

**UNIVERSITY OF GHANA**

**(College of Humanities)**



**ENVIRONMENTAL TAX, ENVIRONMENTAL RELATED GRANT, AND  
CORRUPTION: THE IMPLICATIONS FOR GREEN GROWTH AND  
NATURAL RESOURCE MANAGEMENT IN SUB-SAHARAN AFRICA**

**BY**

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**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA,  
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THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE IN  
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## DECLARATION

I, the undersigned, declare that this thesis is the result of my original research and has not been submitted by me or any other person for the award of a degree in any university. All references cited in this thesis have been duly acknowledged. I bear the responsibility for any errors, omissions and lapses that might appear in this thesis.



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# CERTIFICATION

We, the undersigned, hereby certify that this thesis was supervised in accordance with the guidelines laid down by the university.



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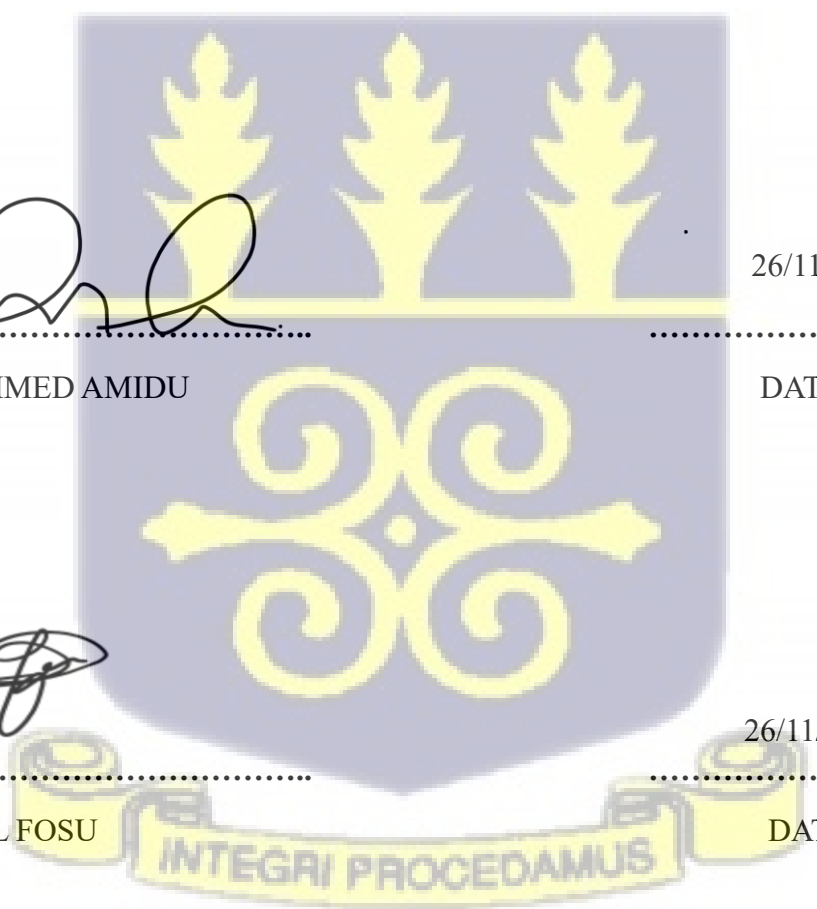
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## **DEDICATION**

To my lovely wife and children.



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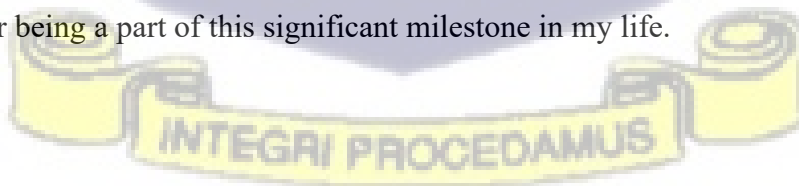
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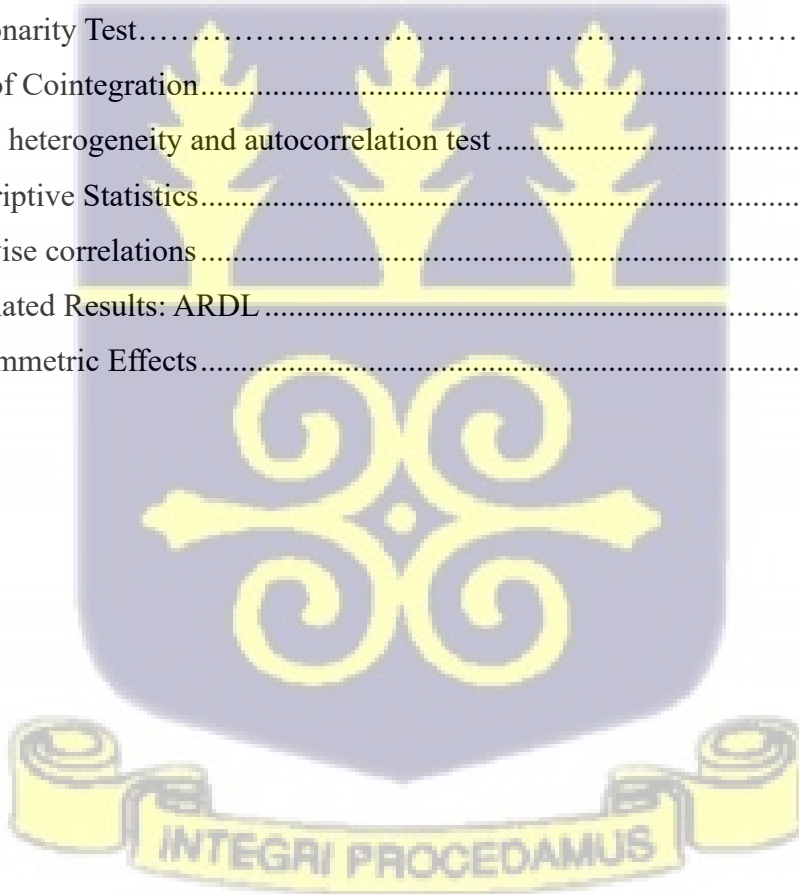
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## LIST OF ACCRONYMS

DDT	Double Dividend Theory
R&D	Research and Development
ETR	Environmental Tax Reform
SMEs	Small and Medium Enterprises
REGQ	Regulatory Quality
RCON	Renewable Energy Consumption
TOE	Tonne of Energy
TES	Tonne Energy Supply
EQ	Environmental Quality
GDP	Gross Domestic Product
USD	United States Dollars
3D	3 Dimension
SD	Standard Deviation
PMG	Pooled Mean Group
IV	Instrumental Variable
GMM	Generalised Method of Moments
LIML	Limited Maximum Likelihood
FE	Fixed Effects
KPMG	Klynveld Peat Marwick Goerdeler
UNGC	United Nations Global Compact
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
CPI	Corruption Perception Index
ECT	Error Correction Term
NRD	Natural Resource Depletion
SDG	Sustainable Development Goals



AU	African Union
IMF	International Monetary Fund
MENA	Middle East and North Africa
2SLS	Two-Stage Least Squares
AMCEN	African Ministerial Conference on the Environment
CO2	Carbon Emissions
PPP	Purchasing Power Parity
PP	Philip Peron
ADF	Augmented Dickey Fuller
EQ	Equation



## ABSTRACT

This thesis investigates the complex relationship between environmental taxation, corruption, and environmental-related grants in sub-Saharan Africa, focusing on natural resource depletion and green growth. The first study examines the moderating role of corruption in the relationship between environmental tax and natural resource depletion, employing multiple econometric methods. Findings reveal that while environmental taxes increase resource depletion, corruption control reduces depletion. Key control variables, such as energy use and urbanisation, also significantly affect depletion, underscoring the importance of corruption control in enhancing environmental tax effectiveness. The second paper examines how environmental taxes and corruption affect green growth across different quantiles, using the Method of Moments Quantile Regression (MMQR) on 15 countries from 2000 to 2020. Results show that the moderating effect of corruption becomes more significant at higher quantiles of green growth, with the strongest impact observed at the 9th quantile. This suggests that environmental taxes are more effective in promoting green growth in countries with stronger corruption control. The findings emphasise the need for tailored environmental tax policies based on the corruption level of individual countries. The third paper investigates the combined impact of environmental taxes and environment-related grants on green growth using an autoregressive distributed lag (ARDL) model and MMQR analysis. Results indicate that environmental taxes alone do not significantly impact green growth. However, the interaction between environmental taxes and grants significantly enhances CO<sub>2</sub> productivity. It reduces energy intensity, highlighting the value of a mixed policy approach that integrates economic incentives with capacity-building support.

The thesis makes several significant contributions to the understanding of environmental policy effectiveness in sub-Saharan Africa, both empirically and theoretically. It advances the literature by elucidating the nuanced role of corruption as a moderating factor in the relationship between environmental taxation and natural resource depletion, highlighting that while environmental taxes alone may inadvertently increase resource use, effective corruption control can mitigate this adverse effect. This finding enriches the theoretical discourse on environmental governance accounting and environmental economics by emphasizing the importance of institutional quality in policy outcomes. The second study extends this understanding by demonstrating that the efficacy of environmental taxes in promoting green growth varies across different levels of development, with corruption control becoming increasingly critical at higher green growth quantiles. This suggests a threshold effect and underscores the need for context-specific policy design, contributing to the literature on asymmetric effects and policy tailoring. The third paper broadens the theoretical framework by illustrating that, environmental taxes, when complemented with environment-related grants, can synergistically enhance green productivity, emphasizing the importance of integrated policy mixes. Collectively, these studies contribute to the theoretical understanding of how institutional factors, such as corruption, interact with fiscal instruments and grants to influence environmental and economic outcomes. They also provide a nuanced perspective that highlights the importance of context-dependent policy approaches, thus enriching both the environmental economics and development policy literatures. Based on the findings, this thesis recommends adopting a context-specific approach to environmental taxation, considering each country's environmental grants and corruption levels. Policymakers in countries with low corruption should leverage higher environmental taxes to drive green growth, while those in high-corruption settings should prioritise corruption control before implementing aggressive tax

policies. Furthermore, the study highlights the importance of combining environmental taxes with grants to maximise their effectiveness. Regional governments are encouraged to adopt mixed policy frameworks integrating fiscal instruments with technical assistance to promote green growth and natural resources. These strategies will be critical for achieving long-term environmental sustainability and economic growth in sub-Saharan Africa.



# CHAPTER ONE

## INTRODUCTION

### 1.1 Background of the study

In recent years, the concept of green growth has gained significant attention as a sustainable development strategy that seeks to balance economic expansion with environmental preservation (OECD, 2011; World Bank, 2012). Traditional growth models, which prioritise economic output without adequately addressing environmental degradation, have proven unsustainable in the face of challenges such as climate change, biodiversity loss, and resource depletion (UNEP, 2019). In response, green growth promotes the use of renewable energy, resource-efficient technologies, and low-carbon policies to ensure that economic progress does not come at the expense of ecological health (Zeeshan et al., 2022). More so, international frameworks like the Paris Agreement and the Sustainable Development Goals (SDGs) have emphasised the importance of transitioning to greener economies, encouraging countries to adopt policies that reduce emissions while fostering innovation and job creation (Hao et al., 2021a). Importantly, the green growth model provides a method for achieving economic growth and development goals more sustainably and efficiently (Hallegate et al., 2011; Khoshnava et. al., 2019). It focuses on making growth processes more resource-efficient and resilient without necessarily slowing them down (Revel, 2011). The concept emphasises integrating environmental sustainability into economic growth, addressing poverty reduction, job creation, and social responsibility (Sharma, 2023; Morssy, 2012). The priority of improving livelihood security and economic prosperity in Africa is linked to agricultural and environmental growth (Ejigu, 2008). Green growth in Africa creates both opportunities and challenges for sustainable development (Nhamo, 2014). While there is no universal model for all African countries, greener approaches to agriculture and energy can help drive economic

transformation (Bishop,2019). However, achieving green growth is often complicated by governance challenges, policy mismatches, and socio-economic factors that vary across regions (Tawiah et al., 2024).

Relatedly, Africa's abundant natural resources are critical for achieving sustainable development goals and economic growth (Ayuk et al., 2019). These resources, both renewable and non-renewable, make a substantial contribution to wealth generation, job creation and industrialisation (Ayuk et al., 2019). Despite this potential, many African countries have struggled to transform their resource wealth into widespread prosperity (Moti, 2019). Relatively, the abundance of natural resources wealth in developing nations results in adverse economic outcomes such as corruption, poverty, impoverished economic growth, and ineffective governance (Tandi & Mishra, 2020; Polterovich et al., 2010; Sachs & Warner, 2001). The "resource curse" phenomenon, characterised by factors such as the "Dutch Disease" rent-seeking behaviour and weak governance, has frequently hampered economic development (Moti, 2019). Thus, empirical literature has documented that resource abundance can exacerbate corruption and rent-seeking behaviors, hindering sustainable development (Leite & Weidmann, 1999; Ross, 2015). Experts have identified critical areas for sustainable resource management, such as soil and water management, sustainable mining, energy and climate, and natural resource integration into global value chains (Ayuk et al., 2019). The resource curse hypothesis suggests that natural resource abundance contributes to poor economic performance in developing countries, frequently caused by corruption (John, 2010). Corruption is a fundamental factor in the resource curse, negatively impacting genuine saving, a measure of sustainable development (Dietz et al., 2007). The relationship between resources and corruption is complex, with taxation playing a critical role (Veisi, 2017).

Undoubtedly, empirical studies have documented that resource abundance can exacerbate corruption and rent-seeking behaviors, hindering sustainable development (Leite & Weidmann, 1999; Ross, 2015). Corruption, in particular, impairs the effective implementation of environmental policies, undermines resource management, and discourages investment in green technologies (Tanzi & Davoodi, 1997; Blackman, 2007). Environmental taxation is increasingly recognized as a tool to internalize environmental externalities, promote sustainable resource use, and combat the resource curse's negative effects (Stiglitz, 2019). However, the effectiveness of such policies is often compromised in contexts with weak governance and pervasive corruption (Khan, 2017). Meanwhile, emerging economies, especially in Sub-Saharan Africa, are often characterized by resource dependence, high levels of corruption, and nascent institutional frameworks (World Bank, 2020). These factors complicate the implementation of environmental policies and challenge the potential benefits of resource revenues. Studies such as Humphreys et al. (2007) argue that resource wealth can entrench corruption and undermine institutions, impeding green growth objectives. Within accounting and financial reporting, resource dependence and corruption influence transparency, disclosure practices, and the perceived legitimacy of institutions (Gray & Bebbington, 2001; Gray, 2010). The role of environmental taxes and grants in fostering transparency and accountability is gaining attention, with recent research emphasizing their importance in enhancing sustainable resource management and aligning accounting practices with green growth (KPMG, 2021; UNGC, 2022).

Environmental taxes, such as carbon taxes and resource levies, are theoretically grounded in Pigovian economics, aiming to internalize externalities, correct market failures, and generate revenues for reinvestment in green technologies (Veisi, 2017; Hao et al., 2021a). However, debates persist regarding their actual efficacy in resource-dependent economies, especially where

institutional weaknesses and corruption are pervasive (Khan, 2017; Humphreys et al., 2007). Some scholars argue that environmental taxes can produce a double dividend by reducing pollution while funding sustainable development, if properly designed and enforced (Zhang & Masui, 2021). Conversely, critics contend that in weak governance contexts, these fiscal instruments may be captured or evaded, thus failing to deliver intended ecological and economic benefits (Ross, 2015; Tandi & Mishra, 2020).

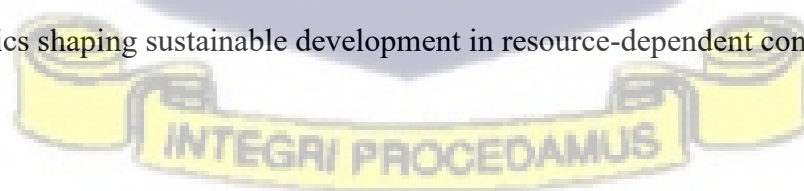
The role of governance, particularly corruption, remains a focal point of ongoing debate. The resource curse hypothesis posits that resource abundance, paradoxically, can hinder sustainable development due to rent-seeking, corruption, and weak institutional capacity (Leite & Weidmann, 1999; Sachs & Warner, 2001). Empirical evidence supports this view, demonstrating that resource-rich countries with high corruption levels often experience slower growth, environmental degradation, and poor resource management (Moti, 2019; Morssy, 2012). The debate centers on whether governance reforms, transparency, and anti-corruption measures can effectively mediate the relationship between resource wealth and sustainable development outcomes. While some scholars advocate for strengthening institutions as a prerequisite for successful green policies (Veisi, 2017; Ameer & Ahmad, 2024), others question the feasibility of reform in contexts where vested interests dominate policymaking, emphasizing the need for context-specific solutions.

Technological innovation is widely recognized as a critical factor in advancing green growth, particularly through improving resource efficiency and reducing environmental impacts (Lindman & Söderholm, 2016). The debate here revolves around the "energy rebound effect," where gains in efficiency inadvertently lead to increased energy consumption, thus offsetting environmental benefits (Vivanco et al., 2015). Some scholars argue that innovation can leapfrog traditional development pathways, enabling resource-efficient industrialization in developing countries

(Diaz-Rainey & Ashton, 2015), while skeptics warn that without complementary policies, technological progress alone may not suffice to achieve sustainability goals. Additionally, discussions continue about the optimal policy mix, balancing market-based instruments like taxes with regulatory and innovation policies, to overcome institutional barriers and realize.

Finally, the effectiveness of policy instruments such as environmental grants, subsidies, and international cooperation remains contested, with ongoing debates about their design, implementation, and contextual suitability (KPMG, 2021; UNGC, 2022). The literature emphasizes that without strong governance and transparency, these financial incentives may be misappropriated or fail to reach intended beneficiaries, thereby diluting their impact on resource management and green growth (Khan, 2017; Gray & Bebbington, 2001). Moreover, theoretical debates continue over whether integrated policy approaches, combining fiscal measures, governance reforms, and technology can synergistically promote sustainable resource use or whether they risk policy fragmentation and conflicting incentives.

This study aims to contribute to these ongoing debates by empirically examining how environmental taxes, governance quality, technological innovation, and resource abundance interact to influence resource management and green growth outcomes in African countries. It seeks to clarify whether strengthening governance and curbing corruption can enhance the effectiveness of fiscal and technological policies, thereby offering nuanced insights into the complex dynamics shaping sustainable development in resource-dependent contexts.



## 1.2 Problem statement

Despite the abundance of natural resources on the African continent, Africa remains underdeveloped because there are not enough policies to manage the resources sustainably (Sharma & Shrestha, 2023; Olopade, 2014). This ongoing circumstance prevents this continent from making the socioeconomic advancement it deserves.

The latest report from the Global Environmental Outlook GEO-6, a regional African assessment, depicts that the environment degrades more quickly than before. The GEO-6 Regional Assessment for Africa emphasises that governments must move quickly to halt the worst trends because the environment is deteriorating faster than previously believed. The report acknowledges Africa's natural resources and notes that the continent's economic development depends on the prudent use of its natural resources (Ampofo et al., 2023; Valensisi, 2024). However, the continent's expanding population is using its natural resources in an unsustainable way, and the authorities are slow to enact laws and regulations to stop the abuse and overuse of these resources (Atta & Sharifi, 2024).

The numerous disasters we are facing are proof that nature is flashing red alerts; if left uncontrolled, it will continue to exacerbate food shortages, water shortages, diseases, conflicts, migration, and poverty, all of which have the potential to cause the economies of Africa to become unstable (Okolo, & Wen, 2023). Resource-endowed regions are the first to reduce corruption and promote technological innovation to improve natural resource management and green growth (Dong et al., 2024). This is because, for these economies, it is more of a challenge as their economic growth relies heavily on managing these natural resources.

In advancing on these insights, the following questions become empirically vital: Should Africa roll out more restrictive environmental taxes, focus on curbing corruption, or both to grow green? Should Africa enact more restrictive environmental taxes, focus on reducing corruption, or both to effectively manage its natural resources? What role can environmental taxes and technological innovation play in helping Africa grow green? This inquiry addresses these questions for a panel of 15 SSA economies from 2000–2021.

Even though literature exists on the impact of environmental taxes, corruption and technological innovation on green growth and natural resource management, it is riddled with limitations as follows:

Firstly, the existing literature discusses the interaction between environmental tax, corruption and green growth in two separate hypotheses. First, the nexus between environmental tax and green growth (Chien et al., 2021; Hao et al., 2021a; X. Sun et al., 2022; Version, 2013), and second, the effect of corruption on green growth (Ganda, 2020; Hao et al., 2021b; Sun et al., 2022; Zeeshan et al., 2022). However, as far as we know, studies have yet to analyse the two related hypotheses in a single study. Indeed, unravelling a more nuanced and insightful discourse that empirically tests the two related hypotheses is imperative.

Practically, it is even more essential to explore the interconnectedness of environmental tax and corruption in green growth because addressing them separately may overlook critical dynamics. Environmental taxes aim to promote sustainable practices, but corruption can undermine their effectiveness, which distorts public policy and resource allocation. Governance quality determines the impact of environmental taxes, as stronger institutions ensure transparency and accountability, maximising the benefits of green growth initiatives. When corruption is present, even well-

designed tax policies may fail to encourage green investments, reducing the potential for environmental innovation. Conversely, successful green growth strategies require fiscal policies and governance reforms that limit corruption and promote compliance.

The absence of studies that jointly analyse these elements creates a knowledge gap that hinders the development of effective policy frameworks. A combined analysis could provide insights into how taxes and governance interact to shape sustainable economic progress. This research would guide policymakers in designing tax policies aligned with anti-corruption measures, ensuring that green growth efforts are effective across various governance contexts. Given the varied levels of corruption across regions, an integrated approach would allow for context-specific strategies. Exploring this nexus is crucial for achieving long-term environmental sustainability and economic resilience.

Secondly, similar scanty and separate lines of discussion exist in the literature on the impact of the environmental tax-natural resource management nexus and corruption-natural resource management nexus (Joarder & Ahmed, 2023). However, a line of discourse that mutually links environmental tax and corruption and their impact on natural resource management must be included, even though it is essential. The need for integrated research connecting environmental taxes, corruption, and natural resource management is crucial because it overlooks fundamental governance dynamics that influence policy effectiveness.

Environmental taxes promote sustainable practices, but corruption can undermine these efforts by weakening enforcement or encouraging illegal activities. Governance is critical in ensuring fiscal tools like environmental taxes achieve their intended impact. Considering environmental taxation and corruption, policymakers may avoid potential interactions or trade-offs, leading to effective

outcomes. A joint analysis could reveal whether strong governance amplifies the impact of environmental taxes or whether taxes reduce opportunities for rent-seeking behaviour.

Addressing this gap is particularly relevant for developing regions, such as sub-Saharan Africa, where environmental degradation and corruption are intertwined. Effective resource management requires a holistic approach that integrates fiscal and governance interventions. This interconnected framework could provide actionable insights for improving environmental sustainability and transparency. Research focusing on these relationships will help create targeted policies that overcome governance challenges while fostering sustainable resource use. Ultimately, this line of inquiry promotes long-term environmental stewardship and sustainable development.

Thirdly, in spite of the substantial theoretical and policy-driven advocacy for environmental taxes, governance reforms, and technological innovation as pathways to sustainable development, empirical evidence on their effectiveness remains inconsistent, especially within the context of resource-dependent economies in Africa. Several studies have demonstrated positive outcomes; for instance, Veisi (2017) highlights those environmental taxes can internalize externalities and promote sustainable resource management, while Hao et al. (2021a) underscore the role of green policies in fostering economic resilience. Conversely, other empirical analyses reveal that weak governance structures, pervasive corruption, and institutional deficiencies often undermine the potential benefits of these policies. For example, Humphreys et al. (2007) and Ross (2015) document that resource-rich countries frequently experience resource curse phenomena, where resource abundance exacerbates corruption, rent-seeking behaviors, and ineffective policy implementation, thereby impeding the realization of green growth objectives. Furthermore, while technological innovation is widely regarded as a catalyst for resource efficiency, some studies (Vivanco et al., 2015; Lindman & Söderholm, 2016) warn of the energy rebound effect, where

efficiency gains inadvertently lead to increased resource consumption, complicating the assumed positive link between innovation and sustainability. These mixed findings point to a critical gap: the contextual factors influencing the efficacy of environmental policies, especially governance quality and corruption levels, are often overlooked, resulting in a limited understanding of how these policies function under real-world institutional constraints.

Adding to this complexity, the literature also presents conflicting evidence regarding the joint impact of environmental taxes, grants, and governance reforms on green growth outcomes. Several recent studies suggest that integrated policy approaches can synergistically enhance resource management and ecological sustainability (KPMG, 2021; UNGC, 2022); however, their success hinges on the strength of institutional frameworks. In resource-dependent African countries, where corruption and weak governance are prevalent, the implementation and enforcement of environmental policies often fall short, nullifying or diminishing their intended effects (Khan, 2017; World Bank, 2020). Empirical investigations such as those by Humphreys et al. (2007) and Tandi & Mishra (2020) highlight that resource wealth and high corruption levels can entrench rent-seeking and erode institutional capacity, thereby impairing policy effectiveness. Consequently, there exists a significant research gap in understanding how governance quality moderates the relationship between environmental fiscal measures and sustainable resource use in African contexts. This gap underscores the need for context-specific empirical analysis to inform policy design that effectively leverages environmental taxes and grants while addressing institutional shortcomings, ultimately advancing the agenda of green growth in the region.



Fourthly, the context of Africa is a continent well noted for its paradoxical position of being resource-wealthy. However, the poorest and most vulnerable to climate change is yet to be consensus in the literature as to the reasons accounting for the many natural resource-rich African countries still face significant economic challenges and how the combined effects of environmental taxes and control of corruption can assist Africa to manage its resources and achieve green growth.

Last but not least, a chunk of the literature (Okombi & Ndoum Babouama,2024; Behera & Sethi, 2022) has used models which suggest linearity in the nexus between these variables, but the argument of this thesis that the variables, like many economic variables, are non-linear in character and could exhibit asymmetry and heterogeneity in the nexus (Khalifaoui et al., 2023; Haw et al., 2020; Saha et al., 2017; Tarverdi, 2016).

Importantly, the ongoing theoretical and conceptual debates surrounding environmental taxes, investments, and corruption underscore the complexity of promoting sustainable development in resource-dependent emerging economies. While classical economic theory advocates for Pigovian taxes as efficient tools to internalize externalities (Pigou, 1920), recent discourse highlights challenges related to institutional weaknesses, political resistance, and socio-economic impacts that hinder their effectiveness in developing contexts (Stiglitz, 2019; van den Bergh & Kallis, 2020). Similarly, the role of environmental investments and grants remains contested; although they can catalyze green transitions (OECD, 2021), concerns about their potential to distort markets or foster dependency persist (Kumar & Sethi, 2021). The literature on corruption emphasizes its dual role as both an impediment and, in some contexts, a facilitator of informal problem-solving, yet the prevailing consensus views corruption as a significant barrier to effective environmental policy implementation, eroding institutional capacity and resource allocation (Leite & Weidmann, 1999; Mauro, 1995). These debates are further complicated by empirical inconsistencies—while

some studies find that environmental taxes foster green growth (Stiglitz, 2019), others reveal that high corruption levels diminish their efficacy (Khan, 2017). Given these conflicting perspectives and the paucity of context-specific research in resource-rich, governance-challenged settings like Sub-Saharan Africa, our study aims to empirically investigate how environmental taxes, grants, and corruption interact to influence green growth, thereby contributing nuanced insights to this vibrant and critical scholarly discourse.

