	7	16.3
	Southern Africa	5	11.6
	Northern Africa	4	9.3
Resource dependence	Resource-rich economies	20	46.5
	Resource-moderate economies	11	25.6
	Resource-poor economies	12	27.9
CO2 emission profile	Low emitters (< 1 tCO2 per capita)	21	48.8
	Medium emitters (1-3 tCO2 per capita)	16	37.2
	High emitters (> 3 tCO2 per capita)	6	14.0

Source: Calculated from WDI

Table 4.2 presents the characteristics of the 43 African countries included in the study. Most countries are classified as low-income (44.2%) and lower-middle-income (37.2%) economies, reflecting the continent's relatively lower-middle level of economic development. Regionally, West Africa (32.6%) and East Africa (30.2%) account for the largest share of the sample, providing broad geographical representation. Nearly half of the countries (46.5%) are resource-rich, indicating the significance role of natural resource extraction in their economies.

Regarding environmental performance, 48.8% of the countries are low CO2 emitters, while only 14.0% are high emitters, suggesting substantial variation in emission levels across the sample.

4.2 Correlation matrix and VIF

The correlation results presented in **Table 4.3** demonstrate the relationships and directions among the variables. CO2 emission is positively correlation with GDP (r=0.014); FDI (r=0.105); TOP (r=0.550); and INQ (r=0.295). In contrast, CO2 emission is negatively correlated with PGR (r= -0.349); and COV (r= -0.012). Relatively, a strong correlation is found to exist between GDP, FDI, TOP, and INQ. Similarly, notable correlation is identified among FDI, TOP, INQ, and PGR. While a comparatively strong correlation is also evident between TOP and INQ. No coefficient exceeds the 0.80 multicollinearity cut-off value, with Gujarati and Porter (2009) suggesting that when a correlation is < 0.80 it lacks the problem of multicollinearity. This study also apply variance inflation factor (VIF) values to evaluate the potential for multicollinearity, the VIF outputs in **Table 4.4** show a variation result between 1.02 and 1.42 among the variables, well below the critical value of 10, reaffirming the lack of multicollinearity issues. Gujarati and Porter (2009) also conclude that a VIF is present when the value of the variables is higher than 10. But in this situation, the results are unlikely to suffer from multicollinearity problems.

Table 4.3. Correlation matrix results

Variables	CO2	GDP	FDI	TOP	INQ	PGR	COV
CO2	1.000						
GDP	0.014	1.000					
FDI	0.105***	0.079**	1.000				
TOP	0.550***	0.066**	0.409***	1.000			
INQ	0.295***	0.112***	0.092***	0.369***	1.000		
PGR	-0.349***	-0.027	0.085***	-0.227***	-0.410***	1.000	
COV	-0.012	-0.102***	-0.048	-0.016	-0.011	-0.084***	1.000

Notes: The notation of ***, **, and * denotes significance at 1%, 5%, and 10% respectively.

Table 4.4. Variance Inflation Factor (VIF) results

Variables	VIF
CO2	-
GDP	1.03
FDI	1.26
TOP	1.42
INQ	1.27
PGR	1.23
COV	1.02

4.3 Principal Component Analysis

To generate a unified measure of institutional quality, this study utilized principal component analysis (PCA) to construct a composite institutional quality index by combining six governance indicators; rule of law, government effectiveness, political stability and absence of violence, control of corruption, voice and accountability, and regulatory quality. **Table 4.5** shows that the first principal component has the largest eigenvalue, indicating that it accounts

for the greatest proportion of the total variation and serves as the most informative summary of the remaining components.

Table 4.5. Principal Component Analysis for Governance Indicators

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp 1	3.92576	2.5812	0.6543	0.6543
Comp 2	1.34456	0.995081	0.2241	0.8784
Comp 3	0.349478	0.192014	0.0582	0.9366
Comp 4	0.157464	0.0296059	0.0262	0.9629
Comp 5	0.127858	0.0329786	0.0213	0.9842
Comp 6	0.0948793	.	0.0158	1.000

Source(s): Author's computation from data from WDI (2002-2023)

Table 4.6 reports the eigen vectors and the proportion of variance associated with each institutional quality indicator, confirming that the first component provides the strongest representation of the underlying variation.

Table 4.6. Principal Component Analysis (PCA) Eigen Vectors

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
POS	-0.0201	0.8461	0.0337	0.1606	0.4628	0.2064	0
ROL	0.3954	0.4795	-0.0802	-0.0020	-0.7208	-0.2962	0
REQ	0.4755	-0.0027	-0.1511	-0.6573	0.4287	-0.3677	0
GOE	0.4712	-0.1049	-0.3982	-0.0551	-0.0847	0.7735	0
COC	0.4609	-0.1931	-0.1844	0.7342	0.2742	-0.3196	0
VAA	0.4274	-0.0769	0.8815	0.0097	0.0094	0.1847	0

Note: pols is political stability and absence of violence, rq is regulatory quality, rol is rule of law, vac is voice and accountability, geff is government effectiveness, and corr is control of corruption. Source(s): Author's computation from data from WDI (2002-2023)

Table 4.7 present the selection of the component, as indicated, regulatory quality, governance effectiveness, and control of corruption exhibit the smallest unexplained variances, suggesting that these indicators contain the most relevant information in capturing institutional quality across African countries. Nevertheless, the contribution of other components was also incorporated into the analysis to ensure a more comprehensive assessment of the relationship between institutional quality and environmental quality.

