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Par

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ESSAIS SUR LA FINANCE VERTE ET LES POLITIQUES D'ATTENUATION AU CHANGEMENT CLIMATIQUE EN AFRIQUE SUB-SAHARIENNE

Soutenu le 29/04/2025

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Graduate School: Climate Change Economics

By

Mahamadi GABA

ESSAYS ON GREEN FINANCE AND CLIMATE CHANGE MITIGATION POLICIES IN SUB-SAHARAN AFRICA

Presented on 29/04/2025

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DECLARATION

I, **Mahamadi Gaba**, certify that this PhD thesis entitled "Essays on green finance and climate mitigation policies in Africa" has not been submitted to any other institution, university or organisation to obtain a degree or academic certification.

I also certify that all the work presented in this manuscript is the fruit of my research. Errors and omissions are entirely my responsibility.

Dedicate to

My Mum
Igna
Dia Dramé
Nathina Santara
Tonton Sarmoye
Béré Bacaina

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Abbreviations

AAAA	Addis Ababa Action Agenda
AF	Adaptation Fund
AMG	Augmented Mean Group
BCEAO	Banque Centrale des Etats de l'Afrique de l'Ouest
BMA	Bayesian Model Averaging
BRICS	Brazil, Russia, India, China and South Africa
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CGE	Computable General Equilibrium
CO2	Carbon dioxide
COP	Conference of the Parties
CS-ARDL	Cross-Sectional Autoregressive Distributed Lag
CSR	Corporate Social Responsibility
E&S	Environmental and Social
ECOWAS	Economic Community of West African States
EP	Equator Principles
EPFI	Equator Principles Financial Institution
ESG	Environmental, Social and Governance
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
ETS	Emissions Trading System/Scheme
FCFA	Francs de la Communauté Financière d'Afrique
FD-2SLS	First Difference Two-Stage Least Squares
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Green Environmental Facility
GHG	Greenhouse gas
ICT	Information and Communication Technology
JETP	Just Energy Transition Partnership
MDB	Multilateral Development Banks
NDA	National Designed Authorities
NDC	Nationally Determined Contribution
OECD	Organisation for Economic Co-operation and Development
PCI	Productive Capacities Index
PIP	Posterior Inclusion Probability
SDG	Sustainable Development Goals
SRI	Socially Responsible Investment
TBL	Triple Bottom Line
UN	United Nations
UNEP	United Nations Environment Program

UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollars
VIF	Variance Inflation Factors
WAEMU	West African Economic and Monetary Union
WAMU	West African Monetary Union

Abstract

The stakes and issues related to access to green finance are central to the fight against climate change. The objectives of our research were to analyse the factors explaining the allocation and adoption of green finance practices, as well as the effectiveness of environmental-related taxes on greenhouse gas emissions reduction. Using an estimation technique based on Bayesian Model Averaging and secondary data, our results reveal that countries with good governance, high levels of social readiness, high gross domestic product per capita and population and low carbon dioxide emissions per capita tend to attract more climate finance from international public sources. In addition, we used primary data and a logistic model approach to analyse the factors motivating commercial banks to adopt green finance practices. Our results reveal that commercial banks are governed by a top-down approach, and decisions to adopt green finance practices come from decision-makers rather than any other factors (such as competitors' pressure or community pressure). Finally, we investigated the impact of environment-related taxes on greenhouse gas emissions using an approach based on Two-Stage Least Squares and Prais-Winsten regression techniques. Our results show that environment-related taxes in their current form do not have a statistically significant impact on reducing greenhouse gas emissions. In light of these results, we have formulated recommendations that could shape green finance policies. The study recommends that recipient countries strengthen their Monitoring, Reporting and Verification systems, which may enhance trust between actors and create an enabling framework conducive to the development of bankable, high-impact projects. International fund providers must allocate climate finance according to the needs of beneficiaries, especially those highly vulnerable to the effects of climate change. The study also recommends that financial sector regulators take measures to promote the development of green finance.

Keywords: Green finance, determinant, adoption, impact, mitigation policies, Sub-Saharan Africa

Résumé

Les enjeux liés à la finance verte se trouvent au centre de la lutte contre le changement climatique. L'objectif de notre recherche était d'analyser les facteurs expliquant l'allocation et l'adoption des pratiques de financement vert ainsi que l'effectivité des taxes environnementales sur la réduction des émissions de gaz à effet de serre. En utilisant une technique d'estimation basée sur le Bayesian Model Averaging et des données secondaires, nos résultats révèlent que les pays ayant une bonne gouvernance, un niveau de préparation social élevé, un produit intérieur brut par habitant et une population importante ainsi qu'une faible émission de dioxyde de carbone par habitant ont tendance à attirer plus de financement climatique provenant des sources publiques internationales. De plus, nous avons utilisés des données primaires et une approche basée sur le model logistique pour analyser les facteurs motivant les banques commerciales à adopter les pratiques de finance verte. Nos résultats révèlent que les banques commerciales sont gouvernées par une approche top-down et que les décisions d'adopter les pratiques de finance verte proviennent des décideurs plutôt que tout autres facteurs (comme la pression venant des concurrents ou de la communauté). Enfin, nous avons investigué les impacts des taxes liées à l'environnement sur les émissions de gaz à effet serre en utilisant une approche basée sur la méthode des moindres carrées en deux étapes et le Prais-Winsten regression techniques. Nos résultats montrent que les taxes liées à l'environnement sous sa forme actuelle n'ont pas d'impact statistiquement significatif sur la réduction des émissions de gaz à effet de serre. Aux regards de ces résultats, nous avons formuler des recommandations pouvant façonner les politiques en matière de finance verte. Ainsi, l'étude recommande que les pays récipiendaires des financement climatiques renforcent les dispositifs de Monitoring, Reporting and Vérification afin de créer un cadre propice au développement de projets bancable, à forts impacts. Les institutions donatrices sont appelées à louer les fonds soit selon les besoins des bénéficiaires particulièrement ceux vulnérables au changement climatique. En outre, l'étude recommande que les autorités de régulation du secteur financier prennent des mesures visant à promouvoir le développement de la finance verte.

Mot clés : Finance verte, déterminants, adoption, impact, atténuation, Afrique Sub-Saharienne

General Introduction

Developments in science have shown that humans, i.e., anthropogenic activities, are the main causes of climate change (Santer et al., 1996; IPCC, 2001; Rahmstorf, 2008). Indeed, according to the IPCC's sixth assessment report (IPCC, 2023b), global net anthropogenic GHG emissions have been estimated to be 59 ± 6.6 GtCO2eq in 2019, about 12% (6.5 GtCO2eq) higher than in 2010 and 54% (21 GtCO2eq) higher than in 1990, with the largest share and growth in gross GHG emissions occurring in CO2 from fossil fuels combustion and industrial processes (CO2-FFI) followed by methane, whereas the highest relative growth occurred in fluorinated gases (F-gases), starting from low levels in 1990. In consequence, global warming reached approximately 1.1°C above pre-industrial levels in 2011-2020 (IPCC, 2023b). At the present rate, global temperature would reach 1.5°C around 2040 (OCE, 2018). This global warming is unequivocally impacting countries around the world, but the African continent bears an exceptionally heavy burden from climate change and disproportionately high costs for essential climate adaptation. On average, African countries are losing 2-5% of GDP, and many are diverting up to 9% of their budgets responding to climate extremes. The cost of adaptation in Sub-Saharan Africa is estimated to range from US$30-50 billion annually over the next decade, or 2-3% of the region's Gross Domestic Product (WMO, 2024).

These adverse impacts of climate change can be explained by different economic models that have primarily underpinned our societies for decades, such as capitalism. One of the objectives of a capitalist economy is to maximise profits and make society richer by creating more value-added products without paying much attention to the environmental impact (Park, 2015; Fletcher, 2012; Klein, 2014) while socialist and communist economies were characterised by inefficiency. Recent crises such as climate change, with its nests of floods, droughts and associated losses and damage, have sounded the alarm bells about the way the current economic systems work and have led to the emergence of new economic theories based on sustainability and the green theory (Brundtland, 1987 ; Barry, 2007). These theories are based on new principles, such as the limits of economic growth, economic development that is not only driven by profit but also considers environmental concerns, and the efficient management of natural resources as the world becomes warmer, with unmistakable consequences for the ecosystem.

Therefore, new approaches that account for contemporary concerns, such as climate change, are at the heart of new economic and social development models. For example, the Dynamic Integrated Climate-Economy model (DICE) and the Regional Integrated Climate-Economics (RICE) models developed by (Nordhaus, 1994; Nordhaus & Yang, 1996) are a Solow optimal growth model of the global and regional economy, with CO2 emissions being a by-product of economic growth and influencing it negatively (Yang, 2020). Since then, current economic and social development policies have incorporated the two dimensions of responding to climate change: adaptation and mitigation. In economics, this is known as internalising the damage caused by externalities (Buchanan & Stubblebine, 1962; Coase, 1960; A. C. Pigou, 1932). The internalisation of environmental damage thus responds to one of the fundamental problems of the capitalist economy, which is the failure of the market. For a long time, it was impossible to set a price on negative externalities, such as air pollution, water pollution, noise pollution, etc. The work of economists has led to the theoretical and mathematical formalisation of a market for externalities (Pigou, 1920; Baumol & Oates, 1971). For many, this means introducing a Pigouvian tax that would be equal to the environmental damage caused by the externalities induced in society (Nordhaus, 1994; A. Pigou, 1920). This idea of introducing a taxation policy or the 'polluter pays' principle has been illustrated in various ways. Firstly, in the early 90s, carbon taxes were introduced in several countries (Norway, Finland, Denmark, etc) to limit atmospheric pollution.

Secondly, another way of internalising environmental damage was illustrated by introducing emission quotas, including cap-and-trade mechanisms. These caps gave polluting companies the right to emit greenhouse gases up to a certain level. Once this level has been reached, companies must pay compensation to continue polluting. A third way of internalising environmental damage is illustrated by the creation of the United Nations Framework Convention on Climate Change (UNFCCC). One of the fundamental principles of the UNFCCC and its founding treaty is that countries have common but differentiated responsibilities to climate change - Article 3 (United Nations, 1992). The main polluting countries, particularly those listed in Annex I[1], are held responsible for current climate change and must, therefore, compensate those most affected by the harmful effects of climate change (non-Annex I countries[2]). Under the aegis of the Convention,

[1] In the UNFCCC, Annex 1 refers to the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.
[2] Non-Annex I refers to developing countries.

several multilateral climate funds have been set up. These include but are not limited to the Global Environment Facility (GEF), the Green Climate Fund (GCF) and the Adaptation Fund, as well as other parallel financing mechanisms such as the carbon market and the cooperation arrangements between countries under Article 6 of the Paris Agreement. The Convention has encouraged countries to adopt low-carbon development plans and strategies. This led to decisions on the establishment of Nationally Determined Contributions (NDCs) through Article 4, paragraph 2 of the Paris Agreement, which requires each Party to prepare, communicate and keep up to date the successive Nationally Determined Contributions (NDCs) it intends to achieve on a five-year basis. The Convention also instituted the formulation of low-carbon development strategies known as LT-LEDS (Article 4, paragraph 19 of the Paris Agreement), which formulate the long-term visions of the Parties' climate ambitions and should lead to net zero by the end of the century.

In addition to these measures based on international texts & treaties, and given the climate emergency, countries are also inviting the private sector to undertake measures aimed at mitigating direct and indirect emissions. Among these private actors is the financial sector, particularly banks, which play a predominant role. For many actors, banks as financial resource providers for economic activity (including financing fossil fuel-based companies and other polluting activities) are responsible directly or indirectly for climate change, but also have the power to drive systemic change. This has led to the emergence of terms such as Corporate Social Responsibility, which encourage companies to adopt more virtuous and environmentally responsible practices. These movements have led to the emergence of a responsible form of finance known as green finance, where banks promote Socially Responsible Investing values and Environmental, Social and Governance principles. To date, several banks and financial institutions have adhered to the international principles and standards for green finance and are therefore considered to be green banks. In addition, during the Summit for a New Global Financial Pact 2024 & the Summit of the Future 2024, many actors, such as Non-Governmental Organisations (NGOs), are calling for a reform of the international financial system. The Bretton Woods institutions, which emerged from the Second World War, as well as the traditional actors in international finance, have remained stuck in their post-war mission and have not been able to invent their response to the many challenges the world is facing (growing poverty and inequality, climate and health crises, historic indebtedness, reconfiguration of international geopolitics and changes in the balance of power with the emergence of the global South, which remains under-represented and under-supported in the

international financial system). This situation constantly forces developing countries to choose between economic development (fighting poverty, educating future generations, investing in infrastructure, etc.) and coping with climate and health disasters or repaying their debts. The reforms announced include massive investment in the fight against climate change, with instruments such as Climate and Sustainability-Linked Financial Instruments (debt swaps for Sustainable Development Goals, Sustainability-Linked Bonds (SLBs) and Loans (SLLs), Loss and Damage Financing.

At the African level, the practice of internalising the environmental damage caused by the effects of climate change has been established by some countries. The idea of introducing a market-based policy is a recent one. Indeed, for a long time, most countries have operated through international climate financing mechanisms such as those under the aegis of the UNFCCC, as well as bilateral development cooperation agencies. Today, most measures to internalise the damage caused by climate change revolve around green finance mechanisms, including measures discussed earlier. So, what is green finance? While there is no universally accepted definition of the concept of green finance, a number of attempts have been made. Thus, according to Höhne et al., (2012), "Green Finance (GF) is a broad term that can refer to financial investments flowing into sustainable development projects and initiatives, environmental products, and policies that encourage the development of a more sustainable economy. Green finance includes climate finance but is not limited to it". Similarly, Lindenberg, (2014) defined "green finance comprises all forms of investment or lending that take into account environmental impact and enhance environmental sustainability. A key element of GF is sustainable investment and banking, where investment and lending decisions are taken based on environmental screening and risk assessment to meet environmental sustainability standards". Climate mitigation policy refers to actions or activities that limit emissions of greenhouse gases (GHGs) from entering the atmosphere and/or reduce their levels in the atmosphere (IPCC, 2023a).

In green finance allocation statistics, there has been an increasing number of publications on the amounts involved. Indeed, green finance, particularly climate finance, has seen a meteoric rise in recent years, reaching $1.5 trillion in 2023[3], up from an estimated $364 billion in 2011 (CPI, 2022).

[3] Climate Policy Initiative website: https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2024/. Last visit: 13.04.2025.

These climate finance flows are characterised by a disproportionate distribution between African countries. In 2021/2022, ten (10) countries[4] received about 46%, while the 10 most vulnerable got just 11% of the total of climate finance in 2021/2022. Of the 43.7 billion dollars in climate finance mobilised by the African continent over the period 2021/2022 (which represented only 3.36% of global climate finance flow), the share mobilised by international public partners for the African continent amounts to 79% of the total volume (CPI, 2024b). In terms of mobilising resources through taxes, financing mechanisms are still under-exploited. Although the majority of countries on the continent have not yet adopted regulations based on carbon taxation. However, several are already levying funds on some carbon-intensive products such as energy, natural resources, transport and pollution. So, in the absence of carbon taxation as such, mobilising sources of finance through these environmental products remains an essential alternative and should enable countries to reduce their carbon footprint while investing the revenue generated in low-carbon projects (such as renewable energy, financing adaptation to climate change, forestation and the fight against deforestation).

Concerning the local private sector, the mobilisation of climate finance is still in its infancy but has nevertheless increased significantly in recent years. Throughout 2021/2022, the domestic private sector mobilised 7% of total climate financing in the African continent (CPI, 2024b). This shows that additional effort should be made if the objectives are to be achieved. The adoption of so-called green banking practices, which consist of promoting investments with environmental benefits in African countries, should increase the mobilisation capacity of the local private sector in the near future. It is, therefore, necessary to analyse the factors explaining the adoption by commercial banks of practices that promote environmentally responsible lending, to propose avenues and recommendations for its adoption by the local private financial system. More broadly, access to green finance in the African continent, and Sub-Saharan Africa in particular, remains the region that benefits the least from climate finance. Indeed, of the 1.3 trillion dollar identified for the period 2021/2022 by CPI (2024a), Sub-Saharan Africa has only mobilised 37 billion dollar, which roughly represents 2.85% of the total annual climate finance accounted for the period, and it mainly comes from international sources. This shows a very low mobilisation capacity and is sufficient proof of the challenges associated with climate financing access facing the Sub-Saharan

[4] The ten countries with the most recipients are Egypt, South Africa, Nigeria, Morocco, Ethiopia, Tanzania, Kenya, Côte d'Ivoire, Democratic Republic of Congo and Mozambique.

region compared to other regions of the world. In addition, there is a wide disparity between the regions and countries of Sub-Saharan Africa. East Africa and West Africa alone accounted for 29% and 25%, respectively, of the total climate financing recorded in Africa (including North Africa) over the period, compared with just 9% and 8% for Southern Africa and Central Africa, respectively. These statistics also conceal the disparity that exists between countries within the same geographical region, as mentioned earlier. For example, while ten (10) countries accounted for about 46% of the African continent's total climate finance flows, another thirty (30) countries accounted for only 10% of the total flows (CPI, 2024b).

However, the concept of green finance is not without controversy. Indeed, the fact that there is no single definition allows each actor the opportunity to define green finance according to their context, and to use the terms that are appropriate to them. As a result, this imprecision fuels greenwashing, where funds earmarked for green finance are often used for non-green projects, which can take many other forms, from changing product labeling to the perception that the product comes from a natural environment (when it doesn't), launching marketing campaigns aimed at polluting industries to promote a green image (Berrou et al., 2019). Another controversy lies even in the theoretical approach related to green finance. As long defended by neoclassicists, who assume that markets, such as they are, can directly internalise environmental externalities without any intervention from public authorities (Coase, 1960), institutionalist approaches insist on the structuring role of regulation and public authorities, in the face of multiple failings: investor myopia, information asymmetry, radical uncertainty about the climate (Campiglio et al., 2017). From an empirical point of view, the controversies mainly concern the allocation and adoption of green finance practices, as well as the effectiveness of the instruments used. Indeed, if we consider the international climate financing driven by the United Nations Framework Convention on Climate Change, which calls for the responsibility of the most polluting states to finance the adaptation and mitigation efforts of countries most impacted by and vulnerable to climate change, the reality is that the climate finance allocation from international sources are not necessarily base on criterium such as vulnerability and the needs of the recipient countries (Barrett, 2014; Carty et al., 2020; Robertsen et al., 2015; Strawson et al., 2015). Rather, criteria of proximity or economic interest explain why some countries receive more climate funding than others (Alesina & Dollar, 2000; Clist, 2011; Dolšak & Crandall, 2013; Robertsen et al., 2015; Halimanjaya, 2015; Robinson & Dornan, 2017). With this in mind, there is an urgent need to understand the real determinants of

climate financing to inform recipient countries about the mechanisms that can help them attract climate financing.

Concerning the adoption of green banking practices, there are several possible explanations. For some (Battiston et al., 2017), the risk-based approach highlights the exposure of banking portfolios to physical risks (extreme events) and transition risks (loss of value of fossil-related assets). Thus, the Network for Greening the Financial System recommend that central banks monitor these risks within the prudential framework (NGFS, 2019). For others, such as (Phan & Baird, 2015), banks are adopting green practices under pressure from investors, NGOs and public opinion, seeking to improve their image (stakeholder theory - Freeman & McVea, 2001). In addition, regulatory incentives such as reporting obligations or green credit policy (Jin & Mengqi, 2011; China Banking Regulatory Commission, 2012) are encouraging banks to orient their portfolios and adopt green finance practices. Which begs the question: are banks adopting green finance out of conviction (sustainability), image strategy (green marketing) or regulation (compliance)?

Last but not least, controversy surrounds the efficiency of green instruments. The work of Nordhaus demonstrates that carbon pricing is economically optimal for correcting climate externality (Nordhaus, 2019). However, authors such as Stiglitz & Stern, (2019) insist that these policies must be accompanied by other well-designed policies tackling various market and government failures, as well as other imperfections, to guarantee their social acceptance. For others, the introduction of a carbon tax will create a risk of carbon leakage rather than an effective reduction in emissions. Indeed, Porter & van der Linde, (1995) defend the idea that ecological taxation can stimulate innovation, but others (Aldy & Stavins, 2012; Branger & Quirion, 2014), point to the risk of industries relocating to less taxed areas, “emission leakage”, reducing the overall impact. This risk has even led to the introduction by the European Union of a border tax (Carbon Border Adjustment Mechanism - CBAM) whose definitive regime will be applied from 2026, while the transitional phase is in force between 2023 and 2025. So, can undeveloped and relatively small economies like those of the West African zone adopt such a measure and have it respected by other exporting countries?

According to the Aldy & Stavins, (2012), the effects on emissions depend largely on the amount and use of the tax revenue. The Swedish and Canadian cases show a significant drop in emissions, but other countries, such as France, have seen massive social rejection (Gilets Jaunes movement),

and the use of revenues from carbon taxes (redistribution, green subsidies, lowering of other taxes) conditions their acceptability (Metcalf, 2019). The controversies surrounding this issue raise a number of questions that will be important to answer in this thesis.

Research Questions

The main question of our thesis is to understand the factors explaining green finance provisions and adoption, as well as the effectiveness of climate policies through environmental taxes on greenhouse gas emissions. Specifically, we address 3 research questions:

- What are the drivers of climate finance access in Sub-Saharan Africa?
- What are the determinants underlying the adoption of green finance practices by commercial banks in the WAEMU countries?
- What are the impacts of environment-related taxes in West Africa?

Research objectives

To address the research questions, it is important to outline the core objectives that guide this work. The main objective of our thesis is to analyse the key drivers of green finance and the factors influencing green banking adoption while assessing the impact of environmental taxation on greenhouse gas emissions. Specifically, it aims to:

- Analyse the role of factors explaining the allocation of climate finance in Sub-Saharan Africa.
- Identify the determinants of the adoption of green finance practices by commercial banks in the WAEMU.
- Examine the impact of environment-related taxes on CO2 emissions in West Africa.

Hypothesises

- Climate finance allocation is driven by institutional and environmental performance, economic level, development needs and physical vulnerability.
- Green banking adoption is determined by regulatory frameworks, financial advantages and branding, as well as customers, community and competitors' pressure.
- An increase in environmental-related taxes lowers carbon dioxide emissions.

Contributions

The contribution of our thesis can be divided into three parts. First, through our 3 essays, we give a new perspective to the literature on green finance. Indeed, the empirical literature on green finance remains relatively recent. Thus, through these works, we bring our contribution to the growing literature on the subject. In a context characterised by constant challenges in mobilising climate finance, we empirically explore the factors contributing to the attraction of climate finance in Sub-Saharan African countries using an advanced methodology based on Bayesian Model Averaging, which is appropriate for analysing determinants compared with previous research on this subject (Halimanjaya, 2015; Nakhooda et al., 2011; Robertsen et al., 2015).

Secondly, we examine the factors that explain the adoption of green banking practices in the WAEMU region. To date, and the best of our knowledge, there is no empirical study that has addressed these issues within the WAEMU region. We, therefore, make an empirical contribution to the factors that may motivate commercial banks to take an interest in green finance while also providing public recommendations for the formulation of measures and regulations conducive to the development of green finance by local private actors. Finally, we provide empirical evidence on the effectiveness of environment-related taxes in West African countries. In recent years, several countries in the West African region have been working on the idea of introducing a carbon tax. In this research, we provide insights into the potential impact of environment-related taxes by countries and formulate policy recommendations for the adoption of a carbon tax by West African countries.

Our thesis consists of 3 essays. The first essay addresses the determinants of the attraction of climate finance to Sub-Saharan African countries. The second essay analyses the factors motivating the adoption of green financing practices by commercial banks. Finally, our last essay investigates the impact of environmental taxes on CO2 emissions.

Essay 1: Drivers of climate finance in sub-Saharan Africa

Abstract

This research aims to identify the drivers of climate finance in the context of sub-Saharan Africa by using the official development aid database on climate-related development finance from 2000 to 2021. By applying the Bayesian Model Averaging in the dynamic panel data framework, our results show that climate finance allocation is a dynamic process. We also found that countries with high populations, strong governance systems, high gross domestic per capita, and low carbon emission levels are likely to attract more climate finance. In addition, the results underpin the important fact that climate finance providers are not paying attention to some important variables such as vulnerability and countries that have significant forest land. Thereby, we suggest that climate finance providers may further consider the vulnerability of recipient countries by providing more climate funds for the most exposed to climate change and those are making considerable efforts in the sequestration of greenhouse gas emissions. Also, international climate finance must be provided in accordance with the needs of the countries concerned so that significant results can be expected. Recipient countries may also strengthen their governance system by establishing strong monitoring, verification and reporting frameworks which may help to build trust between climate finance providers and recipient countries as well as increase the effectiveness of the climate action taken on the ground.

1.1. Introduction

Dealing with the issue of rising greenhouse gas emissions requires new forms of investment, such as investments that consider the environmental aspects, such as climate finance. Climate finance aims to reduce emissions and enhance the sequestration of greenhouse gases. It aims at reducing the vulnerability of and maintaining and increasing the resilience of human and ecological systems to negative climate change impacts (UNFCCC, 2014). In recent years, several new methods for financing environmental projects have been developed worldwide, including green lending, green bonds and climate finance mechanisms. Many international institutions have become key actors in the financing of climate-related actions, such as the World Bank, the African Development Bank, the European Union, and other bilateral or multilateral initiatives. At the same time, some specific climate funds were created under the UNFCCC and other constellations (private funds, philanthropic donors, etc.) to cope with the issues of climate change and ensure sustainable

development goals by 2030. Among these climate funds, we can notice the Green Climate Fund (GCF), the Global Environmental Fund (GEF), the Climate Investment Fund (CIF), and the Adaptation Fund. African countries also take initiatives. Countries like Mozambique have created disaster funds where part of the financing comes from annual budget allocations (IMF, 2020). Mali, Niger, Benin, and Guinea Bissau… have similarly created a national climate fund. Central Banks are also concerned with environmental issues and therefore integrate climate change aspects as part of the macroeconomic policies and numerous Central Banks located in sub-Saharan Africa have joined the Network for Greening the Financial System (NGFS): Bank of Nigeria, South Africa Reserve Bank, Central Bank of West African States (which includes 8 countries), Bank of Ghana, Bank of Mauritius, Bank of Kenya, Central Bank of Seychelles and Central Bank of Mauritania).

Previous studies highlighted that the determinants of climate finance are less studied, particularly in Africa, and warrant further investigation to add to the literature. The study by Doku et al., (2021) shows that Sub-Sahara African countries with higher population growth rates, higher poverty levels, better ease of doing business, weaker governance policies, weaker control of corruption, stronger rule of law enforcement, deepened social inequality, and better usage of information and communication technology (ICT), are likely to attract more climate finance. Barrett, (2014) argues that donor utility and the ability to absorb capital offer the most persuasive explanations for distribution across the state. Along the same line, Halimanjaya, (2015) by using 1998–2010 Rio Marker data on 180 developing countries finds that developing countries with higher CO2 intensity, larger carbon sinks, lower per capita gross domestic product (GDP) and good governance tend to be selected as recipients of climate mitigation finance and receive more of it. In addition, Robertsen et al., (2015) and Samuwai & Hills, (2018) show that the characteristics of climate finance recipients in developing countries are not based on the recipients' needs but tend to focus on the country hosts' “merits”.

Most sub-Saharan African countries struggle to mobilize sufficient funds to cope with the impact of climate change, and the cost and consequence of inaction are higher than the cost of action (Stern, 2007). Therefore, it is necessary to understand how international climate finance works and what determines the financing of developing countries, especially in the sub-Saharan Africa region. The present essay aims to investigate key drivers of climate finance access in the context

of sub-Saharan countries. Additionally, this essay adds a new perspective and knowledge to the literature in three ways: We will use a sample of 47 sub-Saharan African countries with a longer time series climate finance data (2000-2021) compared to previous studies which used a sample from 2006 to 2017 Doku et al., (2021) and Halimanjaya, (2015) which use data from 1998 to 2010 to analyse climate finance mitigation across developing countries. In addition, our focus will be on climate-related development finance, which considers both climate finance adaptation as well as mitigation finance. At, the methodological level, we use the Bayesian Model Averaging (BMA) in the framework of panel data which seems to fit better for analysing determinants or drivers of a particular dependent variable. The essay is split in the following way. After the introduction section (section 1), section 2 discusses the literature review and section 3 addresses the methodological framework followed by the results and discussions in section 4 and a conclusion in section 5.

1.2. Literature review

Climate finance plays a fundamental role in supporting climate change mitigation and adaptation policies, particularly in developing countries. Although several instruments and mechanisms have been created over the years to promote this new type of financing, its distribution remains uneven (CPI, 2024a) and influenced by various economic, institutional and political factors (Rickman et al., 2022). From a theoretical point of view, access to climate finance can be analysed from several angles, including sustainable development theory, the Pigouvian theory of the polluter pays, the theory of the tragedy of the commons, game theory and public choice theory. The empirical examination, for its part, relies on case studies and comparative analyses to identify the factors attracting climate finance and the models used for the empirical analyses. This section is therefore divided into subsections: a theoretical review on the one hand and an empirical review on the other.

1.2.1. Theoretical review

1.2.1.1. Theory of Sustainable Development and Sustainable Growth: Emergence of Sustainable Finance Theory

The development model on which our economies have been based for years has shown its limits with problems related to the depletion of natural resources, land degradation, declining agricultural yields, industrial and energy disasters, the increasing use of chemicals or artificial products and health consequences. Thus, the need to rethink a new form of economy has emerged in many economies around the world. One of the forerunners of the theory of sustainable development was

proposed by the English economist Robert Malthus, who in his essay "An Essay on the Principle of Population" drew attention to the fact that resources increase at an arithmetical rate while human needs increase at a geometrical rate and that if no rational or sustainable use is made of them, the world will end up with shortages (Malthus, 1798).

This notion of sustainability could also find its meaning in the definition of income proposed by (Hicks, 1939). According to him, income is the maximum amount that a person or an economy could consume in a given period and still be as well off at the end of the period as at the beginning. Hicks further argued that the practical reason for calculating income is to have a guide to how much we can consume year after year without eventually impoverishing ourselves (Daly, 1990). This means that income corresponds to maximum sustainable consumption. This concept of sustainability has thus founded the foundations of sustainable growth through the concepts of the circular economy and the green economy advocated concerning the limits of growth (Meadows et al., 1972) and how to govern and manage efficiently commons-pool resources to avoid both excessive consumption and administrative cost (Ostrom, 1990).

Nevertheless, the popularity of the theory of sustainable development is due to the Brundtland report entitled "Our Common World" in 1987, which gave it a formal definition known as development that enables present generations to meet their needs without hindering future generations from meeting theirs. Coming to the finance sector, which had long been based on how to make a profit, began to look at how to make a profit but also to consider environmental issues. Hence, with the emergence of green finance, sustainable finance is defined as finance that supports sustainable development in three combined dimensions, which are the economic dimension, environmental dimension, and social dimension (Ryszawska, 2016). The United Nations Environmental Program (UNEP) and World Bank define sustainable finance as finance that serves to meet the long-term needs of a sustainable and inclusive economy along all dimensions relevant to achieving those needs, including economic, social, and environmental issues; sustainable employment; education; retirement financing; technological innovation; resilient infrastructure construction; and climate change mitigation and adaptation (Maimbo & Zadek, 2017). The creation of sustainable finance can be referred to as initiatives taken at different levels: market-based initiatives, national initiatives and international initiatives (Ozili, 2022).

a) Market-based initiatives:

Green finance initiatives have emerged thanks to a number of financial products that have appeared over the past 30 years. These included the creation of Green, Social, and Sustainability (GSS) bonds and Sustainability-Linked Bonds (SLBs) issued by governments, Multilateral Development Banks (MDBs), corporations and international institutions to finance projects with environmental benefits. Its expansion has been made possible by the adoption of the Green Bonds Principles (GBP) developed by the International Capital Market Association (ICMA), which provide a framework for transparency, disclosure and impact reporting. Other similar initiatives have been created to ensure that these bonds comply with environmental and social criteria such as taxonomies, the Sustainable Banking Network (SBN) and the United Nations Environment Program – Finance Initiative (UNEP FI). These initiatives have set the framework for a financial institution to take into consideration environmental issues, social risks and opportunities (Jeucken, 2001 and Weber, 2014). For instance, the Sustainable Banking Network is a voluntary community of financial sector regulators, central banks, ministries of finance, ministries of environment, and industry associations from emerging markets committed to advancing sustainable finance for national development priorities, financial market deepening, and stability (SBN website). UNEP Finance Initiative is also a network of banks, insurers and investors that aim to implement principles for responsible banking and principles for sustainable insurance, as well as three UN-convened net-zero alliances.

b) National initiatives:

National initiatives have been driven by authorities and policymakers through promoting sustainable finance framework but also Environmental such as sustainable finance regulation and disclosure rules, and social and governance guidelines. Indeed, many countries have already implemented national frameworks for sustainable finance: Ghana (green finance taxonomy), Nigeria (Nigerian sustainable finance framework), Kenya (Kenya Sustainable Finance Guiding Principles), etc. In addition, some countries have created their national fund for environmental and climate change concerns.

c) International initiatives:

At the international level, initiatives have also been taken to consider sustainable finance more by implementing international rules (Ahlström & Monciardini, 2022). Agreement under the UNFCCC has made possible the promoting of sustainable finance. For instance, article 11(a) of the Kyoto

Protocol calls for developed countries to provide new and additional financial resources to developing countries to meet the agreement's implementation. Article 12 of this protocol set the Clean Development Mechanism (CDM) to support Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, while assisting Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 13 of the protocol. Furthermore, the Paris Agreement has reiterated this commitment of mobilizing new and additional climate financing for the benefit of the most vulnerable countries under articles 9.2 and 6. For this aim, multilateral cooperation institutions, Multilateral Development Banks and international financial institutions have been crucial in promoting sustainable finance across the world.

1.2.1.2. Polluter Pay Principle

The polluter pays principle is introduced by Pigou, (1920), is defined as a practice of making the polluter pay for the damage that his consumption or production causes to the environment and the ecosystem. It is part of welfare economics and externality theory. The historical depth of the polluter pays principle is started by the Rio Declaration in 1992 in principle 16 (United Nations, 1992): National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest [...]. Since this declaration, the polluter pays principle has continued to be taken into consideration by the international community and has laid the foundations of global green finance. It has been followed successively by different international agreements that have accentuated the concept of green finance until today (the Kyoto Protocol in 1997, the Copenhagen Accord and the Paris Agreement in 2015). These accords accentuated and strengthened the commitments of states to compensate for the pressures on the environment. Developed countries (industrialized) that are responsible for greenhouse gas emissions are considered polluters and are required to compensate developing countries (low-income countries) that are victims of pollution and thus suffer the full force of the adverse effects of climate change.

1.2.1.3. Tragedy of the Commons

The term “the tragedy of the commons” was first introduced by (Hardin, 1968). “The tragedy of the commons” arises when it is difficult and costly to exclude potential users from common-pool

resources that yield finite flows of benefits, as a result of which those resources will be exhausted by rational, utility-maximizing individuals rather than conserved for the benefit of all (Ostrom, 2008). Indeed, a "tragedy of the commons" is a situation which happens where there is no market to regulate environmental goods. Due to their characteristics, public goods are non-rivalrous and non-excludable, and people exploit more than nature is capable of regenerating. So, in the end, resources are depleted. Hardin (1968) has concluded that "Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit – in a limited world. To date, the concept of the tragedy of the commons constitutes the origin of many environmental issues such as pollution, natural resource depletion and thus, climate change issues. It does not detach itself from issues related to the financing of impacts caused by human overexploitation of natural resources.

1.2.1.4. Game theory

Game theory concerns how interacting choices of economic agents produce outcomes concerning the preferences (or utilities) of those agents, where the outcomes in question might have been intended by none of the agents (Ross, 2021). Game Theory and Climate Change develop a conceptual framework for analysing climate change as a strategic or dynamic game, bringing together cooperative and noncooperative game theory and providing practical analyses of international negotiations (Chander, 2018). Game theory is often linked to the field of climate change negotiations. During the Conference of Parties (COP), countries come up with their positions and prospects and try to see how others will react to their situation. These negotiations (game theory) are very important to climate finance because they determine the funds and pledges made by developed countries to developing countries for environmental purposes. In this context, mitigation is considered a public good in that emissions from any country will affect the global environment, while adaptation is considered a private good because the adoption strategies will benefit the country that implements it (Aman, 2019).

1.2.1.5. Public choice theory

Public choice theory is the political way to deal with economic problems. Its origins date to the mid-20th century, and viewed retrospectively, the theoretical "gap" in political economy that it emerged to fill seems so large that its development seems to have been inevitable (Buchanan, 2003). In other words, public choice theory investigates the behaviour of the agents (managers)

interacting on the political markets. Managers (politicians) try to find how to maximise their well-being (as individuals could do in economic markets), rather than that of the public ("self-interest axiom"). Climate change is nowadays recognised as a global issue and the decision taken to deal with its issues is a political concern. According to Buchanan, people are schizophrenic in the way that they are self-interested in their economic lives, but they suddenly become other-interested and consider the broader social or public interest in efficiency and equity when they turn to the government in their political lives.

The theoretical review of the literature has shown us that several concepts are at the root of the emergence of green finance. From the theory of sustainable development initiated in the classical period through the theory of common tragedies to the theory of public choice. Today, the concept of climate finance has evolved and is often equated with official development assistance, thanks to the considerable contributions of multilateral development institutions and climate finance. However, these theories have defined and shaped sustainable development in its current conception. Current instruments, such as the introduction of a carbon tax, reflect the polluter theory, while the establishment of a carbon market (cap-and-trade and carbon credit) aimed at limiting emissions (and therefore the pollution of a good: clean air) reflects the theory of common tragedies, where individuals had no constraint on emitting pollution into the atmosphere. Green bonds, on the other hand, reflect the theory of sustainable development, which encourages economic actors to integrate environmental and societal considerations into their investment objectives. In addition, game theory, which is an important theory in international negotiations and relations, led to the Paris Agreement, the historic agreement signed by more than 190 countries, and set up major climate financing mechanisms such as the Green Climate Fund, the Loss and Damage Fund and the New Collective Quantified Goal on climate finance, in which developed countries committed to financing developing countries to the tune of 300 billion dollars a year to help them achieve their climate objectives. Finally, the theory of public choice, in which individuals act according to their electoral interests, has been illustrated in recent years by the adoption of massive investment in renewable energies (Angela Merkel's strategic choice in Germany), incentive policies (incentives for the purchase of electric vehicles in the United States by Joe Biden's administration) and the increased climate commitments of many countries. However, the return of Donald Trump, who preaches climate scepticism, has reshuffled the deck in terms of the current approach to climate financing, with the signing of major decrees such as

the withdrawal of the United States from the Paris Agreement, the end of subsidies for the purchase of electric vehicles and the promise to invest massively in fossil fuels (drilling for oil and gas).

1.2.2. Empirical review on green finance determinants

1.2.2.1. Relationship between climate finance and energy transition

The transition of energy systems from fossil fuels to low-carbon technology is evidence of global warming emissions. This energy transition required a huge new investment, especially in the domain of renewable energy and energy efficiency through green finance mechanisms. For some time now, many scholars have shown interest in this domain by studying the link between green finance and energy transition. According to Wang et al., (2021), green finance constitutes the best financial strategy to reduce carbon dioxide emissions. By studying the impact of green finance on the reduction of greenhouse gas emissions, Wang et al., (2021) show that in BRICS countries, there is a negative link between green finance and CO2 emissions and advocate that financial authorities need to participate in the development of the carbon market through encouraging banks to introduce carbon emissions. In addition, Feng et al., (2022) show that government expenditure significantly affects green economic performance in the context of the Green Belt and Road Initiative (BRI) countries. In addition, the finding demonstrates that public expenditure on human capital and renewable energy leads to a productive green economy through labour and technically advanced developmental practices, with varying consequences in distinctive countries. Studies by Nawaz et al., (2021) also show that investment in the energy sector, especially by the private sector, would have an impact on green finance and climate change mitigation in the N-11 and BRICS countries. Nihal et al., (2022) find that increasing the issuance of green bonds by one percent will mitigate CO2 emissions by 1.6 percent in the case of ASEAN countries (Association of South-East Asian Countries). Furthermore, it is estimated that the higher the value of the green energy index, the lower the CO2 emissions will be (Nihal et al., 2022). Ren et al., (2020) have been interested in the relationship between green finance, no-fossil energy use and carbon intensity through empirical evidence from China. By using a vector error correction model, they found that improvement in the green finance development index, as well as the increasing use of non-fossil energy, contributed to a reduction in carbon intensity. This means that there is a positive relationship between the green finance development index and climate change mitigation patterns in China.

On the other hand, Halimanjaya, (2015) study the relationship between the characteristics of developing countries and the amount of official climate mitigation finance inflow. He found that developing countries with higher CO2 intensity, larger carbon sinks, lower per capita gross domestic product (GDP) and good governance tend to be selected as recipients of climate mitigation finance and receive more of it. Ning et al., (2022) were interested in the role of green bond financing on energy efficiency investment and economic growth in the context of a global perspective. The results showed that bank loans are the main determinant of energy efficiency investment. This means that green bonds play a significant role in financing energy efficiency.