Therefore, based on the identified flaws in the literature, this thesis seeks to contribute to the literature by examining the asymmetric and heterogeneous impact of environmental taxes and control of corruption on green growth and natural resource management. Our study aims to fill critical gaps by examining the interplay between environmental taxes, grants, corruption, and their implications for green growth and resource management specifically within the Sub-Saharan African context, an area less explored in existing literature. While prior works have focused broadly on resource dependence and governance, few have explicitly analyzed how fiscal instruments like environmental taxes and grants can mitigate or exacerbate the resource curse in corrupt environments, and how these dynamics influence accounting practices related to environmental and resource management. This research is significant because it offers insights into policy design tailored for resource-dependent emerging economies, emphasizing the role of governance and accounting transparency in achieving sustainable development goals.



### 1.3 Objectives of the study

This thesis is a collection of three related essays on the interactions among environmental taxes, green growth, natural resources, corruption control, and environmental-related grants.

In the light of this, the thesis achieved the following objectives:

- i. To analyse the moderating role of control of corruption on the nexus between environmental tax and natural resources depletion.
- ii. To examine the impact of control of corruption on the relationship between environmental tax and green growth.
- iii. To investigate the joint effect of environmental tax and environmental-related grants on green growth.

### 1.4 Significance of the study

Recent data indicate that corruption remains a serious governance challenge throughout Sub-Saharan Africa. According to Transparency International's Corruption Perceptions Index (CPI) 2024, the region has the lowest average score of any major world region, at 33 out of 100, where 0 is "highly corrupt" and 100 is "very clean" (Transparency International, 2024a). About 90% of the countries in the region score below 50, showing that public sector corruption is widely perceived to be severe (Transparency International, 2024a). Major variance exists: among Sub-Saharan states, Seychelles leads with a CPI score of 72, followed by Cabo Verde (62), Botswana (57), and Rwanda (57) (Transparency International, 2024a). On the other end, South Sudan (8), Somalia (9), Equatorial Guinea (13), and Eritrea (13) are among the lowest scorers (Transparency International, 2024a). Looking at individual countries, Ghana scored 42/100 in CPI 2024, placing it around 80th globally, and ranking 11th among 49 SSA countries; this represents a slight decline

from its 2023 score of 43 (Ghanamma, 2025). On the bases of the above records, this thesis contributes to the literature in many folds:

Firstly, it provides the first empirical evidence of the nexus between environmental tax, control of corruption and green growth. This study answers the pertinent questions in the literature about whether Africa's efforts to grow green should be focused on only levying more environmental taxes or curbing corruption, or both? Also, even if both should be simultaneously undertaken, should there be a balance in the scale of the interventions and towards which intervention? The answers to these pertinent questions will help policymakers, governments, think tanks and other stakeholders map out appropriate policy and practice notes to help Africa grow green.

Secondly, this thesis doubles up as a seminal enquiry into the nexus between environmental tax, control of corruption and natural resource management. This is also in response to the lack of clarity as to whether Africa should focus only on levying more environmental taxes or only curbing corruption or both to enhance its natural resource capital again, even if both should be embarked upon aggressively where potency should be injected more, on taxes or control of corruption to ensure efficient management of its resources.

Thirdly, this thesis has provided insight into the joint effects of environmental taxes and technologically related grants on growing Sub-Saharan Africa green. These indications would be vital in defining and shaping policy and practice interventions to address the issue of green growth.

Moreover, this study contributes to the debate in the literature by employing the novel method of the moments quantile regression model, which helps to capture the actual behaviour of the variables under study appropriately. Recent research using the Method of Moments Quantile Regression has yielded unique insights into environmental degradation drivers and policy

implications. Shahbaz and Patel (2024) discovered that economic development, energy intensity, and fossil fuel consumption raise CO<sub>2</sub> emissions, whereas environmental taxes and renewable energy lower them, particularly at higher quantiles. Khalfaoui et al. (2023) found that corruption reduces environmental quality in MENA nations, with effects changing depending on the extent of degradation. Halidu et al. (2023) found that environmental tax measures considerably reduce global economic disparity.

These findings emphasise the necessity of considering varied impacts across quantiles, as typical mean-based calculations may yield incomplete results (Khalfaoui et al., 2023).

Last but not least, this thesis has further enhanced the theoretical foundations of the double dividend theories by bringing new insight into the understanding and application of this theory relative to the joint roles environmental tax and control of corruption can play in helping boost green growth and natural resource management in Sub-Saharan Africa.

### **1.5 The structure of the thesis**

The thesis is organised into five (5) main chapters. Chapter one focuses on the general introduction, which covers the background of the study, the research problem, the objectives of the study, its significance, and the structure of the thesis.

Chapter two provides empirical evidence using two-stage least squares (2SLS) on the moderating effect of corruption control on the relationship between environmental taxes and natural resources for sub-Saharan African countries.

In Chapter Three, the study examines the heterogeneity in the moderating role of control of corruption on the nexus between environmental tax and green growth; this study empirically employs the Method of Moments Quantile Regression (MMQR),

The study investigated the combined effect of environmental taxes and environment-related grants on green growth in 15 sub-Saharan African countries in chapter four using a panel autoregressive distributed lag (ARDL) model and a moments quantile regression analysis method.

The final chapter, Chapter Five, captures the conclusions, policy implications and recommendations for future research.



## CHAPTER TWO

### ANALYSING THE RELATIONSHIP BETWEEN ENVIRONMENTAL TAX AND NATURAL RESOURCES FOR SUB-SAHARAN AFRICAN COUNTRIES: DOES CORRUPTION MATTER?



## Abstract

This study examines the moderating role of control of corruption on the relationship between environmental tax and natural resource depletion in sub-Saharan Africa. Employing different estimation techniques and methodologies, the results show that a 1% increase in environmental tax leads to a 1.5% rise in natural resource depletion. However, stronger governance reduces this effect, as a 1-unit increase in control of corruption decreases natural resource depletion by 0.32%. The interaction term between environmental tax and corruption control is also significant, where a 1-unit increase in the interaction reduces natural resource depletion by 0.024%, indicating a strong moderating effect. Key control variables like energy use, urbanisation, and population density significantly affect resource depletion, with energy use increasing and urbanisation reducing depletion. These results emphasise the critical role governance plays in the effectiveness of environmental taxation. By extension, these results have important policy implications in assessing the effectiveness of anti-corruption measures and institutional reforms in enhancing the impact of environmental taxes.



## 2.1 Introduction

The constant demand for resources and energy drives the evolution of human society and the economy (Aladejare, 2022). For many years, preserving the sustainability of the global economy and addressing its global difficulties have relied heavily on sustainable development (Sauvé et al., 2016). The dynamics of international development demonstrate the necessity of expanding the macro and microeconomic greening tools (Scricciu et al., 2013).

The fact cannot be denied that Africa is a hub of natural resource wealth. The latest report from the African Ministerial Conference on the Environment (AMCEN) recognises that natural resource wealth underpins the continent's economy, affirming that using this natural resource capital as a gateway to wealth creation and investments will allow for actions towards achievement of the United Nations 2030 Agenda on Sustainable Development and Sustainable Development Goals (SDGs), and the AU Agenda 2063 through financial, economic, social and environmental contribution (United Nations Environment Programme [UNEP], 2022).

Natural resources are mostly valued by considering their economic rents, also known as "resource rents" (Ben-Salha et al., 2021; Canh et al., 2020; Aljarallah, 2021). According to the World Bank (2024), total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents. When managed and used properly, natural resources such as minerals, natural gas, and oil and their rents can facilitate poverty reduction and encourage sustainable growth and development (Toto Same, 2009; Fu & Liu, 2023).

However, recent discourse in the literature on natural resource management underpinned by the "natural resource curse" hypothesis espouses the understanding that the abundance of natural resources such as crude oil, natural gas, coal, and mineral wealth in developing nations results in

a negative economic outcome such as different forms of corruption, poverty, impoverished economic growth, and ineffective governance (Tandi & Mishra, 2020; Menaldo, 2016; Sachs & Warner, 2001). Natural resources in many developing nations, particularly in Africa, are considered a curse instead of a blessing (Ploeg, 2011; Tandil & Mishra, 2020; Henri, 2019; 4; Brunnschweiler, 2008; Sachs & Warner, 2001). Thus, AMCEN contends that, for Africa to reap the economic and social benefits inherent in this natural wealth, it is necessary for Africa to collectively and urgently harness its vast natural resources to guarantee future growth and ensure that exploitation of natural resources is results-oriented, climate resilient and sustainable (Hao et al., 2021; Wan et al., 2022).

One of the propositions of the evidence presented on the resource curse view is that corruption is one of the main causes of the under-development of many resource-rich countries (Joarder & Ahmed, 2023; Harvey, 2014). The nature of corruption in this instance is in the form of rent-seeking and patronage (Ngo, 2008; Kolstad & Søreide, 2009; Fukuyama, 2018). Rent-seeking because the rents from natural resources are so lucrative that they engender a race for the share of the rent rather than a skilful and responsible exploitation of the resources (Auty, 2015; Menaldo, 2016). Patronage is also because many governments of these countries allocate these resources to their financiers to hold onto power, which is done by hampering accountability and transparency (Berenschot & Aspinall, 2022).

To mitigate the problem, environmental tax is widely believed to be a potential instrument for changing, or at the very least reducing, environmentally detrimental behaviour such as environmental pollution (Li et al., 2022; Xu et al., 2023; Bovenberg & Goulder, 2002; Jagers & Hammar, 2009). Environmental tax is an environmental cost charged to enterprises on pollution emissions (Farooq et al., 2023). Environmental tax aids in the internalisation of pollution's negative

externalities, resulting in a green dividend (Zhu et al., 2020; Xu et al., 2023; Li et al., 2021). The fundamental reason is that compared to most other policy options, environmental taxes are cost-effective because of their double dividend, i.e., reduction of emissions and generation of revenues for economic growth. The imposition of taxes on pollution and resource use by the government can encourage the implementation of cleaner technologies and practices toward more sustainable behaviour.

Environmental taxes are rooted in Pigouvian theory, by pricing negative externalities such as pollution and resource overuse, they create incentives to reduce environmentally harmful activities while raising public revenue that can be reinvested in mitigation, remediation, or compensation for affected groups (Metcalf, 2022). In practice, however, the effectiveness of such taxes depends on their design—including coverage, rate, and exemptions, together with the administrative capacity to collect and enforce them (World Bank, 2023). The presence of complementary policies, such as subsidies for clean alternatives or revenue-hypothecation to green investment, also determines outcomes. Recent policy reviews emphasize that environmental taxes and fuel-subsidy reforms can raise revenue at lower administration cost than many other taxes, while also accelerating renewable energy investments (OECD, 2024; Andersson & Atkinson, 2023). Yet, implementation remains technically and politically difficult in low-capacity settings, especially without careful sequencing and social protection measures (World Bank, 2023).

Control of corruption enters this framework as a governance multiplier or inhibitor. Corruption undermines the price signals produced by environmental taxes in several ways: corrupt officials may permit non-compliance or illegal extraction in exchange for bribes, while revenue from green taxes or resource rents may be diverted before funding climate or conservation programs (Davidović, 2024). Moreover, vested interests often capture policy design to secure exemptions or

create loopholes (López & Palanza, 2023). Empirical studies show that higher corruption correlates with weaker enforcement of environmental regulation, reduced public support for carbon pricing, and a greater likelihood that revenues from environmental taxes or natural resources fail to finance sustainable investments (Sundström et al., 2024; Transparency International, 2024). In short, corruption transforms potential public goods—such as tax revenues and grants—into private rents, thereby blunting the environmental and developmental impact of fiscal instruments.

Natural resource depletion is both a cause and consequence in this triangular relationship. On one hand, resource dependence creates fiscal and political incentives that discourage strong environmental taxation, since governments reliant on extractive rents may resist policies that reduce profitability in mining, oil, or forestry (Collier & Venables, 2023). On the other hand, weak governance and corruption accelerate depletion, as illegal logging, unregulated mining, and evasion of extraction levies go unchecked (Tang, 2024). Evidence from Sub-Saharan Africa shows that where control of corruption is weak, the ecological footprint and measured resource depletion are significantly worse (Byaro, 2022). Furthermore, experiences from several African countries demonstrate that environmental taxes introduced without anti-corruption safeguards or transparent public financial management often deliver muted environmental benefits, with proceeds poorly invested into resilience or restoration (World Bank, 2021; IMF, 2022).

The impacts and policy implications follow directly from these mechanisms. Well-designed environmental taxes, when combined with strong anti-corruption controls, transparent hypothecation of revenues, and investment in enforcement and green alternatives, can reduce emissions and slow depletion while expanding fiscal space for sustainable development (OECD, 2024). By contrast, in contexts with entrenched corruption, such taxes risk becoming regressive or

captured, climate finance and grants risk leakage, and natural capital may decline despite rising nominal spending (IMF, 2023). Recent scholarship highlights that strengthening governance is not merely a complementary action but a precondition for successful green taxation (Sundström et al., 2024). Integrated approaches, linking fiscal reform, anti-corruption measures, and independent monitoring of environmental outcomes, so as to offer the most realistic pathway for ensuring that environmental taxes and natural resource rents translate into preserved natural capital and genuine green growth (Transparency International, 2024; UNEP, 2023).

Wilde (2016) argues that environmental taxes alone are insufficient for effective natural resource management. Corruption control can be used in conjunction with environmental taxes to promote effective natural resource management (Veisi, 2017). Corruption control through improved governance and transparency is crucial for environmental sustainability, especially in natural resource-rich developing countries (Ameer & Ahmad, 2024). Corruption has a negative effect on green growth, suggesting the need to control corruption for sustainable development. Tawiah et al. (2024).

The latest report from the Global Environmental Outlook GEO-6, a regional assessment for Africa, depicts that the African environment is degrading more quickly than it has in the past (Abdulsalam, et al., 2025). This is because the continent's expanding population is using its natural resources in an unsustainable way, and the authorities are slow to enact laws and regulations to stop the abuse and overuse of these resources.

Even though natural resources are abundant on the sub-Saharan African continent, sub-Saharan African countries remain underdeveloped because there are not enough policies such as environmental tax and corruption control in place to manage the resources sustainably and help

increase total natural resource rents. This prevents the sub-Saharan African countries from making the socioeconomic advancement they deserve. Thus, a continual depletion of natural resources, if left uncontrolled, will result in a continuous exacerbation of food shortages, water shortages, diseases, conflicts, migration, and poverty, all of which have the potential to cause the economies of sub-Saharan Africa to become unstable (Britchenko, 2025).

This study fills an important research gap by exploring the joint impact of environmental tax and corruption on natural resource management, which remains unaddressed in the literature. Although several studies have examined environmental tax policies (Söderholm, 2006; Sterner & Coria, 2013) and corruption's effect on resource management (Kolstad & Søreide, 2009; Tacconi & Williams, 2020) independently, none have integrated these two dimensions into a single framework.

The interplay between environmental taxes and corruption is essential since governance quality can either amplify or weaken the effectiveness of environmental tax policies. Investigating this relationship will provide new insights into how institutional factors influence sustainable resource management. Additionally, the findings will offer practical guidance on designing fiscal policies that account for corruption risks, thereby improving resource governance outcomes.

This research can contribute to policy reforms by highlighting the importance of aligning environmental taxes with anti-corruption strategies. It will also add value to academic discourse by comprehensively understanding the interactions and trade-offs between fiscal tools and institutional quality. Further, the study's focus on the interaction of these factors is crucial for developing region-specific solutions, especially for resource-dependent economies. Ultimately, it

will lay the foundation for future studies on integrated policy frameworks that promote sustainable management practices.

The findings indicate that an increase in environmental tax tends to intensify natural resource depletion, suggesting that, on its own, taxation may not yield the intended conservation outcomes. However, the presence of stronger governance frameworks plays a crucial role in mitigating this adverse effect. Specifically, improved control of corruption significantly curtails the depletion of natural resources, underscoring the importance of institutional quality in environmental policy effectiveness.

Furthermore, the interaction between environmental tax and corruption control produces a notable moderating effect. As governance improves and anti-corruption measures strengthen, the combined influence of environmental tax becomes more effective, leading to a reduction in resource depletion. This interaction suggests that environmental taxes can work more efficiently when complemented by robust governance mechanisms, highlighting the synergistic potential of aligning fiscal policies with institutional reforms. Thus, the study emphasises the importance of adopting a dual approach, where environmental taxation is accompanied by efforts to strengthen governance to achieve sustainable resource management.

This study contributes by highlighting the pivotal role governance plays in enhancing the effectiveness of environmental taxation. The findings underscore important policy implications, particularly in evaluating how anti-corruption measures and institutional reforms can amplify the impact of environmental taxes.

The rest of the chapter is organised as follows: The second section reviews both the theoretical and empirical literature underpinning and setting the context for the study. Then, the third section discusses the methodology and data used for the analyses, followed by the fourth section that explains the results and discussions. The fifth section examines the conclusions and policy implications, and the last section entails the limitations and future recommendations of the study.

## **2.2 Literature Review**

### **2.2.1 Definition of key concepts**

Hawkins (2000) defined environmental taxes as adapted in this research as financial tools for lessening environmental degradation and advancing sustainable development. This definition was also corroborated by Mpfungu (2022), who defined environmental taxes as green taxes or eco-taxes, which serve as a means of internalising the external costs of environmental degradation and promoting environmentally friendly practices. The Organization for Economic and Cooperation and Development (OECD) also defines environmental taxes as levies that are imposed on activities or products that harm the environment, such as pollution, resource depletion, or climate change (OECD, 2019). Environmental taxes are levies imposed on activities, goods, or services that cause environmental harm (Fullerton et al., 2008).

Environmental taxes place a cost on pollution or the depletion of natural resources in an effort to encourage people and companies to adopt more environmentally friendly activities (Reilly, 2012; Hoerner & Bosquet, 2001; Awan, 2013). According to Panaiotov (1994), the World Bank defines environmental taxes as financial tools intended to incentivise companies and people to use less resources, cut emissions, and adopt greener practices to lessen their environmental impact (Panaiotov, 1994). Falcão (2013) defines environmental taxes as “compulsory, unrequited

payments to the government, levied on tax bases deemed to be of a particular environmental relevance.” They are fiscal measures implemented by governments to promote sustainable development and reduce environmental peripheries (Adams, 2008).

With these levies, polluters will be forced to bear the financial burden of their environmental harm. The primary objective of implementing environmental taxes is to reduce negative environmental externalities by making it more costly to engage in environmentally damaging behaviour (Krass et al., 2013). Government taxes incentivise businesses to adopt more environmentally friendly practices (Prakash, 2002). These taxes promote emission reduction, resource conservation, and general improvement of environmental quality by internalising the external costs of environmental harm (Xu et al., 2023). These policies impose taxes on activities that damage the environment to internalise the external costs of pollution and environmental degradation. Governments can effectively promote sustainable development and eliminate environmental externalities by carefully crafting environmental tax policies that consider social, political, and economic aspects (Su et al., 2023).

A few countries have successfully implemented the environmental tax policy. In 1991, the government of Sweden introduced a carbon tax which has been massively credited with significantly reducing greenhouse gas emissions despite sustaining economic growth (Stern, 2020; Jonsson et al., 2020). The Dutch Landfill tax was also introduced in the 1990s and also helped reduce the amount of waste sent to landfills by incentivising recycling and waste reduction practices (Scharff, 2014; Alexander et al., 2008). Also, in 2008, the British Columbia, Canada

government implemented a revenue-neutral carbon tax where all revenues generated are used to reduce other taxes (Murray & Rivers, 2015; Yamazaki, 2017). In recent times, the government of Ghana has introduced the Emissions Levy, which according to projections, should help generate income for government use (Sakah, Diawuo, Katzenbach, & Gyamfi, 2017).

### **2.2.2 Corruption**

Corruption as applied in this study, is broadly defined as misusing public power for personal gain (Transparency International, 2008). According to Susan (1999), corruption is a widespread problem that affects many nations and erodes public confidence in governments, which impedes the growth of the economy.

Generally speaking, corruption is the misuse of official authority for personal benefit (Kurer, 2005). Corruption is a social canker that has several effects on governance. It leads to a vicious cycle of poor governance and further corruption (Fagbadebo, 2007). It reduces government revenue, muddles decision-making, and erodes governmental structures. Corruption also perpetuates inequality, as those with power and influence are more likely to benefit from corrupt practices (Dobel, 1978).

Corruption is also a multidimensional and intricate problem that impedes public trust, institutions, and economic growth (Coetzee, 2014). According to Vargas-Hernández (2013), the World Bank defines corruption as misusing official positions for personal benefit. The essence of how public servants abuse their positions to obtain money or other rewards is encapsulated in this definition.

Finally, a very popular definition of corruption has been provided by Nye (1967), who defines corruption as a behaviour which deviates from the formal duties of a public role because of private

expectations, like wealth or status gains. "The misuse of public power, office, or authority for private benefit" is how the UNDP defines corruption (Aid, 2013). This covers monetary gains and other advantages like influence or authority. These definitions encapsulate that corruption is a wrong practice perpetuated by individuals who seek personal gains over the public interest.

Corruption can occur in various ways, each with unique traits and effects. The main types are bribery, embezzlement, fraud, and nepotism.

Bribery is the act of offering, donating, receiving, or requesting anything of value to sway the decisions of an official or other person in a position of power (Salbu, 1999; Salbu, 2000). One of the most prevalent types of corruption is this one. Bribery can occur in various settings, such as when a business pays a government official to secure a contract or expedite a service. In the private sector, bribery can take the form of kickbacks for preferential treatment (Argandoña, 2003). Bribery distorts decision-making processes, undermines fair competition, and leads to the misallocation of resources. According to an Indian study on bribery by Shleifer and Vishny, (1993), companies frequently use money to get over complicated legal frameworks and speed up procedures. The study found that bribery leads to increased business costs and perpetuates a cycle of corruption.

The second form corruption takes is embezzlement. Embezzlement is the stealing or misappropriating of money or assets committed to one's care, usually by a trusted or authority figure (Cressey, 1986). Embezzlement can occur in both public and private sectors. While private sector workers may embezzle corporate funds for personal use, public officials may misappropriate funds meant for public benefits. Embezzlement depletes public resources, erodes public trust, and hinders development projects and service delivery (Cressey, 1986). Studies on embezzlement in Nigeria revealed government employees' pervasive misuse of public monies (Smith-Hillman,

2007). The study proved that embezzlement seriously impairs development and public service delivery.

Another form corruption takes is fraud.

Fraud involves deceit or trickery used to gain a dishonest advantage, often involving financial gain. Typical instances include forging financial statements, filing fraudulent claims for reimbursement, or exploiting insider knowledge for one's own benefit. Fraud causes financial losses, erodes the integrity of financial systems, and harms organisations' reputations. Dyck et. al., (2010) investigated corporate fraud in the United States. This study revealed numerous cases of financial statement manipulation and insider trading. In order to mitigate fraud, the research stressed the significance of strong regulatory frameworks and transparency.

### **2.2.3 Theoretical Review**

The nexus between natural resource abundance, environmental policy instruments such as environmental taxes, and governance challenges like corruption constitutes a critical area of inquiry, especially within the context of Sub-Saharan Africa (SSA). This region is endowed with vast natural resources but often faces paradoxical developmental outcomes, including persistent poverty, poor environmental management, and weak institutional frameworks. Understanding this complex relationship requires a robust theoretical foundation, notably the Resource Curse Theory, which offers insights into the potential adverse effects of resource wealth on economic and institutional development. This review explores the core tenets of the Resource Curse Theory, its implications for environmental taxation and resource management, and the moderating role of corruption in shaping these dynamics. The Resource Curse Theory, also known as the "paradox of

plenty," originated from observations in the 1980s and 1990s that resource-rich countries often experienced slower economic growth, weaker institutional development, and higher levels of corruption compared to resource-scarce nations (Auty, 1993; Sachs & Warner, 1995). The seminal work of Auty (1993) and later Sachs and Warner (1995) demonstrated empirically that resource abundance could hinder economic diversification and foster economic volatility.

The theoretical foundations of the resource curse suggest that the presence of abundant natural resources can lead to negative economic and institutional outcomes through several interconnected mechanisms. One key aspect is the phenomenon of economic volatility, where reliance on resource exports exposes a country's economy to global commodity price fluctuations, resulting in unpredictable revenue streams that hinder long-term planning and stability (van der Ploeg, 2011). Additionally, resource abundance often precipitates the Dutch Disease, characterized by an appreciation of the real exchange rate that renders other sectors like manufacturing and agriculture less competitive internationally, thereby stifling economic diversification (Corden & Neary, 1982). On the governance front, resource wealth can weaken institutional quality by reducing incentives for governments to implement sound policies, leading to rent-seeking behavior, corruption, and a concentration of power among elites (Ross, 2001; 2015). This rent-seeking diverts resource revenues away from productive investments and public goods, fostering a cycle of weak institutions and poor developmental outcomes. Furthermore, resource dependence can escalate political instability and conflict, as groups vie for control over lucrative resource assets, further undermining state capacity and governance (Collier & Hoeffler, 2004). These mechanisms collectively illustrate how resource wealth, if unmanaged or misgoverned, can paradoxically hinder economic growth, weaken institutions, and exacerbate environmental degradation, forming the core theoretical basis for understanding the resource curse phenomenon.

## 2.2.4 Empirical Review

Recent scholarly debates have increasingly challenged the deterministic view of the resource curse, emphasizing the importance of contextual factors such as institutional capacity, governance quality, and policy choices in shaping resource-rich countries' developmental trajectories (Lujala & Rød, 2019). While early research highlighted a negative correlation between resource abundance and economic growth, newer studies suggest that resource wealth can be harnessed positively when accompanied by strong institutions and sound policies. For instance, countries like Norway and Botswana have demonstrated that resource wealth can promote sustainable development through transparent management, diversification, and investment in human capital, thereby counteracting the adverse effects traditionally associated with resource dependence (Veblen, 2016; Collier & Goderis, 2012). This has led to a more nuanced understanding that the resource curse is not an inevitability but rather a conditional outcome, heavily influenced by governance structures and policy frameworks. Furthermore, recent developments have expanded the scope of the resource curse to include environmental degradation, social inequality, and political instability, recognizing that resource dependence often exacerbates environmental challenges such as deforestation, pollution, and climate change impacts (Le Billon, 2019). These environmental concerns are particularly salient in Sub-Saharan Africa, where resource extraction frequently occurs in fragile ecosystems with limited regulatory oversight (Ross, 2012). Critics also argue that early empirical analyses suffered from methodological shortcomings, such as limited data coverage, selection bias, and failure to account for endogeneity issues—factors that may have overstated the negative effects of resource dependence (Davis et al., 2014). Consequently, contemporary research emphasizes the importance of incorporating governance indicators, institutional quality measures, and political economy analyses to better

understand the complex dynamics at play (Mehlum, Moene, & Torvik, 2006). Moreover, some scholars advocate for a shift away from viewing resource dependence solely through the lens of economic growth, toward understanding its implications for social development, environmental sustainability, and institutional resilience (Humphreys, Sachs, & Stiglitz, 2007). This broader perspective recognizes that resource wealth can be a double-edged sword, offering opportunities for investment and development if managed prudently, but posing risks of environmental degradation, social inequality, and governance failure if mismanaged (Ross, 2015). As such, recent critiques underscore the importance of context-specific analyses and the development of policies tailored to the unique institutional and socio-economic realities of resource-dependent countries—especially in SSA, where governance challenges are pronounced (Bahiigwa, 2014). Therefore, the evolving scholarly discourse underscores that the resource curse is a multifaceted phenomenon influenced by a constellation of factors beyond resource endowment alone. It encourages policymakers and researchers to focus on strengthening institutions, fostering transparency, and implementing sustainable management strategies to unlock the potential benefits of resource wealth while mitigating its pitfalls (Hilson & Murck, 2000).

#### **2.2.4.1 Environmental Taxation and Resource Dependency: Key Issues**

Resource-dependent economies often face significant environmental challenges arising from extractive activities, such as deforestation, pollution, greenhouse gas emissions, and habitat destruction (Levi & Munk, 2020). As these economies seek to balance economic growth with environmental sustainability, environmental taxation emerges as a policy tool aimed at internalizing environmental externalities and reducing harmful resource exploitation (Barker & Köhler, 2018). However, implementing effective environmental taxation in resource-dependent countries presents several complex issues.