Table 4.7. Principal Component Analysis (PCA) Selected Components

Variable	Comp1	Unexplained
POS	-0.0201	0.9984
ROL	0.3954	0.3862
REQ	0.4755	0.1123
GOE	0.4712	0.1284
COC	0.4609	0.1662
VAA	0.4274	0.2828

Note: pols is political stability and absence of violence, rq is regulatory quality, rol is rule of law, vac is voice and accountability, geff is government effectiveness, and corr is control of corruption. Source(s): Author's computation from data from WDI (2002-2023)

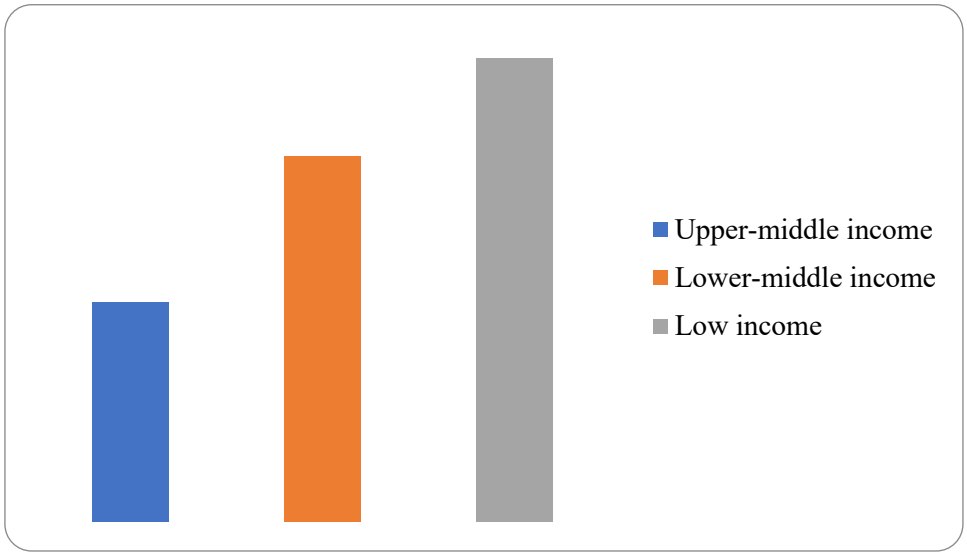
Table 4.8. Results of linear, quadratic, and cubic robustness testing without covid-19

Linear specification			Quadratic specification			Cubic specification		
CO2	Coef.	Sig	CO2	Coef	Sig	CO2	Coef	Sig
GDP	0.519	***				GDP	0.943	**
			GDP	0.809	***	GDP^2	0.00005	**
			GDP^2	-0.00004	**	GDP^3	0.000003	***
FDI	0.007	*	FDI	0.003		FDI	0.001	
TOP	-0.004	**	TOP	-0.005	*	TOP	-0.002	*
PGR	0.102		PGR	0.014		PGR	0.087	
Constant	1.663	***	Constant	1.671	***	Constant	1.693	**
R-square	0.073		R-square	0.077		R-square	0.079	

Note: Coef is coefficient, ** denotes significance at 5%, and *** denotes significance at 1%

Table 4.8 presents the robustness results for the linear, quadratic, and cubic GDP specification estimation of model 7, 8, and 9 without covid-19 variable. The linear specification indicates that economic growth has a positive and significant effect on CO2 emissions. The quadratic specification shows a negative and significant GDP^2 coefficient, suggesting the presence of a nonlinear relationship between economic growth and CO2 emissions. The cubic specification further reveals a positive and significant GDP^3 coefficient, indicating an N-shaped relationship. Additionally, the gradual increase in the R-squared values suggests a modest improvement in explanatory power as higher-order GDP terms are included. These findings confirm that the relationship between economic growth and CO2 emissions is better captured by nonlinear specifications than by a simple linear model.

Figure 4.1. A graph showing the level of development among Africa countries according to their income group



Source: Calculated from World Development Indicators

The graph of Figure 4.1 shows clear disparities in the level of development among African countries. Most countries fall within the low-income and lower-middle-income categories, indicating relatively low levels of economic development, while only a few countries are classified as upper-middle-income. This distribution highlights the uneven pattern of economic progress across the continent and suggests the need for strong policies to promote sustainable growth, industrialization, and income convergence in lower-income economies.

4.4 Results of the direct effects

The results of the direct effects in model (1) in **Table 4.9** examines the impact of economic growth on environmental quality in Africa.

The results show that economic growth (GDP) has a positive and statistically significant impact on CO2 emission (Coef= 0.973, $p < 0.000$), suggesting that a one unit increase in economic growth (GDP) is associated with 973 kg increase in CO2 emission in Africa, while economic growth (GDP^2) exhibits a negative and significant impact on CO2 emission (Coef= -0.00005, $p < 0.000$), such that a one unit increase in GDP^2 is associated with 0.005 kg decrease in CO2 emission, indicating the presence of an inverted U-shaped Environmental Kuznets Curve (EKC). This suggests that, at early stages of development,

economic growth in Africa is associated with environmental deterioration, driven by scale effects, reliance on fossil fuel, dependence pressure, and weak regulatory frameworks. However, as income rises, the negative coefficient of GDP^2 indicates that further growth eventually reduces CO2 emissions in Africa and increase environmental quality, reflecting structural shifts toward services, cleaner technologies, improved energy efficiency, and stronger institutional and regulatory capacities. This finding is consistent with the EKC literature, including (Saud et al., 2019), who find a non-linear relationship between economic growth and environmental quality, as well as (Shokoohi et al., 2022; Dinda et al., 2000), who also document non-linear economic growth and environment quality relationships in their studies. In the Africa context, the EKC finding suggests a transitional process in which growth initially intensifies environmental stress but also creates the fiscal space and technological incentives necessary for environmental improvement. Nevertheless, the turning point is not automatic, it depends critically on complementary investments in institutions, energy systems, and environmental governance.

Institutional quality (INQ) is also found to have a negative and significant impact on CO2 emissions (Coef= -0.064, $p < 0.018$), indicating that a one unit increase in institutional quality is associated with 64 kg decrease in CO2 emission in Africa countries, suggesting that strong institutions can enhance the enforcement of environmental regulations, promote sustainable resource management, and discourage pollution intensive activities. This result is consistent with the findings of Jahanger et al. (2022), who reported that stronger institutional quality significantly mitigates CO2 emissions by improving environmental governance and policy implementation. Similarly, Ali et al. (2019) demonstrates that effective institutions contribute to environmental sustainability by strengthening regulatory enforcement, enhancing accountability, and facilitating the adoption of cleaner production practices.