1.2.2.2. Determinants of climate finance

The bibliometric analysis done by Malhotra & Thakur (2020) shows that there is a growing interest in green finance research. Indeed, the financial sector is supposed to play a considerable role in the fight against climate change. Akomea-Frimpong et al., (2021) were interested in knowing the different variables that may compose the green finance product of the Bank. The finding was that green securities, green investments, climate finance, carbon finance, green insurance, green credit and green infrastructural bonds are part of key green finance products of banks. By analysing the link between adaptation, climate finance distribution and climate vulnerability in the case of Malawi, Barrett (2014) shows that areas with high needs receive little climate finance. Thus, he concluded that, rather than use vulnerability as a determinant of adaptation climate finance distribution, donor utility and the ability to absorb capital offer the most persuasive explanations for distribution across the state. Doku et al., (2021) were interested in knowing the determinants of climate finance for sub-Saharan African countries. By using a data set from 2006 to 2017 and panel regression, they find that Sub-Sahara African countries with higher population growth rates, higher poverty levels, better ease of doing a business profile, weaker governance policies, weaker control of corruption, stronger rule of law enforcement, deepened social inequality, and better ICT usage, have attracted more climate finance. According to Gilder & Rumble (2020), the availability of finance is not commensurate with current needs, and resource deployment tends to be more donor-centric than recipient-focused and exploring the issues of lack of access by focusing on three common challenges faced by countries, namely recipient countries' capacity, needs assessment and knowledge deficiencies. Therefore, by examining the determinants of the development aid efforts of 22 Development Assistance Committee (DAC) members over the 1976–2011 period, Fuchs et al., (2014) find that aid inertia, per-capita GDP, the creation of an independent aid agency, colonial

history, Russian military capacity, peer effects, terror incidents, aid to CEEC/NIS countries, and imports from developing countries as determinants of the Official Development Assistance (ODA)-to-GNI ratio.

A study by Dan & Tiron-tudor, (2021) shows that the issuance of green bonds in the context of the European Union is mostly based on rating, ESG (Environmental, Social, and Governance risk index) index, fiscal balance, inflation rate, and population. On the other hand, Robertsen et al., (2015) studied the determinants of the flow of bilateral adaptation-related climate change financing to Sub-Saharan African countries by analysing the role of environmental, economic, historical, and Political Factors. The finding shows that the recipient policy and an existing aid relationship between donors and recipients are significant determinants of climate adaptation funding.

1.3. Concepts of green finance: A dive into green finance mechanisms

The introduction of more environmentally friendly finance has led industry players to create several mechanisms and instruments to encourage the development of green, environmentally friendly projects. However, these mechanisms and instruments are often complex and unfamiliar to many stakeholders. This section explores the various mechanisms, instruments and frameworks that drive green finance. By understanding these mechanisms, stakeholders can better navigate the financial landscape that supports climate action and sustainability. It highlights the attempted definition of green finance, an overview of the development history of the concept of sustainability and green finance, the mechanisms, institutions and frameworks that govern green finance initiatives and the instruments used.

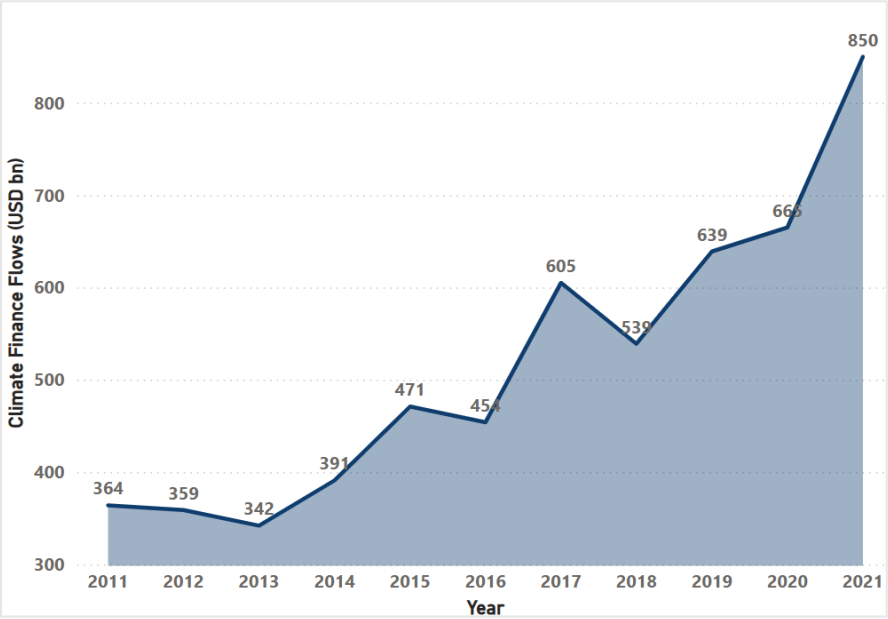
1.3.1. Definition of green finance and current trends

To date, there is not a clear definition or a single definition of green finance. However, some authors are trying to get a definition of the concept of green finance. According to Sachs et al., (2019), green finance is a new form of investment that provides environmental benefits through new financial instruments and new policies, such as green bonds, green banks, carbon market instruments, fiscal policy, green central banking, fintech, community-based green funds... To, Koondhar et al., (2021), green finance has emerged as a strategy that encompasses not only instruments aimed at mitigating greenhouse gas emissions and adapting to climate change, but also financial products and services addressing a broader range of environmental concerns such as

industrial pollution control, waste management, sanitation and hygiene, and ecological protection. The Organisation for Economic Co-operation and Development (OECD) defines green finance as finance for "achieving economic growth while reducing pollution and greenhouse gas emissions, minimizing waste and improving efficiency in the use of natural resources (Matusitz & Berisha, 2020). According to the International Development Finance Club (IDFC), green finance can be defined as referring to financial investments flowing into sustainable development projects and initiatives, environmental products, and policies that encourage the development of a more sustainable economy (Matusitz & Berisha, 2020). Despite all these tentative definitions, there is no consensual official definition of the term green finance at the international level.

According to data from the Climate Policy Initiative (CPI), which has provided a global overview of the climate finance landscape over the last few years, climate finance has received particular attention from donors and investors. The figure has risen from 364 billion dollars in 2011 to 850 billion dollars in 2021, an increase of 2.33 over the period (see Figure 1). Climate financing has seen a speculative upswing over the period of 2021/2022, reaching the trillion-dollar mark for the first time, with an estimated flow of 1.3 trillion dollars. However, this volume is still insufficient to meet current financing needs, which are estimated at 7.4 trillion dollars a year between now and 2030 if we are to be compatible with the 1.5°C commitments stipulated in the Paris Agreement.

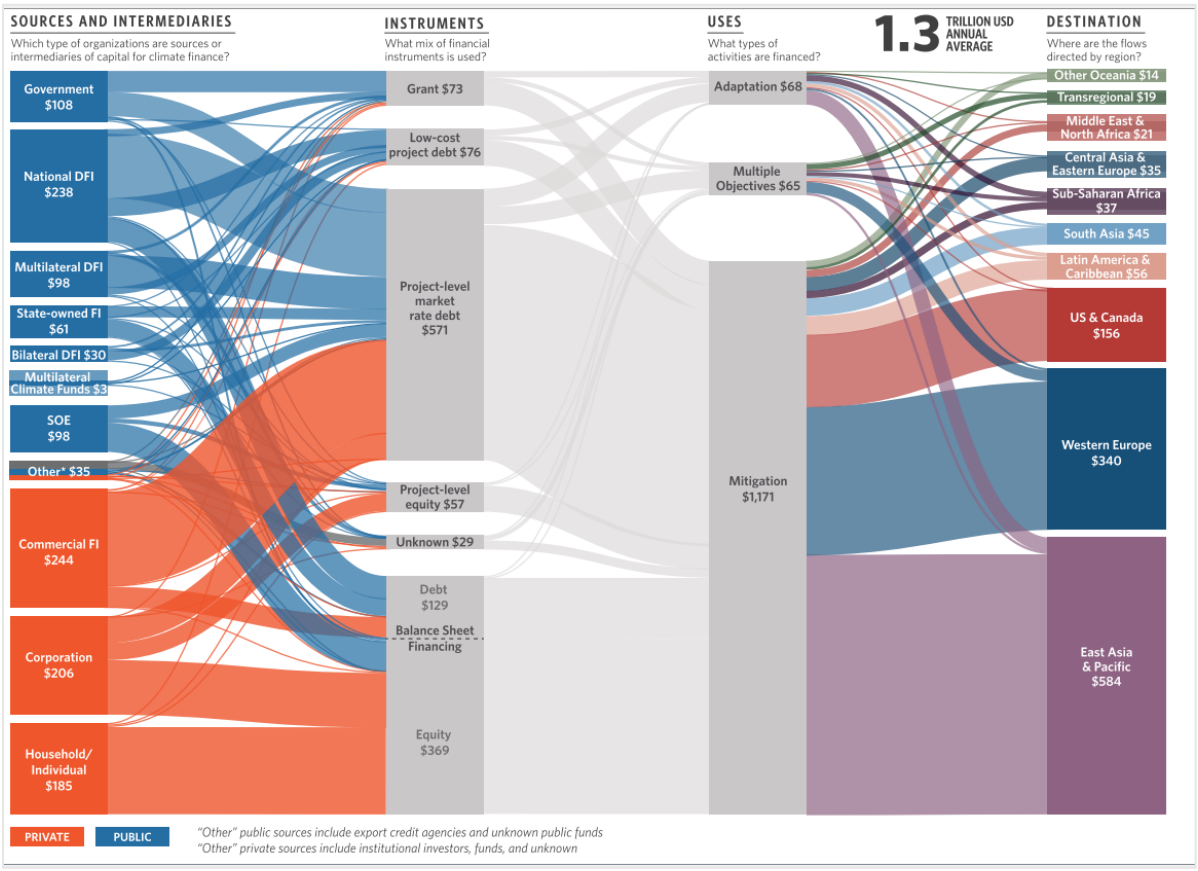
Figure 1: Global climate finance flows (2011-2021)



Source: Data from (CPI, 2022)

Figure 2 shows the sources, instruments, uses and destinations of climate finance for the period 2021/2022. It shows that funding comes almost equally from the public and private sectors. Public sector flows come mainly from national Development Finance Institutions (National DFIs), governments, multilateral DFIs, State-owned FIs, State-owned Entreprises (SOE), bilateral DFIs, multilateral Climate Funds and other public actors. Private sector funding comes mainly from Commercial FIs, Corporations and Households & Individual.

Figure 2: Landscape of Global Climate Finance Flows in 2021/2022



Source: (CPI, 2024a)

Debt instruments continue to be the most widely used climate finance instrument, accounting for almost 95% of the total financing recorded over the period, most of which was earmarked for mitigation projects (i.e. 1.171 trillion dollars), compared with only 68 billion dollars for adaptation projects exclusively, and the remaining 65 billion dollars for projects involving both adaptation and mitigation. The geographical breakdown of climate financing flows shows an unequal distribution. Indeed, 3 regions - East Asia & Pacific, Western Europe and North America - alone account for almost 83% of the total volume of funding (i.e. 1080 billion). The other regions,

namely sub-Saharan Africa, which is one of the most vulnerable and affected by climate change, only accounts for around 2.85% of total funding (i.e. 37 billion dollars). This raises the issue of equity in climate financing, and the need to understand the factors that contribute to attracting this type of financing becomes fundamental.

1.3.2. Historical development of sustainability and green finance

Even if green finance terminology is gaining more attention from the crowd right now, this concept is far from being a new one. Indeed, the evolution of the green finance concept started to get attention from the public in the 1970s with the United Nations (Conference of Human Environment in Stockholm). The Stockholm conference was the first UN conference that employed the term "environment" in the title. This conference is qualified as the birth of environmental diplomacy. The following figure (figure 1) chronologically describes the different dates of conferences, and main decisions that shaped the current state of the sustainability and green finance concept.

Figure 3: Evolution of treaties and accords promoting sustainability and green finance concepts

Note: Figure 1 gives an overview of the main events (conferences) and international agreements that have shaped decisions relating to sustainability and the concept of green finance from 1972 to 2024.
Source: Own illustration

1.3.3. Barriers to access international climate finance

There are many barriers to accessing climate finance, which can be summarised as follows.

1.3.3.1. The financing objective is mainly focused on adaptation, making it difficult to attract large-scale projects.

International climate finance remains dominated by funding for mitigation objectives, given its nature as an international public good and as reductions in greenhouse gas emissions benefit the atmosphere and therefore all countries. However, a large part of the continent's needs remain focused on adaptation objectives, which are private goods in the sense that adaptation efforts benefit in particular the country that implements them and are difficult to quantify at the international level. This factor, therefore, does not encourage international donors seeking emission reduction certificates to invest in adaptation. When it comes to mitigation goals, Africa attracts some investment, mainly in financing access to energy through renewable energy sources. However, the volume of financing and projects remains low compared to other regions (North America, Europe, and Asia). The low volume of financing can be explained by a highly vulnerable economic environment subject to political, macroeconomic, and structural risks.

1.3.3.2. Political and legislative risks

The African continent also faces significant political risk. Regime changes very often lead to changes in policies and development objectives, creating a period of uncertainty at a given moment. Certain measures or contracts signed by regimes are often suspended or reevaluated and subject to subsequent changes. This can be a deterrent in terms of attractiveness. In addition, the legislative and legal framework governing the environmental sector remains underdeveloped and does not provide the incentives and guarantees necessary to attract more climate-related investment.

1.3.3.3. Macroeconomic and monetary risks

The African continent has long faced an overestimation of macroeconomic, monetary, and credit risks. Indeed, international rating agencies very often assign unattractive ratings to African countries. This makes the cost of credit and debt unsustainable for many. However, debt instruments remain the most widely used means of financing climate objectives (particularly mitigation financing). As a result, financing for development goals and climate finance are

becoming increasingly inaccessible for most low-income countries. Furthermore, given that most financing comes in foreign currency, African countries remain exposed to any deterioration in the value of their currency, as a depreciation of the local currency translates into an increase in the value of the amount contracted (most often in US dollars). Countries such as Egypt, Ethiopia, and Ghana have recently experienced a similar situation.

1.3.3.4. Insufficient capacity to develop bankable projects.

One of the challenges facing many African countries is the ability to mobilize climate finance. Indeed, obtaining climate finance is a particularly difficult task, as funding requests undergo several evaluations by multilateral climate finance agencies. Thus, the limited capacity to develop projects that meet donor criteria and climate objectives complicates the mobilization of climate finance for many countries. This weakness in human and institutional capacity is an obstacle that many countries face.

1.3.4. International climate funds entities and mechanisms:

To address the issues of climate change, different mechanisms have been created by national and international institutions. The international framework for financing climate change remains well-known across the world. Those institutions are part of some frameworks such as the UNFCCC, the World Bank, and the IFC. In this section, we will look at different funds that contribute to financing climate change action, such as adaptation and mitigation at the international level. Among the different entities, there are GEF, Adaptation Fund, CIF, and GCF.

1.3.4.1. Global Environmental Facility (GEF)

The Global Environmental Facility is the first climate finance facility. Established in 1991, it served as an operating entity of the financial mechanism since the Convention's entry into force in 1994. It is the world's largest funder of biodiversity protection, nature restoration, pollution reduction, and climate change response in developing countries. GEF works closely with 184 member governments, Civil Society Organizations (CSO), Indigenous Peoples, and the private sector to offer environmental facilities in the domain of climate action. Since its creation, GEF has provided more than 6300 projects[5]. GEF was managed by a collective of three implementing organisations in its creation: the United Nations Development Programme (UNDP), the United

[5] GEF web site: https://www.thegef.org/projects-operations/database. Last visit 30.03.2025.

Nations Environment Programme (UNEP), and the World Bank. Currently, GEF counts 15 other international implementing agencies which make up to 18 agencies. The World Bank represents the trustee of the institution by mobilizing and administrating financial resources. The replenishment process is made every four years and currently, GEF is in its ninth (9) replenishment cycle (2022-2026) for an amount of USD 5.33 billion. Even more donors are from developed countries; some developing countries have also provided financial support to the GEF Trust Fund such as Côte d'Ivoire, Nigeria, Egypt and South Africa…

Moreover, the GEF serves as a "financial mechanism" to five conventions, which are the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), the Stockholm Convention on Persistent Organic Pollutants (POPs), UN Convention to Combat Desertification (UNCCD), and Minamata Convention on Mercury. There are two ways of having access to the GEF funds: traditional access mode through one of the eighteen GEF agencies and direct access mode where countries directly project to the GEF secretariat. The GEF count 5 trust funds, which are: The Special Climate Change Fund (SCCF), Least Developed Countries Fund (LDCF), Capacity-Building Initiative for Transparency (CBIT) and Nagoya Protocol Implementation Fund (NPIF).

1.3.4.2. Adaptation Fund

Although the Adaptation Fund was created under the GEF, which hosted its secretariat board so far, the AF is supervised and managed by its management board (AF Bord). The AF was established in 2001 to finance concrete adaptation projects and programmes in developing countries that are particularly vulnerable to the adverse effects of climate change. It was established under the Kyoto Protocol of the UN Framework Convention on Climate Change and since 2010, has committed funds for localised climate adaptation and resilience activities. AF is one of the innovative funds that initiate the direct access entity process in which accredited National Implementing Entities (NIEs) can directly access climate finance and manage projects from design through implementation while building the country's own local and national adaptive capacity. The accredited implementing entities can be a national, regional or multilateral entity.

The Fund also has a growing Readiness Programme that provides capacity-building workshops, small technical assistance grants and south-to-south cooperation to facilitate the accreditation of new implementing entities and reach more vulnerable communities with urgently needed climate

adaptation solutions[6]. The financial resource of the AF is coming from the Clean Development Mechanism (CDM) in which a levy of 2% is taken to finance the funds under the Kyoto Protocol.

1.3.4.3. Green Climate Fund (GCF)

The GCF was established by the Cancun Agreement in 2010 under Article 11 to serve as an operating entity for the financial mechanism of the UNFCCC. The fund was put into operation in 2015 and since this date, more than 286 projects got approval for a total financing of $61.27 billion (including co-financing). The GCF aims to provide developing countries equal financial resources in adaptation and mitigation to keep global rise under 2°C or preferably to 1.5°C, as indicated by the Paris Agreement. Thus, GCF represents the official financial mechanism for the Paris Agreement (CMA). Like the Adaptation Fund, the GCF operates through a network of National Designed Authorities (NDA) which are representative of the government party to the Convention and elaborate the strategy of the countries in terms of climate change adaptation and mitigation. Through the NDA, which selected the Accredited Entities for the GCF to develop and implement projects aligned with the investment criteria and result areas of the fund. Thus, Accredited Entities are recognized as operating Entities for the fund. The location of the Accredited Entities determines the direct or indirect access of the country to the fund. The GCF is currently the world's largest fund for climate change (adaptation and mitigation) in developing countries.

1.3.4.4. Climate Investment Fund (CIF)

Established in 2008 at the request of G8 and G20, the CIF is currently the world's largest fund focused on transformational climate innovation in 70 middle- and low-income countries across the world. To date, almost 400 projects have been financed in the areas of clean technology, energy access, climate resilience, and sustainable forests in middle- and low-income countries. The total amount disbursed by the CIF is about $ 7.5 billion, and it is mainly managed by the World Group Board. Unlike AF, GCF and GEF, CIF is the only multilateral climate that works exclusively with the Multilateral Development Bank (MDB) as an implementing entity. These MDBs are the CIF funds, the African Development Bank, the World Bank Group, the Inter-American Development Bank, the European Bank for Reconstruction and Development, and the Asian Development Bank.

[6] GEF web site: https://www.thegef.org/who-we-are/funding. Last visit, 30.12.2024.

The CIF is divided into two trust funds: the Clean Technology Fund (CTF) and the Strategic Climate Fund (SCF).

The presentation of the 3 main climate funds showed that there are interesting mechanisms for mobilizing climate financing and cooperation between states. However, it must also be acknowledged that these funds are criticized when it comes to accessibility. Among the most frequently cited reasons for this are administrative and bureaucratic red tape, and complex, slow procedures. Projects submitted take a long time to be validated or even to receive initial feedback, which limits their effectiveness and efficiency, especially in the most vulnerable countries. What's more, the financing granted by these funds is deemed insufficient in relation to the scale of the needs. The funds are also characterised by a technocratic orientation with little involvement of civil society, which is not conducive to taking into account the needs of the most disadvantaged communities. There is also a problem of follow-up after projects have been completed. Given that these funds operate based on country contributions, which can vary from one year to the next. For example, the annual climate financing pledge of $100 billion by 2020 agreed at COP15 was not reached until 2022, according to the OECD (OECD, 2024a), while Zagema et al., (2023) report that the $100 billion pledge has not been met. Now that all countries, including the least developed, are being asked to reduce their CO2 emissions, the question is what will happen to the viability of these funds if the commitments are not fully met?

1.3.5. Instruments of green finance

We distinguish several categories of instruments related to green finance, such as capital/debt/equity facilitation, grants, risk-sharing, carbon markets & emissions trading systems (ETS) and voluntary cooperation instruments.

1.3.5.1. Capital, Debt, and Equity Instruments

a) Seed capital

Seed capital is a financial instrument that provides facilities during the development period of projects or organisations which operate in the domain of energy/green infrastructure. The loans contracted are repaid when the project starts to make revenues. One example of seed capital is the ***UNEP's Seed Capital Assistance Facility,*** which makes financial resources available during the implementation phase of projects in emerging and developing countries. The objective of this fund

is to promote the use of climate-friendly technologies (e.g., renewable energies and energy efficiency).

b) Concessional and non-concessional lending (green bonds)

Concessional and non-concessional loans are also one of the key instruments utilized in climate finance. Concessional loans refer to a debt instrument that offers more generous terms than what is applicable in the market. It is characterised by zero or low interest rates, extended repayment schedules, and provision for interest rate modifications. In climate finance, this instrument is mainly used by bilateral cooperation channels and multilateral development banks. According to Naran et al., (2022), concessional funding represented about 16% of total tracked global climate finance between 2011 to 2020. Non-concessional loans refer to a debt instrument that offers the same condition as a market term. It is the most common instrument used to finance climate mitigation initiatives. According to Buchner et al., (2021), non-concessional loans represented 53% of the global climate finance flow during 2019/2020. Green bonds, as fixed-income debt instruments, are one of the most preferred non-concessional loan instruments used by investors in renewable energy and green technology projects. According to S&P Global, the annual issuance of all GSSSBs (green, social, sustainability, and sustainability-linked bonds) could hit $1.05 trillion in 2024, up from $0.98 trillion in 2023[7]. In 2024, green bonds may represent up to 14% of global bond issuance, and this percentage is expected to grow significantly in the coming years[3].

c) Securitisation

According to Jobst, (2008) securitisation is the process in which certain types of assets are pooled so that they can be repackaged into interest-bearing securities. The interest and principal payments from the assets are passed through to the purchasers of the securities. In the domain of green finance and climate finance, green bonds are the main securitisation instrument used by the market. It is mainly used to finance renewable energy initiatives or mitigate greenhouse gas emissions. In 2015, the green bond issuance reached an amount of $ 40 billion (Kaminker, 2015).

d) Venture capital/Equity

[7] World Economic Forum: https://rb.gy/12r49o. Last visit, 30.12.2024.

Venture capital and equity are also financial instruments for climate change. Venture capital refers to a type of private equity that investors provide to startup companies and small businesses with long-term growth potential. Technically, it consists of giving a share of ownership and voting rights on a project. We distinguish three stages of venture capital: pre-seed, seed funding and early-stage funding. Equity represents the market value of the assets owned by stakeholders after all debts have been paid off. Equity is one of the most important instruments used in the domain of climate finance. According to Buchner et al., (2021), equity is the second largest instrument category that finances climate action and represents around 33% of the global total climate finance flow during the 2019/2020 period.

e) Debt for climate-nature swaps

Debt-for-Climate Swaps (DFCS) is an agreement between a sovereign and its creditors that reallocates a portion of ongoing debt obligations toward investments in climate action[8]. This instrument is often used in bilateral (between governments) and multilateral channels (between MDBs and governments) or even NGOs. As public debt pressure remains an issue for many developing and emerging countries, debt-for-climate swaps are designed to help those countries achieve their climate goals while reducing their macroeconomic and fiscal pressure. It also helps lending parties achieve their international commitments by providing direct and innovative instruments in climate action financing. One example of this debt-for-climate swap was the Ecuador case which was the world's largest "debt-for-nature" swap on record in 2023, selling a new "blue bond" that will funnel at least $12 million a year into the conservation of the Galapagos Islands for 20 years, one of the world's most precious ecosystems. Thus, investors (Credit Suisse) bought back roughly $1.6 billion of the country's debt at a nearly 60% discount, saving around a billion dollars in repayments over 17 years[9,10].

1.3.5.2. Grants

Grant refers to a climate finance instrument that aims to provide financial support without repayment or a compensation system. Grant instruments are mainly used by bilateral cooperation

[8] GCF website: https://rb.gy/rqi2ru. Last visit, 30.12.2024.

[9] Reuters website: https://rb.gy/7smswg. Last visit, 30.12.2024.
[10] World Economic Forum: https://www.weforum.org/stories/2024/04/climate-finance-debt-nature-swap/. Last visit, 30.12.2024.

channels, international financial institutions, philanthropic foundations, and international climate funds to support adaptation and new energy projects. According to Buchner et al., (2021), grant instruments represent around 6% of global climate finance flows during 2019/2020. Specifically, a grant instrument is used to provide financial resources for non-revenue generating activities such as elaborating strategies or climate change policy documents (National Determined Contributions-NDCs, National Adaptation Plan for Actions-NAPAs, National Adaptation Plans-NAPs, National Communications…). It is also used for knowledge management and capacity building.

1.3.5.3. Microfinance instruments

Microfinance instruments refer to people or projects who don't have access to a conventional financial service or institution such as a bank. In certain areas, the microfinance mechanism is used to finance small local green projects such as solar home system projects. Because, of the lack of data availability, this kind of instrument is difficult to track.

1.3.5.4. Risk-sharing instruments

a) Guarantees

Guarantees are risk-sharing instruments that allow borrowers to obtain partial or total cover for their obligations towards a lender in case of non-performance or default in exchange for a fee or a premium. It is generally used to provide financial support for a project that generates revenues such as renewable energy projects in low-income countries or developing countries.

b) Insurance

Green insurance is become recently an instrument that has been used by many investors around the world. It refers to a financial instrument that investors or companies in case of damage. It also provides a financial resource dedicated to clean technologies and emissions-reducing activities. The different types of green insurance are green car insurance, green business insurance, eco-friendly home insurance, green travel insurance, eco-friendly liability insurance, green life insurance and eco-friendly health insurance.

1.3.5.5. Carbon Markets: Clean Development Mechanism (CDM) and Article 6 of the Paris Agreement

The Clean Development Mechanism is the world's first international carbon market scheme that was established by Article 12 of the Kyoto Protocol. As mentioned earlier, the Kyoto Protocol entered into force in 2005 and provided legally binding greenhouse gas emission targets for all developed countries. Through the CDM mechanism, developed countries with a greenhouse gas reduction or emission target are allowed to implement emission reduction projects in developing countries through a Certified Emission Reductions (CER) credit. In practice, each CER corresponds to one tonne of CO2, and these CER can be traded and sold by industrialised countries, especially Annexe 1 members, to meet their emission target under the protocol. Since its creation, the CDM has become one of the main funders of the Adaptation Fund by its 2% levy issued. Most of CDM's projects relied on renewable energy, energy conservation and energy efficiency.

However, the role played by African countries in terms of projects supported by the CDM is, unfortunately, less. Most of the projects are attracted by emerging markets such as China, India, Brazil and Mexico (Winkelman & Moore, 2011). Since the adoption of Article 6 of the Paris Agreement in Glasgow, the CDM has been going through a transitory scheme before the entry into force of Article 6 in 2026. From 2026 on, all the CDM projects must be fully compliant with Article 6, especially Article 6.4. and the carbon credit emissions will take 6.4E.R name. Indeed, through Article 6 of the Paris Agreement, which allows voluntary cooperation between countries to meet their climate goals, the international climate market has taken a new dimension. Article 6.2 of the Paris Agreement allows countries, especially industrialised countries, to trade emission reductions and removals with one another through bilateral or multilateral agreements. These traded credits are known as Internationally Transferred Mitigation Outcomes (ITMOs).

Article 6.4 creates a new global market as the CDM by establishing a mechanism that allows parties to trade GHG emissions reduction under the UNFCCC through a supervision body known as Article 6.4 Supervisory Body. In practice, project developers (countries, companies, or individuals) will request to register their projects with the Supervisory Body, and projects must be approved by both the country where it is implemented and the Supervisory Body before it can start issuing UN-recognised credits.

The CDM and the Paris Agreement have given a recognised framework for the international carbon markets. Since its creation, the CDM has been responsible for 7,700 projects registered in over 95 countries; 1.7 billion Certified Emissions Reductions (CERs) issued and more than $300 billion invested (UNFCCC, 2017). By its 2% levy, it contributed to the Adaptation Fund revenue of about $195 million from the sale of CERs. From 2026 onward, Article 6 might play an important role in the international climate finance scheme and might provide a huge amount for mitigation and energy efficiency projects in the developing world.

1.3.5.6. Just Energy Transition Partnership

a) South African Case

South Africa is the first country to have an agreement on the Just Energy Transition Partnership signed at the 26th Conference of Parties in 2021 (COP 26 in Glasgow). South Africa and a consortium of countries known as the International Partners Group (IPG) which include the United States of America, the United Kingdom, Germany, France and the European Union mobilised an initial amount of $8.5 billion for the Just Energy Transition in the form grant and concessional loans finance over the next three years (Tyler & Mgoduso, 2022). The main objective of this JETP is to move away from coal in the electricity system, which represents about 85% of power generation (Tyler & Mgoduso, 2022), but also help the country to meet the Nationally Determined Contributions (NDC) goals under the Paris Agreement. In the technical view, the JETP is expected to prevent up to 1-1.5 gigatonnes of emissions over the next 20 years. Thus, South Africa has set up an ambitious Investment Plan for its JETP known as the Just Energy Transition Investment Plan (JETP, 2023-2027). The Investment Plan has given priority to 5 main sectors of investments: Electricity, New Energy Vehicle (NEV), Skills Development and Municipal capacity sector. The JETP relies heavily on its financing model for the private sector which may mobilise a considerable amount of investment and the public sector in a low rate. The JETP required a new market-based instrument as well as environment-related financial reforms in the private and public sectors (South Africa Presidency, 2023). On the other hand, the JETP has set some financial principles to better consider the needs and reality of the country. Among these principles, we can note: (i) the finance should support developing countries under the UNFCCC framework; (ii) finance should be additional to existing climate and development commitments, and not divert critical development assistance away from existing development funding; (iii) the finance should take into account the

fiscal sustainability, and incorporate appropriate and equitable risk-sharing arrangements; (iv) Partnerships with the private sector should be supported to foster appropriate risk-sharing arrangements (South Africa Presidency, 2023).

In terms of the instruments, the JETP want to heavily rely on instruments like grants, concessional loans, blended finance, budgetary support (fiscal support), thematic bond issuance (green bonds, transition bonds) and, at the end, markets-related instruments. These instruments should be more flexible and more advantageous for risk-sharing and cost arrangements. Potential investors are CIF/ACT[11] which represents the principal donor with about 30,8% of the total amount, followed by the United Kingdom (21,57%), the European Investment Bank (12,24%), the United States of America (12,07%), France (11,86%) and Germany (11,45%).

b) Senegalese Case

One of the key objectives of Senegal is to achieve universal access to electricity by 2025. Indeed, the rate of access to electricity is about 70,4%, according to the World Bank Indicators (2020), with a great disparity between urban (95.2%) and rural areas (47.4%). Most of the energy used in Senegal comes from oil products with 53.48% and 35.27% from biomass (Sarr & Fall, 2022). The forthcoming exploitation of gas and the just energy transition partnership give a new opportunity for the country to meet its goal. The question will be, how can Senegal ensure its energetic sovereignty in the context of gas exploitation and at the same time promote clean energy?

The just energy transition partnership is a new concept and remains less understood by many of the Senegalese people. Originally, JETPs were conceived as a structure to help emerging high-emitting countries that heavily rely on coal and are willing to increase their ambition (e.g., through increasing their nationally determined contributions-NDC or putting ambitious national plans in place) to transition away from coal in a socially just way (Wemanya & Opfer, 2022). Coal with 9.39% of the total energy supply constitutes the third energy generation source after oil and biomass energy in Senegal (Sarr & Fall, 2022). The JETP is seen as part of the wide climate finance mechanism that aims to provide financial resources and achieve certain goals (SDG 7, Paris

[11] CIF/ACT is the Accelerating Coal Transition (ACT) investment program supported by the Climate Investment Fund.

Agreement, Agenda 21 and national priority). Senegal is the second African country to conclude a JETP accord with the international partners group.

1.3.6. Taxonomy in green finance

Meeting the goals set under the Paris Agreement or other international commitments will require cooperation across all sectors and regions as well as considerable investment estimated at $100-150 trillion by 2050 (GFMA & BCG, 2021)[12]. The mobilisation of such amount will also be required to set up some principles, and harmonised rules but also on what will be considered as climate investment or investment which considers Paris Agreement purposes and sustainable development goals. The definition of green finance taxonomy will be a key element to ensure that investments are aligned with climate goals. According to Bhattacharyya (2021), green finance taxonomy indicates a definition and classification framework related to the type and nature of projects or economic activities that are eligible for financing under green finance schemes or allied policies. On his side, The International Capital Markets Association (ICMA) has not considered taxonomy just a tool served for classification but goes beyond and is considered as a financial product qualification, disclosure, or risk assessment tool (or a combination of several or all of these (Pfaff et al., 2021).

Due to the specificities that exist between countries, regions and sectors, most financial institutions use their taxonomy and jurisdiction, which might consider some activities in a specific sector. Having a single taxonomy applied to all sectors will be uneasy, but having a consistent global regulation which can be applied across all sectors and industries constitutes a milestone for scaling up global green finance and achieving the Paris Accord, UN SDG and net-zero pathway by 2050 (for most of the countries). According to the Organisation for Economic Co-operation and Development (OECD), there are two dimensions to a taxonomy: (i) the system itself in all its complexity, and (ii) the final product (boiled down to its pragmatic essentials) as it will be used by financial market participants and other users (For & Makers, 2020). The first dimension concerns the system, which considers the classifications (metrics) of activities that are accountable for climate actions, as well as the regulation used to define each class. The second dimension concerns

[12] **GFMA**: Global Finance Markets Association
BCG: Boston Consulting Group

the taxonomy as a product or outcome that contains a list of activities and projects, which may be considered under the green taxonomy.

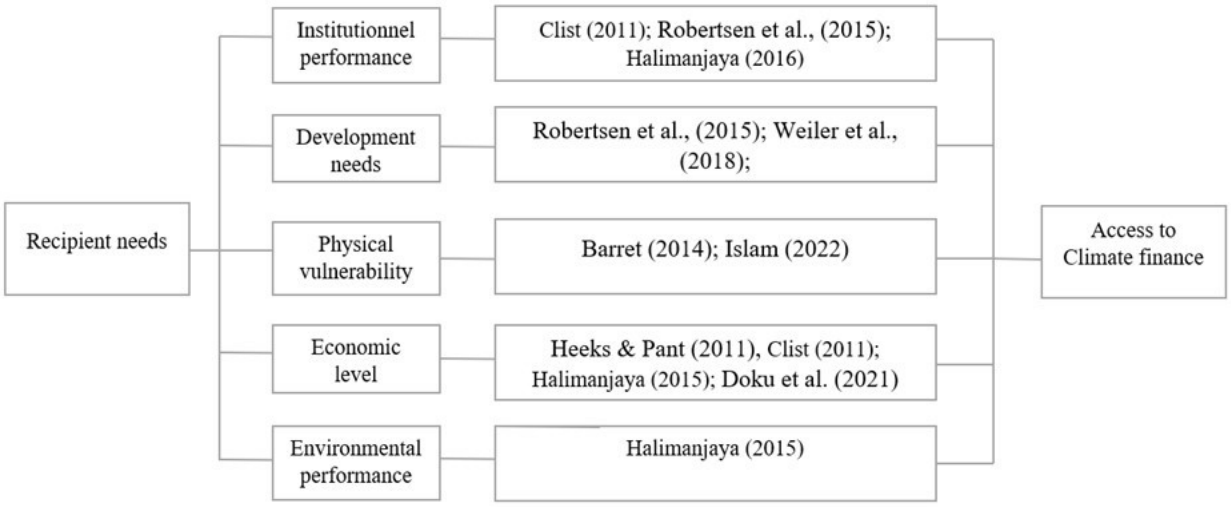
1.4. Methods and Data

In this section, we will discuss the methodology used for this essay. More specifically, we will discuss the conceptual framework, the choice of the econometric model studied and its specification, the description of the variables, the hypothesis and the data source.

1.4.1. Conceptual framework

This study aims to analyse the factors explaining climate finance access through the recipient's perspectives. One question that comes up most often is to know the underlying motivations of climate finance providers. For many scholars, climate justice is broadly used to frame debates and discussions (Ciplet et al., 2013; Islam, 2022; Khan et al., 2020; Qi & Qian, 2023; Sarah Colenbrander & Mitlin, 2018). Thus, the provision of climate finance is seen as a way of increasing justice on the environmental issues the world is facing.

Figure 4: Conceptual framework of climate finance access according to recipient perspectives



Note: The figure provides an overview of the conceptual framework of climate finance access based on the recipient perspectives. We notice that institutional performance, development needs, physical vulnerability, economic level and environmental performance are the factors explaining climate finance access.

Source: Adapted from Qi & Qian, (2023).

Many climate finance initiatives (the USD 100 billion target per year from 2020, the creation of the Green Climate Fund, the Loss and Damage Fund agreed upon at COP 28 and the New

Collective Quantified Goal on climate finance (NCQG), were created with the mandate to combat climate change and to prevent damage to the most vulnerable and affected people regarding the UNFCCC principle of common but differentiated responsibilities between the most emitters and the least emitters countries. Based on the climate justice principles and recipient needs, the conceptual framework of climate finance access according to recipient perspectives is presented as the following (figure 4):

1.4.2. Choice of model

The model used in this essay is the Bayesian Average Modelling (BMA) due to certain advantages that the model presents. Indeed, instead of relying on just one model, the BMA results over multiple plausible models based on the observed data. In Bayesian model averaging (BMA), the "plausibility" of the model is described by the posterior model probability, which is determined using the fundamental Bayesian principles, the Bayes theorem, and applied universally to all data analyses[13]. The use of the BMA as part of a panel data approach allows addressing the inconsistency of empirical estimates, which typically arises with omitted country-specific effects correlated with other regressors or with endogenous variables which may be incorrectly assumed to be exogenous (Moral-Benito, 2010). In other words, BMA can simultaneously deal with model selection, estimation and inference. Applying the BMA approach sounds to be an appropriate method for determining potential determinants or regressors of a given dependent variable. Over the last five years, climate finance has become an interesting topic for many researchers, and the issue of identifying the key drivers of this finance arises in more ways than one. Indeed, donors use significantly different criteria to determine eligibility versus the amount of climate finance allocated (Tennant et al., 2024). Also, scholars have used different variables to analyse the determinants of climate finance. For instance, Clist (2011) used proximity (the relationship between donors' countries and recipients) as a determinant of climate finance by applying an ordinary least square (OLS) and probit model, while Doku et al. (2021) used a System Generalized Method of Moments (GMM-Sys). Nawaz et al. (2021) considered domestic credit to the private sector as a determinant of climate finance mitigation while others such as Doku et al. (2021) ; (Halimanjaya, 2015) and Clist (2011) did not and instead considered other variables to describe the climate finance allocation (such as population growth rate, poverty level, etc.). In this case,

[13] BMA manual Stata: https://www.stata.com/manuals/bmaintro.pdf. Last visit, 30.12.2024.

considering a useful approach that removes such issues on potential determinants remains essential to find consistent results. From an econometric perspective, this issue is known as uncertainty, which emerges because theory does not provide enough guidance to select the proper empirical variable or model (Moral-Benito, 2010). BMA turn out to be a suitable approach to addressing uncertainty. This approach allows to build parameters that formally address the dependence of model-specific estimates.

1.4.3. Model specification

Let's consider the empirical specification given by the following equation:

$$y_{it} = \alpha + \beta_1 y_{it-1} + \beta_k x'_{it} + \mu_i + \varepsilon_t \quad (1)$$

Where, y_{it} represents the dependent variables (climate finance) in the country i at time t, x'_{it} represents the vector of possible regressors, β_k is the vector of the dependent variable coefficient with $k = 2, \dots 13$, α represents the vector of the coefficient of the lag component, μ_i is the individual error term and ε_t is the time component error term.

