Green Transition Efficiency in African Countries

The role of climate aid and climate readiness

MSc in Management of Technology

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by

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Preface

In vast and intricate landscapes like Africa, where rural expanses and formidable challenges intersect, the importance of fostering self-determination becomes all the more evident. The magnitude of this endeavor lies not only in its potential to facilitate progress and growth, but also in its capacity to empower local communities, leaders, and individuals with the tools to navigate complexities autonomously. The intent here is far from one-dimensional; it reaches into the heart of empowerment, resilience, and the cultivation of sustainable advancement. By championing the ability of African nations to take an active role in their own development, this study transcends conventional narratives and highlights the value of promoting African leadership and enabling collaborative solutions. In essence, this pursuit is a profound recognition of Africa's unique challenges and opportunities. It acknowledges that the key to unlocking sustainable progress rests within the hands of its people. With this vision, the study shines a light on the transformative potential of enabling nations to shape their own destiny, not through exploitation, but through empowerment, engagement, and the resolute drive to overcome obstacles and forge a path towards a brighter tomorrow.

Stefano Muciaccia
Delft, September 2023

Summary

This research is designed to provide a structured and comprehensive examination of the complex relationship between climate readiness, climate aid, and carbon efficiency in African countries. At its heart, the primary goal is to construct a climate readiness framework initially designed to assess developing nations and subsequently refine it to align with the distinct contexts of African nations. This framework undergoes a two-fold process, starting with its conceptualization and followed by its adaptation through a combination of theoretical examination and real-world application. It forms the foundation of this research, supplying essential insights relevant to policymakers and institutions engaged in tackling climate-related issues specific to Africa.

In the second phase of the study, a linear regression model is employed to analyze the connections between carbon efficiency, climate readiness, and climate aid. Carbon efficiency is determined using Data Envelopment Analysis (DEA), while the climate readiness variable is derived from the developed framework. The empirical findings underscore the critical role of targeted climate aid, particularly in countries with higher climate preparedness. This synergy contributes significantly to decoupling carbon emissions from economic growth, emphasizing the importance of strategic climate aid in fostering sustainable and environmentally responsible economic development.

Overall, this research aims to shed light on the complex interplay of factors shaping climate outcomes in African countries, providing a foundation for informed decision-making and policy development in the realm of climate change mitigation and adaptation.

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Contents

1

Introduction

Climate change has become a critical challenge that affects all aspects of human life, including economic development, social welfare, and environmental sustainability (Pecl et al. 2017). The impacts of climate change are particularly severe in developing countries, particularly in Africa, where vulnerable populations are disproportionately affected (Leichenko and Silva 2014). Although African countries are responsible for only a small portion of global greenhouse gas emissions, they are among the most vulnerable to the impacts of climate change ((WMO) 2023). To achieve economic growth and development while addressing this challenge, a shift towards a more sustainable and green economy is necessary (Hope Sr 2009). In this context, the need for African countries to transition towards a more sustainable and green economy has become increasingly pressing. Climate aid is a critical factor that can help African countries achieve this transition. However, research conducted in South Africa suggests that the climate aid impact on green transition in African countries remains poorly understood (Nhamo 2013).

Climate aid involves financial and technical support provided by developed countries and international organizations to developing countries to help them mitigate and adapt to the impacts of climate change. Understanding the potential impact of climate aid on green transition is important for allocating resources effectively and ensuring that aid is targeted in a way that maximizes its potential for positive change (ILO 2021). Researchers can help inform policy decisions and guide the direction of international aid efforts by investigating the relationship between climate aid and green transition. However, the efficacy of climate aid measures in encouraging the green transitions can be conceived as being dependent on a country's readiness, where climate readiness in this context refers to a country's ability to address climate change through policies and investments that support sustainable and low-carbon growth.

In the policy space, there is already an ongoing debate on the relationship between climate aid and green transition, and whether the effectiveness of climate aid is influenced by the climate readiness of recipient countries (Dolšak and Prakash 2018). However, there is yet no empirical solid analysis that can inform evidence-based decisions in this regard. The objective of this thesis is to explore this knowledge gap. On the one hand, understanding the relationship between climate finance and climate readiness is crucial in co-designing effective climate aid programs that promote sustainable and green development in developing countries. On the other hand, by evaluating a country's readiness for a green transition, policymakers can better determine how to allocate climate finance resources to areas where they are most needed and ensure that the country has the necessary institutional and technical capacity to implement climate change mitigation and adaptation measures. Therefore, the overarching research question of this is:

To what extent does a country's climate readiness influence the effect of climate aid on its carbon-green transition?

To answer this question, this thesis is broken down into three sub-research questions.

1. How climatically ready is a developing country in Africa?
2. What is the effect of climate aid on carbon green transition?
3. Does the impact of climate aid on green transition depend on climate readiness?

By addressing these three sub-research questions, this thesis aims to provide a comprehensive understanding of the relationship between climate aid, climate readiness, and green transition in African countries. In this case, it will provide evidence-based policy recommendations that help inform policymakers and development practitioners on how best to design effective climate aid programs that promote sustainable and green development in African countries and beyond. To this end, the first sub-question assesses the level of climate readiness of developing countries in Africa, to understand the extent to which they are prepared to transition to a green economy. To my best knowledge, there is currently no established framework for assessing a country's climate readiness to transition to a green economy. To address this question, therefore, I will propose a climate readiness framework as well as use it to develop a novel statistical index that evaluates the climate readiness of developing countries for a green transition. This index can help identify areas that require investment and which factors are most important in promoting sustainable and green development. It can also provide a basis for international comparisons and benchmarking, promoting cooperation and learning among countries facing similar challenges. The second and third questions employ econometrics methods to empirically examine the causal relationship between climate aid and green transition, and whether the nature of this relationship depends on the country's level of climate readiness. To address the second and third questions, the thesis employs the climate readiness index developed while addressing the first research question. As per green transition, it employs carbon efficiency as an empirical measure of the extent of the green transition. Carbon efficiency refers to the amount of carbon emissions produced in relation to economic output. It is a crucial concept for promoting sustainable and green development, as it enables countries to reduce their carbon footprint while maintaining economic growth. The importance of carbon efficiency has been highlighted by the Intergovernmental Panel on Climate Change (IPCC) in its latest reports, which emphasize the need for rapid and substantial reductions in greenhouse gas emissions to limit the impacts of climate change (IPCC 2022). A country's carbon efficiency is determined by different factors such as carbon intensity and energy intensity (Yang and Kim 2022), or use of renewable energy sources, the adoption of energy-efficient technologies, and improvements in resource management and waste reduction (F. Wang et al. 2021). Empirical evidence from different studies suggests that promoting carbon efficiency requires a combination of policy, innovation, and industry-specific strategies, and can contribute to achieving sustainable and green development (Zhou and X. Wang 2022) (Pan and Huan Chen 2021).

My thesis makes three important contributions to the literature. First, it provides a novel framework and corresponding index to evaluate a country's readiness to move to a greener economy. Second, it provides novel evidence on the direct association between climate aid and green transition. Third, it provides the first empirical evidence of how the green transition effect of climate aid depends on a country's climate readiness.

2

Literature Review

Climate change framework: from climate aid to climate finance and carbon efficiency

Climate change is a global issue of utmost urgency, and the United Nations (UN) has been instrumental in addressing this challenge. The UN Institute for Training and Research (UNITAR) is a UN agency that provides training, research, and technical assistance to support the implementation of climate policies and projects. The UN's commitment to addressing climate change globally is evident through the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The UNFCCC provides an international platform for countries to work together to mitigate the negative impacts of climate change. The Kyoto Protocol, implemented by the UNFCCC in 2005, set binding targets for reducing greenhouse gas emissions, while the Paris Agreement in 2015 marked a new era for climate financing, policy, and markets. These international efforts recognize the importance of financing for both mitigation and adaptation in developing countries, and the UN's financial assistance has been critical in helping these countries transition to a low-carbon economy.

In this context, my thesis will focus on climate aid, which can be divided into two main categories: climate change adaptation-related aid and climate change mitigation-related aid. Adaptation-related aid aims to reduce the vulnerability of human and natural systems to climate change and associated risks by enhancing adaptive capacity and resilience. On the other hand, mitigation-related aid contributes to stabilizing greenhouse gas concentrations in the atmosphere, preventing harmful interference with the climate system by reducing emissions or enhancing carbon sequestration (OECD-DAC 2011). It is important to note that climate aid has a direct effect on the attitude of governments, firms, and people on green transition decision-making, and it also has indirect effects on the economy and investment, particularly in terms of climate finance, which can improve carbon efficiency. By understanding and analyzing the different dimensions of climate aid, we can gain insights into its impact on carbon efficiency and its broader implications for sustainable development.

More broadly, climate aid is an intrinsic aspect of climate finance, a vital element in addressing climate change and facilitating the transition to a greener future. Climate finance encompasses both public and private financial resources allocated to climate-related endeavors such as renewable energy, energy efficiency, and climate adaptation. Public financing, exemplified by the Green Climate Fund (GCF) established by the UNFCCC, plays a significant role in supporting climate projects in developing countries, with over $10 billion already disbursed (Fund 2023). Furthermore, public financing, like the European Union's Investment Plan for Europe, stimulates private sector investments in climate action, attracting billions of euros (Commission 2020). Private financing, including investments from corporations and institutions, has also witnessed substantial growth, particularly through sustainable finance instruments like green bonds and sustainability-linked loans. For instance, investments in clean energy technologies reached a record high of $495 Billion in 2022 (BloombergNEF 2023). Moreover, the global green bond market achieved a record issuance of $262.5 billion in 2021 (Initiative 2022). However, despite progress, challenges persist, including insufficient funding for climate action, especially in developing nations, and the need to strike a balance between mitigation and adaptation projects (OECD 2023). Private financing faces obstacles in attracting adequate investment due to the perceived risks and lower returns associated with green investments compared to conventional ones (Loukoianova et al. 2022).

As mentioned above, carbon efficiency stands as a crucial goal for addressing climate change and mitigating its impacts. It plays a significant role in achieving a more sustainable and environmentally friendly future. Climate aid has indirect effects on carbon efficiency, manifesting in two distinct ways. Firstly, it stems from the direct effect of climate aid, which encompasses changes in the cooperative attitudes and behaviors of individuals, businesses, governments, and other entities toward climate-related issues. When climate aid initiatives are implemented successfully, they bring about a shift towards more sustainable practices, encouraging the adoption of climate-friendly approaches. This change in mindset and behavior ultimately contributes to enhanced carbon efficiency across various sectors. Secondly, carbon efficiency is an outcome of the indirect effect of climate aid, particularly in the realm of climate finance. Climate aid programs often allocate funds to support the adoption of green technologies and practices. For instance, financial support may be provided to farmers to facilitate the adoption of climate-friendly farming techniques, such as efficient irrigation systems or sustainable agricultural practices. Similarly, climate finance can enable the deployment of climate-friendly technologies, including renewable energy sources, energy-efficient infrastructure, and eco-friendly transportation alternatives. These investments contribute to improved carbon efficiency by reducing greenhouse gas emissions and promoting sustainable resource utilization. Therefore, carbon efficiency is not only influenced by the direct impact of climate aid on cooperative attitudes but also by the indirect effects of climate aid through financial support for the adoption of climate-friendly technologies and practices.

Climate aid and green transition

This study is related to the broader literature on climate aid and green transition, especially studies focused on climate change adaptation and mitigating the effects of climate aid. The relationship between climate aid and green transition has been analyzed in some papers in the existing literature, highlighting the important role that finance plays in enabling countries to transition to low-carbon, sustainable economies. For example, in the study of Schwerhoff (Schwerhoff and Sy 2017) found that climate finance can play a critical role in accelerating the deployment of renewable energy technologies and reducing greenhouse gas emissions. The study also emphasized the importance of effective policy frameworks and institutional arrangements to ensure that climate finance is used efficiently and effectively. However, there is a need for greater transparency and accountability in the use of climate finance, as well as more effective policy frameworks and institutional arrangements to ensure that it is used efficiently and effectively. Moreover, existing studies have emphasized the need for climate finance to be directed towards supporting sustainable and low-carbon economic activities, such as renewable energy, energy-efficient buildings, and sustainable agriculture, in order to achieve long-term emission reduction goals (Tan et al. 2021).

The green transition in Africa has garnered significant attention in recent years, with numerous studies shedding light on its potential and showcasing successful examples. These studies provide valuable insights into the opportunities and challenges associated with advancing sustainability and renewable energy adoption across the continent. A study investigated the role of renewable energy in facilitating the green transition in Africa (Adenle 2020). The research examined the impact of large-scale solar power projects in the countries of Ghana, Kenya, and South Africa. The findings demonstrated that these projects not only contributed to reducing greenhouse gas emissions but also had substantial socio-economic benefits. They created employment opportunities, improved access to clean energy, and stimulated local economic growth. The study emphasized the importance of supportive policies and investment frameworks in fostering the widespread adoption of renewable energy sources.

Another study (Sovacool, Daniels, and AbdulRafiu 2022) focused on the potential of sustainable transportation systems in driving the green transition in African cities. The research examined in the four African urban areas of Johannesburg (South Africa), Kigali (Rwanda), Lagos (Nigeria), and Nairobi (Kenya) the drivers and barriers afforded by three innovations: automated vehicles, electric mobility, and ridesharing and bike sharing. The study revealed that the adoption of electric buses not only reduced air pollution and carbon emissions but also improved urban mobility and public health. The findings underscored the importance of integrating sustainable transportation solutions into urban planning strategies to promote sustainable and livable cities.

These studies exemplify the growing body of literature on the green transition in Africa, illustrating successful examples of renewable energy adoption, sustainable transportation, and climate-smart agriculture. They emphasize the importance of favorable policy frameworks, technological innovations, and investments to drive the transition toward a sustainable and low-carbon future in Africa. By drawing upon these insights, policymakers, researchers, and stakeholders can foster the implementation of effective strategies and promote sustainable development across the continent.

While climate finance and green transition are important factors in addressing climate change and achieving sustainable development, there is limited existing literature that specifically examines the relationship between climate aid and green transition, particularly in developing countries and African countries.

From climate aid to green transition: the role of climate readiness

Climate aid plays a crucial role in facilitating the green transition, but understanding its effectiveness requires careful consideration of various factors. One important aspect to explore is the level of readiness of developing countries for climate change and the transition to a low carbon-intensive economy. This readiness can significantly impact the successful utilization of climate finance in promoting green productivity. By assessing a country's readiness, we can better gauge how effectively climate aid can be harnessed to drive sustainable development.

Furthermore, effective utilization of climate aid necessitates coordination and collaboration among diverse stakeholders, including government agencies, international organizations, and private sector actors. This collaborative effort ensures that funds are utilized efficiently and avoids redundant or overlapping initiatives. By fostering effective coordination, we can maximize the impact of climate finance and channel resources toward the most beneficial projects.

Moreover, the monitoring and evaluation of climate finance programs are essential for assessing their outcomes and ensuring that the intended results are achieved. By closely monitoring the progress and evaluating the effectiveness of these programs, we can identify areas for improvement, make necessary adjustments, and optimize the allocation of resources.

To evaluate the readiness of a country to invest in a more efficient green transition, analysts have looked at a range of different variables. For example, an article may examine a country's renewable energy policies, its level of investment in clean technologies, its emissions reduction targets, and its public awareness campaigns (Ramanathan et al. 2021)(Zeng et al. 2022)(Neofytou, Nikas, and Doukas 2020).

Despite the lack of a comprehensive index, there are many studies and reports that have analyzed specific variables related to countries' readiness to address climate change and transition to a low-carbon economy. For example, the Global Climate Risk Index (Eckstein et al. 2019) assesses countries' vulnerability to extreme weather events based on indicators such as the number of deaths, number of affected people, and economic losses.

The Climate Policy Initiative's Global Landscape of Climate Finance report tracks the flow of funds towards climate-related projects and assesses the effectiveness of different financial mechanisms (Buchner et al. 2011).

The World Economic Forum's Energy Transition Index evaluates countries' progress towards a secure, affordable, and environmentally sustainable energy system based on indicators such as energy security, energy access, and environmental sustainability (Singh et al. 2019).

These reports and studies provide valuable insights into specific aspects of countries' readiness to tackle climate change, but a more comprehensive index that takes into account multiple variables would provide a more complete picture of countries' overall readiness to invest in a more efficient green transition, particularly in terms of carbon efficiency.

Ultimately, comprehending the relationship between climate aid, climate readiness, and the green transition is vital for promoting sustainable and efficient utilization of climate aid. By aligning these elements, we can work towards achieving the ambitious goals set by the Paris Agreement and effectively address the challenges of climate change.

3

Climate Readiness Framework

In order to assess the readiness of African countries for climate transition, it is important to approach this research with a clear understanding of the social rationales and motivations behind it. Central to the essence of this study is the resounding objective to rouse and empower African nations. This undertaking is not centered on exploiting or subjugating these nations; instead, it is firmly rooted in the profound desire to grant them the norms and autonomy to decisively shape the trajectory of their own future.

With this in mind, the concept of readiness within the context of climate change refers to the degree of preparedness and capacity of a country to undertake the necessary actions and measures for a sustainable transition towards a low-carbon and climate-resilient future. The evaluation framework developed for this study takes into account a range of socio-economic and environmental factors that are essential in determining a country's level of preparedness. These factors encompass institutional capacities, policy frameworks, technological infrastructure, financial resources, and public awareness. The development of this readiness evaluation framework involved a rigorous review of existing literature, international guidelines, and best practices in climate transition assessment. The aim is to create a comprehensive and holistic approach taking into account the diverse factors that influence a country's readiness for climate transition.

In order to assess the readiness of developing countries for climate transition, it is important to create a framework that is designed to be generalizable across diverse contexts. To effectively evaluate it, it is critical to establish a versatile framework. Developing nations contain a broad spectrum of socioeconomic, geographical, and cultural contexts, making a one-size-fits-all approach ineffective. A generalizable framework not only accommodates these diversities but also allows for tailored solutions, comparative analysis, equitable resource allocation, and long-term planning. It serves as a foundation for fair assessment, fosters international cooperation, and ensures policy consistency, all of which are crucial elements in addressing the global challenge of climate change.

It is essential to note that the assumptions made during the framework's creation were based on a serious understanding that readiness is influenced by various factors and that an exhaustive evaluation must consider the distinctive contexts of African countries. In the subsequent sections, specific details will be provided regarding the variables used, the data sources employed, and the methodologies applied in evaluating climate readiness. This will ensure a transparent and thorough account of the assessment process, further emphasizing the intention to empower African nations and enable them to play an active and leading role in their own sustainable and low-carbon development.

3.1. Rationales for the index

The rationale behind the components or variables included in an index is essential because it directly influences the index's validity, relevance, and applicability. Each component represents a distinct aspect of the phenomenon or concept being measured, and their selection should be driven by a clear understanding of the research objectives. The rationale ensures that the chosen components are theoretically and empirically linked to the overarching concept, guaranteeing that the index accurately reflects what it intends to measure. Additionally, a well-defined rationale aids in the interpretation and contextualization of index results, enabling stakeholders and policymakers to make informed decisions based on the understanding of the underlying factors. The rationales of this research are presented in the following list:

1. Relevance to Climate Transition: The variables selected should be directly related to the challenges and requirements of climate transition. They should capture aspects such as mitigation efforts, adaptation strategies, emissions reduction targets, and climate policy frameworks. These variables should reflect the fundamental elements necessary for countries for the transition to a low-carbon and climate-resilient future (Lesk et al. 2022).
2. Data Availability and Quality: When selecting variables, it is essential to consider the availability and quality of data at the national level. The chosen variables should be supported by reliable and up-to-date data sources that provide comprehensive coverage across countries. This ensures that the index can be consistently applied and compared across different nations, allowing for meaningful cross-country analyses (Hong Chen et al. 2014).
3. Policy Relevance: The selected variables should align with international guidelines, frameworks, and policy priorities for climate transition. They should reflect established indicators and targets recognized by global climate agreements and initiatives. This ensures that the index captures aspects of readiness that are considered crucial for effective climate action at the international level (Martin and Sunley 2010).
4. Applicability across Diverse Contexts: It is important to choose variables that are applicable and meaningful across diverse national contexts. While the specific challenges and circumstances may vary across countries, selecting variables that are universally relevant facilitates cross-country comparisons and allows for a broader understanding of global climate readiness (Stirling 2007).
5. Multidimensionality: Climate readiness is a multidimensional concept, encompassing various aspects of social, economic, and environmental dimensions. The chosen variables should reflect this multidimensionality. This ensures that the index covers all aspects of climate readiness, including policy and implementation.
6. Nature of the Variables: When selecting variables for climate readiness, it is crucial to consider them as input rather than output variables. By treating them as inputs, they serve as valuable indicators that can provide insights into the factors influencing climate

readiness. This approach ensures that there is a clear causal relationship between the selected variables and the final result. By focusing on the inputs, we can identify the key drivers and determinants that contribute to the overall level of climate readiness. This methodology enhances the accuracy and reliability of the index, allowing for a more comprehensive understanding of the factors that shape countries' readiness for climate transition.

7. Testing in Diverse Contexts for Validity: Climate readiness is influenced by a multitude of factors, including geography, culture, and socioeconomic conditions. By testing the index in different regions and settings, we can determine whether it effectively captures the unique challenges and strengths of each context. Validity hinges on the index's ability to provide meaningful insights and guide informed decision-making across a spectrum of scenarios. This testing process not only enhances the index's credibility but also ensures that it can serve as a valuable tool for policymakers, practitioners, and researchers working in diverse climate-related contexts (Reeves and Marbach Ad 2016).

3.2. Climate readiness conceptualization

At the beginning of this work lies a preliminary study, a detailed exploration conducted to delineate the outlines of this novel index.

In the preliminary phase of this research, a broad and systematic study was made to establish a robust analytical framework. The deep recognition of the urgent need for sustainable development across the African continent urged the inception of an index designed to quantitatively measure the preparedness of each nation to tackle the climate transition.

Upon an extensive review of relevant literature, international agreements, and existing indices, I have developed an analytical framework. By assimilating insights from diverse sources, the preliminary study not only lays the foundational groundwork for the subsequent phases of the research but also captures the principal elements of the general framework that need to be adapted to the specific where it is to be applied.

The analysis of the green transition considered a wide range of factors. Key dimensions examined included the efficacy of policy and regulatory frameworks established to promote environmentally friendly practices (Dögl and Behnam 2015), the adequacy of technological infrastructure to support green initiatives (Loeser et al. 2017), the ambition and feasibility of carbon emissions reduction targets outlined in national agendas (Barragán-Beaud et al. 2018), the level of public awareness and participation in eco-conscious behaviors, and the extent to which economic diversification efforts accounted for environmental concerns.

The result of the preliminary study brought out the essential categories that could serve as a basis for the climate readiness index as shown in Figure 3.1. These categories were chosen to encompass a wide range of factors that play a significant role in evaluating a country's preparedness to embark on climate transitions and align with global climate goals.

After explaining the importance of assessing climate readiness and the areas involved, the next step is to examine the specific variables. In the following part it will explain these variables and their connections to the respective areas:

1. Policy and Regulatory Framework: This variable examines the existence and effective-

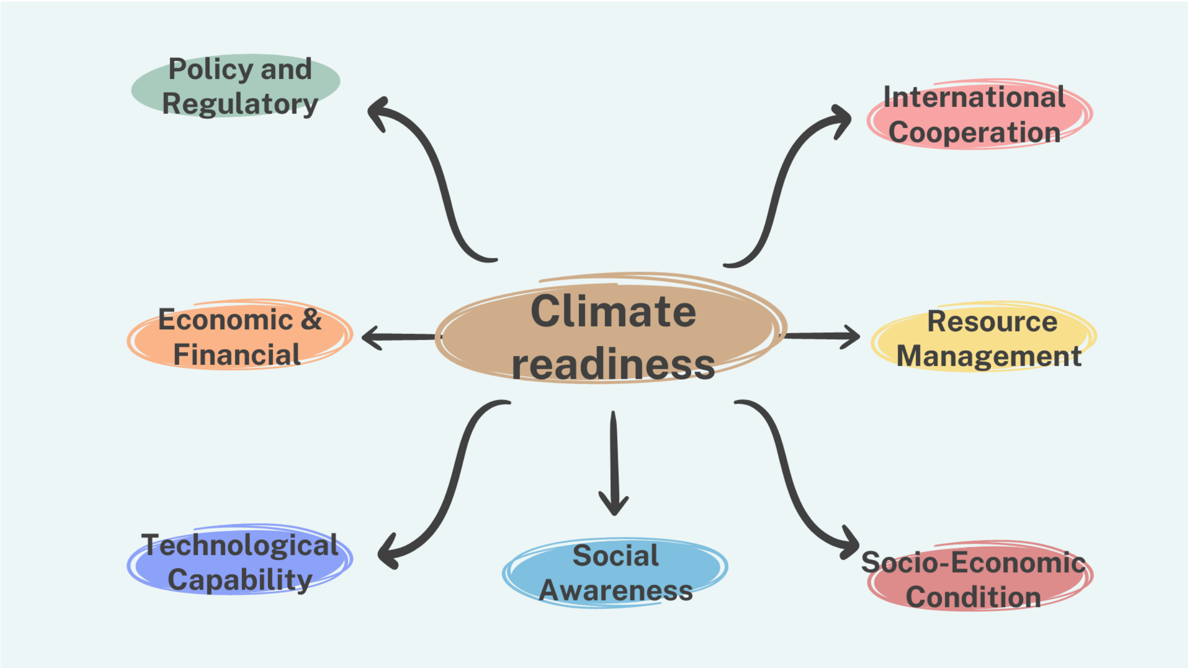


Figure 3.1: Preliminary Study result

ness of climate change policies, regulatory frameworks, and legislative measures. It assesses the strength of climate adaptation and mitigation strategies, the integration of climate considerations into national development plans, and the presence of dedicated climate change departments or ministries. This variable is closely related to the field of policy and planning (Commission 2023).

2. Economic and Financial System: This variable focuses on the financial mechanisms and resources available to support climate change initiatives. It considers the allocation of funds for climate-related projects and the existence of financial instruments that incentivize sustainable practices. (Ionescu et al. 2021)
3. Technological Capability: This variable assesses a country's technological capacity to adopt and deploy climate-friendly technologies. It examines the availability and accessibility of energy-efficient systems and innovative solutions for sustainable practices (Halleck-Vega, Mandel, and Millock 2018).
4. Social Awareness: This variable evaluates the level of public awareness and engagement in climate change issues. It considers the presence of educational programs, training initiatives, and public engagement campaigns aimed at enhancing knowledge and understanding of climate change (T. M. Lee et al. 2015).
5. Socio-economic Conditions: This variable analyzes the socio-economic factors that influence a country's readiness for climate transition. It considers indicators such as poverty rates, income inequality, and social vulnerability. These socio-economic conditions play a crucial role in determining a country's capacity to implement climate change policies effectively (London 2023).
6. Resource Management: This variable focuses on the sustainable management of natural resources, including land, water, forests, and biodiversity. It examines the exploitation

and depletion of natural resources. The objective is to assess the effectiveness of promoting sustainable agriculture and forestry practices while simultaneously safeguarding ecosystems (KOPNINA 2017).

7. International Cooperation: This variable assesses a country's engagement in international climate cooperation efforts. It considers the extent of participation in global climate agreements, collaborations with international organizations, and contributions to global climate finance initiatives. This variable recognizes the importance of international cooperation in addressing climate change challenges (Agrawala 1998).

By examining these variables within their respective fields, the framework gives a comprehensive understanding of the readiness of developing countries to address climate change challenges and promote sustainable and low-carbon development. The subsequent sections will explain my approach for the analysis and evaluation of the framework.

3.2.1. Evaluation of the Framework

The concept of readiness in the context of climate transition encompasses a multidimensional understanding that extends beyond mere preparedness. It involves a country's capacity to effectively navigate and adapt to the intricate challenges and opportunities presented by the ongoing climate transition. Readiness, in this sense, encompasses not only the technological and infrastructural aspects of climate adaptation and mitigation but also the socio-economic, governance, and environmental dimensions. This section elucidates the nuanced nature of readiness, which is paramount for devising an effective framework. Evaluating an index requires a comprehensive approach using also statistical tools. One valuable tool is the visualization of index scores on a geographical map. This approach provides a geospatial perspective, enabling researchers and policymakers to identify regional patterns, hotspots, and disparities in the index's values. Color-coded maps, for instance, can vividly highlight areas of high and low performance, aiding in the identification of regions that may require targeted interventions or resources. Moreover, this visualization technique enhances the communicative power of the index by making complex data more accessible to a broader audience (Graph 2023).