Moreover, in relation to the control variables of the direct effects in **Table 4.9** below, the results show that trade openness (TOP) is also found to have a positive and significant impact on CO2 emissions (Coef= 0.021, $p < 0.015$), indicating that a one unit increase in trade openness is associated with 21 kg increase in CO2 emission in Africa countries, suggesting that the more African countries are integrated into the global markets, the more they are subjected to environmental deterioration, leading to decrease in the environmental quality in the continent. This effect reflects a dominance of scale and composition effects over technique effects, where expanding export-oriented production often concentrated in primary commodities, agro-processing, and low value manufacturing raises energy consumption and

emissions. This result is in line with Le et al (2016), who argue that trade openness can worsen environmental quality when regulatory capacity is weak. Similarly, Aqin, (2017) finds that trade openness increases CO2 emissions in China. However, the finding does not imply that trade is inherently harmful, rather, it signals that Africa's current trade structure remains environmentally biased.

Foreign direct investment (FDI) inflows display a positive and statistically significant impact on CO2 emissions (Coef= 0.024, $p < 0.090$), suggesting that there is insufficient evidence to conclude that FDI affects CO2 emissions in Africa. This result is in accordance with the findings of (Salahuddin et al., 2019), who reported that FDI inflows increase CO2 emissions in Qatar and decreases environmental quality. Similarly, Tsoy & Heshmati (2024) show that FDI inflows have negative and insignificant impact on environmental sustainability, which intensifies environmental pressure where regulatory frameworks are weak. The result suggests that to transform FDI into a tool for environmental quality, African countries must strengthen environmental standards, promote green investment incentives, and channel foreign capital toward renewable energy, clean manufacturing, and climate resilient infrastructure.

COVID-19 has a negative and significant effect on CO2 emissions (Coef= -0.348, $p < 0.007$) in Africa, indicating that a one unit increase in covid-19 pandemic is associated with 348 kg decrease in CO2 emission in the continent, confirming that pandemic related restrictions, economic slowdowns, and mobility limitations increases environmental quality during that period across Africa countries. This mirror global evidence by (Chuan et al., 2022; Shah, 2021), who demonstrate that sharp emission declines during lockdown periods.

Population growth (PGR) is found to have positive and insignificant impact on CO2 emissions (Coef= 0.537, $p < 0.426$), suggesting that there is insufficient evidence to conclude that population growth affects CO2 emissions in Africa. This finding is consistent with the results of (Dimnwobi et al., 2021; Rahman, 2020), who note that population growth can increase CO2 emission, and it depends heavily on income and technology. In the Africa context, this finding highlights a development paradox; high emissions are partly driven by transportation and land-use rather than by green transformation.

4.4.1 Diagnostics test results of the direct effects

The diagnostic tests results of the direct effects in model (1) in **Table 4.9** of the impact of economic growth on environmental quality in Africa, confirm the validity of the model and the use of two-step system GMM estimator. The Hansen tests ($p = 0.573$), supporting that the

choice of instruments used are valid and not identified. Furthermore, the number of instruments (18) is lower than the number of groups (43), suggesting that the model is not affected by instrument proliferation. The Arellano-Bond tests for serial correlation show that AR(1)= 0.034 is significant at 5%, while AR(2) = 0.385 is insignificant. The absence of Second-order serial correlation confirms the validity of the moment conditions and supports the consistency of the estimated coefficients. In addition, the overall significance of the regressors (p-value = 0.000), together with the inclusion of country-specific and time effects, demonstrates that the estimated model adequately captures both structural heterogeneity and time-specific shocks across African countries.

Moreover, lagged values of 2 and 3, together with internal instruments for the endogenous variables, such as economic growth, environmental quality, and trade openness, as well as instrument collapsing, were effectively employed to address endogeneity problems arising from reverse causality in the direct effect results in **Table 4.9,** and the moderating effects results in **Table 4.10,** thereby ensuring consistent and efficient estimates, these lags were selected due to the dynamic and high persistent of the variables (Brambor et al. 2006; Chakravarty & Mandal, 2020; Roodman, 2009) . In addition, during the GMM estimation presented in Table 4.9 and 4.10, 45 observations were lost due to the lagging process, resulting in 901 observations, although, the dataset originally comprised 946 observations. Against this background, the results provide robust empirical evidence and offer meaning insights into the relationship between economic growth and environmental quality in Africa.

Table 4.10. Two-step system GMM results of the impact of economic growth on environmental quality

CO2	Coef.	t-value	p-value	Sig
L.CO2	0.753	21.01	0.000	***
GDP	0.973	5.85	0.000	***
GDP^2	-0.00005	-11.23	0.000	***
INQ	-0.064	-2.38	0.018	**
FDI	0.024	1.71	0.090	*
TOP	0.021	2.46	0.015	**
PGR	0.537	0.84	0.426	
COV	-0.348	-2.68	0.007	***
Constant	-5.631	-3.62	0.000	***
Diagnostics				
Observation	901			
Hansen	0.573			
AR (1)	0.034**			
AR (2)	0.385			
No of instruments	18			
No of groups	43			
Country effect	Yes			
Year effect	Yes			
P-value	0.000			

Notes: This table display the results of the two-step system GMM analysis between economic growth and environmental quality. The notation of ***, **, and * denotes significance at 1%, 5%, and 10% respectively.

4.5 Results of the moderating effects

The results of the moderating effect of model (2) in **Table 4.10** below examines how institutional quality moderates the relationship between economic growth and environmental quality in Africa.