One primary concern is tax design and effectiveness. Environmental taxes, such as carbon taxes or resource extraction levies, must be carefully calibrated to incentivize sustainable practices without causing undue economic hardship. In resource-dependent economies, where government revenues heavily rely on resource extraction, introducing or increasing environmental taxes can provoke resistance from industry stakeholders and political actors wary of potential declines in revenue and competitiveness (Liu et al., 2021). For example, Nigeria's attempts to implement environmental levies have faced pushback due to fears of discouraging investment in oil and gas sectors, which form the backbone of the economy (Ogunleye & Adegbe, 2020). Another issue is revenue allocation and policy coherence. The revenues generated from resource taxes need to be transparently reinvested into environmental protection, social development, and economic diversification. Otherwise, resource-rich countries risk resource rent dissipation and policy incoherence, which undermine sustainability goals (Nguyen et al., 2022). For instance, in Ghana, the mismanagement of mineral revenues has limited the impact of environmental taxes on sustainable development, highlighting the importance of institutional capacity and governance (Amoako-Tuffour et al., 2021). Furthermore, the potential for resource curse effects complicates environmental taxation efforts. Countries heavily dependent on resource exports often experience institutional weaknesses, corruption, and governance failures, which impede the effective design and enforcement of environmental taxes (Ross, 2021). Weak institutions may allow for tax evasion, illegal resource extraction, and corruption, undermining environmental objectives and leading to further environmental degradation. Another critical issue is social equity and political acceptability. Environmental taxes can disproportionately affect low-income populations, especially if resource extraction activities are concentrated in poorer regions. Ensuring that taxation policies are socially equitable while achieving environmental targets requires careful

planning, including revenue-sharing mechanisms and social safeguards (Stern et al., 2022). Failure to address social dimensions can lead to social unrest and political instability, further complicating resource management. Lastly, technological and institutional capacity constraints pose significant challenges. Implementing and monitoring environmental taxes require sophisticated institutions, robust data collection, and enforcement mechanisms—capabilities that are often lacking in resource-dependent economies (Mendelevitch & Gass, 2023). Without these capacities, environmental taxation efforts may be ineffective or lead to unintended negative consequences. Importantly, while environmental taxation holds promise as a policy instrument to address the environmental impacts of resource dependence, its success hinges on careful design, transparent revenue management, institutional strength, and social equity considerations. Resource-dependent economies must navigate these complexities to effectively leverage environmental taxes for sustainable development, balancing ecological imperatives with economic and social realities.

#### **2.2.4.2 The Role of Governance and Corruption in Environmental Policy Outcomes**

Effective governance is widely recognized as a critical determinant of successful environmental policy implementation and outcomes. Empirical studies consistently demonstrate that strong institutions, transparent decision-making processes, and accountability mechanisms significantly enhance environmental management (Andrews et al., 2019). For instance, Brinkerhoff and Crosby (2020) found that countries with higher governance quality, which is measured through variables like regulatory quality, rule of law, and control of corruption, tend to achieve better environmental outcomes, such as reduced pollution levels and sustainable resource management. Similarly, Gunningham and Sinclair (2021) highlight that good governance facilitates enforcement of environmental regulations, reduces illegal activities like illegal logging and mining, and promotes sustainable practices across sectors. However, empirical evidence also underscores that weak

governance structures often hinder environmental policy effectiveness. In many resource-dependent economies, institutional weaknesses—such as lack of capacity, political interference, and limited stakeholder participation, corrupt environmental agencies, resulting in policy failures (Bebbington et al., 2020). For example, a study by Fombad (2022) indicated that in several African countries, poor governance correlates with ineffective environmental regulation, leading to environmental degradation despite policy frameworks.

#### **2.2.4.3 Corruption as a Moderator of Environmental Outcomes**

Corruption acts as a significant moderator in the governance-environment nexus, often exacerbating the adverse effects of weak institutions. Empirical research confirms that corruption undermines compliance with environmental laws, diverts funds intended for environmental protection, and encourages illicit resource extraction (Leite & Weidmann, 2018). For instance, in Indonesia, high levels of corruption in forest governance have been linked to rampant illegal logging and deforestation, despite existing policies (Luttrell et al., 2019). Similarly, in Nigeria's oil sector, corruption has been identified as a core factor undermining environmental regulation, leading to oil spills, pollution, and community health issues (Olabisi & Olaniyan, 2020). Quantitative analyses further suggest that corruption weakens the positive impact of governance on environmental outcomes. Fisman and Svensson (2020) demonstrated that in countries with high corruption indices, the expected gains from policy reforms are significantly diminished. This moderation effect indicates that even with relatively sound governance structures, corruption can negate policy effectiveness, emphasizing the need for anti-corruption measures to complement governance reforms. Recent studies advocate for integrated approaches that address both governance weaknesses and corruption to improve environmental management effectively (Khan et al., 2021). For resource-dependent economies, strengthening institutional integrity and reducing

corruption are vital steps toward achieving sustainable environmental outcomes and curbing resource depletion.

The theoretical and empirical literature synthesised above, underscores the pivotal roles of governance and corruption in shaping environmental policy outcomes, particularly in resource-dependent economies. While strong institutions and transparent governance are consistently linked to improved environmental management, pervasive weaknesses and high levels of corruption often undermine policy effectiveness and exacerbate environmental degradation. Despite extensive research, notable gaps remain in understanding the nuanced mechanisms through which governance quality interacts with resource dependency to influence environmental outcomes, especially in developing country contexts where institutional capacity is limited. Again, the moderating role of corruption as a barrier to effective governance requires further exploration to inform targeted reforms. This study is thus critical as it seeks to empirically investigate these complex relationships, addressing the lacunae in existing literature by focusing on how governance and corruption jointly impact environmental policy success, offering insights that are essential for designing context-specific interventions aimed at sustainable resource management and environmental protection.

## **2.3 Data and Methods**

### **2.3.1 Data source and variable measurements**

This study employs panel data from 2000 to 2020 covering 15 countries to examine the moderating effect of control of corruption on natural resource depletion in sub-Saharan Africa. The main dependent variable is natural resource depletion, and the main independent variable is

environmental taxes. Control of corruption is used as the moderating variable in the relationship, and the rest of the variables, i.e., energy use, renewable energy consumption, urbanisation and population density, represent the control variables. The data on environmental tax is gathered from the Organisation of Economic Cooperation and Development (OECD), and the one on control of corruption is obtained from the World Governance indicators.

The remaining variables, i.e., natural resource depletion, energy use, renewable energy consumption, urbanisation and population density, are obtained from World Development Indicators of the World Bank. Natural Resource Depletion refers to the reduction in natural resource availability, including net forest depletion, energy depletion, and mineral depletion. Net forest depletion is calculated by multiplying the unit resource rent by the amount of roundwood harvested that exceeds natural growth. Energy depletion is measured as the ratio of the value of energy resource stocks to the estimated remaining reserve lifetime, with a cap of 25 years. It covers resources such as coal, crude oil, and natural gas. Mineral depletion is similarly calculated as the ratio of the value of mineral resource stocks to their remaining reserve lifetime, also capped at 25 years. It includes minerals like tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate. Environmental taxes are government-imposed charges to reduce environmentally harmful activities carried out by businesses and individuals. These taxes come in various forms: some penalise those who release harmful emissions, while others incentivise environmentally friendly behaviour. Environmental taxes encompass levies on energy, transportation, pollution, and natural resources and are expressed as a percentage of GDP based on total environmental tax revenues. Control of Corruption captures the control of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Estimate gives the country's score on the aggregate

indicator in units of standard normal distribution, i.e., ranging from approximately -2.5 to 2.5. **Energy use** refers to the use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes minus exports and fuels supplied to ships and aircraft engaged in international transport. **Renewable energy consumption** is the share of renewable energy in total final energy consumption. *Urbanisation* is also represented by the urban population as a percentage of the total population. **Population density** is the count of all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin.

### 2.3.2 Model development and estimation strategy

Regarding our a priori expectation, an environmental tax is expected to reduce natural resource depletion by discouraging harmful environmental practices and encouraging more sustainable resource use. However, the effectiveness of this tax may vary depending on the level of governance. Control of corruption is expected to enhance the effectiveness of environmental policies by ensuring that taxes are properly enforced, and revenues are used efficiently, thereby further reducing depletion.

The moderating effect of controlling corruption on the relationship between environmental taxes and natural resource depletion is anticipated to be positive, meaning that stronger control of corruption will make environmental taxes more effective in achieving their goals.

Energy use is expected to increase natural resource depletion, as greater energy consumption, particularly from non-renewable sources, typically leads to faster resource depletion. Conversely,

renewable energy consumption is expected to reduce depletion by replacing non-renewable energy sources with more sustainable alternatives.

Higher population density may have a mixed impact. While it could increase resource pressure, it may also promote more efficient resource use due to economies of scale and greater reliance on urban infrastructure, which tends to be more resource efficient.

In settings with better control of corruption, the positive effects of environmental taxes and renewable energy on reducing resource depletion are likely stronger, as governance quality plays a key role in ensuring that policies are effectively implemented. Thus, control of corruption is expected to amplify the impact of environmental taxes and renewable energy consumption while mitigating the negative effects of energy use.

To estimate the moderating effect of control of corruption on the relationship between environmental tax and natural resource depletion in sub-Saharan Africa, we specify a simplified natural resource depletion function as follows:

$$NRD_{it} = f(\text{Environmental Tax}_{it}, \text{Control of corruption}_{it}, (\text{Environmental Tax}_{it} \times \text{Control of corruption}_{it}), \text{GDP}_{it}, \text{Popudens}_{it}, \text{Urbanisation}_{it}, \text{Energy Use}_{it}, \text{Renewable energy consumption}_{it}) \quad (2.1)$$

where Natural Resource Depletion (NRD) is a function of Control of corruption, GDP, Population density (popudens), energy use and renewable energy consumption. *i* represent individual countries, and *t* represents time (which is the year in this study).

The NRD equation above can be formalised as follows:

$$NRD_{it} = a_0 + a_1 \text{Environmental Tax}_{it} + a_2 \text{Control of corruption}_{it} + a_3 (\text{Environmental Tax}_{it} \times \text{Control of corruption}_{it}) + a_4 \text{GDP}_{it} + a_5 \text{Popudens}_{it} + a_6 \text{Urbanisation}_{it} + a_7 \text{Energy Use}_{it} + a_8 \text{Renewable energy consumption}_{it} + \varepsilon_{it}$$

(2.2)

where  $a_0$  is the intercept of the regression equation, the remaining  $\alpha$ s are coefficients of their associated explanatory variables, and  $\varepsilon$  represents the disturbance term.

For the purpose of empirical estimation, we employ the Two-stage least square estimator as our baseline estimation technique because our dependent variable is continuous and, in estimating the moderating effect of control of corruption on the nexus between environmental tax and natural resource depletion, a key estimation issue that emerges is endogeneity, where the left-hand-side variable (in this case natural resource depletion), is capable of influencing environmental tax, which may result in biased estimates (see Immurana, 2021). that is, natural resource depletion can influence the level or design of environmental taxes. For instance, regions experiencing high rates of resource depletion may implement stricter environmental taxes as a policy response to curb over-exploitation. This creates a simultaneous relationship where environmental taxes are both a cause and a result of natural resource depletion. In this case, the direction of causality is unclear, leading to reverse causality, which introduces endogeneity.

Similarly, there may be a two-way relationship between control of corruption and natural resource depletion. While better control of corruption is expected to reduce natural resource depletion, it is also possible that countries or regions with lower natural resource depletion have stronger institutions and better governance, including better control of corruption. This creates a feedback loop where both variables influence each other simultaneously, making it difficult to determine the causal direction. To deal with these endogeneity issues, this study employs four major econometric solutions such as Two-Stage Least Squares (2SLS), the Instrumental variable

generalised method of moments (IV-GMM), the limited maximum likelihood (LIML) and the fixed effects models for both baseline and robustness purposes. The study employed the first lag of the natural resource depletion as the instrument, which was found to be correlated with the endogenous variables (environmental tax and corruption control) but uncorrelated with the error term in the natural resource depletion equation. Again, the fixed effects model was used to control for unobserved heterogeneity and measurement error, helping to address endogeneity concerns.

To check the suitability of our instruments, we first employ the Hansen J-statistic test of overidentification. Second, we test for under-identification and weak identification using the Anderson canon. Corr. LR statistic and the Cragg-Donald F statistic, respectively. Moreover, we use robust standard errors in this study to control for any possible heteroscedasticity and autocorrelation. In addition, we test for the absence of multicollinearity using the variance inflation factor (VIF) (see Appendix).

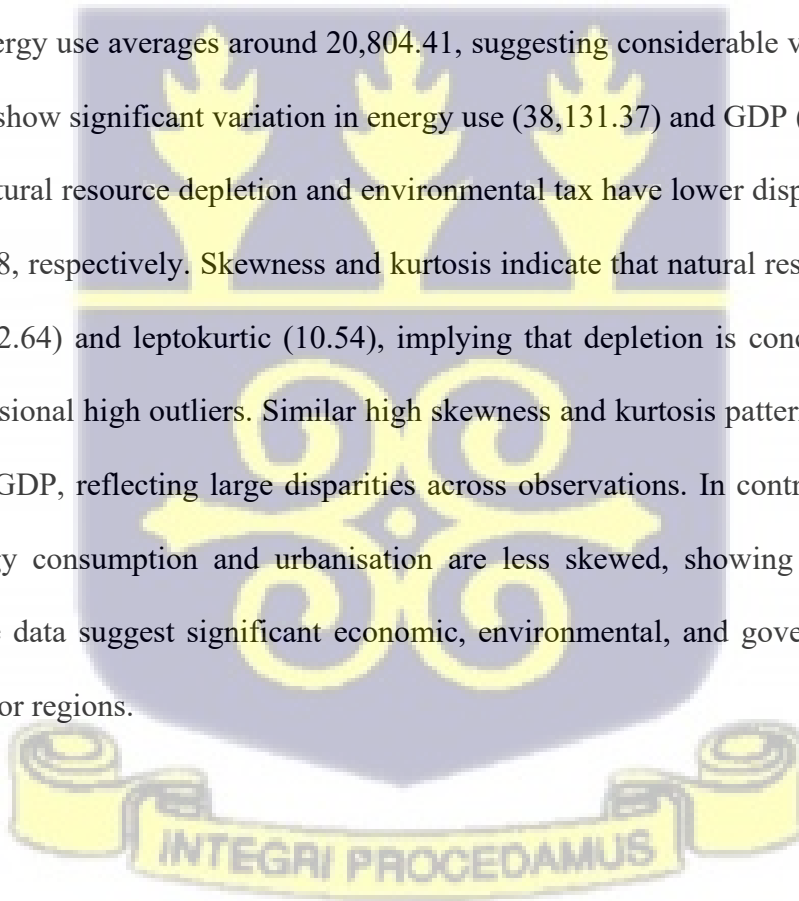
## **2. 4 Empirical Results**

The study in this section presents the results of the data analysis and the discussion of the results.

### **2.4.1 Descriptive Statistics**

The descriptive statistics in Table 2.1 provide an overview of the key variables in the model, including natural resource depletion, environmental tax, control of corruption, and others. The number of observations (N) for most variables is 315, with a slight reduction in sample size for environmental tax and energy use, with 306 and 294 observations, respectively. The minimum values indicate that natural resource depletion is nearly absent in some cases (0.01), while control of corruption can be negative (-3.17), signalling very high corruption in certain instances. For

environmental tax, a negative minimum (-1.24) might suggest rebates or subsidies in place, which could influence resource depletion. The maximum values show that natural resource depletion can reach up to 63.80, while energy use varies widely, up to 174,665.00, suggesting substantial heterogeneity in energy consumption across the observations. Control of corruption has a maximum of 85.19, indicating regions or countries with strong governance frameworks. The interaction term (Environmental tax X Control of corruption) has a maximum of 957.01, highlighting cases where high environmental tax and strong control of corruption coincide. The mean values indicate that, on average, natural resource depletion is relatively low (7.04), while environmental tax and control of corruption have moderate averages at 7.35 and 33.15, respectively. Energy use averages around 20,804.41, suggesting considerable variation. Standard deviations (SD) show significant variation in energy use (38,131.37) and GDP (14,907.08), while variables like natural resource depletion and environmental tax have lower dispersions, with SDs of 10.23 and 6.38, respectively. Skewness and kurtosis indicate that natural resource depletion is highly skewed (2.64) and leptokurtic (10.54), implying that depletion is concentrated at lower values with occasional high outliers. Similar high skewness and kurtosis patterns are observed in energy use and GDP, reflecting large disparities across observations. In contrast, variables like renewable energy consumption and urbanisation are less skewed, showing a more balanced distribution. The data suggest significant economic, environmental, and governance variability across countries or regions.



**Table 2.4. 1: Descriptive Statistics**

Stats	N	Min	Max	Mean	SD	Skewness	Kurtosis
<b>Natural Resource Depletion</b>	315	0.01	63.8	7.04	10.23	2.64	10.54
<b>Environmental Tax</b>	306	-1.24	24.57	7.35	6.38	0.73	2.53
<b>Control of corruption</b>	306	-3.17	85.19	33.15	23.6	0.52	1.91
<b>Environmental tax X Control of corruption</b>	315	-70.14	957.01	222.64	213.72	1.02	3.4
<b>Energy use</b>	294	276.44	174,665.00	20,804.41	38,131.37	2.74	9.94
<b>Renewable Energy Consumption</b>	315	7.72	98.34	65.13	25.41	-0.75	2.39
<b>Urbanisation</b>	315	14.79	92.24	59.1	22.02	-0.26	1.94
<b>Population Density</b>	315	2.18	228.11	64.15	55.92	1.01	3.24
<b>GDP</b>	315	153.59	57,644.50	8,025.07	14,907.08	2.21	6.34

### 2.4.2 Correlation Matrix and Surface Plots

The pairwise correlation matrix provides valuable insights into the relationships between resource depletion, governance, economic, environmental, and demographic factors. Resource depletion shows weak to moderate negative correlations with key variables, including environmental tax (-0.339), population density (-0.167), urbanisation (-0.182), and energy use (-0.276). These negative relationships suggest that higher environmental taxes, greater population density, increased urbanisation, and higher energy consumption are associated with lower levels of resource depletion, potentially reflecting more efficient resource use in well-regulated environments.

The correlation between corruption and resource depletion is almost negligible (-0.021), indicating that corruption might not directly influence resource depletion. However, corruption has a positive but weak correlation with renewable energy (0.310), hinting that countries with higher corruption

may rely more on renewable energy, possibly due to limited fossil-fuel infrastructure or external pressures from international agreements. Environmental tax shows a strong negative correlation with renewable energy (-0.766), suggesting that countries with higher environmental tax rates may have less reliance on renewable energy, perhaps because taxes are used to regulate other environmental aspects or because of challenges in scaling renewable technologies. Furthermore, environmental taxes negatively correlate with population density (-0.389), implying that densely populated regions may face difficulties implementing or enforcing such taxes effectively. GDP displays weak or insignificant correlations with most variables, except for population density (0.558), indicating that wealthier countries tend to have higher population densities, possibly due to urbanisation and economic agglomeration. Interestingly, urbanization shows a weak negative relationship with population density (-0.382), possibly reflecting the dispersal of urban areas rather than concentrated population growth. Energy use is positively correlated with environmental tax (0.351), suggesting that countries with higher energy consumption tend to impose environmental taxes, potentially as a measure to regulate emissions. However, energy use is negatively associated with renewable energy (-0.461), indicating that heavy energy users may still rely more on non-renewable energy sources. The results underscore the complex interplay between environmental policies, economic activity, governance, and resource use, highlighting the need for integrated policy frameworks to address resource depletion effectively.

The Variance Inflation Factor (VIF) values, as shown in Table 2.4.2, suggest that multicollinearity is not an issue among the independent variables. Typically, VIF values above 10 indicate problematic multicollinearity, but the highest VIF is 4.98 for **Control of Corruption**, which is within acceptable limits. The interaction term (**Environmental tax x Control of Corruption**) has a VIF of 4.22, which implies some correlation between the variables in the interaction, but it is

still manageable. Variables like **GDP** (2.14) and **Energy Use** (1.4) exhibit low VIFs, suggesting minimal multicollinearity issues. With a mean VIF of 3.07, the model seems well-specified, and collinearity does not appear to pose a significant threat to the reliability of the regression estimates.

**Figure 2.4. 1: Pairwise Correlation Matrix**

<b>Pairwise correlations</b>								
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Resource depletion	1.000							
(2) Corruption	-0.021	1.000						
(3) Environmental tax	-0.339	-0.101	1.000					
(4) GDP	0.008	-0.110	-0.081	1.000				
(5) Population density	-0.167	0.193	-0.389	0.558	1.000			
(6) Urbanisation	-0.182	-0.079	0.063	0.000	-0.382	1.000		
(7) Energy use	-0.276	-0.148	0.351	-0.216	-0.132	0.138	1.000	
(8) Renewable energy	0.191	0.310	-0.766	0.077	0.320	-0.142	-0.461	1.000

**Table 2.4. 2: Variance Inflation Factor**

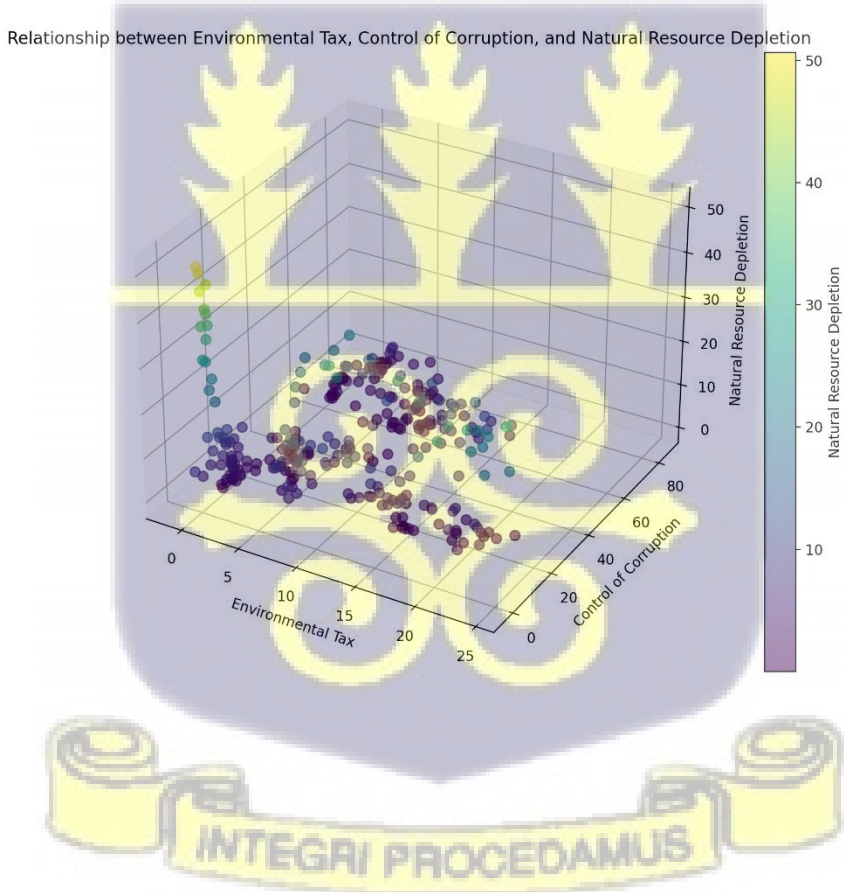
Variable	VIF	1/VIF
Control of Corruption	4.98	0.20072
Environmental tax x Control of corruption	4.22	0.237246
Environmental tax	3.47	0.288528
Renewable Energy	3.43	0.291808
Population Density	3.13	0.319621
GDP	2.14	0.467319
Urbanisation	1.77	0.564199
Energy Use	1.4	0.712877
<b>Mean VIF</b>	<b>3.07</b>	

**Visual Checking of Variables of Interest**

The 3D scatter plot shows the relationship between Environmental Tax, Control of Corruption, and Natural Resource Depletion. Data points are concentrated in the lower ranges of Environmental Tax, with only a few reaching high levels. High Natural Resource Depletion, represented by yellow, is relatively rare across the plot. Most instances of high depletion occur at

lower levels of Control of Corruption. A general trend shows that stronger Control of Corruption tends to be associated with lower Natural Resource Depletion. Environmental Tax levels do not show a clear pattern in relation to resource depletion. The dispersion of points indicates no strong relationship between Environmental Tax and Control of Corruption. The colour scale suggests that high depletion rates are isolated rather than common. Overall, better Control of Corruption appears to help reduce Natural Resource Depletion. This plot highlights the potential of corruption control as an effective means to preserve natural resources.

**Figure 2.4.1: Three-D Surface plot of key variables of interest**



### 2.4.3 Regression Results and Discussion

The results from the four models i.e., Two-Stage Least Squares (2SLS), Fixed Effects (FE), IV-GMM, and IV-LIML—examine the moderating effect of control of corruption on the relationship between environmental tax and natural resource depletion in sub-Saharan Africa. In the 2SLS model, environmental tax shows a strong positive impact on natural resource depletion, with a coefficient of 1.500 ( $p < 0.01$ ), indicating that higher environmental taxes, on their own, are associated with increased depletion. Control of corruption, however, has a significant negative effect, with a coefficient of -0.323 ( $p < 0.05$ ), suggesting that better governance can reduce resource depletion. More importantly, the interaction term (environmental tax X control of corruption) is negative (-0.024,  $p < 0.10$ ), which means that the effect of environmental tax on depletion decreases when control of corruption improves. This suggests that stronger corruption controls can mitigate the otherwise harmful impact of environmental taxes on resource depletion. Other control variables like energy use and urbanisation are significant, but the focus remains on how control of corruption moderates the tax-depletion nexus.

In the Fixed Effects (FE) model, the environmental tax remains significant but with a much smaller effect (0.249,  $p < 0.01$ ), which could reflect the impact of unobserved heterogeneity between countries. The coefficient for control of corruption is no longer significant, suggesting that once fixed country-specific effects are controlled for, corruption may not play as direct a role in resource depletion. However, the interaction term (environmental tax X control of corruption) remains negative and highly significant (-0.006,  $p < 0.01$ ), reinforcing the idea that corruption control still moderates the tax-depletion relationship, albeit weaker than in the 2SLS model. The lower value of the interaction term suggests that in countries with better corruption controls, the effect of environmental tax on resource depletion is further reduced. Control variables like renewable

energy and population density lose significance, reflecting the strength of the fixed effects model in accounting for unobserved heterogeneity.

In the IV-GMM model, environmental tax shows a significant positive effect on natural resource depletion (1.568,  $p < 0.01$ ), reinforcing the earlier findings that environmental taxes, when isolated, tend to be associated with higher resource depletion. The coefficient for control of corruption is again negative and significant (-0.297,  $p < 0.05$ ), indicating that better governance reduces depletion. More importantly, the interaction term (environmental tax X control of corruption) remains negative (-0.027,  $p < 0.05$ ), suggesting a more pronounced moderating effect in this model. This result suggests that the joint presence of environmental tax and corruption control reduces depletion, possibly indicating that environmental taxes may fail to achieve their intended outcomes without good governance. The controls remain consistent, with energy use having a positive effect and urbanisation a negative effect.

Finally, the IV-LIML model produces results similar to IV-GMM. The coefficient for environmental tax remains significant at 1.530 ( $p < 0.01$ ), confirming its robust positive relationship with natural resource depletion. Control of corruption continues to exert a significant negative effect (-0.326,  $p < 0.05$ ), supporting the idea that better corruption controls are key to reducing resource depletion. The interaction term (environmental tax X control of corruption) remains negative and significant (-0.024,  $p < 0.10$ ), reinforcing the conclusion that improved governance mitigates the negative effects of environmental taxes on resource depletion. Once again, the control variables behave as expected, with energy use increasing depletion and population density reducing it.