Comparing data distributions is another indispensable statistical tool. It involves assessing the spread and variability of index scores across countries or entities. Techniques like box plots, histograms, or density plots can help reveal the distribution's central tendency, spread, and skewness. This analysis unveils the diversity of experiences and performance levels among countries, offering insights into potential outliers or anomalies (Krzywinski and Altman 2014). Moreover, comparing data distributions can assist in identifying clusters or groups of countries with similar index scores, facilitating the categorization and classification of nations based on their readiness, performance, or development status. Assessing the correlation between countries is crucial for understanding relationships and dependencies within the data. By calculating correlation coefficients and principal component analysis (PCA), researchers can uncover associations between the index and other relevant factors, such as economic development or environmental indicators. These analyses can reveal which variables or components are most strongly correlated with the index, providing insights into potential drivers of readiness or performance (Jolliffe and Cadima 2016). Furthermore, comparing correlations across different time periods or regions can help identify dynamic trends and shifts in the relationships between variables, contributing to a more nuanced understanding of the index's determinants (Bakdash and Marusich 2017).

In addition, this tool can be very useful and utilized by different entities and for different functions:

- User Base: The evaluation of the Climate Readiness Index (CRI) framework must consider its intended users. One key audience for the framework includes policymakers at various levels of government, from local to national and even international bodies. Policymakers can utilize the CRI to assess the climate readiness of their regions or countries, identify vulnerabilities, and formulate targeted climate resilience strategies. Additionally, researchers and academics can employ the framework to conduct in-depth analyses and contribute to the growing body of knowledge in climate adaptation and mitigation.
- Financial Institutions: Financial institutions play a crucial role in addressing climate-related challenges. They can employ the CRI framework to assess the climate readiness of regions where they invest or provide financial services. This assessment informs investment decisions, allowing institutions to allocate resources more effectively to climate-resilient projects. Furthermore, the framework can help financial institutions align their investments with sustainable development goals, ensuring a positive environmental and social impact.
- Cross-Country Learning: An essential aspect of the CRI framework's evaluation lies in its potential for cross-country learning and knowledge sharing. Countries facing similar climate challenges can learn from each other's experiences, successes, and setbacks. By analyzing and comparing their CRI scores and strategies, nations can identify best practices and innovative solutions that have proven effective in similar contexts. This peer learning approach fosters international collaboration and accelerates climate resilience efforts worldwide.
- Standardization and Resource Allocation: The evaluation should also consider the framework's role in standardizing climate readiness assessments and resource allocation. As countries and organizations increasingly prioritize climate action, a standardized assessment tool like the CRI ensures consistency and comparability across regions and sectors. This standardization facilitates resource allocation by helping governments and international agencies identify areas with the greatest need for funding and support. It streamlines the process of organizing and allocating resources for climate resilience projects, making them more efficient and impactful.

In conclusion, this framework acts as a robust toolkit to assess a nation's ability to not only withstand the impacts of climate change but also capitalize on the transformational prospects inherent in this global transition. The evaluation of the Climate Readiness Index (CRI) framework highlights its versatile user base, including policymakers, financial institutions, researchers, and more. It emphasizes the framework's role in cross-country learning and knowledge sharing, enabling nations to draw lessons from one another's experiences. Furthermore, the CRI contributes to standardization efforts in climate readiness assessments, streamlining resource allocation for climate resilience projects. These aspects collectively enhance the framework's value and impact in addressing climate-related challenges on a global scale.

The next chapter will get into the specific methodologies and data sources used to assess these variables and construct the climate readiness index.

4

Research Design

4.1. Data Collection

In the course of my research work, I have sourced all types of data and literature from reputable academic databases, primarily relying on Scopus and Google Scholar for comprehensive and peer-reviewed information. Additionally, the datasets utilized in my research originate exclusively from publicly accessible data banks such as the World Bank, OECD, and Ourworldindata, ensuring the reliability and transparency of the underlying data sources.

For the practical aspects of data manipulation and the initial stages of data processing, Microsoft Excel proved to be the most user-friendly and accessible tool, facilitating straightforward data organization and computation. However, as the complexity of data analysis escalated, I turned to the advanced capabilities of RStudio and R, which offer powerful analytical tools and statistical functions. This transition allowed me to perform in-depth and sophisticated data analyses, ensuring the robustness and precision of the research outcomes. Consequently, the combination of meticulously curated data from authoritative sources and the proficient use of both Excel and R-based tools has been instrumental in conducting rigorous and insightful research across various domains.

For the temporal span, I decided to consider the range between the years 2005-2020. Initially, the idea was to start from the new century. However, unfortunately, some of the datasets that I consider for the calculation of the climate readiness index start from 2003, 2005, or 2006. Hence, to raise the quality and correctness of the dataset, I decided to shift from 2000 to 2005.

All the datasets created and used are gathered at the 4TU Data Repository on the website:

`https://data.4tu.nl/private_datasets/G8F4H-rr72MeJy5jF2ExVgwrY_6K_my5hb2PbJIhsHM`
DOI:`10.4121/92003bab-4539-481c-b2fc-01754e6cce43`

4.2. Operationalising of Climate Readiness Index

4.2.1. Data requirement

In constructing the Climate Readiness Index, I initially identified seven key dimensions crucial for assessing a country's climate readiness: economics and finance, social awareness, technological capabilities, socio-economic conditions, resource management, international cooperation, and policy and regulatory frameworks.

However, data availability posed challenges. I relied on publicly accessible online data sources, which had limitations, such as missing or incomplete data for African countries and insufficient temporal coverage. I addressed these limitations by judiciously supplementing available data with related sources to create comprehensive datasets where necessary. This adaptive approach involved using other related data sources to create comprehensive datasets for areas where direct data was lacking. The ultimate aim was to maintain the integrity of the study while acknowledging the limitations inherent in working with publicly available data.

Table 4.1: Operationalizing Climate Readiness Index

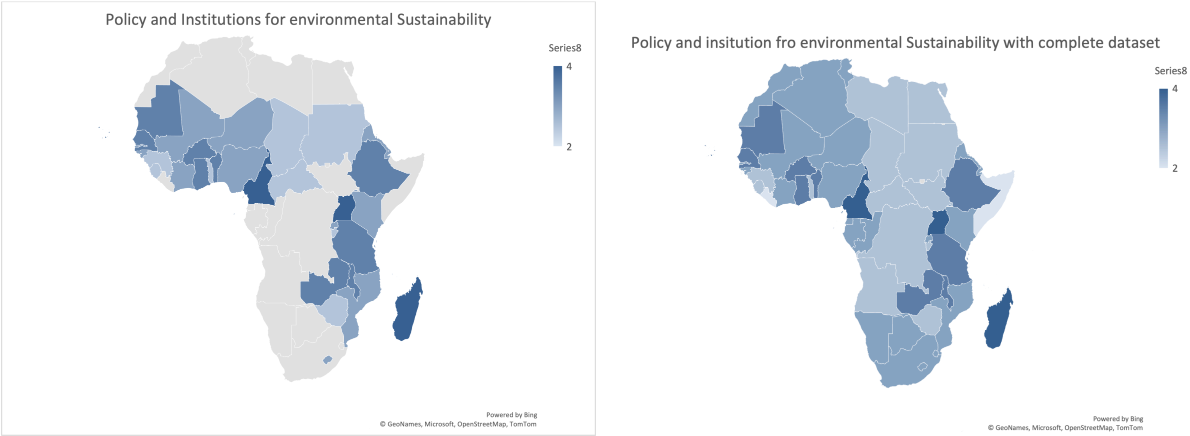
Subcomponent	Variables	Source
Policy	PCIA: Policy and Institution for Environmental Sustainability	World Development Indicators
Economic & Financial	Green bonds	own computation
	Carbon pricing	own computation
	Green tax	own computation
Technological Capability	Development of environmental-related technologies	OECD
Social Awareness	Environmental Performance Index	Yale.edu
Socio-Economic Condition	Human Development Index	Ourworldindata
Resource Management	Natural Resource Depletion	World Development Indicators
International Cooperation	Participation to International programs	own computation

In Table 4.1 is visible as a sum of all the sub-components with the respective variables choices and data source.
In the following sections, all the datasets will be explained and analyzed one by one.

Policy and regulatory System

A dataset from the World Bank's World Development Indicators has been selected for the Policy and Regulatory area. Specifically, the dataset focuses on Policy and Institutions for Environmental Sustainability, which evaluates the impact of environmental policies on the protection and sustainable use of natural resources, as well as pollution management. The evaluation process assigns equal weight to clusters of criteria, contributing 25 percent each to the overall score, calculated by averaging cluster scores. With 16 criteria, countries receive ratings from 1 to 6 based on yearly performance against each criterion, not compared to previous years. Detailed descriptions exist for all 16 CPIA criteria. To address the issue of missing data in the policy dataset, I employed a strategic approach that considered geographical patterns and contextual reasoning.

This dataset primarily comprises institutional and policy values, which tend to remain relatively stable over time when viewed in confluence with trends from other countries. This



(a) Policy map before filling in missing data

(b) Policy map after filling in missing data

Figure 4.1: Policy map comparison before and after filling missing data

stability formed the basis for our data imputation strategy. When dealing with countries that had incomplete data, I filled in the missing values by extrapolating from the closest available data point, thus maintaining the consistency of these institutional and policy variables.

For countries where no data at all were available, a different process was necessary. My goal was to identify potential geographical patterns that could guide data imputation. We recognized that neighboring nations or regions often share similarities in their institutional structures or policy frameworks due to their geographical proximity. By examining the values of nearby countries with available data, I attempted to estimate reasonable values for the missing data of the target country. This approach allowed me to maintain the overall coherence of the dataset while considering the broader geographical context within which these policies and institutions operate, as demonstrated in Figure 4.1.

This robust and multi-dimensional system provides a comprehensive overview of the country's standing in relation to the evaluation criteria, guiding policymakers and stakeholders in identifying areas of strength and potential areas for improvement. The complete dataset and an exhaustive explanation are given in Appendix A.

Economic and Financial System

To thoroughly assess the economic and financial frameworks of nations in terms of their capacity to facilitate the green transition, my focus turned to examining the utilization of green bonds and green taxes within these countries. However, my pursuit for publicly available data that could serve this purpose revealed a dearth of suitable datasets. This compelled me to embark on the creation of a novel dataset tailored to these specific considerations. This dataset comprehends variables: the inception date of a country's initial green bond issuance and the presence of legislation pertaining to carbon pricing or green taxation.

In essence, the formulation of this dataset hinged on the establishment of binary variables corresponding to each of the aforementioned elements. A binary variable assumes the value of 0 if the country in question either hasn't issued any green bonds or lacks active carbon pricing or green tax regulations. Conversely, the variable takes on the value of 1 if a country has initiated green bond emissions and has enacted relevant policies concerning carbon pricing or green taxation. These variables were designed to encapsulate the essence of a nation's alignment

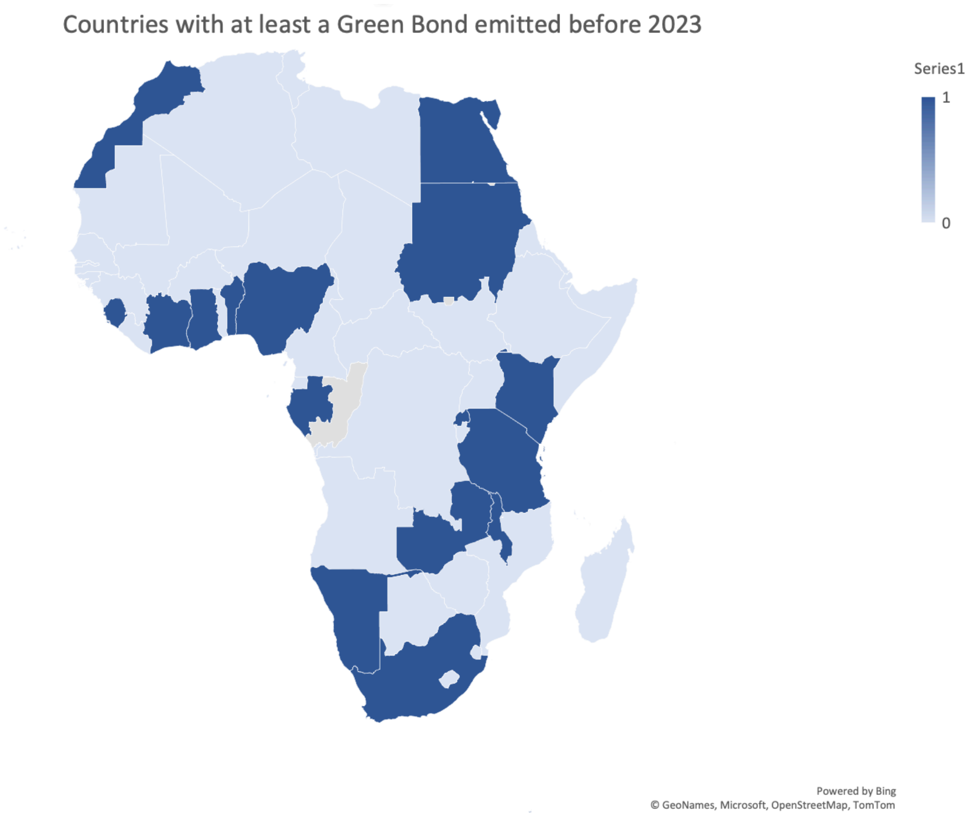


Figure 4.2: Green bond map

with green financial mechanisms.

The culmination of this dataset involved summing these three binary values for each year under consideration. This cumulative summation then allowed for the assignment of a composite score that signifies the extent of a country's engagement with green bonds and environmentally oriented taxation strategies. This scoring mechanism facilitated a nuanced evaluation of a country's performance, where the lowest possible score for any given year is 0, signifying a lack of engagement across all three elements. Conversely, the highest achievable score is 3, indicating comprehensive participation in all three areas.

To comprehensively evaluate the economic and financial aspects of countries regarding their readiness for the green transition, I focused on examining their utilization of green bonds, green taxes and carbon reduction incentives. Unfortunately, my search for readily available data suitable for this purpose revealed a lack of suitable datasets. Consequently, I took the initiative to create a new dataset created specifically for these criteria. It includes three key variables: the date a country initiated its first green bond issuance and the existence of legislation related to carbon pricing and green taxation.

To construct this dataset, I established binary variables corresponding to each of these elements. A binary variable takes the value of 0 if the country has not issued any green bonds or does not have active carbon pricing or green tax regulations in that year. Conversely, it assumes the value of 1 if a country has initiated green bond emissions and has implemented relevant policies on carbon pricing or green taxation in that year. These binary variables capture a nation's alignment with green financial mechanisms.

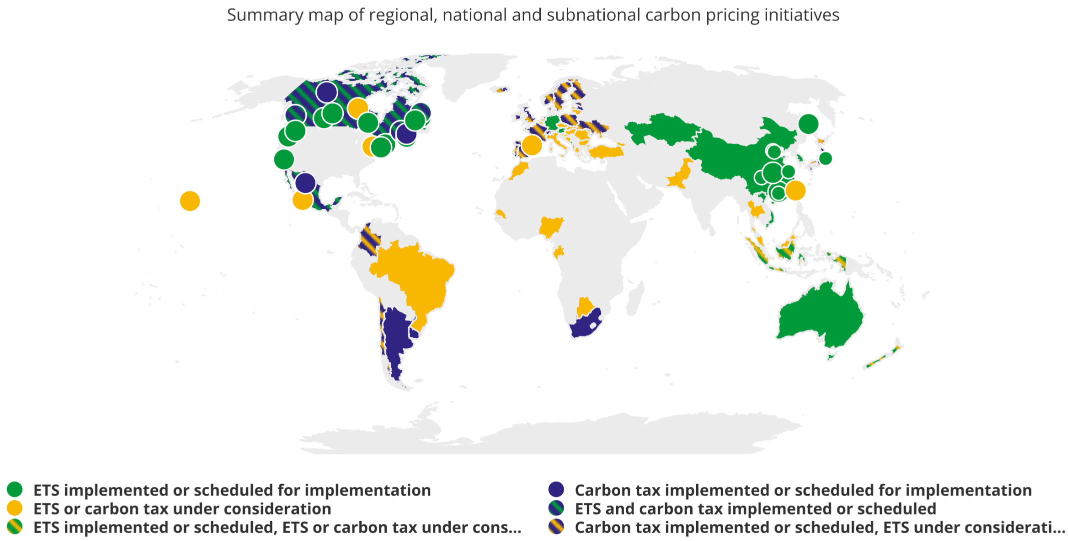


Figure 4.3: Carbon pricing map (Bank 2023)

The dataset's final phase involved summing these three binary values for each year under examination. This implies that, for each year, a country can score from 0 to 3 points. This scoring system facilitated a detailed assessment of a country's performance, with the lowest possible score for any given year being 0, representing no engagement in any of the three elements, and the highest attainable score being 3, signifying comprehensive participation in all three areas.

To create the dataset for carbon pricing, I primarily relied on the World Bank Open Data platform. For the other two variables, I conducted searches using the Google research engine to identify relevant documents and articles. Whenever I found official news or information, I updated the dataset and noted the source. In cases where no information was available online, I interpreted it as a lack of initiatives or consideration in that regard. Consequently, for the binary variable, this implied a value of 0. More details and sources on the table building are given in the appendix .

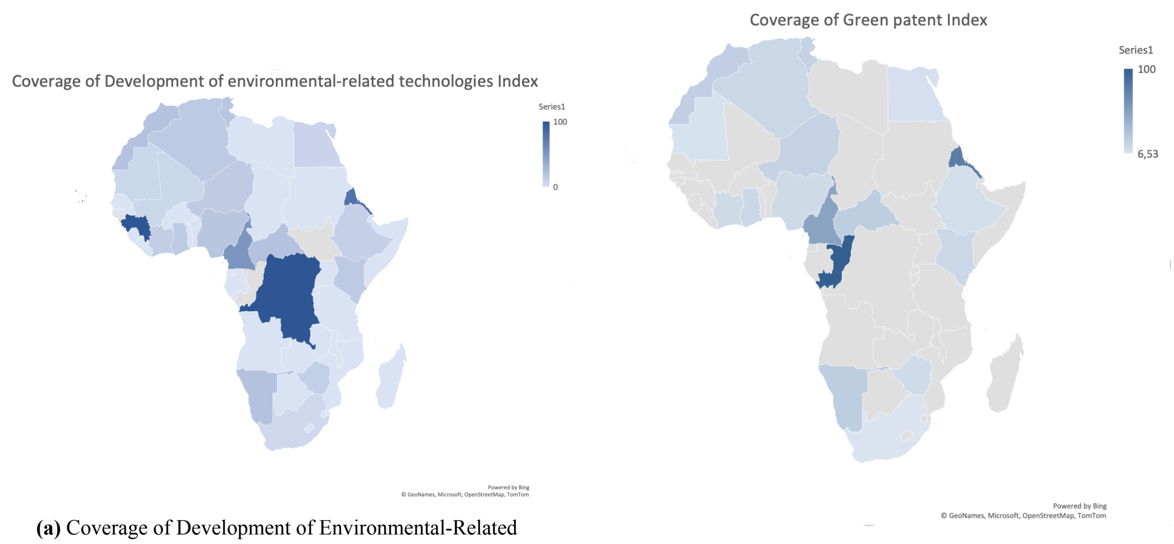
In the two figures Figure 4.2 and Figure 4.3 are shown two of the three subcomponents of the indicator. Respectively, the first one shows the countries that emitted at least one green bond by the end of 2022. While the second one show the carbon pricing map of the world taken from the World Bank website (Bank 2023), the main source of this sub-component within this dataset.

The complete dataset and an exhaustive explanation are given in Appendix B.

Technological Capability

Evaluating a nation's technological capabilities in the context of environmental goals is crucial, and one of the appropriate indicator for such assessment can be the utilization of indexes measuring green patents of a country or the percentage of environmental technologies respect to all the technology used. Within the OECD data repository, a relevant public dataset is available for both these purposes.

The Green Patents Index focuses on counting patents directly related to environmental technologies, offering specificity but potentially missing innovations that aren't patented. On the other hand, the Development of environment-related technologies (% all technologies) Index calculates the proportion of environmentally relevant technologies within the broader technological landscape, providing a comprehensive perspective. While the Green Patents Index captures specific environmental innovations, the % all technologies Index reflects a nation's commitment to environmental sustainability across all technological domains. The choice between these indices depends on research goals, policy priorities, and the desired level of detail when assessing a nation's technological capabilities for environmental sustainability.



(a) Coverage of Development of Environmental-Related Technologies Index

(b) Coverage of Green Patent index

Figure 4.4: Coverage map comparison between green patent and environmental-related technologies index

Instead of relying on green patents, my final decision is to rely on an OECD dataset specifically designed to measure the Development of environment-related technologies as a percentage of all technologies. This decision is motivated by the dataset's greater relevance to assessing technological capabilities in this context and for its more comprehensive coverage.

The Figure 4.4 shows two important evidences: the differences between the coverage of the two different datasets (green patents and development of environmental-related technologies), and the average of countries among all the period.

The second picture of this section, Figure 4.5, illustrates the distribution of values of the technology environmental-related index among African countries. It's evident that, in general, the values for each country mostly fall within the 0 to 40 range. However, what's interesting is the presence of unexpectedly high maximum values in several nations. I use the term "unexpected" because, upon analyzing individual countries, these high values often appear as outliers. Typically, countries with maximum values within their dataset exhibit a pattern of 0, followed by 100, and then return to 0. An example of this pattern is shown in the Figure 4.6. This phenomenon could be attributed to the relatively low utilization of technologies in African countries. Therefore, in years when they begin adopting environmental-related technology, the index score can undergo significant fluctuations.

The complete dataset and an exhaustive explanation are given in Appendix C.

Social Awareness

To assess social awareness in the context of environmental transition, I rely on a comprehensive dataset that offers a holistic view of a country's green transition performance. My focal

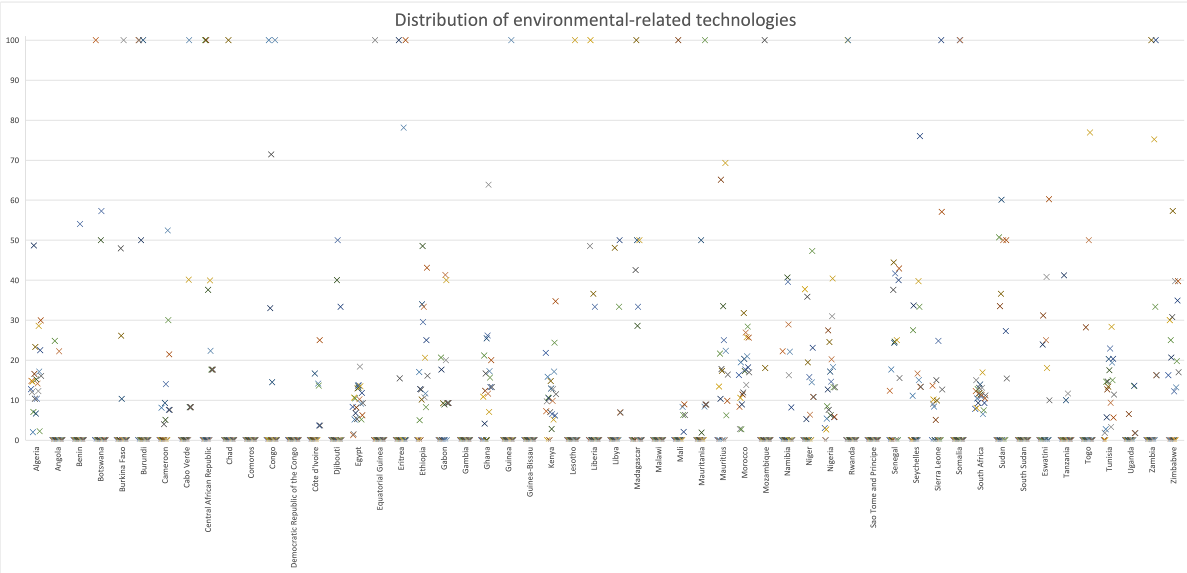


Figure 4.5: Distribution of the environmental-related technologies

point for this evaluation is the Environmental Performance Index (EPI), a globally applicable assessment tool.

The Environmental Performance Index (EPI) serves as a data-driven synthesis, encompassing sustainability on a global scale. This index evaluates 180 countries based on 40 distinct performance indicators spanning 11 crucial environmental categories. By rigorously examining factors like climate change performance, environmental health, and ecosystem vitality, the EPI assigns rankings that reflect a nation's environmental progress (Yale 2022). These global rankings provide insights into a country's ability to tackle universal environmental challenges. Policymakers can dissect performance in specific categories, objectives, peer groups, and individual nations. This in-depth analysis not only reveals a country's standing but also highlights its performance against specific benchmarks. The Environmental Performance Index (EPI) is a globally recognized benchmark, updated biennially. Yale University initiated the EPI computation in 2006, marking its inception.

To address missing data in the dataset, I adopted a systematic approach to ensure data completeness and consistency. The dataset began in 2006, with biennial reports, resulting in gaps for odd-numbered years. Initially, I filled in missing even-year data by calculating the average of available values for the specific country across the years. This approach worked well for most countries, except for South Sudan and Somalia.

For South Sudan, which had an entirely empty dataset, I assigned each year the average value calculated from all countries for that specific year. This method provides a reasonable estimation based on regional trends and it tries not to bias the aggregate result. Somalia posed a different challenge, as it had only one value in 2014, significantly lower than the African average. To address this, I adopted a comparative approach. I selected Sierra Leone, a country with a similar average, as a reference. Using Sierra Leone's data, I conducted a trend analysis to determine Somalia's expected values between 2006 and 2022, ensuring consistency with its comparative counterpart. I opted for this approach because I believed that using the average of the complete dataset would introduce more bias in the case of Somalia. The available data

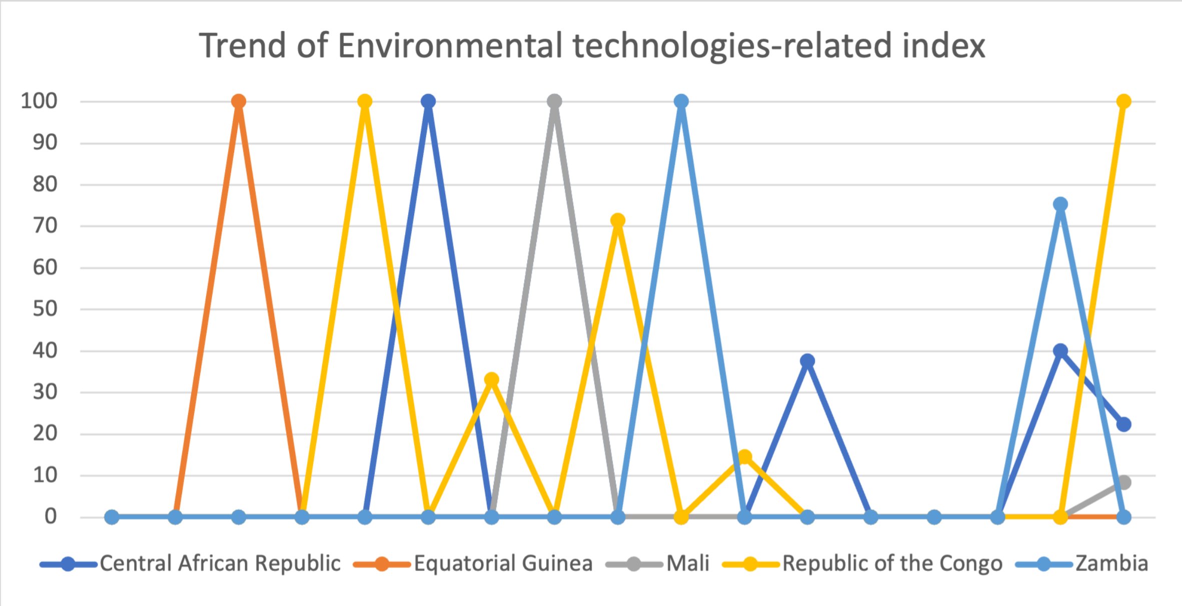


Figure 4.6: Trend of environmental technologies related

for Somalia indicated a significantly lower performance compared to the average value, while South Sudan had no available data to consider.

After the original Yale dataset was filled, attention turned to the odd-numbered years. To fill these gaps between 2005 and 2021, a logical yet reliable method was employed. The missing values were estimated by taking the average of the data from the years immediately preceding and following the gap with the year 2005 being treated as equivalent to 2006. For instance, the value for 2007 was computed as the average of 2006 and 2008. This approach maintained data continuity to ensure a seamless transition across the entire time span.

To illustrate the construction of the dataset, let us consider a practical example. Raw data from the EPI provided the foundational information. Subsequent processing and refinement culminated in the tables of Appendix D—the definitive edited dataset. This progression from raw data to the meticulously curated dataset showcases the transformation of unprocessed information into a refined and coherent resource. A map of the averages of the African countries at the end of the interpolation of the data can be seen in Figure 4.7. The complete dataset and an exhaustive explanation are given in Appendix D.