The results of the interaction term between institutional quality and economic growth (INQ * GDP) exhibits a positive and significant effect (Coef= 0.2245, $p < 0.000$) on CO2 emissions, indicating that a one unit increase in the interaction between institutional quality and economic growth (GDP) is associated with 2245 kg increase in CO2 emissions, while the interactions between institutional quality and the squared term of economic growth (INQ * GDP^2) shows a negative and significant effect (Coef= -0.000000025, $p < 0.000$) on CO2 emissions, indicating that a one unit increase in the interaction between institutional quality and economic growth square is associated with a 0.000025 kg decrease in CO2 emissions in

Africa. These findings suggest that at lower income levels, improvements in institutional quality amplify the emission increasing effect of economic growth. This outcome suggests that when African institutions become more effective by improving regulatory capacity, investment security, and macroeconomic governance, they initially facilitate economic growth, and infrastructure development, which in turn raise energy demand and carbon emissions. In many African countries, early institutional reforms often prioritize economic stabilization, and capital attraction rather than environmental enforcement. Moreover, the negative GDP^2 demonstrates that strong institutions accelerate the downward segment of the EKC. This means that while institutional quality initially magnifies growth induced emissions, it eventually facilitates the transaction toward cleaner production, improved regulation, and technological upgrading as income rises. In essence, institutional quality strengthens the ability of African countries to decouple growth from emissions. These findings resonate with Tinta (2022), who reports that institutional improvements may initially intensify CO2 emissions by stimulating investment. Similarly, Usenobong (2023) finds that institutional quality can reduce environmental quality when environmental governance remains secondary.

Moreover, the results of Model (2) in **Table 4.10** show that the direct effect variables, namely GDP and GDP^2, and the moderating variable, INQ, are consistent with the findings of Model (1) in **Table 4.9.**

Furthermore, the results of the moderating effects in model (2) in **Table 4.10** for the control variables, shows that trade openness (TOP) has a positive and significant impact on CO2 emissions (Coef= 0.048, $p < 0.051$), suggesting that a one unit increase in trade openness is associated with 48 kg increase in CO2 emission in Africa countries, indicating that trade openness amplifies environmental degradation in African countries This outcome suggests that when trade in African become more effective by improving regulatory capacity, investment security, and macroeconomic governance, they initially facilitate economic growth, infrastructure development, and industrial activity, which in turn raise energy demand and carbon emissions. In many African countries like Rwanda, South Africa, Seychelles, Botswana, and Tunisia, early trade reforms often prioritize economic stabilization, and capital attraction rather than environmental enforcement. This result is in line with Le et al (2016) and Aqin, (2017).

Foreign direct investment has a positive and insignificant impact on CO2 emissions (Coef= 0.036, $p < 0.231$), suggesting that there is insufficient evidence to conclude that FDI

affects CO2 emissions in Africa. This result supports the findings of Jinapor et al (2024), who argue that the effect of FDI on the environment is highly dependent on the institutions of the country, and that strong regulations can mitigate the adverse effect of FDI on environment quality. Similarly, Magbondé & Konté (2022) show that governance quality can reduce the marginal effects of FDI inflows.

Population growth demonstrates positive and insignificant impact on CO2 emissions (Coef= 0.175, $p < 0.312$), indicating that there is insufficient evidence to conclude that population growth affects CO2 emissions in Africa. This finding is consistent with the results of (Dimnwobi et al., 2021; Rahman, 2020), who note that population growth can increase CO2 emission.

Covid-19 displays negative and significant effect on CO2 emissions (Coef= -0.674, $p < 0.000$) in Africa, demonstrating that a one unit increase in covid-19 is associated with 674 kg decrease in CO2 emission among Africa countries. The results align with the finding of (Chuan et al., 2022; Shah, 2021), who demonstrate that emission declines during lockdown periods. The results of these control variables are consistent with the findings of the results of the control variables in **Table 4.9.**

4.5.1 Diagnostics test results of the moderating effects

The diagnostic tests results of the moderating effects in model (2) in **Table 4.10** of the moderating role of institutional quality between economic growth and environmental quality in Africa, indicate the validity of the model and the use of two-step system GMM estimator. The Hansen tests ($p = 0.439$), supporting that the choice of instruments used are valid and not identified. Furthermore, the number of instruments (16) is lower than the number of groups (43), suggesting that the model is not affected by instrument proliferation. The Arellano-Bond tests for serial correlation show that AR(1)= 0.021 is significant at 5%, while AR(2) = 0.295 is insignificant. The absence of Second-order serial correlation confirms the validity of the moment conditions and supports the consistency of the estimated coefficients. In addition, the overall significance of the regressors (p-value = 0.000), together with the inclusion of country-specific and time effects, demonstrates that the estimated model adequately captures both structural heterogeneity and time-specific shocks across African countries. Against this background, the results provide robust empirical evidence and offer meaning insights into how institutional quality moderates the relationship between economic growth and environmental

quality in Africa.

Table 4.10. Two-step system GMM results of the moderating role of institutional quality between economic growth and environmental quality

CO2	Coef.	t-value	p-value	Sig
L.CO2	0.817	13.14	0.000	***
GDP	1.082	7.58	0.000	***
GDP^2	-0.000050	-4.11	0.000	***
INQ	-0.061	-1.87	0.063	*
INQ * GDP	0.2245	4.33	0.000	***
INQ * GDP^2	-0.000000025	-3.59	0.000	***
FDI	0.036	1.36	0.231	
TOP	0.048	1.92	0.051	*
PGR	0.175	1.31	0.312	
COV	-0.674	-5.15	0.000	***
Constant	-7.863	-1.76	0.085	*
Diagnostics				
Observation	901			
Hansen	0.439			
AR (1)	0.021**			
AR (2)	0.295			
No of instruments	16			
No of groups	43			
Country effect	Yes			
Year effect	Yes			
P-value	0.000			

Notes: This table display the results of the two-step system GMM analysis between economic growth and environmental quality, moderated by institutional quality. The notation of ***, **, and * denotes significance at 1%, 5%, and 10% respectively.