By considering the Bayesian Model Average terminology, a model is defined by a likelihood function and a prior density. Indeed, considering that our dependent variable (climate finance) has k possible explanatory variables, and then we will have 2^k possible combinations and 2^k possible models indexed by M_j with j= 1, …, 2^k. In addition, M_j represent the weighted average over all of the models for the 2^k combinations of the regressors $\{x\}$. The posterior for the parameters using M_j is given by the following equation:

$$g(\theta^j|X, M_j) = \frac{f(X|\theta^j, M_j)\, g\,(\theta^j|M_j)}{f(X|M_j)} \quad (2)$$

According to Moral-benito (2010), the logic of Bayesian inference suggests that we use Bayes' rule to derive a probability statement about what we do not know (i.e. whether a model is correct or not) conditional on what we do know (i.e. the data). Thus, by deriving Bayes' rule, the probability of such a model can be written as the following equation:

$$P(M_j/X) = \frac{f(X/M_j)\, P(M_j)}{f(X)} \quad (3)$$

$P(M_j)$ represents the probability of meeting the real model M_j before seeing the data. $f(X/M_j)$ is the marginal (or integrated) likelihood. Thus, by doing some transformation and using the probability rules (sum of probability = 1) and using equations (2) and (3), we can obtain the marginal probability of the data given by:

$$f(X/M_j) = \int f(X|\theta^j, M_j)\, g\,(\theta^j|M_j)\, d\theta^j \quad (4)$$

Therefore, we can also calculate the posterior density of the parameters by considering θ as a function of θ^j for each $j = 1, \dots, 2^k$.

$$g(\theta|D) = \sum_{j=1}^{2^K} P(M_j/X)\; g(\theta|X, M_j) \quad (5)$$

By (5), we derive the posterior Esperance and the posterior Variance:

$$E(\theta|D) = \sum_{j=1}^{2^K} P(M_j/X)\; E(\theta|X, M_j) \quad (6)$$

$$V(\theta|D) = \sum_{j=1}^{2^K} P(M_j/X)\; V(\theta|X, M_j) + \sum_{j=1}^{2^K} P(M_j/X)\; E(\theta|X, M_j) - E(\theta|D))^2 \quad (7)$$

The posterior variance incorporates both the weighted average of the estimated variances of the individual models and also the weighted variance in estimates of the θ's across different models (Moral-benito, 2010). Despite the variance providing a highly precise estimate in all models, we can still face the problem of uncertainty. Thus, by using the Markov Chain Monte Carlo Model Composition (MC^3) algorithm, we are now able to calculate the posterior probability given by the following equation:

$$P(\theta_h \neq 0|X) = \sum_{\theta_{h\neq 0}} P(M_j|X) \quad (8)$$

The posterior probability represents the measure of robustness. The variable h is introduced in the model to represent the probability that the variable belongs to the true model. Thus, any variable with high posterior probabilities of being included is considered as a robust determinant of our dependent variable (climate finance). Therefore, we use the Unit Information Prior (UIP) to set the form of the hyperparameter g. We also assume uniform model's priors.

1.4.4. Description of Variables, Hypothesis and Data Source

To perform our analysis, several variables are used as determinants of climate finance based on the available literature.

a) Climate finance

Climate-related finance is the dependent variable of this essay. The amount of climate-related development finance for each year corresponds to the sum of the values of mitigation finance (financing of projects like renewable energy, green technologies, energy efficiency and conservations, forest & land-based carbon sequestration, etc) and of adaptation finance (financing projects like water resource management, climate-smart agriculture, coastal protection & disaster risk reduction, etc) minus the overlap value (which includes both mitigation and adaptation projects). The methodologies used to identify climate-related finance include the Rio Markers. The Rio Markers methodology assesses the degree to which climate considerations are factored into development cooperation activities (Official Development Assistance activities), i.e. if activities are climate-related. The Rio Markers on climate change identify if climate change adaptation or mitigation is the principal (primary) or a significant (secondary) objective of the activities, or if the activity does not target climate change[14]. Bilateral providers adopted a variety of methodologies to produce climate-specific data in their Biannual Transparency Reports (BTRs). Multilateral Development Banks and multilateral institutions apply the climate components methodology which is a climate-specific measure which identifies the share of an activity that directly contributes to climate change adaptation, mitigation or cross-cutting[10].

The data used is coming from the OECD climate-related finance database recipient perspectives over the period 2000 to 2021 from 49 sub-Saharan African Countries (list of countries in Appendix A). Its lag is used as one of the independent variables. Islam, (2022) underpinned that climate finance allocation is a dynamic process, and the allocation of a year t depends on the amount allocated in year t-k (k>0).

H1: A positive relationship is expected between the lag of climate finance and the dependent variable (climate finance).

[14] OECD website: https://rb.gy/epj1ui. Last visit, 30.12.2024.

b) Institutional performance

- **Governance Readiness**

The governance readiness index is part of the readiness component of the ND Gain Index. It measures the institutional factors that enhance the application of investment for adaptation. In other words, governance readiness (GR) represents the level of the institutional preparedness of a country to set favourable institutions that can attract climate investment for adaptation. The GR is composed of 4 indicators, which include political stability and non-violence, control of corruption, rule of law and regulatory quality. Previous studies such as Clist, (2011) ; Robertsen et al., (2015) and Halimanjaya, (2016) found a positive relationship between governance readiness and climate finance.

H2: A positive relationship between governance readiness and climate finance is expected.

c) Economic level

- **GPD per capita:**

GDP per capita is used in this study to consider the level of poverty between countries as it is commonly used as the proxy of poverty. According to Weiler et al., (2018), poorest countries receive relatively little funding, as they are unable to absorb large amounts of funds and taking into account this variable makes sense since it is related to the social dimension of vulnerability (Robertsen et al., 2015; Weiler et al., 2018).

H3: A positive relationship between GDPs per capita and climate finance allocation is expected.

d) Development needs

- **Population:**

The population is considered as a determinant of the allocation of climate finance. Indeed, taking population as an explanatory variable contributes to removing the potential bias that can exist between countries with high and small levels of population (Halimanjaya, 2015). Population data is coming from the Word Development Indicators of the Word Bank. Population can be seen as another variable of need (Clist, 2011) and highlights the hypothesis that a country with a high population has a huge need and is supposed to receive more climate finance compared to a country with a small population (Halimanjaya, 2016; Weiler et al., 2018).

H4: A positive relationship between population and climate finance allocation is expected.

- **Economic Readiness**

Economic Readiness (ER) is one of the indexes computed by ND-GAIN and tends to measure the effectiveness of a country in facilitating a favourable framework for climate investment. In other words, economic readiness reduces sensitivity and improves adaptive capacity. Economic readiness has been taken into account by Doku et al. (2021) and considered by the author as one of the components of proximity variable in 4P's framework (Population, Proximity, Poverty and Policy) provided par (Clist, 2011). ER ranges from 0 (the lowest ER level) to 1 (which is the highest level of ER).

H5: A positive relationship between economic readiness and climate finance adaptation.

- **Social Readiness**

Social readiness refers to the level of preparedness of the society to cope with environmental issues. SR is built by using 4 indicators, which include social inequality, ICT infrastructure, Education and Innovation. In other words, SR sets the social conditions that help society to make efficient and equitable use of investment and yield more benefits from the investment (ND-GAIN). Thus, the 4 indicators are supposed to enhance the mobility of investment and promote adaptation actions. Social readiness is paramount because of certain important indicators such as ICT infrastructure or education. These indicators contribute to enhancing knowledge integration and learning, which is a key driver of adaptive capacity (Doku et al., 2021; Heeks & Pant, 2011). Climate funds dedicated to technical support (sharing experience, technology and knowledge) are provided by many of the international climate funds. Thus, a country with a good level of social readiness is expected to attract more climate funds.

H6: A positive relationship between social readiness and climate finance is expected.

e) Physical vulnerability

- **Vulnerability Index**

The vulnerability index is a country-level indicator that measures vulnerability in terms of exposure, sensitivity, and adaptive capacity. In other words, the vulnerability index evaluates the vulnerability of human populations to extreme climate events and changes. It reveals the capacity

of a country's residents to cope with the issues of climate change. However, the link between climate change vulnerability and climate finance raises debate among researchers. For instance, Barrett, (2014) highlighted the fact that vulnerability is not a determining factor in attracting climate finance in Malawi, while Islam, (2022) found that it is a matter of adaptation and overlapping funding. The vulnerability index is computed using food, water, health, ecosystem service, human habitat, and infrastructure; the data are from the Notre Dame-Vulnerability Index. The vulnerability index ranges from 0 (lowest level of vulnerability) to 1 (highest level of vulnerability). The average level of Sub-Saharan African countries' vulnerability index is about 0.54 (> 0.5), representing a high exposure level. This means that a high vulnerability index contributes to enhancing the attractiveness of the country to receive more climate funds.

H7: A positive relationship between the vulnerability index and climate funding is expected.

f) Environmental performance

- **CO2 emission per capita**

Carbon dioxide emissions (CO_2) are considered by many authors as one of the determinants of climate finance allocation. Dolšak & Crandall (2013) and Halimanjaya (2015) assumed that a country with a higher level of greenhouse gas emissions would be more likely to host climate finance projects such as the Clean Development Mechanism (CDM). However, some donors could also channel funds to small-emitter countries to combat poverty, infant mortality, and other forms of underdevelopment (Halimanjaya, 2016) or to just encourage a low development pathway.

H8: A negative relationship between CO2 emissions and climate finance allocation is expected.

- **Forest land**

The carbon sink index or carbon sequestration index is often considered a determinant of climate change mitigation. In this study, we use forest land (in terms of percentage of total land area) as a proxy for the carbon sink. Forest land area represents the natural capacity to sequester carbon accumulation. Recently, initiatives have been created to support countries that have carbon sequestration potential. Thus, seventeen countries in Eastern Africa and Central Africa countries created the Blue Fund for the Congo Basin in 207. Canadell & Raupach (2008) highlight the fact that forests constitute a key opportunity in tropical regions in the reduction of carbon emissions from deforestation and degradation. In addition, Halimanjaya (2015) hypothesises that the larger

the carbon sink of a developing country, the more likely it is to be selected as a recipient of mitigation finance and to receive more mitigation finance.

H9: A positive relationship between forest land and climate finance is expected.

Following Islam (2022), one-year lagged (L1) values were applied to all our dependent variables to avoid potential reverse causality between the dependent variables and the independent variables. Indeed, choosing one-year lagged (L1) values is also explained by the fact that obtaining approval from climate finance institutions is a time-consuming task, and countries must apply before getting any approval. In addition, the writing up of a project is based on information and data from the precedent year (t-1), as it can be difficult to have data for year t. We also believe as Islam, (2022) that getting climate funds is a dynamic process, and considering that static models cannot be suitable. Our panel model is dynamic and can be expressed as:

$$\begin{aligned}\ln(Climate\ finance_{it})\ \alpha + \beta_1 \ln(Climate\ finance_{it-1}) + \beta_2 \ln(GDP\ per\ capita_{it-1}) \\ + \beta_3 \ln(Population_{it-1}) \\ + \beta_4 \ln(CO2emissions\ per\ capita_{it-1}) + \beta_5 \ln(forestland_{it-1}) \\ + \beta_6 \ln(Economic\ readiness_{it-1}) + \beta_7 \ln(Vulnerability\ readiness_{it-1}) \\ + \beta_8 \ln(Social\ Readiness_{it-1}) + \beta_9 \ln(Governance\ readiness_{it-1}) + \mu_i + \varepsilon_t\end{aligned}$$

1.4.5. Data sources

Table 1: Description of variables

Variables	Unit	Data sources
Climate finance	Thousand US dollars	OECD-DAC
Lag climate finance	Thousand US dollars	OECD-DAC
Population	Number of inhabitants	WDI/WB
GDP per capita	Us dollars	WDI/WB
Vulnerability Index	Index score	ND GAIN
Economic readiness index	Index score	ND GAIN
Governance readiness index	Index score	ND GAIN
Social readiness index	Index score	ND GAIN
CO2 emissions per capita	Metric tons per capita	WDI/WB
Forest land	As a percentage of the country's surface area	WDI/WB

Source: own illustration

1.5. Results

1.5.1. Descriptive statistics

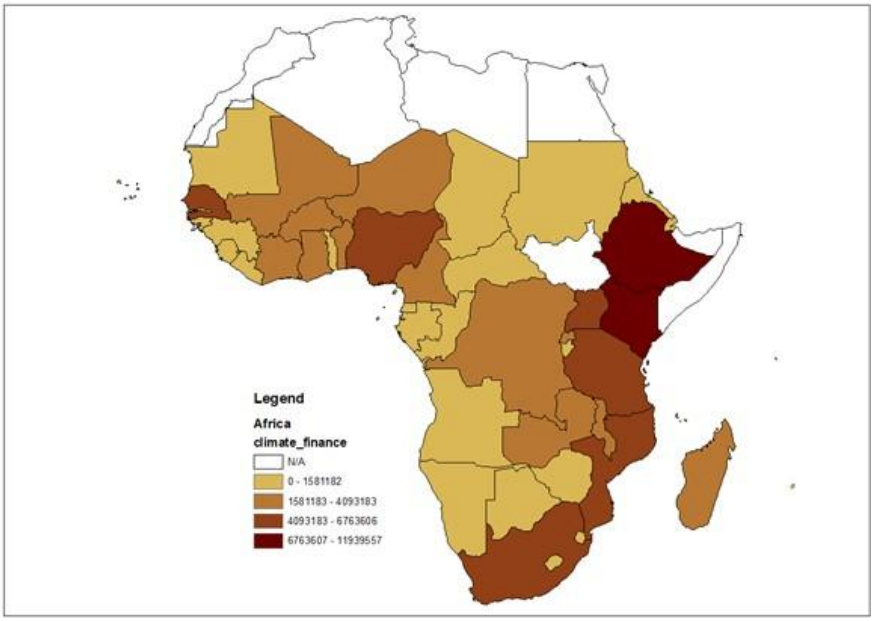
Table 2 displays the descriptive statistics of all the variables included in the model from 2000 to 2021. We can notice that the annual average of climate finance is estimated at $125.8 million in sub-Saharan Africa. The continent is characterised by a low level of GDP per capita of $1983. The 47 sub-Saharan African countries have an average population estimated at around 18.3 million inhabitants per country. The annual average of CO2 emission per capita is estimated at 0.88 metric tons. In addition, forest land represents roughly 32.3% of the total surface area of the 47 sub-Saharan African countries. The average economic readiness index, which is estimated at 0.31, shows a low level of economic preparedness as well as a weak governance system and a low level of social preparedness, characterised by an index score of 0.38 and 0.2 (respectively). The vulnerability index also shows that sub-Saharan Africans are more vulnerable to the effects of climate change, with a vulnerability index score estimated at 0.53.

Table 2: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Climate finance (thousand current $)	920	125761.11	245681.37	1.369	1877375.1
GDP pcap (current $)	1022	1983.107	2876.227	99.757	19849.717
Emission pcap (metric tons per capita)	987	.879	1.513	.022	8.447
Population (nbr. Inhabitant)	1034	18306952	28477048	80410	2.083e+08
Forestland (% of land area)	1034	.323	.25	.002	.935
Economic readiness read (index)	1034	.31	.114	0	.82
Governance readiness (index)	1012	.384	.118	.166	.696
Social readiness (index)	1034	.204	.055	.082	.359
Vulnerability readiness (index)	1034	.53	.06	.385	.664

Source: Own illustration.
Note: Data are from 2000-2021. As we can see in the number of observations column, there is missing data for some variables, such as climate finance, GDP pcap, emissions pcap and governance readiness index.

Figure 5: Climate-related finance allocation for sub-Saharan African countries (2000-2021)



Note: Total amount of climate-related finance allocation for sub-Saharan African countries (2000-2021) in thousands of USD. Kenya, Ethiopia, South Africa, Tanzania and Mozambique are among the top five countries that receive more climate finance, while Eswatini, Sao Tome and Principe, Botswana, Seychelles, and Equatorial Guinea are among the bottom five that receive less climate finance. **Source**: Own illustration.

1.5.2. Preliminary test

Some pre-estimated tests are performed to ensure that our model is fitted to be estimated. Firstly, the Variance Inflation Factors are computed to test multi-collinearity between variables (Table 3). The mean value of the VIFs is equal to 2.72, which is less than 5, and thereby, the variables can be maintained in the same empirical model without the risk of creating a bias in the econometric results (Bayale, 2020). We conclude that there is no multicollinearity between variables, and the model is set to fit the variables. Then, we computed the matrix of correlation. The result shows a low coefficient of correlation between variables in the model (Table 4), which means a low level of dependence.

Table 3: Variance Inflation Factor (VIF)

Variables	VIF	1/VIF
Log emiss pcap (L1)	6.530	0.153
Log_gdp pcap (L1)	5.970	0.167
Log_vul read (L1)	3.300	0.303
Log_pop (L1)	1.720	0.583
Log_gov read (L1)	1.680	0.596
Log_climate finance (L1)	1.510	0.664
Log eco read (L1)	1.430	0.701
Log soc read (L1)	1.250	0.798
Log forestland (L1)	1.070	0.932
Mean VIF	**2.720**	

Source: own illustration

Table 4: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Log_climate_finance	1.000									
(2) Log_climate_finance (L1)	0.731***	1.000								
	(0.000)									
(3) Log_gdp_pcap (L1)	0.059*	0.044	1.000							
	(0.076)	(0.197)								
(4) Log_Lemiss_pcap (L1)	-0.102***	-0.094***	0.877***	1.000						
	(0.002)	(0.007)	(0.000)							
(5) Log_Lpop (L1)	0.421***	0.413***	-0.390***	-0.409***	1.000					
	(0.000)	(0.000)	(0.000)	(0.000)						
(6) Log_forestland (L1)	-0.051	-0.048	0.111***	0.099***	0.006	1.000				
	(0.122)	(0.159)	(0.000)	(0.002)	(0.857)					
(7) Log_eco_read (L1)	-0.109***	-0.069**	0.190***	0.336***	-0.204***	-0.065**	1.000			
	(0.001)	(0.043)	(0.000)	(0.000)	(0.000)	(0.037)				
(8) Log_gov_read (L1)	0.066**	0.077**	0.419***	0.396***	-0.334***	-0.034	0.388***	1.000		
	(0.047)	(0.024)	(0.000)	(0.000)	(0.000)	(0.279)	(0.000)			
(9) Log_soc_read (L1)	0.261***	0.245***	0.111***	-0.022	-0.075**	0.033	-0.107***	0.085***	1.000	
	(0.000)	(0.000)	(0.000)	(0.492)	(0.015)	(0.287)	(0.001)	(0.007)		
(10) Log_vul_read (L1)	-0.004	-0.006	-0.738***	-0.778***	0.219***	-0.146***	-0.323***	-0.474***	0.119***	1.000
	(0.912)	(0.866)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

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

Note: Table 4 displays a correlation matrix of variables included in the empirical model with their significance in brackets. The table shows a low level of correlation among dependent variables, which means that they can be added to an empirical model without the risk of spurious regression. **Source**: own illustration

1.5.3. Empirical results

The results of the Bayesian model approach in a panel data framework are reported in Table 5. The lower part of the table shows the model size, such as the number of observations (759), the model space (512), the number of models visited (512) and the model size distribution, which is equal to 6.044. The upper part shows the names of variables, and the statistics related to each variable of the models. Columns 1, 2 and 3 report the Posterior Inclusion Probability (PIP), the Post Mean (PM) and the Post Standard Deviation (PSD), respectively. The PIP represents the sum of the Posterior Mean Probability (PMP) for all models, which indicates if a covariate is included in the

model. The higher the PIP is, the more the variable is part of the model's prior. The Post mean displays the coefficients averaged over all models and reflects further evidence on the sign of the variables. The negative value of the PM means that the variable negatively affects the independent variable, while the positive value affects it positively. Columns 4 and 5 represent, respectively, the Cond. Pos. Sign and the index of the variables. The Cond.Pos.Sign represents the posterior probability of a positive coefficient expected value conditional on inclusion, respectively, 'sign certainty' (Feldkircher & Zeugner, 2022). And, then we can find that here, all variables with a negative Post Mean have a Cond. Pos. Sign are near zero. The index column denotes the index of the variables' appearance in our data set (the results in Table 5 are sorted by PIP).

According to the results, we noticed that the lag of climate-related finance, social readiness, population, GDP per capita, CO2 emission per capita and governance readiness are highly included in the model. The reminder variables, such as the forest land, vulnerability index and economic readiness, are poorly included in the model. In other words, the lag of the climate finance, the population and social readiness have a PIP of 100%, meaning that all the posterior model mass rests on models that contain lag of climate finance, social readiness and population variables, while only with 4% and 4.5% respectively, all of the posterior model mass rests on models that include economic readiness index and vulnerability index variable.

The post-mean result gives the sign of the variables. Then, it is noticed that the lag of climate-related finance, population, governance readiness, GDP per capita, and social readiness positively influenced the distribution of climate finance in sub-Saharan African countries, while emissions per capita, forest land, economic readiness and vulnerability index negatively influenced the distribution of climate finance.

Figure 3 presents the cumulative model probability based on the 100 models. The BMA approach allows the ranking of the 100 best models that can explain the data based on the posterior probabilities. It ranks horizontally the inclusion of variables according to their posterior probability, which is proportional to the column width. The colour provides information on the sign of the variable; it is blue when the variable positively influences the distribution of climate finance, red where it negatively influences it, and the white colour corresponds to no-inclusion (a zero coefficient). We can also notice that variables with high PIP in Table 5, such as the lag of climate-related finance, social readiness index, population, governance readiness index, GDP per

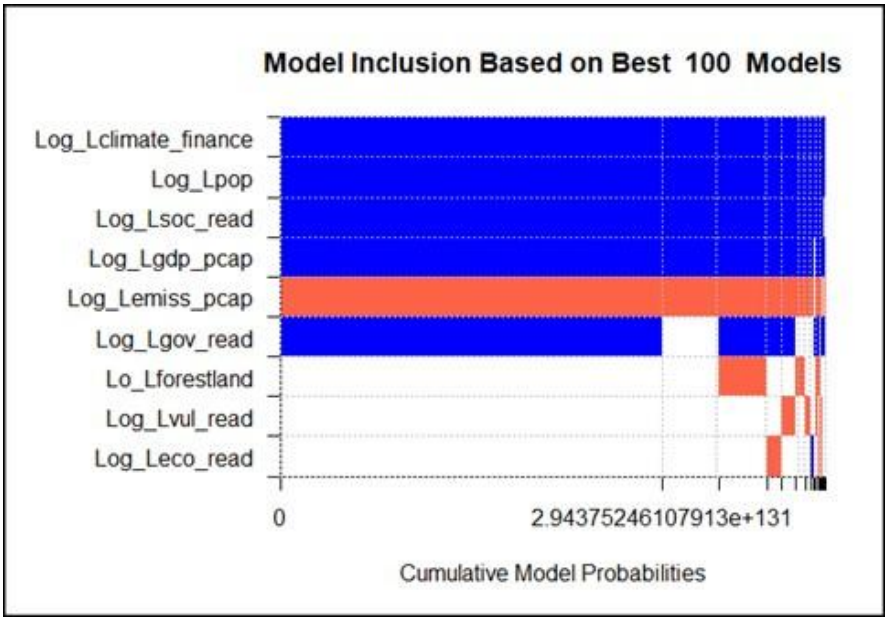
capita and CO2 emissions per capita are the ones which are more included in the graphic and are the most included into the 100 best models. Figure 4 presents the robustness of the analysis and contains the posterior model size distribution and the posterior model probabilities.

Table 5: Bayesian Model Averaging (baseline results for the panel data)

	PIP	Post Mean	Post SD	Cond.Pos.Sign	Idx
Log climate finance (L1)	1.000	0.547	0.029	1.000	1
Log population (L1)	1.000	0.366	0.054	1.000	4
Log social readiness (L1)	1.000	1.128	0.239	1.000	8
Log GDP pcap (L1)	0.994	0.676	0.153	1.000	2
Log emission pcap (L1)	0.992	-0.482	0.119	0.000	3
Log governance readiness (L1)	0.858	0.637	0.337	1.000	7
Log forestland (L1)	0.118	-0.009	0.030	0.000	5
Log vulnerability readiness (L1)	0.045	-0.027	0.249	0.003	9
Log eco readiness (L1)	0.040	-0.001	0.032	0.188	6
Mean no. regressors		**6.0449**	**Model Space 2k**		**512**
No. Models visited		**512**	**No. Obs.**		**759**

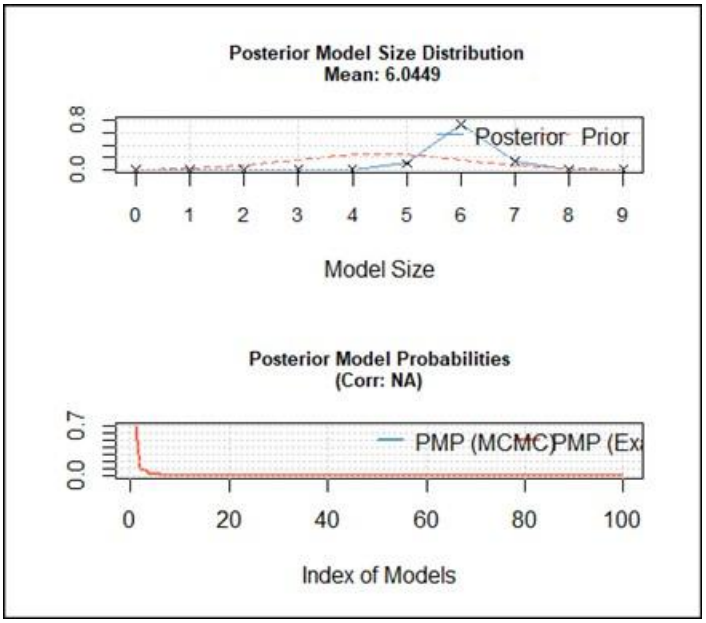
***Note*:** Results of Bayesian Model Averaging (baseline analysis). The PIP represents the Posterior Inclusion Probability. The Post Mean is the coefficient averaged over all models. The post-SD is the Posterior Standard deviation. The Cond. Pos. Sign is the Posterior Probability of a positive coefficient expected value conditional on inclusion. Finally, the Idx represents the index of the variable's appearance on the original data set. This estimation uses the "uniform" model prior to the standard g= "UIP". **Source:** own illustration using R.

Figure 6: Model Inclusion



Source: own illustration
Note: The figure represents the model inclusion based on the best 100 models. The blue colour shows that variables have a positive coefficient while the red colour indicates a negative coefficient for the variables. The horizontal axis represents the best models, scaled by their posterior model probability (PMP). Source: Own illustration using R.

Figure 7: Posterior Model Size Distribution and Posterior Model Probabilities



Note: In this figure, we have two representations. The first one represents the posterior model size distribution, which displays the mean number of regressors, i.e., the average number of regressors. The posterior model size is equal to 6.044, and the theoretical expected model's prior parameter size of K/2 = 9/2 = 4.5, since K, the number of regressors, is equal to 9. The second representation draws the Posterior Model Probability. The PMP (exact) in the red line represent the analytical PMPs and has been calculated by comparing the analytical likelihoods of the best models. In contrast, the PMP (MCMC) represent the MCMC-based PMP, which is derived from the number of iterations counted. The two are very similar in our case and show that all models from the best 100 models may have the same posterior model mass, which is, in our case, equal to 100% [PMP (Exact) = PMP (MCMC)]. **Source**: Own illustration.

Table 6: Bayesian Model Averaging with the ratio post-mean and post-standard deviation

	PIP	**Post Mean**	**Post SD**	**|Post Mean/Post SD|**
Log climate finance (L1)	1.000**	0.547	0.029	18.724
Log population (L1)	1.000**	0.366	0.054	6.752
Log social readiness (L1)	1.000**	1.128	0.239	4.718
Log GDP pcap (L1)	0.994**	0.676	0.153	4.434
Log emission pcap (L1)	0.992**	-0.482	0.119	-4.040
Log governance readiness (L1)	0.858**	0.637	0.337	1.892
Log forestland (L1)	0.118	-0.009	0.030	-0.305
Log vulnerability readiness (L1)	0.045	-0.027	0.249	-0.107
Log economic readiness (L1)	0.040	-0.001	0.032	-0.025
Mean no. regressors		**6.0449**	**Model Space 2k**	**512**
No. Models visited		**512**	**No. Obs.**	**759**

*** p<.01, ** p<.05, * p<.1

Source: Own illustration

Note. By adding the column of the ratio post mean and post SD, we can identify statistically significant variables. Thereby, variables with a PIP >0.5 and a ration PM/Post SD > 1, are significant at 5%.

From Table 5, we have built Table 6 by adding the column of the absolute value of the ratio between the post mean and the post standard deviation. We follow the rule of PIP larger than 0.5 according to Deniz & Stengos (2023) to consider variables which determine climate finance allocation. According to Raftery (1995), the significance of a variable depends on the ratio |Post Mean/Post SD|. If this ratio is >1, then the variable is statistically significant at 95% and not otherwise. Thus, according to this rule, we are identifying variables that are significant and represent the determinants of climate allocation finance in sub-Saharan African countries.

The lag (1) of the climate-related finance variable has a PIP greater than 0.5 and a ratio post-mean over post-standard deviation higher than 1. We conclude that the lag of climate-related finance is a strong determinant of climate finance allocation and is statistically significant. This result is in line with results found by other scholars, such as Islam (2022), concerning mitigation climate funds and overlap funds. This confirms the dynamic nature of climate finance allocation in our model and for the countries considered. The population variable is also a strong determinant of climate finance allocation and is statistically positive. Thus, the more a country has a large population, the better it is supposed to receive climate funds. This result explains, to a certain extent, the needs of the population, and countries with large populations may need more funds to adapt and mitigate the effects of climate change than countries with small populations. In addition, our result is in line with some other empirical findings (Halimanjaya, 2016; Robinson & Dornan, 2017; Weiler et al., 2018).

Moreover, social readiness, which captures factors such as social inequality, ICT infrastructure, education and innovation, is positively correlated with climate finance allocation in sub-Saharan Africa. Thus, countries with a higher readiness are supposed to receive more climate finance. Furthermore, we found that the poverty status measured by the GDP per capita is statistically significant and positively impacts the allocation of climate funds in Sub-Saharan countries. The positive relationship between the poverty level and climate finance in our case shows that the donor's rationale for funding sub-Saharan African countries is based on the economic potential of these countries in terms of investment returns. Countries with higher GDP per capita may have a great level of consumption, particularly in the energy sector, making investments in this area

(mitigation) more profitable for investors. This result corroborates the studies done by Halimanjaya (2016) and Weiler et al., (2018).

Our results also show that the CO2 emissions per capita variable is a consistent determinant of climate finance allocation in sub-Saharan African countries. Indeed, CO2 emissions are statistically significant and negatively impact the allocation of climate finance in SSA. The finding of this result shows that investors and institutions provide funding for countries which present a significant effort in climate change mitigation. Our result is in line with the one found by Islam (2022) showing a positive relationship between climate mitigation funds and per capita CO2 emissions.

Finally, we find that governance readiness is positively and statistically significant. We believe that governance readiness remains one of the key determinants of climate finance. Governance readiness refers to the capacity of countries to appropriately manage and channel funds to the needed sectors. Thus, the results show that countries with a good level of governance are more likely to attract climate finance. This is in line with the results found by Clist, (2011) and Robertsen et al., (2015).

The percentage of country forest land, the vulnerability index and the economic readiness variable have a lower PIP and are statistically not significant in the model's prior. It is then accepted that countries with higher previous climate finance allocation, higher population, higher GDP per capita, lower level of CO2 per capita, strong governance and social readiness index are likely to attract more climate funds according to the model selected of the Bayesian Model Averaging in the framework of panel data analysis.

Table 7: Summary of the results and hypothesis

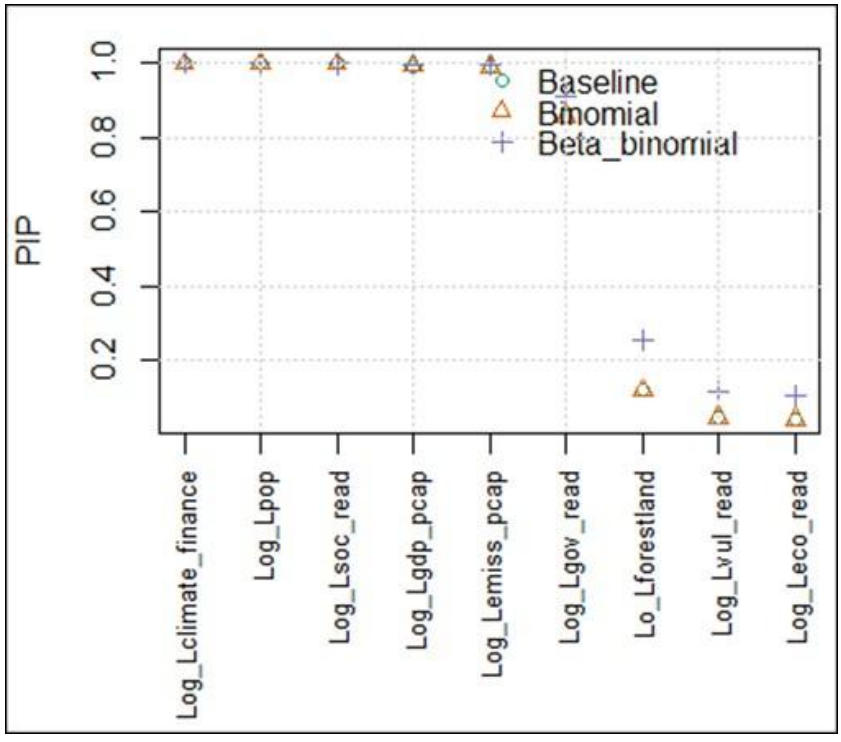
N°	Hypothesis	Decision
1	Lag of climate finance positively affects the allocation of climate finance	Accepted
2	Governance readiness positively affects the allocation of climate finance	Accepted
3	GDP per capita positively affects the allocation of climate finance	Accepted
4	Population positively affects the allocation of climate finance	Accepted
5	Economic readiness positively affects the allocation of climate finance	Rejected
6	Social readiness positively affects the allocation of climate finance	Accepted
7	Vulnerability positively affects the allocation of climate finance	Rejected
8	Greenhouse gas emissions per capita negatively affect the allocation of climate finance	Accepted
9	Carbon sequestration potential (forest land) positively affects the allocation of climate finance	Rejected

Source: own illustration

1.5.4. Sensitivity analysis

One of the advantages of using Bayesian Model Averaging is the increase in out-of-sample predictive performance in comparison to other methods that do not incorporate model uncertainty and have been used for a wide range of datasets (Spiliopoulos, 2010). To perform the robustness test, we used different varieties of the model's priors. While our baseline analysis uses the "uniform model's prior", we perform two more different models' priors called the fixed inclusion probability prior for the model (binomial model's prior) and the random inclusion probability prior for the model (beta-binomial model's prior). The summary of the results is presented in the following figure (see Figure 6), while the complete results are in Table 8. It is noticed that the three results (model uniform, binomial and beta-binomial) are very similar and have the same significance variables. These results (i.e., the PIPs and the Post Mean) are in line with our expectations. In addition, we can also assume that our model remains consistent when we consider changes in our model's prior.

Figure 8: Comparison between the baseline, binomial and beta-binomial model



Note: Figure 6 displays the comparison between the three models. We can see that the three models (i.e., uniform, fixed and random) look very similar. Therefore, our uniform prior for the model is consistent. As we realise the lag of climate finance, the population, social and governance readiness, GDP per capita, and CO2 emissions per capita remain strong determinants of climate finance allocation in Sub-Saharan Africa. Source: Own illustration using R.

Thus, as we realise that, the lag of climate finance, the population, governance readiness, GDP per capita, regional dummy variable (countries located in eastern Africa), economic readiness and CO2 emissions remain important factors that investors look at when allocating climate finance in sub-Saharan Africa. Additionally, a second sensitivity analysis was performed by using a greatly unfair prior for those variables. In practice, we set a prior inclusion probability of $\theta = 0.01$ (very low prior) for the variables cited above, while defining for the other the standard prior inclusion probability of $\theta = 0.5$. The results reported in Table 7 show that the lag of climate finance, the population, governance readiness, GDP per capita, regional dummy variable (countries located in eastern Africa), economic readiness and CO2 emissions variable remain valuable determinants of climate finance in sub-Saharan Africa.

Table 8: Sensitivity analysis results

Variables	Baseline/Uniform				Binomial				Beta-binomial			
	PIP	PM	PSD	|PM/PSD|	PIP	PM	PSD	|PM/PSD|	PIP	PM	PSD	|PM/PSD|
Log climate_finance (L1)	1.000**	0.547	0.029	18.724	1.000**	0.547	0.029	18.724	1.000**	0.546	0.029	18.882
Log_population (L1)	1.000**	0.366	0.054	6.752	1.000**	0.366	0.054	6.752	1.000**	0.369	0.053	6.912
Log_soc_read (L1)	1.000**	1.128	0.239	4.718	1.000**	1.128	0.239	4.718	1.000**	1.132	0.239	4.734
Log_gdp_pcap (L1)	0.994**	0.676	0.153	4.434	0.994**	0.676	0.153	4.434	0.996**	0.679	0.148	4.580
Log_emiss_pcap (L1)	0.992**	-0.482	0.119	4.04	0.992**	-0.482	0.119	4.040	0.995**	-0.487	0.117	4.173
Log_gov_read (L1)	0.858**	0.637	0.337	1.892	0.858**	0.637	0.337	1.892	0.909**	0.673	0.309	2.180
Log_forestland (L1)	0.118	-0.009	0.03	0.305	0.118	-0.009	0.030	0.305	0.255	-0.020	0.041	0.476
Log_vul_read (L1)	0.045	-0.027	0.249	0.107	0.045	-0.027	0.249	0.107	0.113	-0.061	0.375	0.162
Log_eco_read (L1)	0.04	-0.001	0.032	0.025	0.040	-0.001	0.032	0.025	0.105	-0.005	0.051	0.094

*** p<.01, ** p<.05, * p<.1

Source: own illustration

1.6. Partial conclusions and recommendations

During these past years, Sub-Saharan African countries have experienced a serious challenge in accessing climate finance. The role of international climate funds and funds provided by bilateral channels has become very precious. Investors and climate finance providers are considering different factors when providing climate finance. Thereby, authors have used different variables to explain the allocation of climate finance and the issues of identifying the key drivers of this climate finance arises in more ways than one. To overcome this limitation and avoid the model uncertainty, this study uses the Bayesian Model Averaging in the framework of a linear and dynamic panel data

model over the period 2000-2021. Beyond that, we use sensitivity analysis to check the robustness of our analysis with a different inclusion probability model's prior: fixed or uniform model's prior, binomial model's prior, and the random model's prior (beta-binomial model's prior). The model remains consistent while using these different priors for the models.

Among the main results of climate finance drivers, we note that climate finance allocation is a dynamic process, and the amount of funds provided in previous years positively affects the amount for the coming years due to the multiplication of climate financing channels year after year. Indeed, the creation of the Green Climate Fund in 2015, which is nowadays, the largest international climate fund, the new collective quantified goal on climate finance (NCQG, just negotiated during COP29 and expected to provide more realistic support to developing countries build on the $100 billion goal set in 2009 in Copenhagen), the Just Energy Transition Partnership (JETP) which start supporting developing nations on their energy transition and other initiatives demonstrate as well the evolutive character of the allocation of climate fund. Secondly, we found that countries with high populations are attracting more climate funds. High-population countries may have huge needs compared to countries with a low population. The governance system is also one of the factors taken into consideration by investors and climate finance institutions while providing climate funds. Countries with a strong system of governance are getting more funding than countries with weak governance systems.

Additionally, our results show that social readiness is positively correlated to the allocation of climate finance, and countries with a high index of social readiness are likely to receive more climate finance, meaning that countries' social adaptation capacities, innovations and knowledge in ICT, for example, matter while allocating climate finance. Another variable is that the poverty level measured by the GDP per capita constitutes a motivating factor for the allocation of climate funds. Countries with a high GDP per capita are attracting more climate funds than others. Lastly, the country's pollution level, measured by the annual CO2 emission per capita, is a determinant of climate finance allocation. Our results found that a high level of CO2 emission negatively affects the allocation of climate funds.

Considering these results, it is important to draw up public policy recommendations. As shown by our results, the variables such as social readiness, GDP per capita, carbon emissions per capita and governance readiness are statistically significant. Thus, to attract more climate financing, recipient

countries must strengthen their social readiness by prioritising social inequality reduction programs, which will also increase the adaptive capacity of the countries. But more importantly, this also goes into investing in the capacity of people throughout education and public awareness programs with curricula on climate literacy, environmental science and disaster preparedness. Also, strengthen health systems to better respond to climate-sensitive diseases (malaria, heatstroke, respiratory illnesses), while implementing and expanding adaptive social protection programs to assist people in case of climate-related extreme events. Also, as part of the indicator that builds the social readiness index, countries must enhance the information and communication technology (ICT) infrastructure. High access to ICT tools (phone, internet, network) is critical in sharing information and communicating with people in case of extreme climate event emergencies. The results also show that low level of greenhouse gas emissions is likely to attract climate finance. While priorities for most Sub-Saharan African countries are to invest in adaptation, recipient countries must follow a low-carbon trajectory, as all of them ratified the Paris Agreement. A good way to start is to implement the Nationally Determined Contributions (NDC) and the Long-Term Low Emission Development Strategies (LT-LEDS), as well as other national and regional climate-related strategies. Investing in greenhouse gas emissions reduction will also create social and economic benefits, such as access to electricity with renewable energy in rural areas, jobs, etc.

GDP per capita is also statistically significant, and therefore, we recommend that recipient countries must pursue their economic development efforts. Lastly, recipient countries may strengthen their governance system by establishing a strong monitoring, verification and reporting (MRV) framework, which may help to build trust between climate finance providers and recipient countries but also increase the effectiveness of the climate action taken on the ground. For that, recipient countries may need to settle strong institutional arrangements that manage and monitor the process of the implementation of climate-related projects. Investors (public and private) are looking for a predictable environment for their long-term capital. Climate projects - particularly in green infrastructure or energy - have investment horizons of 10 to 30 years. Conflicts, political crises or social instabilities (renewable energy projects) compromise the viability and profitability of these investments. Thus, recipients' countries must enhance their regulatory framework to provide a long-term legal basis for national climate policy, and to establish clear targets for emissions reduction, adaptation and financing, while guaranteeing legal certainty for investors.

To overcome the negative impacts of climate change, international climate finance must be provided following the needs of the countries concerned so that significant results can be expected. A possible extension of this study is to see the effectiveness of the allocation of these climate funds in terms of impacts and progress made by beneficiary countries in coping with climate change and its effects.