The above results suggest that, the conceptual link between corruption, resource depletion, and environmental tax policies is rooted in the way corruption undermines the efficacy of

environmental measures designed to promote sustainable resource use. Corruption can facilitate tax evasion and the diversion of environmental tax revenues, thereby reducing the financial incentives for firms and individuals to reduce their resource consumption or pollution emissions. Furthermore, corrupt practices weaken enforcement mechanisms, allowing violators to bypass regulations and continue exploitative practices unchecked. This erosion of regulatory integrity ultimately exacerbates resource depletion, as the intended deterrent effects of environmental taxes are diminished. Empirical studies support this conceptual framework; for example, Torgler (2007) demonstrates that corruption correlates negatively with tax compliance, including environmental taxes, and that high corruption levels are associated with increased environmental degradation. Similarly, Bratberg et al. (2015) find that in countries with weak institutions, environmental taxes are less effective in curbing resource exploitation, emphasizing that corruption significantly diminishes the environmental benefits of taxation and accelerates resource depletion. These findings underscore the critical need to address corruption as a fundamental barrier to achieving the goals of environmental taxation policies.

Similar findings have been observed in the literature where corruption control moderates the relationship between environmental policies and outcomes. For example, Pellegrini and Gerlagh (2006) found that better governance strengthens the effectiveness of environmental policies in reducing resource depletion. Likewise, Cole (2007) highlighted that without strong institutions to enforce environmental taxes, their impact on reducing environmental degradation is limited. Other studies also support the moderating role of governance in environmental policy effectiveness. Damania et al. (2003) show that corruption weakens environmental regulation enforcement, reducing the effectiveness of environmental taxes. Lopez and Mitra (2000) found that countries with stronger institutions achieve better outcomes in controlling resource depletion when

implementing environmental policies. Fredriksson and Svensson (2003) argue that political instability and weak governance dilute the impact of environmental taxation. Torgler and Schneider (2007) demonstrate that higher levels of corruption lead to worse environmental outcomes, even with environmental regulations in place. Finally, Leitão (2010) found that corruption control positively moderates the relationship between environmental regulation and environmental performance across countries.

In summary, across all models, the moderating role of control of corruption is consistently negative and significant, suggesting that stronger governance reduces the adverse effects of environmental taxes on natural resource depletion. While environmental tax alone is associated with higher depletion, its impact is moderated by good governance, highlighting the importance of anti-corruption measures in ensuring that environmental policies achieve their intended outcomes. The findings suggest that environmental taxes may not effectively reduce natural resource depletion without proper control of corruption. The consistency of this result across multiple estimation techniques highlights its robustness. Control variables like energy use and urbanisation maintain significant effects, but the key takeaway is the critical role of governance in moderating the relationship between environmental policy and resource outcomes.

**Table 2.4. 3: The moderating effect of control of corruption on the nexus between environmental tax and natural resource depletion in sub-Saharan Africa.**

	TWO-STAGE	FIXED EFFECTS	IV-GMM	IV-LIML
<b>GDP</b>	0.001*** (0.000)	-0.000 (0.000)	0.001*** (0.000)	0.001*** (0.000)
<b>Environmental tax</b>	1.500*** (0.361)	0.249*** (0.069)	1.568*** (0.359)	1.530*** (0.372)
<b>Control of corruption</b>	-0.323** (0.128)	-0.007 (0.028)	-0.297** (0.128)	-0.326** (0.130)

<b>Environmental tax X Control of corruption</b>	-0.024*	-0.006***	-0.027**	-0.024*
	(0.013)	(0.002)	(0.013)	(0.013)
<b>Energy Use</b>	0.000***	0.000	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
<b>Renewable Energy</b>	-0.132*	-0.044	-0.129*	-0.135*
	(0.071)	(0.037)	(0.072)	(0.072)
<b>Urbanisation</b>	-0.419***	-0.002	-0.405***	-0.426***
	(0.086)	(0.050)	(0.088)	(0.088)
<b>Population Density</b>	-0.354***	-0.032***	-0.350***	-0.359***
	(0.063)	(0.012)	(0.064)	(0.064)
<b>_cons</b>	54.587***	10.656**	52.492***	55.277***
	(13.027)	(4.498)	(13.272)	(13.172)
<b>N</b>	251	285	251	251
<b>N_g</b>		15.000		
<b>r2</b>	-2.739	0.157	.	.
<b>r2_o</b>		0.000		
<b>F</b>	5.536	6.122		
<b>chi2</b>			45.368	44.627
<b>p</b>	.	0.000	0.000	0.000
<b>Fp</b>	0.000			
<b>idstat</b>	43.599			
<b>idp</b>	0.000			
<b>cdf</b>	22.859			
<b>rkf</b>				
<b>j</b>	1.326			
<b>jp</b>	0.250			
<b>estat</b>	25.839			
<b>estatp</b>	0.000			

Standard errors in parentheses

+  $p < 0.10$ , \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

## 2.5 Conclusions and Policy Implications

The chapter investigates the moderating role of control of corruption on the relationship between environmental tax and natural resource management in sub-Saharan Africa, using different estimation strategies. The results show that while environmental tax is associated with higher natural resource depletion, strong governance (measured by control of corruption) significantly reduces this adverse impact. This suggests that without proper institutional frameworks to enforce

environmental taxes, these policies might fail to achieve their intended purpose or exacerbate environmental degradation. The moderating effect of control of corruption across all models reveals that environmental taxes are more effective in curbing resource depletion in countries with better governance. The results align with the hypothesis that governance plays a crucial role in the success of environmental policies. Environmental taxes may be evaded or misused without mechanisms to prevent corruption, leading to increased natural resource depletion rather than conservation. Moreover, control variables like energy use, urbanisation, and population density were found to significantly affect natural resource depletion, indicating that broader structural factors need to be considered when formulating environmental policies. For instance, high energy use consistently leads to greater depletion, while urbanisation and population density have mixed effects, suggesting that development patterns also play a role in resource management. From a methodological standpoint, instrumental variable techniques (IV-GMM and IV-LIML) helped address potential endogeneity issues, particularly regarding GDP and environmental tax, ensuring that the relationships observed were not driven by reverse causality or omitted variable bias. The robustness of the findings across different econometric models lends credibility to the conclusion that controlling corruption is critical in making environmental taxes effective. Regarding policy implications, governments in sub-Saharan Africa should prioritise anti-corruption measures to make environmental taxes work in reducing natural resource depletion. Policies designed to enhance transparency, strengthen institutions, and reduce rent-seeking behaviour can improve the efficacy of environmental taxation. Additionally, complementary policies that address energy efficiency and promote renewable energy should be considered to reduce dependency on non-renewable resources. Furthermore, international organisations and development partners could focus on supporting governance reforms as part of their environmental aid programs, recognising

that without strong institutions, environmental taxes may be insufficient to drive sustainable outcomes. Policymakers should also consider the broader socio-economic context, including urbanisation trends and energy use patterns when designing comprehensive environmental policies. The chapter thus underscores the importance of governance in achieving environmental goals. Stronger corruption controls improve the effectiveness of environmental taxes and promote sustainable resource management. Going forward, both environmental policies and anti-corruption strategies need to be integrated for long-term environmental sustainability in sub-Saharan Africa.



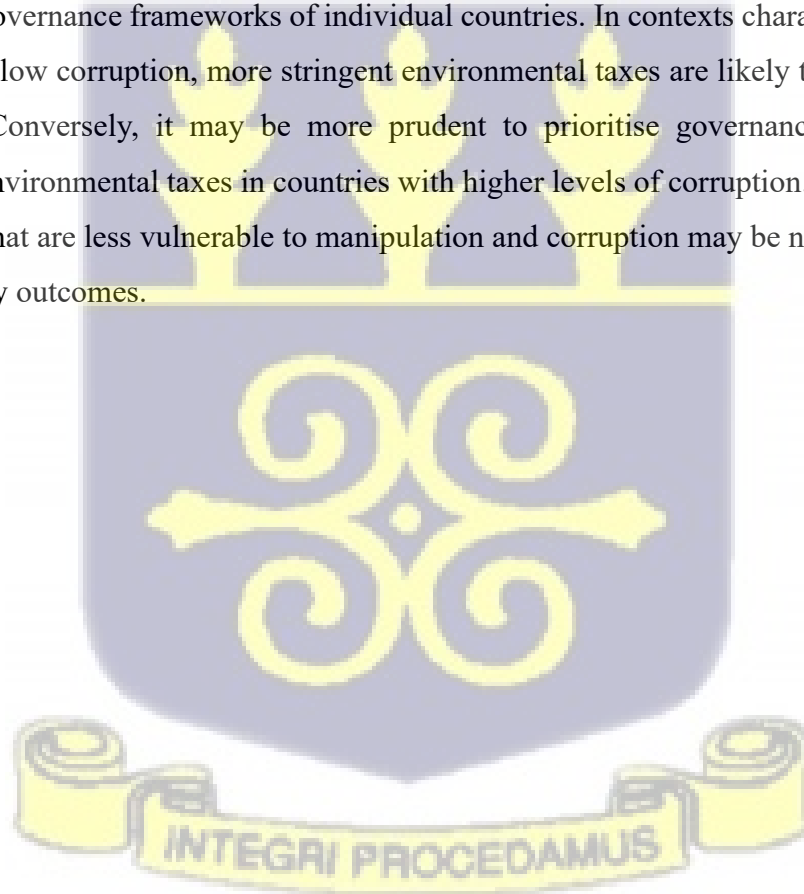
## CHAPTER THREE

### THE EFFECT OF CORRUPTION ON THE RELATIONSHIP BETWEEN ENVIRONMENTAL TAX AND GREEN GROWTH FOR SUB-SAHARAN AFRICAN COUNTRIES



## Abstract

This chapter examines the effect of control of corruption on the relationship between environmental tax and green growth in sub-Saharan Africa. Using the Moments Quantile Regression (MMQR) method with fixed effects, with panel data from 15 countries spanning 2000 to 2020, the results show that the moderating effect is insignificant at the lowest quantile. However, it becomes increasingly significant and positive in higher quantiles, with the highest impact observed in quantile 9, where the coefficient is significant. This demonstrates that the synergistic effect of environmental tax and good governance in regions with higher green growth is particularly significant in driving further green growth. The findings suggest that a standardised, one-size-fits-all approach to environmental taxation may be unsuitable for sub-Saharan Africa. Due to the region's heterogeneous levels of corruption, environmental tax policies must be adapted to the specific governance frameworks of individual countries. In contexts characterised by strong governance and low corruption, more stringent environmental taxes are likely to be both feasible and effective. Conversely, it may be more prudent to prioritise governance reforms before implementing environmental taxes in countries with higher levels of corruption. Alternatively, tax policy designs that are less vulnerable to manipulation and corruption may be necessary to ensure successful policy outcomes.



### 3.1 Introduction

The relationship between environmental policies, such as environmental taxes, and economic growth, particularly green growth, is central to sustainable development. In Sub-Saharan Africa, a region rich in natural resources but facing environmental degradation and socio-economic challenges, understanding the interplay between environmental policies and green growth is particularly relevant. Environmental taxes are fiscal tools to reduce environmental harm by taxing activities contributing to pollution or resource depletion. In theory, these taxes incentivise businesses and individuals to adopt greener practices, which could help Sub-Saharan Africa achieve sustainable growth. However, these benefits rely heavily on effective policy implementation, which is often undermined by governance issues, including corruption (Dam et al., 2024; Hutajulu et al., 2024; Tawiah et al., 2024).

Green growth, which fosters economic development while protecting natural resources, is essential for Sub-Saharan African countries. These economies often depend on agriculture and natural resources, so green growth strategies are crucial for sustainability and resilience against climate change (Khan et al., 2022; Yu et al., 2022; Tang et al., 2022; Barros et al., 2021). For this region, green growth also presents opportunities for poverty reduction, economic diversification, and climate resilience, creating a sustainable pathway for future generations. However, corruption is a significant barrier in many of these countries and can weaken the efficacy of environmental taxes. If companies can evade taxes through corrupt practices, the intended incentives for sustainable behaviour are undermined, reducing the positive impact on green growth (Chen et al., 2023). Therefore, the effectiveness of environmental taxes is likely to be lower in countries with high levels of corruption, where resources may be misappropriated instead of funding environmental protection initiatives (Razzaq et al., 2023; Kwilinski, 2023; Zhang & Crooks, 2012).

Good governance—characterised by transparency, accountability, and control of corruption—is essential to the success of environmental policies. In Sub-Saharan Africa, enhancing the control of corruption can strengthen the effectiveness of environmental taxes. Improved governance ensures that tax revenues are used efficiently and that regulatory frameworks are enforced, amplifying the positive effects of environmental taxes on green growth by promoting sustainable practices. Nonetheless, implementing environmental taxes in this region faces additional challenges, such as limited administrative capacity, lack of public awareness, and potential resistance from certain industries. These issues underscore the need for policy interventions tailored to the specific socio-economic conditions and governance structures in Sub-Saharan Africa.

Empirical studies show mixed results regarding the relationship between environmental taxes, corruption, and green growth (Muhammad et al., 2021). In countries with high corruption, environmental taxes often fail to reduce emissions and promote green growth effectively, while in countries with low levels of corruption, such taxes have a stronger positive impact (Ghosh, 2020; Ashford et al., 2020). This indicates that corruption can significantly diminish the effectiveness of policies that support sustainable development in Sub-Saharan Africa. For environmental taxes to contribute effectively to green growth in this region, improving governance and reducing corruption are essential (Chen et al., 2018; Zhou & Li, 2021). Policies that strengthen the rule of law increase transparency and enhance institutional capacity, creating an environment where environmental taxes can be successfully implemented.

International organisations and donors can support Sub-Saharan African countries in controlling corruption and implementing effective environmental policies by providing technical and financial

assistance (Incoom, 2024; Guo et al., 2024; Occhiali, 2024). These efforts can help build institutional capacity, improve regulatory frameworks, and promote accountability, complementing domestic anti-corruption initiatives and enhancing the region's ability to achieve green growth through environmental taxation. Thus, the relationship between environmental tax and green growth in Sub-Saharan Africa is significantly influenced by corruption control. Strengthening institutions and promoting transparency are crucial to maximising the potential of environmental taxes to foster sustainable development and green growth. This issue is critical for policymakers addressing Sub-Saharan Africa's unique environmental and economic challenges.

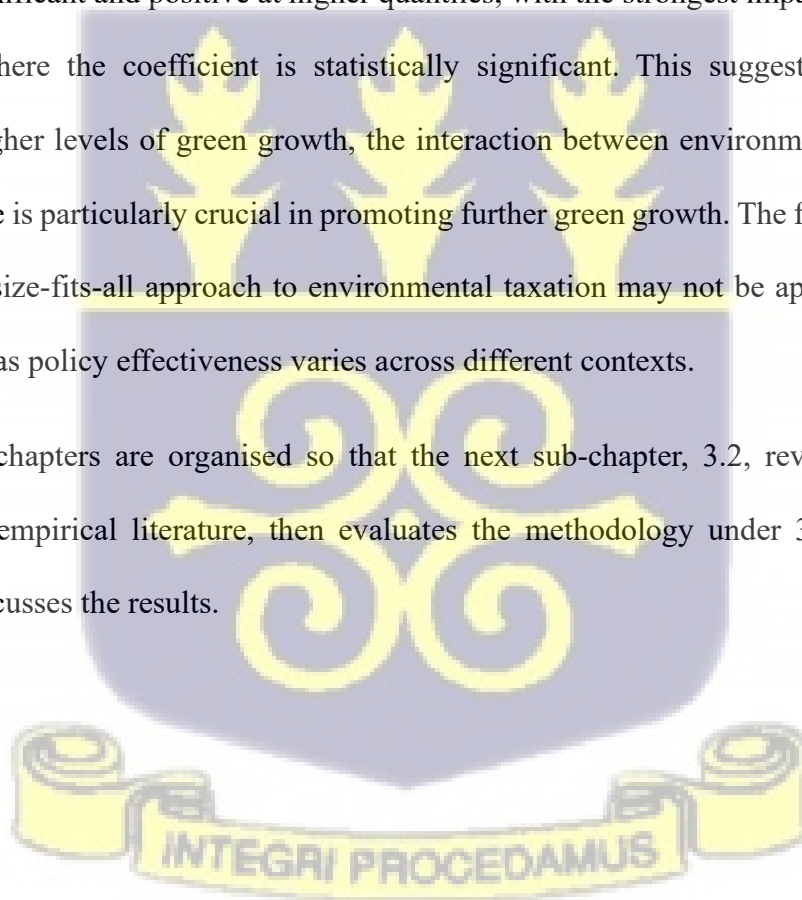
Previous literature, despite being very scanty, has only looked at the nexus between environmental tax and green growth separately (Chien et al., 2021; Hao et al., 2021a; Sun et al., 2022), and corruption and green growth also separately (Tawiah et al., 2024; Ganda, 2020; Hao et al., 2021b; Sun et al., 2022; Zeeshan et al., 2022).

A more insightful discourse that links the two separate but related hypotheses in the literature is missing. Studying these two factors independently may overlook the complex interactions that arise when policies and institutional factors are considered simultaneously. The interaction between environmental tax and corruption is particularly important because corruption can undermine the effectiveness of environmental taxes. In countries with weak governance, environmental taxes might not achieve their intended purpose, as tax revenues may be misappropriated, or enforcement may be compromised. On the other hand, in countries with low corruption, environmental taxes can more effectively drive green investments and reduce pollution, thereby promoting green growth. Moreover, corruption can create regulatory loopholes that allow firms to evade environmental taxes or comply superficially, limiting such policies'

environmental and economic benefits. Therefore, an empirical analysis of their combined effect is essential to understand how governance quality influences the effectiveness of environmental taxes and, in turn, affects green growth outcomes. This integrated approach provides deeper insights for policymakers, enabling the design of context-specific strategies that account for governance challenges while fostering sustainable development. Therefore, based on the above, this chapter examines the joint effect of environmental tax and control of corruption on green growth in 15 sub-Saharan African counties using panel data from 2000-2020.

The results indicate that the moderating effect is not significant at the lower quantiles but becomes increasingly significant and positive at higher quantiles, with the strongest impact observed at the 9th quantile, where the coefficient is statistically significant. This suggests that in regions experiencing higher levels of green growth, the interaction between environmental taxation and good governance is particularly crucial in promoting further green growth. The findings imply that a uniform, one-size-fits-all approach to environmental taxation may not be appropriate for sub-Saharan Africa, as policy effectiveness varies across different contexts.

The remaining chapters are organised so that the next sub-chapter, 3.2, reviews the relevant theoretical and empirical literature, then evaluates the methodology under 3.3, and then 3.4, presents and discusses the results.



## 3.2 Literature Review

### 3.2.1 Theoretical Review

#### 3.2.1.1 Double dividends theory and green growth in Sub-Saharan Africa

Encouraging economic expansion and development while ensuring that natural resources continue to deliver the environmental services essential to our well-being, green growth is a strategy for attaining sustainable development (Adamowicz, 2022). The Organization for Economic Co-operation and Development (OECD) defines green growth as fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies (OECD, 2011).

Green growth is critical in Sub-Saharan Africa (SSA) because of the region's high reliance on natural resources, susceptibility to climate change, and socioeconomic difficulties (Mohammed et al., 2013). According to the double dividends idea, green taxes and other environmental policies can have positive effects on the economy and the environment. This review examines the connections between these ideas and how they affect SSA.

The double dividends hypothesis posits that environmental taxes have the potential to produce two distinct benefits: a reduction in pollution that benefits the environment and a reduction in other taxes that distort the economy (Goulder, 1995). The immediate benefit to the environment from less pollution is the first dividend. This is achieved by internalising the external pollution costs, leading to a decrease in environmentally harmful activities (Meade, 1973). The second dividend is the possible financial gain from lowering other taxes that distort the money raised by these levies (Meade, 1973).

The theoretical underpinnings, empirical support, and policy implications of the double dividend hypothesis are examined in this literature review. David Pearce first proposed the idea of a "double dividend" by claiming that environmental levies could positively affect the economy and the environment. These taxes can improve environmental quality by resolving market failures related to environmental externalities, and the money raised can be utilised to offset other taxes that stifle free enterprise (Pearce, 1991). Bovenberg and de Mooij (1994) examined the relationship between environmental taxes and the larger tax system in one of the foundational studies on the double dividend concept. They discovered a "tax interaction effect," according to which imposing an environmental tax could worsen already-existing tax distortions and, hence, partially negate any economic gains (Bovenberg & De Mooij, 1994). The double dividend hypothesis presents a compelling case for environmental taxes as tools for achieving both environmental and economic benefits. Goulder (1995) thoroughly analysed numerous papers on the double dividend concept.

The studies concluded that although the economic dividend is more debatable and heavily reliant on the particular context and structure of the tax system, the environmental dividend is typically backed by empirical data. Although environmental taxes have successfully lowered emissions, the economic benefit varies greatly based on the current tax structures and how the revenue is allocated (Ekins & Speck, 2011). The economic dividend, however, has produced conflicting results; while some research suggests a limited impact on overall economic efficiency, others show beneficial effects on employment and growth.

Reducing pollution and environmental damage is the main advantage of green taxes. Carbon taxes, for instance, can encourage reduced carbon emissions, improve air quality, and reduce the effects of climate change. The secondary benefit arises when the revenue from environmental taxes is

used to reduce other distortionary taxes or fund public goods, potentially leading to higher economic efficiency and growth (Goulder, 1995). Implementing carbon taxes in SSA can help reduce greenhouse gas emissions while generating revenue. For instance, South Africa introduced a carbon tax in 2019 to curb emissions and fund sustainable development projects (World Bank, 2019). The effective use of revenue from environmental taxes is crucial. Funds can be used to reduce taxes on labour and capital, invest in renewable energy, or improve public services, thereby achieving both environmental and economic benefits.

According to Heine and Black (2019), the double dividend theory assumes that implementing environmental taxes will reduce negative environmental externalities and that the revenue generated from these taxes will be invested in environmentally beneficial projects.

A critical evaluation of the central assumption of double dividend theory reveals that the suggestion that environmental taxes could not only help reduce negative externalities but also provide other benefits, such as improving economic efficiency, is saddled with limitations that must be acknowledged.

Environmental taxes alone may not be sufficient to promote green growth and reduce emissions (Yu et al., 2023). Multiple factors work together to drive sustainable development (Hao et al., 2020). Wolde-Rufael and Mulat-Weldemeskel (2023) postulated that the effectiveness of environmental levies in accomplishing their intended environmental goals might be restricted or enhanced by other variables. These highlight the complicated and diverse character of environmental taxation and the importance of carefully considering various issues (economic, technological, political) when determining its potential impact of ensuring effectiveness and sustainability (He et al., 2023). Kou et al. (2021) argue that, despite environmental taxes helping

to reduce negative environmental externalities, other elements, such as environmental technology and control of corruption, contribute positively to the process of environmental taxes achieving their intended goals. The institutional, technological and economic environment determines whether green taxes are successful and double dividends are realised. Policies must be adapted to the opportunities and problems that Sub-Saharan Africa presents (Dabor et al., 2024).

This chapter's application of this theory relates to the expected outcome of environmental tax on natural resources. Environmental tax is expected to propel natural resources by putting a price on polluting products. The environmental polluting behaviours are expected to dwindle to enhance the quality of the environment. At the same time, the revenues generated could be rechanneled to growth prospective areas to improve economic growth and welfare.

One major theoretical contribution of this study is the extension and empirical testing of assumptions relating to the double dividend theory, which has been employed to provide theoretical bases for linking environmental tax and green growth.

Evidence from this study could extend the practicality of the double dividend theory's foundational position by investigating how controlling corruption could enhance the intended objectives of the rollout of an environmental tax on green growth.

### **3.2.2 Empirical Review**

The relationship between environmental taxation, control of corruption, and green growth in Sub-Saharan Africa is complex and requires a nuanced understanding of the region's socio-economic and political contexts. Environmental taxes are designed to encourage sustainable practices and

reduce environmental degradation, while effective governance and corruption control are essential to successfully implementing such policies. This empirical review synthesises existing literature to explore how the control of corruption influences the effectiveness of environmental taxes in promoting green growth across Sub-Saharan African countries.

Environmental taxation is a critical tool for promoting green growth by incentivising businesses and individuals to adopt environmentally friendly practices (Dokholyan et. al., 2024). However, the effectiveness of these taxes is significantly influenced by the governance structures in place, particularly the control of corruption. Corruption can undermine the intended effects of environmental taxes by diverting funds, misallocating resources, and creating an environment where compliance is not enforced (Damania et. al., 2020). Studies have shown that countries with higher levels of corruption tend to experience less effective environmental policies, as corrupt practices can lead to tax evasion and reduced public trust in governmental institutions (Houngbédji & Bassongui, 2023; Kamasa et al., 2019; Busse et al., 2016). This relationship is particularly pronounced in Sub-Saharan Africa, where governance challenges are prevalent.

### **3.2.2.1 Environmental tax policies**

Environmental tax policies are levies governments impose on a financial basis to mitigate negative environmental effects and promote ecologically beneficial conduct (Mpofu, 2022). These policies impose taxes on activities that damage the environment in an effort to internalise the external costs of pollution and environmental degradation. By promoting sustainable practices, these policies seek to address market failures linked to environmental externalities (Reinhardt, 1999). These policies are fiscal measures implemented by governments to promote sustainable development and

reduce environmental peripheries (Adams, 2008). Government taxes incentivise businesses and individuals to adopt more environmentally friendly practices (Prakash, 2002). These taxes promote emission reduction, resource conservation, and general improvement of environmental quality by internalising the external costs of environmental harm. Environmental taxes as “compulsory, unrequited payments to the government, levied on tax bases deemed to be of a particular environmental relevance.” Tan et al. (2022) defined environmental taxes as “levies on the emission of pollutants or on goods whose use produces such emissions, as well as taxes on natural resources or land use designed to internalise the environmental costs of activities.

According to Panaiotov (1994), the World Bank defines environmental taxes as financial tools intended to incentivise companies and people to use fewer resources, cut emissions, and adopt greener practices to lessen their environmental impact. By encouraging ecologically friendly behaviours and practices, these definitions emphasise environmental tax policies' roles in correcting market failures associated with environmental externalities and advancing sustainable development.

The conception and application of environmental tax laws differ greatly. Carbon, energy, and waste disposal taxes are common environmental tax types (Tan et al., 2022). Governments can effectively promote sustainable development and eliminate environmental externalities by carefully crafting environmental tax policies that consider social, political, and economic aspects (Su, Qamruzzaman, & Karim, 2023). A few countries have successfully implemented the environmental tax policy. In 1991, the government of Sweden introduced a carbon tax which has been massively credited with significantly reducing greenhouse gas emissions despite sustaining economic growth (Sterner, 2020; Jonsson, Ydstedt, & Asen, 2020). The Dutch Landfill tax was

also introduced in the 1990s and also helped reduce the amount of waste sent to landfills by incentivising recycling and waste reduction practices (Scharff, 2014; Alexander, Ingo, & Tojo, 2008). Also, in 2008, the British Columbia, Canada government implemented a revenue-neutral carbon tax where all revenues generated are used to reduce other taxes (Murray & Rivers, 2015; Yamazaki, 2017). In recent times, the government of Ghana has introduced the Emissions Levy, which, according to projections, should help generate income for government use (Sakah, Diawuo, Katzenbach, & Gyamfi, 2017).

Environmental tax policies have a variety of objectives, attempting to solve various environmental, social, and economic issues (Smith, 2014). These policies are vital to the shift towards a more sustainable and fair future because they internalize external costs, encourage sustainable development, lower pollution, and foster innovation.

One objective, as defined by Nguyen, Laratte, Guillaume, and Hua (2016), is to internalize environmental externalities. By representing the social costs of pollution and resource depletion in market pricing, environmental taxes seek to represent the true cost of economic activity. The idea that "polluter pays" underpins this (Smith, 2014; Fullerton, Leicester, & Smith, 2008).