4.6 Calculation of the turning points

4.6.1 Direct model coefficients

Using the direct model coefficients, the mechanical turning point is USD$ 9,730. Therefore, the estimated EKC turning point suggests that African countries reach the income threshold at approximately USD 9,730 (constant 2015 US$ per capita), beyond which further economic growth is associated with declining CO2 emissions. This finding indicates that environmental quality improves only after certain countries attain this level of economic development, providing empirical support for the inverted U-shaped EKC hypothesis.

Table 4.11. The moderation effect of the marginal effect of GDP on CO2 emission across income levels

GDP (Constant 2015 US$)	Institutional Quality	Marginal Effect
500	-2	0.5831
500	-1	0.8075
500	0	1.0320
500	1	1.2565
500	2	1.4810
3000	-2	0.3333
3000	-1	0.5577
3000	0	0.7820
3000	1	1.0064
3000	2	1.2307
6000	-2	0.0336
6000	-1	0.2578
6000	0	0.4820
6000	1	0.7062
6000	2	0.9304
9000	-2	-0.2661
9000	-1	-0.0421
9000	0	0.1820
9000	1	0.4065
9000	2	0.6301
12000	-2	-0.5658
12000	-1	-0.3419
12000	0	-0.1180
12000	1	0.1059
12000	2	0.3298

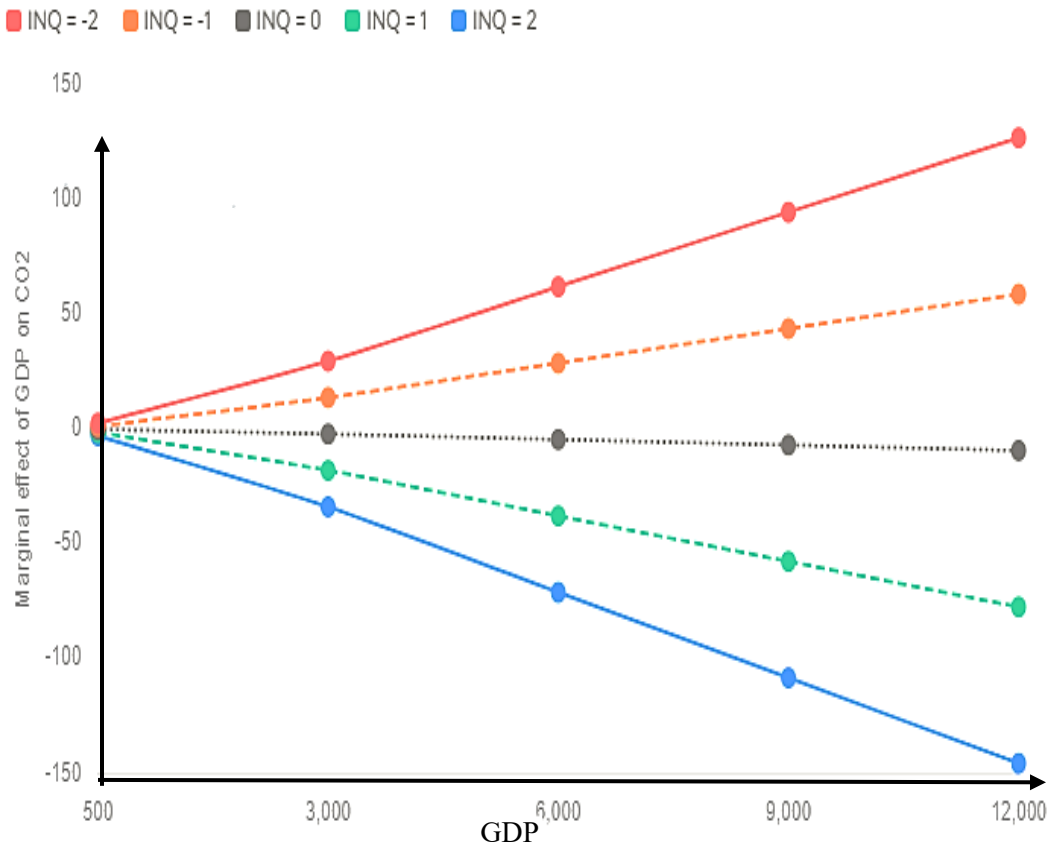
The results in Table 4.11 indicate that the marginal effect of economic growth on CO2 emissions varies significantly across different levels of institutional quality. At low institutional quality (INQ = -2 and -1), economic growth has a positive and increasing effect on CO2 emissions as GDP per capita rises, whereas at average and high institutional quality (INQ = 0, 1, and 2), the marginal effect becomes increasing negative, suggesting that strong institutions mitigate and eventually reverse the environmental impact of economic growth.

Table 4.12. Conditional turning points at representative institutional quality values.

Institutional quality	Conditional turning points (GDP constant 2015 USD$)
-2 (weak)	6,336.34
-1	8,579.29
0 (average)	10,820.00
+1	13,058.47
+2 (strong)	15,294.71

The results of the the conditional turning point in Table 4.12 shows that the EKC threshold increases progressively with improvements in institutional quality. The GDP per capita turning point rises from USD$ 6,336.34 under weak institutional quality (INQ = -2) to USD$ 15,294.71 under strong institutional quality (INQ= +2), suggesting that institutional quality significantly influences the income level at which economic growth begins to reduce CO2 emissions. This finding implies that, in African countries, strong instituions shift the environmental transition to higher levels of economic development, highlighting the important moderating role of institutional quality in the economic growth-CO2 emissions nexus.

Figure 4.2 A graph showing an interaction plot of marginal effect of GDP on CO2 emissions



Source: Calculated from WDI

The chart in Figure 4.2 shows how the marginal effect of GDP per capita on CO2 emissions varies across different levels of institutional quality (INQ). The results indicate that the effect of GDP on CO2 emissions is conditional quality, demonstrating a significant moderating effect. The figure provides evidence that institutional quality moderates the relationship between economic growth and environmental quality in Africa. Specifically, strong institutions weaken and eventually reverse the positive impact of economic growth on CO2 emissions, supporting the view that improving governance structure can help achieve sustainable economic growth while reducing CO2 emission.