Essay 2: Adoption of green banking in WAEMU countries

Abstract:

The emergence of new types of financial products is essential in fighting the negative effects of climate change. Green banking is seen by many as a key element in the development of the financial market toward a low-carbon and climate-resilient economy. In this essay, we have analysed the factors motivating commercial banks to adopt green banking practices in the West African Economic and Monetary Union (WAEMU) using empirical methods based on a logistic regression model. Our results show that pressure from the management board is likely to be the factor influencing bankers to adopt green banking practices. Therefore, our study confirms the validity of the institutional theory within the context of commercial banks in the WAEMU zone, where pressure from actors such as the management board impacts the adoption of new practices. In addition, the results highlight that the financial sector in the WAEMU region is mostly driven by a top-down approach; decisions and changes mainly come from top management rather than the bottom-up approach, where community and customers have a great impact. Through this research, we are contributing to the growing literature on green banking and making recommendations for financial authorities in shaping green finance policies in the West African region.

2.1. Introduction

With the climate crisis, the global financial sector has undergone considerable changes. These changes concern integrating new financial rules and practices that come through some terminology such as Corporate Social Responsibility (CSR). The term CSR has a particular connotation with Socially Responsible Investing (SRI). The origin of SRI dates to the 1950s as investors started using screening to prevent investment in “nonethical” businesses in line with religious beliefs (Barua, 2020). The socially responsible investing term evolved over the years and has incorporated new aspects, including Environmental, Social, and Governance (ESG) factors into investment decisions.

Friedman (1970) points out that the social responsibility of a businessman is to increase their profits rather than any social purpose. Indeed, there are “two opposite production technologies: dirty and clean. Dirty production has a higher per-unit financial return but entails significant social costs, while clean production is financially less attractive but socially preferable because it

generates lower (although not necessarily zero) social costs" (Oehmke & Opp, 2021). The social performance of clean production or investment has been evaluated by the Social Profitability Index (SPI), which measures the "bang for the buck", i.e., the value created for socially responsible investors per unit of socially responsible capital consumed (Oehmke & Opp, 2021).

Several scholars tend to define the concept of CSR; for Safarzad (2017), Corporate Social Responsibility is defined as a legal requirement for a company, including continued commitment toward the community. Even though a company's main goal is to increase its operations' efficiency and productivity and maximise its shareholders' profit, this must be done by integrating the community's ethical and environmental expectations into the company's economic processes. Three main theories are currently associated with the CSR concept, namely, the Carroll theory, the triple bottom line theory, and the stakeholder theory.

Unlike CSR, the concept of ESG is more focused on the environmental aspect of corporate social responsibility and was officially used through the United Nations report entitled "*Who Cares Wins*" in 2004. The initiative (Who Cares Wins) was endorsed by 23 financial institutions (including the World Bank Group), collectively representing more than US$ 6 trillion in assets, and was focused on how financial institutions can better integrate environmental, social and governance issues in capital allocation and portfolio management processes. Thus, the ESG principles have allowed financial institutions to formulate long-term goals, the introduction of organisational learning, change processes and a strong commitment at the board and senior management level. The growing interest in CSR and ESG led to the establishment of a sustainable finance framework. Many definitions exist for sustainable finance. For example, sustainable finance can be defined as finance that considers ESG considerations when making investment decisions in the financial sector or economic activity (Bakken, 2021; Ozili, 2021). Thus, the need for the financial sector, especially the banking sector, to play a significant role in promoting a green economy and low-emission development pathway has become a mainstream consideration for many scholars (Ozili, 2021; Weber, 2014) and leads to the establishment of green banking.

Thus, Triodos Bank was the first commercial bank in 1980 to introduce environmental sustainability in the banking sector. In 1990, Triodos Bank launched a "green fund" for funding environment-friendly projects and all the other projects followed later (Dash, 2008). The development of environmental sustainability in the banking sector shows a sudden rise through

the adoption of measures and principles such as the Equator Principle in 2003[15] and the Green Bank Act[16] in 2009 in the United States. Today, green banking is practised by several commercial banks across the world, including in the West African Economic and Monetary Union (WAEMU) region.

Green banking is defined as a category of banking practices that use innovative financing instruments to defend the environment, preserve natural resources, accelerate the transition to clean energy and fight against climate change. It is also called ethical banking or sustainable banking. In addition, green banking comprises all forms of investment or lending practices that consider environmental impact and enhance environmental sustainability. The adoption of green banking practices is part of market solutions to the environmental crisis, which differs from the regulation's solutions, such as the Pigouvian tax widely used around the world over the last 30 years. The adoption of market-based solutions is to address the financial constraint, unlike the regulatory approach, which addresses the externality issues of a given economic activity.

There are two types of green banking practices. One is in-house green banking, which consists of creating an eco-friendly environment, such as adopting green building, online banking, waste management, using renewable energy, reducing sound pollution, promoting online activities, etc. Another is practised by the bankers in their business area, such as financing green projects: renewable energy projects, energy efficiency projects, effluent treatment plants, bio-fertiliser initiatives... (Lalon, 2015).

In recent years, many researchers have shown an interest in understanding the factors behind the adoption of environmentally friendly practices by banks. Lalon (2015) studied the green banking activities of the commercial banks established in Bangladesh by focusing on policies, guidelines and regulations facilitating the adoption of green banking practices. Shaumya & Arulrajah (2017) studied the impact of green banking practices on banks' environmental performance in Sri Lanka by collecting data from selected bank employees. They found that green banking practices have a positive and significant impact on a bank's environmental performance. By analysing survey data from commercial banks, Ahmad et al., (2013) found that 6 factors influence commercial banks to

[15] See sub section 2.3.4.2.

[16] The Green Bank Climate Act finances climate change mitigation and adaptation projects at the state and local level by capitalising regional, state, and municipal green banks (Congress: https://www.congress.gov/bill/116th-congress/house-bill/3423). Last visit: 24.04.2025.

adopt green finance practices, namely: economic factors, policy guidelines, loan demand, stakeholder pressure, environmental interest and legal factors. Thus, these factors have a positive impact on banks' adoption of green practices.

Stampe (2014) argues that the capacity to help manage risks and capitalize on opportunities is the main driver for the integration of sustainable banking in the banking sector. Indeed, adopting sustainable practices in the banking sector allows banks to strengthen' capacity to rely on long-term benefits rather than focus on short to medium-term gains. Weber (2005) goes beyond this explanation by arguing that the conventional financial sector takes sustainability considerations into account because it is a business case, regulators prescribe it and because of the personal attitudes of leaders or because of the demand of clients.

Oyegunle & Weber (2015) analyse the sustainable finance framework for some emerging countries and have identified that three main factors drive green banking adoption. Firstly, internal pressures, such as social pressure and environmental pollution, are the main drivers of green banking adoption in China, Brazil, and Bangladesh. Secondly, external pressure from financial (aid) institutions such as the Dutch Entrepreneurial Development Bank (FMO) and the International Financial Corporation (IFC) are the main drivers for green banking adoption in countries like Nigeria, Mongolia, and Indonesia. Finally, peer pressure from regional neighbours is seen as a driver of green banking adoptions in countries like Colombia and Peru.

Coming to the WAEMU region, green banking practices are a new concept but have recently received attention from investors and financial sector regulators. Thus, the West African Monetary Union (UMOA) established its first green taxonomy applicable to issues of green, social and sustainable bonds on the regional financial market. This taxonomy has been elaborated based on the need expressed in the Nationally Determined Contributions (NDC) of the 8 countries of the WAEMU aggregated into 3 categories: green category (which includes renewable energy and energy efficiency, clean transportation, sustainable management of water, etc.), social category (social infrastructure, job creation, food security, etc.) and blue category (ocean pollution, plastic and chemical waste, green tourism, etc.). Thus, several institutions, such as the West African

Development Bank (BOAD[17]), private financial institutions and government states started the issuance of green bonds in the UMOA financial sector.

In addition to this, several commercial banks have started to establish their own sustainable finance frameworks in the WAEMU region which will increase consideration of the financing of green projects. However, research on the adoption of green banking practices is limited in the WAEMU region. Thus, to the best of our knowledge, there is not yet any study that is focused on green banking adoption using empirical evidence. Our research tends to fill this gap by contributing to the literature and the understanding of bankers' motivation to adopt green finance in their sector. Recommendations are drawn from the results, which will help regulators shape their decisions for the development of sustainable finance within the region.

The first essay enabled us to learn a little more about the factors that contribute to attracting climate financing, especially from public international sources. We have concluded that countries with good governance, high levels of social readiness, high gross domestic product per capita and population and low carbon dioxide emissions per capita tend to attract more climate finance from international public sources. In this second, we are interested in analysing the mobilisation of climate finance by the local private sector. Thus, the main research question of this second essay is to identify the key determinants of green banking adoption by commercial banks established in the WAEMU region. Primary data from the survey will be analysed by using a binary logistic regression model. The rest of the document is organised into four (4) sections. The first section addresses the literature review. The second section evaluates the state of sustainable finance in the WAEMU region and at the international level. Section 3 covers the methodological aspects, and Section 4 discusses the results, followed by the conclusion and recommendations.

2.2. Literature review

In recent years, the role of banks in the fight against climate change has become very important. Although they do not appear to be major emitters of greenhouse gases, their role in financing polluting companies (oil companies, industry, etc.) is obvious. In this section, we explore existing theories, research and empirical work related to the adoption of green banking practices. It is divided into two main sub-sections: a theoretical review based on the founding theories of green

[17] BOAD : Banque Africaine de Développement (the acronym in French)

finance practices, including Carroll's Theory of Corporate Social Responsibility (CSR), the Triple Bottom Line Theory, Stakeholders Theory, Socially Responsible Investment Theory and Institutional Theory. The empirical review explores the various research studies, case studies and applications of financing practices in the banking system in the international and African context.

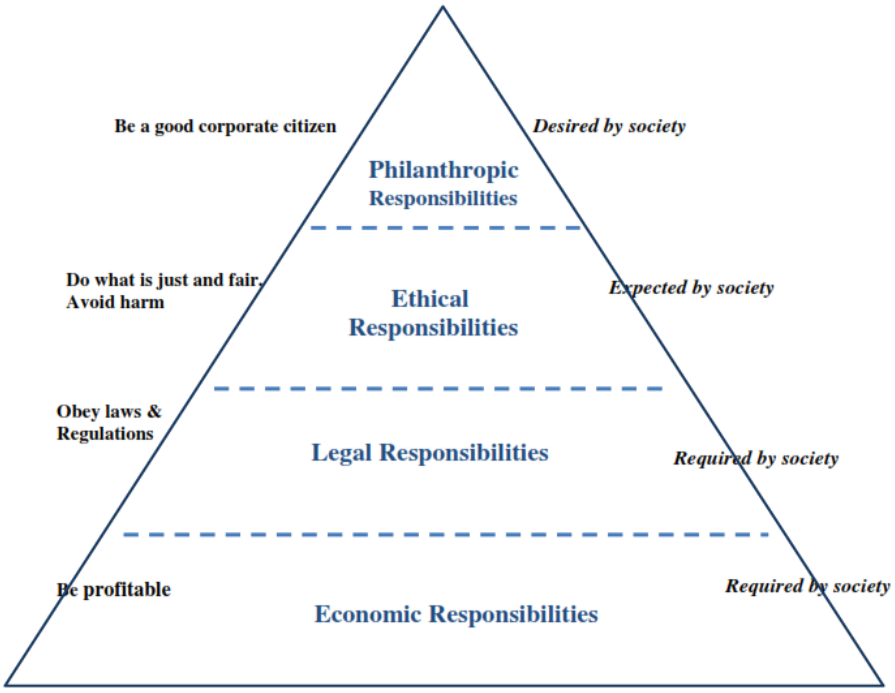
2.2.1. Theoretical review

2.2.1.1. Carroll's Theory of Corporate Social Responsibility (CSR)

The concept of sustainability has gained attention from many scholars around the world. Friedman, (1970) was one of the precursors who was interested in the concept of CSR and pointed out that the responsibility of a business is to make money rather than pursue any other objectives. In contrast, it is obvious that companies must follow the economic aspects of their business, but at the same time, this must be done to the community's ethical and environmental expectations (Safarzad, 2017). For Brussaeau (2011), the concept of CSR is composed of 4 companies' obligations: (i) economic responsibility to make money, (ii) legal responsibility to adhere to rules and regulations, (iii) ethical responsibility to adhere to moral values and do what is right even if not required legally and (iv) philanthropic responsibility to contribute to community well-being and give back to the society. This definition of CSR, introduced by Brusseau, has been consolidated by Carroll and is known nowadays as "Carroll's Pyramid of CSR". The question is: What do the business community and commercial enterprises get out of CSR practice?

Kurucz et al., (2008) highlighted four effective arguments that companies benefit from engaging in CSR policies. These include cost and risk reductions, positive effects on competitive advantage, company legitimacy and reputation, and the role of CSR in creating win-win situations for the company and society. Other reasons to embrace CSR practice include brand differentiation, employee engagement, and customer engagement. According to Carroll, (2016), companies must integrate the Pyramid of CSR in their activities to ameliorate the perceived conflicts and tensions between and among the four categories of responsibilities.

Figure 9: Carroll's Pyramid of CSR



Source*: (Carroll, 2016)*

Therefore, the pyramid is seen as an integrated, unified whole where companies must simultaneously fulfil the four components. Indeed, the pyramid should not be interpreted to mean that a business is expected to fulfil its social responsibilities in some sequential, hierarchical fashion, starting at the base. Rather, business is expected to fulfil all responsibilities simultaneously (Carroll, 2016). In addition, the pyramid is seen as a sustainable stakeholder framework because the four responsibilities represent long-term obligations that overarch into future generations of stakeholders, and each of the four components addresses different stakeholders in terms of the varying priorities in which the stakeholders might be affected. This is why there is some appeal for CSR to be renamed Corporate Sustainability Responsibility or Corporate Stakeholder Responsibility (Carroll & Buchholtz, 2015).

If in 1979, Carroll developed the original component of the pyramid in the context of American society, there has been a debate regarding the validity of this pyramid in other countries, especially developing countries, where needs and priorities may be different. Thus, several scholars proposed that the pyramid needs to be reordered or redefined to meet the specificity of each region or country (Crane & Matten, 2004). In the African context, Visser (2005) argued that the relative priorities of the African pyramid will likely differ from the classical one. Indeed, according to Visser, economic

responsibilities still get the most emphasis, but philanthropic responsibility becomes the second pillar of the pyramid compared to the classic one. This can be explained by the fact that the socio-economic needs of the African societies in which companies operate are so great that philanthropy is an expected norm. The lower order of legal responsibility in the pyramid is explained by the fact that legal infrastructure is poorly developed and often lacks independence, resources and administrative efficiency in Africa. So, there is less pressure for good conduct, and the government's capacity for enforcement remains low. Finally, ethical responsibility has the least influence on the CSR agenda within the African continent. One of the reasons for this situation is that companies operating in the African continent lack basic ethics infrastructure or initiatives such as ethics training and senior management responsibility rules and codes.

2.2.1.2. Triple Bottom Line Theory

The triple bottom line theory is one of the main theories in the corporate management sphere, and it was introduced by Elkington in his book “Cannibals with Forks: The Triple Bottom Line of 21st Century Business” (Elkington, 1997). Triple bottom line theory can be considered as a sustainability framework that incorporates three dimensions of performance: economic, social and environmental. Thus, by maximising all three bottom lines, organisations are more likely to have a positive impact on the world and more success. TBL brought sustainability to the heart of the business system to achieve continuous profits and long-term social and environmental projects. Elkington, (1997) mentioned 7 practices that must guide every business in promoting sustainable projects.

a) The economic bottom line

The economic bottom line refers to the profitability of a business or project. The economic bottom line is not just limited to the traditional internal profit of a corporation but also includes financial benefits that society may benefit from a company, such as the payment of taxes, the creation of jobs for the communities, payment of social security, etc. The economic performance must also guide the reduction of externalities. For example, suppose a factory is relocated from one place to another to reduce production costs. In that case, the firm must also care about the economic sustainability of such a decision and the negative externality it might create.

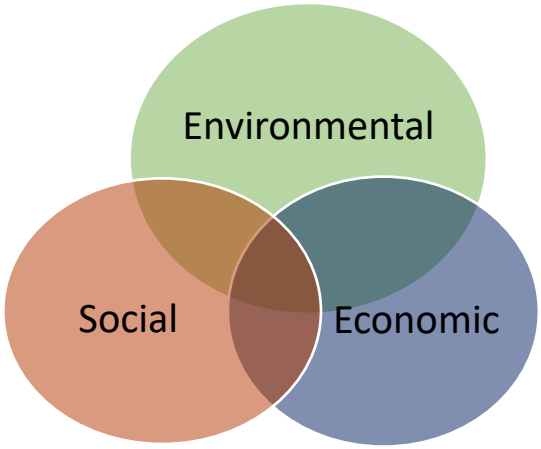
b) The social bottom line

The social bottom line refers to the importance of caring about society while making profits. This encompasses the impact on all the shareholders and stakeholders and how it creates benefits for them as well as future generations. The social bottom line is closely interlinked with the CSR concept and tries to meet some of the social expectations, such as social justice, equity and equality, promoting values such as human rights and dignity both inside and outside the business. Thus, every company must engage in finding solutions for the problems society and communities are facing and help local authorities, which may include health services, educational facilities, culture and heritage conservation, minority unemployment issues, wages and working conditions, land rights, etc. By doing so, companies contribute as much as possible to meet social needs, which leads to a safe and profitable environment and markets for business.

c) The environmental bottom line

Environmental sustainability is one of the main components of the TBL theory. The environmental bottom line is closely connected to the sustainable development concept initiated by the Brundtland Report, which emphasises that development must be done to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. Thus, businesses must be done by following environmental legislations and treaties of the countries where they are operating, but also by efficiently using the natural resources. One of the ways to do so is, for example, to promote the use of renewable energy instead of relying on fossil fuels, which are not renewable and are available in limited quantities, but more importantly, the remaining carbon budget of the atmosphere. Companies must also avoid releasing toxic waste into the environment (such as chemical products, polluted water, nuclear waste, air pollution, environmental dumping, etc.). The environmental bottom line also refers to one of the crucial issues of modern society, such as environmental justice, where the one responsible for environmental damages must pay for it. Business decisions must then be based on the evaluation and establishment of some criteria based on the results of an environmental audit (company footprint and their potential impact on the ecosystem), environmental, social and Governance indicators (ESG), and companies must regularly publish their environmental performance indicators. By doing so, companies will contribute to promoting a viable and liveable environment for society.

Figure 10: Graphical representation of the triple bottom line



Source: Construction based on the TBL theory (Elkington, 1997).

Since its popularisation in 1994 by John Elkington, the triple bottom line has become an important foundation of sustainability around the globe. The concept has influenced substantial sustainability benchmarks such as the Dow Jones Sustainability Indexes (DJSI) and Global Reporting Initiative (GRI) as well as accounting strategies like social return on investment (SROI), full cost accounting, and ESG reporting frameworks, Corporate Sustainability Reporting Directive (CSRD), Index for Sustainable Economic Welfare (ISEW) and many others. This benchmark also has a close connotation in the financial system and leads to the consideration of sustainable lending by financial market actors (commercial banks, credit rating agencies, stock market, etc).

2.2.1.3. Stakeholder theory

The stakeholder approach to strategy emerged in the middle of the ’80s through the work published by R. Edward Freeman’s “Strategic Management- A Stakeholder Approach in 1984” based on the process work of Mason & Mitroff (1984) and Emshoff (1978). Freeman defined a stakeholder as “any group or individual affected by or that can affect the achievement of an organisation’s objectives. The impetus behind stakeholder management was to try and build a framework that was responsive to the concerns of managers who were being buffeted by unprecedented levels of environmental turbulence and change” (Freeman & McVea, 2001). Thus, the stakeholder approach is becoming an important management strategy where, during the decision-making processes, managers tend to formulate and implement processes which satisfy all the stakeholders and not only those groups who have a stake in the business (Freeman & McVea, 2001). Thus, the

stakeholder theory calls for the involvement of each specific stakeholder during the decision-making process and each must be represented by at least one representative during this process. This ensures that the concerns and interests of all have been included in social and environmental concerns.

The stakeholder theory should also contribute to increasing transparency and prevent business managers from using their influence to ignore the community's demands. Fassin, (2009) categorised the stakeholders into three groups, namely the real stakeholders, stake-watchers and stake-keepers. According to Nnadi and Mutyaba, (2023), the real stakeholders have an actual stake in the company and possess a legitimate claim, power and influence, and the firm has a responsibility and moral obligation toward them. The stake-watchers do not truly have a stake themselves but act as proxies or intermediaries who protect the interests of real stakeholders, and the stake-keepers are independent regulators such as the governments, courts, regulatory agencies, the press and the media (Nnadi & Mutyaba, 2023). Market actors such as commercial banks could act in favour of the environment if the stakeholders put pressure on managers so that a sustainable lending framework can be established and implemented for each specific loan and project that the banks and their partners will engage in. Ultimately, the stakeholder approach becomes an integral part of responsible investment as many stakeholders attach importance to environmental issues and ask their companies to make environmentally responsible decisions.

2.2.1.4. Theory of Socially Responsible Investment (SRI)

The concept of socially responsible investment has recently gained attention from scholars. From the literature perspective, this concept of SRI can be divided into two main strands: exclusion and impact investing. According to Heinkel et al., (2001), the exclusionary investment aims to screen out socially irresponsible investments. This might mean avoiding firms producing goods and services that can harm society or investments that are ethical or green for society. The analytic model presented by Heinkel et al., (2001) showed that exclusionary ethical investing leads to polluting firms being held by some investors since green investors eschew polluting firms' stock, which also leads to lower stock prices for polluting firms. Thus, if the higher cost of capital more than overcomes the cost of reforming (i.e. cleaning up their activities), then polluting firms will become socially responsible because of exclusionary ethical investing (Heinkel et al., 2001).

Unlike exclusionary ethical investing, which imposes additional costs on polluting companies to access financial services, impact investing aims to facilitate access to financial services that may help companies to adopt clean technologies. The Socially Responsible Investment provides a framework for financial sector players to influence investment assets by promoting clean technologies, either by increasing the capital cost for dirty production companies or providing incentives for investors who may be interested in clean technology. The theory provided a significant influence on the establishment of the Social Profitable Index (SPI), an investment criterion that characterises the optimal ranking of impact investments when socially responsible capital is scarce (Oehmke & Opp, 2021).

2.2.1.5. Institutional theory: Emergence of green banking theory

As one of the oldest industries, the banking sector has always been an integral part of the capitalist system, where banks were accountable to no one except the shareholders and were perceived to be an environmentally neutral industry (Ahuja, 2015). However, due to the unprecedented global climate crisis, the banking sector, as well as the manufacturing sector, is seen as one of the major causes of climate change (Bukhari et al., 2019). This situation has resulted in pressure on green banking adoption. The objective of these pressures is to limit the negative environmental externalities produced by the banking sector, both directly and indirectly (Meena, 2013). Thus, many international frameworks have been created to take care of the implications of banking sectors in the climate crisis, such as the Equator Principles, the Sustainable Banking Network (SBN), etc.

From a theoretical perspective, the framework of green banking theory has been mostly based on institutional theory. Indeed, organisations such as banks are embedded in a specific social and institutional context or institutional framework that both constrains and enables strategy and corporate governance. Institutional theory is defined as a theory based on the external pressures that an organization faces, which forces an organization to change its policies, procedures or structure. According to DiMaggio and Powell, (1983), institutions mean a collective and regulatory complex consisting of political and social agencies that dominate other organizations through the enforcement of the law, rules and norms. Indeed, from the point of view of DiMaggio and Powell, who were interested in analysing why organisations behave similarly, explained that organisations

are isomorphic due to institutional pressures that result in more homogeneous organisational structures within institutional environments.

Bukhari et al., (2019) considered that four elements from the institutional theory may influence the adoption of green banking, namely: top management pressure, customer pressure, competitor pressure and community pressure. Top management pressure and customer pressure are considered internal and coercive pressure, while competitor and community pressure are external to the bank. Thus, the increase in environmental commitment from the customers or the bank may have a significant impact on the adoption of green banking (Tang et al., 2013 ; Yen and Yen, 2012). Banks may make decisions based on the innovation or policy made by competitors (Pleasant et al., 2014). Thus, with the climate crisis, many banks have started to include environmental loans in their lending portfolio, influencing others to join green banking initiatives.

2.2.1.6. Innovation theory and adoption of change

Rogers (1995) defined innovation as an idea, practice or object perceived as new by an individual or other unit of adoption. In the context of this research, green banking practices are considered innovative in the sense that they might involve introducing new products on the financial market, such as sustainable loans, green bonds, etc. However, the process whereby individuals and communities adjust or abandon customs and associated leading ideas, values, and purposes to act differently in response to random (unique) or systemic factors is no simple matter (Serrat, 2017) and requires a change within the community. Adopting these changes toward new technology or practices will lead to expected results or impact. In the context of green banking, the adoption of new practices is seen as the approach that has been taken by bank managers, employees, customers and stakeholders to include green banking practices in their financial system.

Several theories and frameworks support the adoption or motivation for new practices or technologies by individuals, organisations and communities. For example, the Theory of Reasoned Action (TRA) introduced by Ajzen and Fishbein (1975) and its extension, the Theory of Planned Behaviour (TPB), is often cited to describe how individuals and organisations behave regarding their intention to adopt a practice. Thus, the TRA aims to investigate the relationship between attitude and behaviour based on two major concepts: “principles of compatibility” and “behavioural intention”. With these characteristics, the TRA is designed as a predictive model and,

therefore, is used in a variety of fields, such as banking, public, education, and industries to predict individual actions based on certain criteria (Mishra et al., 2014).

Additionally, the Technology Acceptance Model (TAM) is one of the most effective contributions of the theory of reasoned action and is the most widely utilized model of acceptance and usage of innovative technology by users (Davis, 1989). The Innovation Diffusion Theory (IDT) was introduced by Rogers (1962) and is also used to explain how, over time, an idea or product gains momentum and diffuses (or spreads) through a specific population or social system.

The theoretical review has shown us that the adoption of virtuous finance and responsible environmental and societal principles has been influenced by several authors and theories. Carroll's Theory of Corporate Social Responsibility laid the foundations for responsible business and the principles that should guide economic activities so that they are mutually beneficial for the entire ecosystem. These principles have been reinforced by the Triple Bottom Line (TBL) Theory, which recalls the 3 fundamental axes of sustainable development (economic, social and environmental). Stakeholder theory reminds us that the adoption of new practices is guided by pressure from the various stakeholders involved in the economic activity concerned. For example, the fact that commercial banks are adopting new practices such as green finance is motivated by stakeholders such as investors, management, customers, the community, etc. Institutional and regulatory pressures have also played an important role in the adoption of environmentally friendly finance. Similarly, the Theory of Socially Responsible Investment has shown that investors are increasingly concerned about ESG criteria and have incorporated them into their financing decisions. Finally, the theory of innovation describes how a change in attitude may influence the adoption of new practices such as green banking practices.

2.2.2. Empirical literature

The empirical literature on green banking adoption and practices is quite recent and remains limited, with a concentration in the Asian region. Thus, in the context of commercial banks in Bangladesh, Ahmad et al., (2013) found that there are six factors determining the adoption of green banking, namely, economic factors, policy guidelines, loan demand, stakeholder pressure, environmental interest, and legal factors. Thus, banks are adopting green practices because it might create economic benefits. Studies showed that there is a positive correlation between

environmental performance and financial performance (Blacconiere and Patten, 1994 ; James, 1995). The motivation of environmental practices is also motivated by policy regulation which forces companies to adapt their activity according to the climate crisis. Indeed, the climate crisis has also created demand for green new products and markets such as renewable energy and other green technology and there is currently a huge demand for these products.

Additionally, in the context of Vietnamese banks, Tu and Dung (2017) identified five (5) variables as explanatory variables for green banking adoption namely (i) understanding the definitions of green banking; (ii) the current activities of green banking; (iii) the barriers to the adoption of green banking practices (iv) the advantages of developing green banking; and (v) the focused business sectors of green banking. All the factors positively correlate with green banking adoption, except the barriers, which negatively impact the adoption of green banking.

By using a partial least squares (PLS) approach, Shafique and Majeed (2020) found that policy guidelines, attitudes towards usage, central bank regulations, and management commitment and support influence bankers' intention to adopt green banking in Pakistan. Similarly, Aslam and Jawaid (2022) found that there is a relationship between green banking adoption practices and improving environmental, financial, and operational performance in Pakistan. The study found that GBAP largely affects environmental performance, followed by operational performance and financial performance, respectively.

In the context of Malaysia, Arumugam and Chirute (2018) found that environmental interest, stakeholder pressure, policy guidelines, economic factors, and loan demand are the main factors determining the adoption of green banking practices by Malaysian commercial banks. Also, the same results have been observed in the context of Nepal, where brand image, financial benefits, regulatory policies, environmental interest and stakeholder demand are the factors determining the adoption of green banking by Nepalese commercial banks (Mishra, 2023). In addition, an empirical study done by Tandukar et al., (2021) in Nepal showed that large numbers of bankers are less mindful of green financial practices in their banks. Nevertheless, empirical results from a probit regression uncover that education, preparing for green banking, fixed expense, client fascination, related parties' directions, and security of the climate have critical and constructive impacts on green financial practices in banks (Tandukar et al., 2021). The study recommends that

Nepalese commercial banks provide training to their employees and offer effective online services to their clients so that green banking practices can spread accordingly.

Looking from the customer's perspective, i.e. analysing the factors influencing commercial bank customers to adopt green banking products, Majeed and Rasheed (2024) found that facilitating conditions and performance expectancy are the most significant driving factors for green banking proliferation, followed by emotional and conditional values, social influence, and effort expectancy. Similarly, Bouteraa et al. (2022) have analysed and investigated the determinants of consumers' adoption of GB technology. They found that six (6) elements explain the adoption of green banking by consumers in the United Arab Emirates (UAE), namely, customer awareness, personal innovativeness, bank reputation, security and privacy, system quality, and government support. By looking at some of the green product viability in the context of commercial banks in Pakistan, the results of Afridi et al., (2021) revealed that green loans are less risky investments. Further, the findings also provide useful information to managers who are looking to grow their business loans and minimise default risk, which suggests that banks must invest more in green projects.

In the African context, few studies have been done to analyse the factors determining the adoption of green bank practices. Thus, from the bank employee’s perspective, Okyere-Kwakye and Nor (2021) found that there is a positive relationship between green and financial knowledge and personal green attitude. In other words, individuals with a firmer attitude toward sustainability in their daily life consumer decisions also have a stronger attitude toward green finance. However, a positive attitude is not enough to choose a green product. The research empirically supports that a subsidy policy and promoting financial and eco-literacy together would strengthen the demand for green financial products (Okyere-Kwakye and Nor, 2021). In addition, among the 3 factors selected as determinants of green, namely management support, customer pressure and competitor pressure, only the first factor is statistically significant at 5%. The remaining two factors are not significant in the context of commercial banks in Ghana. These funds show that green bank practices will be adopted within the bank when the management board is fully committed to environmental issues. As banks evolve in a competitive environment with the existence of several competitors, it is surprising that competitor and customer pressure are not affecting banks' attitudes toward the adoption of green banking.

Research is done by focusing on the annual reports from two (2) South African banks. Elsner and Neumann (2023) found that there is a substantial difference between the 2 banks regarding their practice toward green financing. For example, Nedbank, on the one hand, understands climate change as a key challenge for society and portrays a low-carbon transition as inevitable. Thus, the bank considers green transformation and the SDGs at the centre of its report and concludes that the risks emerging from climate change offer a business opportunity, but concrete actions on the ground remain limited, especially regarding its planned coal phaseout (Elsner and Neumann, 2023). In comparison, Standard Bank, considered South Africa's largest bank by assets, identifies climate change merely as one of seven impact areas for future business. They argue that a balance between these areas should be kept, especially between profit-driven business and climate change-related investments and climate change should be considered a burden rather than an opportunity for future profits (Elsner and Neumann, 2023).

Carroll's Theory of Corporate Social Responsibility laid the foundations for responsible business and the principles that should guide economic activities so that they are mutually beneficial for the entire ecosystem. These principles have been reinforced by the Triple Bottom Line (TBL) Theory, which recalls the 3 fundamental axes of sustainable development (economic, social and environmental). Stakeholder theory reminds us that the adoption of new practices is guided by pressure from the various stakeholders involved in the economic activity concerned. Thus, the fact that commercial banks are adopting new practices such as green finance is motivated by stakeholders such as customers, the community, investors, etc. In addition, institutional and regulatory pressures have also played an important role in the adoption of environmentally friendly finance. Institutional and regulatory pressures have also played an important role in the adoption of environmentally friendly finance. Similarly, the Theory of Socially Responsible Investment has shown that investors are increasingly concerned about ESG criteria and have incorporated them into their financing decisions.

2.3. Stylised facts on green banking: focus on the WAEMU region

The development of the theories cited in the literature review has led to an acceleration in green finance practices around the world. Today, several terms and concepts are associated with the adoption of more environmentally friendly banking. In this section, we review the various concepts associated with green banking, with a focus on WAEMU countries. This includes an analysis of

the banking system in the WAEMU region, the region's experiences with green finance, green taxonomy and the green bond market, and the international treaties governing green finance.

2.3.1. The Banking system in the WAEMU region

The West African Economic and Monetary Union (WAEMU) is a sub-regional institution created in 1994 that brings together eight coastal and Sahelian states in West Africa namely Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo. The main objective of the WAEMU is to build a harmonised and integrated economic area in West Africa, within which there is total freedom of movement for people, capital, goods, services and factors of production, as well as effective enjoyment of the right to practice and establish a business for the liberal professions, and the right of residence for citizens throughout the community. The WAEMU covers an area of 3,512,233 km^2 and has a population of 141.7 million[18]. The region's economic growth is estimated at 5.9% in 2022. The economy is mainly based on the primary sector, namely agriculture and extractive industries, and the major export products are gold, cocoa, petroleum products, cotton, rubber and cashew nuts.

The banking system in the WAEMU region is composed of 4 main actors: central banks (BCEAO), regulatory authorities (Banking Commission of UMOA), commercial banks & financial institutions with a banking nature and financial intermediary institutions (for example, the regional stock market-BRVM, etc). BCEAO represents the central banks for the eight countries of the Union (Benin, Burkina Faso, Cote d'Ivoire, Guinea Bissau, Mali, Niger, Senegal and Togo) where the headquarters is in Senegal and each country has a country office. Thus, BCEAO is the joint issuing bank of the eight Member States of the West African Monetary Union (WAMU) in which countries share the same currency FCFA (Franc de la Communauté Financière Africaine). For this purpose, BCEAO's role is: (i) to define and implement the monetary policy within WAMU, (ii) ensure the stability of the banking and financial system in WAMU, (iii) promote the smooth operation and ensure the supervision and security of payment systems in the region, (iv) implement the exchange rate policy of WAMU under the conditions laid down by the Council of Ministers, and (v) manage the official foreign exchange reserves of WAMU Member States.

[18] WAEMU website: https://www.uemoa.int/presentation. Last visit, 30.12.2024.

The Banking Commission (BC) supervises the financial sector. The mission of the banking commission is to (i) define and implement monetary policy within WAMU, (ii) ensure the stability of the banking and financial system in WAMU, (iii) promote the proper functioning and ensure the supervision and security of payment systems in WAMU, (iv) implement the exchange rate policy of WAMU under the conditions laid down by the Council of Ministers and (v) manage the official foreign exchange reserves of WAMU Member States. Since 2018, the WAEMU Banking Commission has been structured around two decision-making bodies: the supervisory board and the resolution board. Thus, several laws and regulations are guiding the financial sector. Among them, there is the uniform law on banking regulations and its implementing instructions, the law regulating decentralised financial systems, its implementing decree and instructions, the prudential framework applicable to WAMU credit institutions and financial companies, regulation on payment systems in the Union, etc. Concerning the financial institutions, the WAEMU region had 132 active banking institutions in December 2022. The following table represents the number of banking institutions by country and some performance indicators.

Table 9: List of active banking institutions in the WAEMU region in 2022

Country	Number of institutions			Total balance sheet (in bn FCFA)	Market share	Number of Bank accounts	Bank penetration rate
	Banks	Financial institutions	Total				
Benin	14	1	15	5 933	9.2%	2 414 034	35.7%
Burkina Faso	15	4	19	9 315.7	14.5%	3 135 260	21.8%
Cote d'Ivoire	28	2	30	21 581.2	33.6%	6 331 550	29.5%
Guinea Bissau	06	0	6	489.8	0.8%	210 601	16.4%
Mali	14	3	17	7 346.9	11.4%	2 297 126	24%
Niger	14	6	20	2 631.1	4.1%	1 003 225	8.7%
Senegal	27	4	31	12 271.5	19.1%	2 920 268	22.5%
Togo	14	3	17	4 737.4	7.4%	1 358 697	29.8%

Source: SGCB of UMOA, 2022 and BCEAO: https://rb.gy/lvlt6p. Last visit: 30.12.2024.

Lastly, the stock market, which represents the fourth actor, remains embryonic and dominated by the regional stock market (Bourse Régional des Valeurs Mobilières-BRVM). BRVM is the regional stock market common to all eight (8) WAEMU countries members. BRVM's main missions are to

(i) organise the stock market, (ii) list and trade securities and other stock products, (iii) disseminate stock market information and (iv) promote & develop the stock market within the region.

Ultimately, the banking market in the WAEMU zone remained solid despite the crises caused by the COVID-19 health crisis and the Russian & Ukrainian crisis, which increased the prices of products. As a result, banking activity continued to grow compared with previous years. The macroeconomic outlook is also good for the union, where the economic growth rate should continue to rise thanks to the start of hydrocarbon exports in Senegal and Niger. However, efforts need to be made in the financial inclusion sector, as up to ¾ of the region's population still does not have access to banking services.

2.3.2. Green finance experiences in WAEMU countries

Sustainable banking is a new concept in the WAEMU region and remains under the leadership of the international climate finance initiative. Indeed, with the creation of the Green Climate Fund (GCF) and the Adaptation Fund (AF), some commercial banks got accreditation from the GCF and the Adaptation Fund to finance the private sector, states, and civil society organisations (CSO) with climate finance. Among them, there are some entities at the national level such as ‘‘La Banque Agricole du Sénégal (LBA)’’, Banque Agricole du Niger (BAGRI), “La Banque Nationale de Développement Agricole (BNDA-Mali) as well as public entities such as the “Centre de Suivi Ecologique (CSE-Senegal)”, the ‘‘Fonds National pour l’Environnement (FNEC-Benin)’’, the ‘‘Fonds Interprofessionnel pour la Recherche et le Conseil Agricole (FIRCA-Cote d’Ivoire)’’. The particularity of these national entities is that they are allowed to mobilise climate resources for micro and small projects whose costs per project are limited to up to USD 10 million for micro-projects and between USD 10 to USD 50 million for small projects. These projects were focused on adaptation and resilience projects (climate-smart agriculture), as well as mitigation initiatives (renewable energy projects). In addition, some commercial banks have received support from bilateral development agencies to implement sustainable lending initiatives, such as the SUNREF initiative, which targets commercial banks established in the WAEMU region.

At the regional level, the West African Development Bank (BOAD), as a regional bank for WAEMU countries, has been accredited by GCF since 2017. BOAD is thus authorised to mobilise climate finance resources of up to USD 250 million per project within the GCF. This accreditation

enables BOAD to mobilise grants, loans, guarantees and refinancing lines at interest rates of between 0 and 1.75% to combat the harmful effects of climate change for the benefit of WAEMU member states. At the African level, the African Development Bank (AfDB), which is the continental development bank, and the Islamic Development Bank (IsDB), which intervenes in many countries, including WAEMU countries, have been accredited to provide financial resources for climate-related projects. In addition, due to their traditional role as development banks, AfDB and IsDB provide resources for climate-related projects and initiatives in the WAEMU region. Besides these entities, it also recognised that some bilateral developing agencies have received accreditation from international funds. Thus, the French Development Agency (AFD), the Luxembourg Development Cooperation Agency (LuxDev), the German Cooperation Agency (GIZ), ENABEL and the Japan International Cooperation Agency (JICA) are apt to mobilise resources for developing countries, including WAEMU countries.

Lastly, some international institutions also support developing countries in their access to climate finance. Among these organisations include the Consortium of International Agricultural Research Centres (CGIAR), the Food and Agriculture Organization of the United Nations (FAO), the World Bank, the International Fund for Agricultural Development (IFAD), the International Union for Conservation of Nature (IUCN), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), the World Wildlife Fund (WWF) and the World Food Programme (WFP). Thus, with their status as implanting entities with direct access to international finance mechanisms, can finance and implement projects around the world, including in the WAEMU region.

Besides these international mechanisms, WAEMU countries have started mobilising climate finance on their own. Indeed, Benin was the first African country to mobilise green bonds for sustainable development goals. This operation raised €500 million (328 billion FCFA), with a repayment date of 2035 at a coupon of 4.95%, reflecting investors' confidence in Benin's credit rating. At the same time, the West African Development Bank (BOAD) has launched the continent's first sustainable development bond. The operation raised €750 million over a twelve-year maturity at a very attractive rate of 2.75%, well below the market price. The funds raised will be invested in projects with a high social and environmental impact, in line with the United Nations' Sustainable Development Goals (SDGs). Priority sectors include agriculture and food

security, renewable energy, basic infrastructure, health, education and social housing. Senegal is also preparing a green finance taxonomy, and the country signed a new initiative called the Just Energy Transition Partnership (JETP), which will allow the country to mobilise up to €2.5 billion for energy transition projects (Gaba, 2023). Likewise, the ECOWAS Bank for Investment and Development (EBID) is launching the first green and sustainable bond issue by Public Offering in the WAEMU zone for a total amount of CFA 70 billion with an interest rate of 6.5% per annum over 7 years. This transaction is the third tranche in a series of fund-raising operations totalling FCFA 240 billion initiated by the bank to finance investments to boost its member states' economies, which has already raised FCFA 170 billion. The operation is intended to finance projects with a high social and environmental impact in priority sectors such as agriculture, renewable energy, health and industry. Côte d'Ivoire, Senegal and Benin intend to finance their Nationally Determined Contributions (NDC) by using the green bonds mechanism.