Another objective of environmental tax policies is to promote sustainable development (Mpofu, 2022; Mathieu-Bolh, 2017). This objective encourages activities that are sustainable in the long term. This is achieved by encouraging the preservation of natural resources and the development of renewable energy sources by raising the cost of ecologically detrimental activities and rewarding sustainable ones (Omer, 2008).

Environmental tax policies also encourage innovation and adoption of green technologies (Karmaker, Hosan, Chapman, & Saha, 2021). By raising the price of traditional, polluting

technologies, environmental levies stimulate the market for green technologies by encouraging the development and use of cleaner alternatives (Dutz & Sharma, 2012). This stimulates the development and use of environmentally friendly technologies and methodologies.

Decreasing the over-dependence on non-renewable energy resources was one of the objectives of environmental tax policies identified by Afshan, Ozturk, and Yaqoob (2022). Carbon emissions and fossil fuel usage taxes boost the competitiveness of renewable energy sources and hasten the shift to a low-carbon economy (Wang, Sami, Khan, Alamri, & Zaidan, 2023).

Countries can show leadership and dedication to international environmental agreements, like the Paris Agreement, by enacting environmental levies, and they can also inspire other countries to follow suit (Weiss & Jacobson, 2000). In that vein, another objective of environmental tax policies is to foster global environmental responsibility. This objective is also backed by the works of Yang and Percival, (2009).

Another objective of environmental tax policies is to improve public health. These policies reduce health risks associated with pollution and environmental degradation (Omodero, 2022; Haines et al., 2009). Lower pollution levels increase the quality of the air and water, which can benefit public health by lowering medical expenses and improving quality of life.

Countries implement environmental tax policies to encourage innovation and the adoption of green technologies. This is to stimulate the development and use of environmentally friendly technologies. By raising the price of traditional, polluting technologies, environmental levies stimulate the market for green technologies by encouraging the development and use of cleaner alternatives (Akhtar et al., 2022; Yi, Wang, Fu, & Li, 2022).

Perhaps the most important of all the objectives is the generation of internal revenue for environmental and social programs. Governments can raise funds that can be used to support environmental protection and social equity initiatives by implementing environmental tax policies (Heine & Black, 2019). The money generated from environmental taxes can be used to support energy-efficient improvements, public transit, renewable energy initiatives, and rebates to low-income households subject to the taxes, as in the case of China (Lo, 2014).

### **3.2.2.2 Corruption and Governance**

Susan (1999) described corruption as a pervasive issue that affects many countries and thus undermines the trust in governments, thereby hindering economic development. Generally, corruption is the misuse of official authority for personal benefit (Kurer, 2005). It is the misuse of public power for personal gain (Transparency International, 2008). Contrarily, governance describes the procedures and frameworks employed in a nation or organisation to oversee and control its affairs (Rosenau, 2021). Studies have indicated that corruption is one of the biggest barriers to effective governance (Julius Otusanya, 2011; Kaufmann, 2005; Kaminski & Kaminski, 2001). Sanyal and Samanta (2002) identified economic, political, cultural, and social factors contributing to corruption.

Good governance requires accountability, transparency, and the rule of law (United Nations, 2006). Corruption, however, erodes these principles, thus leading to a vicious cycle of poor governance and further corruption (Fagbadebo, 2007). Corruption has several effects on governance. It weakens governmental institutions, confuses decision-making, and lowers government revenue. Corruption also perpetuates inequality, as those with power and influence are more likely to benefit from corrupt practices (Dobel, 1978). To combat corruption and improve governance, various

strategies have been proposed. These include strengthening institutions, increasing transparency, and promoting civic engagement (World Bank, 2000).

Effective governance is vital for battling corruption. Governments have proposed and implemented several strategies and frameworks to combat corruption (Vian, 2020). Research has shown some of these strategies and frameworks governments have used to combat corruption. These include legal and institutional reforms, civil society and media, internal cooperation, and transparency and accountability (Vian, 2020; Doig, 1995).

Often cited as a success story, Botswana has managed to maintain low levels of corruption (Acemoglu, Johnson, & Robinson, 2002). This has been achieved by attaining political stability, sound economic policies and the setting up of strong institutions to tackle corruption. Singapore has also implemented strict laws and ensures they have institutions that effectively enforce these laws and a meritocratic civil service (Poocharoen & Brillantes, 2013). This is, however, not the case for a country like Nigeria. Nigeria has been branded as one of the most corrupt countries in the world. Nigeria still faces systemic corruption despite numerous anti-corruption initiatives because of its weak institutions and political difficulties (Ogundiya, 2011).

Research indicates that corruption negatively impacts green growth and innovation. A study of 123 countries found that a 1% increase in corruption leads to a 15.47% decrease in green growth (Tawiah et al., 2024). Similarly, global evidence confirms corruption's detrimental effect on green innovation (Wen et al., 2023). Corruption perpetuates patronage and rent-seeking behaviours, hindering sustainable natural resource management (Sulistyani & Nurlinda, 2019).

Fighting corruption is still a difficult task in spite of all the efforts made because of things like vested interests, political opposition, and changing corruption patterns (Scott, 1969; Stapenhurst

& Kpundeh, 1999). Future research and policy efforts should focus on innovative approaches, strengthening institutions and public awareness and education. Leveraging technology, such as blockchain and big data analytics, can enhance transparency and accountability (Scott, 1969). This can help in the fight against corruption. Also, building robust institutions can withstand political pressures and enforce anti-corruption measures effectively (Doig, 1995). Anassi (2004) states that raising awareness and educating the public about the malice of corruption and the pros of good governance can be a way to tackle corruption and ensure good governance.

### **3.2.2.3 Environmental taxes and green growth**

A study by the Organization for Economic Cooperation and Development (OECD) in 2019 posited that environmental tax policies can increase green growth by incentivising eco-friendly practices (OECD, 2019). OECD countries have increased their use of environmental taxes, with revenues growing by 50% between 2005 and 2015 (OECD, 2019). The study notes that environmental taxes can be regressive, disproportionately affecting low-income households, and recommends measures like tax credits or social benefits to mitigate this impact. By examining the evidence on environmental taxes, the OECD study aims to inform policymakers on effective strategies to promote green growth, reduce pollution, and achieve sustainable development goals.

Research conducted in the European Union indicates that, in contrast to developing nations, less corruption may have a role in the effective execution of environmental tax laws (Harring, 2014). Countries with robust governance structures and low corruption levels, such as Sweden and Denmark, have seen significant improvements in green growth indicators due to effective environmental taxation (Schaffer, 2021). However, empirical studies in Sub-Saharan Africa reveal a complex interaction between corruption and environmental policies (Abid, 2016). High levels of corruption frequently result in policy failures and only modest gains in green growth indicators,

despite the fact that some nations have achieved progress in enacting environmental taxes (Altenburg & Rodrik, 2017).

Stavins (2003), posited that the effectiveness of environmental tax in driving green growth can also depend on factors like policy design, enforcement and complementary regulations. The structure and specifics of the tax policy can significantly impact its effectiveness. This includes tax base, tax rate, exemptions and exceptions, and revenue allocation (Stavins, 2003). According to Stavins (2003), the interplay between these factors can significantly influence the success of environmental tax policies in driving green growth. However, poorly planned or implemented policies can lead to unintended consequences such as economic burdens on certain industries, inequitable distribution of costs and benefits and an ineffective reduction of environmental impacts (Stavins, 2003). Policymakers can develop efficient environmental tax laws that facilitate the shift to a greener, more sustainable economy by considering these variables.

Research by Gani (2012) also showed that countries with low corruption levels tend to have more effective carbon tax policies that significantly reduce carbon dioxide emissions and its related gases, thus protecting the environment in the long run. Well-designed environmental tax laws in nations with low levels of corruption encourage investments in cleaner technology, which in turn boosts energy efficiency (Chang, Wen, Zheng, Dong, & Hao, 2018). Corruption can discourage investment in renewable energy by raising operating costs and fostering an unstable business climate.

Research by Wang, Wang and Sun (2020) demonstrated that corruption has seriously hampered China's environmental tax programs' ability to do their jobs. Pollution issues persist because local officials frequently participate in corrupt activities that erode the enforcement of strict restrictions. In India also, research indicates that high levels of corruption have made it difficult to impose

environmental taxes successfully (Das, Mahalik, & Sadorsky, 2023). Because of lax enforcement brought on by corruption in regulatory agencies, the effectiveness of these taxes in decreasing environmental pollution is diminished (Wang, Wang and Sun, 2020).

### 3.3 Evaluation Methodology

#### 3.3.1 Data Sources

This chapter uses data from 15 countries in sub-Saharan Africa to investigate the moderating effect of corruption on the relationship between environmental tax and green growth. The sample countries have been chosen only due to data availability across all the variables used in the study. The period for the study spans from 2000 to 2020. The data on environmental tax and green growth were obtained from the OECD database. Control of corruption and regulatory quality were also collected from the World Governance Indicators website. The rest of the data, i.e., population density and renewable energy consumption, were also gathered from the World Development Indicators (WDI) of the World Bank.

#### 3.3.2 Variables Measurement

The main dependent variable is **Green Growth, represented by Energy productivity, which** is calculated as GDP per unit of TES (USD/toe). It reflects efforts to improve energy efficiency and reduce carbon and other atmospheric emissions. Together with energy intensity, these indicators also reflect structural and climatic factors. TES comprises production + imports - exports - international marine bunkers- international aviation bunkers ± stock changes. Using PPP, Gross Domestic Product (GDP) is expressed at constant 2015 USD. **Environmental tax** is the main independent variable, which refers to a wide range of legislative charges on activities of businesses

and private individuals aimed at reducing practices that cause damage to the environment. There are many forms of environmental taxes, some aimed at penalising those who emit harmful chemicals, while others aim to reward those who employ environmentally friendly practices. Environmental taxes are made up of the combined total of the total taxes on energy, transport, pollution, and natural resources and measured as total environmental tax revenues as a percentage of GDP. **Control of Corruption** entails the perceptions of the extent to which public power is exercised for private gain, including petty and grand forms of corruption, and "capture" of the state by elites and private interests. **Population density**, which is measured by the people per sq. km of land area, is defined by the population count of all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelves, and exclusive economic zones (Khoso et al., 2021; Immurana et al., 2021). **Regulatory quality** captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. **Renewable energy consumption** is the share of renewable energy in total final energy consumption.

### 3.3.3 Model specification and development

The basic model developed for this study is captured in equation 1, with Natural Resource Depletion (NRD) as the dependent variable:

$$Green\ Growth = f(Environmental\ Tax, Control\ of\ corruption, Population\ density, Regulatory\ quality, Renewable\ energy\ consumption,) \quad (3.1)$$

Green growth, represented by Green Growth, is a function of the main independent variables, i.e., environmental tax, as proxied by Environmental Tax, and control of corruption, also shown as Control of corruption. The control variables are population density, proxied by Population density, regulatory quality, shown as Regulatory quality, and renewable energy consumption, represented by Renewable energy consumption.

The above basic model can be restated as:

$$\begin{aligned}
 \text{Green Growth}_{it} = & a_0 + a_1 \text{Environmental Tax}_{it} + a_2 \text{Control of corruption}_{it} + \\
 & a_3 \text{Population density}_{it} + a_4 \text{Regulatory Quality}_{it} + \\
 & a_5 \text{Renewable energy consumption}_{it} + \varepsilon_{it}
 \end{aligned}
 \tag{3.2}$$

Green Growth represents green growth as a function of the main independent variables, i.e., environmental tax, as proxied by Environmental Tax, and control of corruption, also shown as Control of corruption. The control variables are population density, proxied by Population density, regulatory quality, shown as Regulatory quality, and renewable energy consumption, represented by Renewable energy consumption.  $i$  is the individual countries, and  $t$  is the time in years for the study.  $\varepsilon$  represents the disturbance term.  $a_0$  to  $a_5$  are the coefficients

### 3.3.4 Estimation strategy

Prior to determining the link between the variables under consideration in this paper, a few preliminary tests were conducted to determine the underlying characteristics of the variables. This was done by first examining the descriptive statistics (see Table 1) to assess the overall understanding of the data series. Then, a q-q plot was used to test the normality of the data and a 3D contour plot was drawn to assess the linearity or otherwise of the data's structure to determine

an appropriate model for the estimation (See Figures **1 and 2**). The correlation matrix plot has been drawn next to identify multicollinearity, simplifying feature selection, and guiding exploratory data analysis. Additionally, it aids in hypothesis generation, detecting spurious correlations, and assessing data quality for more reliable modelling. Subsequent to the preliminary check the baseline model using the method of moments quantile regression and simultaneous quantile regression was used to test the robustness of the model and the results.

### **3.3.5 Method of moments quantile regression**

To investigate the heterogeneity in the moderating role of control of corruption on the nexus between environmental tax and green growth, this study empirically employs the Method of Moments Quantile Regression (MMQR), which was recently developed by Machado & Santos Silva(2019). The choice of the MMQR model is because it addresses a number of limitations found in the traditional regression models (Wolde-Rufael & Mulat-Weldemeskel, 2023). Firstly, it provides accurate and vigorous results when the distribution of the dataset is non-parametric, particularly when the data is not normal and therefore might entail outliers, minimal or no correlation. Secondly, through its moment conditions, the technique can simultaneously deal with endogeneity and heterogeneity in the data, which can lead to biased results. Thirdly, MMQR allows for individual fixed effects across the conditional distribution enabling the predictors to accommodate the location and scale functions (Alhassan et al., 2020).f Again, it also permits not only a location-based asymmetry because the parameters may depend on the position of the predicted variables but also produces good estimates in diverse conditions, even if the model is non-linear. MMQR is described as a practice-based approach in view of its ability to deal with heterogeneity and endogeneity via moment restrictions simultaneously, hence, appeals to both asymmetric and non-linear estimations. A distinctive factor of MMQR is its distinctiveness for

handling non-crossing estimates without giving invalid responses. In line with Machado & Santos Silva, (2019), the conditional quantile of the random variable in the panel data for the location and scale  $Q_{y_{it}(\delta|x_{it})}$  is specified in equation (5) as follows:

$$y_{it} = \alpha_i + x'_{it}\beta + (\partial_i + N'_{it}\theta)v_{it} \quad (3.3)$$

where  $y_{it}$  is the dependent variable,  $x'_{it}$  is an i.i.d endogenous variable, and  $(\alpha, \beta, \partial, \text{ and } \theta)$  are parameters to be assessed. The probability,  $P \{ \partial_i + N'_{it} > 0 \} = 1$ .  $v_{it}$  is an i.i.d unobserved random variable distributed across individuals and is orthogonal to  $x'_{it}$  satisfying the c, moment conditions (see Ma, 2022; Sun, 2022).  $i = 1 \dots n$ , denotes the individual I fixed effects, and  $N$  is a k-vector of known components of X (see Adebola et al., 2022). Again,  $x'_{it}$  is orthogonal to cross-sections (i) and time (t) in the expression, as captured in Machado & Santos Silva. Thus, reserves and external variables stabilise. Hence, equation (1), (2), and (3) might be rewritten as follows:

$$Q_{y(\delta|x_{it})} = (\alpha_i + \partial_i r(\delta)) + x'_{it}\beta + X_{it}\theta r(\delta) \quad (3.4)$$

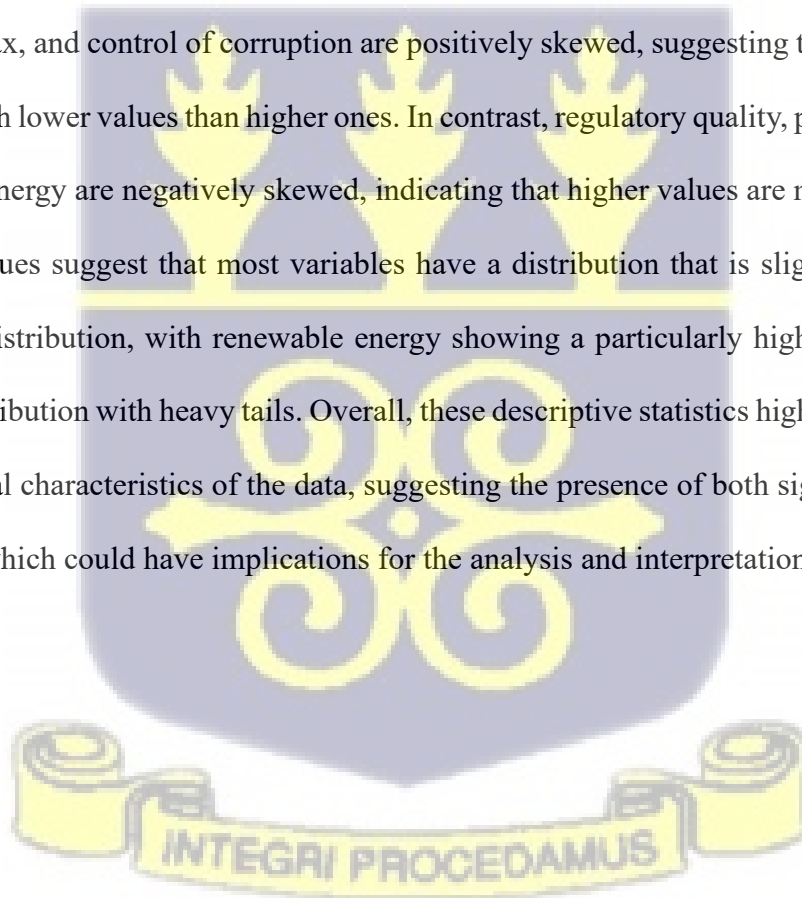
Where  $Q_{y_{it}(\delta|x_{it})}$  is the quantile distribution of the dependent variable,  $Y_{it}$ .  $\alpha_i(\delta) \equiv \alpha_i + \partial_i r(\delta)$  is the scalar coefficient and  $\delta$ th is the sample quantile.  $Z$  denotes a k-vector of known components of  $X_{it}$ , which is normalised to satisfy the Machado & Santos Silva, (2019) moment conditions  $E(U) = 0$  and  $E(|U|) = 1$  (see Xie & Jamaani, 2022).

### 3.4 Empirical Results

#### 3.4.1 Descriptive Statistics

The descriptive statistics provided offer valuable insights into the distribution and characteristics of the variables under study. Green growth has the highest standard deviation (SD) of 3,678.91, indicating significant variability in the data, which is also reflected in its wide range between the

minimum (2,038.63) and maximum (17,311.81) values. Environmental tax, with an SD of 0.85, also shows considerable variability but less so compared to green growth, with a range between 0.0028 and 4.1414. Control of corruption shows a moderate SD of 0.66, with values ranging from -1.59 to 1.24, indicating both negative and positive assessments in different regions or periods. Regulatory quality, with the lowest SD of 0.10, is relatively consistent across observations, as seen in its narrow range from 0.0633 to 0.5911. Population density and renewable energy also exhibit some variability, with SDs of 0.54 and 0.26, respectively, but they are less variable than green growth and environmental tax. Population density ranges from 0.3443 to 2.3593, while renewable energy ranges from 0.8808 to 1.9926. The skewness values indicate that green growth, environmental tax, and control of corruption are positively skewed, suggesting that there are more observations with lower values than higher ones. In contrast, regulatory quality, population density, and renewable energy are negatively skewed, indicating that higher values are more frequent. The kurtosis values suggest that most variables have a distribution that is slightly more peaked than a normal distribution, with renewable energy showing a particularly high kurtosis of 5.80, indicating a distribution with heavy tails. Overall, these descriptive statistics highlight the diversity and distributional characteristics of the data, suggesting the presence of both significant variation and skewness, which could have implications for the analysis and interpretation of the results.



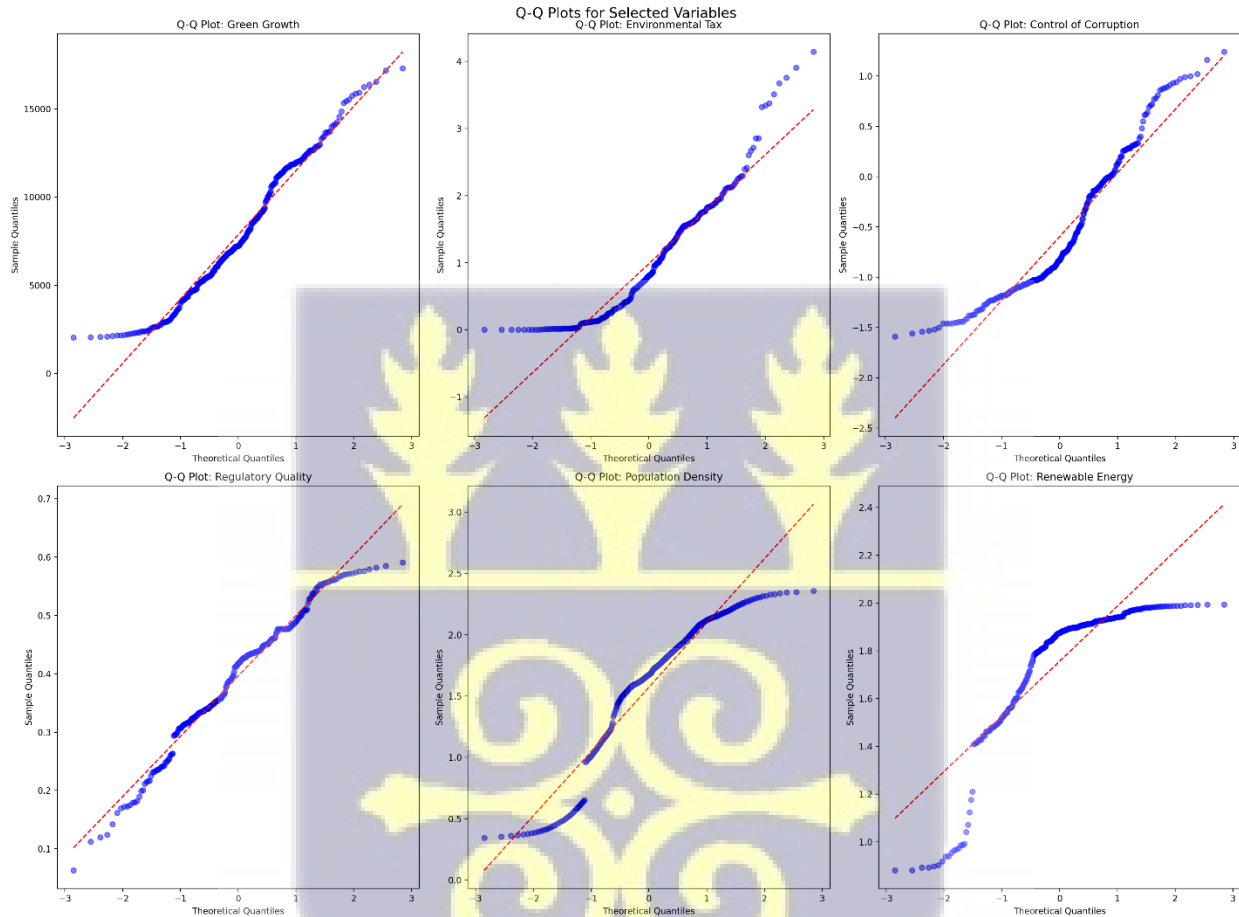
**Table 3. 1: Descriptive Statistics**

Stats	Green Growth	Environm ental Tax	Control of Corruption	Regulatory Quality	Population Density	Renewable Energy
N	315	292	300	315	315	315
SD	3,678.9140	0.8463	0.6581	0.1039	0.5439	0.2625
Min	2,038.6300	0.0028	- 1.5900	0.0633	0.3443	0.8808
Max	17,311.8100	4.1414	1.2400	0.5911	2.3593	1.9926
Skewness	0.3399	0.9702	0.7852	- 0.4444	- 0.7944	- 1.7938
Kurtosis	2.2856	3.8912	2.6974	2.9174	2.7072	5.8014

The Q-Q plots provide a visual assessment of how well the data for each variable follows a normal distribution, where points falling along the red diagonal line indicate normality. From the plots, we can see that none of the variables perfectly follow a normal distribution, as all variables have deviations from the diagonal line. Green Growth and Regulatory Quality show the closest approximation to normality, with points generally following the diagonal line but deviating at the tails. Environmental Tax, Control of Corruption, and Population Density show more significant deviations from normality, with curved patterns indicating skewness or heavy tails. Renewable Energy shows the most substantial deviation from normality, with a distinct S-shaped curve suggesting a bimodal or highly skewed distribution. The Shapiro-Wilk test results confirm these visual observations, with all variables having p-values much smaller than 0.05, indicating strong evidence against the null hypothesis of normality. Renewable Energy has the lowest Shapiro-Wilk statistic (0.7623) and the smallest p-value (4.9866e-21), confirming it as the variable furthest from a normal distribution. Green Growth and Regulatory Quality have the highest Shapiro-Wilk statistics (0.9668 and 0.9760, respectively), aligning with their Q-Q plots that showed the closest approximation to normality. However, even for these variables, the low p-values indicate that they

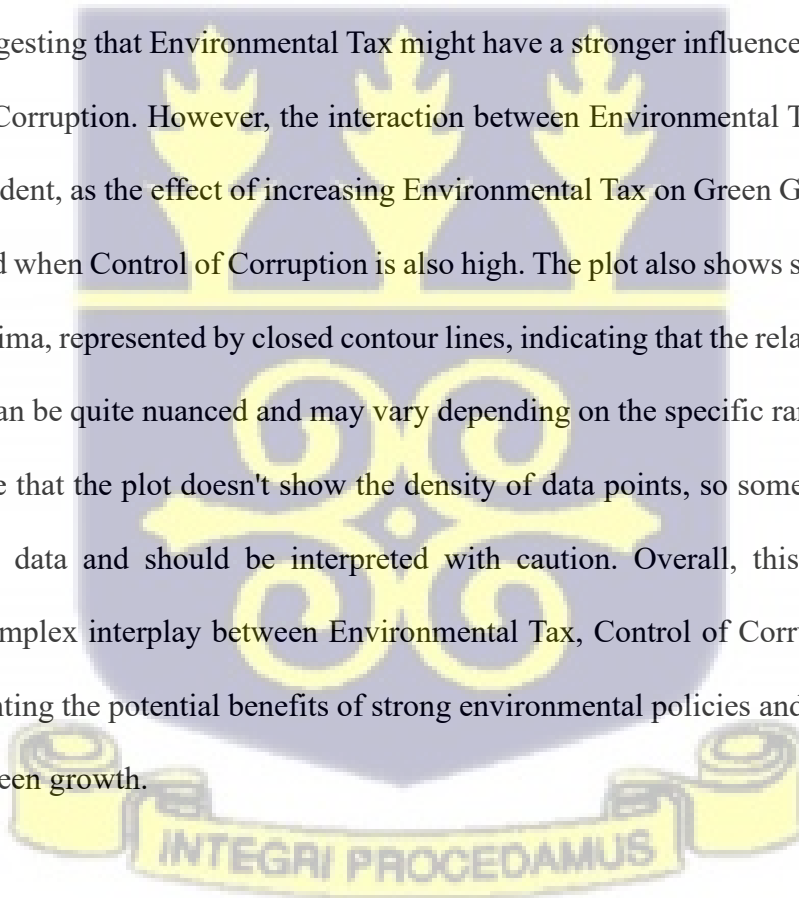
still deviate significantly from a normal distribution. These results suggest that non-parametric statistical methods or data transformations might be more appropriate for further analysis of these variables, as the normality assumption is not met for any of them.