4.7 Discussion of Results

In this discussion section, the study provides a detail explanation of the empirical findings that were discussed in the previous sections. The study discusses the estimated results

by highlighting notable patterns that may explain the observed variations across the outputs in Africa countries. The analysis is anchored in the research questions and research objectives as mentioned earlier in chapter one, thereby facilitating the development of well-grounded conclusions, policy implications, and recommendations.

4.7.1 Discussion of the direct effects results

The results of the direct effect in Model (1) of the impact of economic growth on environmental quality, show that economic growth (GDP) has a positive and significant effect on CO_2 emissions. This is in line with the economic structure of many African economies, where economic growth is centered on resource-based industries such as mining, agriculture and low-end manufacturing industries which use fossil fuel-based energy and relatively outdated technologies. Consequently, higher production translates into greater energy and carbon consumption and therefore a greater environmental burden (Shokoohi et al., 2022). Furthermore, the lack of effective regulation and enforcement of environmental policies in some African countries intensifies this relationship, as environmental protection is frequently sideline in favor of economic growth (Kahia & Omri, 2021). In addition of the economic growth (GDP^2) show a significant aspect to the analysis, as it has a negative and significant coefficient on CO_2 emissions. For Africa, this suggests that while the initial phase of economic growth may be environmentally deleterious, the latter stage may see environmental improvement as economies reach a certain income level and adopt more eco-efficient technologies (Dinda et al., 2000). This shift can be explained by a range of factors, such as growing environmental consciousness, institutional strengthening and sustainable infrastructure investments. The validation of the EKC hypothesis in this research signifies the dynamic relationship between economic growth and environmental degradation in African countries. This finding is consistent with the EKC literature, including (Saud et al., 2019), who demonstrate a non-linear relationship between economic growth and environmental quality.

Moreover, the findings also show that institutional quality has a negative and significant effect on CO_2 emissions, implying that African countries such as Seychelles, Rwanda, Morocco, South Africa, and Mauritius with stronger institutions are better positioned to formulate compliance with sustainability standards, and curb environmental harmful activities, thereby reducing CO2 emissions. This result is consistent with the new institutional economics theory, which posits that well-functioning institutions establish the formal rules,

regulatory frameworks, and enforcement mechanisms that shape the behaviors of governments, firms, and individuals toward socially desirable outcomes. From this perspective, high institutional quality strengthens accountability, reduces regulatory inefficiencies and corruption, and encourages adherence to environmental policies, ultimately contributing to improved environmental performance. The finding is supported by previous empirical evidence. For instance, Mavragani et al. (2016) finds that institutional quality significantly reduces CO2 emissions by enhancing environmental performance and policy effectiveness. In addition, Ahmed et al. (2020) demonstrate that effective institutions improve environmental quality by reinforcing regulatory compliance, fostering sustainable development, and facilitating the transition to cleaner production technologies. These findings collectively suggest that strengthening institutional quality is an essential policy instrument for mitigating CO2 emissions and advancing sustainable environmental outcomes in Africa countries.

Therefore, **H1:** Economic growth increases CO2 emissions in the short-run but may decrease it in the long-run after reaching a certain income threshold, and **H2:** Institutional quality decreases CO2 emissions are supported. This outcome underscores the presence of a nonlinear relationship between economic growth and environmental quality, consistent with the Environmental Kuznets Curve (EKC) hypothesis, and support of the New Institutional Economics Theory (NIE).

Environmental Kuznets Curve hypothesis suggests a non-linear relationship between economic growth and environmental quality. This theory posits that, in the early stages of economic development, economic growth leads to increase in environmental degradation because of industrialization, energy use and poor environmental governance (Bibi & Jamil, 2021). But as income continues to grow, economies of Africa countries are more likely to embrace environmentally friendly technologies, strengthen environmental quality and transition to less polluting industries. The inverted U-shaped pattern between economic growth and CO_2 emissions in Africa supports this view, implying that Africa is moving through various stages of environmental and economic growth (Dogan & Inglesi-Lotz, 2020). This demonstrates that the long-term environmental gains depend on continued growth under the condition of efficient regulations and technological improvements.

4.7.2 Discussion of the moderating effects results

The interaction effects between institutional quality and economic growth in Model (2) reveal a more complex effect on the environment. The findings indicate that the interaction effect of institutional quality and economic growth (GDP) has a positive and significant impact on CO2 emission, suggesting that the environmental benefits of strong institutions diminish as economic activity expands. In other words, although institutional quality independently reduces CO2 emissions, its interaction with GDP indicates that higher levels of economic growth are associated with increased emissions, implying that rapid economic expansion may outweigh the capacity of institutions to effectively mitigate environmental degradation. This finding may reflect the continued reliance of many African economies on energy intensive production processes, fossil fuels, and natural resource exploitation during period of growth. Moreover, Jinapor et al. (2024) emphasize that institutional quality plays a central role in the emergency of the declining phase of the EKC. Likewise, the finding supports the evidence of (Xu, Jilenga, & Deng, 2019), who report that the interaction between institutional factors and economic expansion may increase CO2 emissions in developing economies where environmental regulations are not sufficiently stringent to counterbalance the environmental costs of rapid growth.