Socio-Economic Condition

To measure a country's socio-economic condition, I employed the Human Development Index (HDI) (Roser 2014). This index offers a comprehensive assessment of a nation's socio-economic landscape, considering crucial developmental dimensions. By evaluating longevity, education, and standard of living, the HDI offers a well-rounded perspective on human well-being. Its multidimensional nature ensures that it accounts for various aspects of human development, making it a valuable tool for cross-country socio-economic comparisons.

Within the context of the Human Development Index (HDI), addressing missing data primarily concerned Somalia and South Sudan. The Somalia dataset presented an empty value for all the years of the time span. To overcome this lack, I decided to use the average HDI value across

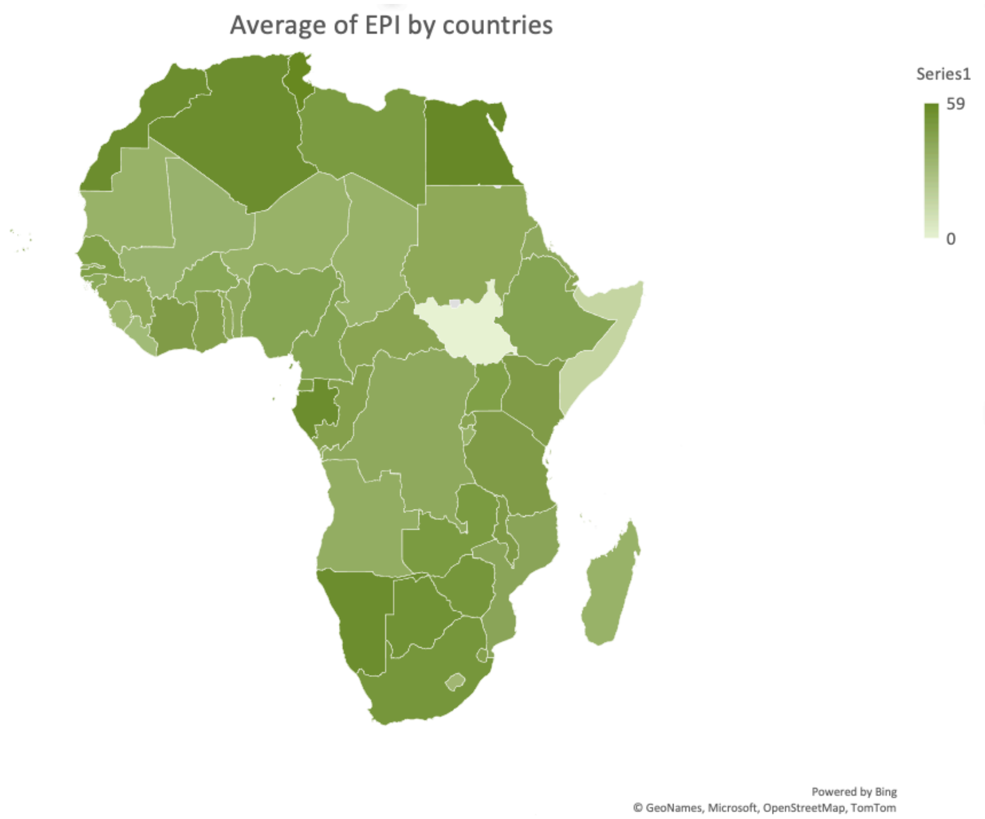


Figure 4.7: Environmental Performance Index map

all African countries for that specific year as an approximation. This method ensured that the missing data aligned with the aggregate regional trends and context.

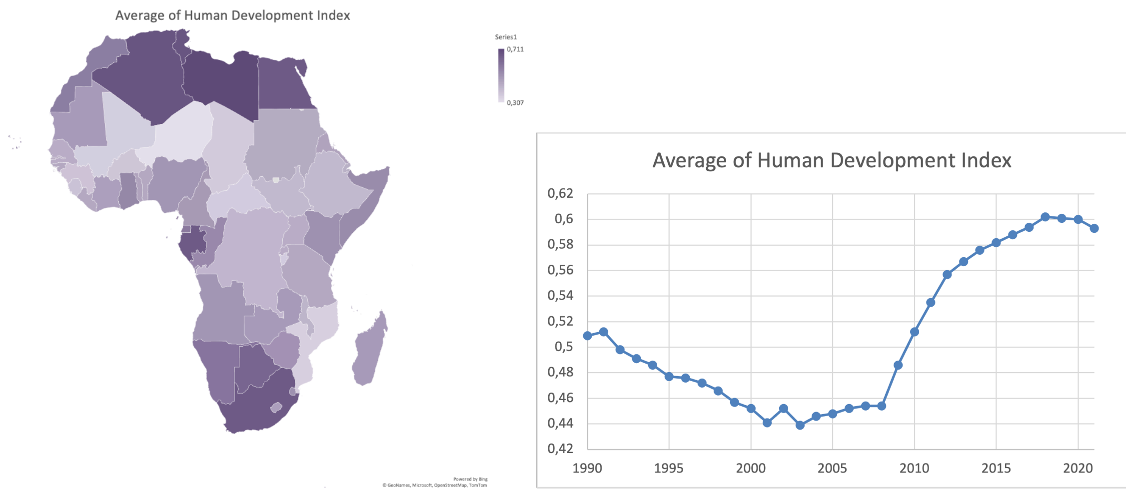
In contrast, South Sudan's dataset exhibited a detectable trend, facilitating a systematic approach to filling gaps. I employed a linear continuation of the observed trend, guaranteeing that the absent HDI values for South Sudan remained consistent with the historical trajectory derived from available data. This approach maintained data coherence and represented South Sudan's HDI within its historical development context. A map displaying the averages of the final dataset is presented in Figure 4.8a. Additionally, analyzing the average African values over the years gives us an interesting observation. The average value experienced a gradual decline from the 1990s, followed by a rapid logarithmic increase between 2008 and 2020, as evident in Figure 4.8b.

The complete dataset and an exhaustive explanation are given in Appendix E.

Resource Management

Assessing a nation's ability in natural resource management is intrinsically complicated. In this analysis, we concentrate on a crucial element of this assessment which is the natural resource depletion employing data from the World Bank. This indicator describes three crucial dimensions: net forest depletion, energy depletion, and mineral depletion. Each of these dimensions reveals distinct aspects of resource scarcity and its consequences.

Addressing gaps in the Natural Resource Depletion dataset I used a data-driven strategy, guided by distinctable trends observed in most countries. When a clear and consistent trend was iden-



(a) Average of the Human Development Index

(b) African average by year of the Human Development Index

Figure 4.8: Human Development Index datasets analysis

tified, the logical approach was to continue along that established path. This method preserved the dataset's internal coherence and alignment with observed patterns.

However, challenges arose in cases like Eswatini, Sudan, and South Sudan, characterized by data absence of the entire dataset or by the presence of outlier values. To maintain dataset consistency and prevent undue disruptions, missing values were substituted with average values derived from all African countries for the corresponding years. This approach aimed to provide a more balanced and regionally relevant representation of natural resource depletion, enhancing dataset robustness for analysis and evaluation. The map displaying the final results is depicted in Figure 4.9.

The map clearly illustrates that the majority of countries exhibit low scores. Notably, a closer examination of countries with higher values is of interest. As seen in the graph presented in Figure 4.10, countries like Algeria, Guinea-Bissau, and Liberia demonstrate minimal variance, while others exhibit greater inconsistency and feature high-value outliers.

It is essential to underscore the uniqueness of this dataset, as it signifies an "inverse" relationship. In essence, a high value in the Natural Resource Depletion Index corresponds to a reduction in the Climate Readiness Index. Therefore, to ensure consistency in the final average calculation, the reciprocal value (1 minus the Natural Resource Depletion score) was employed. This approach offers a more coherent and intuitive representation of the dataset, aligning with the anticipated inverse association between natural resource depletion and climate readiness.

The complete dataset and an exhaustive explanation are given in Appendix F.

International Cooperation

This variable aims to encapsulate the extent of international collaboration exhibited by countries. A methodical approach to quantify this variable involves an examination of various international environmental congresses and protocols that nations have ratified. In the absence of a readily available dataset, a new novel dataset was constructed. It aims to establish the level of involvement of countries in significant environment-related protocols. To achieve this, a scoring mechanism was designed, which implies assigning scores to countries based on their

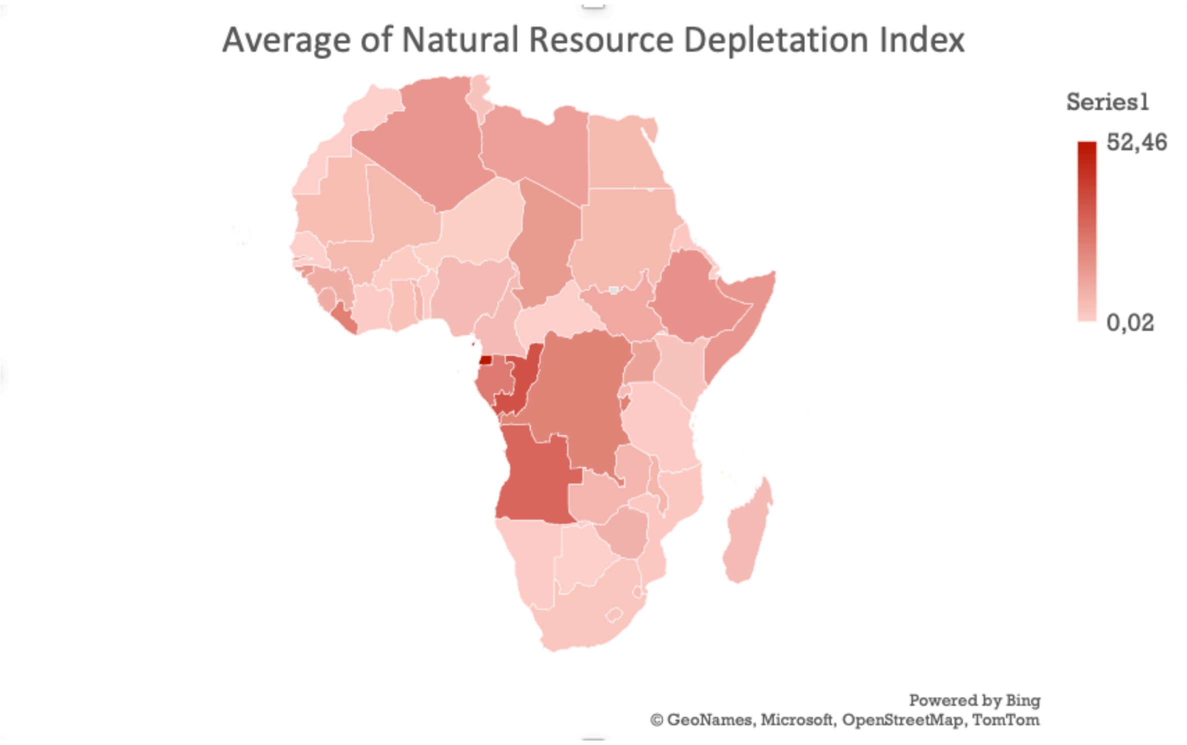


Figure 4.9: Average of the Natural Resource Depletion Index

agreement to participate in specific protocols. The scoring system was structured to award one point to a country for each protocol it adhered to, commencing from the year of its entry into the respective protocol. Subsequently, this score was restarted and assigned if the country continued to agree with the protocol. Conversely, if the country didn't sign any protocol, it would be allocated zero points for that particular protocol. This approach allows for the aggregation of points across all the protocols a country is respectful of, offering a comprehensive picture of its cooperative participation.

Furthermore, a monitoring system was incorporated throughout the data production process to monitor the maximum achievable score in succeeding years. This included counting active protocols and creating a standard against which different nations' cumulative scores could be assessed. This dual-track method, which involves both the accumulation of points and the contemporaneous tracking of the greatest possible score based on active protocols, contextualizes and validates nations' joint involvement in the ever-changing world of environmental protocols. Below in the tables in Appendix G is shown the final score of the countries and the relative number of active protocols in the specific year.

An interesting insight is shown by the data presented in Figure 4.11b. As depicted in the graph, African countries have consistently participated in international cooperation initiatives over the years, and progressively narrowing this small gap.

The complete dataset and an exhaustive explanation are given in Appendix G.

4.2.2. Data comparability

In the process of constructing an index, one of the foundational imperatives is to ensure the comparability of variables and datasets employed within the index framework. The validity of

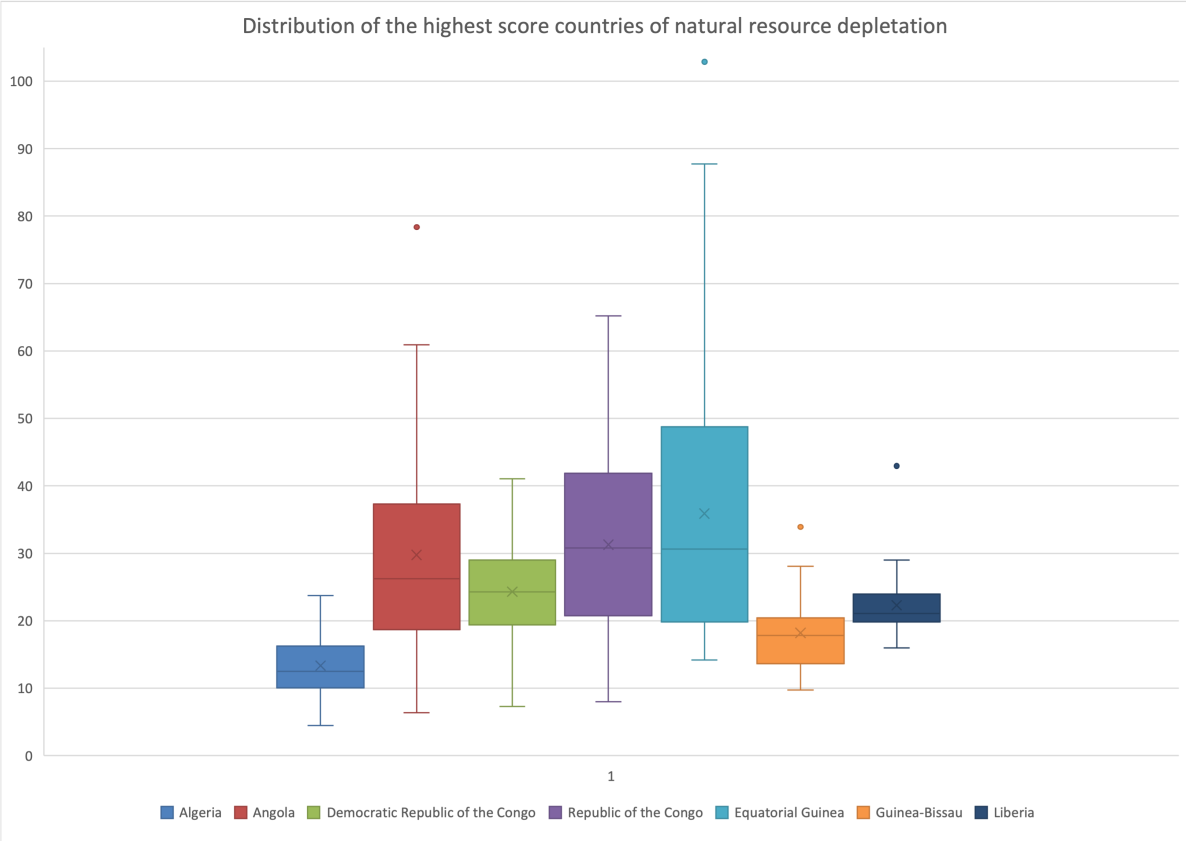
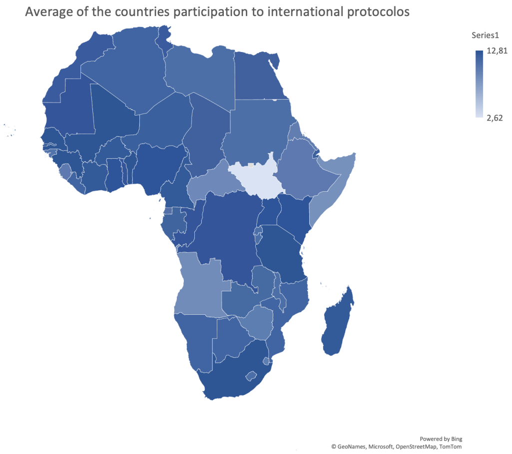


Figure 4.10: Natural resource depletion distribution of the countries with the highest values

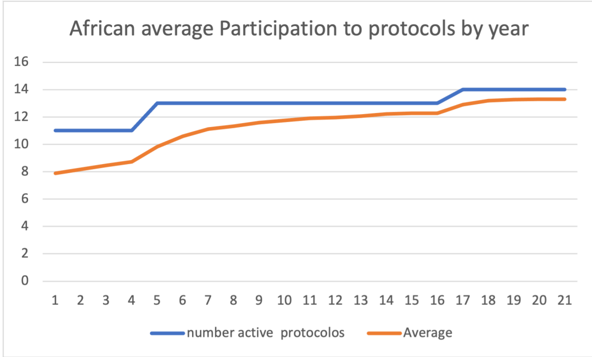
the index relies on conforming diverse variables and data sources to enable meaningful comparisons over time and across sections. Comparable variables and datasets enable a consistent assessment of the phenomena under study, mitigating biases and ensuring that the index accurately reflects the underlying realities. By aligning measurement methodologies, units, and scales, researchers can establish a solid foundation for drawing insightful conclusions and making informed decisions based on the index's findings. The pursuit of comparability underlines the commitment to a rigorous and reliable index that stands as a dependable tool for analysis, policy formulation, and informed decision-making.

The initial step in any data analysis process, especially when dealing with datasets from diverse sources, is to adjust the data to ensure comparability. This process is essential due to several inherent challenges associated with disparate datasets:

- Differing Units of Measure: Data from various sources may employ different units of measurement for the same underlying concept. For example, one dataset might express temperature in degrees Celsius, while another uses Fahrenheit. Such variations can lead to incomparable data unless converted into a standardized unit.
- Varying Orders of Magnitude: Data can exhibit significant differences in the order of magnitude. Some variables may range from very small values (e.g., fractions or percentages) to extremely large ones (e.g., population figures or GDP). The wide range of scales makes direct comparisons problematic, as it can disproportionately impact the analysis and visualization of the data.



(a)



(b) Comparison between the number of active protocols and the African average year by year

Figure 4.11: Analysis of international cooperation of the African countries

- Data Collection Methods: Datasets often originate from different data collection methods or instruments, leading to variations in precision and accuracy. These discrepancies can result in noise or bias in the data, further complicating direct comparisons.
- Geographical and Temporal Variability: Spatial and temporal variations are common in many datasets. These variations can affect the comparability of data points, especially if the datasets cover different geographic regions or time periods.

To address these challenges and enable meaningful comparisons, data standardization and preprocessing techniques are applied. These techniques involve converting data into a common unit of measure, normalizing data to a consistent scale, and handling missing or erroneous data points. The goal is to create a level playing field where data from various sources can be analyzed, visualized, and interpreted effectively. By doing so, I ensure that the analysis is based on accurate and comparable information, ultimately leading to more robust and reliable research outcomes.

Standardization and normalization are data preprocessing techniques commonly used in data analysis, machine learning, and statistics to prepare data for modeling and analysis. These techniques are not standalone tools or software but rather data transformation methods. They are applied to modify the scale or distribution of data attributes (features) to make them suitable for analysis or modeling. In particular, standardization (or Z-score normalization) is a process that rescales a feature's values to have a mean of 0 and a standard deviation of 1. It subtracts the mean from each data point and then divides by the standard deviation. Standardization is useful when features have different units or scales, and it ensures that they all have the same scale, making it easier for models to learn and converge efficiently. Excel standardize is available under Excel Statistical Functions. It returns a normalized value, which is also called Z-score (Simplilearn 2023). The formula is shown in the following equation:

$$\text{Standardized Value (z-score)} = \frac{\text{Value} - \text{Mean}}{\text{Standard Deviation}} \tag{4.1}$$

In this formula:
"Value" represents the data point you want to standardize.

"Mean" is the mean (average) of the dataset.
"Standard Deviation" is the standard deviation of the dataset.

On the other hand, normalization (or Min-Max scaling) transforms data so that it falls within a specified range, typically between 0 and 1. It is achieved by subtracting the minimum value of the feature from each data point and then dividing by the range (the difference between the maximum and minimum values). Normalization is helpful when you want to compare values with different ranges and ensure that all features are on a similar scale. The formula used in Excel to normalized data is the following:

$$\text{Normalized Value} = \frac{\text{Value} - \text{Min}}{\text{Max} - \text{Min}} \tag{4.2}$$

In this formula:
"Value" represents the data point you want to normalize.
"Min" is the minimum value in the dataset.
"Max" is the maximum value in the dataset.

After ensuring the comparability of all data within a standardized range of 0 to 1, the ultimate index emerges as an amalgamation of these variables. This culminates in the calculation of an index score that represents the average of all relevant variables for a given country in a specific year. However, it's important to note that not all countries possess complete data availability across all variables, posing a challenge to the index's accuracy. Despite this limitation, the resulting index produces insightful outcomes that offer a valuable perspective on the climate readiness of African countries.

4.2.3. Calculation of the Climate Readiness Index

To understand the importance of the different sub-components in the index calculation some statistical tools can be utilized. Factor analysis and Principal Component Analysis (PCA) are powerful statistical techniques that can be beneficial for index calculation.

Factor analysis and PCA are used for dimension reduction, which is particularly useful when dealing with a large number of variables contributing to an index. These techniques identify underlying latent factors or principal components that capture most of the variability in the data, simplifying the index calculation. They can help in identifying key drivers or underlying factors that influence the variables in an index. For example, when calculating a climate readiness index, these methods can pinpoint primary dimensions (e.g., infrastructure, policy, education) that contribute significantly to a country's readiness for climate change.

These techniques allow for the assignment of weights to variables based on their factor or component loadings, enhancing the index's robustness and alignment with the data's structure. While they reduce dimensionality, the resulting factors or components are often more interpretable than the original variables, aiding in a better understanding of the index's underlying structure. I embarked on the journey of understanding my dataset by initially computing a Principal Component Analysis (PCA). As a crucial initial step in this analysis, I examined the correlation matrix of the variables within my dataset.

As depicted in Figure 4.12, the correlation matrix revealed a meaningful observation: the variables displayed a small level of correlation. In essence, this observation signifies that there

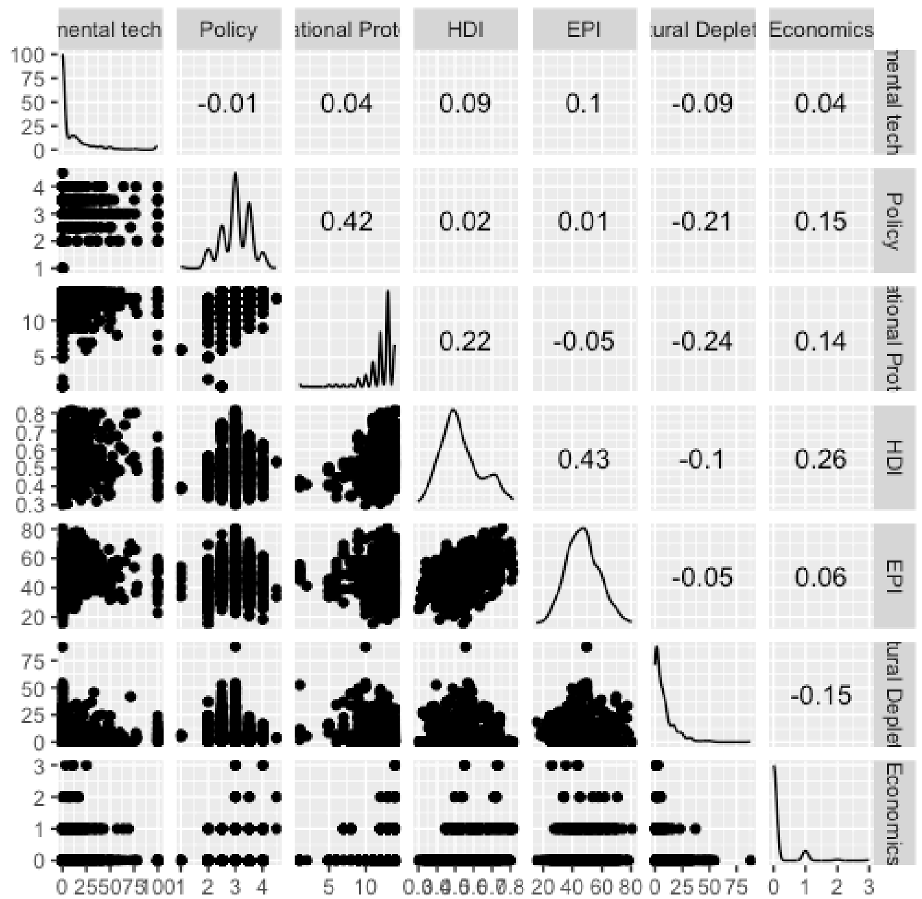


Figure 4.12: Correlation matrix and distribution of the dataset

exists little to no discernible linear relationship or association between these variables. Such a scenario has important implications for the outcome of a Principal Component Analysis.

In cases where variables exhibit weak correlations, as they do in my dataset, it implies that the potential for capturing substantial variance through PCA may be limited. To assess the validity of this conjecture, I performed a PCA analysis using R.

The summary of the PCA yielded a set of insightful results is shown in Table 4.2.

Table 4.2: PCA summary

	Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6
Standard deviation	0.5868572	0.4789389	0.3731278	0.3338145	0.25854272	0.1560879
Proportion of Variance	0.3761285	0.2505138	0.1520501	0.1216976	0.07300221	0.02660785
Cumulative Proportion	0.3761285	0.6266423	0.7786924	0.9003899	0.97339215	1

These results, outlined in Figure 4.13 and summarized in Table 4.2, reveal a pertinent aspect of the PCA analysis. The first principal component accounts for approximately 37% of the total variance. Subsequently, the second component contributes an additional 25%. Notably, the cumulative contribution of these first two components remains below 63%. To surpass the significant threshold of capturing over 90% of the variance, it becomes crucial to take into consideration at least the first four principal components.

To totally comprehend the PCA analysis, an exploration of the loadings is essential. Loadings

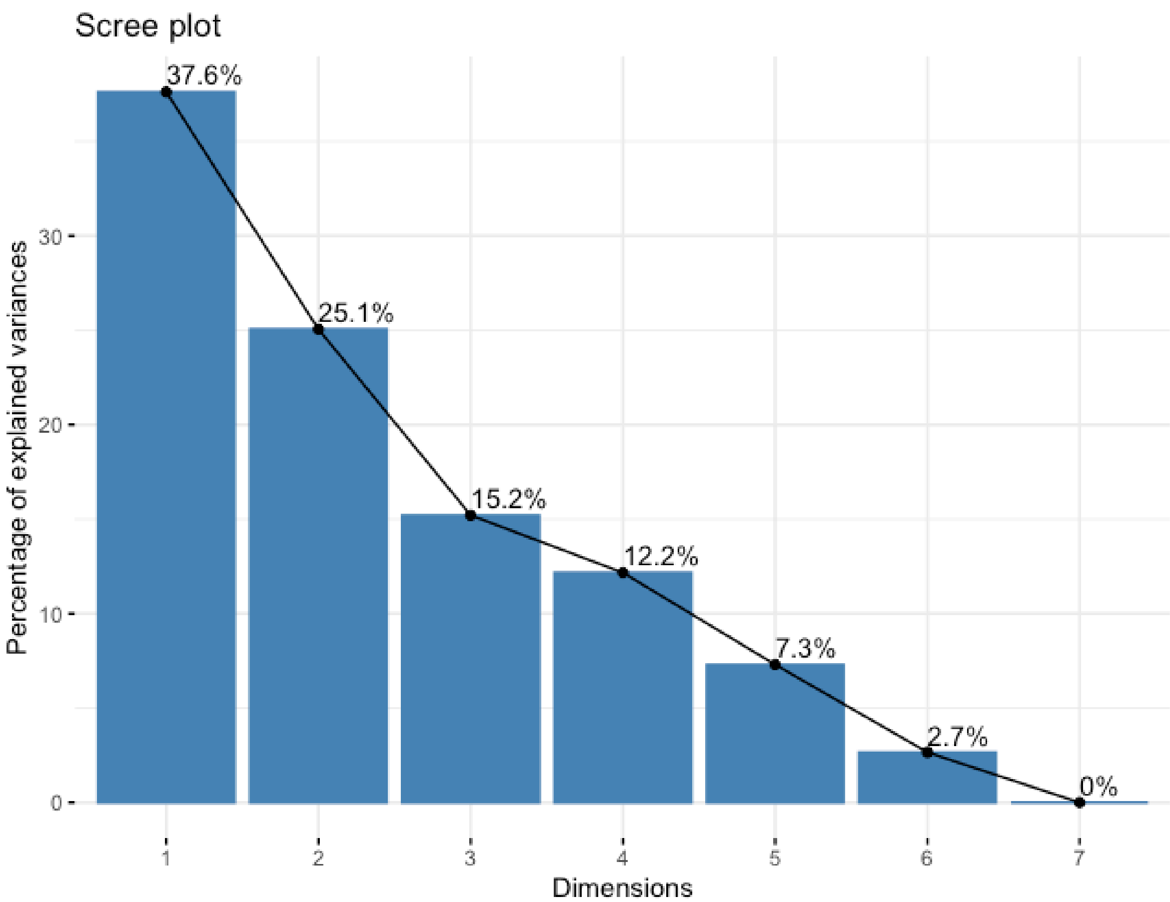


Figure 4.13: Percentage of explained variance

can be interpreted as the coefficients of the linear combination of the original variables used to construct the principal components. Numerically, they are determined by the coordinates of the variables divided by the square root of the eigenvalue associated with the respective component.