**Figure 3. 1: Q\_Q plot of the variables in the study**

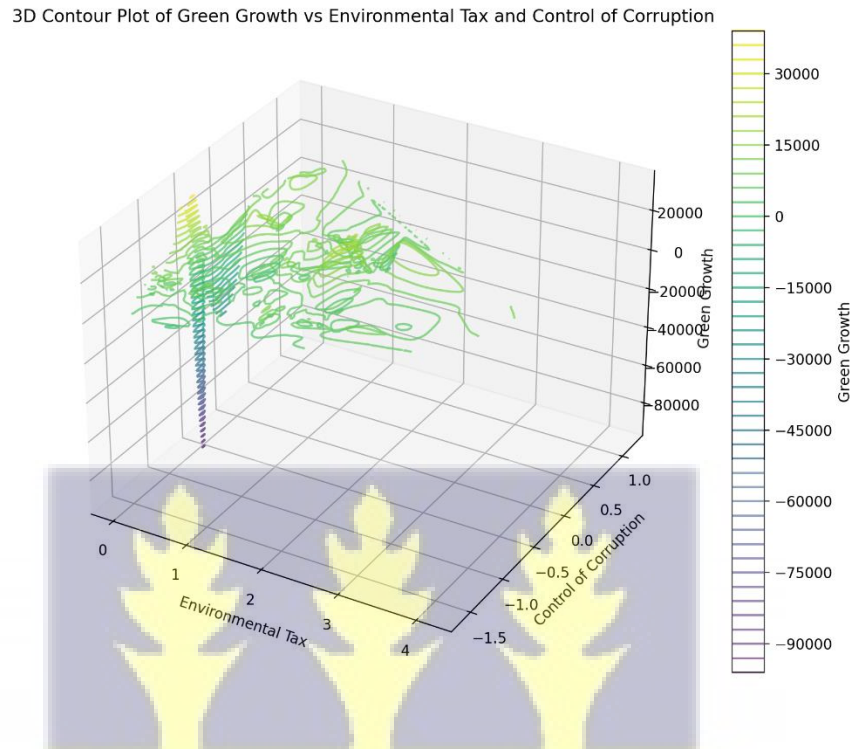


Analysing the 3D contour plot of Green Growth, Environmental Tax, and Control of Corruption reveals several interesting patterns and relationships between these variables. The plot shows a complex, non-linear relationship between the three variables, with Green Growth levels represented by different colours and contour lines. We can observe that the highest levels of Green Growth (represented by warmer colours and higher contour lines) tend to cluster in the upper-right

region of the plot, corresponding to higher values of both Environmental Tax and Control of Corruption. This suggests that countries with stronger environmental tax policies and better control of corruption generally experience higher levels of green growth. Conversely, the lowest levels of Green Growth (represented by cooler colours and lower contour lines) are predominantly found in the lower-left region, indicating that countries with lower environmental taxes and poorer control of corruption tend to have lower green growth. The contour lines are not perfectly parallel or evenly spaced, which indicates that the relationship between these variables is not simple or linear. There appears to be a steeper gradient in Green Growth as we move from left to right (increasing Environmental Tax) compared to the gradient from bottom to top (improving Control of Corruption), suggesting that Environmental Tax might have a stronger influence on Green Growth than Control of Corruption. However, the interaction between Environmental Tax and Control of Corruption is evident, as the effect of increasing Environmental Tax on Green Growth seems to be more pronounced when Control of Corruption is also high. The plot also shows some areas of local maxima and minima, represented by closed contour lines, indicating that the relationships between these variables can be quite nuanced and may vary depending on the specific ranges of values. It's important to note that the plot doesn't show the density of data points, so some regions might be based on sparse data and should be interpreted with caution. Overall, this 3D contour plot visualises the complex interplay between Environmental Tax, Control of Corruption, and Green Growth, highlighting the potential benefits of strong environmental policies and good governance for promoting green growth.



**Figure 3. 2: 3D plot of the key variables of interest in the study**



### 3.4.2 Correlation Matrix

The correlation matrix reveals several important relationships among the variables under consideration. First, green growth exhibits a weak negative correlation with environmental tax (-0.307), suggesting that higher environmental taxes may not directly translate into higher levels of green growth. In contrast, control of corruption shows a weak positive correlation with green growth (0.333), indicating that better governance may support sustainable development. Similarly, regulatory quality is positively correlated with green growth (0.304), implying that improved regulatory frameworks may promote green growth outcomes. The relationship between environmental tax and control of corruption is almost non-existent (-0.009), suggesting that corruption levels might not directly affect the adoption of environmental taxes. Regulatory quality,

however, is moderately positively correlated with control of corruption (0.560), reflecting that countries with better regulatory environments tend to have stronger anti-corruption measures. Population density shows weak correlations with most variables, although it is negatively associated with control of corruption (-0.316) and regulatory quality (-0.228), hinting that densely populated areas may face governance challenges. Interestingly, renewable energy usage is negatively correlated with both control of corruption (-0.734) and regulatory quality (-0.399), suggesting that countries with weaker governance may rely more heavily on renewable energy, potentially due to limited industrial infrastructure or external pressures. Additionally, renewable energy shows a weak positive correlation with environmental tax (0.245), indicating that countries adopting environmental taxes might also be promoting renewable energy. The negative correlation between green growth and renewable energy (-0.443) is unexpected, potentially reflecting challenges in translating renewable energy investments into sustainable economic outcomes. Overall, the matrix underscores the complexity of interactions between governance, environmental policies, and sustainability outcomes, suggesting that no single factor alone can drive green growth.

**Table 3.2: Correlation Matrix**

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Green growth	1.000					
(2) Environmental tax	-0.307	1.000				
(3) Control of corruption	0.333	-0.009	1.000			
(4) Regulatory Quality	0.304	0.299	0.560	1.000		
(5) Population density	-0.093	0.126	-0.316	-0.228	1.000	
(6) Renewable energy	-0.443	0.245	-0.734	-0.399	0.244	1.000

### 3.4.3 Baseline Results from the Method of Moments Regression

The results from the Method of Moments Quantile Regression, as shown in Table 3.2 and Figure 3.3, provide valuable insights into the moderating role of corruption on the relationship between environmental tax and green growth across different quantiles in Sub-Saharan African countries. Starting with the location (first moment) results, environmental tax has an average positive effect on green growth with a coefficient of 115.5, though this effect is not statistically significant, indicating that the tax may have a mixed impact on green growth when averaged across the sample. However, the scale (second moment) results reveal that environmental tax significantly increases the dispersion of green growth outcomes, as indicated by the positive coefficient of 1,503, which is statistically significant at the 1% level. This suggests that while environmental tax may have an overall positive effect, it also leads to greater variability in green growth outcomes, which could indicate uneven implementation or varying levels of effectiveness across different contexts.

When analysing the effects across different quantiles (third moment), the results show that environmental tax has a significant negative impact on green growth in the lowest quantile (1), with a coefficient of -2,056, significant at the 1% level and a negative impact in quantile 25 with a coefficient of -1,290, significant at the 10% level. This indicates that in countries or regions with the lowest levels of green growth, environmental taxes may actually hinder growth, possibly due to economic structures that are highly sensitive to increased costs. However, in the higher quantiles (75 and 9), the impact of environmental tax becomes positive, with coefficients of 1,396 and 2,727, respectively, the latter being significant at the 5% level. This suggests that environmental taxes can stimulate growth in contexts where green growth is already higher by encouraging more efficient resource use and investments in green technologies.

The role of control of corruption is also significant in promoting green growth. The average effect (location) is positive with a coefficient of 1,348, significant at the 10% level, indicating that better control of corruption generally supports green growth. However, the scale result shows a negative but insignificant effect on dispersion, suggesting that improvements in corruption control do not significantly affect the variability of green growth outcomes. Across quantiles, the control of corruption has a positive and significant impact on green growth at the lower quantiles (1 and 25), with coefficients of 1,531 and 1,467, respectively, both significant at the 5% level. This underscores the importance of good governance in fostering green growth, particularly in regions struggling with low initial levels of development. The impact remains positive but loses statistical significance in the highest quantiles, suggesting that while governance remains important, other factors may become more influential as green growth increases.

The moderating effect of corruption control on the relationship between environmental tax and green growth is evident in the positive and significant coefficients for the interaction term (Moderator). The average effect is positive with a coefficient of 1,796, significant at the 5% level, indicating that the combination of environmental tax and strong governance (i.e., control of corruption) significantly boosts green growth. The scale result shows a highly significant positive effect on dispersion, suggesting that this interaction increases the variability in green growth outcomes, likely reflecting differences in how effectively environmental taxes are implemented in varying governance contexts. Across quantiles, the moderating effect is not significant at the lowest quantile. Still, it becomes increasingly significant and positive in the higher quantiles, with the highest impact observed in quantile 9, where the coefficient is 4,903, significant at the 1% level. This demonstrates that in regions with higher green growth, the synergistic effect of environmental tax and good governance is particularly powerful in driving further growth.

Additional variables such as regulatory quality, population density, and renewable energy also play important roles. Regulatory quality has a very strong positive effect on green growth across most quantiles, especially at the lower and middle levels, indicating the critical role of strong regulatory frameworks in fostering sustainable development. Population density significantly impacts green growth, particularly at lower quantiles, suggesting that higher population densities may strain resources and hinder green growth in less developed regions. Meanwhile, renewable energy consistently shows a positive and highly significant impact on green growth across all quantiles, with the effect being strongest in the highest quantile, highlighting the crucial role of renewable energy in driving green growth at all stages of development.

Indeed, much as Environmental taxes can generate revenue that can be used to fund environmental protection programs, research, and infrastructure projects. This can help to accelerate the transition to a green economy (Wang et al., 2019). However, as observed in a study on European countries which found that carbon taxes led to significant reductions in carbon dioxide emissions, but the effectiveness of these taxes varied across countries depending on the level of corruption and the strength of governance institutions (Tchapchet-Tchouto et al., 2022). The results are also in sync with a study on African countries which highlighted the potential of environmental taxes to promote green growth but emphasised the need for strong governance and anti-corruption measures to ensure their effectiveness (Shahzad et al., 2021).

In conclusion, these results suggest that while environmental taxes can contribute to green growth, their effectiveness is highly dependent on the governance context, particularly the control of corruption. Environmental taxes may hinder green growth in regions with poor governance, especially in less developed areas. However, combining environmental taxes and good governance in regions with strong governance can significantly boost green growth, particularly in more

developed contexts. This highlights the need for tailored policy approaches that consider economic and governance contexts to effectively promote green growth in Sub-Saharan Africa.

**Table 3. 3: Baseline Results from Method of Moments Quantile Regression on the moderating role of corruption on the relationship between environmental tax and green growth**

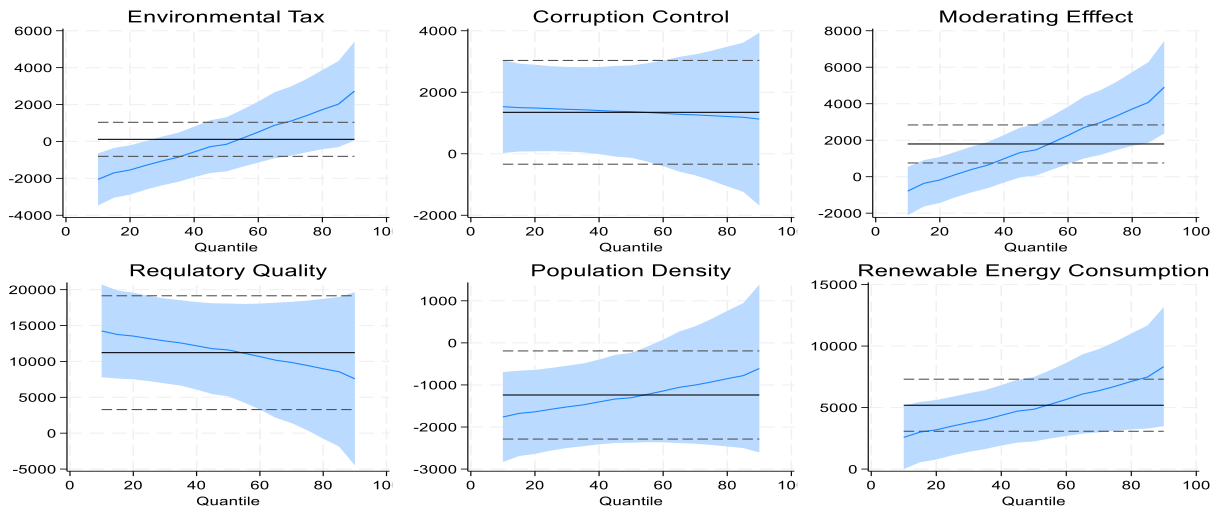
VARIABLES	(1) location	(2) scale	(3) qtile_1	(4) qtile_25	(5) qtile_5	(6) qtile_75	(7) qtile_9
Environmental Tax	115.5	1,503***	-2,056***	-1,290*	-156.7	1,396	2,727**
Control of Corruption	1,348*	-126.8	1,531**	1,467**	1,371*	1,240	1,128
Environmental Tax X Control of Corruption	1,796**	1,788***	-787.9	123.7	1,472**	3,320***	4,903***
Regulatory Quality	11,222***	-2,095	14,249***	13,181***	11,602***	9,437**	7,582
Population Density	-1,239**	362.5	-1,763***	-1,578***	-1,305**	-930.1	-609.0
Renewable Energy	5,189***	1,808**	2,577*	3,499***	4,862***	6,730***	8,331***
Constant	-1,889	-1,163	-208.7	-801.6	-1,679	-2,880	-3,910
	(2,723)	(1,660)	(2,596)	(2,383)	(2,595)	(3,631)	(4,845)
Observations	281	281	281	281	281	281	281

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

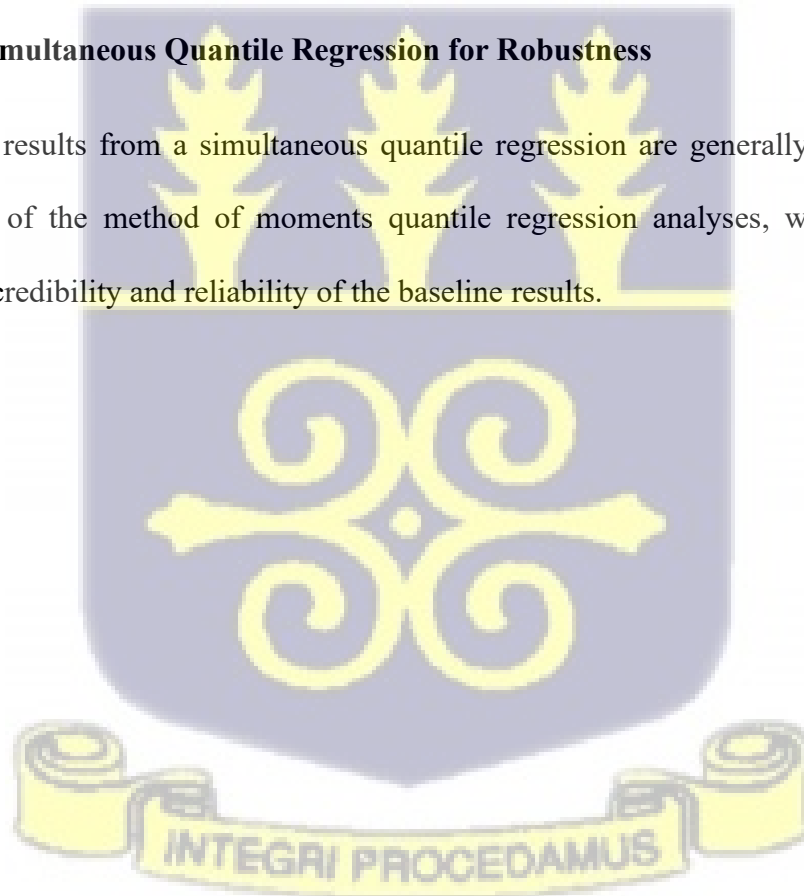


**Figure 3. 3: Graphical view of the trend of the nexus between the independent variables and Green Growth**



### Results from Simultaneous Quantile Regression for Robustness

Robustness test results from a simultaneous quantile regression are generally in sync with the baseline results of the method of moments quantile regression analyses, which indeed adds credence to the credibility and reliability of the baseline results.



**Table 3. 2: Robustness Results from Simultaneous Quantile Regression on the moderating role of corruption on the relationship between environmental tax and green growth**

VARIABLES	(1) q10	(2) q25	(3) q50	(4) q75	(5) q90
Environmental Tax	-1,758*** (386.6)	-1,808*** (563.7)	-1,437 (1,156)	1,055 (755.7)	1,545*** (584.6)
Control of Corruption	863.5* (507.1)	798.0 (677.9)	656.8 (1,378)	-458.1 (2,156)	-2,677 (3,823)
Environmental Tax X Corruption	-523.7 (409.7)	-860.3 (540.4)	326.4 (1,038)	2,986*** (721.9)	3,202*** (1,036)
Regulatory Quality	16,638*** (2,118)	17,431*** (3,669)	16,031** (6,490)	13,880** (5,442)	8,522 (16,522)
Population Density	-2,959*** (421.7)	-2,585*** (621.6)	-1,405* (750.4)	-582.0 (1,086)	1,562 (1,134)
Renewable Energy	3,371*** (827.7)	2,600** (1,093)	2,514 (3,631)	669.4 (6,996)	-15,299 (9,828)
Constant	-1,122 (1,632)	11.51 (2,439)	812.8 (5,835)	4,558 (11,243)	31,391** (14,742)
Observations	281	281	281	281	281

Standard errors in parentheses  
 \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### 3.5 Conclusions and Policy Implications

The main objective of this chapter is to examine the effect of control of corruption on the relationship between environmental tax and green growth. The results of the quantile regression analysis provide critical insights into the complex relationship between environmental tax, control of corruption, and green growth in sub-Saharan African countries. The analysis reveals that environmental tax, while generally intended to promote environmentally sustainable practices, significantly negatively affects green growth in these countries. This suggests that, in the context of sub-Saharan Africa, the imposition of environmental taxes may not be achieving its intended goals and could be stifling green growth instead. This outcome may be due to several factors, including the economic structure of these countries, where industries might be heavily reliant on

practices that are penalised by environmental taxes. Consequently, imposing such taxes could increase operational costs, reduce competitiveness, and ultimately hinder the adoption of green technologies.

However, the analysis also shows that control of corruption has a significant positive impact on green growth, highlighting the critical role of good governance in promoting sustainable development. Corruption often undermines environmental policies by allowing for the evasion of regulations, misallocating resources, and general inefficiency in implementing environmental initiatives. When corruption is reduced, governments can better enforce environmental regulations, allocate resources efficiently, and support developing and adopting green technologies. This finding underscores the importance of strengthening governance structures and reducing corruption to enhance the effectiveness of environmental policies.

Moreover, the results reveal a significant moderating effect of control of corruption on the relationship between environmental tax and green growth. Specifically, the negative impact of environmental tax on green growth is significantly mitigated when corruption is effectively controlled. In countries with strong governance and low levels of corruption, environmental taxes are more likely to contribute positively to green growth. This suggests that the success of environmental taxation in promoting green growth is highly contingent upon the governance context within which these taxes are implemented. Where corruption is rampant, the intended benefits of environmental taxes may be undermined, leading to negative outcomes. Conversely, in well-governed countries, these taxes can serve as effective tools for promoting environmental sustainability.

The policy implications of these findings are profound. Firstly, policymakers in sub-Saharan African countries should be cautious when implementing environmental taxes, especially in

contexts where corruption is pervasive. The negative impact of such taxes on green growth in corrupt environments suggests that environmental taxation alone may not lead to the desired outcomes without addressing governance issues. It may even exacerbate economic challenges by increasing business costs and reducing overall economic growth.

Secondly, policies that focus on improving governance and reducing corruption are a prerequisite for the successful implementation of environmental taxes. Strengthening anti-corruption measures, enhancing transparency, and building institutional capacity are critical steps that should accompany any environmental taxation policy. By improving governance, countries can create an environment where environmental taxes are more likely to be effective, supporting green growth rather than hindering it.

Thirdly, the findings suggest that a one-size-fits-all approach to environmental taxation may not be appropriate for sub-Saharan Africa. Given the varying levels of corruption across the region, environmental tax policies should be tailored to the specific governance context of each country. More aggressive environmental taxes may be feasible and effective in countries with strong governance and low corruption. In contrast, in countries with high levels of corruption, it may be necessary to focus first on governance reforms before introducing environmental taxes or to design tax policies that are less susceptible to corruption.

Finally, these results highlight the importance of integrating environmental and governance policies. Sustainable development in sub-Saharan Africa requires a holistic approach that simultaneously addresses environmental and governance challenges. Policymakers should, therefore, consider combining environmental tax policies with broader governance reforms to ensure that the transition to a green economy is equitable and effective. This integrated approach

can help maximise the positive impacts of environmental taxes on green growth while minimising potential negative effects.

In conclusion, the relationship between environmental tax, control of corruption, and green growth in sub-Saharan Africa is complex and highly dependent on the governance context. While environmental taxes have the potential to promote green growth, their success is contingent upon the effectiveness of governance structures. Policymakers must prioritize governance reforms and anti-corruption measures to create an enabling environment for environmental taxes to contribute positively to sustainable development. By doing so, sub-Saharan African countries can better harness the power of environmental taxes to drive green growth and achieve long-term environmental and economic sustainability.



## CHAPTER FOUR

### EXAMINING THE JOINT EFFECT OF ENVIRONMENTAL TAXATION AND ENVIRONMENTAL RELATED GRANTS ON GREEN GROWTH



## Abstract

This study examines the combined effect of environmental taxes and environment-related grants on green growth sampling 15 Sub-Saharan African countries from 2000 to 2020. Using a panel autoregressive distributed lag (ARDL) model and a method of moments quantile regression analysis, the chapter reveals that environmental taxes alone do not significantly influence green growth, measured by economic productivity per CO<sub>2</sub> emission and energy intensity per unit of GDP. However, the interaction between environmental taxes and environmental-related grants significantly improves CO<sub>2</sub> productivity while reducing energy intensity per GDP output. The results demonstrate a significant synergistic effect between the two policies, highlighting the importance of a balanced policy approach that utilises both economic incentives (environmental taxes) and capacity-building support (environmental-related grants) to drive green growth. The study provides valuable insights for regional policymakers on designing effective environmental policy mixes that harness the complementary relationship between fiscal and technical assistance instruments to accelerate sustainable development.



## 4.1 Introduction

This study examines the joint effect of Environmental tax and environmentally related grants on green growth. Environmental taxation and technical assistance are two policy tools that governments can use to promote green growth and sustainable development (Shahzad, 2020; Bashir et al., 2021; Guo et al., 2022). Environmental taxes aim to internalise the costs of pollution and resource depletion by making environmentally harmful activities more expensive (Bashir et al., 2021; Wang & Yu, 2021). This creates financial incentives for firms and consumers to reduce emissions and adopt cleaner technologies, as conceptualised in the green dividend hypothesis of the environmental double dividend theory (Bashir et al., 2021; Wang & Yu, 2021). Environmental technical assistance, on the other hand, involves providing knowledge, skills, and resources to help implement green practices and technologies (Wang & Guo, 2023). The United Nations Environment Programme (UNEP) has offered environmental-related Grants to many Sub-Saharan African nations, providing essential resources like expertise, training, and knowledge-sharing to bolster their environmental governance capabilities and policy implementation (Enusah et al., 2024; Pandey, 2022).

While environmentally related taxes are aimed at incentivising industries and businesses to reduce pollution by increasing the costs of polluting activities, such taxes alone may not be very effective in driving the required level of green growth if countries lack resources and technical know-how (Gunningham & Sinclair, 2019, 1999; Rogge & Reichardt, 2015). At the same time, providing environmental technical assistance to upgrade to greener production processes will also have a limited impact without the economic incentive created by environmental taxes (Gunningham & Sinclair, 2019, 1999; Rogge & Reichardt, 2015). Therefore, studying their joint effect can provide

insights into how these policies can reinforce each other to maximise green growth, where economic growth and development are environmentally sustainable.

#### **4.2 Problem statement**

The existing literature on environmental taxation and technical assistance reveals significant gaps that this study aims to address. While a growing body of research focuses on the individual impacts of environmental taxes and technical assistance programs, there remains a notable deficiency in studies exploring their synergistic effects (Yu et al., 2022). Most existing studies tend to isolate these policy tools, failing to recognise that their combined implementation may yield more substantial benefits for green growth than either could achieve independently (Yu et al., 2022). This oversight limits the understanding of how these policies can be strategically integrated to maximise their effectiveness in promoting sustainable development (Kardos, 2012). By focusing solely on one aspect, previous research has overlooked the potential for a comprehensive approach that leverages the strengths of both environmental taxes and technical assistance to create a more robust framework for achieving green growth (Rogge & Reichardt, 2016).

Meanwhile, prior studies suggest that environmental challenges are complex and require a comprehensive policy mix rather than relying on a single instrument study (Gunningham & Sinclair, 2019, 1999; Rogge & Reichardt, 2015). Gunningham and Sinclair (2019, 1999) argue that all policy instruments have strengths and weaknesses, necessitating a combination of complementary tools tailored to specific goals. This approach harnesses individual mechanisms' strengths while compensating for their limitations (Schmidt & Sewerin, 2019; Ladu et al., 2020)

This gap in the literature highlights the need to investigate the joint impact of environmental taxes and ETCG in promoting green growth. By understanding how the policies can work together, policymakers can design more effective strategies to promote sustainable development (Yu et al., 2023; Hao et al., 2021; Khan et al., 2023; Chien et al., 2021; Lin & Ullah, 2024; Aldakhil et al., 2020). Therefore, the study seeks to achieve three key research objectives: to examine the effect of environmentally related tax on green growth, to examine the effect of Environmental grants on green growth, and to investigate the joint effect of environmentally related tax and Environmental grants on green growth.

The chapter draws on a panel of 15 countries in Sub-Saharan Africa studied over 21 21-year period (2000-2020) due to the availability of data across all variables to examine the relationships in the study. An autoregressive distributed lag model and a moment-of-method Quantitative regression technique are implemented to estimate the joint effect of environmental taxes and TCG on green growth. The findings indicate that, in isolation, environmental taxes do not significantly impact green growth, suggesting that the mere imposition of taxes may not be sufficient to drive sustainable development. This could be attributed to factors such as poor tax design, limited compliance, or governance challenges that diminish the effectiveness of environmental taxation in promoting green outcomes. However, the analysis reveals that the synergistic effect of environmental taxes and environmental-related grants plays a more substantial role in fostering green growth. This interaction improves green growth by enhancing CO<sub>2</sub> productivity, meaning that economies are able to generate higher economic output per unit of carbon dioxide emissions. At the same time, it contributes to reducing energy intensity, which refers to the amount of energy required to produce a unit of GDP. These improvements suggest that grants targeted at environmental objectives can complement environmental tax policies by addressing funding gaps,

incentivising technological innovations, and supporting the transition toward cleaner production practices. Such grants may provide the necessary financial resources to promote green technologies and investments that would otherwise be difficult to achieve through taxation alone. This finding underscores the importance of policy complementarities, where fiscal policies (like environmental taxes) are more effective when aligned with direct support mechanisms such as grants. It also highlights the need for targeted environmental funding and investment to maximise the effectiveness of environmental policies. Ultimately, this combination creates a more conducive environment for sustainable development, balancing economic growth with environmental protection.

The rest of the study is organised into four sections. Section 4.2 reviews relevant literature and offers insights into this study. Section 4.3 presents the research methodology, while section 4.4 presents the study's results and discusses them. The last section draws conclusions about the study and offers policy recommendations.

## **4.2 Literature Review**

### **4.2.1 Theoretical Review**

#### **4.2.1.1 The Environmental Double Dividend Theory and Green Growth**

The Environmental Double Dividend Theory (DTT) posits that well-designed environmental policies can yield two significant economic benefits: enhancing environmental quality and stimulating economic growth (Shahzad, 2020; Bashir et al., 2021; Guo et al., 2022). Instruments such as environmental taxes and environmental-related grants are central to this theory.