On the other hand, the interaction term of institutional quality and GDP^2 has a negative and significant effect on CO_2 emissions. This finding suggests that strong institutions enhance the ability of economic development to reduce CO2 emissions at higher income levels. In other words, improvements in institutional quality reinforce the environmental benefits associated with advanced stages of economic growth by ensuring that rising income is accompanied by effective environmental governance, strict regulatory enforcement, and great investment in cleaner technologies. This finding implies that institutional quality acts as a complementary factor that enables African economies to achieve more sustainable growth rather than allowing economic expansion to intensify environmental degradation. Quality institutions strengthen the effectiveness of environmental policies and improve environmental outcomes as economies develop (Chinonye et al., 2022). Moreover, institutional quality moderates the relationship between economic growth and environmental degradation by fostering regulatory compliance, promoting technological innovation, and encouraging the transition toward sustainable production and consumption (Zhang et al., 2025). These findings underscore that institutional quality is a critical mechanism through which economic progress can be translated into lower carbon emissions.

Thus, **H3:** Institutional quality significantly moderates the interaction effects between economic growth and CO2 emission is supported. This outcome underscores that the effect of economic growth on environmental quality is conditional on the level of institution, as countries with good governance are expected to adopt more stringent institutions strategies in response to the increased in industrial waste, and environmental degradation, driven by the risk aversion and control motivations of poor institutions.

The New Institutional Economics Theory (NIE) argues that institutions shape economic outcomes by defining the formal and informal rules governing economic activities (Chinonye et al., 2022. According to the theory, effective institutions reduce transaction costs, enforce environmental regulations, protect property rights, and create incentives for innovation and efficient resource allocation (Tinta, 2022). Consequently, while improved institutions may initially facilitate faster economic expansion that increases emissions, they eventually enable economies to adopt cleaner technologies, enforce stricter environmental standards, and promote sustainable development, leading to lower CO2 emissions as income levels continue to rise. This demonstrates that the environmental impact of economic growth depends not only on the pace of growth but also on the quality and effectiveness of the institutional framework within which that growth occurs.

CHAPTER V

CONCLUSION AND POLICY RECOMMENDATIONS

This chapter presents the summary, implications, policy recommendations, limitations, and directions for future research. It offers conclusions based on the findings of the empirical analysis and presents policy recommendations. It also highlights the limitations that were faced during the study, and thus provides directions for future studies.

5.1 Summary

This thesis explores the impact of economic growth on environmental quality, and addresses the moderating role of institutional quality in this relationship for African countries over the period 2002 to 2023. The aims of this study were; to examine the impact of economic growth on environment quality, to investigate the impact of institutional quality on environmental quality, and to examine the role of institutional quality in moderating the relationship between economic growth and environmental quality in Africa.

Chapter one of this study provided background of issues surrounding economic growth's potential to improve environmental quality with the framework of EKC hypothesis. The challenges surrounding on improving environmental quality is still pertinent to many African countries despite poor economic growth among these countries. The problem statement highlighted the importance of institutional quality in strengthening the capacity of economic growth in enhancing environmental quality, as emphasized in previous studies. Furthermore, the significance of the study was outlined. The primary objective of this study is to contribute to the existing studies by providing a comprehensive empirical analysis of the moderating role of institutional quality in the relationship between economic growth and environmental quality in Africa. Africa was chosen due to its widespread of air and water pollution, deforestation, land degradation, economic activities, limited environmental policy, and the availability of data for all variables in the study.

Chapter two of this study began with an overview of the theoretical frameworks underpinning this study, name the EKC Hypothesis, and the New Institutional Economics Theory (NIE). These theories provided the foundation for the study's analytical model. Subsequently, an empirical review of the literature on the relationship among economic growth, environmental quality, and institutional quality was conducted. The review revealed diverse findings across different periods, contexts, locations, and dimensions, which facilitated

the identification of the research gap and reinforced the study's contribution to the existing body of knowledge. Finally, the chapter presented the conceptual framework, highlighting the dynamic interactions among the study variables through a diagram.

In chapter three, the study presents the research methods. It begins by outlining the research type and research approach adopted in the study. Moreover, the chapter describes the data, their sources, and the study variables, including the dependent, explanatory, moderating, and control variables. Furthermore, it provides a detailed explanation of the analytical techniques employed to examine the impact of economic growth on environmental quality within econometric framework and to assess correlation of the variables. Thereafter, this was followed by the used of two-step system GMM estimator as a dynamic panel data estimation technique, highlighting its importance in addressing various endogeneity issues commonly associated with panel data analysis.

Chapter four of this study presents the empirical findings of the study, including the two-step system GMM estimator results and other diagnostics tests such as correlation, linear, quadratic, and cubic. The analysis began with descriptive statistics, including the mean, median, minimum, maximum, standard deviation, and observations, to provide an overview of the characteristics of the data. This was followed by correlation matrix tests, which revealed that the variables lack the issues of multicollinearity. Subsequently, the VIF tests was also conducted to determine the existence of multicollinearity among the variables, and the results affirm that the variables are unlikely to suffer from multicollinearity problems. Thereafter, the study calculates the mechanical turning point of GDP on CO2 emission, and the conditional turning point of institutional quality variables as well. Moreover, the Two-Step System Generalized Method of Moment Estimator (GMM) was employed to investigate the impact of economic growth on environmental quality in Africa, while accounting for the moderating role of institutional quality. Moreover, in order to address endogeneity problems arising from reverse causality, the study used lagged 2 and 3 values, and internal instruments of the endogenous variables, such as economic growth, environmental quality, and trade openness, these lags were used due to the high persistent of the variables. The findings revealed a non-linear relationship between economic growth and environmental quality, consistent with the inverted U-shaped curve proposed by the EKC Hypothesis. Furthermore, institutional quality was found to be significant. While, the interaction terms between economic growth and institutional quality were found to be statistically significant. However, the control variables,

such as FDI, and population growth exhibits a positive an insignificant effect on CO2 emissions, while covid-19 displays a negative and significant impact on CO2 emissions in Africa. Moreover, TOP displays a positive and significant impact on CO2 emissions.