Table 4.3: Loadings of the 7 variables for the first 4 principal components

	Comp.1	Comp.2	Comp.3	Comp.4
Environmental technologies	0.05266172	0.1176376	0.90162621	0.10157775
Policy	-0.5081781	-0.2890292	-0.0692067	-0.2506223
International Protocolos	-0.5420436	-0.1604858	-0.040167	-0.23650051
HDI	-0.1058888	0.5891623	-0.2201129	-0.054622
EPI	0.11417827	0.6183155	-0.1001807	-0.3964381
Natural Depletion	0.59838263	-0.340739	-0.2812872	-0.0168599
Economics	-0.250718	0.1770268	-0.2075063	0.84291574

In Table 4.3, I have presented the loadings for all seven variables across the first four principal components. In my analysis, the four principal components are characterized by:

- Comp.1: Environmental Technologies has a positive influence, while Policy, International Protocols, and HDI have negative influences. This suggests that higher values of

Comp.1 correspond to more advanced Environmental Technologies but less favorable Policy, fewer International Protocols, and lower HDI scores.

- Comp.2: HDI and EPI have strong positive influences on Comp.2, indicating that higher values of Comp.2 are associated with higher human development and better environmental performance.
- Comp.3: Comp.3 is primarily shaped by Environmental Technologies, with a strong positive influence.
- Comp.4: Economics strongly influences Comp.4 positively, implying that higher Comp.4 values correspond to stronger economic indicators.

The application of Principal Component Analysis (PCA) is a valuable tool, but its suitability should be determined by the specific research objectives, the characteristics of the dataset, and the theoretical framework supporting the study. In my particular research context, the utilization of statistical techniques like PCA has encountered notable challenges and inaccuracies, largely due to the inherent limitations in the datasets employed. As illustrated in Figure 4.12, the correlations among the variables are exceedingly weak. This implies that it may be more reasonable and efficient to consider that all variables contribute uniformly to the final climate readiness index, given the minimal discernible variation in their relationships.

Hence, I ultimately opted for a different approach to construct the index. The index construction process lies in the computation of average values for each entity and time period. This was accomplished by summing the normalized values of all selected indicators in that specific year and subsequently dividing by the total number of indicators. The resulting average index values represented the comprehensive assessment of the concept for each entity-year combination. The final calculation can be summed in the following equation:

$$\text{CRI}_{i,y} = \frac{\text{Policy}_{i,y} + \text{Economic}_{i,y} + \text{Green patents}_{i,y} + \text{Protocols}_{i,y} + \text{HDI}_{i,y} + \text{EPI}\ _{i,y} + \text{Resource}_{i,y}}{\text{Number of the total variables}} \tag{4.3}$$

In this formula:
$\text{CRI}_{i,y}$ = Climate Readiness Index of country i in the year y
$\text{Policy}_{i,y}$ = normalized score of the variables policy and institutions for environment sustainability of country i in the year y
$\text{Economic}_{i,y}$ = normalized score of the economic and financial score of country i in the year y
$\text{Green patents}_{i,y}$ = normalized score of the green patents of country i in the year y
$\text{Protocols}_{i,y}$ = normalized score of the participation to the international protocols of country i in the year y
$\text{HDI}_{i,y}$ = normalized score of the Human Development Index of country i in the year y
$\text{EPI}_{i,y}$ = normalized score of the Environmental Performance Index of country i in the year y
$\text{Resource}_{i,y}$ = normalized score of the adjusted value of the natural resource depletion of country i in the year y

The final result is shown in Figure 4.14, which represents the average of the temporal span for each African country.

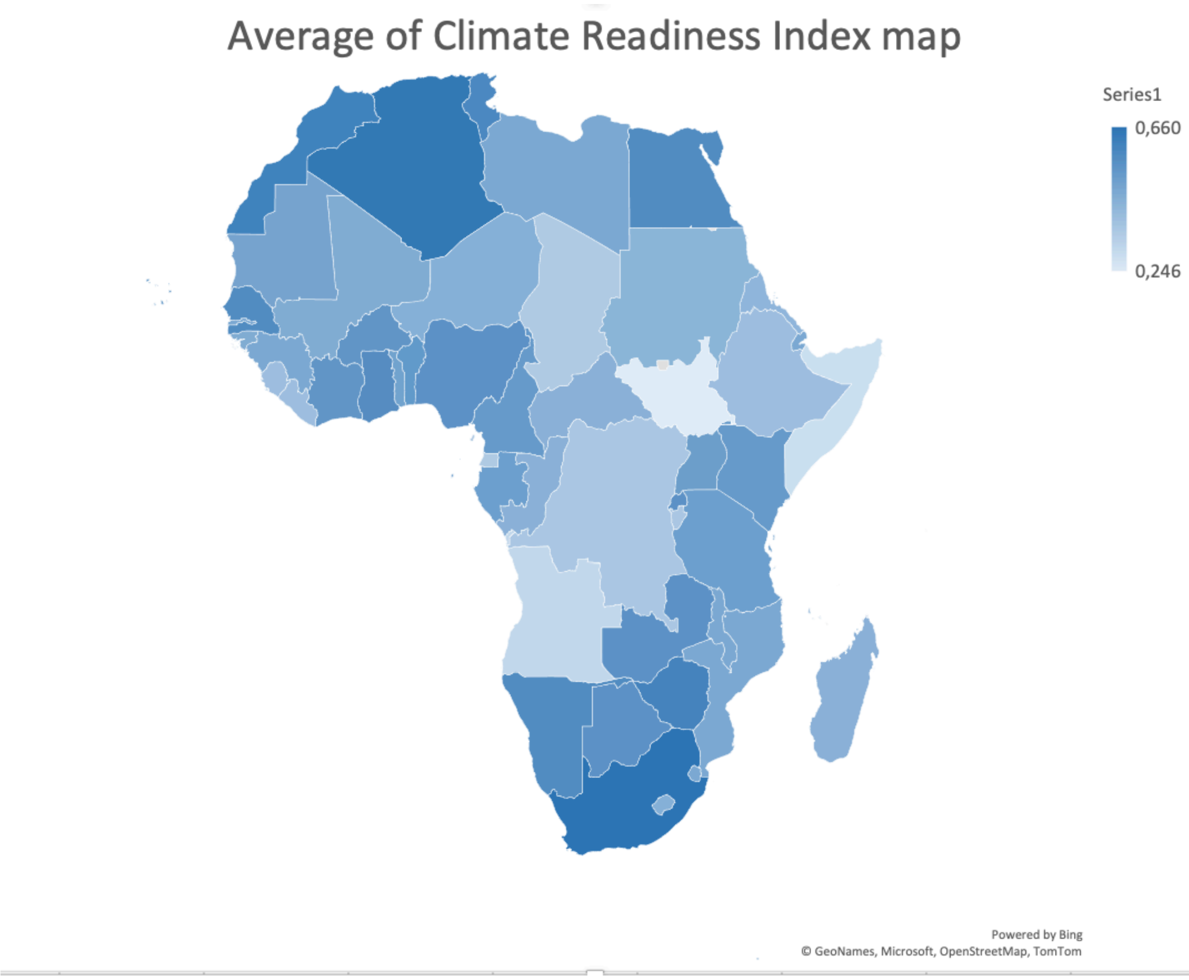


Figure 4.14: Climate Readiness Index map

4.3. Econometric Examination

First and foremost, we need to carefully consider the selection of variables and the construction of the regression equation. This includes identifying the core variables of interest, incorporating control variables, and integrating dummy variables. These variables play a crucial role in capturing the nuanced dynamics at play in the analysis. Once we've determined the variables, the next step is to source and acquire the right dataset that accurately represents these variables. This meticulous data collection process is vital for ensuring the accuracy and reliability of the findings.

My primary focus in this analysis is on carbon efficiency, a key metric for measuring the green transition. However, we aim to go beyond a simple examination of carbon emissions reduction. Instead, we intend to calculate the efficiency of carbon emissions as the primary output of the regression. This approach allows us to gain deeper insights into the effectiveness of emissions reduction efforts.

Two key parameters we intend to explore are the relationship between carbon efficiency and climate aid, and the impact of the recently calculated Climate Readiness Index on carbon efficiency. These variables are crucial in understanding how financial assistance for climate-related initiatives and a strong foundation of climate readiness influence carbon efficiency.

To enhance the precision and relevance of the model, we'll introduce control variables. These variables help us account for external factors and potential confounding variables that might influence carbon efficiency in the African region.

Lastly, we'll incorporate two dummy variables into the model. These dummy variables are designed to capture variations among countries and historical factors that could shape carbon efficiency trends.

This phase of the research involves a comprehensive econometric exploration to uncover the complex factors that influence carbon efficiency in Africa. Through accurate variable selection, data acquisition, and statistical modeling, my goal is to provide valuable insights into how climate aid, climate readiness, control variables, and historical factors collectively contribute to the region's green transition.

4.3.1. Model Specification

The model that guides my research question follows the panel data regression model:

$$CE_{t,i} = \beta_0 + \beta_1 CA_{t-1,i} + \beta_2 CRI_{t-1,i} + X'_{t,i}\delta + \lambda_i + \lambda_t + \epsilon \tag{4.4}$$

where $CE_{t,i}$ is a measure of the relative carbon efficiency of country i's at period t, and $CA_{t,i}$ is total climate aid to country i at period t. $CRI_{t-1,i}$ is a country readiness level calculated by the climate readiness index of country i at period t-1. β_0 is the intercept. In line with the first research objective, it follows that β_1 is the parameter of interest and thus I expect that $\beta_1 > 0$. That is, higher Climate aid increases the carbon efficiency of a country i in period t. $X'_{t,i}$ is a vector of time-varying country characteristics used as control variables. By considering these control variables, we aimed to isolate the specific impacts of the independent variables of interest on carbon efficiency, while controlling for potential biases. I also include full sets of country λ_i and time λ_t dummies, respectively, as their omission may bias the results. The country dummies capture unobserved time-invariant country-specific characteristics, while the time dummies capture time-specific shocks. By including these dummy variables in the regression models, we enhance the robustness of the analysis by explicitly considering the influence of cultural differences (via λ_i) and temporal events (via λ_t) on carbon efficiency. This approach allows us to isolate and quantify the effects of these factors, facilitating a more accurate understanding of the underlying dynamics and contributing to a comprehensive assessment of carbon efficiency determinants. $\epsilon_{i,t}$ is the error term.

In my equation, I've introduced a lag, which means that I am accounting for a time delay in the relationship between the climate readiness index variable and the climate aid variable in the context of a linear regression model. This lag suggests assuming a one-year delay in the effects of climate aid on climate readiness. In the industrial world, it is often considered legitimate to incorporate such lags because investments in various sectors, including climate-related initiatives, typically require some time before their impacts become measurable and significant. This lag allows for a more accurate representation of how changes in climate aid today may affect climate readiness in the future, recognizing the practical reality that outcomes often take time to materialize.

Addressing the third research question requires augmenting the previous equation to account for the interaction between climate aid and climate readiness of a country. Hence, the baseline

Equation that guides the third research question is the following:

$$CE_{t,i} = \alpha_0 + \alpha_1 CA_{t-1,i} + \alpha_2 CRI_{t-1,i} + \alpha_3 (CA_{t-1,i} \times CR_{t-1,i}) + X'_{t,i}\delta + \lambda_i + \lambda_t + \epsilon_{i,t} \quad (4.5)$$

where all variables are as defined above, and only the interaction between Climate Readiness Index and Climate Aid is added to see if the money given to a more prepared country can influence the final outcome.

4.3.2. Estimation strategy

For the estimation of the two regression models previously provided, appropriate estimation strategies are employed to obtain reliable and meaningful results.

In the first regression model, which will focus on the relationship between climate aid and carbon efficiency, an ordinary least square (OLS) method with country and time dummies will be employed. By estimating the regression coefficients, I will assess the magnitude and direction of the relationships between climate aid and carbon efficiency. In the second regression model, which explored the influence of Climate readiness on the causal relationship between climate aid and carbon efficiency at the country level, I will also employ an OLS method.

Both regression models will be estimated using appropriate statistical software, taking into account the assumptions of linear regression, such as linearity. Robust standard errors will be also computed to improve the reliability of the coefficient estimates.

Overall, the chosen estimation strategies allowed for a rigorous analysis of the relationships between climate aid, carbon efficiency, and the factors influencing regional disparities and readiness for the green transition. By employing these robust estimation techniques, I aim to provide accurate insights into the complex dynamics driving climate action and inform evidence-based decision-making in the pursuit of sustainable and low-carbon development.

4.3.3. Variables and data sources

This section provides an overview of the variables used in the previous regression models and the corresponding data sources. By understanding the variables and data sources employed in the analysis, we can gain insights into the factors driving climate aid and carbon efficiency at the regional level.

Climate readiness

To assess the readiness of regions for climate action, I rely on the climate readiness index developed in Section 3.1. This index serves as a comprehensive measure of a region's readiness and capacity to address climate challenges effectively. By incorporating multiple indicators and dimensions, it provides a holistic assessment of regional climate readiness.

Climate aid

To investigate the relationship between climate aid and carbon efficiency, I will rely on climate aid data from the Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) database. The OECD DAC maintains this comprehensive database on international aid flows from donor countries to recipient countries, including climate aid. The database provides detailed information on the type of aid, recipient country, donor country, and sector of investment. It is considered the most authoritative source of data on international aid flows and is widely used in research studies.

Within this dataset, comprehensive records of financial commitments made by developed nations to developing countries are meticulously documented for each year spanning from 2000 to 2019. To focus my analysis, I've narrowed down the dataset based on the recipient country. Specifically, I've isolated instances where a developed country consistently provided financial assistance to the same African nation across all those years. For each of these pairings, I've aggregated the cumulative Climate-related development finance commitments in 2019, measured in thousands of US dollars, for each individual year. This dataset now serves as a crucial component of my analysis, representing the data that characterize $CA_(t-1, i)$. In this context, CA stands for Climate Aid, t-1 signifies a one-year time lag, and i denotes the African recipient country. This dataset offers valuable insights into the trends and dynamics of climate-related development financing over time.

Carbon efficiency

In my research, I build upon the methodology and findings of a previous study (Feng et al. 2022). This study investigates the relationship between trade in services and carbon efficiency using international panel data. The authors focus on national carbon emission efficiency as the dependent variable and employ a data envelopment analysis (DEA) framework to measure carbon efficiency index scores.

To calculate the carbon efficiency index, the study combines the slacks-based measure (SBM) model under the variable return to scale (VRS) assumption with the Global Malmquist-Luenberger (GML) index. The GML index evaluates the efficiency growth rate of the Decision Making Unit (DMU) over time, with a base level set at 1 in the year 2000. By multiplying the GML index results for each year, the authors obtain the carbon efficiency index scores for the sample countries, reflecting changes in carbon efficiency over time.

In my research, I opted to use specific Decision Making Units (DMUs) as input and output variables for my Data Envelopment Analysis (DEA) to assess carbon efficiency. To do this, I carefully selected these particular DMUs based on their relevance to the determination of carbon efficiency.

For the input variables, I included the total Labor Force, Adjusted savings - measured as the consumption of fixed capital in current US dollars - and Renewable energy consumption as a percentage of total final energy consumption. These inputs were chosen because they represent key factors that can significantly influence carbon efficiency. Labor force size reflects the human resources available for economic activities, adjusted savings signifies the capacity for capital investment, and renewable energy consumption indicates the sustainability of energy sources – all of which have a direct impact on carbon emissions.

On the output side, I considered GDP as a desirable output and CO2 emissions as an undesirable output. GDP reflects economic productivity and growth, which is often associated with increased carbon emissions. Conversely, CO2 emissions are a critical factor in assessing carbon efficiency, as reducing emissions is a primary environmental goal.

By using these specific DMUs as inputs and outputs in an input-oriented DEA, I aim to shed light on the efficiency of entities in terms of their resource allocation and management (inputs) with a focus on achieving economic growth (GDP) while minimizing the environmental burden (CO2 emissions). This approach allows for a comprehensive evaluation of carbon efficiency and highlights the complex interplay between economic and environmental factors.

The choice of input orientation for my DEA analysis was deliberate. Input orientation is preferred in this context because I am primarily interested in assessing the efficiency of the DMUs concerning their resource utilization. By focusing on input orientation, I aim to determine how effectively these entities are utilizing their inputs (Labor Force, Adjusted savings, and Renewable energy consumption) to generate the desired outputs (GDP) while minimizing the undesired output (CO_2 emissions). This orientation allows me to gain insights into how efficiently these entities are managing their resources and making productive use of them in relation to their economic and environmental performance.

To perform the described model I used the software R in which I used the package deaR.

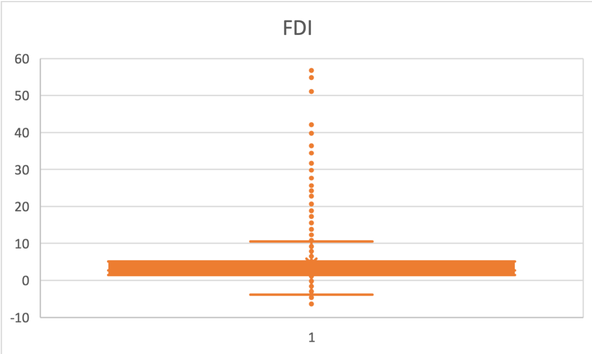
Control variables

The choice of control variables for the two regression models will be carefully considered to account for potential confounding factors and enhance the robustness of the analysis. These variables will be selected based on their theoretical relevance and availability from reputable data sources. I highlight some of the variables I will consider and their respective data sources below:

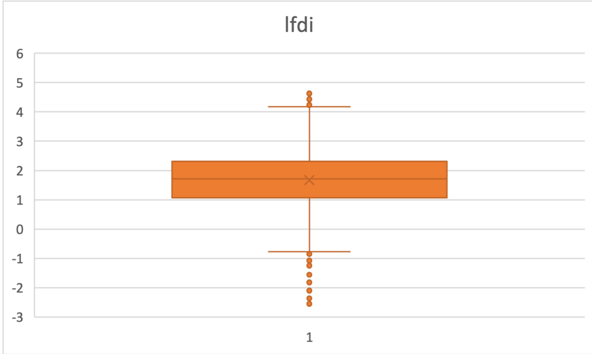
- *Foreign Direct Investments (FDI)*: FDI, sourced from the World Bank, represents the inflow of investments from foreign entities into a region and can reflect the level of economic integration and international collaboration. The inclusion of FDI aimed to capture the potential impact of foreign investment on carbon efficiency and the availability of financial resources for climate aid. According to the research (J. W. Lee 2013), the study demonstrates that FDI has played a key role in economic growth for the G20 while limiting its influence on a rise in CO_2 emissions in the economies.
- *Share of manufacturing in total GDP*: The share of manufacturing in total GDP is an economic indicator, sourced by UNCDAT, which provides insights into the region's industrial structure and its potential implications for carbon efficiency. For example, a study (Yuan et al. 2020) relates manufacturing agglomeration with green efficiency.
- *Institutional qualities and political factors*: they will be considered through the inclusion of institutional quality and political regime index sourced from the Worldwide Governance Indicators. These variables aimed to capture the governance framework, political stability, and the rule of law within a region, as these factors can significantly influence the implementation and effectiveness of climate aid and carbon efficiency initiatives.

4.3.4. Computation of the Linear Regression

When conducting a linear regression analysis, it is fundamental to ensure that the variables and datasets used in the mathematical model are comparable. The validity of the model relies on the ability to conform diverse variables and data sources, allowing for meaningful comparisons across different timeframes and sections of the study. Comparable variables and datasets facilitate a consistent evaluation of the phenomena being investigated, helping to reduce biases and ensuring that the index accurately represents the underlying realities. By aligning measurement methods, units of analysis, and scales, researchers establish a robust foundation for drawing meaningful conclusions and making well-informed decisions based on the insights derived from the index. The pursuit of comparability underscores a commitment to producing a rigorous and trustworthy index, which, in turn, serves as a reliable tool for analysis, policy development, and informed decision-making. In particular, three variables have been treated: foreign direct investments (FDI), climate aid, and manufacturing GDP. Preparing the



(a) Distribution of the original foreign direct investment dataset



(b) Distribution of the dataset with the foreign direct investment variable treated

Figure 4.15: FDI dataset comparison

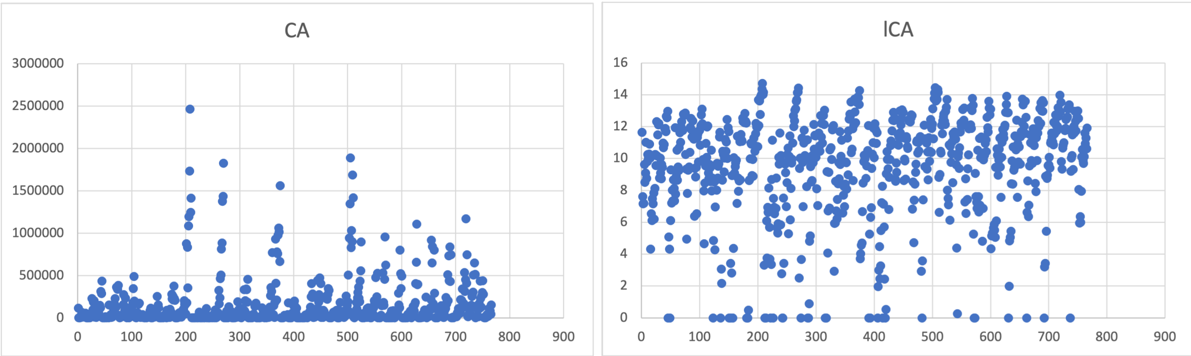
FDI dataset for regression involves several critical steps. This process includes addressing missing data and outliers, transforming variables as needed to meet regression assumptions, encoding categorical variables, handling time-series considerations, mitigating multicollinearity, normalizing variables, and confirming adherence to regression assumptions. Each of these steps ensures that the data is suitable for analysis and that the subsequent regression results are accurate, unbiased, and interpretable. Properly treating the FDI dataset before regression enhances the overall quality and reliability of the analysis, leading to more robust insights and conclusions.

Using the inverse hyperbolic function in a linear regression analysis, when comparing it with another variable like foreign direct investment (FDI), is a technique employed to address non-linear relationships between variables. Linear regression assumes a linear relationship, where changes in one variable result in proportional changes in the other. However, real-world data often exhibits non-linear patterns where this assumption doesn't hold. The inverse hyperbolic function transformation helps linearize such non-linear relationships, making the data more suitable for linear regression modeling. By applying this transformation, I aim to capture the underlying patterns and associations more accurately. Additionally, it can help stabilize variances, which is crucial for meeting linear regression assumptions.

$$lnFDI = \ln\left(FDI + \sqrt{FDI^2 + 1}\right) \tag{4.6}$$

This approach allows for the interpretation of results in a linear context, which is beneficial when researchers want to assess the impact of one variable on another while still maintaining interpretability. The Figure 4.15 shows the two different distribution before and after the treatment of the dataset. However, it's essential to choose the transformation method carefully based on the characteristics of the data and the theoretical understanding of the relationship. Moreover, interpreting the regression coefficients in such models requires attention, as they represent the effect of changes in the transformed variable rather than the original one.

Treating the variable "climate aid" before conducting a linear regression analysis is crucial for several reasons, especially when its distribution has a wide range like the one you've described (minimum of 0, maximum of 2,462,810.903, and standard deviation of 276,795.5684). Firstly,



(a) Scatter plot of the original Climate Aid dataset

(b) Scatter plot of the dataset with the ln of Climate Aid variable

Figure 4.16: Climate aid dataset comparison

addressing the extreme values (in this case, the maximum) is essential to avoid undue influence on the regression model. Outliers can significantly impact the results and may lead to biased coefficient estimates. Various methods, such as transforming the variable, winsorizing (capping) extreme values, or using robust regression techniques, can be employed to handle extreme values like the maximum value in the dataset.

Secondly, the variable's scale, which ranges from 0 to 2,462,810.903, can affect the stability of the regression model. Large variations in variable values can lead to convergence issues or make it challenging to compare the magnitudes of coefficients. Rescaling the variable, for example, by standardization (subtracting the mean and dividing by the standard deviation), can alleviate these problems while preserving the variable's interpretability.

Additionally, endogeneity and reverse causality are important considerations in regression analysis. In the context of climate aid, it's possible that the variable itself may be influenced by the outcome variable (e.g., climate readiness) or other unobserved factors. To address reverse causality, researchers may employ instrumental variables or carefully designed econometric models to establish causality and reduce the risk of endogeneity.

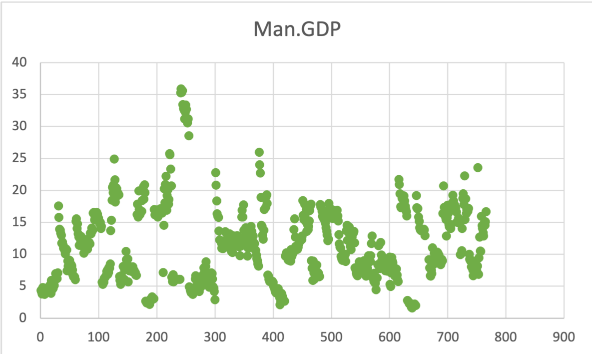
To tackle this challenge I decided to take into consideration the natural logarithm of the variable as expressed in the following equation:

$$lnCA = \ln{(CA)} \tag{4.7}$$

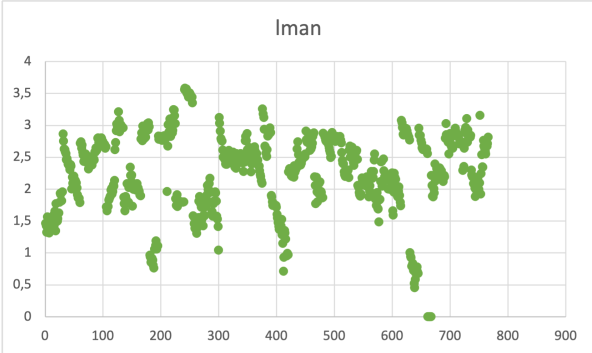
The decision to take the natural logarithm (ln) of the "climate aid" variable in my analysis likely stems from several key considerations. First, it's important to recognize that many economic and financial relationships exhibit non-linear patterns. In the context of climate aid, the effects on outcomes like climate readiness might not be proportional to the absolute dollar amounts. Taking the ln transformation allows to capture of potential multiplicative relationships, making it easier to model and interpret the impact of changes in aid.

Furthermore, the ln transformation can be particularly useful when dealing with a variable that has a wide range of values, as is the case with climate aid data. Extreme values and substantial variability in the dataset can lead to issues with model stability and interpretability. By applying the ln transformation, I mitigate the influence of outliers and bring the data closer to a normal distribution, which aligns with the assumptions of linear regression.

Another advantage is the enhanced interpretability of coefficients in the regression model. The ln transformation shifts the focus from absolute changes in aid amounts to percentage changes, which can be more meaningful in understanding the impact of aid on climate readiness. It allows you to describe how a one percent increase in climate aid is associated with a change in climate readiness, which can facilitate the communication of results. the Figure 4.16



(a) Scatter plot of the original manufacturing of GDP dataset



(b) Scatter plot of the dataset with the ln of manufacturing of GDP variable

Figure 4.17: Manufacturing of GDP dataset comparison

For the same reason and explanation, I opted for the same treatment for the variable Manufacturing of GDP. Treating the ”manufacturing as a percentage of GDP” variable in my analysis may be driven by its scale and potential impact on the regression model and may also facilitate the comparability of data across different countries or time periods. It allows to evaluation of manufacturing's relative importance within economies, making it easier to assess trends and differences. As shown the following equation I use the natural logarithm also for manufacturing of GDP Variable.

$$lnManGDP = \ln(ManGDP) \tag{4.8}$$

The Figure 4.17 shows the two scatter plots of the two datasets.

In the next chapter will be analyzed the results of the two methodologies of this thesis research.

5

Results and discussion

5.1. Climate Readiness Index Discussion

5.1.1. Analysis of Africa as a region

Following the computation of the final index, a preliminary examination of the results reveals notable variations in climate readiness among African countries.