Environmental taxes serve as a mechanism to incentivise firms and individuals to adopt cleaner production technologies, reduce waste, and conserve natural resources, thereby decreasing greenhouse gas emissions and mitigating other negative environmental impacts (Bashir et al., 2021; Wang & Yu, 2021). This aligns with the "polluter pays" principle, which holds that those who cause environmental harm should bear the costs associated with it (Bashir et al., 2021; Wang & Yu, 2021). Furthermore, the tax revenues can be reinvested into the economy, allowing for the reduction of other distortionary taxes and funding for green infrastructure, education, and training initiatives. Such reinvestment stimulates green economic growth and fosters additional economic activity and job creation within the green sector. In contrast, environmental-related grants from development partners are crucial for realising the environmental double dividend by providing the necessary financial and technical assistance to developing countries (Hidayat & Virgianita, 2019). These grants help lower the costs associated with environmental degradation by supporting initiatives that enhance resource efficiency and promote sustainable practices. They also facilitate knowledge transfer and capacity building, which are vital for effectively implementing environmental policies that can lower production costs and enhance competitiveness. This, in turn, leads to increased productivity and economic development.

Recent studies have advanced the Environmental Double Dividend Theory. For instance, some studies assert that the effect of environmental policies on green growth is not linear or straightforward, suggesting that the relationship between these policies and economic outcomes can be complex and influenced by various factors (Chang et al., 2023; Hussain et al., 2022). For instance, Chang et al. (2023) suggest that stringent environmental policies can lead to sectoral shifts from dirty to clean sectors, resulting in an inverted U relationship between GDP growth and environmental policy. Studies suggest that the dividends of environmental policies often follow a

U-shaped trajectory. In the long run, when complemented by technological advancements and a shift towards renewable energy sources, stringent environmental policies can positively impact green growth, creating a sustainable and prosperous future (Dong & Ullah, 2023; Dźwigoł et al., 2023).

## **4.2.2 Empirical Review**

### **4.2.2.1 Environmental Taxes and Green Growth**

By increasing the cost of environmentally damaging activities, environmental taxes encourage firms to adopt cleaner technologies and invest in abatement R&D (Krass et al., 2013; Beladi et al., 2021). However, the relationship between tax levels and technology adoption is complex, with potential reverse effects at higher tax rates (Krass et al., 2013; Tchorzewska et al., 2022). Initial tax increases may encourage the adoption of greener technologies, but further increases could lead to reverse effects (Krass et al., 2013). Conversely, low environmental tax levels may be ineffective in stimulating green growth, while higher levels show increased effectiveness (Tchorzewska et al., 2022). However, very high environmental taxes can lead to a reverse effect (Krass et al., 2013; Marsiglio & Tolotti, 2020). Combining taxes with subsidies for green technologies can help avoid these reverse effects and improve overall outcomes (Krass et al., 2013). Inferring from Li and Rao (2023), governments in developing countries, where environmental taxes are typically low, should consider gradually increasing environmental tax rates and strengthening subsidy supervision to achieve the desired green growth.

Furthermore, environmental tax reform (ETR), which shifts the tax burden from labour and capital to environmentally harmful activities, can stimulate innovation and investment in clean sectors

while reducing greenhouse gas emissions (Ekins & Speck, 2011). Case studies in Germany demonstrate ETR's potential to stimulate innovation and investment in clean sectors, such as renewable energy, construction, and waste management (Ekins & Speck, 2011). The effectiveness of ETR depends on careful policy design, with revenue redistribution through reduced capital taxation potentially offering the best efficiency outcomes in terms of aggregate welfare (Karydas & Zhang, 2017). Theoretical models suggest that mobile labour between manufacturing and R&D activities, along with a low elasticity of substitution between labour and energy in manufacturing, can lead to a growth dividend even with preexisting tax distortions (Karydas & Zhang, 2017). Thus, this study suggests that well-designed taxes can stimulate innovation that offsets compliance costs, driving long-term competitiveness and green growth (Porter & van der Linde, 1995). Recent empirical work confirms this complexity, finding that the effect is highly heterogeneous; it is often negligible at low tax rates but becomes significantly positive as stringency increases (Tchorzewska et al., 2022). Consequently, the hypothesis posits that the environmental tax effect is significant but varies critically with its level of stringency and the underlying economic and industrial structure, and stated as follows:

H1: Environmental tax has a heterogeneous and significant effect on green growth, with its positive impact being conditional on the stringency of the tax rate and the mitigating/amplifying factors of the recipient economy's structure.

#### **4.2.2.2 Environmental-related Grants and Green Growth**

Environmental-related grants have emerged as a critical instrument in promoting global green growth and sustainable development (Pandey et al., 2022; Kirchherr & Urban, 2018). These grants, typically provided by international organisations, donor countries, and development agencies, aim

to address environmental challenges and support green initiatives in recipient countries (Suzuki, 2015; Adamowicz, 2022).

Studies have shown that such grants are crucial in facilitating the transfer of environmentally sound technologies and best practices from developed to developing nations (Erdem Türkelli 2021; Choi & Cho, 2023). Studies suggest that the effectiveness of environmental-related grants lies in their multifaceted approach (Erdem Türkelli, 2021). They fund capacity-building efforts, technology transfer, and knowledge sharing, collectively empowering recipients to adopt environmentally friendly practices and improve environmental management (Choi & Cho, 2023; Horton, 2019). Furthermore, by supporting innovation and research and development, these grants enhance the effectiveness of environmental projects through shared resources and coordinated efforts (Erdem Türkelli 2021), thereby promoting green growth.

However, the literature also highlights challenges in implementing these grants. Keohane and Victor (2011) point out that the success of these initiatives depends on coherent policy positions and a clear understanding of the economic nature of technology transfer processes. Similarly, Ockwell et al. (2010) emphasise the importance of addressing barriers to technology transfer, such as weak institutional capacity and inadequate regulatory frameworks in recipient countries. Despite these challenges, environmental-related grants have shown promising results in various contexts.

This study contends that environmental-related grants address a different type of market failure, the dual externalities of green innovation. Since the social benefits of green R&D often exceed a firm's private returns, grants function as a supply-push instrument, directly reducing the private cost and risk of developing cleaner technologies. Theoretically, grants are most effective when

they successfully 'crowd-in' private investment, avoiding a mere substitution of private for public funds. The significance of their effect is highly heterogeneous, largely depending on their target. Empirical evidence shows that financial support, often proxied by R&D spending, is vital for promoting green economic growth, particularly by easing capital constraints for small and medium-sized enterprises (SMEs), which are less likely to undertake high-risk, high-cost environmental projects on their own (Song et. al., 2019; Lin and Zhu, 2019; Yu et. al., 2023). Therefore, the refined hypothesis focuses on the grant's significant but differential impact based on the degree to which it targets innovation barriers and firm-level financial constraints. The researcher therefore hypothesizes that:

H2: Environmentally-related grant has a heterogeneous and significant effect on green growth, acting as a crucial supply-push mechanism whose efficacy is greatest when targeted at alleviating capital constraints for firms engaged in genuine green technological innovation.

#### **4.2.2.3 The joint effect of Environmental taxes and environmental-related grants**

Environmental taxes and environmental grants work in tandem to promote green growth and environmental sustainability. Environmental taxes serve as a deterrent against environmentally harmful activities by imposing costs on actions like carbon emissions or pollution (Ullah et al., 2023; Bashir et al., 2021). This encourages stakeholders to rethink their actions and consider more environmentally friendly alternatives. On the other hand, environmental-related grants act as a supportive measure, providing financial aid, expertise, and technology transfer to help implement eco-friendly projects (Pandey et al., 2022; Kirchherr & Urban, 2018). This not only eases the financial burden of transitioning to greener practices but also provides the necessary knowledge and resources. The complementary effect here is that while environmental taxes discourage harmful practices, environmental-related grants simultaneously encourage and support the

adoption of greener alternatives. This dual mechanism creates a balanced approach to environmental sustainability: one part punitive, discouraging harm to the environment, and one part supportive, promoting the adoption of sustainable practices.

Moreover, the joint effect of these two mechanisms extends to driving innovation and technology transfer (Erdem Türkelli 2021; Choi & Cho, 2023). While environmental taxes create a market incentive for businesses to invest in clean technologies and sustainable practices (Ullah et al., 2023; Bashir et al., 2021), environmental-related grants facilitate the transfer of these technologies, especially to developing countries (Pandey et al., 2022; Kirchherr & Urban, 2018). This results in a global culture of innovation and rapid adoption of cleaner, more efficient solutions. In terms of capacity building and institutional strengthening, these two mechanisms again work hand in hand. While environmental taxes establish a regulatory framework promoting compliance with environmental standards, environmental-related grants provide resources for capacity-building initiatives and knowledge sharing (Enusah et al., 2024; Canton, 2021). This combination enhances the overall effectiveness of environmental initiatives and ensures the long-term sustainability of green growth efforts.

Additionally, the combination of environmental taxes and environmental-related grants fosters a culture of collaboration and knowledge sharing (Nawaz & Koç, 2020; Oliveira-Duarte et al., 2021). While environmental taxes encourage businesses to share best practices in adopting sustainable measures, environmental-related grants facilitate international partnerships and joint initiatives (Mariani et al., 2022; de Carvalho Alves et al., 2006). This integrated strategy addresses economic, technological, and institutional barriers to green growth, accelerating the transition towards a more sustainable economy and laying the foundation for a greener future (Nawaz & Koç, 2020; Oliveira-Duarte et al., 2021; Mariani et al., 2022). It is this study's proposition that the

synergistic effect of combining both a price instrument (tax) and a support instrument (grant) to create a comprehensive policy portfolio, in that, the tax generates the demand-pull by penalizing pollution, while the grant provides the necessary supply-push to accelerate the development and adoption of the desired clean technologies. This combination the researcher argues leads to a mutually reinforcing joint effect that is superior to either policy in isolation and critically, the grant can make even low levels of environmental taxation effective, acting as a catalyst for investment that would otherwise be inert. Moreover, the tax provides a market-driven incentive that helps ensure the subsidized R&D is directed toward high-quality, effective innovation, mitigating the risk of grants incentivizing 'strategic innovation'. The researchers also posit that the joint effect is inherently heterogeneous, as its success depends on the optimal calibration and coordination of the two instruments, a nuanced policy challenge that requires targeted empirical investigation. The study therefore hypothesis that:

H3: The joint effects of environmental tax and environmental grant have a heterogeneous and significantly synergistic effect on green growth, demonstrating a multiplier impact that effectively combines demand-pull incentives with supply-push support, particularly in overcoming the initial barriers to green technology adoption.

### **4.3 Evaluation of methodology**

#### **4.3.1 Data sources**

This chapter examines the joint effect of Environmental tax and environmentally related technical cooperation grants on green growth in Sub-Saharan Africa. In this regard, the study utilises secondary data obtained from the databases of the World Development Indicators, under the World Bank and the Organisation of Economic Co-operation for Development (OECD) for 15 Sub-

Saharan African countries from 2000-2020. The Organisation for Economic Co-operation and Development (OECD) maintains a vast collection of databases covering a wide range of economic, environmental, and social statistics for its member countries and selected non-member economies. Access to this data is primarily managed through the OECD Data Explorer. The World Development Indicators (WDI) is the World Bank's premier compilation of international statistics on global development and the fight against poverty. It is a comprehensive, publicly accessible database containing a vast array of time-series data for most countries in the world. The sample countries were selected based on data availability and their representation of the Sub-Saharan African region. The 15 countries included in the study are: Botswana, Cameroon, Congo, Cote d'Ivoire, Democratic Republic of the Congo, Ghana, Kenya, Madagascar, Namibia, Niger, Nigeria, Senegal, South Africa, Togo, Uganda.

#### **4.3.2 Measurement of Variables**

Green growth (Ggrowth) is the dependent variable of interest is proxied by two variables i.e. energy productivity and energy intensity. Energy productivity is calculated as GDP per unit of TES (USD/toe). It reflects efforts to improve energy efficiency and reduce carbon and other atmospheric emissions. Together with energy intensity, these indicators also reflect structural and climatic factors. TES comprises production + imports - exports -international marine bunkers- international aviation bunkers ± stock changes. Using PPP, Gross Domestic Product (GDP) is expressed at constant 2015 USD. The study uses two key independent variables, entailing environmentally related taxes and environmentally related technical cooperation grants. The study incorporates three control variables to strengthen the reliability and validity of the analysis. Gross domestic product (GDP) is included to account for the overall level of economic development, as

a country's green growth performance may be influenced by its stage of economic maturity. Regulatory quality (REGQ) is controlled to capture the institutional and governance environment, which can shape the effectiveness of environmental policies. Finally, renewable energy consumption (RCON) is included to represent the energy mix and adoption of cleaner energy sources, which would be expected to impact both CO<sub>2</sub> productivity and energy intensity. Including these relevant control variables helps isolate the specific effects of the policy instruments under investigation and enhance the robustness of the quantitative findings.

Therefore, the relationship between the dependent and independent variables can be specified as:

$$CO2Prod = f(ETax, TGrants, GDP, REGQ, RenCON) \quad \text{EQ (4.1)}$$

$$Eintensity = f(ETax, TGrants, GDP, REGQ, RenCON) \quad \text{EQ (4.2)}$$

Where CO<sub>2</sub>prod is carbon dioxide productivity, measured as economic productivity per unit of CO<sub>2</sub> emission. Eintensity is energy intensity, measured as energy consumption per GDP output. Etax is environmental tax, measured as environmental tax revenues mobilised by the state during a particular year. These three variables were obtained from the OECD database. Additionally, GDP is gross domestic product, and REGQ is regulatory quality. REG Q is an index of Government Effectiveness. It captures the quality of public services, the quality of civil service, the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Recon is renewable energy consumption. TGrants is technical cooperation grants, measured as the value of environmental technical cooperation grants received in a period. GDP, Recon, and TGrants were obtained from the World Bank's World Development Indicators. REGQ was obtained from the global economy database.

### 4.3.3 Econometric Model and Estimation Technique

The study employs a panel Autoregressive Distributed Lag (ARDL) model to examine the long-run and short-run relationships between the variables. The ARDL model is suitable for this study because it can be applied irrespective of whether the underlying regressors are purely I(0), purely I(1), or mutually cointegrated. Besides, it provides unbiased estimates of the long-run model and valid t-statistics even when some of the regressors are endogenous (Sarkodie & Strezov, 2018). The study's data is also suitable for the ARDL model since the number of periods (T) is larger than cross-sample units (N). This study follows the PMG-ARDL pathway utilised in Sarkodie and Strezov (2018), expressed in EQ (3) and EQ (4) as follows:

$$\Delta \ln y_{i,t} = \phi_i ECT_{i,t} + \sum_{j=0}^{q-1} \Delta \ln X_{i,t-j} \beta_{i,j} + \sum_{j=1}^{p-1} \psi_{i,j} \Delta \ln y_{i,t-j} + \varepsilon_{i,t} \quad \text{EQ(4.3)}$$

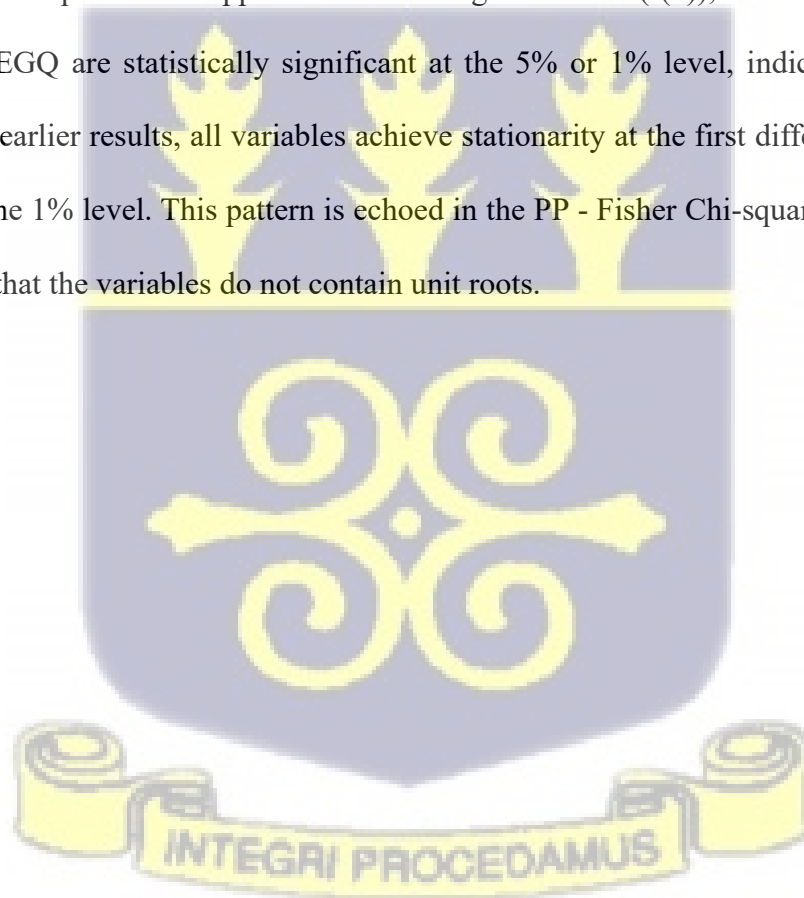
$$ECT_{i,t} = y_{i,t-1} - X_{i,t} \theta \quad \text{EQ(4)}$$

Where  $y$  is the dependent variable (GG),  $X$  is a vector of regressors (ETax, TGrants, GDP, REGQ, Recon) with lags  $q$  across individual cross-sectional units  $i$  in time  $t$ ,  $\Delta$  denotes the difference operator,  $\phi$  represents the adjustment coefficient,  $\theta$  denotes the long-run coefficient that produces  $\beta$  and  $\psi$  estimates after reaching convergence, and  $\varepsilon$  represents the error term. The study employs the Pooled Mean Group (PMG) estimator to estimate the ARDL model. The PMG estimator allows for heterogeneous short-run coefficients and common long-run coefficients across countries. Similarly, it is more efficient when the long-run coefficients are indeed homogeneous and provide consistent estimates of the long-run parameters under the assumption of cross-sectional independence of the error terms.

#### 4.3.4 Data Diagnostics

The study employs a comprehensive set of diagnostic tests and robustness checks to ensure the validity and reliability of the results. Firstly, it conducts unit root tests to determine the order of integration of the variables, which is crucial for understanding the data's stationarity properties.

From Table 1, unit root tests, entailing the Im, Pesaran, and Shin W-stat, reveal that variables including Ggrowth, Etax, and REGQ are stationary at level (I(0)), as indicated by statistical significance at the 5% or 1% level. Also, all variables become stationary at the first difference (I(1)), showing significance at the 1% level, highlighting that the data are stationary. Similarly, the ADF - Fisher Chi-square test supports these findings. At level (I(0)), variables such as Etax, TGrants, and REGQ are statistically significant at the 5% or 1% level, indicating stationarity. Consistent with earlier results, all variables achieve stationarity at the first difference (I(1)), with significance at the 1% level. This pattern is echoed in the PP - Fisher Chi-square test, reinforcing the observation that the variables do not contain unit roots.



**Table 4. 1: Stationarity Test**

Tests		Ggrowth	Etax	TGrants	GDP	RenCon	REGQ
		<i>t-stat</i>	<i>t-stat</i>	<i>t-stat</i>	<i>t-stat</i>	<i>t-stat</i>	<i>t-stat</i>
<b>I(0)</b>	Im, Pesaran and Shin W-stat	-2.02**	-1.79**	-2.65***	1.68	-0.42	-7.56***
	ADF - Fisher Chi-square	50.02**	56.29***	49.59**	29.84	28.1	130.66***
	PP - Fisher Chi-square	45.48**	57.43***	62.47***	33.45	30.66	111.65***
<b>I(1)</b>	Im, Pesaran and Shin W-stat	-9.02***	-9.01***	-7.15***	-3.08***	-6.22***	-13.19***
	ADF - Fisher Chi-square	136.33***	134.51***	106.51***	61.04***	97.27***	206.73***
	PP - Fisher Chi-square	502.74***	549.32***	472.38***	100.64***	172.93***	556.97***



The mixed order of integration (I(0) and I(1)) found in these stationarity tests supports using the ARDL approach. The ARDL model is advantageous because it accommodates variables with different orders of integration, unlike traditional cointegration methods that require uniform integration. This flexibility and the ability to handle different optimal lag lengths make ARDL particularly suitable for the current dataset, providing a solid basis for subsequent analysis.

In Table 2, the Kao Residual Cointegration Test results indicate a strong long-term equilibrium relationship among the variables in the series, as evidenced by the highly negative ADF t-statistic of -10.8273 and a probability value of 0. This low probability value allows us to reject the null hypothesis of no cointegration with high confidence. Additionally, the residual variance of 0.002543 and HAC variance of 0.001501 suggest that the residuals are well-behaved, adjusting for potential heteroskedasticity and autocorrelation. These results confirm that the variables move together over the long term, maintaining a stable relationship despite short-term fluctuations.

**Table 4. 2: Test of Cointegration**

<b>Kao Residual Cointegration Test</b>		
	t-Statistic	Prob.
ADF	-10.827	0.000
Residual variance	0.003	
HAC variance	0.002	

Moreover, Pesaran and Yamagata's (2008) test for slope homogeneity was implemented. The test results (Table 3) suggest insufficient evidence to reject the null hypothesis of homogeneous slope

coefficients. The Delta statistic is 0.436 with a p-value of 0.663, and the adjusted statistic is 0.521 with a p-value of 0.603. Both p-values are high, indicating that any observed variation in slope coefficients is not statistically significant. Thus, it is reasonable to conclude that the slope coefficients are likely homogeneous across the dataset. Similarly, the Wooldridge test for autocorrelation in panel data shows that the F-statistic is 0.108 with a p-value of 0.747. Since the p-value is much higher than typical significance levels (e.g., 0.05), we fail to reject the null hypothesis of no first-order autocorrelation. This suggests that there is no significant evidence of autocorrelation in the panel data.

**Table 4. 3: Slope heterogeneity and autocorrelation test**

<b>Slope heterogeneity</b>		
	<b>Delta</b>	<b>p-value</b>
	0.436	0.663
adj.	0.521	0.603
<i>H0: slope coefficients are homogenous</i>		
<b>Autocorrelation</b>		
F-statistic	0.108	0.747
<i>H0: no first-order autocorrelation.</i>		

The study conducts several robust checks to confirm the findings' robustness. One such check involves using alternative measures of green growth, entailing energy intensity, to validate the results obtained from the primary analysis. By exploring different proxies for green growth, the

study ensures the reliability and consistency of the conclusions drawn regarding the joint effect of environmental taxes and environmental-related grants on green growth in Sub-Saharan Africa.

Additionally, given that the ARDL does not consider the asymmetric relationship between the dependent and independent variables of interest, this study further estimates a method of moments quantile regression (MMQREG) to assess whether the observed relationship in the baseline model will vary with the different conditional quantiles of the dependent variable. The MMQREG is robust to distributional assumptions and can be combined with fixed effects to absorb heterogeneity in data (Machado and Silva, 2019).

#### 4.3.5 Preliminary Results

The descriptive statistics (Table 4) provide an initial understanding of the key variables in the analysis. For instance, CO2 productivity (CO2Prod) shows a mean of 1.094 and a range from 0.525 to 1.636, representing a 211.6% difference. The standard deviation of 0.231 (21.1% of the mean) suggests a substantial spread in carbon efficiency. Environmental tax (Etax) displays a mean of 0.447, ranging from 0.301 to 0.788, with moderate variability indicated by a standard deviation of 0.119 (26.6% of the mean).

**Table 4. 4: Descriptive Statistics**

	CO2Prod	Etax	TGrants	REGQ	RenCon
Mean	1.094	0.447	5.132	0.396	1.756
Median	1.126	0.434	6.076	0.418	1.874
Maximum	1.636	0.788	9.712	0.591	1.993
Minimum	0.525	0.301	0.301	0.063	0.881
Std. Dev.	0.231	0.119	3.039	0.104	0.263

Similarly, technical cooperation grants (TGrants) exhibit the most pronounced variability, with a mean of 5.132 and an extreme range from 0.301 to 9.712, representing a 3126.6% difference. The standard deviation of 3.039 (59.2% of the mean) underscores the highly uneven distribution of grants. These contrasts highlight the complex landscape of environmental and economic factors across different entities in the sample.

From the correlation Table (Table 5), CO2 productivity shows a strong positive correlation (0.845) with renewable energy consumption, suggesting that higher renewable energy use is associated with improved carbon efficiency. Conversely, CO2 productivity has a strong negative correlation (-0.733) with energy intensity, indicating that lower energy consumption is linked to higher carbon productivity.

**Table 4. 5: Pairwise correlations**

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) CO2Prod	1.000					
(2) Eintensity	-0.733***	1.000				
(3) Etax	0.148***	-0.393***	1.000			
(4) TGrants	0.165***	-0.079	0.552***	1.000		
(5) GDP	-0.213***	0.569***	0.474***	0.646***	1.000	
(6) RenCon	0.845***	-0.855***	-0.326***	0.065	-0.312***	1.000

Environmental tax (Etax) shows moderate positive correlations with technical cooperation grants (0.552) and GDP (0.474), suggesting that countries with higher environmental tax revenues tend

to receive more technical cooperation grants and have higher GDP levels. Interestingly, environmental tax has a weak positive correlation (0.148) with CO2 productivity, implying that higher environmental taxes might be associated with slightly improved carbon efficiency.

The correlation matrix reveals some other notable relationships. Technical cooperation grants (TGrants) have a strong positive correlation (0.646) with GDP, indicating that countries with higher GDP tend to receive more environmental grants. Renewable energy consumption (RenCon) shows a strong negative correlation (-0.855) with energy intensity, suggesting that higher renewable energy use is associated with lower overall energy consumption.

#### 4.4 Empirical Results

**Table 4. 6: Estimated Results: ARDL**

Long Run Results	CO2 Productivity	Energy Intensity
TGrants	0.197*** (0.073)	-0.017 (0.012)
Etax	.740 (1.185)	-.393 (0.323)
ETax * TGrants	.601*** (1.141)	-0.184*** (0.039)
GDP	-.483 (0.991)	.175** (0.126)
Recon	.811***	-0.627***

	(1.58)	(0.236)
REGQ	.644***	-0.014**
	(4.036)	(0.021)
<b>Short Run Results</b>		
Error correction	-0.167***	-0.239**
	(0.064)	(0.084)
D(TGrants)	-0.045	NA
	(0.057)	(NA)
D(ETax * TGrants)	0.852	NA
	(1.698)	(NA)
D(Recon)	.1307*	-0.450**
	(2.132)	(0.270)
D(REGQ)	0.904	NA
	(5.408)	
Model selection method:	(AIC)	(AIC)
Number of models evaluated:	64	128
Selected model:	PMG (1,1,0,1,0,1,1)	PMG (1,0,0,1,0,0,0,0)

*Standard errors in parenthesis (\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ )*

Starting with the long-run results, as depicted in Table 4.9 above, the analysis indicates that environmental technical cooperation grants (TGrants) have a positive and statistically significant effect on CO2 productivity. A 1% increase in environmental technical cooperation grants is associated with a 19.7% increase in CO2 productivity, which is a measure of economic

productivity per unit of CO<sub>2</sub> emissions. In contrast, the direct effect of environmental taxes (Env. Tax) on CO<sub>2</sub> productivity is not statistically significant. However, the interaction term between environmental taxes and technical grants (Env. Tax \* Grants) has a positive and significant effect. A 1% increase in the interaction between environmental taxes and technical grants is associated with a 60.1% increase in CO<sub>2</sub> productivity. This suggests that combining these two policy instruments has a synergistic effect, amplifying the positive impact on CO<sub>2</sub> productivity.

It is important to also infer from the findings that dependency on foreign aid can create issues related to fiscal sovereignty, reduce incentives for domestic revenue mobilization, and lead to sustainability concerns once aid flows diminish or cease. Also, the long-term effectiveness of grant-based interventions may be compromised if they are not integrated into a broader, sustainable development strategy. Empirical evidence, such as the work by Rajan and Subramanian (2008), indicates that heavy dependence on foreign aid can hinder the development of robust domestic revenue systems and may lead to aid dependency traps. Moreover, studies like those by Minoiu and Reddy (2010) suggest that aid effectiveness diminishes over time without proper institutional capacity and sustainability measures. Addressing these issues explicitly would provide a more nuanced understanding of the limitations and considerations necessary for implementing grant-based interventions alongside taxation policies, ensuring their long-term viability and effectiveness.