2.3.3. Green taxonomy and green bonds market in the WAEMU region

Although all eight countries adopt no taxonomy, the WAMU Financial Markets Authority have announced the establishment of a new taxonomy applicable to green, social and sustainable bond issuance on the WAMU regional financial market. This taxonomy of green, social and sustainable projects has been drawn up based on the Nationally Determined Contributions (NDCs) of the eight (8) WAEMU countries and the eligible sectors of various national and international climate funds. The taxonomy focuses on 3 main categories, namely green, social and blue.

Table 10: Categories of green taxonomy

Green category	**Social category**	**Blue category**
Renewable energy and energy efficiency	Affordable basic infrastructure	Ocean pollution and chemical and plastic waste
Clean transport of people and goods	Essential services	Sustainable tourism
Sustainable water management	Affordable housing	Protecting against coastal erosion
Ecologically sustainable management of natural and living resources and land use (sustainable agriculture)	Equitable participation and integration into the market and society	Fisheries, aquaculture and the seafood value chain
Conservation and restoration of terrestrial biodiversity	Reduction in income inequalities	Restoring the marine ecosystem and biodiversity

Pollution prevention and control	Food security	
Low-energy green real estate	Job creation	
Circular economy and waste management.		

Source: the WAMU Financial Markets Authority

This taxonomy aims to identify potential areas for sustainable investment and strengthen sustainable financial flows, increase the attractiveness of the regional financial market for responsible investors and help economic policies in the WAMU zone to develop the market for green, social and sustainable bonds and the creation of new jobs in this sector. It constitutes a framework for financial actors and intermediaries including commercial banks, investment companies, asset management institutions, brokerage firms and insurance companies, and for the region's government and investors. It has 5 principles: (i) fighting against the effects of climate change on the environment, (ii) considering the main economic sectors for the development of the region, (iii) considering national policies and priorities of state members, (iv) contribute to the economic development and the resilience of population and (v) be aligned with standards and international practices.

As regards the green bond market, the Regional Council for Public Savings and Financial Markets (Conseil Regional de l'Epargne Publique et des Marches Financiers - CREPMF) issued a circular (guide) in 2020 on the implementation of a guide for green, social and sustainable bond issues on the WAMU regional financial market. The guide is mainly based on the principles laid down by the International Capital Markets Association (ICMA), which is one of the benchmarks for green finance at the international level, while taking account of the specific characteristics of the sub-region. The guide is aimed at bond issuers wishing to benefit from a green, social or sustainable label (GSS label) for their bonds. The guide is based on ICMA's 4 principles for green bonds[19]:

- **Use of Proceeds**

The cornerstone of a Green Bond is the utilisation of the proceeds of the bond for eligible Green Projects, which should be appropriately described in the legal documentation of the security. All designated eligible Green Projects should provide clear environmental benefits, which will be assessed and, where feasible, quantified by the issuer. The eligible Green Projects categories, listed

[19] ICMA's Green Bonds Principles. https://shorturl.at/hOyCt. Last visit, 30.12.2024.

in no specific order, include but are not limited to renewable energy; energy efficiency; pollution prevention and control; environmentally sustainable management of living natural resources and land use; terrestrial and aquatic biodiversity; clean transportation; sustainable water and wastewater management; climate change adaptation; circular economy adapted products, production technologies and processes, certified eco-efficient products, green buildings.

- **Process for Project Evaluation and Selection**

The issuer of a Green Bond should clearly communicate to investors: (i) the environmental sustainability objectives of the eligible Green Projects; (ii) the process by which the issuer determines how the projects fit within the eligible Green Projects categories (examples are identified above); and (iii) complementary information on processes by which the issuer identifies and manages perceived social and environmental risks associated with the relevant project(s).

- **Management of Proceeds**

The net proceeds of the Green Bond, or an amount equal to these net proceeds, should be credited to a sub-account, moved to a sub-portfolio or otherwise appropriately tracked by the issuer, and attested to by the issuer in a formal internal process linked to the issuer's lending and investment operations for eligible Green Projects.

- **Reporting**

Issuers should make, and keep, readily available up-to-date information on the use of proceeds to be renewed annually until full allocation and on a timely basis in case of material developments. The annual report should include a list of the projects to which Green Bond proceeds have been allocated, as well as a brief description of the projects, the amounts allocated, and their expected impact. Where confidentiality agreements, competitive considerations, or many underlying projects limit the amount of detail that can be made available, the GBP recommend that information is presented in generic terms or on an aggregated portfolio basis (e.g. percentage allocated to certain project categories).

The establishment of principles and guidelines favourable to the development of a green bond market led to the closing of the first issue of green and sustainable bonds in the WAEMU, oversubscribed at FCFA 70 billion by Public Offering over 7 years (2024-2031) with a coupon of

6.5% thanks to the consortium made up of IMPAXIS (Coris Bourse) and EDC Investment Corporation. With the interest shown by investors in this type of financing, green bonds should see significant growth within the WAEMU in the coming years.

2.3.4. Contraintes pour l'adoption des pratiques de finance verte :

Comme évoqué précédemment, l'adoption des pratiques de finance verte reste nouvelle en Afrique, particulièrement dans la zone UEMOA. Dans cette sous-section, nous passons en revue, les contraintes et barrières qui empêchent l'adoption des pratiques de finance verte.

2.3.4.1. Contraintes réglementaires

Les réglementaires en matière de finance verte dans la zone UEMOA reste encore sous-développés. En effet, dans plusieurs de ses pays, ils n'existent pas une définition juridique claire de ce qu'est un produit financier vert. Cette ambiguïté laisse les banques commerciales ainsi que les usagers du système financier dans une situation qui ne favorisent pas les pratiques de finance verte et qui laissent une interprétation multiple selon la compréhension de chaque acteur. En outre, pour l'instant, il n'existe pas une réglementation concrète qui obligent les banques commerciales installées dans la zone UEMOA à considérer un certain nombre de pratiques verts comme le fait de limiter le financement des secteurs des énergies fossiles ou des projets jugés dangereux pour l'environnement. Toutefois, la commission bancaire de l'Union Monétaire Ouest Africaine a adopté une taxonomie verte sur l'émission des obligations vertes, sociales et durables. Cette taxonomie est censée renforcer et développer davantage le secteur des financement verts dans la sous-région.

2.3.4.2. Information and technical constraints

Green financial products remain little known to the general public and many banks. During the data collection phase with commercial banks, many staff members stated that they had no knowledge of green finance practices. In addition, commercial banks often lack internal expertise in environmental, climate, or sustainability analysis. The integration of ESG (environmental, social, and governance) criteria into credit risk analysis is not yet systematic, due to a lack of tools and training. Furthermore, there is a shortage of reliable and comparable data on climate risks, greenhouse gas emissions, and the carbon footprint of projects, which complicates the identification, monitoring, and classification of green assets.

2.3.4.3. Economic and financial barriers

Green products are often perceived as riskier and less profitable in the short term than traditional financing due to the significant initial investment required. In addition, the lack of historical data on the performance of green projects makes it difficult to assess credit risk and limits banks' willingness to finance them. Given that many banks in the WAEMU zone operate in environments where the cost of capital is high (low ratings from credit rating agencies) and margins are low, banks are forced to favor short-term, quick-return investments at the expense of green projects, which often have a delayed return on investment, even if it is significant.

2.3.4.4. Cultural and organisational barriers

Many banks have an organisational culture dominated by short-term financial profitability and an aversion to change. The lack of high-level leadership or strategic will hinders the integration of climate considerations into banking business models. As a result, several commercial banks in the WAEMU zone do not have climate strategy or CSR specialists, which hinders the institutional anchoring of green banking practices. Furthermore, banks may perceive green finance as an externally imposed constraint (e.g., by lenders or regulators) rather than a strategic opportunity for sustainable growth.

2.3.4.5. Barriers related to the lack of market incentives

In many countries, there are no mechanisms to make green finance competitive: no effective carbon pricing, no green tax incentives, and no regulatory bonuses for green assets (e.g., capital relief for green loans). The absence of a clear price signal on environmental externalities means that green products often compete unfavorably with traditional products (fossil fuels, pollutants).

2.3.5. International treaty for promoting green financing

2.3.5.1. Principles for Responsible Banking of United Nations Environmental Program Finance Initiative (UNEP FI)

Created in 1992, the UNEP FI was the first institution to engage the finance sector on sustainability and incubated the Principles for Responsible Investment. Today, it is considered the world’s leading proponent of responsible investment. UNEP Finance Initiative brings together a large network of banks, insurers and investors that catalyses action across the financial system to deliver more sustainable global economies. In 2019, a group of 132 banks convened by UNEP FI

developed the first global sustainability framework for the banking sector. This framework comprises six (6) principles that aim to align signatory banks' finance strategy with fully committed to implementing the UN Sustainable Development Goals (SDG) and the Paris Agreement. Signatories commit to embedding the principles across all business areas, at the strategic, portfolio and transactional levels. The six principles are:

Principle 1 - Alignment: Financial signatory institutions will align their business strategy to be consistent with and contribute to individuals' needs and society's goals, as expressed in the Sustainable Development Goals, the Paris Climate Agreement and relevant national and regional frameworks.

Principle 2 - Impact and target setting: Financial signatory institutions will continuously increase their positive impacts while reducing the negative impacts on, and managing the risks to, people and the environment resulting from their activities, products and services. To this end, we will set and publish targets where we can have the most significant impacts.

Principle 3 - Clients and customers: Financial signatory institutions will work responsibly with their clients and customers to encourage sustainable practices and enable economic activities that create shared prosperity for current and future generations.

Principle 4 – Stakeholders: Financial signatory institutions will proactively and responsibly consult, engage and partner with relevant stakeholders to achieve society's goals.

Principle 5 - Governance and culture: Financial signatory institutions will implement their commitment to these Principles through effective governance and a culture of responsible banking.

Principle 6 - Transparency and accountability: Financial signatory institutions will periodically review their individual and collective implementation of these Principles and be transparent about and accountable for their positive and negative impacts and their contribution to society's goals.

To date, roughly 542 members (banks, insurance and investment institutions) have adopted the principles, including financial institutions in the WAEMU region. Together, these financial institutions' assets exceed USD 170 trillion. Under the UN Principles for Responsible Investment, several initiatives have been put in place such as the UN-convened Net-Zero Asset Owner Alliance launched in 2019 (which is a member-led initiative of institutional investors committed to

transitioning their investment portfolios to net zero Greenhouse gas emissions (GHG) by 2050 – consistent with a maximum temperature rise of 1.5°C); the Net-Zero Banking Alliance launched in 2021 (which is a group of leading global banks committed to aligning their lending, investment, and capital markets activities with net-zero greenhouse gas emissions by 2050), and the Net-Zero Insurance Alliance also initiated in 2021 to foster availability of insurance and finance for transition projects and technologies and net-zero activities both created in 2021.

2.3.5.2. Equator Principles (EP)

Known as one of the major initiatives for promoting responsible financing, the Equator Principles were created in 2003 to serve as a common baseline and risk management framework for financial institutions to identify, assess and manage environmental and social risks when financing Projects. Thus, the Equator Principles guide both borrowers and lenders on project assessment and how improvement measures can be incorporated into project and loan agreements.

The Equator Principles apply globally to all industry sectors and the following five financial products[20]:

a) ***Project finance advisory services*** where total project capital costs are USD 10 million or more.
b) ***Project finance*** with total project capital costs of USD 10 million or more.
c) ***Project-related corporate loans*** (including export finance in the form of buyer credit) where all three of the following criteria are met:
    - Most of the loan is related to a project over which the client has effective operational control (either direct or indirect).
    - The total aggregate loan amount and the EPFI's (Equator Principles Financial Institution) commitment (before syndication or sell-down) are each at least USD 50 million.
    - The loan tenure is at least two years.
d) ***Bridge loans*** with a tenor of less than two years that are intended to be refinanced by project finance or a project–related corporate loan that is anticipated to meet the relevant criteria described above.

[20] https://www.mizuhogroup.com/sustainability/business-activities/investment/equator/about. Last visit, 30.12.2024.

e) ***Project-related refinance, and project-related acquisition finance*** where all the following three criteria are met:
    - The underlying project was financed following the Equator Principles framework.
    - There has been no material change in the scale or scope of the project.
    - Project completion has not yet occurred at the time of the signing of the facility or loan agreement.

Additionally, the EP is founded on 10 principles:

- ***Principle 1 - Review & categorisation***: Projects are classified into 3 categories A, B and C, according to their potential social and environmental impact. Projects presenting serious negative risks are classified in Category A, those with limited adverse environmental and social risks and/or impacts are classified in Category B and those presenting minimal negative risks are in Category C.
- ***Principle 2 - E&S assessment***: The customers or project owners must carry out an environmental and social risk assessment process and propose measures to offset any negative impacts of its projects.
- ***Principle 3 - Applicable E&S standards***: Financial institutions that are signatories to the EP ensure that they comply with the necessary environmental and social laws, regulations and authorisations in the host country concerned. In addition, the assessment of the E&S requirements process should, in the first instance, address compliance with the relevant host country laws, regulations and permits that pertain to environmental and social issues.
- ***Principle 4 - E&S management system & EP action plan***: For Category A and B projects, financial institutions that are signatories to the EP will require the client to develop an environmental and social management system (ESMS) and an environmental and social management plan (ESMP).
- ***Principle 5 - Stakeholder engagement***: For category A and B projects, financial institutions (EPFI) that are signatories to the EP will ask the client to provide evidence of effective stakeholder participation as part of a process adapted to the local culture with affected communities, workers and, where relevant, other stakeholders.
- ***Principle 6 - Grievance mechanism***: For all Category A and, as appropriate, Category B Projects, the EPFI will require the client, as part of the ESMS, to establish effective

grievance mechanisms which are designed for use by affected communities and workers, as appropriate, to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance.

- ***Principle 7 - Independent review***: For all Category A and, as appropriate, Category B Projects, an independent environmental and social consultant, will carry out an independent review of the assessment process including the ESMPs, the ESMS, and the stakeholder engagement process documentation to assist the EPFI's due diligence and determination of Equator Principles compliance.
- ***Principle 8 – Covenants***: The customer undertakes to comply with the laws, regulations and permits in force, to provide periodic reports and to dismantle the installations (if planned). If the customer fails to comply with its undertakings, the financial institutions that are signatories to the EP reserve the right to exercise the remedies they deem appropriate.
- ***Principle 9 - Independent monitoring & reporting***: The independent environmental and social consultant or external experts will verify the data reported in the periodic reports.
- ***Principle 10 - Reporting & transparency***: The client is required to make publicly available and accessible a summary of the environmental and social impact assessment and GHG emission levels. Financial institutions that are signatories to the "Principles" will publish their reports at least once a year.

The EP has been revised four times and aligns with the International Financial Corporation (IFC) Performance Standards and World Bank Group Environmental, Health, and Safety Guidelines. The latest version (EP4) has been effective since 2020. The objective of this update is to both broaden its scope of applicability and to reflect the changing environmental and social (E&S) landscape and challenges that we have come to understand better. Thus, the EP4 have introduced specific requirements for human rights impact assessments and climate change assessments to collate and share biodiversity information. To date, roughly 130 financial institutions globally are signatories to the Equator Principles including banks operating the WAEMU region. There are three categories of EP signatories. Probationary and full signatories are active in providing in-scope financial products and are referred to as Equator Principles Financial Institutions (EPFIs). Affiliate Signatories are inactive financial institutions.

2.3.5.3. United Nations Global Compact

The United Nations Global Compact is a voluntary initiative launched in 2000 and is based on the CEO's commitment to implementing universal sustainability principles to achieve the UN Sustainable Development Goals. The initiative is composed of 10 principles adopted by businesses and firms in over 167 countries. To date, it is considered the world's largest corporate sustainability initiative with more than 48000 members. More than 160 businesses and firms have adopted the principles in the WAEMU countries. However, only a few commercial banks are part of this initiative in the WAEMU region. The ten Principles of the United Nations Global Compact are derived from the Universal Declaration of Human Rights, the International Labour Organization's Declaration on Fundamental Principles and Rights at Work, the Rio Declaration on Environment and Development, and the United Nations Convention Against Corruption.

a) Human Rights

- *Principle 1*: Businesses should support and respect the protection of internationally proclaimed human rights; and
- *Principle 2*: Make sure that they are not complicit in human rights abuses.

b) Labour

- *Principle 3*: Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining.
- *Principle 4*: the elimination of all forms of forced and compulsory labour.
- *Principle 5*: the effective abolition of child labour; and
- *Principle 6*: the elimination of discrimination in respect of employment and occupation.

c) Environment

- *Principle 7*: Businesses should support a precautionary approach to environmental challenges.
- *Principle 8*: Undertake initiatives to promote greater environmental responsibility; and
- *Principle 9*: Encourage the development and diffusion of environmentally friendly technologies.

d) Anti-Corruption

- ***Principle 10***: Businesses should work against corruption in all its forms, including extortion and bribery.

The implementation of these principles constitutes a real milestone toward sustainable development as it embarks on core values drawn from major international agreements for a better world. Companies, especially commercial banks in the WAEMU region must fully adopt such initiatives to decarbonise their activities but also enable a more profitable business which benefits all the stakeholders. The UN Global Compact is a founding member of the United Nations Sustainable Stock Exchanges (SSE) initiative along with the Principles for Responsible Investment (PRI), the United Nations Environment Programme Finance Initiative (UNEP-FI), and the United Nations Conference on Trade and Development (UNCTAD).

2.3.5.4. The Addis Ababa Action Agenda on Financing for Development (AAAA)

The Addis Ababa Action Agenda was adopted at the Third International Conference on Financing for Development and subsequently endorsed by the UN General Assembly in its resolution 69/313 of 27 July 2015. The Action Agenda establishes a strong foundation to support the implementation of the 2030 Agenda for Sustainable Development. It provides a new global framework for financing sustainable development by aligning all financing flows and policies with economic, social and environmental priorities[21]. The agreement is a follow-up to the 2002 Monterrey Consensus and the 2008 Doha Declaration on Financing for Development. Thus, it is based on seven areas of intervention:

- Domestic public resources
- Domestic and international private business and finance
- International development cooperation
- International trade as an engine for development
- Debt and debt sustainability
- Addressing systemic issues
- Science, technology, innovation, and capacity building

The second intervention area of the agreement (domestic and international private business and finance) mentions the important role the private sector, including private financial institutions, may play in ensuring sustainable development. Thus, the AAAA invites businesses to engage as partners in the development process, to invest in areas critical to sustainable development, and to

[21] https://www.un.org/esa/ffd/publications/aaaa-outcome.html. Last visit, 30.12.2024.

shift to more sustainable consumption and production patterns. In addition, the AAAA also acknowledges the important need to develop policies and, where appropriate, strengthen regulatory frameworks to better align private sector incentives with public goals, including incentivising the private sector to adopt sustainable practices and foster long-term quality investment. The Addis Agenda strengthens the follow-up process, including an annual ECOSOC Forum on Financing for Development and the creation of an Inter-agency Task Force on Financing for Development, which reports annually on progress and the means of implementing the 2030 Agenda for Sustainable Development[22].

2.4. Methodology

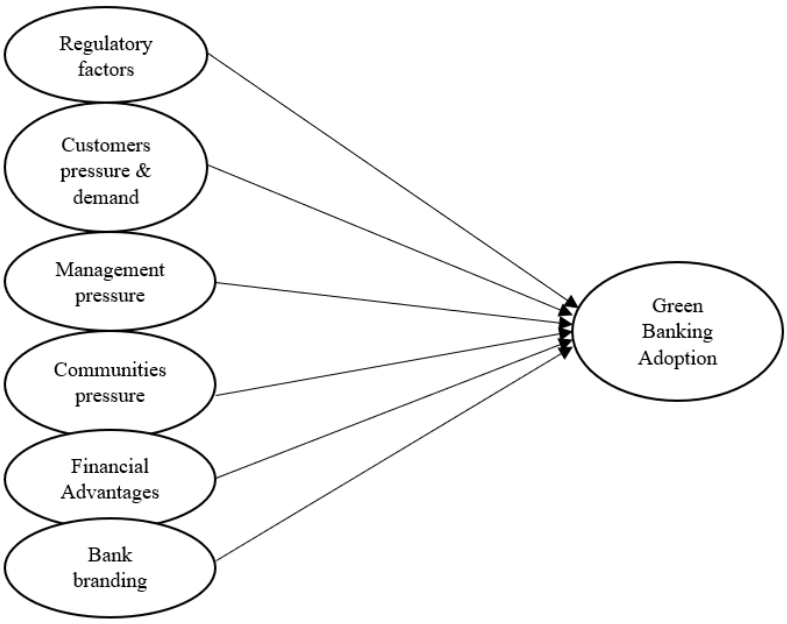
In this section, we will discuss the methodology used in this study. More specifically, we will discuss the conceptual framework, the choice of the econometric model studied and its specification, and the description of the variables, assumptions and data source.

2.4.1. Conceptual framework

As shown in the literature review, several variables explain the motivation behind adopting sustainability practices in the banking industry. Following Kurucz et al., (2008), there are numerous advantages for a bank to implement CSR practices, which can lead to cost and risk reductions, as well as positive effects on competitive advantage, company legitimacy, and reputation. Additionally, CSR plays a crucial role in creating win-win situations for both the company and society. Additionally, following Bukhari et al., (2019), coercive pressure (i.e. top management pressure and customer pressure), mimetic pressure (competitor pressure), and normative pressure (which is the pressure coming from the community) are among the factors determining the adoption of green banking practices. Ahmad et al., (2013) added new variables that may explain the adoption of green banking, namely economic factors (financial advantages, policy guidelines & legal factors and environmental interest. Based on this literature, we have drawn our conceptual framework, which is represented by the following figure:

[22] Addis Ababa Action Agenda. https://en.wikipedia.org/wiki/Addis_Ababa_Action_Agenda. Last visit, 30.12.2024.

Figure 11: Factors affecting green banking adoption



Note: Figure 9 displays the conceptual framework of green banking adoption by commercial banks. We notice that regulatory factors, customer pressure and demand, management pressure, community pressure, financial advantage and bank branding are the factors often used to explain green banking adoption. **Source:** Own illustration.

2.4.2. Empirical methods

Analysing factors behind the adoption of green banking practices is quite new in the literature, as few studies have empirically focused on the determinants of green banking adoption. To analyse the challenges affecting bank consumers' intention to adopt green banking technology in the framework of the United Arab Emirates, Bouteraa et al. (2023) have adopted a Unified Theory of Acceptance and Use of Technology (UTAUT) -based mixed-methods approach. This method consists of combining a preliminary qualitative approach with a quantitative model. For the quantitative model, Partial Least Squares-Structural Equation Modelling (PLS-SEM) was used. One of the objectives of the PLS-SEM is that the model can handle non-normal, categorical, and ordinal data. However, the PLS-SEM does not provide a global measure for model fit, and the PLS-SEM does not test the significance of the model parameters using standard errors and confidence intervals or account for measurement errors. Additionally, the PLS-SEM model does not seem to be suitable for small-sized data. Afridi et al., (2021) have applied a two-stage least squares regression model to analyse banks' engagement in green financing projects in Pakistan. Even though the two-stage least squares regression model has some advantages, it is not adaptable

to this study as it requires longitudinal data across different years. Tandukar et al., (2021) use a probit model to analyse the investigation bankers' overall arrangement and elements influencing their viewpoint on green banking performance. The probit model is one of the widely used models to analyse binary outcomes. However, the probit model is not easy to estimate (mathematically) for more than 4 to 5 choices (variables). Therefore, for this essay, a logistic model is used to analyse the determinants of green bank adoption by commercial banks operating within the WAEMU countries.

The logistic model is considered one of the suitable models to analyse binary outcomes and was initially developed by Cox (1958) and Walker & Duncan (1967). The model does not necessarily need a large sample size. It also allows the classification of observations of the dependent variable and offers better interpretability of coefficients compared to other binary models, such as the probit model. Let's set the mathematical framework of our model by referring to (Harrell, 2015).

In the case of this estimation, the dependent variable is explained by the variable Y, which is equal to 1 (Y=1) when commercial banks have adopted green banking practices and 0 (Y=0) otherwise. And let's consider X, the vectors of predictors: X= $\{X1, X2, \ldots . Xk\}$. k represents the number of independent variables in our model. Thus, the expected average of the binary logistic regression model for Y=1 given X can be expressed as follows:

$$\text{Prob}\{Y = 1|X\} = [1 + \exp(-\beta X)]^{-1} \qquad (1)$$

With βX the vector of predictor variables and stands for $\alpha + \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k$. α represent the constant term.

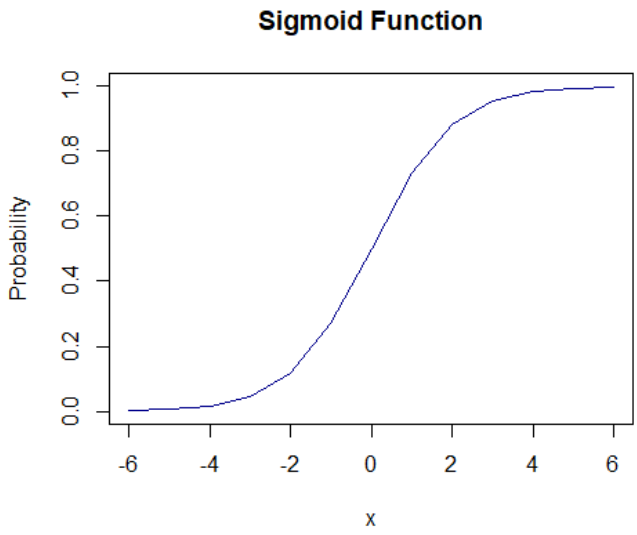
Following the primary works done by Cox (1958) and Walker & Duncan (1967), the regression parameters β = $\{\beta_0 , \beta_1 , \beta_2 \ldots \beta_k\}$ are estimated by the method of maximum likelihood, which allows us to draw the logistic function, also known as the sigmoid function

$$P = \frac{1}{[1+\exp(-x)]} \qquad (2)$$

The sigmoid function is best to describe the probability of a logistic regression as it ranges from 0 to 1 and takes a real value number. By giving values for x which range here from x = -6 to x = 6,

Figure 1 shows that the probability varies from 0 to 1 as attended. This remains valid even if the values for x change.

Figure 12: Graphical representation of sigmoid/logistic function



Source: Own illustration using R.

Let's solve the equation (2) by expressing x in terms of P.

$$1 - P = 1 - \frac{1}{[1+\exp\ (-x)]} \qquad (3)$$

$$1 - P = \ (1 + \exp\ (-x) - \ 1)\ /[1 + \exp\ (-x)]$$

$$1 - P = \ \exp\ (-x)\ /[1 + \exp\ (-x)]$$

$$1 - P = \ \exp\ (-x) * P \qquad (4)$$

By taking the logarithm of the two sides from equation (4), we have:

$$\log\ (1 - P) = \ -x + \log\ \ P$$

$$x = \ \log P - \ \log\ (1 - P)$$

$$x = \ \log\ (\frac{P}{1-P}) \qquad (5)$$

Thus, the odds that an event Y=1 happens is expressed by the logit (Y=1|X).

$$logit\ \{Y = 1|X\} = logit\ (P) = \log[P/(1 - P)] \qquad (6)$$

The probability of the opposite event $logit\{Y = 0|X\}$ can be found by taking $1 - logit\{Y = 1|X\}$.

$$logit\ \{Y = 1|X\} = \ [1 + \exp\ (-\beta X)]^{-1}$$

The general assumption made by the logistic model is that the logit function is linear in βX and then this can be expressed as the following:

$$logit\ \{Y = 1|X\} = logit\ (P) = log\left[\frac{P}{1-P}\right] = \beta X$$

The general equation with the vectors of the dependent variables can be written as:

$$logit\ \{Y = 1|X\} = \ \alpha + \ \beta_0 + \ \beta_1 X_1 + \beta_2 X_2 + \cdots + \ \beta_k X_k$$

$\frac{P}{1-P}$ is also known as the odds ratio, which is defined as the probability of success over the probability of failure, and it is obtained by taking the exponential of the $e^{\beta X}$.

2.4.2. Description of variables and hypothesis

The variables used in the framework of this research consist of binary outcomes.

2.4.2.1. Variables

- Adoption of green banking practices by commercial banks

The dependent variable for this research is the adoption of green banking practices by commercial banks established in the WAEMU region. It is measured by the binary outcomes with 1 if the banks have adopted the green banking practices and 0 otherwise. Green banking adoption practices in this study refer to a sustainable lending framework or policy established by commercial banks to mitigate climate change and safeguard the ecology. This means establishing internal policy or referring to international guidelines for financing projects that reduce external carbon emissions, use green technologies and weigh up the environmental risks of a project before making financing decisions. The banking industry itself has never been considered as a polluting industry, but in recent times, banks are financing projects that are leaving a massive carbon footprint due to their massive use of energy (Barua, 2020). Therefore, banks should adopt technology, processes, and products that result in a substantial reduction of their carbon footprint and promote a sustainable business(Bhardwaj & Malhotra, 2013).

- **Regulatory framework and policies**

With the climate crisis, national regulations and policies are key to achieving the Nationally Determined Contributions goals (NDC), the Land Degradation Neutrality (LDN) and the National Biodiversity Strategies and Action Plans (NBSAPs). These documents, as well as other national policies on the environment and sustainable development, have been elaborated by many of the countries that ratified the three Rio Conventions, including the WAEMU countries. Mobilising green finance is, therefore, the way to implement these policies and private actors, especially financial institutions, are highly recommended to provide support and means of implementation. Additionally, as part of the Network for Greening the Financial System (NGFS), the WAEMU's central bank (BCEAO) is committed to promoting green finance in the financial industry by (i) designing and integrating into the regulation framework and/or supervisory practices of climate and environmental risk analysis tools, (ii) adopting policy measures aiming at mobilising capital for green and low carbon, investments in the broader context of environmentally sustainable development. Therefore, green policies are likely a part of the codes of conduct in the corporate social responsibility of banks and a risk management tool to protect the financial market (Nguyen, 2023). Many others believe that regulatory frameworks and policies affect the adoption of green banking practices by commercial banks (Nguyen, 2023; Park & Kim, 2020; Dikau & Ryan-Collins, 2017).

Hypothesis 1: Regulatory frameworks and policies positively affect the adoption of green banking practices.

- **Customer pressure and demand**

Customers are part of the main stakeholders in the banking sector and the way they behave may have an impact on the banking sector. With the climate crisis, many customers are concerned about the environment, and they have adopted green products, such as investing in renewable energy (solar energy), purchasing energy efficiency technologies, etc. Therefore, customer pressure and demand for green products are seen as an important factor that motivates commercial banks to adopt green banking practices. Many scholars including (Nguyen, 2023 ; and Lin & Sheu, 2012) support that customer pressure and demand for green products affect the adoption of green banking.

Hypothesis 2: Customer pressure and demand positively affect the adoption of green banking practices.

- **Management Pressure**

Investors, shareholders and managers from the banking industry play a direct and coercive role in the financial system. Their behaviours matter as they can decide the internal strategies of the banks in which they are operating. Hopefully, they are becoming increasingly aware of the environmental impacts of their financing projects. This has led to the emergence of several green products in the banking sector, such as green bonds, sustainable lending, financing carbon-neutral projects, etc. Tara et al., (2015) argue that banking management is likely a direct factor that involves high influencing and the cooperative ability for green banking adoption. Additionally, Mishra, 2023 ; Arumugam & Chirute, 2018 ; Okyere-Kwakye & Nor, 2021 and Arumugam & Chirute, 2018 have shown that stakeholders, including management bodies, constitute a determining factor in adopting green banking practices.

Hypothesis 3: Management pressure positively affects the adoption of green banking practices

- **Community pressure**

In the spirit of reducing the negative impact of climate change, communities such as Non-Governmental Organisations (NGOs), Civil Society Organisations (CSOs), Associations and activists are becoming key actors that exercise influence in the business world. We all witnessed the famous lawsuit between a group of NGOs and Shell, which led to the Dutch courts forcing Shell to reduce its CO2 emissions and comply with the objectives of the Paris Agreement[23]. The same group of NGOs has also summoned the Netherlands' largest commercial bank (Dutch Bank ING), which also happens to be the main funder of US Liquefied Natural Gas (LNG), to appear in court. These actions are a reminder of just how important the activities of NGOs and CSOs are and can force companies to make environmental concerns a priority. Similar action has been taken against other commercial banks such as BNP Paribas. Thus, the banking industry is experiencing intense pressure from the community, who demand banks implement green banking practices in their core internal business operations (Bukhari et al., 2019) and many scholars argue that the

[23] The lawsuit is still ongoing, and Shell has defeated the previous ruling. The Guardian: https://www.theguardian.com/environment/2024/nov/12/shell-wins-appeal-against-court-ruling-ordering-cut-in-carbon-emissionsLast visit: 24.04.2025.

community positively affect green banking adoption (Bukhari et al., 2019; Hoejmose et al., 2014; Zhu et al., 2007).

Hypothesis 4: Community pressure positively affects the adoption of green banking practices.

- **Financial advantages**

Even if today's companies are trying to endorse environmental objectives, their primary objective remains the quest for profit, as pointed out by Friedman (1970). So, with the growing interest in climate ambitions and the need to act, new market opportunities are opening for companies, including commercial banks, which need to position themselves and benefit from this profitability. The market for green products such as renewable energy, recycling, energy efficiency, etc., is profitable. Kruse et al., (2020) have shown that green revenues from listed global companies, covering around 98% of the world's market capitalisation, earned large companies' revenues of $1.6 trillion in 2016. In addition, there are now several mechanisms, projects and support to enable financial institutions to adopt green finance practices. These include the Green Climate Fund and the Adaptation Fund, which give local commercial banks accreditation to finance climate projects using the funds they mobilise for them. These initiatives are an incentive for many financial institutions to adopt green financing practices and to comply with and align with national and international climate objectives.

Thus, several studies show that the adoption of green banking practices enhances the profitability of banks (Inegbedion, 2024 ; Hussain et al., 2019). Additionally, a significant number of researchers agree that GB confers numerous benefits on banks (Burhanudin et al., 2019; Ibe-enwo et al., 2019).

Hypothesis 5: Financial advantages positively affect the adoption of green banking practices.

- **Bank branding**

In this current business world, the concept of green banking has become extraordinarily popular as everyone is speaking about the concept of green banking. Thus, many financial institutions want to be considered ‘‘green banks” because the concept of green banks constitutes a positioning strategy to improve the brand image of the bank itself (Prasetyo, 2015). Companies such as banks use the green banking concept to strengthen their positive image and, therefore, be socially

acceptable. Because customers are now aware of the negative impact of financing dirty sectors and carrying a certain amount of value and accountability. Bahl (2012) argued that the concept of green banking is promotional material for environmentally friendly practices as the strategy of green banking itself can be used as a business model. Also, many authors have defined that there is a strong relationship between company image and its attractiveness, but it can also be the most important asset for the owner of the company (Sondoh-Jr et al., 2007; Arslan & Altuna, 2010; Kotler et al., 2017).

Hypothesis 6: Bank branding positively affects the adoption of green banking practices.

- **Pressure from competitors**

The banking sector in the WAEMU is a competitive market with the presence of several financial institutions from different geographical locations (locally, regionally and internationally). Competitors' pressure may influence the adoption of green banking practices. For example, (Lin & Sheu, 2012) found that the adoption of green certification by firms is significantly driven by competitors' pressure. Thus, firms get motivated to adopt new practices and products when their competitors also do so.

Hypothesis 7: Competitors' pressure positively affects the adoption of green banking practices

2.4.4. Data and sources

Primary data have been collected to analyse factors that affect green banking adoption. For that, a questionnaire has been developed and administered to bank employees, especially to corporate social responsibility officers or communication officers for the banks operating in each of the 8 countries of WAEMU. According to BCEAO in 2022, the WAEMU zone has 155 banks and financial institutions with a banking nature in activity. However, a list of 151 banks and financial institutions was considered, as the 4 other financial institutions are not part of the scope of this study. The questionnaire was sent to the banks by enumerators physically, but some officers had the preference to reply by using the online version of the questionnaire. The convenience sampling method has been used where the number of banks established in the WAEMU is obtained from the last update from the BCEAO website, as indicated above. The following table shows how the key variables (dependent and independent variables) have been measured.

Table 11: Measurement of variables

Variables	Measures
Green banking adoption	$\begin{cases} 1 & adoption \\ 0 & non-adoption \end{cases}$
Regulatory and policy framework	$\begin{cases} 1 & yes \\ 0 & No \end{cases}$
Clients pressure	$\begin{cases} 1 & yes \\ 0 & No \end{cases}$
Management board pressure	$\begin{cases} 1 & yes \\ 0 & No \end{cases}$
Communities pressure	$\begin{cases} 1 & yes \\ 0 & No \end{cases}$
Financial advantages	$\begin{cases} 1 & yes \\ 0 & No \end{cases}$
Bank Branding	$\begin{cases} 1 & yes \\ 0 & No \end{cases}$
Competitors pressure	$\begin{cases} 1 & yes \\ 0 & No \end{cases}$

Source: own illustration

2.5. Results and discussions

In this section, we analyse and interpret the results obtained from our econometric models. More specifically, we analyse descriptive statistics, preliminary tests, empirical results and sensitivity analysis.

2.5.1. Descriptive statistics

Table 12 summarises the number of bank respondents per country and the number of banks that adopt green banking practices. With over 151 banks in total, 139 have replied to the questionnaire, which represents a response rate of 92.05%. Côte d'Ivoire and Senegal, as the region's leading economies, hold most of the banks in the WEAMU region. Thus, of the 151 respondents' banks, 50 had adopted green banking practices, and the remaining (i.e. 89 banks) hadn't yet adopted green banking practices. The adoption of green banking practices remains dominated by the multinational banks, which are present in many countries across the African region. Additionally, Table 13 summarises the descriptive statistics of binary outcomes.

Table 12: Summary of banks and bank respondents by country

Countries	Number of banks by country (in 2022)	Number of banks that respond to the question	Rate of response
Benin	15	15	100.00%
Burkina Faso	20	18	90.00%
Cote d'Ivoire	30	30	100.00%
Guinea Bissau	6	4	66.67%
Mali	17	14	82.35%
Niger	14	13	92.86%
Senegal	32	30	93.75%
Togo	17	15	88.24%
Total	**151**	**139**	**92.05%**

Note: Table 12 shows that the various banks installed in the UEMOA zone are well represented, with an overall response rate of around 92% at the time of our data collection. Source: own illustration.

Table 13: Descriptive statistics for binary outcomes

Variables		Proportion
Adoption	0	64.03%
	1	35.97%
Regulatory and policy framework	0	46.04%
	1	53.96%
Customers pressure	0	76.98%
	1	23.02%
Competitors pressure	0	75.54%
	1	24.46%
Community pressure	0	74.80%
	1	25.20%
Financial advantage	0	59.00%
	1	41.00%
Image	0	44.60%
	1	55.40%
Management pressure	0	33.10%
	1	66.90%

Source: own illustration

2.5.2. Preliminary Test

Before computing the logistic regression, a preliminary test of multicollinearity was done. Indeed, the logistic regression assumes that there is little to no collinearity between independent variables.

Thus, the multicollinearity test, where the Variance Inflation Factor (VIF) for each variable is less than 5, which means that there are no significant issues related to the multicollinearity of variables. Therefore, the model's stability and the coefficient's robustness are not at stake (Table 14).

Table 14: Multicollinearity Test (Variance Inflation Factor)

	VIF	1/VIF
Regulation and policy framework	1.089	.918
customers pressure	1.081	.925
management pressure	1.21	.827
Competitors' pressure	1.16	.862
community pressure	1.13	.885
financial advantage	1.182	.846
Image	1.229	.813
Mean VIF	1.154	

Source: own illustration

2.5.3. Empirical findings and discussions

Table 15 summarises the results of the logistic regression model with the odds ratios. Unlike linear regression, where the coefficients are directly interpretable, the outputs from logistic regression may need further computation to be interpreted. Therefore, the margins effects are often used to interpret the outputs of logistic regression. For categorical variables (as the case here), the marginal effect of a predictor estimates how much the probability of a response level changes as the predictor changes. Table 16 shows that only management pressure is statistically significant at 1%.