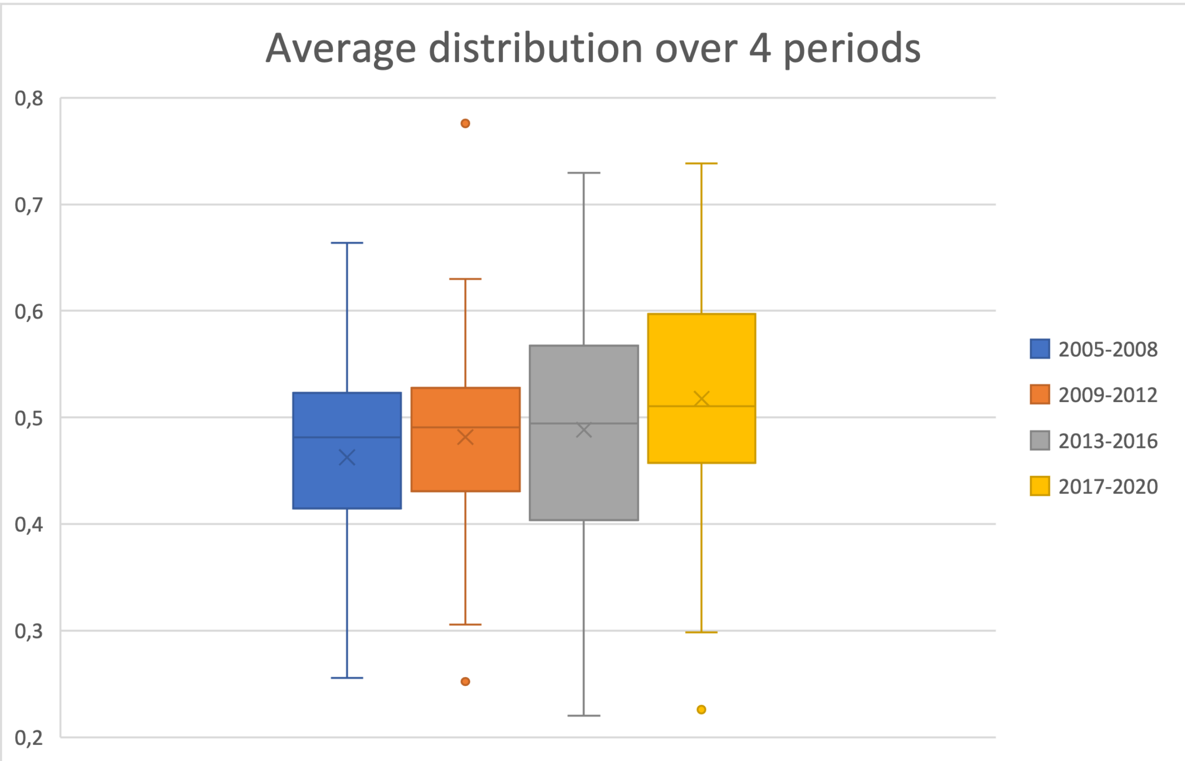


Figure 5.1: Distribution over 4 periods

Upon analyzing Figure 4.14, which illustrates the yearly averages of countries over time, it becomes apparent that there is no readily discernible geographical pattern. The minimum value is given by South Sudan with 0.246 and the maximum by Mauritius with 0.721. However, specific regions, notably Northern Africa, Southeast Africa, and insular territories exhibit darker shades on the map, indicative of higher index scores concentrated in these areas. Contrarily, the central region of Africa maintains its predominantly rural character. This is evident not only from the lighter shading on the map but also from the dataset's lack of information in this area. Notably, countries with substantial gaps in data coverage include South Sudan, Sudan, and Somalia.

A key observation stemming from this analysis pertains to the broader regional trends within Africa throughout the years. Figure 5.1 provides insight into how the African average has evolved, delineated into four distinct temporal periods. While the trend exhibits an overall upward trajectory, it does not display a pronounced incremental pattern, despite a noticeable linear progression.

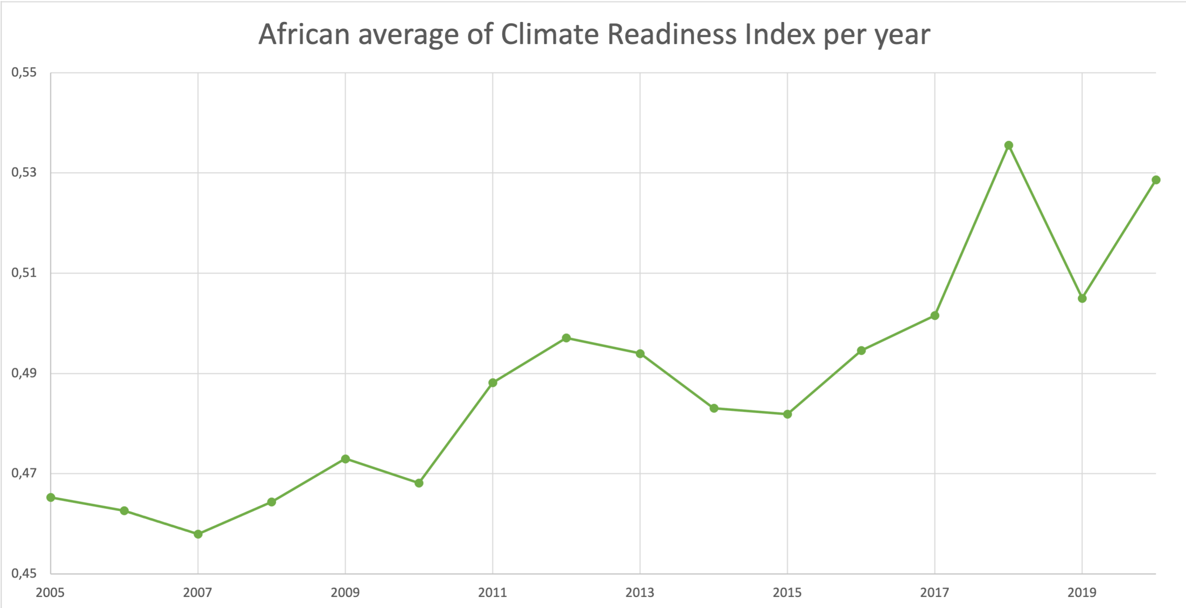


Figure 5.2: Climate Readiness Index average by year

To get deeper into this phenomenon, a closer examination of the African average on an annual basis is depicted in Figure 5.2. This representation vividly illustrates the oscillations and non-linearity characterizing the African average trend. It can be characterized as a generally increasing index, with two notable exceptions: a substantial overflow in the index in 2011, preceded by a severe decline in 2010. Conversely, since 2018, the index has been undergoing rapid fluctuations, oscillating by approximately 0.05 points each year. This perspective underscores the complexity of the climate readiness landscape across the African continent, demanding a greater understanding of the factors influencing these trends.

In order to solve the underlying factors driving these trends, a comprehensive analysis of the individual components becomes imperative. Figure 5.3 provides valuable insights by highlighting three primary influencers shaping the fluctuations in the index: the Environmental Performance Index, the Policy Index, and the Environmental Technology Index.

Significantly, the Environmental Performance Index emerges as the predominant contributor to the distinctive patterns observed in the index over time. It notably played a substantial role

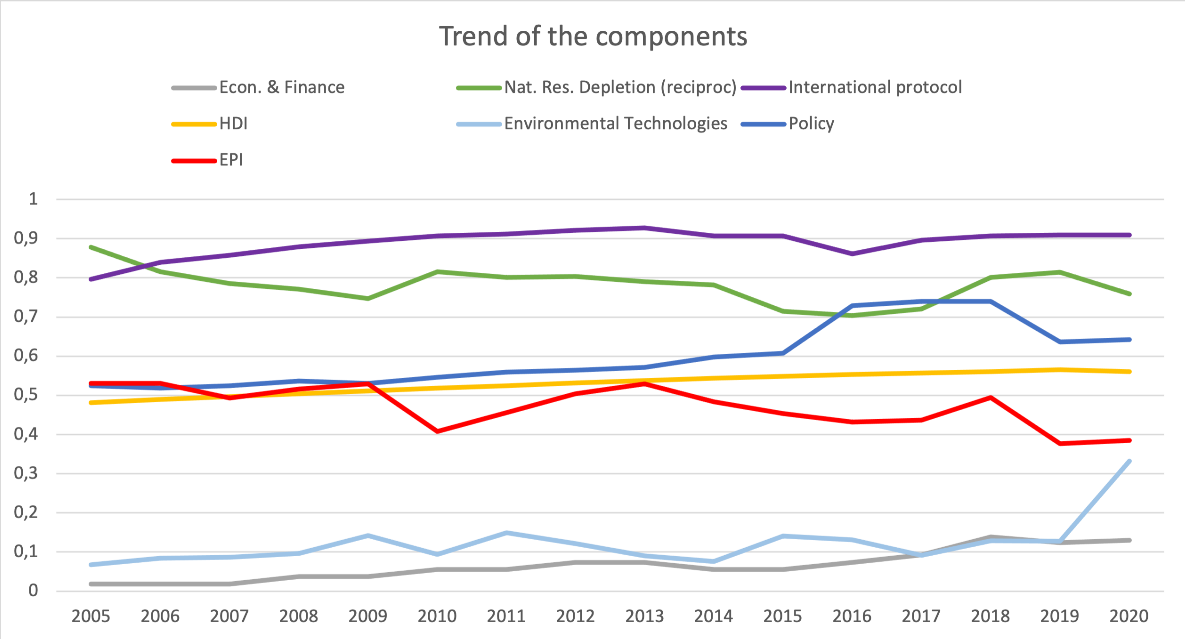


Figure 5.3: Trend of the Components of the Climate Readiness Index

in the downturn experienced in 2010 and the subsequent decline in 2019. The Policy Index also played a pivotal role in exacerbating the downward trajectory of the index, particularly in 2019, further emphasizing its influence on climate readiness. Finally, also the Environmental Technology Index, which exhibited relatively stable behavior over most of the examined period with minimal fluctuations, had a big influence in the last year, characterized by a significant upswing.

This study of the contributing components elucidates the multifaceted dynamics influencing the overall index trend, allowing for a more precise understanding of the driving forces behind the observed fluctuations.

5.1.2. Countries analysis

In order to facilitate a comprehensive comparison of all countries simultaneously, the Pareto graphic proves to be an effective tool. As depicted in Figure 5.4, it reveals a distinct division into two groups: one comprising the top-performing nations and the other consisting of those with the lowest climate readiness. Mauritius emerges as the most climate-prepared among the countries assessed, showcasing the highest value in the index. A substantial gap separates Mauritius from the second-ranked country, South Africa, indicating a considerable difference in their climate preparedness efforts. Subsequently, Algeria, Seychelles, and Morocco occupy positions among the top five countries in terms of climate readiness, highlighting their proactive approach to addressing environmental challenges.

The figures depicting the trends and distribution of the top-rated five countries can be observed in Figure 5.5a and Figure 5.5b. It is apparent that Mauritius consistently maintained a superior position relative to the other countries for a significant portion of the time series, except for the most recent years. Conversely, the remaining four countries exhibited substantial growth: South Africa experienced rapid growth in its initial years, whereas South Algeria, Seychelles,

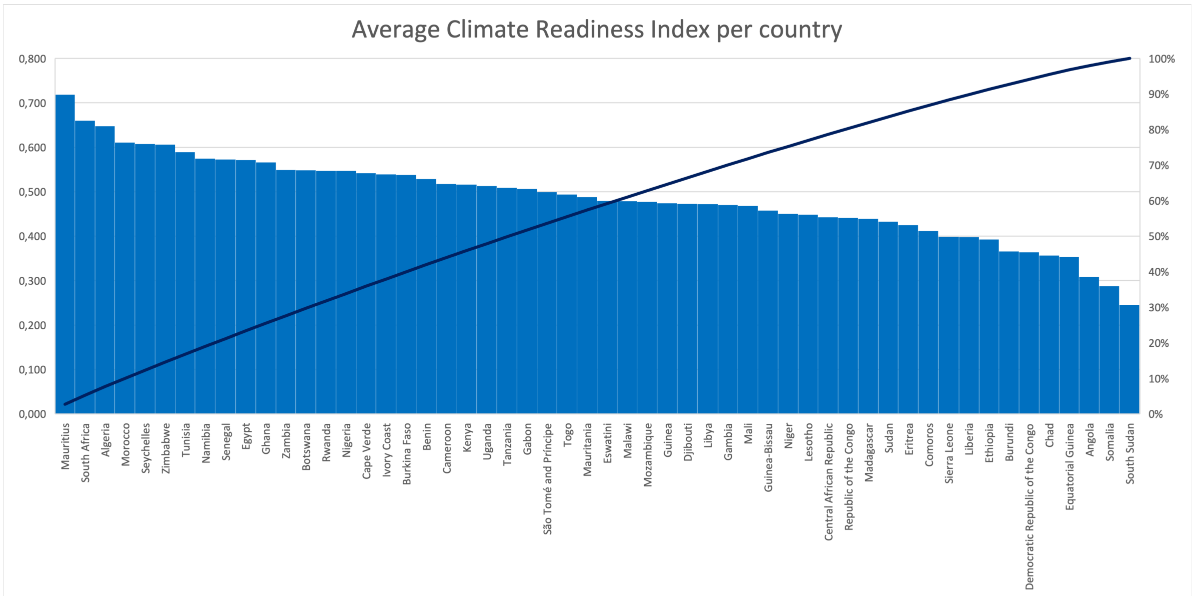


Figure 5.4: Pareto graphic of Climate Readiness Index

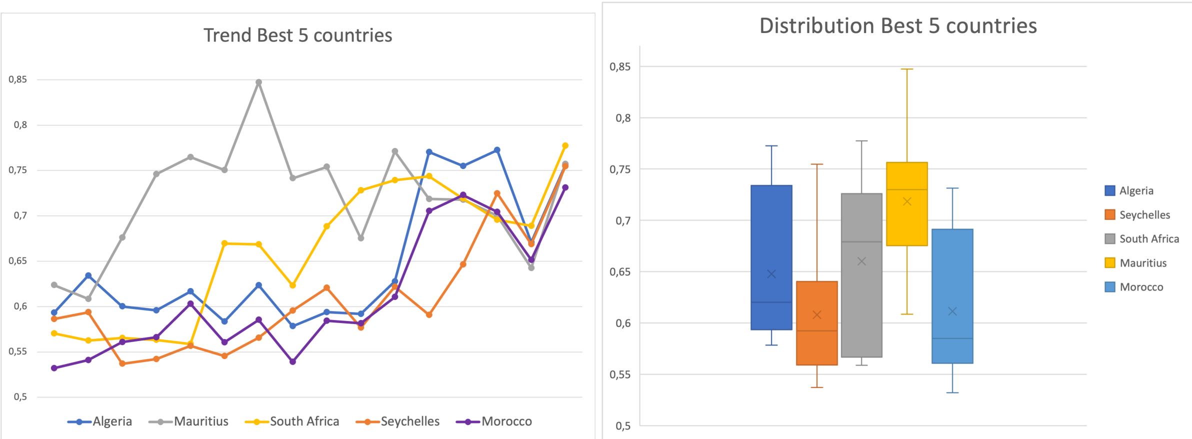
and Morocco displayed a synchronized increase in the latter part of the timeline. In a broader context, the distribution graphs indicate that both Mauritius and Seychelles exhibited less variability in their scores compared to the other three countries.

Many factors can influence the success of these countries. Some of these are:

- Geographic Location: These countries are strategically located within the southern, central, and insular regions of Africa. Their proximity to the southern hemisphere and the sea provides unique advantages. Coastal areas often have access to renewable energy sources such as wind and solar power, making it easier to transition away from fossil fuels.
- Infrastructure Development: Over the years, these countries have invested in robust infrastructure development. Well-maintained infrastructure is essential for adapting to the impacts of climate change, such as building resilient transportation systems and flood defenses.
- Political Stability: In Africa, the political landscape presents a diverse range of governance structures, including democracies, authoritarian regimes, and countries grappling with internal conflicts. Against this backdrop, political stability takes on heightened significance. While some nations exhibit relatively stable political environments, others contend with challenges stemming from strict regimes or ongoing internal conflicts. In regions characterized by political stability, there is a unique opportunity to attract investments and nurture long-term sustainability initiatives. The presence of a stable political foundation can facilitate the development and implementation of environmentally conscious policies and regulations, emerging as a symbol of advancement in the midst of the intricate and unpredictable situations encountered by neighboring countries.
- Economic growth and tourism: This correlation is rooted in their ability to allocate resources for climate resilience, harness advanced technologies, implement stringent environmental policies, and prioritize sustainable practices to attract tourists. These factors

collectively contribute to their enhanced climate readiness, making them better prepared to tackle the challenges posed by climate change.

- International Collaboration: Some of these nations actively engage in international collaborations and agreements related to climate change mitigation and adaptation. These partnerships can provide access to funding, technology, and expertise needed for green transitions.



(a) Trend of the top 5 score-countries

(b) Distribution of the top 5 score-countries

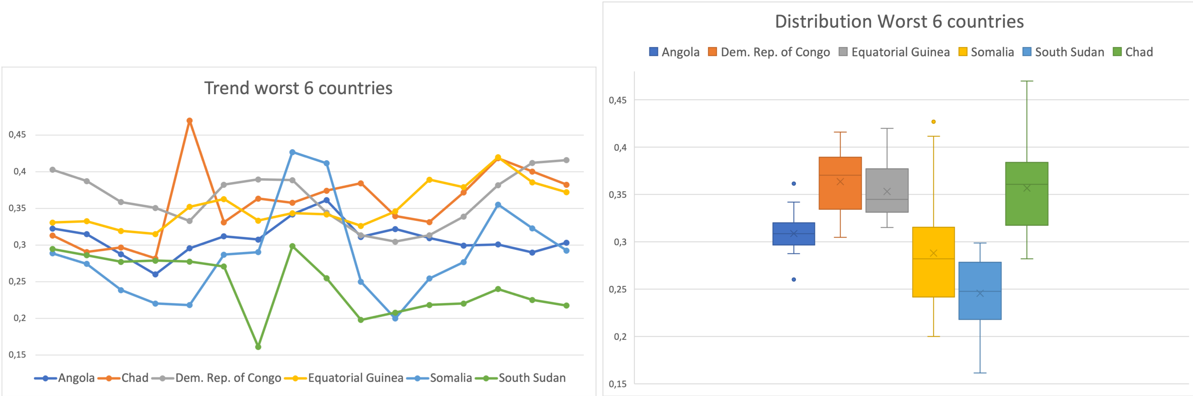
Figure 5.5: Analysis of the top 5 score-countries

These countries have positioned themselves as leaders in climate readiness and the green transition in Africa due to their favorable geographical locations, stable economies, robust infrastructure, political stability, education initiatives, natural resource management, international collaborations, adaptation measures, and investments in renewable energy. These factors collectively enable them to address climate challenges effectively and pave the way for a greener and more sustainable future.

Conversely, the analysis also identifies South Sudan and Somalia as the two countries with the lowest climate readiness scores by a considerable margin, underscoring the pressing need for comprehensive climate resilience strategies and support in these regions. Other countries, including Angola, Equatorial Guinea, Chad, and the Democratic Republic of Congo, occupy intermediate positions in the index, reflecting varying degrees of climate readiness within this diverse continent. The disparities among these countries signify the importance of tailored interventions and policies to enhance their climate resilience and preparedness.

The pictures illustrating the patterns and dustribution of the least favorably ranked five countries can be found in Figure 5.6a and Figure 5.6b. It is evident that, in general, no discernible trend can be found. Furthermore, an examination of the distribution reveals that all these countries tend to exhibit stability and comparatively low variance in their scores, with the notable exceptions being South Sudan, Somalia, and Chad.

In the case of Chad, there is a year where a noticeable increase is evident, but it subsequently regresses to a relatively stable, lower value. As for South Sudan and Somalia, it is important to note that the scarcity of data may be a key contributing factor. These two countries experienced the most significant data gaps, which can limit the ability to draw meaningful conclusions about



(a) Trend of the bottom 6 score-countries

(b) Distribution of the bottom 6 score-countries

Figure 5.6: Analysis of the bottom 6 score-countries

their climate readiness. Nonetheless, the absence of data itself can also be indicative of these nations' rural status and their limited preparedness for climate-related challenges.

In general, the lowest-rated countries may have faced challenges such as limited infrastructure, insufficient access to sustainable energy sources, and inadequate climate adaptation strategies, which contributed to their lower index scores. Other factors could include economic constraints, political instability, and limited investments in green technologies and sustainable practices. It's essential to acknowledge that addressing climate readiness involves a multi-faceted approach, requiring coordinated efforts across various sectors, from governance and finance to education and infrastructure development.

Furthermore, It is very interesting to compare the best 5 countries with the worst 5 countries. Analysing the internal politics of these countries it is clear that all the best countries have a very stable political situation, while the worst completely the opposite. In fact, their historical background shows us as in Chad ISIS is still present, South Sudan and DEmocratic Republic have still different wars and internal conflicts. This information gives a logical deduction from political stability brings to a higher climate readiness.

An additional valuable tool in pinpointing the group of nations facing the greatest challenges in terms of climate readiness is analysis by using the standard deviation. Utilizing the standard deviation is a valuable approach to identify countries that have experienced significant changes over the years for several reasons. First of all, standard deviation quantifies the degree of variability or dispersion within a dataset. In the context of climate readiness indices, it measures how much individual country scores deviate from the mean or average value over time.

Countries with high standard deviations have scores that consistently deviate from the mean. These outliers can indicate substantial fluctuations or trends in climate readiness over the years, drawing attention to countries undergoing noteworthy changes. A high standard deviation signifies that a country's climate readiness index has been subject to fluctuation or volatility. This can help pinpoint countries where climate-related factors or policies have evolved significantly, either positively or negatively.

Governments and policymakers can use standard deviation analysis to assess the effectiveness of climate policies and interventions. High standard deviations may suggest that certain policies have had a notable impact, prompting further investigation. In addition, high variance means that countries experiencing substantial changes may require tailored climate resilience strategies or international support to address emerging challenges.

In summary, the standard deviation is a useful statistical tool to identify countries that have undergone significant changes in climate readiness over time. It can assist in pinpointing outliers, tracking trends, evaluating policies, and guiding targeted interventions to enhance climate preparedness. Figure 5.7 shows the trend of the country with more than 0.7 stand deviation considering the data from 2005 and 2020.

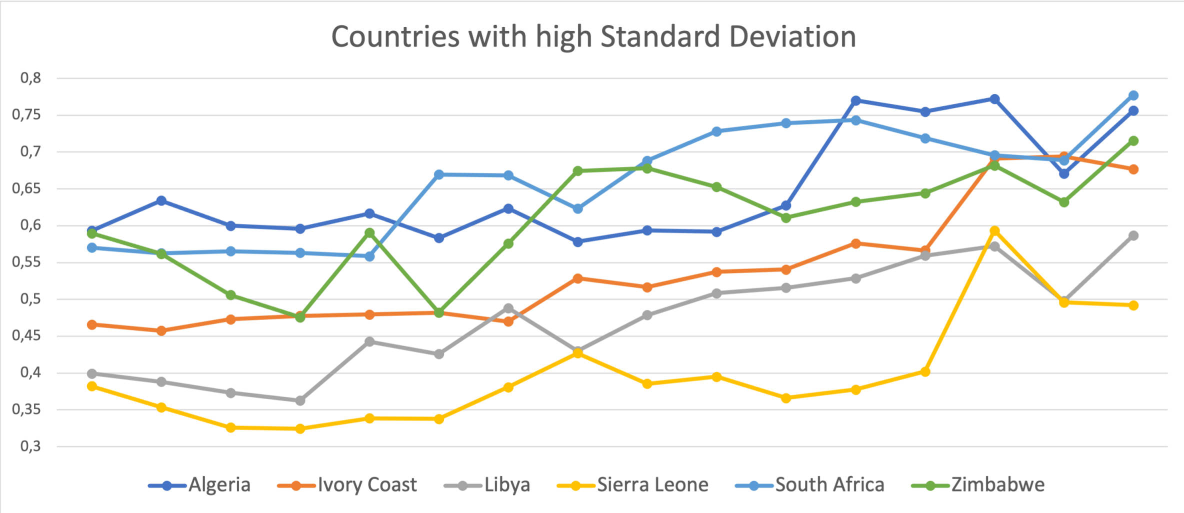


Figure 5.7: Trend of the countries with a high standard deviation value

5.1.3. Recommendation

African countries with higher climate readiness scores, such as Mauritius, Seychelles, South Africa, Morocco, and Algeria, can play a crucial role in sharing their successful climate resilience strategies with neighboring nations. Establishing regional knowledge-sharing networks can facilitate the dissemination of effective approaches. These top-performing countries should continue to prioritize investments in renewable energy, sustainable agriculture, and green infrastructure. By doing so, they can set an example for others and demonstrate the economic benefits of a low-carbon, sustainable development path. Engaging in international collaborations and climate agreements is essential. These countries should continue to participate actively in global efforts to mitigate climate change and adapt to its impacts while advocating for climate finance and technology transfer to support African nations. Maintaining a focus on climate education and public awareness campaigns is vital too. Educated and informed citizens are more likely to support green initiatives, adopt sustainable practices, and hold governments accountable for climate action.

Very important is the natural resource management that distinguished the region with the higher score. These nations should continue their efforts to sustainably manage their natural resources, including forests and water sources. Responsible resource management contributes to both climate resilience and biodiversity conservation.

On the other side, countries with lower climate readiness scores, such as Somalia, Chad, Democratic Republic of the Congo, South Sudan, Angola, and Equatorial Guinea, should prioritize capacity building. This includes training local experts and institutions to better understand

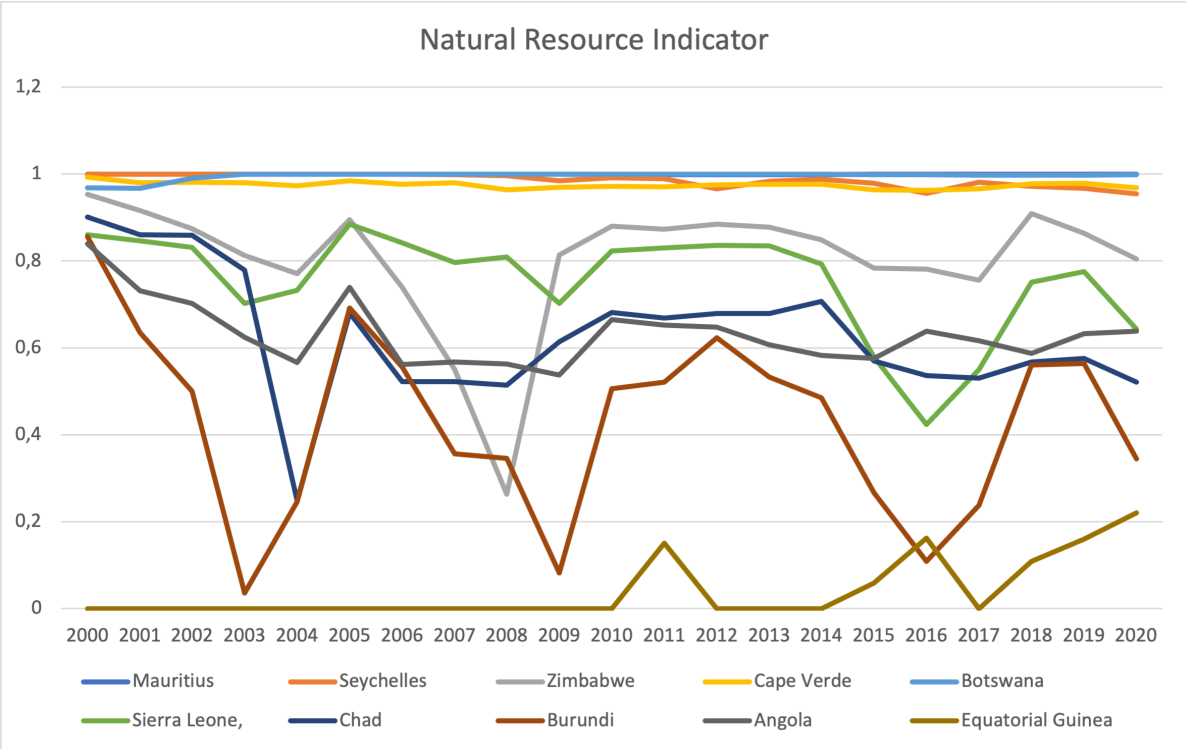


Figure 5.8: Natural Resource Indicator that compares the two groups of countries with the higher and lower scores of Climate Readiness Index

and address climate change-related challenges. It is also important to develop and implement comprehensive climate adaptation plans tailored to the specific vulnerabilities of each country.

The shift towards sustainability is a complex and evolving process. Monitoring the progress of countries, as seen in this analysis, provides valuable insights into which regions have made strides in embracing the green transition and which areas require targeted interventions. Part of the growth is also improving data collection and monitoring systems related to climate impacts. Enhanced data can inform evidence-based decision-making and better-targeted interventions.