Subsequently, the study provided an analysis of the results and a comprehensive discussion of the empirical findings, covering both the direct and moderating effects of the variables. The findings indicate that economic growth (GDP) is positively related to CO2 emissions, suggesting that Africa's current development and globalization pathways intensify environmental degradation. However, the negative and significant coefficient on economic growth (GDP^2) confirms the EKC hypothesis, indicating that beyond a certain income threshold, further economic growth increases environmental quality. Moreover, the study also found that institutional quality has a negative and significant impact on CO2 emissions, suggesting that strong institution has the tendency to mitigate CO2 emissions in Africa. Furthermore, the results of the interaction term between institutional quality and economic growth indicate a positive and significant effect of economic growth (GDP) on CO2 emissions, while the interactions between institutional quality and economic growth (GDP^2) show a negative and significant effect on CO2 emissions, suggesting that strong institutions moderate these effects by reducing the environmental impact of economic growth.

Lastly, this thesis advances the literature in several ways. First, while prior studies have largely examined the effects of economic growth on environmental quality using different sample size and study locations (Abbas et al., 2025; Cialani, 2007; Hao et al., 2020; Le et al., 2016; Salahuddin et al., 2019), this study examines the impact of this macroeconomic driver on environmental quality in Africa, and extend the existing literature by providing empirical evidence supporting the EKC hypothesis in the presence of institutional quality. Second, this study advances the literature by focusing on the moderating role of institutional quality in the relationship between economic growth and environmental quality in Africa, suggesting that institutions are not merely background conditions but active mechanisms that shape whether growth and trade globalization deteriorate or improve environmental quality. Third, this study demonstrates that environmental challenges in Africa is not solely a function of economic growth, but of the quality of governance. Fourth, the study enriches the empirical debate by offering continent wide evidence that institutional development can realign economic activities toward cleaner production patterns in Africa

5.2 Policy implications of the findings

The findings of this study have significant practical implications for policymakers, governments, stakeholders, investors, and development partners.

1. The positive impact of economic growth on CO2 emissions suggests that economic growth increases CO2 emissions in Africa, underscoring the urgency of government and policymakers to integrate climate objectives into national development plans.

2. The confirmation of the EKC implies that sustained growth alone is insufficient because the EKC is conditional. African countries must support structural transformation, clean energy adoption, and technological upgrading by strengthening environmental regulations to reach the stage where economic growth improves environmental quality.

3. The negative impact of institutional quality on CO2 emissions suggests that stronger governance system can reduce CO2 emissions in Africa, therefore, stakeholders and policymakers should strengthen the governance structure in Africa, thereby ensuring governance effectiveness. This underscores the urgency of enforcing regulatory to strengthen environmental sustainability goals.

4. The results of the moderating effect of institutional quality highlights the need for stronger regulatory frameworks, transparent governance systems, and effective environmental enforcement mechanisms to ensure that economic expansion and external integration do not come at the expense of ecological sustainability.

5. The findings suggest that strengthening institutional quality is essential for helping African countries achieve their Nationally Determined Contributions (NDCs) under the Paris Agreement. Effective institutions can improve environmental policy enforcement, accelerate the adoption of clean technologies, and promote sustainable economic growth. For example, Rwanda, South Africa, and Seychelles have integrated strong governance with green development policies to support its emissions reduction targets, while Morocco has expanded renewable energy investments to advance its NDC commitments. These experiences demonstrate that stronger institutions can help African countries reconcile economic growth with environmental sustainability.

5.3 Recommendations

Based on these findings, several policy recommendations emerge.

1. Given that economic growth has a positive impact on CO2 emissions, African governments should prioritize economic reforms that embed environmental accountability within economic and investment policies, including strict environmental regulations, credible enforcement systems, and transparent monitoring frameworks. They should also adopt green growth policies by incorporating clean energy and energy efficient technologies into their development plans to decouple growth and CO_2 emissions.

2. Institutional quality has a negative effect on CO2 emissions in Africa, this demonstrate that even though most Africa countries such as Burundi, Sierra Leone, and Sudan have weak governance structure, the findings demonstrate that stronger institutions have the capacity to mitigate CO2 emissions in Africa, therefore, governments and stakeholders should focus on building institutions that promote environmental quality such as national climate change policy, national forestry policy, etc.

3. Regional bodies and development partners should support capacity building initiatives that strengthen environmental governance, and judicial bodies responsible for upholding economic right and accountability to enhance climate commitments. This enhances quality of governance, transparency, and citizen participation in the policy-making process, which improves trust in the institutions.

4. Due to the fact that the interaction term between institutional quality and economic growth (GDP) is positive, while the interaction term between institutional quality and economic growth (GDP^2) is negative, voice and accountability, and governance effectiveness should be prioritized and accompanied by environmental safeguards at low-income stages. African countries should implement policy measures at lower income levels to limit emissions, since institutional quality has a negative effect on the environment in the early stages of development. In addition, there is a need to strengthen regional and international cooperation to promote sustainable economic activities and green industrialization so that strong institution can support environmental benefits at higher income levels.

5.4 Limitations of the study and directions for future research

However, this study has its limitations.

1. The sample only focuses on African countries ignoring other continents.
2. This study excludes other parameters that could capture environmental quality, as it used only CO2 emission to measure environmental quality.
3. This study used limited sample size as some African countries were excluded due to data availability.
4. This study used only GMM as the main approach, and did not compare the results to pooled OLS, and FE/RE
5. There could be possible endogeneity concerns beyond GMM treatment as GMM relies on instrument validity.

Therefore, future research should utilize alternative approaches to address endogeneity concerns that may arise in similar study. Moreover, future research should extend this study by incorporating disaggregated sectoral emissions, and country specific dimensions, as well as by exploring threshold effects to better identify the income levels at which Africa's growth path becomes environmentally sustainable. Future research should compare the results of GMM pooled OLS, and FE/REF in order to understand the assumption of the results from all the model. Future research should explore energy as additional variable to properly capture the impact on environmental degradation. Finally, future research should also split the focus into lower, middle, and upper-level income countries in Africa in the model. Future research should examine manufacturing and commodity shares in exports to clearly understand commodity-export dependence in Africa and order region.

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