Table 15: Logistic regression results (coefficients)

Adoption	Coef.	St. Err.	t-value	p-value	[95% Conf Interval]	
regulation & policy	-0.312	0.396	-0.79	0.43	-1.087	0.463
customers pressure	-0.685	0.498	-1.38	0.169	-1.661	0.291
competitors' pressure	0.459	0.465	0.99	0.324	-0.452	1.37
community pressure	0.314	0.456	0.69	0.491	-0.58	1.208
financial advantage	-0.25	0.411	-0.61	0.542	-1.056	0.555
Image	-0.022	0.412	-0.05	0.957	-0.83	0.785
management pressure	1.327***	0.483	2.75	0.006	0.38	2.274
Constant	-1.305	0.501	-2.61	0.009	-2.287	-0.323
Mean dependent var		0.36		SD dependent var		0.482
Pseudo r-squared		0.081		Number of obs.		139
Chi-square		14.767		Prob > chi2		0.039
Akaike crit. (AIC)		182.837		Bayesian crit. (BIC)		206.313

*** $p<.01$, ** $p<.05$, * $p<.1$

Source: own illustration

Table 16: Margins effects

Adoption	dy/dx	Std.Err.	z	P>z	[95%Conf.	Interval]
regulation & policy	-0.065	0.082	-0.790	0.428	-0.225	0.095
customers pressure	-0.136	0.092	-1.480	0.139	-0.317	0.044
competitors pressure	0.097	0.099	0.980	0.327	-0.097	0.292
community pressure	0.066	0.096	0.690	0.493	-0.122	0.254
financial advantage	-0.052	0.085	-0.610	0.541	-0.219	0.115
image	-0.005	0.085	-0.050	0.957	-0.172	0.163
Management pressure	0.265	0.083	3.180	0.001	0.102	0.428

**** p<.01, ** p<.05, * p<.1*

Source: own illustration

Thus, a commercial bank operating in an institutional environment exposed to pressure from top management (Xi=1) is 26.5 percentage points more likely to adopt green finance than a bank that is not exposed to such pressure (Xi=0). The perception of management pressure is more likely to impact green banking adoption by commercial banks established in the WAEMU zone. Management pressure is positively and significantly correlated with adopting green banking practices. This result aligns with the hypothesis set above. In addition, the result demonstrates a kind of rigidity of the financial industry in the WAEMU zone, where decisions from the management board are essential to put new policies and products on the market. Thus, green banking consciousness within the managing board of commercial banks will likely increase the adoption of green banking practices. In other words, change is internally driven rather than externally driven within the banking sector. This result aligns with the ones found in the literature by Mishra (2023), where stakeholders' demand (including bank commitment to go green) is statistically significant in adopting green banking practices in the case of Nepalese commercial banks. Similarly, Okyere-Kwakye & Nor (2021) found a positive relationship between management support and the intention of banks to adopt green banking in the case of commercial banks established in Ghana. Thus, for Okyere-Kwakye & Nor (2021), the banks would adopt green practices when management is committed and in support of its implementation, which means that the management is supportive that logistics, finances and other resources will be made available for the green banking implementation. Therefore, banks would not be able to adopt green banking practices if the management does not support the implementation of green initiatives within the banks (Okyere-Kwakye & Nor, 2021).

However, the remaining variables, such as regulatory and policy factors, customer pressure, competitors' pressure, community pressure, financial advantages and bank image, are not statistically significant at the threshold of 5%. This finding is not the one expected as defined above within the hypothesis. However, it brings an insight that regulatory and policy factors, customers, community, competitors, financial advantages, and bank images are not determinant factors impacting the adoption of green banking practices in the context of commercial banks established in the WAEMU zone. Similar results are also found by Okyere-Kwakye & Nor, (2021) where customer and competitor pressure is not statistically significant in the context of commercial banks in Ghana.

Table 17: Summary of the results and hypothesis

N°	Hypothesis	Decision
1	Regulatory frameworks and policies positively affect the adoption of green banking practices	Rejected
2	Customer pressure and demand positively affect the adoption of green banking practices	Rejected
3	Management pressure positively affects the adoption of green banking practices	Accepted
4	Community pressure positively affects the adoption of green banking practices	Rejected
5	Financial advantages positively affect the adoption of green banking practices	Rejected
6	Bank branding positively affects the adoption of green banking practices	Rejected
7	Competitors' pressure positively affects the adoption of green banking practices	Rejected

Source: own illustration

2.5.4. Robustness test and Goodness of fit tests

To ensure that the regression outcomes are robust, we have conducted robustness tests and goodness tests. For the robustness test, we used the probit regression model to analyse the adoption of green banking practices. The results in Table 18 show similar outcomes to our main regression model. Thus, pressure from bank management seems to be the most important element that affects the adoption of green banking practices. This confirms that the model remains stable and robust even when the estimation technique changes. In addition, the skewed logistic regression is often used when the effects of the regressors on the probability of success are not constrained to be the largest when the probability is 0.5 (StataCorp, 2019). Indeed, the scobit model introduces an extra parameter α (alpha), which allows asymmetry in the response curve.

$$\text{When} \quad \begin{cases} \alpha = 1, \ we\ get\ the\ regular\ logit\ model \\ \alpha < 1\ or\ \alpha > 1, the\ curve\ becomes\ skewed \end{cases}$$

Thus, in the skewed logit regression, the maximum marginal effect of an independent variable doesn't have to occur at a predicted probability of 0.5, it could happen at 0.3, 0.6, or elsewhere. This model is, therefore, used to test the robustness of a logistic regression model. The results are like the ones obtained with the main regression model. Pressure from the management board seems to be the only significant variable regarding the adoption of green banking practices in the WAEMU countries (Table 19). Additionally, we have conducted the Pearson or Hosmer-Lemeshow goodness-of-fit test, which aims to determine whether the probabilities deviate from the expected probabilities in a way that the logistic distribution does not predict in population subgroups. The null hypothesis is that the probabilities are well predicted, i.e. the probabilities do not deviate from the deserved probabilities. With a p-value = 0.8597 higher than the threshold level of 0.05, the null hypothesis cannot be rejected. Thus, the estimated model is a good fit and adequately specified (Table 20).

Table 18: Robustness test with probit model

Adoption	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]
regulation & policy	-.191	.239	-0.80	.425	-.659	.278
customers pressure	-.375	.288	-1.30	.193	-.939	.189
Competitors' pressure	.274	.279	0.98	.325	-.272	.821
community pressure	.188	.277	0.68	.498	-.356	.731
financial advantage	-.177	.25	-0.71	.479	-.666	.313
image	-.015	.249	-0.06	.951	-.504	.473
management pressure	.785	.277	2.83	.005	.241	1.329
constant	-.770	.292	-2.64	.008	-1.343	-.198
Mean dependent var		0.360	SD dependent var			0.482
Pseudo r-squared		0.081	Number of obs			139
Chi-square		14.641	Prob > chi2			0.041
Akaike crit. (AIC)		182.964	Bayesian crit. (BIC)			206.439

*** p<.01, ** p<.05, * p<.1

Table 19: Robustness test with a skewed logistic regression

Adoption	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]
regulation & policy	-.255	.309	-0.82	.409	-.86	.35
customers pressure	-.615	.413	-1.49	.137	-1.424	.195
Competitors' pressure	.363	.363	1.00	.317	-.348	1.074
community pressure	.262	.345	0.76	.448	-.415	.938
financial advantage	-.138	.318	-0.43	.665	-.761	.486
image	-.001	.322	-0.00	.998	-.633	.631
Management pressure	1.119	.419	2.67	.008	.297	1.941
Constant	-14.213	1473.768	-0.01	.992	-2902.746	2874.32
lnalpha	12.732	1473.767	0.01	.993	-2875.799	2901.263
Mean dependent var		0.360	SD dependent var			0.482
Number of obs		139.000	Akaike crit. (AIC)			.

*** p<.01, ** p<.05, * p<.1

Table 20: Table collapsed on quantiles of estimated probabilities

number of observations	139
Number of groups	10
Hosmer-Lemeshow chi2(8)	3.97
Prob > chi2	0.8597

Source: own illustration

2.5.5. Model validation

In addition to the goodness of fit test, the classification statistics are also computed to evaluate the accuracy of the fitness of the model regarding some indicators such as sensitivity, specificity, and positive and negative predictive value. The classification table presents information on the degree to which the observed outcomes are predicted by the model. The first information, which is the sensitivity statistics, refers to the percentage of cases observed falling in the target group (Y=1; e.g., commercial banks observed as adopting green banking practices), which were correctly predicted by the model to fall into that group (e.g., predicted adoption). In effect, it is an index of the sensitivity of the model to correctly identify cases that fall into the target group.

Table 21: Classification statistics

	------True------		
Classified	**D**	**~D**	**Total**
+	**13**	**11**	**24**
-	37	78	115
Total	50	89	139

Classified + if predicted Pr (D) >=.5
True D is defined as adoption! =0

Sensitivity	Pr (+| D)	**26.00%**
Specificity	Pr (-|~D)	**87.64%**
Positive predictive value	Pr (D| +)	**54.17%**
Negative predictive value	Pr (~D|-)	**67.83%**
False + rate for true ~ D	Pr (+|~D)	**12.36%**
False - rate for true D	Pr (-| D)	**74.00%**
False + rate for classified +	Pr (~D|+)	**45.83%**
False – rate for classified –	Pr (D| -)	**32.17%**
Correctly classified		**65.47%**

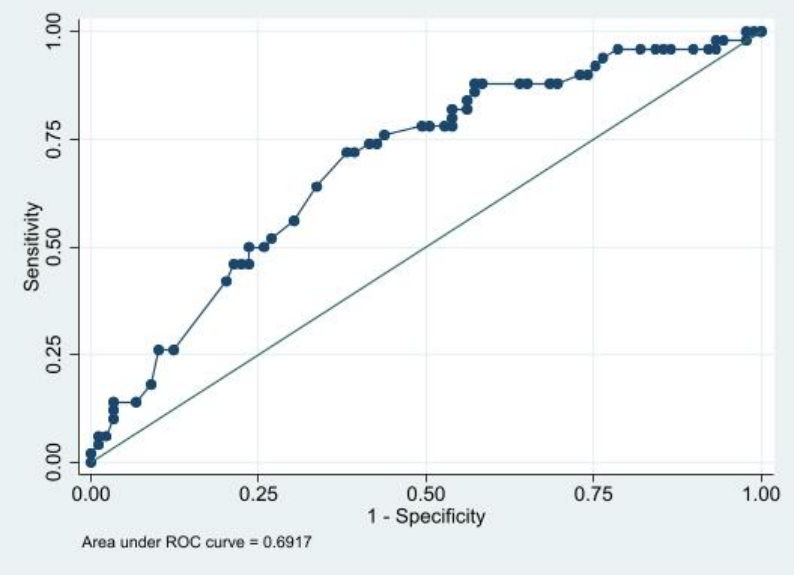
Source: own illustration

Thus, 26% of commercial banks are observed and predicted by the model to adopt green banking practices within the total number of banks that adopt green banking practices (see Table 21). Specificity refers to the percentage of cases observed to fall into the non-target (or reference)

category (e.g., commercial banks observed did not adopt green banking practices), which were correctly predicted by the model to fall into that group (e.g., predicted did not adopt green banking practices). In other words, it reflects the degree to which the model correctly identifies cases that do not fall into the target group. The specificity statistic is equal to 87.64%. Alternative statistics to evaluate the accuracy of the classification are given by the positive predictive value (54.17%) and the negative predictive value (67.83%).

Overall, the predictive accuracy rate was acceptable at 65.47%. The model also exhibits strong specificity since among commercial banks which did not adopt green banking practices, 87.64% were correctly predicted not to adopt green banking practices (see Table 21). It confirms that the model is well-specified, and this is also validated by the LROC, which shows a strong predictive power of 65.47% (see Figure 13).

Figure 13: LROC curve



Source: Own illustration

2.6. Partial Conclusion and Policy Recommendations

Corporate social responsibility has become an increasingly important topic in the business world since climate change and its many impacts have challenged the entire planet. The financial industry has been known as one of the major contributors to climate change, both directly and indirectly. The objective of this study is to investigate the intention behind the adoption of green banking practices by commercial banks established in the West African Economic and Monetary Union

(WAEMU zone). Based on the empirical research findings, the study concludes that pressure from the management body is likely to be one of the most important factors that influence bankers to adopt green banking practices. Given the recent nature of green finance practices in the WAEMU zone, this study is intended to stimulate debate and make an important contribution to the literature on the adoption of green banking within the WAEMU. From a theoretical perspective, the study confirms the validity of the institutional theory within the context of commercial banks in the WAEMU zone, where pressure from actors such as the management board may potentially impact the adoption of new practices.

Based on these findings, policy recommendations have been drawn to help policymakers in their decisions toward the establishment of a more responsible investment framework for the region. Indeed, as highlighted above, there is no regulatory framework for the adoption of green banking practices in the WAEMU region as it exists in other countries within the West African region such as in Nigeria with “the Nigerian Sustainable Banking Principles” and in Ghana with the “Sustainable Banking Principles and Sector Guidance Notes”. BCEAO is highly recommended to elaborate such as guidance that will regulate the financial industry and allow more commitment from bankers to green their business. This may help to identify all the investments that align with sustainability and contribute to the achievement of countries' commitment to the Paris Agreement and other international agreements. In addition, many observers believe that central banks will have to introduce green monetary policies that incorporate targets for reducing the impact of climate change on the economy. This decarbonisation of central banks' balance sheets should result in the gradual abandonment of polluting portfolios or assets, such as those held by oil and gas or industrial chemical companies, in favour of cleaner assets such as renewable energies.

Similarly, financial institutions within the region are also intended to adopt internal policies, green banking policies and international frameworks such as the Equator Principles. Commercial banks are also designed to enhance the capacity of their employees to adopt green practices in their entire process. Many employees from the banking sector have noticed that they do not know much about green banking, maybe management did not focus much on the aspect of green practices. Thus, joining international initiatives on greening the financial sectors and organising international capacity building will be greatly beneficial for employees in their understanding of sustainable finance concepts. In addition, as the financial sector is most driven by the top-down approach

(decisions and changes mainly come from top management) rather than the bottom-up approach (where community and customers have a great impact), it is highly recommended that regulatory authorities exert more pressure on top management so that important decisions can be taken and implemented by banks.

This study is not without limitations. One of the challenges was the data collection. The financial industry is known to be very inaccessible and closed. So, getting the responses from the bank's employees has been challenging, and certain information has been completed from the information posted on the website. Also, the fact that many employees did not know much about green banking and the early stage of green banking practices has made the data collection stage difficult. Thus, more openness from the banking sector will be valuable for future research on green finance. Also, concerning the availability of data, future research can investigate the relationship between green banking adoption and financial performance. This may also enhance the attractiveness of green financial products by financial institutions and lead to their adoption.

Essay 3: Impacts of environment-related tax on reducing CO2 emissions in West Africa

Abstract

Introducing an environmental tax to internalise the negative externalities and increase social welfare is one of the most popular instruments promoted by economists. This essay aims to analyse the effectiveness of environment-related taxes on carbon dioxide emissions in the context of West African countries. Using advanced econometric models consisting of a Prais-Winsten model and a two-stage least squares model, the empirical results show that the interest variable, i.e. the environmental-related tax revenue, does not significantly impact the carbon dioxide emissions in both regression techniques. Carbon dioxide emissions are impacted by other indicators such as energy intensity and GDP per capita. Additionally, we performed a diagnostic identification test. The results confirmed that the model doesn't suffer from underidentification, overidentification and weak identification issues. Thus, the actual environment-related tax levied on energy, transport, natural resources, and pollution doesn't have a sufficient impact on carbon dioxide emissions. It then becomes important to think about how future climate mitigation policies, such as carbon tax initiatives, will be designed. Indeed, the adoption of a carbon tax is becoming a popular topic in the climate action space, and many countries are working on how to consider it in their national environmental policies. Our results bring insights into the literature that may help in shaping climate change mitigation policies within the West African context.

3.1. Introduction

Among the various instruments to reduce greenhouse gas emissions (GHG), environmental tax is seen by many economists as one of the most preferred tools. Theoretically introduced in 1920 by Pigou, environmental taxes such as carbon taxes aim to establish market-based solutions for activities that create a negative externality, or an additional cost borne by individuals not directly involved in the transaction. Thus, the principal motivation for introducing carbon is aimed at increasing social welfare, as stated in the Pareto optimum. Indeed, in the case of environmental goods (such as clean air, biodiversity, natural resources, and landscape), the proprietary right is often not well defined, which may cause damage or externality within the chain. Thus, scholars consider that a carbon tax can serve as an instrument to bring optimal social welfare, which is Pareto efficient (Otaki, 2013).

Nowadays, while the adoption of an environmental tax is widely agreed upon among economists, debates exist on how this instrument must be set. First of all, the neoclassical approach conceived by Pigou (1932) and formalised by Baumol (1972) calculates carbon tax as a damage function for different rates of emissions of the pollutant and then seeks to equate the marginal net private benefit to the activity causing the pollution with the marginal external cost to which it gives rise (Ekins & Barker, 2001). The problem with doing so is that some impacts of climate change are non-marketable (such as human lives, human health, cultural heritage loss, migration, and displacement), and quantifying a damage function for these impacts is highly speculative and non-comprehensive (Bruce et al., 1996).

The second approach is the "environmental pricing and standard approach" initiated by Baumol Oates (1971). This approach aims to levy a uniform set of prices to achieve specific acceptability standards rather than attempting to base them on the unknown value of marginal net damages. This procedure differs from the initial Pigouvian formulation based on a unit tax or subsidy to control externalities. This approach has become the principal instrument in the definition of carbon taxes and will be considered in the framework of this research study.

In the past year, environmental taxes have been known for various developments depending on the context and countries where this instrument was used. The adoption of a market-based solution started with the adoption of the Montreal Protocol in 1987, which allowed for limited emission trading and led to the creation of tradeable permits and production quotas for chlorofluorocarbons (CFCs) and other ozone-depleting substances by the US, Europe, Canada, New Zealand, and Singapore. Although Finland was the first country in the world to introduce a carbon tax in 1990 (Haugland, 1993), it was necessary to wait for the creation in 1992 of the United Nations Framework Convention on Climate Change (UNFCCC) to see the expansion and adoption of a market-based framework aimed at cutting down GHG. Indeed, the UNFCCC adopted in 1997 the Kyoto Protocol, which is the first UN legally treated for developed countries to cut down their greenhouse gas emission. Thus, many developed countries have started implementing environmental measures to reduce their emission. The United Kingdom set different policies, such as the Climate Change Levy (CCL), which is an environmental tax that entered into force in 2001, and the world's first large-scale application of the emissions trading system (ETS) to greenhouse gases that began in 2002. The Chicago Climate Exchange (CCX) was established in 2003 as a

voluntary greenhouse gas emission reduction program that includes all fifty states of the United States, 8 provinces of Canada, and 16 countries that have joined the initiative (CCX, 2011). In 2005, the European Union ETS entered into force, and the country's members were committed to reducing their emissions by 8% compared to 1990 levels by 2012. Ten (10) years later, in 2015, a new treaty known as the Paris Agreement was adopted and aims to limit global warming to 2°C (if possible, at 1.5°C) by the end of the century. The Paris Agreement, unlike the Kyoto Protocol, calls for both developed (Annex 1) and developing countries (Non-Annex 1) to reduce their emissions and requires each Party to submit its Nationally Determined Contributions (NDC) to achieve the goal of the treaty.

To date, 194 of 197 Parties have officially ratified the treaty and are committed to reducing their emissions through their NDCs. However, the first-ever Global Stocktake (GST) conducted in 2023 has shown that the world is off track in meeting the goal of the Paris Agreement, and concrete actions need to be taken to limit global warming. In the African context, the Nairobi declaration, as part of the outcomes of the 2023 African Climate Summit, proposes a global tax regime to finance climate action at scale by crowding in and de-risking private capital, including but not limited to financial transactions tax (FTT) and emission levies. To date, only South Africa has set a proper carbon tax to cut down its emissions in 2016, and the literature debate among economists is still embryonic, although interest has been growing in recent years.

The main motivation behind the introduction of a carbon tax is to reduce greenhouse gas emissions. In recent years, emission levels have risen considerably, creating major climate risks. For example, according to the latest IPCC assessment report: “cumulative net CO2 emissions between 1850 and 2019 were 2400 ± 240 GtCO2, of which more than half (58%) took place between 1850 and 1989, and around 42% between 1990 and 2019 (IPCC, 2023b)”. In 2019, atmospheric concentrations of CO2 (410 parts per million) were the highest in at least 2 million years, and concentrations of methane (1,866 parts per billion) and nitrous oxide (332 parts per billion) were the highest in at least 800,000 years (IPCC, 2023b). These increases in the concentrations of the three main greenhouse gases have contributed to a global temperature rise of 1.1°C (on average), with varying degrees of variability in different regions compared with the period 1850-1900. This climate change is having a number of impacts on West African countries (IPCC, 2023b). The IPCC has predicted that by 2050, agricultural land will have shrunk by an average of 20%, with a 40.2%

reduction in cereal production. In addition, precipitation will decrease by 5%, leading to an increase in arid and semi-arid lands from 5% to 8.1% by 2050 (IPCC, 2018). In addition, extreme climatic events such as floods and heat waves, as well as land salinisation and coastal erosion, will be frequent under the climate change assumption, leading to significant economic losses.

However, implementing a carbon tax is not without its contradictions. From a theoretical point of view, there is debate about the need for state intervention to introduce such a tax. Indeed, while Pigou (1920) and his followers would like to see regulation by the authorities through the imposition of a tax, Coase, (1960) believes that markets alone are capable of achieving the optimum, provided that property rights are established and transaction costs are low. The effectiveness of taxes is also often called into question. Indeed, while the hypothesis of a double dividend is often evoked as a potential impact of carbon taxes (Terkla, 1984; Tullock, 1967), some empirical results have shown that this double dividend is not guaranteed, and that it strongly depends on how the revenues from such taxation are recycled (Freire-González & Puig-Ventosa, 2019). In addition, the introduction of a tax can also creates distortions for the most fragile companies exposed to foreign markets and could lead to the introduction of a carbon tax at the border to countries that have not implemented such a tax (the European carbon border adjustment mechanism), which could create trade tensions between states.

From an empirical point of view, debates exist on the potential effects of the introduction of a carbon tax. Thus, Fullerton & Metcalf (2001) criticised the adoption of tax policies and showed that equivalent welfare results of environmental protection can be achieved when the government adopt alternative policies such as (i) subsidies for non-polluting activities or (ii) mandated technology adoptions. Additionally, they found that small changes in any of these policies do not affect the real net wage or the labour market distortion. However, Devarajan et al., (2011) used a detailed computable general equilibrium (CGE) model of South Africa to explore the implications of using tax policy to mitigate CO_2 emissions in a second-best environment characterised in particular by labour market distortions. They found that tax policy adoption could reduce pollution by 15 per cent with a low welfare cost. Along the same line, Cissé et al. (2023), in the case of Senegal, evaluate the impact of the adoption of tax policies on greenhouse gas emissions and macroeconomic indicators by implementing carbon price scenarios ranging from 5 to 170 dollars per tonne of CO_2. They found that all scenarios contributing to reducing CO_2 emissions will have

a negative effect, but a negligible one on economic growth and other macroeconomic indicators, with concentrated effects in the sectors directly covered by the tax (energy and cement sectors). However, the scenario compatible with reducing emissions by 5% by 2030 as stipulated in the NDC is the scenario of USD 170 per tonne of CO2, which is unrealistic in Senegal and even in several industrialised countries, given that the direct price of carbon globally averaged USD 23/t CO_2[24] in 2023.

In essays 1 and 2, we looked at the factors explaining green financing from the international public and private sectors as well as the domestic private sector. In this third and final essay of our thesis, we analyse the effectiveness of environmental taxes on reducing greenhouse gas emissions in West Africa. Thus, through this essay as well as the two previous ones, we are interested in understanding all 3 dimensions of green financing (international sources, local domestic and public domestic), which allows us to address the issues associated with this concept in its entirety.

In this third essay, we use an advanced econometric model consisting of a Prais-Winsten regression and two-stage least square techniques to investigate the impact of environmental-related tax on greenhouse gas emissions in eleven West African countries namely Burkina Faso, Cabo Verde, Cote d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. The current climate scenario shows that West African countries will experience a high level of warming, where the temperature will increase at 0.6°C per decade and will reach 2.3°C by 2060, which is greater than the desired level in the Paris Agreement (ECOWAS, 2022a). Precipitation will be more erratic and will lead to an increase in the frequency and intensity of the extreme weather conditions already being experienced in the region: floods, increased variability of rainfall, coastal and soil erosion in river basins, extremely long pockets of drought among other corollaries, with dramatic human and economic consequences for all economic sectors and the most vulnerable sections of the population, particularly, women, young people and the elderly (ECOWAS, 2022a). Moreover, West Africa is home to some of the world's most vulnerable countries.

By analysing existing environmental-related tax policies, we analyse how West African countries can reduce their emissions and enhance their resilience against the effects of climate change. Our contribution to the literature is threefold: (i) this research will contribute to the understanding of

[24] Statista. https://www.statista.com/topics/6674/carbon-pricing-worldwide/#topicOverview. Last visit: 17.01.2025.

the adoption of future carbon tax policies in the West African context. Without claiming to be exhaustive, there is limited research on market-based instruments for cutting down emissions in West Africa, and Ghana is the only country that formally adopted a carbon tax in the region in February 2024. However, many countries are expecting to set carbon incentive measures in the near future regarding their international climate commitment to promote low emissions within the region. This study is of the utmost importance to help in understanding such policies. (ii) we offer recommendations that can help in shaping future carbon tax policies in the region.

The rest of the document is organised into 6 parts. After the introduction (section 1), section 2 covers the literature review by discussing the theoretical and empirical literature. In section 3, we analyse the current state of carbon adoption globally and the current initiatives. Section 4 discusses the methodological approach, while Section 5 presents and interprets the results. We finish with a conclusion and policy recommendations (section 6).

3.2. Literature reviews

Among the instruments for coping with climate change effects and negative externalities, taxation is seen by many economists as one of the most effective and is used by many countries around the world. In this section, we explore the founding theories of environmental taxes, which include the theory of externalities based on the polluter pays principle, the theory of property rights and the public good theory. We will then analyse the empirical studies that have been carried out on the subject, without forgetting to highlight the specific features that belong to the African continent.

3.2.1. Theoretical review

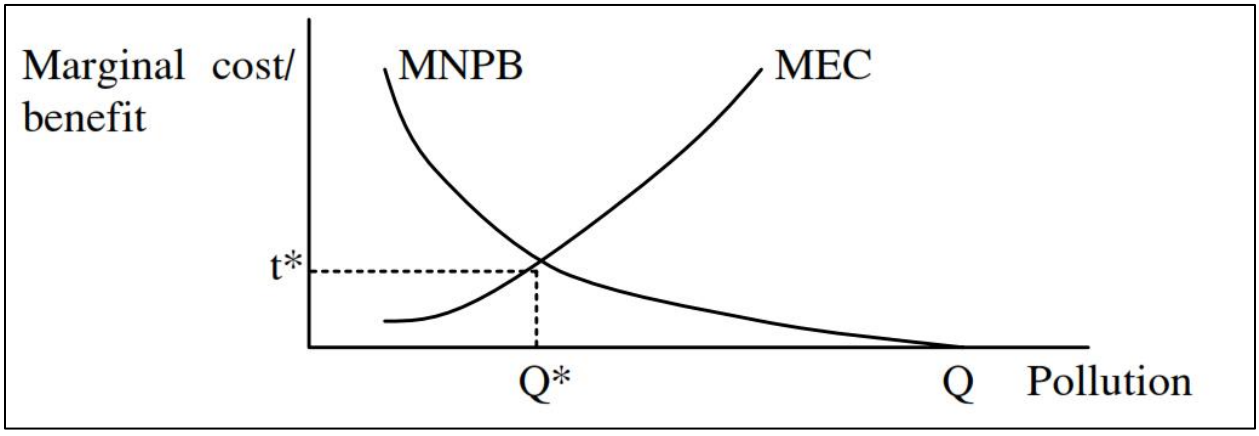
3.2.1.1. Theory of externality: Foundation of green and environmental tax theory

There are usually two arguments that motivate green tax adoption. Tax discourages activities or commodities that are environmentally damaging and encourages those that are ecologically beneficial by considering two principles (i) considering issues of equity, economic effect and administrative feasibility, and (ii) ensuring positive environmental impact. This term of environmental tax was first introduced by Pigou, (1920) and is known as the polluter pays principles. The principle aims to capture the cost of activities that have a negative environmental impact on society. From the polluter pays principles to now, multiple concepts have been

developed to describe environmental tax, such as the double dividend theory, also known as ecological tax reform.

Practically, there has been a debate on the best way to introduce a market-based instrument which internalises the environmental damages of economic activities. On the one hand, we have the optimisation approach formalised by (Baumol, 1972) that aims to equate the marginal net private benefit (MNPB) of the activity responsible for the pollution (P) with the marginal external cost (MEC) to which it gives rise (Ekins & Barker, 2001). As it is difficult to determine these two functions (MNPB and MEC) and maintain them stable even with prices and output changes, the optimal level of pollution measured by (Q*) and the optimal level of tax measures by (t*) seem to be unpredictable and speculative.

Figure 14: Carbon price determination by social cost



Source: Ekins & Barker (2001)

On the other hand, the standard and pricing approach aimed to address the implementation issue of the neoclassical approach or the optimisation approach earlier developed by (Baumol and Oates, 1971; Baumol, 1972). The standard and pricing approach consists of setting an environmental tax and standard based on the desired effect of the externality induced by economic activities. The price is set on an iterative basis and aims to bring down the pollution/damage at the standard level. The latter approach has inspired many countries and decision-makers around the world, and it is at the heart of the environmental tax mechanism, including the emissions trading scheme (ETS). However, the theory of external effect developed by Bohm, (1970) shows that the traditional approach of taxing or regulating polluting firms according to the level of their pollution may not be valid in the presence of an alternative of central purification, i.e. when there is a relevant

solution for the pollution. According to Bohm, (1970), when a firm finds a solution to reduce its emissions with an efficient cost (less than the marginal cost of the tax or has a net positive benefit), this solution will be preferable for the firm.

At the end of the ’60s, we witnessed the emergence of a new concept, namely “double dividend”, first used by Tullock (1967) and then by Terkla (1984). The concept of double dividend refers to the fact that the implementation of an environmental tax creates simultaneously an environmental benefit as well as an economic benefit. This concept emerged because of a long debate that has taken place about the efficacity of environmental tax vis-à-vis some alternative solutions such as the instauration of an emission trading scheme, the allocation of property rights, etc. Thus, Tullock (1967) and Terkla (1984) argue that the recycling of revenue coming from environmental tax could reduce or even cancel out the gross cost of implementing environmental taxes. Thus, this theoretical assumption was confirmed by the empirical studies (Lemiale & Zagamé, 1998). The double dividend can be obtained in different ways depending on the country and the application of this tax. For example, we have (i) an employment dividend when the recycling of the tax reduces unemployment through the reduction of social charges on labour; (ii) an efficiency dividend when the tax reform increases the efficiency of the tax system by reducing distortions caused other types of tax; (iii) a redistributive dividend (sometimes called a social dividend) when the redistribution process chosen improves equity. We talk about the no “regret strategy” which corresponds to measures which, even if the overall risk turns out to be unfounded, are in their interest and have zero economic cost and even negative (Chiroleu-Assouline, 2001).

However, the double dividend will not be realistic if the economy is not in an optimal situation and perfect competition. Debates have arisen among economists about the existence of this double dividend. Bovenberg & de Mooij, (1994) argued that even though carbon tax improves environmental outcomes, it exacerbates tax distortions. They have demonstrated that in preexisting distortionary taxes, the optimal pollution tax typically lies below the Pigouvian tax, which fully internalises the marginal social damage from pollution. To improve social welfare, Bovenberg & de Mooij, (1994) propose that the government, instead of cutting labour taxes, could use the revenues from pollution taxes to raise lump-sum transfer. This argument has also been discussed in the literature. For example, Goulder (1994) argued that returning tax revenues through cuts in

distortionary taxes leads to cost savings relative to the case where revenues are returned in a lump sum.

3.2.1.2. Property right theory

In his article entitled "The Problem of Social Cost", Coase (1960) criticises the analysis proposed by Pigou in his article "Economics of Welfare", in which Pigou demonstrates that there is a divergence of interests between the social product and the private product. Coase defined the private product as the value of the additional product resulting from an economic activity and the social product as the private product minus the reduction in the value of the production generated by another activity for which there is no compensation. For Coase, the value of the social product has no social significance. According to Pigou, to resolve this discrepancy, we need to make the person who causes the damage responsible by imposing a tax on the damage he creates or imposing a premium to encourage him to reduce this nuisance, which is proportional to the quantity produced. This proposal aims to include the cost of an externality (positive or negative) in the net social product. Furthermore, Pigou states that this situation can be improved, and that government intervention is precisely what is needed to improve "natural tendencies" because in every state, there are imperfections or market failures that hinder the efficient distribution of resources and the total well-being of individuals. In making this assumption, Pigou is taking a stand against the “laissez-faire” economists who advocate that the free functioning of the market naturally produces an optimal situation in which production value is maximised.

According to Coase, Pigou had failed to demonstrate anything satisfactory and had not grasped the true meaning of the problem. Coase believes that the total product generated by various social arrangements should be compared before deciding whether it is desirable to make the person causing the nuisance responsible. Systematically making this person responsible by imposing a tax that is not paid to the injured parties makes no sense, since the tax would increase according to the number of people affected by the same amount of damage, and this has nothing to do with paying compensation to these people through a pricing system, as Coase suggests. Moreover, this Pigouvian tax has no effect on the nuisance caused and will not reduce the negative effects such as pollution since the firm's aim would then be to reduce the tax rather than the damage, with the consequence that if the costs of reducing the damage are higher than the tax, the firm would agree to pay the tax rather than reorganise its production. The same applies to forcing a company to

relocate: the aim would be to achieve an optimal amount of damage to maximise the value of production rather than to avoid the damage itself.

As a result, Pigou's analysis, based on the divergence between private and social products, is biased because even if it seems to eliminate the damage, this is not the case since the corrective measures taken do not consider the new changes, which are sometimes more damaging than the nuisance itself. So, Coase says that we should tax the value in terms of the reduction of the total production caused by the nuisance rather than the damage caused by it. But this is impossible in practice. So, the pricing system devised by Coase comes into play here. It involves comparing the value of the total product under the various social arrangements that are possible; in other words, looking at the value of the total product when the nuisance exists and the value of the total product when the nuisance has been restricted to determine whether it is desirable to make the person causing the nuisance responsible and therefore to restrict it. According to Coase, we need to look at the situation from a macroeconomic point of view rather than a microeconomic one, because the cost of producing while emitting a nuisance, while it maximises the total value of production, is always a loss for the person who suffers the nuisance, but this loss for an individual contributes to maximising the total product. The heart of Coase's argument is, therefore, the property right because, for him, the differences in analysis between him and Pigou result from a conflict over the concept of the factor of production.

For Coase, a factor of production is not a physical entity that an economic agent owns to carry out his production but rather a right to carry out certain actions with this entity. In the example of land, what an economic agent owns is not arable land but land on which he has the right to carry out activities that are profitable for him. Once this notion of property rights has been established, a factor of production, even if it causes a nuisance to another person, by reciprocity, the duty to do something that may have a harmful effect is also a factor of production. This is the reciprocal nature introduced by Coase at the beginning of his article. The problem of the social cost as formulated in the title of the article is then at the centre of the arbitration, since whereas Pigou spoke of the social product, Coase formulates that it is a question of maximising the value of production, but that this has a social cost.

Ultimately, according to Coase, what is desirable are only those actions that enable us to gain more than what is lost through the nuisance caused. To achieve this trade-off, it is then necessary to

consider transaction costs (both on the market and administrative costs) and the costs incurred in moving from one situation to another, which can, of course, lead to a worsening of one individual's situation to the benefit of another. The Coase theorem argues that in the presence of transaction costs, the amount of pollution depends on the initial allocation of property rights.

3.2.1.3. Public good theory

The public good theory is considered one of the most environmental economics theories. Introduced by Samuelson (1954), public goods refer to goods that cannot be produced efficiently by the private sector because of the presence of market failure and require, therefore, the intervention of public actors. Greenhouse gas emissions (pollution) or clean air are considered part of public goods according to the definition of Samuelson, who considered public goods as goods that are characterised at least by one of the two attributes: non-excludable and jointness in consumption (non-rivalry). The non-excludable concept refers to goods that producers cannot prevent people from consuming the good. In the case of environmental pollution, economic agents are emitting greenhouse gases without paying for it, and clean air consumers cannot prevent polluters from emitting their greenhouse gases. Therefore, the non-excludability creates an economic problem known as the ‘‘free rider problem. Jointness in consumption refers to the fact that public goods are characterised by collective consumption and are also known as non-rival consumption goods. Thus, everyone has the same access to the environment, and some countries are contributing to destroying the global environment, while the burden is shared by everyone. In the same way, some others are making efforts to preserve the environment without being paid. To solve the problem of non-excludability and non-rivalry, the introduction of a market price became the solution recommended by many economists to exclude any potential consumers who are not ready to afford the minimum price of this good. Indeed, no one can prevent another from emitting greenhouse gas emissions into the atmosphere. Similarly, anybody can decide if the population benefit from clean air or not. In this case, having clean air or emitting greenhouse gases into the atmosphere has become a public affair and requires the intervention of the government to regulate the distortion. Nowadays, climate change as the result of global warming due to the continuous increase of greenhouse gas emissions is considered a global public good (Grasso, 2004; Hasson et al., 2010; Nordhaus, 2019).

The theoretical review has shown that all three theories that explain the necessity of introducing environmental taxes are characterised by market failure because of the special character of environmental goods. Therefore, setting a price and a market solution is a suitable way to deal with the issues, whether it is unpriced external costs, ambiguous property rights, or the public good nature of the environment.

3.2.2. Empirical review of carbon tax

The relationship between a carbon tax and environmental benefits has received attention from several authors, as witnessed by the rich theoretical foundation on the topic. Thus, economists and many international organisations consider environmental taxes as a useful tool to reduce greenhouse gas emissions and increase government revenues. Sovacool (2013) showed that implementing certain policies, such as prolonged taxes on energy fuels, electricity, and carbon dioxide, has largely contributed to reducing the dependency of Denmark on foreign sources of energy to zero. To date, Denmark is arguably one of the most energy-secure and sustainable countries in the Organization of Economic Cooperation and Development – OECD (Sovacool, 2013).

By using a learning curve concept, Zou et al., (2016) found that the introduction of carbon taxes (tax scenarios of 20 CNY/ton and 30 CNY/ton starting from 2010 to 2040) in China shifts energy production technologies away from high-carbon content fossil fuels towards low-carbon content fossil-based and renewable energies. In addition, the study shows that carbon taxes must be sufficient to influence energy generation systems and greenhouse gas emissions. In the same way, Cao et al., (2009) used a dynamic multisector model of the Chinese economy that includes an environmental module and implements green tax scenarios (taxes on output based on the damages per unit of output and taxes on fossil fuels based on damages per unit of fuel used) on electricity, non-metallic mineral products, metals smelting, transportation and other commodities. The results demonstrate that environmental tax policy contributes to reducing China's carbon emissions and reducing China's contribution to global greenhouse gas emissions.

Freire-González & Puig-Ventosa (2019) used a dynamic computable general equilibrium (CGE) model with an energy and an environmental sub-model to test the economic and environmental effects of reformulating electricity taxes in Spain. The findings show that the different tax policy

scenarios positively impact environmental outcomes, with a negative impact on economic outcomes at a very low cost and decreasing level over the year. Thus, taxing fossil fuel energy sources creates incentives for more adoption of renewables. In the same way, Freire-González & Ho (2018) introduce an environmental fiscal reform to evaluate the impact of the adoption of a carbon tax in Spain. They found outstanding results on the variables that were considered. All revenue recycling options provide both economic and environmental benefits, suggesting that the "double dividend" hypothesis can be achieved. Thus, three to four years after implementing environmental fiscal reform, the Gross Domestic Product (GDP) is higher than the base case, hydrocarbon consumption declines, and all analysed pollutants show a reduction. Similarly, Wissema & Dellink (2007) evaluate the impact of energy taxation on carbon dioxide emissions in Ireland. They find that the reduction target for energy-related CO2 emissions in Ireland of 25.8% compared to base year levels can be achieved with a carbon energy tax of 10–15 euros per tonne of CO2.

By using an energy sectorial model and a dynamic stochastic general equilibrium model in Chile, Benavides et al., (2015) show that with a carbon tax price of 20 dollars per tonne of CO2, the average annual emission reduction would be between 1.1 and 9.1 million tons of CO2 equivalent (tCO2e), and the price shock will decrease the annual GDP growth rate by a maximum amount of 0.13%. Wang et al., (2016) studied the distributional effect of a carbon tax, and they found that pure carbon tax without revenue recycling in developed economies tends to be regressive, i.e. lower income households are more affected, while the research does not support the perception that it reveals progressivity in developing countries. Additionally, sectors with higher energy intensity are more affected by a uniform carbon tax, while preferential measures to protect these industries face a trade-off between environmental effectiveness and economic growth. Finally, the study stressed that different designs for carbon tax mechanisms play a key role in affecting the distributional impacts and impacts in other policy arenas, indicating that trade-offs between efficiency and equity always exist when designing a carbon tax.

Similarly, Yusuf and Resosudarmo, (2015) assess the distributional effect of a carbon tax in developing countries by considering the case of Indonesia. Using a CGE model with disaggregated households, the results show that, in contrast to most studies from industrialised countries, introducing a carbon tax in Indonesia is not necessarily regressive. In addition, the expenditure of

lower-income households, especially in rural areas, is less sensitive to the prices of energy-related commodities. Revenue recycling through a uniform reduction in commodity tax rate may reduce the adverse aggregate output effect, whereas uniform lump-sum transfers may enhance progressivity. Ultimately, the results show that the adoption of pollution abatement policies may not only increase the efficiency of carbon abatement globally but also have desirable distributional implications in the developing countries themselves. This confirms that the double dividend of environmental tax is realised in developing countries.

Chhay & Limmeechokchai (2019) use the Low Emissions Analysis Platform (LEAP) to analyse mitigation policies including carbon tax measures in the electricity sector in Thailand. The results showed that the adoption of a carbon price starting from \$20/tCO_2 to \$500/tCO_2 by 2050 will significantly reduce greenhouse gas emissions in the power sector and have the highest CO2 emissions potential compared to the other scenarios such as carbon capture storage scenario and renewable energy scenario and business as usual scenario.