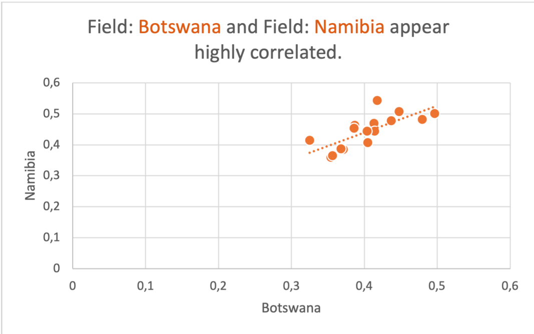
Policy reforms must be implemented, especially considering the significant data gap in that specific area. These reforms should encourage the adoption of sustainable practices, including the utilization of renewable energy, afforestation efforts, and sustainable land management, which greatly enhance climate readiness. By fortifying regulatory frameworks, they can establish a conducive environment for effective climate action.

Engage in regional cooperation with neighboring nations to tackle cross-border climate challenges. By exchanging vital information, resources, and best practices, they can bolster the collective resilience of the entire region in the face of climate change. Examining data on covariation between regions can provide valuable insights to further strengthen this collaborative effort. Covariation, or the tendency of certain countries to exhibit similar trends or scores in climate readiness, can help us identify common challenges that regions or groups of nations are facing. For example, if multiple countries in a particular geographical area or economic grouping consistently have low scores, it may indicate shared vulnerabilities that require collective attention.

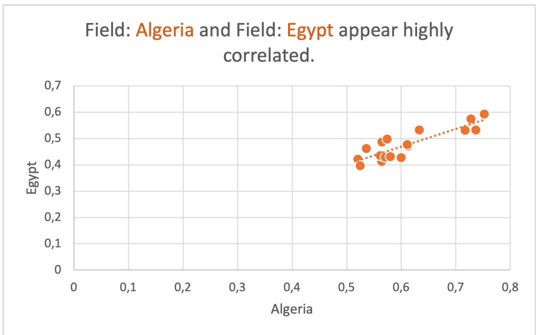
Recognizing covariation allows policymakers, international organizations, and development agencies to design more targeted interventions. Instead of approaching climate readiness on a country-by-country basis, they can focus on specific clusters of countries with similar challenges. This approach can lead to more efficient resource allocation and impactful programs. Countries with high covariation in climate readiness may find value in sharing their experiences and best practices. When nations face similar climate-related issues, collaborating on solutions can accelerate progress. For instance, countries with successful renewable energy programs can provide insights to others looking to expand their clean energy capacity.

Covariation can be the foundation for the formation of regional alliances or collaborations. Countries with similar climate vulnerabilities can come together to jointly address shared challenges. This can lead to the development of regional climate resilience strategies, the pooling of resources, and the negotiation of collective agreements to tackle common issues. High covariation provides opportunities for peer learning among nations. Countries with more advanced climate readiness can mentor and support those facing greater challenges. Such mentorship can include knowledge transfer, technical assistance, and capacity-building efforts. In the global fight against climate change, recognizing covariation can strengthen international cooperation. It fosters a sense of shared responsibility and encourages countries to work together to meet global climate goals, such as those outlined in the Paris Agreement.

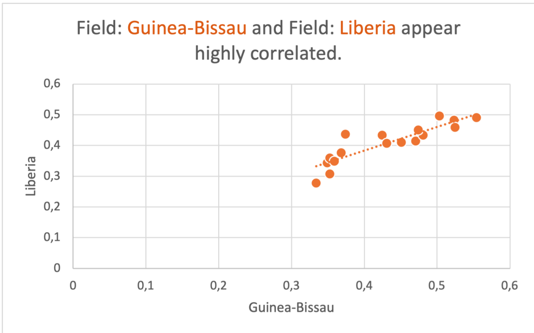
In conclusion, the analysis reveals a temporal pattern in which the second part of the period generally demonstrates improved climate readiness. Meanwhile, the initial period highlights vulnerabilities among specific countries, underlining the importance of ongoing efforts to enhance climate resilience, adapt to environmental changes, and accelerate the green transition. Both top-performing and lower-performing African countries have critical roles to play in addressing climate change. Collaboration, capacity building, sustainable investment, and policy reforms are key elements in the collective effort to build climate resilience and ensure a sustainable future for the continent.



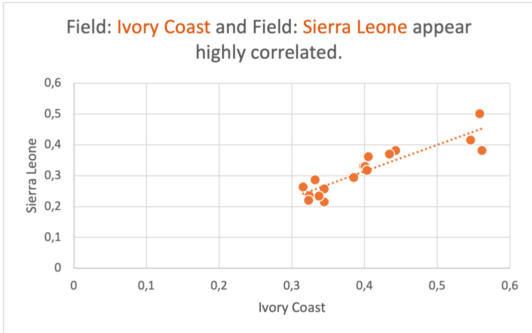
(a) Correlation between Botswana and Namibia



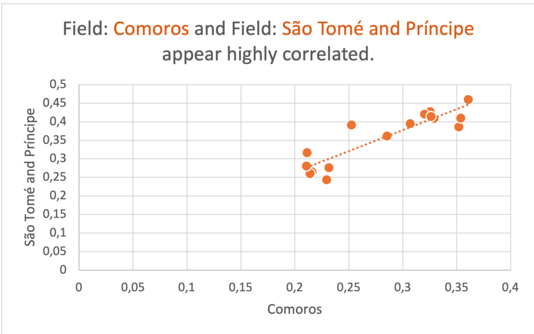
(b) Correlation between Algeria and Egypt



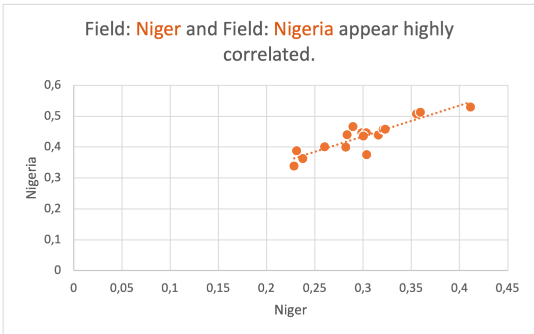
(c) Correlation between Guinea-Bissau and Liberia



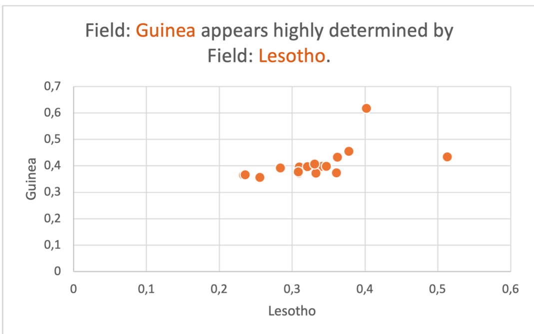
(d) Correlation between Ivory Coast and Sierra Leone



(e) Correlation between Comoros and Sao Tomé and Principe



(f) Correlation between Niger and Nigeria



(g) Correlation between Guinea and Lesotho

Figure 5.9: Some examples of high-correlated countries

5.2. Econometrically examination

5.2.1. Results of the different linear Regression

In this section, I delve into the comprehensive analysis of the econometric results obtained through the application of Equation 4.4 and Equation 4.5, which were elucidated in the preceding chapter. The culmination of this analytical journey lies in the final computation of each linear regression model, which was executed using the statistical software Stata. To establish these ultimate results, multiple crucial steps were undertaken. Specifically, for Equation 4.4, I engaged in four distinct iterations.

The first iteration entailed a regression analysis involving the dependent variable 'CE' (Climate Efficiency) and independent variables 'CRI' (Climate Readiness Index), 'i.year' (year indicator), and 'i.id' (country identification variable). This initial analysis provided valuable insights into the direct relationship between Climate Efficiency and the Climate Readiness Index.

In the subsequent iteration, the focus shifted to the relationship between Climate Effectiveness and the natural logarithm of 'CA' (Climate Aid). By transforming 'CA' using the ln function, I aimed to capture the impact of this transformed variable on Climate Efficiency.

The third iteration introduced a more comprehensive analysis by combining both the Climate Readiness Index ('CRI') and the ln-transformed Climate Aid ('lnCA') as independent variables. This allowed me to explore the joint effects of these critical factors on Climate Efficiency.

Finally, in the fourth iteration, the analysis expanded to incorporate additional covariates such as 'lnFDI', 'lManGDP', 'i.Politicalregime3(Democracy)', 'i.Politicalregime2(strict regime)', 'i.Politicalregime1(dictatorial regime)', 'i.year,' and 'i.id.' By including these covariates, I considered a more complex model that accounts for various economic, political, and temporal factors that may influence Climate Efficiency.

The results of the regression analysis, shown in Table 5.1 provide valuable insights into the relationship between Climate Efficiency (CE) and various independent variables. As the first comment, it is clear that the coefficients of Climate aid and CRI don't change with the different iterations. This means that the introduction of the new variables doesn't change the correlation between the Climate aid carbon efficiency before, and between the climate readiness index and carbon efficiency after. Following is the interpretation of the coefficients and their associated significance levels:

- **Climate Readiness Index (CRI)**: The coefficient for CRI is positive at 0.103, and it is statistically significant at the 1% level (indicated by **). This suggests that an increase in the Climate Readiness Index is associated with a positive and significant increase in Climate Efficiency. It implies that nations with higher levels of preparedness and readiness for climate-related challenges tend to have more effective climate policies and outcomes.
- **ln-transformed Climate Aid (lnCA)**: The coefficient for lnCA is -0.006, and it is highly statistically significant at the 1% level (indicated by ***). This indicates that an increase in the natural logarithm of Climate Aid is associated with a significant decrease in Climate Efficiency. The negative sign suggests a diminishing return effect, implying that as countries receive higher levels of climate aid, the incremental impact on climate effi-

	(1) CE	(2) CE	(3) CE	(4) CE
CRI		0.103**	0.105**	0.105**
	(0.051)		(0.051)	(0.050)
lnCA		−0.006***	−0.006***	−0.006***
		(0.002)	(0.002)	(0.002)
lnFDI				0.001
				(0.04)
lnManGDP				0.009
				(0.022)
Democracy				0.057***
				(0.013)
Strict regime				0.030**
				(0.013)
Dictatory				0.006
				(0.022)
N	766	766	766	748
r^2	0.924	0.926	0.926	0.931

Table 5.1: Results of the first Linear regressions
Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

ciency becomes less pronounced.

- **ln-transformed Foreign Direct Investment (lnFDI)**: The coefficient for lnFDI is 0.001, although it is not statistically significant at conventional levels (p-value > 0.05). This suggests that lagged FDI does not have a significant impact on Climate Efficiency in the model.
- **ln-transformed Manufacturing as a Percentage of GDP (lManGDP)**: The coefficient for lManGDP is 0.009, and while it is positive, it is not statistically significant (p-value > 0.05). This implies that the lagged percentage of manufacturing in GDP does not have a significant association with Climate Efficiency in the model
- **Political Regime Indicators**: The model includes three indicators for different political regimes: Democracy, strict regime, and dictatorial regime. These indicators capture the effects of political regime types. Democracy and strict regime have positive coefficients at 0.057 and 0.030, respectively, and both are statistically significant at the 1% and 5% levels (indicated by *** and **). This suggests that countries with certain political regime types tend to have higher Climate Efficiency compared to a dictatorial regime.

The results indicate that Climate Readiness Index (CRI), ln-transformed Climate Aid (lnCA), and certain political regime types are significant factors associated with Climate Efficiency. However, FDI and the percentage of manufacturing in GDP do not appear to significantly influence Climate Efficiency in this model.

The second step of the econometrically examination is introducing the interaction between climate aid and climate readiness index. Also this time different iterations will be applied, specifically, two. The first one aim to study only the variables CA CRI and their interactions. While the second iteration investigates the full model with all the control variables.

	(1) CE	(2) CE
CRI	-0.257^{**}	-0.381^{***}
	(0.121)	(0.117)
lnCA	-0.022^{***}	-0.027^{***}
	(0.005)	(0.005)
CRI*lnCA	0.035^{***}	0.046^{***}
	(0.011)	(0.010)
lnFDI		0.002
		(0.004)
lnManGDP		0.020
		(0.022)
Democracy		0.047^{***}
		(0.012)
Strict regime		0.022^{*}
		(0.012)
Dictatory		-0.006
		(0.021)
N	766	748
r^2	0.928	0.934

Table 5.2: Results of the final Linear regressions
Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

The results of the final regression analysis, shown in Table 5.2 provide valuable insights into the relationship between Climate Efficiency (CE) and various independent variables.

- **CRI (Climate Readiness Index)**: The coefficient for CRI is -0.257 in Model (1) and -0.381 in Model (2). This suggests that for each unit increase in CRI, the dependent variable CE (Climate Efficiency) decreases by approximately 0.257 in Model (1) and 0.381 in Model (2). Both coefficients are statistically significant, indicating that CRI has a negative impact on CE.
- **lnCA (Natural Log of Climate Aid)**: The coefficient for lnCA is -0.022 in Model (1) and -0.027 in Model (2). This implies that for each unit increase in the natural logarithm of Climate Aid, CE decreases by approximately 0.022 in Model (1) and 0.027 in Model (2). Both coefficients are statistically significant, indicating that higher levels of Climate Aid are associated with lower CE.
- **Interaction Term CRI*lnCA**: This term captures the interaction effect between CRI and lnCA. In Model (1), the coefficient for this interaction term is 0.035, and in Model (2), it is 0.046. Both coefficients are statistically significant. The positive sign of these coefficients suggests that the impact of lnCA on CE is moderated by the level of CRI. In other words, the relationship between Climate Aid and Climate Efficiency is influenced by the Climate Readiness Index.

- **lnFDI (Foreign Direct Investment)**: In Model (2), there is a variable labeled lfdi with a coefficient of 0.002. However, this coefficient is not statistically significant ($p > 0.05$), indicating that lfdi does not have a significant effect on CE in this model.
- **lnManGDP (Natural Log of Manufacturing of GDP)**: In Model (2), there is a variable labeled lManGDP with a coefficient of 0.020. This coefficient is not statistically significant ($p > 0.05$), suggesting that the natural log of the Manufacturing of GDP does not have a significant effect on CE in this model.
- **Political Regime Variables**: Model (2) includes three political regime variables (1.Politi 3, 1.Politi 2, and 1.Politi 1). These variables have coefficients indicating their impact on CE. For example, 1.Politi 3 has a coefficient of 0.047, indicating that a certain political regime type is associated with higher CE. These coefficients are statistically significant.
- **Model Fit**: The R-squared (r^2) values for Model (1) and Model (2) are 0.928 and 0.934, respectively. These values suggest that the models explain a substantial portion of the variance in CE, indicating a good fit. However, it's essential to consider the context and domain knowledge when interpreting the results and their practical significance.

These regression results suggest that CRI, lnCA, and their interaction have a significant influence on Climate Efficiency (CE). The impact of lnCA on CE is moderated by the level of CRI. Additionally, certain political regime types are associated with differences in CE. Other variables, such as lfdi and lManGDP, do not appear to have a significant impact on this model.

To see the result of the final regression analysis with all the coefficients and t values see Appendix H

5.2.2. Discussion

Impact of Climate Aid (lnCA) and Climate Readiness (CRI)

At first glance, the initial linear regression models without interaction terms revealed a somewhat counterintuitive result – the negative coefficient for lnCA suggested that increasing the amount of climate aid provided to a country was associated with a decrease in carbon efficiency. This initial finding might appear puzzling, as one might expect that more financial support for climate-related initiatives would lead to improved carbon efficiency. However, this initial observation requires a closer examination within the broader context.

This seemingly paradoxical result can be explained by considering that climate aid, when not adequately targeted or aligned with a country's climate readiness, can lead to suboptimal outcomes. In other words, providing substantial financial assistance to countries that may not have the institutional, technical, or infrastructural capacity to effectively utilize these funds for emission reduction or climate resilience projects can yield limited environmental benefits.

However, the introduction of interaction terms, particularly the interaction between lnCA and CRI, provided a more nuanced perspective. This interaction term revealed that the cumulative effect of lnCA interacted with CRI became positive. In simpler terms, it suggests that when climate aid is directed towards countries that are already climate-ready (as indicated by a higher CRI), it has a positive and statistically significant impact on carbon efficiency. This insight underscores the importance of strategic allocation of climate finance.

In practice, this means that directing climate aid toward countries with the necessary capabilities and infrastructure to implement effective climate action initiatives can yield positive results in terms of carbon efficiency. Such countries are better equipped to deploy financial resources efficiently, invest in clean technologies, and implement policies that lead to emission reductions. The interaction term highlights the value of aligning climate aid with a country's level of climate readiness to maximize the impact of international climate finance.

This understanding emphasizes the need for policymakers and international organizations to consider not only the quantity but also the quality and appropriateness of climate aid allocation. It encourages a shift toward targeted, context-specific interventions that empower climate-ready countries to lead in the transition to a more sustainable and carbon-efficient future.

Effect of Climate Readiness (CRI)

Initially, when examining the relationship between Climate Readiness (CRI) and carbon efficiency (CE) without the introduction of interaction terms, it appeared that CRI had a positive effect on CE. In simpler terms, countries with higher CRI values, indicating greater preparedness for climate-related challenges, tended to exhibit better carbon efficiency. This finding may intuitively suggest that countries that are well-equipped and ready to address climate issues are more likely to have sustainable and carbon-efficient practices in place.

However, the picture becomes more complex when interaction terms, such as the interaction between lnCA (Natural Log of Climate Aid) and CRI, are introduced into the regression models. It's observed that the relationship between CRI and carbon efficiency becomes biased by the lnCA variable present in the interaction. This implies that the cumulative result of CRI on carbon efficiency becomes negative when considering the moderating effect of lnCA.

This shift in the relationship can be explained by recognizing that climate readiness, while valuable, is not a standalone determinant of carbon efficiency. In the presence of climate aid (lnCA), the effectiveness of climate readiness in improving carbon efficiency is contingent on how well financial resources are allocated and utilized. Climate readiness may provide the foundation, but it alone cannot ensure positive outcomes in carbon efficiency.

In practical terms, this suggests that even in countries with high climate readiness scores, the impact on carbon efficiency may vary depending on the level and effectiveness of climate aid. It emphasizes that effective climate action requires more than just preparedness; it necessitates strategic financial allocation, policy implementation, and technological adoption.

Furthermore, it's essential to consider that climate readiness itself may be influenced by external factors, including access to international climate finance. Countries that receive targeted and well-utilized climate aid may enhance their climate readiness over time, leading to improved carbon efficiency. Therefore, the complex interplay between climate readiness, climate aid, and carbon efficiency requires a nuanced understanding.

In conclusion, the effect of Climate Readiness (CRI) on carbon efficiency is not solely determined by the readiness level itself. It is influenced by various contextual factors, including the presence of climate aid and the effectiveness of its utilization. This underscores the need for a comprehensive and integrated approach to climate action, where both climate readiness and effective climate finance allocation play vital roles in achieving carbon efficiency and broader sustainability goals.

Impact of Democracy (Political Regime 3)

One of the intriguing findings emerging from the regression analysis is the positive influence of democracy, represented by Political Regime 3, on carbon efficiency (CE). This observation suggests that countries governed by democratic systems tend to demonstrate higher levels of carbon efficiency, indicating that they are more adept at managing their carbon emissions relative to their economic output.

Several factors contribute to this phenomenon. Firstly, democratic governance often prioritizes transparency and accountability in the administration of public affairs. This commitment extends to environmental policies and practices. In democratic societies, citizens have access to information concerning environmental matters, enabling them to scrutinize and hold governments and corporations accountable for their carbon emissions. This transparency creates incentives for leaders to adopt environmentally responsible policies and practices.

Secondly, democratic systems promote active public participation in decision-making processes. Environmental issues, particularly those related to climate change, consistently rank among public concerns. In democratic settings, public engagement and activism can drive the adoption of cleaner technologies, stricter emissions standards, and policies aimed at promoting sustainability.

Moreover, political competition within democratic nations can also drive environmental improvements. Political parties competing for voter support often incorporate green policies into their platforms, leading to the adoption of progressive climate policies designed to reduce carbon emissions.

Additionally, democratic nations are more accountable to international agreements. Many global climate accords require countries to establish and fulfill emissions reduction targets. In democratic states, leaders face heightened accountability in adhering to international commitments. They may experience pressure from the international community and their own citizens to meet these obligations, fostering more substantial efforts to enhance carbon efficiency.

Furthermore, democratic countries frequently boast open economies that stimulate innovation and technological advancement. These innovations can result in the development and adoption of cleaner, more energy-efficient technologies, thereby contributing to heightened carbon efficiency.

Lastly, the stability of political systems in democracies enables long-term planning and policy continuity. Addressing climate change and improving carbon efficiency necessitate sustained efforts over time, making long-term planning a critical success factor.

It is important to acknowledge that while democracy exhibits a positive impact on carbon efficiency, the relationship is multifaceted and can be influenced by numerous contextual factors. These include specific policies and practices implemented by individual countries, regional variations, and temporal dynamics.

In conclusion, the positive effect of democracy on carbon efficiency underscores the crucial role that political systems and governance play in addressing environmental challenges. However, achieving sustainable carbon efficiency necessitates a multifaceted approach, encompassing not only democratic governance but also a combination of policies, public engagement, technological innovation, and international cooperation. Further research and analysis are warranted to gain a more comprehensive understanding of how democracy contributes to enhanced carbon efficiency and to identify best practices for environmental governance within democratic societies.

5.2.3. Recommendation

Here are some recommendations on how various institutions can utilize the results of the linear regression and econometric examination, taking into account the significance and coefficients:

- Government and Policy-Making Institutions: Government agencies and policymakers can benefit significantly from the findings. The positive coefficient of climate aid (lnCA) suggests that directing financial resources toward climate-ready countries can lead to improved carbon efficiency. Policymakers can use this information to guide the allocation of climate-related development finance to maximize its impact on carbon efficiency. Additionally, the positive impact of democracy (Political Regime 3) on carbon efficiency underscores the importance of fostering democratic governance for effective climate policies. Policymakers can prioritize transparency, public participation, and international commitments to enhance carbon efficiency.
- International Organizations and Donors: International organizations such as the United Nations, World Bank, and donor agencies play a vital role in climate finance. They can use the results to inform their funding strategies. The significance of the coefficients related to climate aid and democracy highlights the importance of targeting climate aid to countries with democratic governance and a strong commitment to carbon efficiency. Donors can use this information to refine their aid programs and ensure that funding is directed toward projects and initiatives that have the most significant impact.
- Environmental NGOs and Advocacy Groups: Environmental non-governmental organizations (NGOs) and advocacy groups can leverage the findings to advocate for evidence-based policies and initiatives. They can use the results to highlight the positive effects of climate aid and democracy on carbon efficiency. This information can strengthen their advocacy efforts and support their calls for increased climate financing and democratic governance reforms to combat climate change effectively.
- Private Sector and Industry Associations: Businesses and industry associations can incorporate the results into their sustainability strategies. The positive coefficients related to climate aid and democracy indicate that environmentally responsible practices and investments can yield positive outcomes for carbon efficiency. Companies can use this information to guide their corporate social responsibility initiatives, investments in green technologies, and efforts to reduce carbon emissions.
- Academic and Research Institutions: Academic and research institutions can use the results as a basis for further research and analysis. Researchers can delve deeper into the mechanisms through which climate aid and democratic governance impact carbon efficiency. They can also explore specific case studies and regional variations to gain a more comprehensive understanding of the relationships you've identified. Additionally, scholars can use the work as a foundation for policy evaluations and comparative studies.
- Climate and Environmental Advocates: Climate and environmental advocates can use the results to engage with policymakers, raise public awareness, and mobilize support for climate action. The findings can help advocates craft persuasive narratives about

the importance of climate aid, democratic governance, and sustainable development in achieving carbon efficiency goals.

- Educational Institutions: Educational institutions can incorporate research into their curricula to educate the next generation of leaders and policymakers about the complex relationship between climate aid, democracy, and carbon efficiency. This can help inspire future generations to address climate challenges more effectively.

6 Limitation

This research endeavors to shed light on a novel and intricate aspect within the academic literature, one that is characterized by both its novelty and its inherent data scarcity. Focusing on the unique context of Africa, my study ventures into uncharted territory to explore factors crucial for understanding climate readiness—a subject of paramount importance in today's world. However, this pursuit comes with significant challenges, particularly in the realm of data availability. In the African context, access to comprehensive, high-quality data is often constrained, with much of the available information being limited to publicly accessible sources. This constraint paints a challenging landscape for research, where uncovering valuable insights relies on ingenuity and resourcefulness in navigating through the complexities of public data. Despite these challenges, the quest for knowledge and the aspiration to contribute to a greater understanding of climate readiness in Africa remain central to the research's core objectives. Even though there are different limitations for this research and I would like to divide them in two sections for the two different methodology and model that I used within the research.

6.1. Limitation of the Climate Readiness Index

In the Climate Readiness Index framework and calculation, I identify the following limitations:

- External Validity: The index is based only on public data available. No interviews and no data have been gathered: this methodology makes the external validity lower.
- Data Availability and Quality: The index's accuracy and comprehensiveness heavily depend on the availability and quality of data. In some regions, data may be limited, outdated, or unreliable, which can lead to inaccuracies in the assessment and results.
- Lack of Context: This limitation arises because the CRI typically offers a broad overview of readiness at a global or national level, which may not capture the specific challenges and nuances of different regions or sectors. Climate readiness can vary significantly due to factors like geography, climate conditions, cultural practices, and socioeconomic contexts. Policymakers, decision-makers, and local communities often require more specific, context-specific data to formulate effective strategies and interventions. To address this limitation, it is essential to consider sub-indices, localized adaptations, improved data collection efforts, and customization options within the CRI framework. These measures can help enhance the relevance and usefulness of the CRI in diverse

contexts and promote more effective climate resilience efforts.

- Variable Selection: The choice of variables used to calculate the index is subjective and may not capture all relevant factors influencing climate readiness. Different researchers might choose different variables, leading to variations in results.
- Weighting of Variables: Assigning weights to different variables in the index can be challenging. Weighting decisions can impact the overall score and may not always accurately reflect the relative importance of each variable in the context of climate readiness.
- Cultural and Regional Differences: Cultural and regional factors can significantly influence a country's readiness to address climate change. The index may not adequately capture these nuances, potentially leading to misrepresentations.
- Dependency on Economic Factors: Some variables, such as GDP per capita, might heavily depend on economic performance. This could result in countries with strong economies ranking higher, even if their environmental practices are less favorable.
- Policy Implementation: The index may not fully account for the effective implementation of climate policies and initiatives, which can vary widely within countries. A nation might have strong policies on paper but struggle with enforcement and execution.
- Lack of Local Context: The index provides a broad overview of climate readiness at a national level but may not capture local variations within a country. Climate readiness can vary significantly between urban and rural areas or among different regions.

6.2. Limitation of the Climate Readiness Index

In the Econometrically examination, I identify the following limitations:

- Variable Selection: The choice of the control variables used to calculate the linear regression is not all significant and may not capture all relevant factors influencing carbon efficiency. Different researchers might choose different variables, leading to variations in results.
- Endogeneity: Endogeneity arises when the independent variable is correlated with the error term in the regression equation. In the model, factors like government policies, cultural influences, or unobserved variables could influence both climate aid and carbon efficiency, potentially leading to biased results.
- Data Quality: The quality and accuracy of the data used in the regression model can significantly impact the results. The DEA analysis, and the linear regression comprehensiveness heavily depend on the availability and quality of data. In some regions, data may be limited, outdated, or unreliable, which can lead to inaccuracies in the assessment and results. It must be ensured that the data sources are reliable and that any potential errors or inconsistencies are addressed. Additionally, missing data can affect the completeness of the analysis.
- Model Specification: The choice of variables and the functional form of the regression model can impact the results. Consider conducting sensitivity analyses with different model specifications to test the robustness of the findings.
- Temporal and Spatial Variation: The model covers a specific time period (2006-2020) and focuses on specific regions or countries. The results may not generalize to other

time periods or geographic areas, as climate policies, economic conditions, and other factors may change over time and across regions.

- Omitted Variable Bias: Omitted variables, which are not included in the regression model, can lead to omitted variable bias. Factors that are not accounted for in the model but are relevant to carbon efficiency could lead to biased coefficient estimates.
- Cultural and Contextual Factors: the model may not fully capture cultural, historical, or contextual factors that influence climate aid, climate readiness, and carbon efficiency. Qualitative research or case studies may be necessary to provide a more comprehensive understanding.
- Reverse Causality: While the model may imply causal relationships, it's essential to be aware of the possibility of reverse causality, where effects can flow in both directions. For example, countries with better carbon efficiency may receive more climate aid.
- Model Complexity: Adding interaction terms and multiple variables can increase the complexity of the model.

These limitations highlight the importance of careful data collection, model specification, and interpretation of regression results. Addressing these limitations and conducting sensitivity analyses can enhance the reliability and validity of the findings.