Turning to energy intensity, the long-run results show that the direct effects of both environmental taxes and technical grants are not statistically significant. Nevertheless, the interaction term (ETax \* TGrants) has a negative and significant effect. A 1% increase in the interaction between environmental taxes and technical grants is associated with an 18.4% reduction in energy intensity, which is a desirable outcome for green growth.

The control variables also provide additional insights. Gross domestic product (GDP) negatively but insignificantly affects CO<sub>2</sub> productivity. In contrast, GDP has a positive significant effect of 17.5% on energy intensity, suggesting that economic growth is associated with higher energy intensity. Additionally, renewable energy consumption (RenCon) has a positive effect of 81.1% on CO<sub>2</sub> productivity and a negative effect of -62.7% on energy intensity, demonstrating its beneficial impact on green growth. Regulatory quality (REG. Q) also has a positive effect of 64.4% on CO<sub>2</sub> productivity and a negative effect of -1.4% on energy intensity, highlighting the importance of good governance for sustainable development. The short-run results complement the long-run findings, indicating that the error correction term is negative and significant for both CO<sub>2</sub> productivity (-16.7%) and energy intensity (-23.9%), suggesting that the system adjusts to restore the long-run equilibrium following a shock. Additionally, the short-run changes in renewable energy consumption have a positive effect of 13% on CO<sub>2</sub> productivity and a negative effect of -45.0% on energy intensity.

We further examined the robustness of the findings by assessing whether the results will vary according to different conditional quantiles of the dependent variable, as presented in Table 4.10. The quantile regression results show that the interaction between environmental taxes and technical grants has a positive and statistically significant effect on CO<sub>2</sub> productivity only at the medium to higher levels of the distribution (50th percentile and above), indicating the synergistic impact of these policy instruments is more pronounced for when countries already perform at medium to high levels of green growth. Specifically, at the 50th quantile, a 1% increase in the interaction term is associated with a 10.3% increase in CO<sub>2</sub> productivity. At the 75th and 90th percentiles, a 1% increase in the interaction term is associated with a 16.1% and 19.5% increase in CO<sub>2</sub> productivity, respectively. Meanwhile, the interaction term failed to establish a significant

relationship with CO2 productivity at the lower quantile (i.e., 10<sup>th</sup> and 25<sup>th</sup> quantiles). This suggests that the synergistic effect of environmental taxes and technical grants is more pronounced at the upper end of the distribution, indicating that a comprehensive policy approach can significantly enhance economic productivity per unit of CO2 emissions.



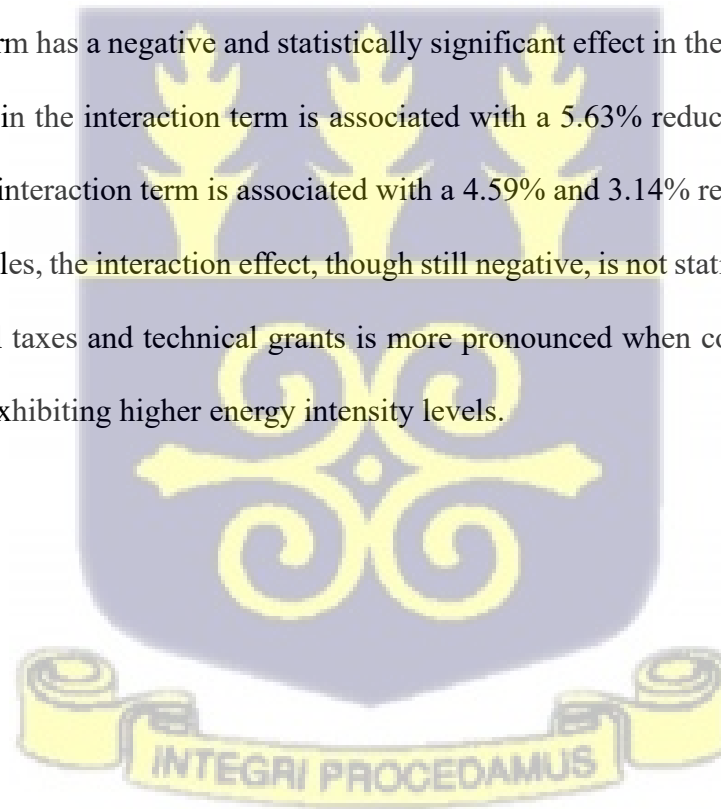
**Table 4. 7: Asymmetric Effects**

	10th		25th		5th		75th		90th	
	CO2pro		CO2pro		CO2pro		CO2pro		CO2pro	
	d	E.Int	d	E.Int	d	E.Int	d	E.Int	d	E.Int
ETax	0.0147	0.0669	0.0527	-0.060*	0.0841	-0.051*	0.133**	-0.0375	0.163	-0.0304
	(0.24)	(-0.72)	(1.05)	(-2.48)	(1.84)	(-2.14)	(2.67)	(-1.24)	(1.93)	(-0.84)
TGrants	-0.0408	0.0405	-0.0002	0.0209	0.0334	-0.0063	0.0858	-0.0445	0.117*	-0.065
	(-0.51)	(0.92)	(-0.00)	(0.57)	(0.66)	(-0.19)	(1.72)	(-1.19)	(2.15)	(-1.47)
ETax*TGrant	-	-	-	-	-	-	-	-	-	-
s	0.0214	0.0563***	0.0662	0.0459***	0.103	-0.0314**	0.161***	-0.0111	0.195***	-0.0001
	(0.30)	(-5.04)	(1.14)	(-4.88)	(1.94)	(-3.26)	(6.73)	(-0.32)	(8.99)	(-0.00)
GDP	-0.273***	0.108*	-0.257***	0.112**	-0.244***	0.119**	-0.224***	0.128**	-0.213**	0.132*
	(-3.76)	(2.20)	(-4.32)	(2.68)	(-4.47)	(3.12)	(-3.64)	(2.85)	(-2.94)	(2.51)
RCon										
	0.0367*	-0.0392**	0.0407*	-0.0004**	0.044***	0.0555***	0.0492***	-0.133***	0.0524**	0.174***
	(-2.30)	(-2.70)	(-2.41)	(-2.68)	(-6.34)	(0.52)	(-5.31)	(6.31)	(-3.69)	(7.37)

REGQ								-		-
	0.393*	-0.0682*	0.381**	-0.0895**	0.371**	-0.119*	0.355**	0.161***	0.346**	0.183***
	(2.56)	(-2.51)	(3.06)	(-2.71)	(3.27)	(-1.98)	(2.76)	(-5.97)	(2.98)	(-4.71)
_cons	4.154***	-0.957	3.847***	-0.855	3.593***	-0.714	3.197***	-0.516	2.961**	-0.41
	(3.58)	(-1.10)	(4.09)	(-1.19)	(4.30)	(-1.14)	(3.60)	(-0.66)	(2.92)	(-0.43)

*t statistics in parenthesis*

For energy intensity, the interaction term has a negative and statistically significant effect in the lower to median part of the distribution. At the 10th percentile, a 1% increase in the interaction term is associated with a 5.63% reduction in energy intensity. At the 25th and 50th percentiles, a 1% increase in the interaction term is associated with a 4.59% and 3.14% reduction in energy intensity, respectively. However, at the 75th and 90th percentiles, the interaction effect, though still negative, is not statistically significant. The findings suggest that the joint impact of environmental taxes and technical grants is more pronounced when countries have low energy intensity. Still, the impact becomes muted for those exhibiting higher energy intensity levels.



#### 4.4.1 Discussions of Results

The direct effect of environmental taxes on green growth is insignificant. This finding agrees with Belletti (2020), suggesting that environmental taxes alone may not be sufficient to drive targeted green growth outcomes in the region. Several factors may contribute to this, including limited enforcement mechanisms, taxpayer non-compliance, and structural or economic barriers (OECD, 2019). For instance, a joint study by the OECD and IMF in 2021 revealed that environmental tax rates in the SSA region are too low to incentivise significant changes in production processes or energy sources, reducing their ability to influence green growth. Furthermore, the lack of viable alternatives for firms to adopt, even if motivated to reduce emissions, can hinder the effectiveness of environmental taxes (United Nations Environment Programme, 2018).

In contrast, environmentally-related technical cooperation grants improve green growth. This finding corroborates earlier studies (Maiti, 2022; Lin & Ullah, 2024; Söderholm, 2020) that suggest that international support and knowledge-sharing in the form of technical assistance and capacity building can effectively complement domestic environmental policies. The SSA region is historically known to lack adequate resources (e.g., financial, human, technical) needed for developmental projects, such as mitigating climate change and transitioning to clean and efficient energy systems (Occhiali, 2023; Mpofo, 2022; Youssef & Dahmani, 2024). In this regard, transferring green technologies, expertise, and best practices from development partners may help sub-Saharan African countries overcome resource and capability constraints, improving their CO<sub>2</sub> productivity more effectively (Pandey et al., 2022; Maiti, 2022). This points to the value of strengthening environmental governance through collaborative efforts between national governments and the international community.

On the other hand, the joint effect of environmental taxes and technical cooperation grants on green growth is positive and significant. This suggests that combining domestic policy instruments and external support can be a powerful driver of green growth in sub-Saharan Africa (Liu et al., 2022; Shao & Huang, 2023; Zhang et al., 2023). Implementation of environmental taxes faces obstacles such as lack of data, analytical capacity, coordination among government actors, and concerns about regressivity and industrial development (Occhiali, 2023; Youssef & Dahmani, 2024). These suggest that a nuanced approach combining domestic policy instruments, external support, and tailored strategies is necessary to drive green growth in Sub-Saharan Africa. The synergistic interaction between these two factors may enhance their individual effectiveness, creating a multiplier effect on CO<sub>2</sub> productivity improvements. This finding aligns with the idea that environmental challenges are complex and require a comprehensive policy mix rather than relying on a single instrument (Gunningham & Sinclair, 2019, 1999; Rogge & Reichardt, 2015).

The analysis of energy intensity provides further insights. When considering energy intensity as a measure of green growth, the findings generally align with those observed for CO<sub>2</sub> productivity. The insignificant effect of environmental taxes on energy intensity further reinforces the challenges of implementing standalone fiscal measures in the region. However, the positive significant effect of environmentally-related technical cooperation grants on reducing energy intensity highlights the importance of direct support for technological improvements and knowledge transfer in these developing economies. Interestingly, the joint effect of environmental taxes and technical cooperation grants on energy intensity is negative and significant, suggesting that combining financial disincentives (taxes) and positive support for improvement (grants) creates a robust framework for reducing energy intensity and promoting green growth. The

interaction between these policy instruments appears to address some of the structural and institutional barriers that previously limited the effectiveness of environmental taxes in isolation.

These findings collectively emphasise the importance of a holistic approach to environmental policy in sub-Saharan Africa. While environmental taxes alone may not drive targeted green growth outcomes, their impact becomes pronounced when combined with technical cooperation grants. This synergistic effect suggests that the efficacy of environmental taxes is enhanced when supported by capacity-building measures and knowledge transfer.

#### **4.5 Conclusions and Policy Implications**

This study examines the combined effect of environmental taxes and environment-related grants on green growth sampling 15 Sub-Saharan African countries from 2000 to 2020. Using a panel autoregressive distributed lag (ARDL) model and a method of moments quantile regression analysis. The study reveals that environmental taxes alone are insufficient to drive green growth in Sub-Saharan Africa (SSA), while environmentally-related technical cooperation grants show a positive impact. Most importantly, combining these two policy instruments demonstrates a significant positive effect on green growth, as measured by CO<sub>2</sub> productivity and energy intensity per GDP.

Considering these results, policymakers in SSA countries should prioritise implementing a balanced policy mix. While environmental taxes should remain a part of the strategy, they must be carefully designed and implemented. Countries should consider introducing environmental taxes gradually, starting with modest rates and progressively increasing them over time. This approach, successfully implemented in countries like Sweden and Denmark, allows businesses and consumers to adapt while providing a clear long-term signal for green investments.

Simultaneously, SSA countries should actively seek and effectively utilise environmental-related grants. These grants should target capacity building, technology transfer, and institutional strengthening. For instance, establishing dedicated environmental policy units within finance ministries, as done in Colombia and Indonesia, can enhance the design and implementation of green fiscal policies. Moreover, grants should support the development of green alternatives in key sectors, such as renewable energy and sustainable agriculture, to provide viable options for businesses seeking to reduce their environmental impact.

To maximise the synergistic effect observed in the study, SSA countries should design integrated programs that combine environmental taxes with technical support. For example, a portion of the revenue from environmental taxes could be earmarked for a "Green Technology Fund," which, supplemented by international grants, can provide low-interest loans or subsidies for green investments. Similar to Thailand's Energy Conservation Promotion Fund, this approach can create a virtuous cycle of environmental improvement and economic growth. Similarly, regional cooperation should be strengthened to enhance the effectiveness of these policies. SSA countries could establish a regional green growth initiative, similar to the Association of Southeast Asian Nations (ASEAN) Green Growth Initiative, to share best practices, coordinate policies, and jointly negotiate for international support. This collaborative approach can help address common challenges, such as limited enforcement capacity and the need for harmonised standards, while also increasing the region's collective bargaining power in international climate negotiations. By implementing these recommendations, SSA countries can create a robust green growth framework that leverages domestic policy instruments and international support.

Lastly, the quantile analysis highlights the importance of tailoring policy approaches based on a country's current level of green growth performance. For countries with lower CO<sub>2</sub> productivity,

initial efforts may need to focus more heavily on capacity building and technical assistance to establish a foundation for green growth. As these countries improve their performance, introducing and gradually strengthening environmental taxes, combined with ongoing technical support, can lead to more substantial improvements in CO<sub>2</sub> productivity. Similarly, for countries with high energy intensity, a strong initial push combining environmental taxes with targeted technical assistance can yield significant improvements in energy efficiency. As these countries approach higher levels of energy efficiency, policy focus may need to shift towards maintaining gains and addressing more specific sector-level inefficiencies.



## CHAPTER FIVE

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS



## 5.1 Introduction

This final chapter synthesises the key findings from the various papers, highlighting the central issues that have emerged throughout the research. It summarizes the overarching conclusions drawn from each paper, linking them to the broader objectives of the thesis. In addition, this chapter presents actionable recommendations for public policy based on the insights gained. It emphasises the distinct contributions of each study, acknowledges the limitations faced during the research process, and outlines potential pathways for future research in this field.

## 5.2 Overview

This thesis is a collection of three related studies on the relationships between environmental taxes, green growth, natural resources, control of corruption, and environmental-related grants. The first chapter focuses on the general introduction, which covers the study's background, the problem statement, the study objectives, the significance of the study, and the thesis structure.

Chapters two to four present empirical articles that explore the relationship among the variables of interest. In chapter two, the paper uses the Two-Stage Least Squares economic model to analyse the moderating effect of corruption control on the relationship between environmental taxes and natural resource depletion in Sub-Saharan Africa. The results demonstrate that a 1% increase in environmental taxes leads to a 1.5% increase in natural resource depletion. However, improved governance mitigates this effect, with a one-unit increase in control of corruption, reducing natural resource depletion by 0.32%. The interaction term between environmental tax and control of corruption is also significant with a one-unit increase in reducing depletion by 0.024%, showing a

strong moderating effect. These findings highlight the essential role that governance plays in determining the effectiveness of environmental taxes.

Chapter three employs the Method of Moments Quantile Regression (MMQR) to examine the heterogeneity in the moderating effect of corruption control on the relationship between environmental tax and green growth. The MMQR model is chosen because it addresses several limitations of the traditional regression models (Wolde-Rufael & Mulat-Weldemeskel, 2023). Firstly, it produces reliable and robust results when the dataset's distribution is non-parametric, especially when the data is abnormal, which may include outliers and minimal or no correlation. Secondly, the technique's moment conditions can deal with both endogeneity and heterogeneity in the data, which might lead to biased results. Thirdly, MMQR accommodates individual fixed effects across the conditional distribution, allowing predictors to account for location and scale functions (Alhassan et al., 2020).

Again, it allows for not just location-based asymmetry, as the parameters may vary according to the position of the predicted variables, but it also produces good estimates under diverse conditions, even if the model is non-linear. The results from the Method of Moments Quantile Regression provide valuable insights into the moderating role of corruption on the relationship between environmental tax and green growth across different quantiles in sub-Saharan African countries. Starting with the location (first moment) results, environmental tax has an average positive effect on green growth with a coefficient of 115.5, though this effect is not statistically significant, indicating that the tax may have a mixed impact on green growth when averaged across the sample. However, the scale (second moment) results reveal that environmental tax significantly increases the dispersion of green growth outcomes, as indicated by the positive coefficient of 1,503, which is statistically significant at the 1% level. This suggests that while environmental tax

may have an overall positive effect, it also leads to greater variability in green growth outcomes, which could indicate uneven implementation or varying levels of effectiveness across different contexts.

When analysing the effects across different quantiles (third moment), the results show that environmental tax has a significant negative impact on green growth in the lowest quantile (10), with a coefficient of -2,056, significant at the 1% level and a negative impact in quantile 25 with a coefficient of -1,290, significant at the 10% level. This indicates that in countries or regions with the lowest levels of green growth, environmental taxes may actually hinder growth, possibly due to economic structures that are highly sensitive to increased costs. However, in the higher quantiles (75 and 90), the impact of environmental tax becomes positive, with coefficients of 1,396 and 2,727, respectively, and the latter being significant at the 5% level. This suggests that environmental taxes can stimulate growth in contexts where green growth is already higher by encouraging more efficient resource use and investments in green technologies. The role of control of corruption is also significant in promoting green growth. The average effect (location) is positive with a coefficient of 1,348, significant at the 10% level, indicating that better control of corruption generally supports green growth. However, the scale result shows a negative but insignificant effect on dispersion, suggesting that improvements in corruption control do not significantly affect the variability of green growth outcomes. Across quantiles, the control of corruption has a positive and significant impact on green growth at the lower quantiles (10 and 25), with coefficients of 1,531 and 1,467, respectively, both significant at the 5% level. This underscores the importance of good governance in fostering green growth, particularly in regions struggling with low initial levels of development. The impact remains positive but loses statistical significance in the highest

quantiles, suggesting that while governance remains important, other factors may become more influential as green growth increases.

The moderating effect of corruption control on the relationship between environmental tax and green growth is evident in the positive and significant coefficients for the interaction term (Moderator). The average effect is positive with a coefficient of 1,796, significant at the 5% level, indicating that the combination of environmental tax and strong governance (i.e., control of corruption) significantly boosts green growth. The scale result shows a highly significant positive effect on dispersion, suggesting that this interaction increases the variability in green growth outcomes, likely reflecting differences in how effectively environmental taxes are implemented in varying governance contexts. Across quantiles, the moderating effect is not significant at the lowest quantile, but it becomes increasingly significant and positive in the higher quantiles, with the highest impact observed in quantile 90, where the coefficient is 4,903, significant at the 1% level. This demonstrates that in regions with higher green growth, the synergistic effect of environmental tax and good governance is particularly powerful in driving further growth.

Chapter four investigates the combined effect of environmental taxes and environmental-related grants on green growth in 15 Sub-Saharan African countries between 2000 and 2020. The analysis, which is based on the double dividend hypothesis, investigates how these two policy instruments work together to support sustainable economic development. Using a panel Autoregressive Distributed Lag(ARDL)model and Method of Moments Quantile Regression analysis, he concludes that environmental taxes and environmental-related grants significantly improve CO2 productivity while lowering energy intensity per GDP output.

### 5.3 Summary and Public Policy Implications

This thesis's conclusions and policy implications offer valuable insights: First, it emphasises the critical relationship between environmental taxes, governance, and green growth in sub-Saharan Africa (SSA). It reveals that environmental taxes, in isolation, can lead to higher natural resource depletion. However, strong governance—particularly through the control of corruption—significantly mitigates this effect. This, therefore, highlights the importance of governance frameworks to ensure that environmental taxes achieve their intended goals of reducing resource depletion. Without effective governance mechanisms, environmental taxes may fail, exacerbating environmental degradation instead. Key structural factors, like energy use and urbanisation, also play significant roles in determining the outcomes of environmental policies. It also underscores the need for SSA policymakers to prioritise anti-corruption measures, enhance transparency, and strengthen institutions to make environmental taxation effective. Again, complementary policies addressing energy efficiency and renewable energy promotion should be incorporated to reduce dependency on non-renewable resources. In this regard, the broader policy implication is that governance reforms are a prerequisite for successfully implementing environmental policies aimed at sustainable resource management.

Secondly, the thesis also brings to the fore the nuanced relationship between environmental tax, control of corruption, and green growth. While environmental taxes are intended to foster environmentally sustainable practices, they may hinder SSA's green growth due to these countries' economic structure, where industries rely heavily on practices penalised by environmental taxes. However, the control of corruption has a significant positive impact on green growth, emphasising that good governance is essential for the success of environmental policies. The results also show that the negative impact of environmental tax on green growth is mitigated in countries with strong

governance. Therefore, environmental taxes can effectively contribute to green growth in well-governed countries. The findings suggest that policymakers should exercise caution when introducing environmental taxes in corrupt environments, as these taxes may further strain the economy. Strengthening governance is essential before such taxes can be effectively implemented. The policy recommendation is that environmental tax policies must be tailored to each country's governance context, with more aggressive taxes feasible in low-corruption environments. Integrating governance reforms with environmental policies is necessary to achieve sustainable development, as good governance enables environmental taxes to contribute to green growth.

Thirdly, in the investigation of the combined effect of environmental taxes and technical cooperation grants on green growth in SSA, this thesis finds that environmental taxes alone do not significantly impact green growth, but when paired with technical cooperation grants, the combination yields a positive effect on green growth, as measured by CO<sub>2</sub> productivity and energy intensity per GDP. The findings, thus, highlight the importance of a balanced policy approach that combines fiscal tools with capacity-building support. Policymakers should consider gradually introducing environmental taxes while actively seeking and effectively utilising technical cooperation grants to enhance institutional capacity, technology transfer, and green policy design. For example, revenue from environmental taxes could be earmarked for a "Green Technology Fund" to support green investments. Regional cooperation, through initiatives like a green growth framework, could also enhance the effectiveness of these policies by sharing best practices and coordinating efforts. This combination of domestic and international support can drive green growth in SSA. The study also suggests tailoring policy approaches to the level of green growth performance, with lower-performing countries initially focusing on capacity-building and

technical assistance, while higher-performing countries can adopt more aggressive environmental taxes.

On the strength of the above analyses, the thesis makes several recommendations. First, a sequenced and context-sensitive implementation roadmap is necessary to ensure the feasibility of policy recommendations across SSA's diverse governance and resource-capacity settings. In the short term (1–3 years), countries with weaker institutions should prioritise anti-corruption reforms through transparent procurement systems, e-governance platforms, and independent audit mechanisms. Development partners should provide technical assistance grants targeted at training tax administrators, strengthening national audit offices, and digitising revenue collection systems, while regional bodies such as the African Union could coordinate peer review mechanisms to benchmark progress on governance reforms before aggressive taxation measures are implemented. In the medium term (3–5 years), countries with moderate governance scores should begin with low-rate, sector-specific environmental levies—for instance on fossil fuels, extractive industries, or plastic use—while simultaneously earmarking revenues for visible, high-impact projects such as renewable energy programmes or reforestation schemes. To reduce resistance, governments should adopt revenue earmarking rules that ensure collected taxes visibly finance climate and energy initiatives, thereby increasing public acceptance. In the medium to long term (5–10 years), governments should integrate tax policies with international partnerships that provide green technology transfers, capacity-building grants, and concessional financing. Revenues from environmental taxes could partly finance a Green Technology Fund dedicated to supporting local enterprises and communities in adopting renewable technologies, while regional cooperation through the African Continental Free Trade Area (AfCFTA) and other sub-regional blocs can support harmonised tax structures, joint research platforms, and knowledge-sharing on green fiscal

tools. In the long term (10 years and beyond), well-governed countries may transition to broader-based, higher-rate environmental taxes integrated into national fiscal frameworks and aligned with green growth strategies, whereas less-governed contexts should scale reforms more gradually by prioritising capacity-building and international support before expanding the tax base. By laying out these phased and differentiated recommendations, the study provides a clear operational roadmap for policymakers. Rather than advocating a uniform implementation of environmental taxation, it emphasises a governance-first, taxes-second approach that is sensitive to institutional realities, while also recognising the critical role of development partners in financing governance reforms, supporting technology adoption, and fostering regional policy coordination.

Regarding the Sustainable Development Goals (SDGs), the findings have several key implications for SSA. Stronger governance and anti-corruption efforts directly align with SDG 16 (Peace, Justice, and Strong Institutions), as improved governance enables enforcing environmental policies and resource management. The combination of environmental taxes and technical cooperation supports SDG 13 (Climate Action) by promoting CO<sub>2</sub> productivity and energy efficiency. The study's emphasis on energy efficiency and renewable energy also ties into SDG 7 (Affordable and Clean Energy), as complementary policies are necessary to reduce reliance on non-renewable energy sources. Furthermore, integrating governance and environmental policies contributes to SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production), fostering sustainable development through comprehensive policy approaches. Lastly, regional cooperation and capacity-building initiatives that promote green growth align with SDG 17 (Partnerships for the Goals), encouraging collaboration between SSA countries and international partners.

The theoretical insights and contextual implications of this study rest on the integration of Pigouvian theory and the resource curse framework within the governance context of Sub-Saharan Africa. The Pigouvian principle suggests that environmental taxes can correct market failures by internalizing the social cost of environmental degradation, thereby aligning private and social incentives for sustainable resource use. However, the effectiveness of this mechanism is conditional upon institutional quality and the degree of corruption control. In highly corrupt environments, the intended corrective function of environmental taxation may be undermined as rent-seeking, misappropriation of revenues, and policy capture distort incentives and weaken enforcement. The resource curse theory, on the other hand, explains how resource-rich countries—particularly in Africa, which often experience slower growth, weaker institutions, and higher levels of corruption due to overdependence on extractive rents and the political economy of natural resource management. Contextually, this study highlights that the interaction between environmental taxation, environmental-related grants, and corruption control determines whether fiscal instruments produce the “green dividend” or exacerbate natural resource depletion. In Sub-Saharan Africa, where governance challenges persist, these findings imply that environmental taxes alone may not yield the desired outcomes unless accompanied by effective anti-corruption measures, transparent revenue allocation, and institutional reforms that promote accountability and reinvestment in green sectors. Thus, the study contributes to the theoretical understanding that the environmental and developmental efficacy of fiscal instruments is not solely an economic function but deeply embedded in the political and institutional fabric of the region.

Overall, this thesis stresses the importance of a governance-driven approach to environmental policies in SSA, where environmental taxes alone are insufficient without addressing corruption and institutional weaknesses. By integrating environmental taxes with technical cooperation and

international support, SSA countries can drive green growth and contribute to achieving multiple SDGs.

#### **5.4 Limitations of the study**

Notwithstanding the enormous and invaluable contributions this thesis makes to the body of knowledge and practice in the areas of environmental tax, natural resource natural resource management and green growth, a few limitations can be identified in the research.

The research did not capture a sub-analysis of the relationship between environmental tax, natural resource management, and green growth at the continental level. Therefore, it does not give an understanding of the nature of the relationship compared to other continents.

However, the above limitation notwithstanding, the thesis provides intriguing results, analysis, and policy prescriptions in environmental tax, natural resource management, and green growth.

#### **5.5 Future Research**

Based on the limitations outlined above, future research should address the limitations identified in this study to provide more comprehensive insights into the relationship between environmental taxes, governance, and green growth across continents to account for the unique socio-economic and institutional conditions in different continents, which may affect the success of environmental policies.



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