In the African context, a few empirical studies aim to evaluate the impact of the environmental and economic benefits of a carbon tax with a predominance of analysis done in South Africa. Thus, with a computable general equilibrium, Van Heerden et al., (2016) demonstrated that by establishing a carbon price of R120/tCO_2 on coal, gas and petroleum fuels, South Africa's greenhouse gas emissions (GHG) will be reduced by between 1 900MtCO_2 equivalent to 2 300MtCO_2 equivalent from 2016 to 2035. However, the carbon tax has a net negative impact on the GDP but is greatly reduced by how the tax revenue is recycled, such as recycling carbon tax revenues in the form of a production subsidy for all industries results in the lowest negative impact on GDP. Following a similar methodology, Alton et al. (2014) show that a carbon tax of 30 dollars per tonne of CO2 can achieve the national emissions reduction targets set for 2025 but with a negative consequence on employment and national welfare.

Devarajan et al., (2011) used a detailed computable general equilibrium (CGE) model of South Africa to explore the implications of using tax policy to mitigate CO2 emissions in a second-best environment characterised by labour market distortions. They found that the adoption of a tax policy could reduce pollution by 15 percent with a low welfare cost. Additionally, in a framework of the global computable general equilibrium model (GTAP-E-Power), Nong (2020) shows that establishing a carbon tax price at \$9.15 can reduce South Africa's GHG emissions by between

12.25%–15.6% at the cost of real GDP reduction by 1.17%–1.59% and with such policy, the country is likely to move to a low emission and sustainable economy and meet as well its international climate commitment.

In Senegal, Cissé et al. (2023) analyse the impact of carbon tax adoption in different indicators. They find that the optimal carbon tax ranges from 5 to 170 dollars and all scenarios will reduce the CO2 emissions in the country with a negligible effect on economic growth (an exception for the tax at 170 dollars, which may affect the GDP growth). Additionally, the gains in public revenues and savings from the carbon tax are greater when part of the revenue from the tax is used to reduce the initial level of VAT on gas and electricity. This can be assimilated to the double dividend that was discussed above and reduce existing fiscal distortions. By using descriptive and causal research design methods in the context of Nigeria, Omodero et al., (2022) found that environmental-related taxes such as the petroleum profit tax and gas profit tax have not yet assisted in enhancing the Nigerian environment for healthy living, and recommended that the government develop policies that would lead to the introduction of more meaningful environmental levies. Moreover, by using primary data collected in Ghana, Kombat, (2015) shows that taxes have failed to reduce the consumption of fuel products, urban congestion and air pollution for the attainment of the tax goal due to inelastic demand for fuel products, limited use of sustainable fuel products alternatives (e.g. biofuels) and transport options (such as bicycle and train systems), the surge in private car ownership (drive alone road users) and a general increase in demand for vehicular transport.

Besides the empirical results, debates have been arising about the empirical methodology to be adopted to analyse the potential impact of the carbon tax and the distribution of its revenues. According to Combet et al., (2012), there is a misconception inherited from partial equilibrium analyses, and thus no mechanical link between a carbon tax and its ultimate distributive effects, which is contrary when utilising a general equilibrium approach. Also, a tax policy led to contrasting impacts on different household classes. Fremstad and Paul, (2019) studied the relationship between carbon tax policy and inequality in the United States. They found that a carbon tax would cost poor households a higher percentage of their expenditures than the rich, making it a regressive tax. However, when using carbon tax revenue to reduce labour taxes, a carbon tax can be made progressive by rebating revenues to the public in equal, lump-sum

payments. Thus, using revenues to pay for carbon dividends increases the income of the American people in the poorest decile.

3.3. Climate policies and carbon tax initiatives

Since the conception of the first carbon taxes based on Pigouvian theory, we have seen the emergence of several forms of taxation made possible by the introduction of carbon markets. Companies and states can now buy property rights to pollute. In this section, we explore carbon tax initiatives and climate policies aimed at mitigating greenhouse gas emissions, with a particular focus on West African countries. We analyse the integration framework to which most of the West African countries studied in this essay belong, namely ECOWAS, and its policies and strategies: climate, renewable energy and energy efficiency policies. We then explore the lessons and opportunities presented by the adoption of a carbon tax on a global scale through case studies of the few countries that have adopted such a policy.

3.3.1. Climate policies in the West African region

3.3.1.1. General context

The West African countries' environmental policies are endorsed by the Economic Community of West African States (ECOWAS). ECOWAS is a regional political and economic union of fifteen countries located in West Africa which include: Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal and Togo and created in 1975. However, in January 2024, Burkina Faso, Mali and Niger announced their withdrawal from the Community and create the Confederation of the Alliance of Sahel States (AES). The vision of ECOWAS toward 2050 is a fully integrated community of people in a peaceful, prosperous region with strong institutions and respect for fundamental freedoms and working towards inclusive and sustainable development. The population is estimated at 403.6 million inhabitants in 2020, with an annual growth rate of 2.75%[25] spread over an area of 5.2 million square kilometres (ECOWAS, 2022b). The GDP per capita is estimated at $1276 in 2020, with a disparity between countries where GDP per capita is estimated at $505 in Sierra Leone and $3 398 in Cape Verde, which makes it one of the poorest regional blocs of the African continent[26].

[25] Demographic prospects of West African countries, UNO data, World Population Prospects 2019.
[26] World Development Indicator of the World Bank. 2024

The region is experiencing serious climate conditions disparities characterized by four starkly different broad climatic areas: the desert region in the north part with an average annual cumulative rainfall of less than 200 mm, the Sahel in the centre with annual rainfall between 200 and 600 mm, the Sudanian region towards the south with annual rainfall between 600 and 1,200 mm, and the Guinean region with over 1,200 mm of rain per year (ECOWAS, 2022a). West Africa has experienced climate change through drought, flood, land degradation, loss of croplands and ecosystem services, high water stress and scarcity. These impacts impact the living conditions of millions of people where agriculture is the main source for securing income and overcoming poverty. Additionally, ECOWAS' region is considered among the regions with the highest warming compared to the global level and the temperature increase around 0.3°C per decade from 1990 to 2020. Future trend scenarios SSP2 4.5 and SSP5 8.5 show an increase in the temperature level of 0.24°C and 0.6°C per decade, respectively.

Despite its contribution to greenhouse gas emissions being among the lowest, the region is experiencing an increase in its emissions making it one the fastest regions in terms of CO2 emissions in the African continent. These emissions are mainly coming from the energy sector, as well as Agriculture, Forestry and Other Land Use (AFOLU), which combined represent roughly 85% of the regional emissions. To reduce the impacts of climate change within the region and to achieve its international commitment, ECOWAS has put in place a couple of measures that can help strengthen the adaptative capacity of its member countries and mitigate the increasing rate of CO2 emissions.

3.3.1.2. ECOWAS Climate Regional Strategy

The ECOWAS climate regional strategy aims to build a community that is resilient to the effects and impacts of climate change and that has managed to seize the associated economic opportunities in favour of long-term, low-carbon, sustainable development by 2030. It was created in 2020 on the path of the ECOWAS environmental program and suck to reiterate the importance of collective and concerted action to support the effective implementation of the Nationally Determined Contributions (NDC), the Paris Agreement but also contribute to achieving the continental goals such as the African Union's Climate Change and Resilient Development Strategy and Action Plan for the period 2022-2032 and the 2063 agenda of the African Union.

3.3.1.3. ECOWAS Renewable Energy Policy

In the energy sector, ECOWAS is characterised by poor access to energy, with only 56% of the population having access to electricity in 2021 (Chitou & Ramde, 2023). This statistic hides a great disparity between countries, where in Burkina Faso, only 18.5% of the population has access to electricity, compared with 93.7% in Cape Verde[27] in 2020. A great disparity between rural and urban areas also characterises the region. On average, only 30% of the rural population had access to electricity compared to 77.9% in urban areas in 2020, despite the great renewable energy potential in the region. Meanwhile, the electricity supply is most reliant on fossil energy, with roughly 79.3% of electricity generated by oil, gas and coal in 2020, with a high consumer cost estimated at 13.6 c€/Kwh (ECOWAS, 2022b).

Domestic final energy consumption is dominated by traditional biomass energy (charcoal and firewood), which causes considerable health issues for the population, especially women. Energy security still faces challenges with increased demand, low supply capacities and limited capital investment.

To overcome the energy poverty issues, enhance energy security and better exploit the renewable energy potential of the region, the ECOWAS member states express the need for stronger regional cooperation and integration in the sector of renewable energy which led to the creation of the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) in 2010 and adopted during the 43rd Ordinary Session of the ECOWAS Authority of Heads of State and Government in 2013 the ECOWAS Renewable Energy Policy (EREP). The vision of the EREP is to secure an increasing and comprehensive share of the Member States' energy supplies and services from timely, reliable, sufficient, least cost and affordable uses of renewable energy sources enabling: (i) Universal access to electricity by 2030, and (ii) a more sustainable and safe provision of domestic energy services for cooking thus achieving the objectives of the White Paper for access to modern energy (ECREEE, 2015). Thus, one of the EREP targets is to achieve the following by 2030:

- 48% as renewable energy share compared to 32% in 2010
- 25% of the off-grid share of the rural population is served by renewable energy
- 100% of the population has access to improved cookstoves

[27] World Development Indicator of the World Bank. 2024

- 100% of the population has access to efficient charcoal production share
- 41% of the population has access to modern fuel alternatives for cooking services (e.g. LPG)
- 20% of the renewable energy equipment by value installed in 2020 is regionally manufactured.

3.3.1.4. ECOWAS Energy Efficiency Policy

The energy system of ECOWAS is facing serious challenges, among them climate change issues, deforestation, poor energy access, increased energy demand, loss in the energy value chains, etc. Indeed, the energy sector is the main emitter sector of greenhouse gas emissions and represents 69% of the regional emissions (ECOWAS, 2022a) mainly dominated by fossil fuel energy and biomass. The region is also characterised by a high loss in electricity grids, ranging from 15% to 40% compared to normal losses of 7%. To overcome all these challenges inherent to the sector, ECOWAS member states decided to elaborate a regional policy focusing on energy efficiency, namely the ECOWAS Energy Efficiency Policy (EEEP).

3.3.1.5. Synthesis on ECOWAS climate-related policies

Over the years, the Economic Community of West African States (ECOWAS) has developed a number of policy instruments to combat climate change and promote the energy transition. Among these instruments, three initiatives stand out: the Regional Climate Strategy, the Renewable Energy Policy and the Energy Efficiency Policy. Although they reflect a strong regional commitment to sustainable transformation, a critical analysis reveals notable strengths, but also structural and operational weaknesses that limit their scope.

The ECOWAS Regional Climate Strategy, adopted for the period 2022-2030, aims to strengthen the climate resilience of member countries while aligning their actions with the commitments of the Paris Agreement. It features a multi-sectoral approach articulating climate issues with those of agriculture, water, health and energy. It also provides technical support for the development and implementation of Nationally Determined Contributions (NDCs), as well as a regional climate financing framework. However, this strategy suffers from a lack of strong regulatory mechanisms, making its application dependent on the goodwill of member states. It remains poorly integrated into national economic policies, which sometimes continue to subsidise fossil fuels, in

contradiction with climate objectives. In addition, the lack of institutional capacity in several states and the risk of overlap with other African initiatives reduce the effectiveness of this strategy. In short, the strategy is politically ambitious but lacks a strong normative basis and rigorous monitoring.

The ECOWAS Renewable Energy Policy sets ambitious targets, including raising the share of renewable energy in electricity generation. It also aims to promote access to clean energy, notably through the development of solar mini-grids and off-grid systems in rural areas. One of the highlights of this policy is the establishment of the Centre for Renewable Energy and Energy Efficiency (ECREEE), which acts as a regional technical coordination body. However, its implementation remains highly uneven across member countries, with little transposition of objectives into national policies and a lack of regionally harmonised tax and customs incentives. In addition, dependence on external funding, particularly from multilateral donors, and regulatory obstacles to the integration of independent power producers into national grids hamper the achievement of its objectives. Although strategically coherent, this policy requires in-depth reform of national regulatory frameworks and better institutional coordination.

The Energy Efficiency Policy has enabled the development of common standards for lamps, refrigerators and other appliances, often in coordination with WAEMU institutions. However, the effectiveness of this policy remains limited by the absence of concrete incentives, such as targeted subsidies, green credit schemes or carbon market mechanisms. In addition, consumer and business awareness of the importance of energy efficiency remains very low, as does the quality of statistical data available to assess progress. As a result, despite a solid technical base, this policy is struggling to generate large-scale appropriation in the absence of effective economic levers. In sum, the three ECOWAS strategic initiatives illustrate a clear political will to steer the region towards low-carbon, climate-resilient development. Nevertheless, they share several structural limitations, including a lack of binding legal integration, weak ownership by national policies, underdeveloped economic instruments and often deficient monitoring and evaluation. To enhance their effectiveness, it is essential to consolidate regional governance in climate matters, strengthen economic incentives at the Community level, and better link regional technical instruments with the socio-economic realities of member countries. The energy transition in West Africa cannot be

achieved without strong political will, increased regional coordination, and coherent mobilisation of public, private or mixed financing.

3.3.2. Carbon Emission in ECOWAS

Carbon emissions in ECOWAS have been increasing over the past thirty years. Thus, emissions rose from 85,542 kt of CO2 in 1990 according to the World Development Indicators to 588,014 KteqCO2 in 2020 (ECOWAS, 2022a). The increase in the region's emissions can be explained by the increase in the consumption of energy and the increase in the population. According to the latest projection made in their NDC, ECOWAS country's emissions are likely to reach 775,956 KteqCO2 by 2025 and 1,023,435 KteqCO2 by 2030, representing an increase of 74% between 2020 and 2030. The main sources of emissions are the energy sector, with an average share of 63% of total GHG emissions, followed by the Agriculture, Forestry and Other Land Use (AFOLU) sector with an average percentage of 23%, and in third place by the waste sector with an average share of 9% of the region’s total GHG emissions (ECOWAS, 2022a). The fossil fuel sector plays an important role in the energy sector and deserves special attention so that emissions can be reduced.

3.3.3. Adoption of a carbon tax: Lessons learned and opportunities

3.3.3.1. Carbon pricing

To mitigate carbon emissions, experts and policy designers have proposed different forms of instruments that aim to define carbon pricing. Among these instruments, we note the emission trading scheme (ETS), carbon capture and storage, results-based climate finance (RBCF), reform of fossil fuel subsidies and course carbon tax. Regarding the dependence of most countries on fossil fuel energy, a carbon tax on non-renewable energy is seen by many as the optimal instrument to define carbon pricing. In the African context, the concept of a carbon tax is still embryonic despite the growing interest of countries in participating in international carbon markets. However, a few initiatives have been taken, such as the West African Alliance on Carbon Markets and Climate Finance (WAA) and the East African Alliance on Carbon Markets and Climate Finance (EAA). South Africa is the first African nation to adopt a domestic carbon price on greenhouse gas emissions. In West Africa, countries like Burkina Faso, Cote d’Ivoire, Senegal and Nigeria

expressed their interest in establishing a domestic carbon price. Additionally, 45 of 54 African countries mentioned carbon tax as an instrument in achieving the NDC.

Indeed, the establishment of a carbon tax is encouraged in Article 6 of the Paris Agreement, especially Article 6.2 and Article 6.4, which call on parties to engage voluntarily in cooperative approaches that involve the use of internationally transferred mitigation outcomes such as a carbon credit mechanism. Stiglitz and Stern (2019) estimated that the explicit carbon price level consistent with achieving the Paris temperature target is at least US$40–80/tCO2 by 2020 and US$50–100/tCO2 by 2030.

3.3.3.2. International experiences of carbon taxes

To date, many countries around the world have adopted markets based on instruments. In this section, we pass on a review of some countries that implemented carbon taxes and draw lessons learned.

a) Finland

In 1990, Finland was the first country to introduce a carbon tax as an instrument for climate change mitigation based on fossil fuel products despite the low emissions of the country, estimated at this time at 0.3% of global emissions. The tax was charged at €1.12 per tonne of carbon dioxide. Several reforms have been put in place over the past 30 years, and it has now evolved into a combined carbon and energy tax by carbon price instruments and emissions trading system (ETS) permit prices. Nowadays, Finland has joined the European Union ETS. The adoption of a carbon tax in Finland created a positive environmental benefit. According to an empirical study done by Mideksa (2021), Finnish emissions were 16% lower in 1995, 25% lower in 2000, and 30% lower in 2004 than emissions in the counterfactual consistent with carbon taxes whose value increased by 20 fold in 1990 - 2005.

Thus, the carbon tax in Finland has resulted in a distributional effect thanks to the combination of tax-shifting packages for making the carbon tax revenue-neutral such as the reducing tax on incomes. By doing this, the Finnish government seems to be using the carbon tax cuts for income transfer from the higher-income group to the lower-income group[28]. In 2021, the carbon tax rate

[28] Carbon tax in Finland. https://blogs.ubc.ca/rosonluo/2013/02/07/finlands-carbon-tax-system/. Last visit, 30.12.2024.

in Finland was estimated at $73.02 per tonne of carbon dioxide compared to $137 per tonne of CO2 in Sweden the highest rate in the world. Additionally, 76.8% of greenhouse gas (GHG) emissions in CO2e were covered by the carbon tax instrument in Finland[29].

b) European Union Emissions Trading Scheme (ETS)

To achieve this climate commitment under the Kyoto Protocol, the European Union established the first cap-and-trade system for carbon dioxide emissions in the world in 2005. The ETS is so far from the pillar of the European Union's environmental policy and aims to internalise the external costs of pollution through a signal price such as setting a carbon price or incentive for emission saved. Unlikely the carbon tax instrument where the price is fixed for a given period and the quantity of emissions adjusts, with the ETS it is the quantity of carbon emitted that is fixed, and the price of the emission permits that adjusts. However, the two instruments impose similar financial implications for emitters. The ETS is characterized by 3 different phases. The initial phase (2005-2007) was a trial period in which the EU learned valuable lessons about the allocation of allowances, and the design of the system and aimed to ensure the compliance of the system with the Kyoto Protocol in its implementation phase. Thus, during this phase I, the EU ETS covered only CO2 emissions from heavy emitters in the heat and power generation industry, as well as some large emitters from other industries such as producers of steel, glass, cement, lime, pulp and paper, among others, which accounted for about 50% of EU's total CO2-emission (Haraldsson & Logren, 2022). In addition, about 95% of the allowances were allocated to these actors free of charge.

The second phase (2008-2012) saw the expansion of the ETS with the integration of additional sectors (such as the aviation sector) and gases (such as nitrous oxide) with more stringent emissions caps and coincided with the first commitment period of the Kyoto Protocol. During this phase II, three new countries joined the initiative: Iceland, Norway and Liechtenstein and the number of allowances was reduced by 6.5%. The penalty for non-compliance was increased to €100 per tonne compared to €50 per tonne of CO2 of phase I.

[29] OECD: Pricing greenhouse gas emission: https://www.oecd.org/tax/tax-policy/carbon-pricing-finland.pdf. Last visit, 30.12.2024.

The third phase (2013-2020) showed significant changes compared to phases I and II. Among the changes, we note[30]: (i) a single, EU-wide cap on emissions in place of the previous system of national caps; (ii) auctioning as the default method for allocating allowances (instead of free allocation); (iii) harmonised allocation rules applying to the allowances still given away for free; more sectors and gases included. During this period, Croatia joined the initiative.

Phase four (2021-2030) is characterized by a decrease in the cap on emissions annually at an annual linear reduction factor of 2.2% compared to 1.74% in the previous phase. Additionally, 10 Member States with a GDP per capita below 60% of the EU average in 2013 may opt to continue allocating part of their auction volumes as free allowances to the energy sector up to 2030 under Article 10c of the ETS Directive[31]. The implementation of the ETS led to a positive environmental benefit and covered roughly 50% of the EU's total CO2 emissions. According to Bayer & Aklin (2020), the EU ETS saved about 1.2 billion tons of CO2 between 2008 and 2016 (3.8%) relative to a world without carbon markets, or almost half of what EU governments promised to reduce under their Kyoto Protocol commitments while Dechezleprêtre et al., (2023) found that 10% reduction between 2005-2012. Emission reductions in sectors covered under the EU ETS were higher.

c) South African Carbon tax

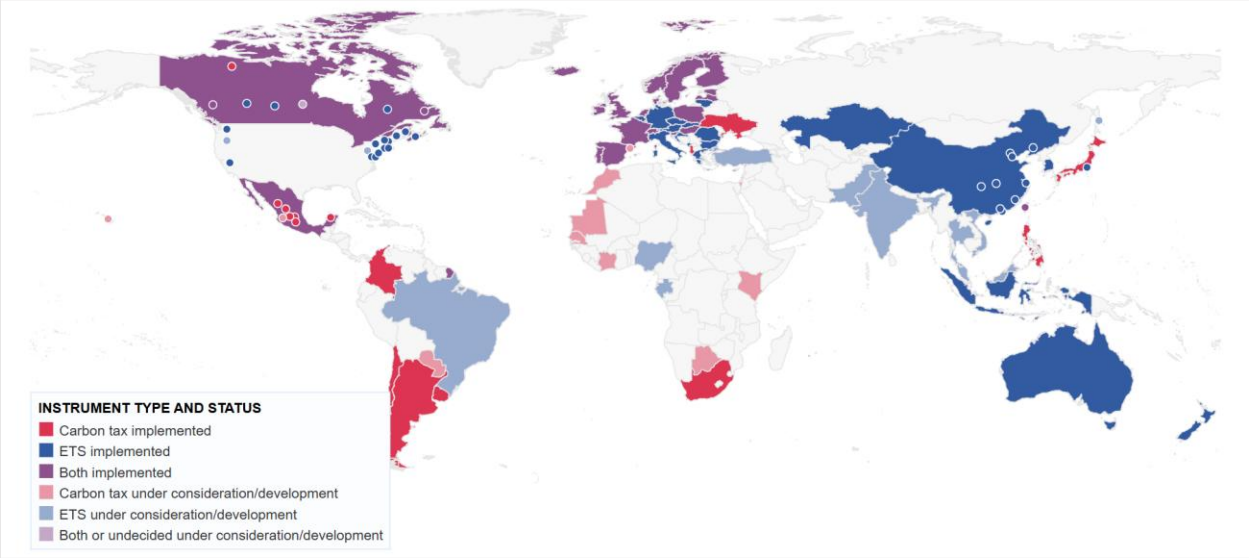
South Africa is the first and the largest emitter in Africa that adopted a national market-based solution to cut down its CO2 emissions, which entered into force in 2019. The South African tax follows the polluter-pays principle and is imposed on fuel inputs based on emission factors and procedures in line with the standards published by the Intergovernmental Panel on Climate Change (IPCC). The tax covers about 90 per cent of the country's total GHG emissions, with only agriculture, forestry, land use, and waste excluded (Qu et al., 2023). This currently has two phases: Phase 1 (2019-2022) and Phase II (2023-2030). The design of the carbon tax also provides significant tax-free emission allowances ranging from 60 per cent to 95 per cent in this first phase. This includes a basic tax-free allowance of 60 per cent for all activities, a 10 per cent process and fugitive emissions allowance, a maximum 10 per cent allowance for companies that use carbon offsets to reduce their tax liability, a performance allowance of up to 5 per cent for companies that reduce the emissions intensity of their activities, a 5 per cent carbon budget allowance for

[30] European Commission: Development of EU ETS (2005-2020). https://rb.gy/sd8wqc. Last visit, 02.02.2024.
[31] European Commission: https://rb.gy/f7rk2c. Last visit, 02.02.2024.

complying with the reporting requirements and a maximum 10 per cent allowance for trade-exposed sectors[32].

The introduction of the carbon tax will also not have any impact on the price of electricity for the first phase. This will result in a relatively modest carbon tax rate ranging from R6 to R48 per tonne of CO2 equivalent emitted, which is a relatively low tax rate to further provide current significant emitters time to transition their operations to cleaner technologies through investments in energy efficiency, renewables and other low carbon measures.

Figure 15: Compliance mechanisms in 2024.



Source: WB Carbon pricing dashboard. https://carbonpricingdashboard.worldbank.org/compliance/instrument-detail. Last visit: 18/01/2025.

The different tax policies show that market-based instruments had a positive impact on environmental outcomes with a lower impact on socio-economic variables. Depending on the characteristics of each country, a carbon tax can be designed to reflect the country's specificity regarding the most pollutant sector and the country's climate engagement. Based on the experiences learned from the countries that already adopted carbon price mechanisms, new countries could build their environmental tax policy through such policies. Figure 13 shows the carbon pricing initiatives based on geographical representation. At the global level, we note 73 carbon pricing initiatives under 39 national jurisdictions and 33 subnational jurisdictions. In 2023,

[32] South Africa National Treasury. https://rb.gy/q11kzz. Last visit, 30.12.2024.

this covered 11.66 GtCO2e, representing 23% of global GHG emissions. At the African level, countries like Botswana, Cote d'Ivoire, Gabon, Morrocco, Nigeria and Senegal are planning to adopt a carbon compliance mechanism.

d) Carbon Crediting Mechanism

Besides carbon tax and emissions trading scheme (ETS) instruments, other mechanisms that aim to reduce greenhouse emissions exist. Among these, we note a carbon crediting mechanism in which companies can own permits that allow the owner to emit a certain amount of carbon dioxide or other greenhouse gases. Companies that pollute are awarded credits that allow them to continue to pollute up to a certain limit, which is reduced periodically. Meanwhile, the company may sell any unneeded credits to another company that needs them.

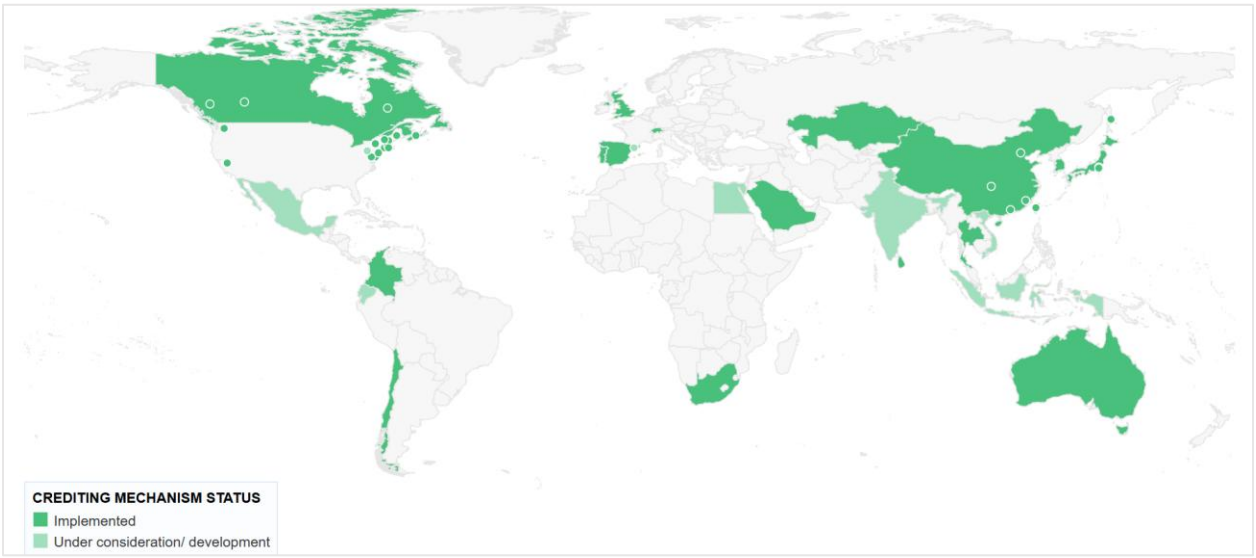
Figure 14 shows the geographical repartition of carbon crediting initiatives. At the global level, 27 carbon crediting initiatives were adopted, and 5 other initiatives are under development. Among the carbon crediting initiatives, we note the California Compliance Offset Program which is a mechanism that supplies carbon offset credits within California's cap-and-trade program. The Compliance Offset Program is implemented and overseen by the California Air Resources Board (CARB). It leverages the administrative services of approved offset project registries (OPRs) to administer the offset project registration and credit issuance application process. In the African context, only South Africa had adopted a carbon credit mechanism. The South African carbon offsetting system operates through a "gatekeeping" model, whereby projects in South Africa developed under the CDM, the Verified Carbon Standard (VCS), and the Gold Standard are potentially eligible (World Bank, 2022).

Under the UNFCCC body (Kyoto Protocol and Paris Agreement), Annex 1 countries can collaborate with non-Annex 1 to reduce their emissions through carbon crediting mechanisms. Thus, the Kyoto Protocol led to the creation of the Clean Development Mechanism (CDM) where countries with an emission-reduction or emission-limitation commitment implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets[33]. Operational since the beginning of 2006, the mechanism has already

[33] UNFCCC: Clean Development Mechanism. https://rb.gy/dc329h. Last visit, 30.12.2024.

registered more than 12,524 projects (of which 386 projects were implemented in Africa) in 2023 and is estimated to produce CERs amounting to more than 14.5 billion tonnes of CO2 equivalent by 2020[34]. The CDM is the main source of income for the UNFCCC Adaptation Fund, which was established to finance adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol and are particularly vulnerable to the adverse effects of climate change. The Adaptation Fund is financed by a 2% levy on CERs issued by the CDM[35].

Figure 16: Carbon credit markets in 2024.



Source: WB Carbon pricing dashboard. https://carbonpricingdashboard.worldbank.org/credits/instrument-detail. Last visit: 18/01/2025.

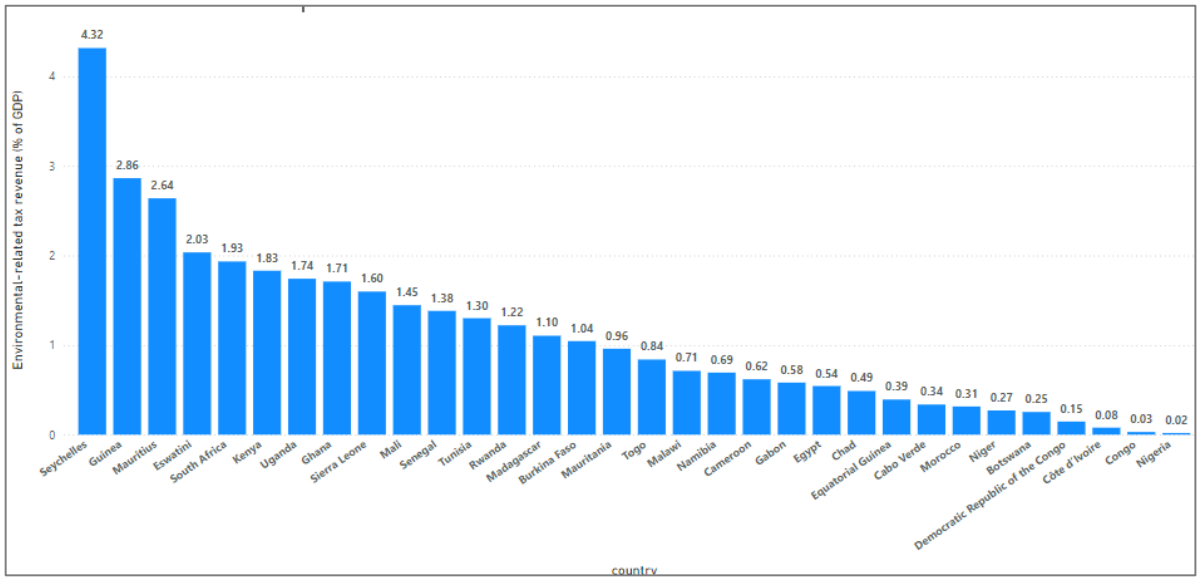
Another market-based instrument of the Kyoto Protocol is the Joint Implementation (JI). The JI defined in Article 6 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to earn Emission Reduction Units (ERUs) from an emission-reduction or emission removal project in another Annex B Party, each equivalent to one tonne of CO2, which can be counted towards meeting its Kyoto target. The main difference between CDM and JI is that CDM projects are exclusively implemented between industrialised countries and developing countries while JI is implemented concerning collaboration between developed or industrialised countries.

[34] IGES: CDM Project Database: https://www.iges.or.jp/en/pub/iges-cdm-project-database/en. Last visit, 30.12.2024.
[35] UNFCCC: Clean Development Mechanism: https://cdm.unfccc.int/about/index.html. Last visit, 30.12.2024.

e) Environmental-related tax

In the absence of a carbon tax as such, several countries have introduced taxes on environmental products, or the revenue generated by these products. Several countries across the continent have adopted these measures. According to the World Bank[36], environmental taxation can contribute to achieving multiple objectives, such as the Sustainable Development Goals (SDGs), and domestic resource mobilization and can help developing countries achieve low-carbon transformation while supporting an inclusive and equitable growth pathway. Many African countries have environmental-related laws and have generated substantial revenue since its launching. Figure 15 shows environmental-related tax revenue in percentage of GDP in 32 African countries. Seychelles (4.32%), Guinea (2.86%), Mauritius (2.64%), Eswatini (2.03%) and South Africa (1.93%) are among the top five countries that levy environmental-related tax compared to their GDP. Botswana (0.25%), the Democratic Republic of Congo (0.15%), Cote d'Ivoire (0.08%), Congo (0.03%) and Nigeria (0.02%) constitute the bottom five countries in levying environmental-related tax compared to their GPD.

Figure 17: Environmental-related tax revenue in 2020, African countries (% of GDP)



Source: Own illustration, data from OECD. OECD Policy Instruments for the Environment (PINE) database. Last updated: 11/07/24.

[36] WB Global Tax Program: https://www.worldbank.org/en/programs/the-global-tax-program/environmental-taxes. Last visit,30.12.2024.

According to OECD, (2024), the environmental-related tax revenue is composed of four categories of tax which include energy tax (fossils fuels-based products), transport (one-off import or sales taxes on transport equipment, recurrent taxes on ownership, registration or use of motor vehicles, and other transport-related taxes), pollution-based tax (SOx and NOx emission taxes, taxes on ozone-depleting substances such as chlorofluorocarbons (CFCs), carbon tetrachloride and chlorofluoromethanes (HCFCs), taxes on the discharge of wastewater, taxes on packaging (e.g. plastic bags), on final disposal of solid waste and other waste-related taxes (e.g. batteries, tyres)), resources-based tax (taxes on water extraction, forest products, hunting and fishing taxes, mining royalties, excavation taxes (e.g. sand and gravel).

3.4. Methodology and data

In this section, we will discuss the methodology used in this study. More specifically, we will discuss the conceptual framework, the choice of the econometric model studied and its specification, and the description of the variables, hypotheses and data source.

3.4.1. Methods

To analyse climate mitigation policy, different types of methodologies are often used among them, we note top-down approaches such as the Computable General Equilibrium model (Nong, (2020); Freire-González and Puig-Ventosa, (2019); Benavides et al., (2015); Alton et al., (2014)) which is primarily used to analyse the impact of climate mitigation scenarios on some outcomes. Indeed, this model is generally used to analyse country-level scenarios and may not be suitable for multi-country analysis. Additionally, using a CGE model requires data on parameters and elasticity that may not be often available for some countries in this study and is based on a top-down approach with economy-wide analysis perspectives. The top-down approach is also less relevant for long-term horizons. They typically do not feature technological details of energy production or conversion and may omit some branches, such as non-energy sectors. Consequently, conventional top-down models cannot readily incorporate different assumptions about how discrete energy technologies and costs will evolve in the future; top-down models may also violate fundamental physical restrictions such as the conservation of matter and energy. Similarly, using a partial equilibrium model requires a certain amount of data, which is not publicly available for most African countries and may not be generalised for the different economic sectors. For this reason,

using econometric models constitutes an alternative for analysing the impact of an environmental tax on carbon emissions, offering flexible and less data-driven estimation methods. Indeed, several research studies were conducted to analyse mitigation measures in developing and developed countries' contexts (Farooq et al., 2023; Rakpho et al., 2023).

The empirical specification is based on the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model provided by (Dietz, T., Rosa, 1997). The STIRPAT model took inspiration from the initial model (IPAT) developed by (Ehrlich and Holdren, 1971; Commoner, 1972). The IPAT assumes that environmental impacts of human activities (I) are driven by the size of the population (P), the affluence (A) and the technology used (T). Since the development of this initial concept, the model has undergone several developments, and alternative formulations have been proposed (Dietz and Rosa, 1997; Schulze, 2002; Willey, 2000). However, the STIRPAT model offers better flexibility in its application in social research and statistical tools (Haas et al., n.d.). Indeed, where the classical and other formulations assume a linear relationship between environmental quality and explanatory variables, the STIRPAT offers flexibility in its application in social science. In the framework of panel data analysis, the STIRPAT formula is defined as the following:

$$I_{it} = \gamma P_{it}^{\alpha} A_{it}^{\beta} T_{it}^{\delta} \varepsilon_{it} \quad \text{(Eq.1)}$$

By transforming Eq.1 in logarithmic form, the formula becomes:

$$lnI_{it} = \gamma + \alpha lnP_{it} + \beta lnA_{it} + \delta lnT_{it} + \varepsilon_{it} \quad \text{(Eq.2)}$$

In the context of this study, supplementary variables are added, such as the environmental-related tax, to capture the role of environmental tax in CO2 emissions. In the STIRPAT model, the P stands for Population. Affluence (A) and Technology (T) variables are often defined by GDP per capita, energy intensity (Al Shammre et al., 2023) and level of industrialisation, which is captured in our case by the productive capacities index. The model is then specified as the following:

$$lnCO2emissions = \gamma + \alpha lnPOP_{it} + \beta lnGDPcap_{it} + \delta lnEI_{it} + \rho lnEnvTax_{it} + \vartheta lnPCI_{it} + \varepsilon_{it} \quad \text{(Eq.3)}$$

Where CO2 emissions represent the dependent variable while the other variables represent the independent variables, POP is defined as the population, GDP cap as the GDP per capita, EI for

Energy Intensity, Envtax for the environment tax revenue in percentage of GDP, PCI as the productive capacities index and ε for the stochastic error term. α, β, δ, ρ, and ϑ represent the coefficients for the independent variables, and γ is the constant term.

The estimation technique is based on the First Difference Two Stage Least Squares (FD-2SLS) and Prais-Winsten corrected standard errors (PCSEs) methods. The two-stage least squares method was developed by Schaffer, (2010) and is suitable to deal with potential endogeneity problems that may exist because of the correlation between unobservable observations or omitted variables bias, and error terms (Antonakis et al., 2010). Using instrumental variables through a two-stage least squares is a way of dealing with endogeneity issues and providing more robust outcomes than the traditional panel data estimation techniques (Kyriazidou, 1997). The first difference estimator (FD-2SLS) provides, therefore, robust outcomes to any correlation between unobserved effects and explanatory and instrumental variables (Semykina & Wooldridge, 2006).

On the other hand, the Prais-Winsten corrected standard errors (PCSEs) method initially introduced by Prais & Winsten (1954) deals with the potential cross-sectional dependence issues. While most panel data estimation techniques assume slope homogeneity, external shocks may affect cross-sectional units differently. For example, the COVID-19 crisis has deeply affected countries like Cabo Verde, Liberia, Guinea-Bissau, Sierra Leone, Mali and Nigeria with negative economic growth. In contrast, the other countries in the ECOWAS region have kept their economic growth positive, even though the rate experienced a reduction (ECOWAS, 2021). Using advanced techniques, such as the Prais-Winsten corrected standard error method, is a way of dealing with cross-sectional dependence issues as well as heteroskedasticity. The method is also suitable for $N < T$ (Tobechukwu & Azubuike, 2020). We perform robustness tests to ensure that the estimations are consistent when changing estimation techniques. For that, the Augmented Mean Group (AMG) and Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) are used. The AMG and CS-ARDL seem to be more suitable for our analysis because of the limited cross-sectional unit (N=11 countries) and the relatively short period (T=22 years).

For the estimation of the 2SLS method, we used the logarithm of GDP squared values as the instrumental variable. We believe that there is a risk of having reverse causality between GDP and carbon emissions, as economic development can explain pollution, while similarly high emission intensity can also explain important economic activities (GDP). So, the GPD variable can

potentially present a risk of endogeneity. In this case, we choose GDP squared as an instrument to explain the GDP variable. However, using GDP squared as an instrument can also lead to a bias if the data-generating process follows the Environmental Kuznets Curve (EKC). We test the presence of the EKC in our data-generating process, and the results show that the EKC is not supported and, therefore, GDP squared can be used as an instrument (please see Annex 2 for more clarification).

This study analyses the potential effects of environment-related taxes on CO2 emissions in eleven West African countries. Two main findings characterise the literature on the topic. On one hand, some findings indicate that environmental-related taxes negatively affect pollution levels. Indeed, Farooq et al., (2023) using the generalized method of moments (GMM) and the generalized least square (GLS) methods find an inverse causality between CO2 emissions and environmental tax in ten industry-intensive economies and top polluting countries namely China, the United States, Japan, Germany, the Republic of Korea, India, Italy, France, the United Kingdom, and Mexico on a sample of 20 years data (2000-2019). Additionally, using different techniques, such as the Computable General Equilibrium model in the case of China, Lin & Jia, (2018) found that an increase in environmental taxes mitigates pollution. Similarly, according to Han & Li, (2020), increasing environmental taxes promotes investments in low-emission technologies and improves energy efficiency by mitigating the emissions of polluting technologies. Following the same perspective, Youssef et al. (2023) analyse the impact of environmental tax on CO2 emissions within the European Economic Area (EEA) using cross-sectional autoregressive distributed lag (CS-ARDL) and dynamic common correlated effects (DCCE). Their findings reveal that environmental taxes negatively impact CO2 emissions.