7
Future Research

As I conclude the present study, I recognize that the pursuit of knowledge in the field of climate finance and sustainability is an ongoing and dynamic endeavor. While the current research has provided valuable insights into the relationships between climate aid, climate readiness, and carbon efficiency, it is essential to acknowledge that this field is continuously evolving. Therefore, this chapter is dedicated to outlining potential avenues for future research that can extend and enhance the understanding of these complex and interrelated phenomena.

The previous chapters of this study have delved into the development of the Climate Readiness Index (CRI) and the econometric analysis of climate aid's impact on carbon efficiency. These efforts have shed light on important relationships and have identified key factors influencing countries' abilities to mitigate carbon emissions and adapt to a changing climate. However, in the spirit of academic inquiry and the pursuit of comprehensive solutions to global challenges, there remain unexplored dimensions and opportunities for further investigation.

In this chapter, I present a roadmap for future research endeavors that can contribute to the refinement and expansion of the current findings. These suggestions encompass a range of strategies, from broadening the geographical scope of the analysis to incorporating additional control variables and exploring qualitative methodologies. By embarking on these future research directions, I aim to deepen the comprehension of climate finance dynamics and carbon efficiency outcomes. Ultimately, the objective is to provide a robust foundation for policymakers, researchers, and stakeholders as they navigate the intricate landscape of climate action and sustainable development.

7.1. Expanding the Climate Readiness Index (CRI)

The Climate Readiness Index (CRI) has emerged as a valuable tool in assessing a nation's preparedness and capacity to address the challenges posed by climate change. In the course of the research, I have developed and applied the CRI to gain insights into the intersection of climate readiness, climate aid, and carbon efficiency. However, the journey of understanding climate readiness is far from complete. This section explores promising avenues for expanding the CRI, offering new dimensions and opportunities to refine the assessment of nations' climate readiness profiles.

As the global community increasingly recognizes the urgency of climate action, there is a growing demand for comprehensive and nuanced assessments of a country's readiness to confront climate-related challenges. The CRI, as it stands, provides a solid foundation, but its continued development and expansion can better serve the needs of policymakers, researchers, and stakeholders worldwide. Following will be discussed potential enhancements, data enrichment strategies, and methodologies that can contribute to a more encompassing and accurate representation of climate readiness. These efforts aim to ensure that the CRI remains a dynamic and invaluable resource in the pursuit of a sustainable and climate-resilient future.

1. Regional Expansion: Extend the CRI to encompass other world regions, such as Asia and South America. This expansion would provide a more comprehensive view of climate readiness on a global scale, allowing for cross-regional comparisons and insights into regional variations in climate readiness.
2. Data Enhancement: Continuously work on improving the data quality and coverage for the CRI. Seek out more complete datasets, particularly for countries and regions where data gaps currently exist. Enhanced data can lead to a more accurate representation of climate readiness.
3. External Validity: To increase external validity, consider conducting interviews, surveys, or case studies with policymakers, experts, and stakeholders in countries with varying levels of climate readiness. Qualitative research can provide valuable context and insights to complement quantitative index findings.
4. Temporal Analysis: Conduct longitudinal studies to track changes in climate readiness over time. Analyzing trends and shifts in climate readiness can help identify evolving patterns and factors influencing preparedness.
5. Sub-Indices: Develop sub-indices within the CRI that focus on specific aspects of climate readiness, such as adaptation capacity, mitigation efforts, or policy implementation. These sub-indices can offer more nuanced insights into a country's climate readiness profile.

7.2. Expanding the Regression Analysis

In the goal of the research to unravel the relationships between climate aid, climate readiness, and carbon efficiency, the regression analysis has played a pivotal role in unveiling important insights. Yet, the journey of empirical inquiry is marked by a continuous search for deeper understanding and improved methodologies. This section delves into the prospects of expanding the regression analysis to refine the understanding of the complex dynamics at play.

The initial regression analysis has provided valuable findings regarding the impact of climate aid, climate readiness, and external factors on carbon efficiency. However, the world of climate finance and sustainability is multifaceted, and the analysis can evolve to capture its intricacies more comprehensively. Following will be suggested some future research to explore avenues for enriching the regression model, addressing potential biases, and uncovering additional factors that may influence carbon efficiency outcomes.

1. Additional Control Variables: Introduce additional control variables into the regression model, such as the Human Capital Index (HCI). HCI can capture the educational and health aspects of a country's development, which may influence carbon efficiency.

2. Addressing Omitted Variables: Address the potential omitted variable bias identified in the limitations. Identify and incorporate relevant variables that were not considered in the initial analysis. For example, variables related to technological innovation or specific climate policies.
3. Dynamic Models: Explore dynamic regression models, such as panel data analysis, to account for time lags and cumulative effects in the relationship between climate aid, climate readiness, and carbon efficiency. These models can capture how changes over time affect carbon efficiency.
4. Contextual Analysis: Investigate how contextual factors, such as regional climate challenges, economic structures, or cultural norms, interact with climate aid and readiness to influence carbon efficiency. This can provide a more nuanced understanding of the relationship.
5. Policy Evaluation: Evaluate the effectiveness of specific climate policies and interventions in contributing to carbon efficiency. This can involve assessing the impact of targeted climate investments or regulatory changes.
6. Case Studies: Conduct in-depth case studies of countries or regions that exhibit noteworthy patterns or anomalies in the regression results. Qualitative case studies can provide valuable insights into the mechanisms at play.
7. External Validity: Validate the regression findings by comparing them with real-world outcomes and policy implementations. Assess whether countries that receive climate aid and exhibit higher climate readiness indeed experience improvements in carbon efficiency.

These future research directions can help build upon the current work, address limitations, and contribute to a more comprehensive understanding of the complex relationships between climate aid, climate readiness, and carbon efficiency.

8

Conclusion

This thesis represents a significant stride in addressing a knowledge gap, unraveling the complex dynamics between climate aid, climate readiness, and the transition to green economies in African nations. Notably, this research carries profound implications for Africa, emphasizing the potential for embracing green technology to enhance economic efficiency and energy sustainability. It highlights the opportunity for specific African countries to leapfrog carbon-intensive phases of development, guided by the innovative framework. The inventive framework offers a holistic means of evaluating climate readiness, providing a structured approach to comprehensively assess a country's preparedness for green productivity and carbon intensity reduction.

In particular, The climate readiness framework delves deep into the intricate web of factors that contribute to a country's readiness to address climate-related challenges. Among these factors, one of the most profound and influential is the level of political stability within a nation. Political stability is more than just the absence of internal conflicts or upheavals; it represents the strength and resilience of a country's political institutions and governance systems. In a stable political environment, government agencies can function effectively, policies can be formulated and implemented coherently, and resources can be allocated efficiently toward climate resilience and mitigation efforts. Furthermore, in politically stable countries, there is a higher likelihood of policy continuity, reducing the risk of short shifts in climate-related policies that could disrupt ongoing efforts. This predictability attracts investments in green technologies and encourages private sector involvement in sustainability projects.

Additionally, the selection of carbon efficiency as an indicator, calculated through the DEA model, proves its worth as a robust measure of a nation's ability to decouple economic growth from carbon emissions—a fundamental aspect of sustainable development.

The analysis of climate aid offers intriguing insights. Initially, when we examine climate aid in isolation, the direct impact on carbon efficiency may not appear substantial. However, the true significance of climate aid becomes apparent when we consider its interaction with the climate readiness index. This interaction, which we have rigorously explored and quantified, reveals a cumulative effect that holds profound implications for the pursuit of efficient and environmentally responsible economic development. The results demonstrate that climate aid, when strategically targeted and directed towards countries that exhibit a high degree of climate preparedness, can yield remarkable outcomes. In these climate-ready countries, climate aid acts as a catalyst, accelerating the green transition process and bolstering carbon efficiency. This synergistic effect suggests that the financial resources provided through climate aid initiatives can play a pivotal role in driving sustainable economic growth while simultaneously curbing carbon emissions.

In the end, this research serves as a critical link in addressing the existing knowledge gap concerning climate aid, climate readiness, and the transition to green economies in African nations. Its ultimate objective is to leverage these insights as a catalyst, inspiring institutions and policymakers to forge alliances among African countries. These alliances would facilitate the exchange of acquired knowledge and the introduction of innovative policies, with the aspiration of emulating the successes of countries that have demonstrated higher levels of readiness and efficiency in the realm of climate action.

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A

Policy and Institution dataset

In the following section is presented index: CPIA policy and institutions for environmental sustainability. In the Table A.1 and Table A.2 is illustrated the complete dataset. The first column represent the country while the other columns correspond to the index score for the specific year. The yellow cells correspond to the missing data from the original dataset which after have been computed by me.

This dataset primarily comprises institutional and policy values, which tend to remain relatively stable over time when viewed in conjunction with trends from other countries. this is reasonable to think and is demonstrated by the original data from the World Bank dataset. Indeed, in the original dataset, the following countries presented part of the years as missing data: Angola, Liberia, Somalia, and South Sudan. For these countries, I decided to fill the missing data with the same value of the closest available data point of the same country.

For countries where no data at all were available, a different process was necessary. Analyzing the map before filling in the data, it is evident that the missing data come from two big areas: the northern area, and the south-west region. My first Idea then was to try to identify potential geographical patterns that could guide data the imputation. Considering also that the averages always stay around 3 and lower. Hence, The ideal value that I want to assign to the missing data is 2.5 or 3. In this way, I will not heavily influence the aggregate result of the index.

Analyzing possible patterns, I recognized that closer nations or regions often share similarities in their institutional structures or policy frameworks due to their geographical proximity. By examining the values of nearby countries with available data, I attempted to estimate reasonable values for the missing data of the target country.
For the northern regions, I noticed that the countries below were precisely divided into two clusters: the eastern cluster with a value of 2.5, and the western cluster with a value of 3. Indeed, I computed the values of the missing countries utilizing the same reasoning.
For the south-west countries, I used the same reasoning as the previous paragraph of analyze the closer country and continue the vertical pattern. While, going closer to the South, and becoming more policy-adverse let me decide to higher the value to 3.
For the insular countries, seeing Madagascar performance, I decided to give the value higher than the average and assign the score of 3.

This approach allowed me to maintain the overall coherence of the dataset while considering the broader geographical context within which these policies and institutions operate, as demonstrated in Figure 4.1.

see https://data.worldbank.org/indicator/IQ.CPA.ENVR.XQ for the original dataset.

Table A.1: Policy Dataset part 1

Country Name	2005	2006	2007	2008	2009	2010	2011	2012
Algeria	3	3	3	3	3	3	3	3
Angola	2.5	3	3	3	3	3	2.5	2.5
Benin	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Botswana	3	3	3	3	3	3	3	3
Burkina Faso	3.5	3.5	3.5	3.5	3.5	3.5	4	4
Burundi	2.5	3	3	3	3	3	3	3
Cabo Verde	4	3.5	3.5	3.5	3.5	3.5	3.5	3
Cameroon	4	3	3	3	3	3	3	3
Central African Republic	2.5	2.5	2.5	2.5	3	3	3	3
Chad	2.5	2.5	2.5	2	2	2	2.5	2.5
Comoros	2	2	2	2	2	2	2.5	3
Democratic Republic of the Congo	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Republic of the Congo	3	2.5	2.5	2.5	2.5	2.5	3	3
Cote d'Ivoire	3	3	2.5	2.5	2.5	2.5	2.5	3
Djibouti	3	3	3	3	3.5	3.5	2.5	2.5
Egypt	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Equatorial Guinea	3	3	3	3	3	3	3	3
Eritrea	3	2	2	2	2	2	2	2
Eswatini	3	3	3	3	3	3	3	3
Ethiopia	3.5	3.5	3.5	3	3	3	3.5	3.5
Gabon	3	3	3	3	3	3	3	3
Gambia, The	3	3	3	3.5	3.5	3.5	3.5	3.5
Ghana	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4
Guinea	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3
Guinea-Bissau	3	2.5	2.5	2.5	2.5	3	3	2.5
Kenya	3	3	3.5	3.5	3.5	3.5	3.5	3.5
Lesotho	3	3.5	3.5	3	3	3	3.5	3.5
Liberia	2	2	2	2	2	2.5	3	3
Libya	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Madagascar	4	4	4	4	3.5	3.5	3.5	3
Malawi	3.5	3.5	3.5	3.5	3.5	3.5	4	3.5
Mali	3	3	3.5	3	3	3	3.5	3.5
Mauritania	3.5	3.5	3.5	3.5	3	3	3	2.5
Mauritius	3	3	3	3	3	3	3	3
Morocco	3	3	3	3	3	3	3	3
Mozambique	3	3	3	3	3	3.5	3	3.5
Namibia	3	3	3	3	3	3	3	3
Niger	3	3	3	3	3	3.5	4	4
Nigeria	3	3	3	3	3	3	3.5	3.5
Rwanda	3	3	3	3.5	3.5	3.5	3.5	3.5
Sao Tome and Principe	2.5	2.5	2.5	2.5	2.5	3	3.5	3.5
Senegal	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Seychelles	3	3	3	3	3	3	3	3
Sierra Leone	2.5	2	2	2	2.5	2.5	3	3
Somalia	2	2	2	2	2	2	2	2
South Africa	3	3	3	3	3	3	3	3
South Sudan	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Sudan	2.5	2.5	2.5	2	2	2	2	2
Tanzania	3.5	3.5	3.5	3.5	3.5	3.5	3	3.5
Togo	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Tunisia	3	3	3	3	3	3	3	3
Uganda	4	4	4	4	4	4	3.5	3.5
Zambia	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Zimbabwe	2.5	2.5	2.5	2	2	2	3	3

Table A.2: Policy Dataset part 2

Country Name	2013	2014	2015	2016	2017	2018	2019	2020
Algeria	3	3	3	3	3	3	3	3
Angola	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Benin	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Botswana	3	3	3	3	3	3	3	3
Burkina Faso	4	4	4	4	4	4	4	4
Burundi	3	3	3	3	3	3	3	3.5
Cabo Verde	3	3	3	3	3.5	3.5	3.5	3.5
Cameroon	3	3	3	3	3	3.5	3.5	3.5
Central African Republic	2	2	2.5	2.5	2.5	2.5	2.5	2.5
Chad	2.5	2.5	2.5	2.5	2.5	2.5	3	3
Comoros	3	3	3	3	3	3	3	3
Democratic Republic of the Congo	2.5	2.5	3	3	3	3	3	3.5
Republic of the Congo	3	3	3	2.5	2.5	2.5	2.5	2.5
Cote d'Ivoire	3	3	3	3	3.5	3.5	4	4
Djibouti	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Egypt	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Equatorial Guinea	3	3	3	3	3	3	3	3
Eritrea	2	2	2	2	2	2	2	2
Eswatini	3	3	3	3	3	3	3	3
Ethiopia	3.5	3.5	4	3.5	3.5	3.5	3.5	3.5
Gabon	3	3	3	3	3	3	3	3
Gambia, The	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Ghana	4	4	4	4	4	4	4	4
Guinea	3	3.5	3.5	3.5	3.5	3.5	4	4
Guinea-Bissau	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Kenya	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Lesotho	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Liberia	3	3	3	3	3	3	3	3
Libya	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Madagascar	3	3	3	3	3	3	3	3
Malawi	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Mali	3.5	4	4	3.5	3.5	3.5	3.5	3.5
Mauritania	3	3	3	3	3.5	3.5	3	3
Mauritius	3	3	3	3	3	3	3	3
Morocco	3	3	3	3	3	3	3	3
Mozambique	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Namibia	3	3	3	3	3	3	3	3
Niger	3.5	3.5	3.5	3.5	3	3	3.5	3.5
Nigeria	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Rwanda	3.5	4	4	4	4	4	4.5	4.5
Sao Tome and Principe	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Senegal	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Seychelles	3	3	3	3	3	3	3	3
Sierra Leone	3	3.5	3.5	3	3	3	3	3
Somalia	2	2	2	2	2	2	2	2
South Africa	3	3	3	3	3	3	3	3
South Sudan	2	2	2	1	1	1	1	1
Sudan	2	2	2	2	2	2	2	2
Tanzania	3.5	3.5	3	3	3.5	3	3	3
Togo	2.5	3	3.5	4	4	4	4	4
Tunisia	3	3	3	3	3	3	3	3
Uganda	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Zambia	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Zimbabwe	3	3	3.5	4	4	4	4	4

B

Economics and Finance dataset

Table B.1: Economics and Finance dataset part 1

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Algeria	0	0	0	0	0	0	0	0	0	0
Angola	0	0	0	0	0	0	0	0	0	0
Benin	0	0	0	0	0	0	0	0	0	0
Botswana	0	0	0	0	0	0	0	0	0	0
Burkina Faso	0	0	0	0	0	0	0	0	0	0
Burundi	0	0	0	0	0	0	0	0	0	0
Cameroon	0	0	0	0	0	0	0	0	0	0
Cabo Verde	0	0	0	0	0	0	0	0	0	0
Central African Republic	0	0	0	0	0	0	0	0	0	0
Chad	0	0	0	0	0	0	0	0	0	0
Comoros	0	0	0	0	0	0	0	0	0	0
Democratic Republic of the Congo	0	0	0	0	0	0	0	0	0	0
Djibouti	0	0	0	0	0	0	0	0	0	0
Egypt	0	0	0	0	0	0	0	0	0	0
Equatorial Guinea	0	0	0	0	0	0	0	0	0	0
Eritrea	0	0	0	0	0	0	0	0	0	0
Eswatini	0	0	0	0	0	0	0	0	0	0
Ethiopia	0	0	0	0	0	0	0	0	0	0
Gabon	0	0	0	0	0	0	0	0	0	0
Gambia, The	0	0	0	0	0	0	0	0	0	0
Ghana	0	0	0	0	0	0	0	0	0	0
Guinea	0	0	0	0	0	0	0	0	0	0
Guinea-Bissau	0	0	0	0	0	0	0	0	0	0
Ivory Coast	0	0	0	0	0	0	0	0	0	0
Kenya	0	0	0	0	0	0	0	0	0	0
Lesotho	0	0	0	0	0	0	0	0	0	0
Liberia	0	0	0	0	0	0	0	0	0	0
Libya	0	0	0	0	0	0	0	0	0	0
Malawi	0	0	0	0	0	0	0	0	0	0
Madagascar	0	0	0	0	0	0	0	0	0	0
Mali	0	0	0	0	0	0	0	0	0	0
Mauritania	0	0	0	0	0	0	0	0	0	0
Mauritius	0	0	0	0	0	1	1	1	1	1
Mozambique	0	0	0	0	0	0	0	0	0	0
Niger	0	0	0	0	0	0	0	0	0	0
Namibia	0	0	0	0	0	0	0	0	0	0
Morocco	0	0	0	0	0	0	0	0	0	0
Nigeria	0	0	0	0	0	0	0	0	0	0
Republic of the Congo	0	0	0	0	0	0	0	0	0	0
Rwanda	0	0	0	0	0	0	0	0	0	1
Sao Tome and Principe	0	0	0	0	0	0	0	0	0	0
Senegal	0	0	0	0	0	0	0	0	0	0
Seychelles	0	0	0	0	0	0	0	0	0	0
Sierra Leone	0	0	0	0	0	0	0	0	0	0
Somalia	0	0	0	0	0	0	0	0	0	0
South Africa	0	0	0	0	0	0	0	1	1	1
South Sudan	0	0	0	0	0	0	0	0	0	0
Sudan	0	0	0	0	0	0	0	0	0	0
Togo	0	0	0	0	0	0	0	0	0	0
Tanzania	0	0	0	0	0	0	0	0	0	0
Tunisia	0	0	0	0	0	0	0	0	0	0
Uganda	0	0	0	0	0	0	0	0	0	0
Zambia	0	0	0	0	0	0	0	0	0	0
Zimbabwe	1	1	1	1	1	1	1	1	1	1

Table B.2: Economics and Finance dataset part 2

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Algeria	0	0	0	0	0	0	0	0	0	0	0
Angola	0	0	0	0	0	0	0	0	0	0	0
Benin	0	0	0	0	0	0	1	1	1	1	1
Botswana	0	0	0	0	0	0	0	0	0	0	2
Burkina Faso	0	0	0	0	0	1	1	1	1	1	1
Burundi	0	0	0	0	0	0	0	0	0	0	0
Cameroon	0	0	0	0	0	0	0	0	0	0	0
Cabo Verde	0	0	0	0	0	0	0	0	0	0	1
Central African Republic	0	0	0	0	0	0	0	0	0	0	0
Chad	0	0	0	0	0	0	0	0	0	0	0
Comoros	0	0	0	0	0	0	0	0	0	0	0
Democratic Republic of the Congo	0	0	0	0	0	0	0	0	0	0	1
Djibouti	0	0	0	0	0	0	0	0	0	0	0
Egypt	0	0	0	1	1	1	1	0	2	2	2
Equatorial Guinea	0	0	0	0	0	0	0	0	0	0	0
Eritrea	0	0	0	0	0	0	0	0	0	0	0
Eswatini	0	0	0	0	0	0	0	0	0	0	0
Ethiopia	0	0	0	0	0	1	1	2	2	2	2
Gabon	0	0	0	0	0	0	0	0	0	1	1
Gambia, The	0	0	0	0	0	0	0	0	0	0	1
Ghana	0	1	1	1	1	1	1	1	2	2	2
Guinea	0	0	0	0	0	0	0	0	0	0	0
Guinea-Bissau	0	0	0	0	1	1	1	1	1	1	1
Ivory Coast	0	0	0	0	0	2	3	3	3	3	3
Kenya	0	0	0	0	0	0	1	1	1	3	3
Lesotho	0	0	0	0	0	0	0	0	0	0	0
Liberia	0	0	0	0	0	0	0	0	0	0	0
Libya	0	0	0	0	0	0	0	0	0	0	0
Malawi	0	0	0	0	0	0	0	0	0	0	0
Madagascar	0	0	0	0	0	0	0	0	1	1	1
Mali	0	0	0	0	0	0	0	0	0	0	0
Mauritania	0	0	0	0	0	0	0	0	0	0	0
Mauritius	1	1	1	1	1	1	1	1	1	1	1
Mozambique	0	0	0	1	1	1	1	1	1	1	1
Niger	0	0	0	0	0	0	0	0	0	0	0
Namibia	0	0	0	0	0	1	1	1	1	2	3
Morocco	0	0	0	0	0	0	0	0	0	0	0
Nigeria	0	0	0	0	1	1	1	1	1	1	2
Republic of the Congo	0	0	0	0	0	0	0	0	0	0	0
Rwanda	1	1	1	1	1	1	1	2	2	2	2
Sao Tome and Principe	0	0	0	0	0	0	0	0	0	0	0
Senegal	0	0	0	0	0	0	0	0	0	0	0
Seychelles	0	0	0	0	0	0	1	1	1	1	2
Sierra Leone	0	0	0	0	0	0	0	0	0	1	1
Somalia	0	0	0	0	0	0	0	0	0	0	0
South Africa	1	2	2	2	2	2	3	3	3	3	3
South Sudan	0	0	0	0	0	0	0	0	0	0	0
Sudan	0	0	0	0	0	0	0	0	1	1	1
Togo	0	0	0	0	0	0	0	0	0	2	2
Tanzania	0	0	0	0	0	0	0	0	0	0	0
Tunisia	0	0	0	0	0	0	0	0	0	0	1
Uganda	0	0	0	0	0	0	0	0	0	0	0
Zambia	0	0	0	0	0	0	0	0	0	1	1
Zimbabwe	1	1	1	1	1	1	1	1	1	1	1

Table B.3: Economics and Finance sources

Country	**Sources**
Nigeria	https://thelawreviews.co.uk/title/the-sustainable-finance-law-review/nigeria;
Egypt	https://thelawreviews.co.uk/title/the-renewable-energy-law-review/egypt https://www.worldbank.org/en/news/feature/2022/03/02/supporting-egypt-s-inaugural-green-bond-issuance https://www.oecd.org/tax/tax-policy/taxing-energy-use-egypt.pdf
Democratic Republic of the Congo	https://www.orbitax.com/news/archive.php/Democratic-Republic-of-the-Con-52011
Kenya	https://thelawreviews.co.uk/title/the-environment-and-climate-change-law-review/kenya https://cma.or.ke/index.php/news-publications/press-center/219-press-release-cma-approves-kenya-s-first-green-bond#: :text=The%20green%20bond%20seeks%20to,public%20offer%20for%20sophisticated%20investors https://www.greenbondskenya.co.ke/ https://www.cliffedekkerhofmeyr.com/en/news/publications/2022/Practice/Tax/tax-and-exchange-control-alert-4-july-Ready-for-take-off-Kenya-introduces-a-tax-incentive-for-carbon-trading.html
Sudan	https://www.reuters.com/article/sudan-energy-idUSL5N2NI1R6
Algeria	https://www.giz.de/en/worldwide/90188.html
Mozambique	https://www.worldbank.org/en/news/press-release/2021/10/15/mozambique-becomes-first-country-to-receive-emission-reductions-payments-from-forest-carbon-partnership-facility
Ghana	https://www.mfw4a.org/news/ghana-launch-dedicated-green-bond-exchange ; https://www.oecd.org/tax/tax-policy/taxing-energy-use-ghana.pdf ; Zeldin, W. (2014) Ghana: New Tax on Petroleum Products. [Web Page] Retrieved from the Library of Congress, https://www.loc.gov/item/global-legal-monitor/2014-12-02/ghana-new-tax-on-petroleum-products/.
Madagascar	https://www.imf.org/en/Publications/CR/Issues/2022/11/14/Republic-of-Madagascar-Technical-Assistance-Report-Climate-Macroeconomic-Assessment-Program-525665 https://www.worldbank.org/en/news/press-release/2021/02/05/madagascar-signs-landmark-agreement-with-the-world-bank-to-reduce-poverty-deforestation-and-carbon-emissions;
Ivory Coast	https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/a-green-debut-in-cote-d-ivoire#: :text=IFC%20was%20one%20of%20the,renewable%20energy%20and%20energy%20efficiency. ; https://www.carbonpricingleadership.org/calendar/2018/7/12/launch-of-the-pmr-project-on-carbon-taxation-in-cte-divoire
Burkina Faso	https://www.oecd.org/tax/tax-policy/carbon-pricing-burkina-faso.pdf
Zambia	https://www.trade.gov/country-commercial-guides/zambia-import-tariffs
Senegal	https://adelphi.de/en/projects/economic-impact-assessment-of-carbon-tax-in-senegal
Zimbabwe	https://www.herald.co.zw/what-role-can-carbon-tax-play-to-achieve-zims-climate-goals/
Rwanda	https://unfccc.int/climate-action/momentum-for-change/financing-for-climate-friendly-investment/rwanda-green-fund-fonerwa ; http://greenfund.rw/ ; https://allafrica.com/stories/202208300028.html
Benin	https://www.uncdf.org/article/8091/ecotaxes-on-polluting-goods-channelled-to-eco-friendly-community-adaptation-in-benin
Tunisia	https://www.giz.de/en/worldwide/74572.html ; https://thearabweekly.com/tunisia-mulls-introduction-green-bonds
Libya	https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/112321-libyas-upstream-appeal-re-emerging-on-low-cost-low-carbon-credentials
Liberia	https://www.afdb.org/fr/news-and-events/liberia-to-transform-renewable-energy-sector-with-support-from-the-african-development-bank-and-the-climate-investment-funds-17139
Mauritania	https://eiti.org/sites/default/files/2022-04/Mauritania%20Energy%20Transition%20Factsheet%20EN.pdf ,
Namibia	https://www.bankwindhoek.com.na/Pages/News/Bank-Windhoek-issues-first-Green-Bond.aspx , https://economist.com.na/69184/markets/rmb-arranges-fnb-namibias-inaugural-green-bond-issuance/ , https://www.undp.org/namibia/press-releases/promotion-carbon-markets-namibia-enhanced-implementation-nationally-determined-contributions-ndc-towards-net-zero-emissions
Gambia	https://www.orbitax.com/news/archive.php/Gambia-Tax-Changes-for-2023-51871
Botswana	https://www.engineeringnews.co.za/article/botswana-namibia-outline-efforts-towards-green-bonds-sustainable-stock-exchanges-2021-09-28
Gabon	https://www.euronews.com/green/2021/06/23/gabon-is-the-first-african-country-to-get-paid-for-reducing-carbon-emissions
Mauritius	https://greenfiscalpolicy.org/policy_briefs/mauritius-country-profile/
Comoros	https://greenfiscalpolicy.org/policy_briefs/comoros-country-profile/
São Tomé and Príncipe	https://www.undp.org/pt/sao-tome-principe/press-releases/sao-tome-and-principe-targets-transition-clean-energy-climate-pledge-meet-paris-agreement
Seychelles	https://www.worldbank.org/en/news/press-release/2018/10/29/seychelles-launches-worlds-first-sovereign-blue-bond
Other sources	https://greenfiscalpolicy.org/ https://carbonpricingdashboard.worldbank.org/map_data https://africabusinesscommunities.com/ https://www.un.org/ldcportal/content/local-climate-adaptive-living-facility-local https://www.climatebonds.net/market/data/ https://projectsportal.afdb.org/dataportal/ https://www.forestcarbonpartnership.org/
Interesting articles	https://unfccc.int/sites/default/files/resource/Summary%20of%20East%20Africa%20carbon%20pricing%20report.pdf https://openknowledge.worldbank.org/server/api/core/bitstreams/5afce9b5-03e0-5557-a550-6fac52275dde/content https://abmagazine.accaglobal.com/global/articles/2021/apr/business/is-africa-ready-for-carbon-tax-.html https://www.inderscience.com/info/inarticle.php?artid=122650 https://www.brookings.edu/blog/africa-in-focus/2021/03/26/africas-green-bond-market-trails-behind-other-regions/ http://cdn-odi-production.s3-website-eu-west-1.amazonaws.com/media/documents/ODI_Policy_brief_3_FINAL_clean_xxP8GTN.pdf https://www.un.org/africarenewal/magazine/june-2022/green-bonds-serve-africa%E2%80%99s-sustainable-investment-needs