On the other hand, researchers stated that environmental taxes may not have the desired impact on environmental pollution if it is not properly designed. Indeed, some authors support that environmental taxes may slow down industrial activities and limit some business activities (Farooq et al., 2023). In the case of the European Union, Aydin & Esen (2018) have shown that the impact of environmental tax depends on a given threshold level beyond which the effect of environmentally related taxes (excluding transport taxes) on CO2 emissions changes from insignificantly positive to significantly negative. Similar results were found by Zaghdoudi & Maktouf, (2017) in the context of 26 OECD countries and for BRICS countries (Brazil, Russia, India, China and South Africa) by using a panel smooth regression threshold model (Ulucak et al.,

2020), which is translated by a positive and significant impact on CO2 emissions when environmental taxes increase. The opposite expected outcomes of environmental taxes translated by an increase in CO2 emissions equivalent, is known as the green paradox. The green paradox arises in a situation where the Hotelling (1931) rule is no longer valid. Indeed, Hotelling (1931) assumes that the decision to extract fossil energy is made by maximising the net present value of profits over time, such that the resource rent increases at the discount rate. In the case of environmental tax, fossil fuel energy extraction time may be shorter than planned, which leads to an increase in non-renewable extraction in the short term, and the cumulative environmental damage remains unchanged.

Hypothesis: Environment-related tax is significantly and negatively impacting CO2 emissions.

3.4.2. Data and sources

The present study aims to understand the effects of the environment-related tax on CO2 emissions in West African countries. Based on the availability of data, 11 countries including (Burkina Faso, Cabo Verde, Cote d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo) were considered in this study. The period of the data is from 2000 to 2021. Following the STIRPAT model, variables are composed of the CO2 emissions (which measures the pollution level), the environmental-related tax (representing the interest variable) and the others controls variables, including GDP per capita, energy intensity, productive capacities index, and the population. Environmentally related taxes are effective policy instruments to shape the relative prices of goods and services. The Environmental Related Tax Revenue Database (ERTR) categorises taxes based on their environmental relevance, constructing environmentally related tax revenue with a breakdown by tax-based category, including energy, transport, pollution, and resources[37]. Table 22 describes the variables used in the regression models.

[37] OECD: https://data-explorer.oecd.org/?lc=en&tm=DF_ERTR&pg=0&snb=1. Last visit, 30.12.2024.

Table 22: Description of variables

Variable	Unit	Source
CO2 emissions per capita (CO2 pcap)	tCO2e/capita	WDI-WB
Environmental-related tax (EnvTax)	Percentage share of GDP	OECD
Energy intensity (EI)	TBTU per U.S. Dollar of GDP per person	U.S. Energy Information Administration
Productive Capacity Index (PCI)	Ranging from 0-100	UNCTADSTAT
Population (pop)	Number of inhabitants	WDI/WB
Gross Domestic Product per capita (GDP pcap)	Current US Dollar	WDI/WB

Source: Own illustration

3.5. Results and discussions

In this section, we analyse and interpret the results obtained from our econometric models. More specifically, we analyse the descriptive statistics, preliminary tests, empirical results and discussions, and sensitivity analysis.

3.5.1. Descriptive Statistics

Table 23 summarises the descriptive statistics of the variables introduced in the regression models. Environmental indicators measured by CO2 emissions reveal that West African countries are characterised by a low level of CO2 emissions, with an average of 0.398 tons of CO2 per capita. Niger had the minimum emission per capita with a value of 0.056 tCO2 per capita in 2006 and the Cabo Verde had the highest emissions per capita (1.647 tCO2 per capita in 2021). The environment-related tax has generated a certain amount of revenue for West African countries, with an average of 1.109% of GDP, a minimum level of 0.009% of GDP in Nigeria in 2011 and a maximum level of 5.358% of GDP in Guinea in 2002. GDP per capita remains also low in the eleven West African countries as the average value stands at 1,146 US dollars, characterised by disparities between countries as the minimum value is equal to 138 US dollars for Sierra Leone in 2000 and the maximum stands for 3,903 US Dollar for Cabo Verde in 2019. The energy intensity in the eleven West African countries is relatively low, with an average of 1.814 trillion BTU per U.S. dollar per person, while the minimum stands at 0.59 trillion BTU per US dollar for Mali in 2003, and the maximum was about 4.16 trillion BTU US dollars for Togo in 2009. The productive capacities index which measures a range of indicators including (natural capital, human capital, energy availability and accessibility, transport capabilities, etc) reveals a low level of productive capacities index with an average of 0.27, a minimum of 0.094 in Nigeria (2009) and a maximum

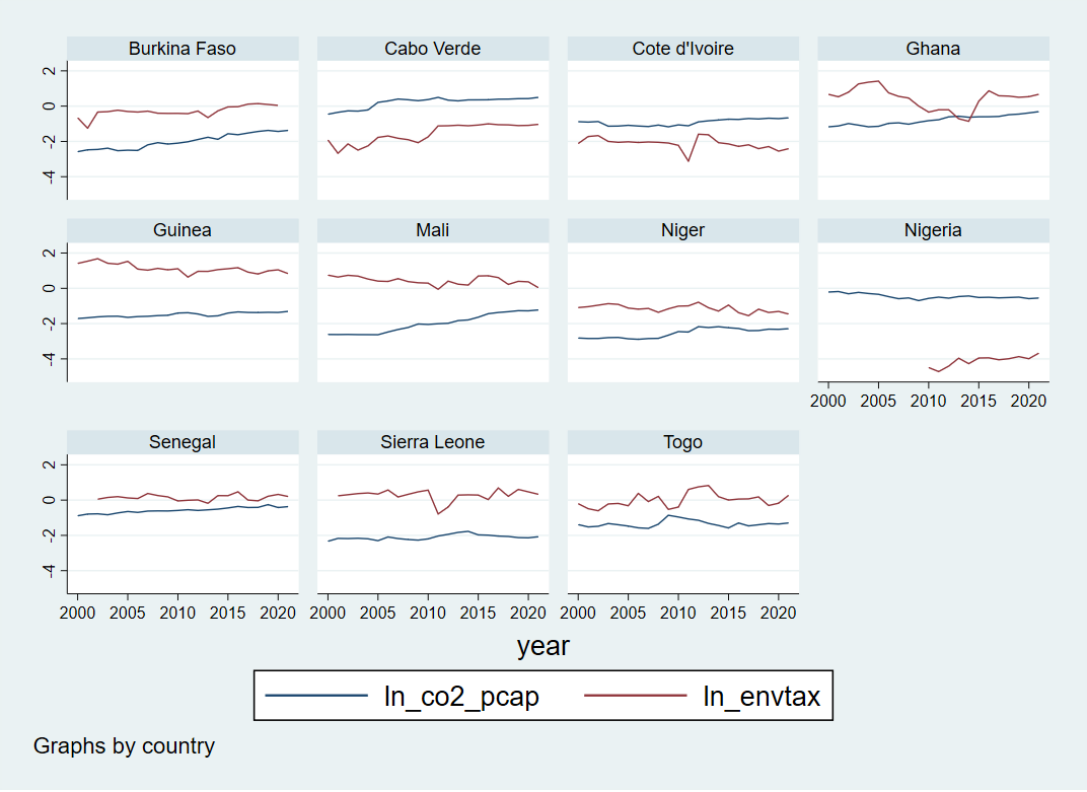
of 0.511 in Cabo Verde (2008). Lastly, the population size in the eleven countries is estimated at an average of 27.28 million inhabitants, with a minimum population of 458,251 inhabitants in Cabo Verde in 2000 and a maximum of 213.4 million inhabitants in Nigeria in 2021.

Table 23: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
co2 pcap	242	.398	.356	.056	1.647
envtax	228	1.109	1.009	.009	5.358
gdp pcap	242	1146.043	888.103	138.714	3903.05
ei	242	1.814	.754	.59	4.16
pci	242	.27	.093	.094	.511
pop	242	27288607	45051160	458251	213.4e+06

Source: own illustration

Figure 18: Environmental-related tax revenue and CO2 emission trend, 2000-2021



Source: Own illustration

Figure 18 illustrates the trend of CO2 emissions per capita and environmental-related tax revenue. We can notice that CO2 emissions per capita are slightly increasing over time in most countries, while they likely remain constant in Nigeria. However, environment-related tax revenue has

different trends depending on the country. It's likely increasing in Burkina Faso, Cabo Verde, Nigeria, Senegal and Togo, remaining constant in Ghana and Sierra Leone and decreasing trend in Guinea, Cote d'Ivoire, Mali and Niger.

3.5.2. Preliminary test

3.5.2.1. Matrix of correlations and multicollinearity test

Table 24 represents the matrix of correlations between the variables of the model. The table shows a possible correlation between the dependent variable (log CO2 emissions) and the independent variables, and a relatively low correlation between the independent variables themselves. Additionally, we also noticed a negative correlation between CO2 emissions and environment-related tax revenue. Table 25 reports the multicollinearity test and displays the variance inflation factor (VIF) of each variable. We notice that the VIF remains relatively low (i.e. below 5). This means there are no issues of multicollinearity, and variables can be put together in the same model without any risk of fallacious results.

Table 24: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) ln_co2_pcap	1.000					
(2) ln_envtax	-0.318***	1.000				
	(0.000)					
(3) ln_gdp_pcap	0.857***	-0.499***	1.000			
	(0.000)	(0.000)				
(4) ln_ei	0.778***	-0.055	0.559***	1.000		
	(0.000)	(0.409)	(0.000)			
(5) ln_pci	0.252***	-0.067	0.153**	0.386***	1.000	
	(0.000)	(0.316)	(0.017)	(0.000)		
(6) ln_pop	-0.151**	-0.184***	-0.053	-0.433***	-0.483***	1.000
	(0.019)	(0.005)	(0.409)	(0.000)	(0.000)	

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

Note: Table 22 displays a correlation matrix of variables included in the empirical model with their significance in brackets. The statistics show a low level of correlation among dependent variables, which means that they can be added to an empirical model without the risk of spurious regression. **Source**: Own illustration.

Table 25: Variance inflation factor

	VIF	1/VIF
ln gdp pcap	2.387	.419
ln ei	2.303	.434
ln pop	1.964	.509
ln pci	1.676	.597
ln envtax	1.597	.626
Mean VIF	1.985	.

Source: own illustration

3.5.2.2. Serial correlation

Analysing the relationship between series and their historical values in panel data analysis is important. Thus, we perform several serial correlation tests using the portmanteau test proposed by Jochmans (2020) and the seasonal difference test proposed by Arellano & Bond (1991) and (Yamagata, 2008). The serial correlation test results reveal that the null hypothesis of no autocorrelation cannot be rejected. This means that the degree of correlation of our variables between their lag value is very low or not influenced by each other over time. Therefore, we conclude that the series are not correlated, and statistical regression models are suitable in such a context.

Table 26: Serial correlation test

portmanteau test	chi2(11) =	11.000
H0: no autocorrelation of any order	Prob > chi2 =	0.4433
Collapsed test in first differences	Chi2(1) =	0.1253
H0: no autocorrelation up to order 3	Prob > chi2 =	0.7234
Collapsed test in first differences	Chi2(1) =	0.0017
H0: no autocorrelation up to order 4	Prob > chi2 =	0.9672
Collapsed test in first differences	Chi2(1) =	0.0043
H0: no autocorrelation up to order 5	Prob > chi2 =	0.9479
collapsed test in seasonal differences	chi2(11) =	11.000
H0: no autocorrelation of any order	Prob > chi2 =	0.4433

Source: own illustration

3.5.2.3. Cross-sectional dependence test

Performing cross-sectional dependence (CSD) tests is also important in panel data analysis. However, the presence of cross-sectional dependence or the absence of this problem determines the path that is to be followed next (Tugcu, 2018). Additionally, in the presence of cross-sectional dependence, the outcomes using traditional fixed effects or random effects may not be efficient (Hoyos & Sarafidis, 2006). Several CSD tests exist, such as the Pesaran test, the Friedman test and the Frees test. However, these three popular tests are valid when the number of cross-sectional units (N) is larger than the time dimension (T). In the case of T larger than N, the Breusch and Pagan Lagrangian multiplier test (LM) is suitable (Hoyos & Sarafidis, 2006). For this reason, the test by Breusch & Pagan, (1980) is performed. Table 27 summarises the cross-sectional dependence test with the null hypothesis of cross-sectional independence. According to the result (p-value is less than the threshold level of 0.05), we reject the null hypothesis of cross-sectional

independence and conclude that errors are dependent over periods and across cross-sectional units. Therefore, choosing the estimation techniques that deal with cross-sectional dependence issues is critical to have consistent and efficient outcomes.

Table 27: Breusch and Pagan Lagrangian multiplier test (LM) of cross-sectional independence

chi2(55)	**167.365**
Pr	0.0000

Source: own illustration

3.5.2.4. Unit root test

Unit root tests are important in panel data analysis because they help to identify the stationarity of variables over the period. According to the precedent test of cross-sectional dependence, there is an issue of cross-sectional dependence of error terms. In the presence of cross-sectional dependence, using traditional methods such as the first-generation test of unit root test can lead to biased outcomes. We perform the Cross-sectionally Augmented Dickey-Fuller test (CADF) proposed by (Pesaran, 2003). The results show that CO2 emissions, environmental-related tax revenue and population variables are stationary at the level (I(0)) while productive capacities index, GDP per capita and energy intensity variables are stationary at the first difference (i.e. after a first differentiation (I(I)). We conclude that all variables of the model are stationary and that choosing estimated techniques which introduce variables in the first difference is important to avoid fallacious regression problems (Shammre et al., 2023). Therefore, the first difference two-stage least squares method is one of the regressions used in our regression techniques.

Table 28: Test of stationarity

Variable	At Level		First difference		
	Statistic	P-value	Statistic	P-value	Integration level
(1) ln_co2_pcap	-1.929	0.027	-	-	I(0)
(2) ln_envtax rev	-1.839	0.033	-	-	I(0)
(3) ln_pci	3.711	1.000	-3.235	0.001	I(1)
(4) ln_gdp_pcap	-1.057	0.855	-2.629	0.004	I(1)
(5) ln_ei	0.128	0.551	-3.235	0.001	.I(1)
(6) ln_pop	-2.257	0.012	-	-	I(0)

Source: own illustration

3.5.3. Empirical results and discussions

Table 29 summarises the empirical results using the first-difference two-stage least squares and the Prais-Winsten estimation techniques. The two methods report similar results but differ slightly in their magnitude and sign of the environmental-related tax revenue and population variable in the Prais-Winsten regression, and the FD-2SLS are different. We noticed that the interest variable (environmental-related tax) is not statistically significant in both cases. At the same time, GDP per capita, energy intensity and productive capacities index are statistically significant (at 1% and 10%). The impact of control variables such as the GDP per capita is statistically positive and significant at 1% and aligns with the expected sign. Indeed, the augmentation of GDP per capita, which results from economic expansion, contributes to improving living conditions and an increase in consumption, including CO2-intensive products (such as energy). Thus, a rise of 1% of the GDP per capita increases the CO2 emissions by 0.14% in the FD-2SLS method, while it increases the emissions by 0.567% in the Prais-Winsten regression. Our results corroborate the ones found in the literature by Youssef et al., (2023) and Ghazouani et al., (2021) in the case of the European countries, Wolde-Rufael & Mulat-Weldemeskel, (2021) in the context of seven (7) emerging economies and (Dahmani, 2024) in G7 countries. Similarly, the energy intensity variable is also positively associated with CO2 emissions and is statistically significant at the 1% threshold level. Indeed, an increase in energy intensity by 1% will increase the CO2 emissions by 0.613% in the FD-2SLS method and by 0.768% in the Prais-Winsten regression models. The energy intensity as the leading factor of CO2 emissions is expected to positively impact the CO2 emissions level. This finding corroborates the ones found by (Shammre et al., 2023) in the context of OECD countries. The productive capacities index is statistically significant at a 10% threshold level and negatively associated with CO2 emissions. The increase in the productive capacities index can be interpreted as a way of investing in low-emission technologies. This may help in increasing the energy efficiency and decreasing the overall energy intensity. Similar evidence was found by (S. Lin et al., 2023; Xin et al., 2023; and Youssef et al., 2023). The population variable is not statistically significant.

As previously highlighted, the interest variable (environmental-related tax revenue) is not significant in the context of the eleven West African countries. This means an increase or decrease in environmental-related tax revenue will not have a significant impact on CO2 emissions. These results corroborate the ones found by (Omodero et al., 2022) in the context of Nigeria, while Gas-

related tax and petroleum profit tax didn't have any significant impact on CO2 emissions. Similar results were also found in Ghana, where the petroleum tax is not hampering pollution (Kombat, 2015). While the generally expected results were to have a significant coefficient and be negatively associated with CO2 emission, the result found here in this study is not surprising. Indeed, the West African countries are relatively low-emitting countries with huge needs in terms of energy access and economic expansion. According to World Bank data[38], about 45% of the population didn't have access to electricity in the eleven West African countries, while 87% of the population in West Africa did not have access to clean cooking (IRENA & AfDB, 2022)[39]. Adding to the issue of the availability and accessibility of energy, the region is also facing affordability issues. As one of the poorest regions in the world (average GDP per capita stands at 1146 US Dollars), energy products are relatively more expensive in the region than in other parts of the world, with the price of electricity among the highest in the world (IRENA, 2023). The question which may be asked is: Is an environment-related tax effective in an unclear market? In the context where clear market conditions are not met, such as the case of West African economies, it is difficult to have an impact of an environmental tax on CO2 emissions. The region is already facing a shortage in accessing energy services, while the demand is not being met. In such a context, adopting a tax which will increase the cost of energy and aiming to reduce CO2 emissions may not have the desired outcomes. Another issue may concern the determination of energy products' prices. Indeed, in most West African countries, energy carriers (such as electricity, oil, and gas fuels) are highly subsidised to make them affordable for the population. So, adding a tax on such products may not be effective.

Given that environmental-related taxes are statistically insignificant, the question is whether those taxes were specifically intended to mitigate CO2 emissions or if there were any CO2 emissions reduction targets. The answer to this question is likely to be no, as no CO2 emissions reduction targets were associated with these taxes; rather, these taxes were mainly targeted to raise revenue for governments. Thus, even levied on environmental goods, these taxes become just a normal tax that aims to generate additional income for the government instead of having a specific environmental goal.

[38] World Development Indicators: Author(s) calculation.
[39] IRENA: International Renewable Energy Agency.

Given that the data used in this study covers the period from 2000 to 2021, there were no West African countries during this period which established a carbon tax, i.e. a tax that aims to reduce CO2 emissions. However, countries like Côte d'Ivoire, Nigeria and Senegal are working on implementing a carbon tax in the near future. Recently, Ghana's Parliament has passed the Emissions Levy Act, 2023, Act 1112, effective from February 1st, 2024. The Act imposes a levy on carbon dioxide equivalent emissions from specified sectors (construction, manufacturing, mining, oil and gas, electricity and heating) and combustion emissions from vehicles (motorcycles and tricycles, motor vehicles, buses and coaches up to 3000 cubic centimetres).

Similarly, Cabo Verde's government proposes to create in 2025 a carbon tax aimed exclusively at financing actions to mitigate and adapt to the effects of climate change. Therefore, to ensure the effectiveness of such tax policies, West African governments must work on increasing the substitutability of energy carriers within the region, as it is currently very low. Even though West African countries have great potential for renewable energy, the scalability and deployment of renewable energy is a concern, as the required investment is below the current investment level. Another challenge to the effectiveness of such a policy concerns the intermittency of renewable energy, which requires backup technologies for the energy generated.

Table 29: Environmental related tax and CO2 emission – FD-2SLS and Prais-Winsten regression

	(FD-2SLS) estimation		**Prais-Winsten regression**	
ln_co2_pcap	**Coef.**	**P>z**	**Coef.**	**P>z**
ln_envtax	0.015	0.332	-0.012	0.448
ln_gdp_pcap	0.142	0.002***	0.567	0.000***
ln_ei	0.613	0.000***	0.768	0.000***
ln_pci	-0.045	0.061*	-0.051	0.056*
ln_pop	0.123	0.862	-0.032	0.157
cons	0.013	0.480	-5.066	0.000
F(5, 211)	43.73		R-squared	0.816
Prob > F	0.000		Wald chi2(5)	708.19
Centered R2	0.508		Prob > chi2	0.000
Root MSE	0.070		Rho	0.844

*** *p<.01,* ** *p<.05,* * *p<.1*

Source: own illustration

According to Wesseh & Lin, (2016), backup technologies usually result in higher carbon emissions and offset the opportunities for environmental protection, especially when the cost of switching

between technologies is considered. Additionally, the capacity factor[40] of conventional fossil fuel energy is relatively higher than that of renewable energy sources. For the majority of West African countries, while oil, gas, coal and nuclear plants have a high level capacity factor of 85%, renewable energy such as solar has a capacity factor of only 27%, 58% for large hydropower, and 10% for wind plants (Allington et al, 2021).

Have there been any effective carbon tax policies? As part of the first-tier countries that adopted an environmental tax in the world, Sweden's carbon tax is often cited as a successful example. Since its adoption in 1991, greenhouse gas emissions in Sweden have fallen by 27% from 1990 to 2018, while at the same time showing a solid increase in GDP growth and GDP per capita[41]. One of the reasons for the success of the Swedish carbon tax policy is arguably its high price of around $127 per metric ton of CO2 (for a long time, the highest in the world), which can be considered an incentive for many polluting industries to invest in cleaner energy sources. Nevertheless, the Swedish carbon tax grants exemptions to certain strategic sectors and covers only 40% of total emissions. This prompted criticism, but at the same time, it gives these sectors leeway to remain competitive with foreign companies and to control the economic distortions that the carbon tax could create. The tax was implemented in several stages, starting with a relatively low carbon price, then reducing certain existing taxes so as not to disrupt industrial activity too much and continuing to increase them gradually. This way of introducing the tax has therefore enabled businesses to prepare themselves while gradually refining their greenhouse gas reduction ambitions. Since the EU-ETS came into force in 2005, Sweden has applied two carbon tax regimes. A tax regime aligned with the European Union tax (EU-ETS) and the national carbon tax for sectors not covered by the EU-ETS, ensuring a coherent policy based on national objectives. This environmental tax also benefits from a favourable environmental policy, as the country is considered one of the pioneers in terms of climate and environmental governance. This consistency in terms of climate policy has led to substantial results.

Is the Swedish case replicable in West African countries? To a certain extent, West African countries can draw on the lessons learned by Sweden over the last 35 years to implement their

[40] The capacity factor of a power plant is the ratio of its actual output over a period of time, to its potential nominal output if operating constantly at full nameplate capacity over the same period of time (Muratori et al., 2017).
[41] Tax foundation: https://taxfoundation.org/research/all/eu/sweden-carbon-tax-revenue-greenhouse-gas-emissions/#_ftn15. Last visit. 09.04.2025.

environmental taxation policy, but this requires a profound adaptation to the local economic, institutional and social context. Firstly, the countries of the West African zone need to re-establish trust between government departments and economic agents by clearly explaining the objectives, targets, advantages and benefits that the country can gain by adopting carbon taxation, based on the transparency and predictability of the measures that will be taken as they are implemented. The authorities must also clearly explain the mechanisms that will be implemented to recycle and transfer the revenues generated by the carbon tax. For example, revenues from the tax could be used to (i) expand access to electricity, (i) subsidise clean cooking fuels and solar energy, and (i) strengthen health and education systems. In this way, climate policy can be aligned with poverty reduction and development objectives while creating complementarity. The implementation of such a policy must also benefit from a stable political environment. In many West African countries, regime change, vision and political instability make it difficult to implement a coherent, long-term policy. The carbon tax should also adopt a differentiated sectoral approach by applying transitional support or reduced rates for sectors essential to livelihoods (e.g. agriculture or small-scale manufacturing), while taxing highly polluting activities such as diesel transport or oil and gas flaring. Given the present strength of the informal sector in the economies of West African countries, the carbon taxation policy must first prioritise those sectors where institutional oversight is strong (e.g. oil extraction, electricity production, transport fuels) and gradually prepare the other sectors for this new policy. Once these steps have been taken, African countries can, in the best way, consider adopting carbon taxation.

3.5.4. Diagnostic tests

It is common practice to undertake identification tests when performing instrumental variables tests. In this case, there are multiple identification tests to perform, such as the under-identification test proposed by (Cragg & Donald, 1993, 1997 and Kleibergen & Paap, 2006), the weak identification test proposed by (Cragg & Donald, 1993; Stock & Yogo., 2005) ; and the overidentification test proposed by (Sargan, 1988).

In the case of under-identification tests, the null hypothesis assumes that the instruments have insufficient explanatory power to predict the endogenous variable(s) in the model for the identification of the parameters (Windmeijer, 2024). Under-identification implies that the number of instruments used is less than the number of endogenous regressors in the simultaneous

equations. Table 30 shows that the null hypothesis of under-identification (existence of under-identification issues) is rejected at the 1% threshold level. We conclude that the model is well-identified or exactly identified. The second identification test concerns the weak identification test, which may arise when the correlations between the endogenous regressors and the excluded instruments are nonzero but small (Baum et al., 2007). The null hypothesis assumes that instruments are weak, which may cause bias in the estimation results. Table 30 shows that the null hypothesis is rejected, and therefore, the instruments used are valid. Finally, the overidentification test is also performed under the null hypothesis that the number of instruments used is greater than the number of endogenous regressors. The Sargan statistic shows that the null hypothesis is rejected at the 1% threshold level. Therefore, the instrument used is not correlated with the error, and our model is well-identified.

Table 30: Diagnostic test of identification

Under-identification test		
Anderson canon. Corr. LM statistics:		124.390
Chi-sq. (1) P-value		0.000
Weak identification test		
Cragg-Donald Wald F statistic:		1700.0
Stock-Yogo weak ID test critical values:	10% Maximal IV size	16.38
	15% maximal IV size	8.96
	20% maximal IV size	6.66
	25% maximal IV size	5.53
Overidentification test		
Sargan statistic		0.000

Source: own illustration

3.5.5. Sensitivity analysis

To ensure the robustness of our results, we applied further estimation techniques. We first employ the cross-sectional autoregressive distributed lag model (CS-ARDL) as the model suffers from cross-sectional dependence issues. Then, we use the augmented mean group techniques (AMG), which will allow us to counter structural breaks and shocks. The CS-ARDL estimation results are displayed in Table 31. We can see that the explanatory variable (environmental-related tax revenue) is not as significant as obtained in the previous estimations. Additionally, energy intensity and GDP per capita are statistically significant at the 1% threshold level, while the productive capacities

index and population variable are insignificant. The CS-ARDL offers further information on the impact of regressors in the short and long term. The results obtained in the short-term and long-term are roughly the same in terms of their sign and magnitude. We also perform a cointegration test based on Kao (1999) cointegration's techniques. The results presented in the annex show that there is a long-term equilibrium relationship between variables at a significant level of 10% (see Annex 3).

Table 32 reports the AMG estimation results. The results obtained display findings similar to those of the CS-ARDL. Environmental-related tax revenue is not a significant determinant of CO2 emissions in West Africa, while GDP per capita and energy intensity affect it positively and significantly. The remaining variables (productive capacities index and population) are not statistically significant. The results of the sensitivity analysis confirm the results we find in our main regression models (2SLS and Prais-Winsten regression). However, we also noticed that the productive capacities index variable is not statistically significant in the robustness model, as it was significant at the 10% threshold level in the main results. This leads us to reject the importance of productive capacities as a factor affecting CO2 emissions.

Table 31: Estimation results using CS-ARDL

ln_co2_pcap	Coef.	Std.Err.	z	P>z	[95%Conf. Interval]	
Short Run Est.						
L.ln_co2_pcap	0.039	0.045	0.860	0.391	-0.049	0.126
ln_envtax	0.010	0.020	0.490	0.624	-0.029	0.048
ln_ei	0.853	0.069	12.410	0.000***	0.718	0.988
ln_pci	-0.055	0.060	-0.910	0.363	-0.173	0.063
ln_pop	1.720	1.579	1.090	0.276	-1.374	4.814
ln_gdp_pcap	0.315	0.112	2.810	0.005***	0.095	0.536
Adjust. Term	-0.961	0.045	-21.430	0.000***	-1.049	-0.874
Long Run Est.						
ln_ei	0.893	0.064	13.960	0.000***	0.768	1.019
ln_envtax	0.010	0.021	0.490	0.622	-0.030	0.051
ln_gdp_pcap	0.317	0.108	2.930	0.003***	0.105	0.530
ln_pci	-0.062	0.064	-0.970	0.334	-0.188	0.064
ln_pop	1.599	1.661	0.960	0.336	-1.657	4.854
F(130, 78)	5.520		R-squared (MG)		0.040	
Prob > F	0.000		Root MSE		0.980	

**** p<.01, ** p<.05, * p<.1*

Source: own illustration

Table 32: Estimation results using AMG

ln_co2_pcap	Coef.	Std.Err.	z	P > z	95%Conf.	Interval]
ln_envtax	0.004	0.014	0.290	0.774	-0.023	0.030
ln_ei	0.652	0.078	8.360	0.000***	0.499	0.804
ln_pci	-0.051	0.047	-1.070	0.283	-0.143	0.042
ln_pop	0.096	0.256	0.370	0.708	-0.405	0.597
ln_gdp_pcap	0.216	0.059	3.660	0.000***	0.100	0.331
Constant	-4.356	3.860	-1.130	0.259	-11.921	3.210
Wald chi (2)	124.27		Root MSE	0.045		
Prob > chi2	0.000					

*** *p<.01, ** p<.05, * p<.1*

Source: own illustration

3.6. Partial conclusions and recommendations

Reducing greenhouse gas emissions is one of the most preferred responses to mitigate the effects of climate change. Several governments have proposed different instruments, such as investing in renewable energy and planting trees, but they have also adopted binding instruments that constrain polluters to reduce CO2 emissions. Among these instruments, we noticed carbon tax and emissions cap schemes adopted by countries like Australia, Canada, the European Union, South Africa, etc. In West Africa, no countries have adopted carbon taxes or emission cap schemes. However, many countries levy environment-related taxes on energy products, natural resources, transport and pollution.

The objective of this study is to analyse the potential impact of environment-related taxes on CO2 in eleven West African countries. Using data from 2000 to 2021, we performed advanced panel data analysis with a combination of a two-stage least squares method and the Prais-Winsten regression model. The two-stage least squares deal with endogeneity issues and omitted bias, while Prais-Winsten accounts for cross-sectional dependence issues. The empirical results show that the targeted variable, i.e. the environmental-related tax revenue, does not significantly impact the CO2 emissions in both regression techniques. CO2 emissions are impacted by other indicators, such as energy intensity and GDP per capita. Additionally, we performed a diagnostic identification test. The results confirmed that the model doesn't suffer from underidentification, overidentification and weak identification issues. Therefore, the model is well-specified. Then, we perform a sensitivity analysis by applying two additional regression models, the cross-sectional autoregressive distributed lag model and the augmented man group (AMG) estimator. The results are quite similar to our main results, where the environmental-related tax revenue remains

insignificant. Our results bring new insights into the literature that may help in shaping climate change mitigation policies within the West African context.

As the current environmental-related tax doesn't have a sufficient impact on CO2 emissions, it becomes important to think about how future climate mitigation policies, such as carbon pricing, will be designed. Indeed, the adoption of a carbon tax is becoming a popular topic in the climate action space, and many countries are working on how to consider it in their national environmental policies. For instance, in the West Africa region, countries like Cote d'Ivoire, Nigeria, and Senegal are working on setting a carbon tax framework, while Ghana's Parliament has recently passed the Emissions Levy Act, 2023, Act 1112, effective from February 1st, 2024. Serious investigations must be carried out into the potential impact of these policies on climate mitigation. Also, it is important to question the alternative proposed by the government for the effectiveness of this policy. To be effective, such policy must be accompanied by the promotion of charging points for electric vehicles in all major cities as well as incentives for people to invest in electric vehicles, given that the price of electric vehicles is relatively higher than that of conventional vehicles. Otherwise, the adoption of electric vehicles will still be pending, and emissions from vehicles will not go down even if a carbon tax is imposed on vehicles.

Considering a carbon tax in the energy sector can also be a challenge. Most of the West African countries experienced unclear market situations, particularly where energy demand is likely higher than the supply, and the level of substitutions remains low. Thus, a carbon tax on final energy demand may also be unaffordable for the population where GDP per capita is relatively low compared to countries that have implemented carbon taxes or emissions schemes. Therefore, social considerations must be considered when designing carbon tax policies in low-income countries. Nevertheless, a carbon tax may be viable when it is well-designed and targets specific sectors. For instance, one way to consider a carbon tax is to levy carbon in energy-intensive industries such as the mining and cement industry, the oil and gas sector and the air transportation sector, which are now more mature, and actors are ready to bear additional costs without impacting significantly the overall economy. The income generated from this carbon tax policy may be used to create national climate funds or strengthen existing climate funds. Then, in the short and medium term, this income generated must help to increase investment in renewable energy and increase the energy supply capacities, which will benefit the entire economy.

Failure to adopt the right environmental policy can lead to additional risks such as technological lock-in and loss of competitiveness, which may have a lasting effect on the entire economy. Indeed, instead of reducing pollution, the carbon tax led to reduced greenhouse gas emissions, countries may face an increase in their emissions and create a green paradox situation. Sinn, (2008) provides a prior analysis of the issues of the green paradox. He argued that in the fossil fuel sector, implementing a carbon tax on the demand side will not have any effect if anything is done to regulate the supply side. In the context of West African countries, possible action on the supply side is to massively invest in alternative sources so that substitutes can exist. Carbon tax policy must also be accompanied by supplementary action, such as private, to prevent any potential competitiveness issues. In addition, the West African countries must find a balance between environmental goals and socioeconomic development objectives.

General conclusion

The fight against climate change will unquestionably require the adoption of a more virtuous and environmentally friendly form of finance. According to available estimates, the annual climate finance needed to be mobilised for the African continent will amount to 2 trillion dollars by 2030 (i.e. approximately 190 billion dollars per year), whereas the current amounts are less than 50 billion dollars per year (CPI, 2024b). Given this situation, it is vital to find sustainable solutions to the current climate challenges.

In this thesis, we analysed the current drivers of climate finance access and the factors explaining the adoption of green finance practices, as well as their impact on reducing greenhouse gas emissions. First, we analysed the drivers contributing to the attraction of climate finance to Sub-Saharan African countries using an empirical method based on Bayesian Model Averaging and secondary data. The results show that climate finance allocation is a dynamic process and is mainly explained by factors such as governance readiness, social readiness, population and GDP per capita, which affect it positively, whereas CO2 emissions per capita affect it negatively. Thus, countries characterised by good governance, a high level of social readiness, a large population and low per capita emissions tend to attract more climate finance than others.

Secondly, we analysed the factors determining the adoption of green finance practices by commercial banks. Using primary data collected from commercial banks in the UEMOA zone, we

have identified that the banking sector is driven by a top-down approach and decisions from the management board (management pressure) are the main cause of the adoption of green finance practices by commercial banks in the UEMOA zone. Thus, in a context where legislation on green finance is virtually non-existent, only the willingness or motivation of management boards is a determining factor in the adoption of green finance practices. Finally, our empirical study on the impact of environment-related taxes reveals that the environment-related tax levied in its current form has no statistically significant effect on greenhouse gas emissions in West African countries.

Through this thesis, we have contributed to the growing literature on green finance by addressing aspects of the private sector as well as the public sector (local and international) mobilisation of green finance. Given that the bulk of financing comes from international public sources, the authorities in recipient countries need to improve their institutional governance and their Monitoring, Reporting and Verification (MRV) mechanisms. This will help to strengthen confidence between donor institutions and recipient countries. As far as the donor institutions are concerned, it is also important to allocate the funds in line with the needs of the recipient countries. It has long been criticised that climate funding does not generally go where it is most needed. By way of illustration, over the period 2021/2022, 46% of total climate funding went to just 10 countries (Egypt, Nigeria, Ethiopia, Tanzania, Côte d'Ivoire, Morocco, South Africa, Democratic Republic of Congo, Kenya, Uganda), while the 10 most vulnerable countries on the continent (Somalia, Chad, Niger, Guinea-Bissau, Eritrea, Sudan, Liberia, Mali, the Central African Republic, and Uganda) received barely 11% of total climate funding (CPI, 2024b) which may raise concerns about climate justice. The recent New Collective Quantified Goal on Climate Finance, which has just been negotiated at COP29 and should increase the commitments of polluting countries to vulnerable countries, has not lived up to expectations. Much remains to be done to implement the nationally determined contributions of African countries.

In terms of domestic public mobilisation, there is still a lot of work to be done. CPI estimates show that domestic mobilisation by the public sector (including governments, national development finance institutions and state-owned finance institutions) accounts for less than 3% of total climate financing over the 2021/2022 period. In addition, instruments such as taxes related to some carbon-intensive products such as energy, resources, transport and pollution appear to be statistically insignificant in reducing emissions. This raises questions about the effectiveness of these measures

and the design of these taxes. Can a carbon tax be sufficient to reduce carbon emissions and put the continent on a low-carbon development path? Much depends on how these taxes are designed. A carbon tax based on clear CO2 emission reduction targets could a priori help to reduce CO2 emissions. However, this needs to be accompanied by additional measures such as massive investment in renewable energies and the production of alternative energy sources. Without alternative energy sources, there is a risk that emissions will increase. The introduction of a carbon tax must also consider the specific nature of African countries, where the energy demand generally exceeds the available supply. Under this unclear market situation, increasing the price of access to energy products is likely to increase income inequalities or prevent a large part of the population from gaining access to energy. So, the design of an initiative must consider social issues and poverty concerns when adopting new carbon tax policies, especially in Côte d'Ivoire, Ghana, Nigeria and Senegal, where governments show interest in setting up such policies.

As far as the mobilisation of private players is concerned, funds are still lacking. The regional financial authorities need to look at legislation that is conducive to the development of green finance. Although there are a few commercial banks that have adopted the principles of green finance due to the current trend, there is little legislation encouraging the local financial sector to move towards green banking. The BCEAO, as the regulatory authority for the financial sector in the WAEMU zone, needs to look at laws and regulations to integrate green finance into the WAEMU financial sector. The idea of developing a regional green taxonomy is seen as a rapid means of equipping the sector with the principles for virtuous finance in line with countries' climate and sustainability objectives and international commitments.

Finally, this thesis is not without its limitations. One of the difficulties encountered is related to data constraints in terms of green financing, which forced us to reduce our sample for Essay 3. The availability of data in the future will make it possible to consider many countries. In addition, during the collection of primary data on commercial banks, it was difficult to obtain the responses and some of the information was collected via the websites of the banks concerned. We also removed certain questions from our interview guide, such as the share of green financing granted by these banks and other financial questions, to speed up the response process. The openness of the banks and their accessibility to future research will enable future research to gain a better understanding of evolving practices in green finance.

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Annex

Annex 1:

Table 33: List of Sub-Saharan countries

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

Annex 2

To ensure that GDP squared can be considered as our instrument variable. Let's consider the following equation:

$$CO2_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_3 EnvTax_{it} + \beta_4 EI_{it} + \beta_5 PCI_{it} + \beta_6 POP_{it} + \varepsilon_{it}$$

The data-generating process follows an Environmental Kuznet Curve is:

$$\begin{cases} \beta_1 > 0 \text{ and } \beta_2 < 0, \text{the relationship is inverted } U-\text{shaped } (EKC). \\ \beta_1 < 0 \text{ and } \beta_2 > 0, \quad \text{the EKC is not supported} \end{cases}$$

The results from the estimation of the model are presented in the following table:

Table 34: GLS regression output

Regression results

co2	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]
ln_gdp	-.361	.298	-1.21	.225	-.945	.222
ln_gdpsq	.055	.019	2.89	.004	.017	.092
ln_envtax	-.005	.034	-0.15	.88	-.071	.061
ln_ei	.862	.081	10.68	0	.704	1.021
ln_pci	-.033	.074	-0.45	.651	-.179	.112
ln_pop	.091	.119	0.76	.447	-.143	.325
Constant	-3.358	1.604	-2.09	.036	-6.501	-.214
Mean dependent var		-1.311	SD dependent var			0.852
Overall r-squared		0.876	Number of obs			228
Chi-square		543.759	Prob > chi2			0.000
R-squared within		0.847	R-squared between			0.918

**** p<.01, ** p<.05, * p<.1*

Let's test the joint significance of the coefficient:

Table 35: Testing the joint significance of coefficients

Variables		Null hypothesis
(1) ln_gdp	=	0
(2) ln_gdpsq	=	0
(3) ln_envtax	=	0
(4) ln_ei	=	0
(5) ln_pci	=	0
(6) ln_pop	=	0
Chi2 (6)	=	543.76
Prob > chi2	=	0.000

The results show that the coefficients are statistically different from zero, as the null hypothesis is rejected for all the variables, and we conclude that the coefficients are different from zero. Therefore, we conclude that the coefficients $\beta_1 < 0 \; and \; \beta_2 > 0$ and therefore, the EKC is not supported.

Annex 3:

Kao cointegration test

Kao test for cointegration		Number of panels	11
Cointegration vector:	Same	Avg. Number of periods	18.727
Panel means:	Included	Kernel:	Bartlett
Time trend:	Not included	Lags:	1.91 (Newey-West)
AR parameter:	Same	Augmented lags:	1
		statistics	**p-value**
Modified Dickey-Fuller t		-1.2943	0.0978*
Dickey-Fuller t		-1.5597	0.0594*
Augmented Dickey-Fuller t		-1.4051	0.08*
Unadjusted modified Dickey-Fuller t		-3.3647	0.0004*
Unadjusted Dickey-Fuller t		-2.5786	0.005*

*** p<.01, ** p<.05, * p<.1