C

Development of environmental-related technologies dataset

Table C.1: Development of environmental-related technologies dataset table part 1

Country name	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Algeria	12.8	14.8	12.0	14.7	2.0	7.1	48.7	16.6	10.4	23.3	6.7
Angola	0.0	0.0	0.0	0.0	0.0	24.8	0.0	0.0	0.0	0.0	0.0
Benin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Botswana	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Burkina Faso	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.0	26.1	10.4
Burundi	0.0	100.0	100.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	100.0
Cameroon	0.0	0.0	0.0	0.0	8.1	0.0	0.0	0.0	4.0	0.0	9.3
Cape Verde	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central African Republic	0.0	0.0	0.0	0.0	0.0	100.0	0.0	100.0	0.0	0.0	0.0
Chad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Comoros	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Democratic Republic of the Congo	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Djibouti	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Egypt	8.3	1.3	1.5	10.6	5.2	10.5	6.8	8.2	5.3	12.9	13.7
Equatorial Guinea	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eritrea	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	15.5	0.0	0.0
Eswatini	0.0	0.0	0.0	0.0	0.0	0.0	23.9	31.2	0.0	0.0	0.0
Ethiopia	0.0	0.0	0.0	0.0	17.1	5.0	12.8	0.0	12.7	10.2	34.0
Gabon	0.0	0.0	0.0	0.0	0.0	20.7	17.7	0.0	0.0	9.2	0.0
Gambia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ghana	0.0	0.0	0.0	10.9	0.0	21.2	4.2	12.4	16.7	0.0	25.5
Guinea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Guinea-Bissau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ivory Coast	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7
Kenya	21.8	7.2	9.7	0.0	15.9	10.6	10.5	0.0	7.0	14.8	12.9
Lesotho	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liberia	0.0	0.0	48.5	100.0	0.0	0.0	0.0	0.0	0.0	36.6	0.0
Libya	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.1	0.0
Madagascar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.5	100.0	50.0
Malawi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mali	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Mauritania	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
Mauritius	0.0	0.0	0.0	13.4	0.0	21.6	10.3	65.1	17.8	17.3	0.0
Morocco	16.3	8.4	2.8	10.6	19.5	2.7	8.9	11.4	11.9	31.8	20.3
Mozambique	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	18.0	0.0
Namibia	0.0	22.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Niger	0.0	0.0	0.0	37.7	0.0	0.0	5.3	0.0	35.9	19.4	0.0
Nigeria	3.0	0.0	0.0	2.7	5.4	8.5	12.7	27.4	7.6	24.5	17.1
Republic of the Congo	0.0	0.0	0.0	0.0	100.0	0.0	33.0	0.0	71.4	0.0	14.5
Rwanda	0.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
São Tomé and Príncipe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Senegal	0.0	12.4	0.0	0.0	17.7	0.0	0.0	0.0	37.6	44.4	24.3
Seychelles	0.0	0.0	0.0	0.0	11.1	27.5	33.7	0.0	0.0	0.0	0.0
Sierra Leone	0.0	13.6	9.1	10.2	8.4	0.0	0.0	5.1	15.0	9.9	0.0
Somalia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Africa	7.8	12.3	15.0	8.0	10.4	12.7	9.3	11.6	13.1	11.8	13.9
South Sudan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sudan	0.0	0.0	0.0	0.0	0.0	50.7	0.0	33.5	0.0	36.6	60.1
Tanzania	0.0	0.0	0.0	0.0	0.0	0.0	41.2	0.0	0.0	0.0	10.0
Togo	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.2	0.0	0.0	0.0
Tunisia	0.0	0.0	1.8	0.0	2.8	14.6	5.7	12.7	14.7	13.4	20.3
Uganda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0
Zambia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Zimbabwe	16.2	0.0	0.0	30.0	0.0	25.0	20.7	0.0	30.8	57.3	0.0

Table C.2: Development of environmental-related technologies dataset table part 2

Country name	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Algeria	15.2	10.4	14.2	12.3	28.6	17.1	2.2	22.5	30.0	16.1
Angola	0.0	0.0	22.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benin	0.0	54.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Botswana	50.0	57.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Burkina Faso	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Burundi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cameroon	5.1	14.0	0.0	0.0	0.0	52.4	30.0	7.6	21.5	7.6
Cape Verde	0.0	0.0	0.0	0.0	40.1	100.0	8.2	8.2	8.2	8.2
Central African Republic	37.6	0.0	0.0	0.0	39.9	22.3	17.6	17.6	17.6	17.6
Chad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Comoros	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Democratic Republic of the Congo	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Djibouti	40.0	50.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0
Egypt	13.1	13.7	10.2	18.4	13.5	9.2	5.2	11.8	6.3	9.3
Equatorial Guinea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eritrea	0.0	0.0	0.0	0.0	0.0	78.1	0.0	0.0	100.0	0.0
Eswatini	0.0	0.0	25.0	40.8	18.0	0.0	0.0	0.0	60.2	10.0
Ethiopia	48.5	29.5	33.3	10.7	20.6	11.7	8.3	25.0	43.1	16.1
Gabon	8.9	0.0	41.3	20.0	40.0	0.0	9.3	9.3	9.3	9.3
Gambia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ghana	0.0	26.2	11.6	63.9	7.1	17.2	15.7	13.3	20.0	13.3
Guinea	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Guinea-Bissau	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ivory Coast	0.0	0.0	0.0	0.0	0.0	14.2	13.6	3.7	25.0	3.7
Kenya	2.8	6.5	9.8	12.8	5.2	17.2	24.4	6.2	34.7	11.5
Lesotho	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Liberia	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Libya	0.0	0.0	0.0	0.0	0.0	0.0	33.3	50.0	6.9	6.9
Madagascar	28.6	33.3	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0
Malawi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mali	0.0	0.0	0.0	0.0	0.0	8.3	6.3	2.1	9.0	6.3
Mauritania	1.9	0.0	0.0	0.0	0.0	8.4	100.0	8.9	8.9	8.9
Mauritius	33.5	25.0	0.0	0.0	69.3	22.3	6.2		9.8	16.4
Morocco	17.3	17.7	26.9	13.8	25.8	21.0	28.4	18.2	25.6	17.0
Mozambique	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Namibia	40.7	39.6	28.9	16.2	0.0	22.1	0.0	8.2	0.0	0.0
Niger	0.0	15.8	6.4	0.0	0.0	14.5	47.3	23.1	10.8	10.8
Nigeria	6.2	14.6	20.2	31.0	40.4	18.3	13.2	5.8	5.8	13.2
Republic of the Congo	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Rwanda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
São Tomé and Príncipe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Senegal	24.6	41.7	0.0	0.0	25.0	0.0	0.0	40.0	42.9	15.5
Seychelles	0.0	0.0	16.7	0.0	39.8	15.0	33.3	76.0	13.3	13.3
Sierra Leone	0.0	24.8	0.0	0.0	0.0	0.0	0.0	100.0	57.1	12.7
Somalia	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Africa	11.5	10.9	11.3	13.1	16.9	6.5	7.5	9.3	10.5	11.2
South Sudan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sudan	0.0	0.0	50.0	0.0	0.0	0.0	0.0	27.3	50.0	15.4
Tanzania	0.0	0.0	0.0	11.7	0.0	0.0	0.0	0.0	0.0	0.0
Togo	0.0	0.0	50.0	0.0	76.9	0.0	0.0	0.0	0.0	0.0
Tunisia	17.5	22.9	9.4	3.3	28.3	19.4	15.0	20.3	5.7	11.4
Uganda	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.6	1.8	1.8
Zambia	0.0	0.0	0.0	0.0	75.2	0.0	33.3	100.0	16.2	16.2
Zimbabwe	0.0	12.2	0.0	39.8	0.0	13.2	19.8	34.9	39.8	17.0

D

Environmental Performance Index dataset

Table D.1: Environmental Performance Index dataset part 1

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
Algeria	66.2	66.2	71.6	77.0	72.2	67.4	58.0	48.6	49.3
Angola	39.3	39.3	39.4	39.5	37.9	36.3	42.0	47.6	38.1
Benin	58.4	58.4	57.3	56.1	47.8	39.6	45.0	50.4	41.4
Botswana	53.0	53.0	60.8	68.7	55.0	41.3	47.5	53.7	50.7
Burkina Faso	43.2	43.2	43.8	44.3	45.8	47.3	44.7	42.1	41.3
Burundi	51.6	51.6	53.2	54.7	49.3	43.9	41.0	38.0	31.9
Cameroon	54.1	54.1	59.0	63.8	54.2	44.6	43.8	43.0	39.8
Cape Verde	45.8	45.8	45.8	45.8	45.8	45.8	45.8	45.8	44.9
Central African Republic	57.3	57.3	56.7	56.0	44.7	33.3	39.2	45.1	44.0
Chad	30.5	30.5	38.2	45.9	43.4	40.8	38.5	36.2	33.6
Comoros	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	35.8
Democratic Republic of the Congo	46.3	46.3	46.8	47.3	49.5	51.6	49.6	47.5	36.3
Djibouti	42.4	42.4	46.5	50.5	55.5	60.5	51.4	42.3	35.4
Egypt	57.9	57.9	67.1	76.3	69.2	62.0	58.6	55.2	58.1
Equatorial Guinea	49.9	49.9	49.9	49.9	45.9	41.9	45.9	49.9	45.5
Eritrea	40.1	40.1	49.7	59.4	57.0	54.6	46.5	38.4	32.1
Eswatini	47.2	47.2	47.2	47.2	50.8	54.4	50.8	47.2	42.3
Ethiopia	36.7	36.7	47.8	58.8	51.0	43.1	47.9	52.7	46.1
Gabon	73.2	73.2	75.3	77.3	66.9	56.4	57.2	57.9	52.3
Gambia	52.3	52.3	47.1	41.9	46.1	50.3	46.1	41.9	35.6
Ghana	63.1	63.1	67.0	70.8	61.1	51.3	49.4	47.5	39.8
Guinea	49.2	49.2	50.3	51.3	47.8	44.4	43.3	42.2	35.6
Guinea-Bissau	46.1	46.1	47.9	49.7	47.2	44.7	43.5	42.4	39.2
Ivory Coast	57.5	57.5	61.4	65.2	59.7	54.3	53.9	53.6	46.6
Kenya	56.4	56.4	62.7	69.0	60.2	51.4	50.3	49.3	43.1
Lesotho	33.1	33.1	33.1	33.1	33.1	33.1	33.1	33.1	26.9
Liberia	51.0	51.0	42.5	34.0	34.0	34.0	34.0	34.0	29.0
Libya	48.6	48.6	48.6	48.6	49.4	50.1	43.9	37.7	40.2
Madagascar	48.5	48.5	51.6	54.6	51.9	49.2	43.6	38.0	32.4
Malawi	56.5	56.5	58.2	59.9	55.7	51.4	49.9	48.4	44.2
Mali	33.9	33.9	39.1	44.3	41.9	39.4	37.5	35.6	27.0
Mauritania	32.0	32.0	38.1	44.2	38.9	33.7	34.6	35.5	31.3
Mauritius	58.0	58.0	58.0	58.0	69.3	80.6	69.3	58.0	58.0
Morocco	64.4	64.4	68.3	72.1	68.9	65.6	55.7	45.8	48.8
Mozambique	45.7	45.7	49.8	53.9	52.6	51.2	49.5	47.8	38.9
Namibia	56.5	56.5	63.6	70.6	64.9	59.3	55.0	50.7	47.2
Niger	25.7	25.7	32.4	39.1	38.3	37.6	36.4	35.2	35.7
Nigeria	44.5	44.5	50.4	56.2	48.2	40.2	40.2	40.1	39.7
Republic of the Congo	49.4	49.4	59.6	69.7	61.8	54.0	50.6	47.2	43.3
Rwanda	57.0	57.0	56.0	54.9	49.8	44.6	44.5	44.3	39.9
São Tomé and Príncipe	49.0	49.0	49.0	49.0	53.2	57.3	53.2	49.0	49.0
Senegal	52.1	52.1	57.5	62.8	52.5	42.3	44.5	46.7	43.8
Seychelles	60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6	58.1
Sierra Leone	49.5	49.5	44.8	40.0	36.1	32.1	34.4	36.6	29.2
Somalia	43.2	43.2	38.5	33.7	29.8	25.8	28.1	30.3	22.9
South Africa	62.0	62.0	65.5	69.0	59.9	50.8	42.7	34.6	44.0
South Sudan	50.4	50.4	53.1	55.9	51.8	47.7	46.5	45.2	41.2
Sudan	44.0	44.0	49.8	55.5	51.3	47.1	46.5	46.0	35.3
Tanzania	59.0	59.0	61.5	63.9	55.9	47.9	51.1	54.3	45.2
Togo	52.8	52.8	57.6	62.3	49.4	36.4	42.5	48.7	38.3
Tunisia	60.0	60.0	69.1	78.1	69.3	60.6	53.6	46.7	52.8
Uganda	60.8	60.8	61.2	61.6	55.7	49.8	49.0	48.3	43.7
Zambia	54.4	54.4	54.8	55.1	51.1	47.0	51.3	55.6	48.6
Zimbabwe	63.0	63.0	66.2	69.3	58.6	47.8	50.3	52.8	51.2

Table D.2: Environmental Performance Index dataset part 2

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Algeria	50.1	60.2	70.3	63.7	57.2	51.0	44.8	37.2	29.6
Angola	28.7	40.3	52.0	44.7	37.4	33.6	29.7	30.1	30.5
Benin	32.4	38.0	43.7	40.9	38.2	34.1	30.0	29.8	29.6
Botswana	47.6	59.2	70.7	61.2	51.7	46.1	40.4	47.2	54.0
Burkina Faso	40.5	42.1	43.7	43.3	42.8	40.6	38.3	36.9	35.5
Burundi	25.8	34.6	43.4	35.4	27.4	27.2	27.0	28.8	30.5
Cameroon	36.7	46.9	57.1	49.0	40.8	37.2	33.6	31.9	30.2
Cape Verde	44.1	48.0	52.0	54.5	56.9	44.9	32.8	37.4	41.9
Central African Republic	42.9	44.7	46.5	41.4	36.4	36.7	36.9	40.9	44.9
Chad	31.0	34.4	37.8	41.6	45.3	36.0	26.7	27.4	28.1
Comoros	31.4	40.3	49.2	46.7	44.2	38.2	32.1	37.3	42.5
Democratic Republic of the Congo	25.0	33.5	42.1	36.2	30.4	33.4	36.4	36.7	36.9
Djibouti	28.5	36.9	45.3	42.7	40.0	34.1	28.1	37.8	47.5
Egypt	61.1	63.8	66.5	63.8	61.2	52.3	43.3	39.4	35.5
Equatorial Guinea	41.1	53.3	65.6	63.0	60.4	49.3	38.1	41.5	44.8
Eritrea	25.8	32.9	40.1	39.7	39.3	34.9	30.4	31.1	31.7
Eswatini	37.4	49.0	60.6	50.5	40.3	37.1	33.8	39.4	44.9
Ethiopia	39.4	42.6	45.8	45.3	44.8	39.6	34.4	33.1	31.8
Gabon	46.6	57.0	67.4	56.2	45.1	45.4	45.8	47.8	49.7
Gambia	29.3	40.7	52.1	47.3	42.4	35.2	27.9	34.9	41.9
Ghana	32.1	45.5	58.9	54.3	49.7	38.6	27.6	27.7	27.7
Guinea	29.0	42.2	55.4	51.0	46.6	36.5	26.4	29.0	31.6
Guinea-Bissau	36.0	42.1	48.2	46.4	44.7	36.9	29.1	34.7	40.2
Ivory Coast	39.7	49.8	59.9	52.6	45.3	35.5	25.8	29.3	32.8
Kenya	37.0	49.7	62.5	54.9	47.3	41.0	34.7	32.8	30.8
Lesotho	20.8	34.0	47.2	40.5	33.8	30.9	28.0	30.2	32.3
Liberia	24.0	33.7	43.4	42.5	41.6	32.1	22.6	23.8	24.9
Libya	42.7	53.0	63.3	56.5	49.8	49.2	48.6	49.4	50.1
Madagascar	26.7	31.9	37.1	35.4	33.7	30.1	26.5	27.3	28.0
Malawi	40.1	44.9	49.7	49.5	49.2	43.8	38.3	39.5	40.6
Mali	18.4	30.0	41.5	42.6	43.7	36.6	29.4	29.0	28.5
Mauritania	27.2	36.8	46.3	42.8	39.2	33.5	27.7	27.9	28.1
Mauritius	58.1	64.5	70.9	63.7	56.6	50.9	45.1	45.0	44.8
Morocco	51.9	63.0	74.2	68.8	63.5	52.9	42.3	35.4	28.4
Mozambique	30.0	35.9	41.8	44.1	46.4	40.1	33.9	32.8	31.7
Namibia	43.7	57.3	70.8	64.7	58.5	49.3	40.2	45.6	50.9
Niger	36.3	36.9	37.5	36.6	35.7	33.3	30.8	34.3	37.7
Nigeria	39.2	48.7	58.3	56.5	54.8	42.9	31.0	29.7	28.3
Republic of the Congo	39.4	49.5	59.6	51.0	42.4	36.6	30.8	23.4	16.0
Rwanda	35.4	42.9	50.3	47.0	43.7	38.7	33.8	33.3	32.8
São Tomé and Príncipe	49.0	48.7	48.3	51.1	54.0	45.8	37.6	45.3	52.9
Senegal	40.8	52.3	63.7	56.6	49.5	40.1	30.7	32.3	33.9
Seychelles	55.6	60.2	64.9	65.5	66.0	62.1	58.2	56.9	55.6
Sierra Leone	21.7	33.9	46.0	44.3	42.5	34.1	25.7	29.2	32.7
Somalia	15.5	27.6	39.7	38.0	36.3	27.9	19.4	22.9	26.4
South Africa	53.5	62.0	70.5	57.6	44.7	43.9	43.1	40.2	37.2
South Sudan	37.1	45.6	54.1	50.1	46.2	40.1	34.1	35.2	36.3
Sudan	24.6	33.4	42.3	46.9	51.5	43.1	34.8	31.2	27.6
Tanzania	36.2	47.3	58.3	54.6	50.8	41.0	31.1	32.7	34.2
Togo	27.9	37.0	46.1	43.9	41.8	35.6	29.5	31.8	34.0
Tunisia	59.0	68.1	77.3	69.8	62.4	54.5	46.7	43.7	40.7
Uganda	39.2	48.4	57.6	50.9	44.3	39.9	35.6	35.7	35.8
Zambia	41.7	53.9	66.1	58.5	51.0	42.8	34.7	36.6	38.4
Zimbabwe	49.5	54.4	59.3	51.3	43.4	40.2	37.0	41.6	46.2

E

Human Development Index dataset

Table E.1: Human Development Index dataset part 2

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
Algeria	0.69	0.69	0.70	0.71	0.71	0.72	0.73	0.73	0.73
Angola	0.45	0.46	0.48	0.49	0.50	0.51	0.53	0.54	0.55
Benin	0.46	0.46	0.47	0.48	0.49	0.49	0.50	0.51	0.52
Botswana	0.60	0.62	0.63	0.64	0.65	0.66	0.67	0.67	0.69
Burkina Faso	0.33	0.34	0.33	0.35	0.36	0.37	0.38	0.40	0.40
Burundi	0.34	0.36	0.37	0.39	0.40	0.41	0.41	0.42	0.42
Cameroon	0.48	0.48	0.49	0.50	0.51	0.51	0.52	0.53	0.54
Cape Verde	0.61	0.62	0.63	0.64	0.64	0.64	0.65	0.66	0.67
Central African Republic	0.34	0.35	0.35	0.36	0.36	0.37	0.38	0.39	0.37
Chad	0.33	0.33	0.34	0.34	0.36	0.36	0.37	0.38	0.39
Comoros	0.49	0.49	0.50	0.51	0.51	0.52	0.53	0.53	0.54
Democratic Republic of the Congo	0.40	0.40	0.41	0.42	0.42	0.43	0.44	0.44	0.45
Djibouti	0.41	0.42	0.43	0.43	0.45	0.46	0.47	0.48	0.48
Egypt	0.64	0.65	0.66	0.66	0.67	0.68	0.68	0.69	0.69
Equatorial Guinea	0.56	0.57	0.58	0.58	0.59	0.58	0.59	0.59	0.59
Eritrea	0.45	0.45	0.46	0.45	0.46	0.46	0.48	0.49	0.48
Eswatini	0.45	0.46	0.47	0.48	0.49	0.50	0.52	0.53	0.55
Ethiopia	0.35	0.36	0.38	0.40	0.40	0.41	0.42	0.43	0.44
Gabon	0.65	0.65	0.66	0.66	0.66	0.66	0.67	0.68	0.69
Gambia	0.43	0.44	0.44	0.45	0.46	0.46	0.46	0.47	0.47
Ghana	0.53	0.54	0.55	0.56	0.57	0.57	0.59	0.59	0.60
Guinea	0.39	0.39	0.40	0.41	0.41	0.42	0.42	0.43	0.43
Guinea-Bissau	0.40	0.42	0.42	0.43	0.44	0.44	0.45	0.46	0.46
Ivory Coast	0.46	0.46	0.46	0.46	0.47	0.47	0.47	0.48	0.48
Kenya	0.52	0.53	0.53	0.54	0.54	0.55	0.55	0.55	0.55
Lesotho	0.45	0.45	0.45	0.46	0.46	0.47	0.48	0.49	0.49
Liberia	0.44	0.44	0.45	0.45	0.46	0.46	0.46	0.47	0.48
Libya	0.74	0.74	0.74	0.74	0.74	0.74	0.69	0.73	0.72
Madagascar	0.47	0.48	0.48	0.49	0.49	0.49	0.49	0.50	0.50
Malawi	0.41	0.42	0.42	0.43	0.45	0.46	0.46	0.47	0.48
Mali	0.37	0.38	0.38	0.39	0.40	0.40	0.41	0.41	0.41
Mauritania	0.49	0.50	0.50	0.50	0.51	0.51	0.52	0.52	0.53
Mauritius	0.72	0.73	0.73	0.74	0.75	0.76	0.76	0.78	0.78
Morocco	0.57	0.57	0.58	0.59	0.59	0.60	0.61	0.62	0.64
Mozambique	0.36	0.36	0.38	0.39	0.40	0.40	0.41	0.41	0.43
Namibia	0.56	0.56	0.57	0.58	0.58	0.59	0.59	0.60	0.61
Niger	0.30	0.31	0.31	0.32	0.33	0.34	0.35	0.35	0.36
Nigeria	0.47	0.48	0.48	0.48	0.48	0.48	0.49	0.50	0.51
Republic of the Congo	0.52	0.53	0.53	0.54	0.55	0.56	0.56	0.58	0.58
Rwanda	0.42	0.44	0.46	0.47	0.48	0.49	0.50	0.51	0.51
São Tomé and Príncipe	0.53	0.54	0.55	0.55	0.55	0.55	0.56	0.56	0.57
Senegal	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49	0.50
Seychelles	0.76	0.75	0.77	0.77	0.77	0.78	0.77	0.79	0.79
Sierra Leone	0.37	0.38	0.40	0.41	0.42	0.43	0.43	0.45	0.46
Somalia	0.48	0.49	0.50	0.50	0.51	0.52	0.52	0.53	0.54
South Africa	0.63	0.64	0.64	0.65	0.67	0.68	0.69	0.70	0.70
South Sudan	0.42	0.42	0.42	0.42	0.43	0.43	0.43	0.40	0.41
Sudan	0.45	0.47	0.47	0.48	0.49	0.49	0.49	0.49	0.50
Tanzania	0.45	0.46	0.47	0.47	0.48	0.49	0.50	0.50	0.51
Togo	0.46	0.46	0.46	0.46	0.47	0.48	0.49	0.49	0.50
Tunisia	0.69	0.70	0.71	0.71	0.72	0.72	0.72	0.72	0.73
Uganda	0.45	0.47	0.48	0.48	0.49	0.50	0.51	0.50	0.51
Zambia	0.47	0.48	0.50	0.51	0.52	0.53	0.53	0.55	0.55
Zimbabwe	0.45	0.45	0.45	0.45	0.49	0.51	0.54	0.56	0.57

Table E.2: Human Development Index dataset part 2

Year	2014	2015	2016	2017	2018	2019	2020	2021
Algeria	0.74	0.74	0.74	0.74	0.75	0.75	0.74	0.75
Angola	0.56	0.58	0.60	0.60	0.60	0.60	0.59	0.59
Benin	0.52	0.53	0.53	0.53	0.53	0.53	0.52	0.53
Botswana	0.70	0.70	0.71	0.72	0.72	0.72	0.71	0.69
Burkina Faso	0.41	0.42	0.43	0.44	0.45	0.45	0.45	0.45
Burundi	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Cameroon	0.55	0.56	0.56	0.57	0.58	0.58	0.58	0.58
Cape Verde	0.67	0.66	0.67	0.68	0.67	0.68	0.66	0.66
Central African Republic	0.37	0.38	0.39	0.40	0.41	0.41	0.41	0.40
Chad	0.39	0.39	0.39	0.39	0.40	0.40	0.40	0.39
Comoros	0.54	0.54	0.55	0.55	0.56	0.56	0.56	0.56
Democratic Republic of the Congo	0.46	0.46	0.47	0.48	0.48	0.48	0.48	0.48
Djibouti	0.49	0.49	0.50	0.50	0.51	0.51	0.51	0.51
Egypt	0.70	0.71	0.71	0.72	0.73	0.74	0.73	0.73
Equatorial Guinea	0.60	0.60	0.60	0.60	0.60	0.61	0.60	0.60
Eritrea	0.50	0.48	0.49	0.48	0.49	0.50	0.49	0.49
Eswatini	0.56	0.58	0.59	0.60	0.61	0.62	0.61	0.60
Ethiopia	0.45	0.46	0.47	0.48	0.49	0.50	0.50	0.50
Gabon	0.69	0.70	0.70	0.71	0.71	0.71	0.71	0.71
Gambia	0.47	0.48	0.48	0.49	0.50	0.50	0.50	0.50
Ghana	0.60	0.61	0.61	0.62	0.62	0.63	0.63	0.63
Guinea	0.44	0.44	0.45	0.46	0.46	0.47	0.47	0.47
Guinea-Bissau	0.47	0.47	0.48	0.48	0.48	0.49	0.48	0.48
Ivory Coast	0.50	0.51	0.52	0.53	0.54	0.55	0.55	0.55
Kenya	0.56	0.56	0.57	0.57	0.58	0.58	0.58	0.58
Lesotho	0.50	0.50	0.51	0.52	0.52	0.52	0.52	0.51
Liberia	0.47	0.47	0.48	0.48	0.48	0.48	0.48	0.48
Libya	0.70	0.70	0.70	0.71	0.72	0.72	0.70	0.72
Madagascar	0.50	0.50	0.51	0.51	0.51	0.51	0.50	0.50
Malawi	0.49	0.49	0.50	0.51	0.51	0.52	0.52	0.51
Mali	0.42	0.42	0.42	0.43	0.43	0.43	0.43	0.43
Mauritania	0.54	0.54	0.54	0.55	0.56	0.56	0.56	0.56
Mauritius	0.79	0.80	0.80	0.81	0.81	0.82	0.80	0.80
Morocco	0.64	0.65	0.66	0.67	0.68	0.68	0.68	0.68
Mozambique	0.43	0.44	0.44	0.45	0.45	0.46	0.45	0.45
Namibia	0.62	0.63	0.63	0.64	0.64	0.64	0.63	0.62
Niger	0.37	0.38	0.38	0.39	0.40	0.41	0.40	0.40
Nigeria	0.51	0.52	0.52	0.53	0.53	0.54	0.54	0.54
Republic of the Congo	0.59	0.59	0.59	0.58	0.58	0.57	0.57	0.57
Rwanda	0.51	0.52	0.52	0.53	0.53	0.53	0.53	0.53
São Tomé and Príncipe	0.58	0.60	0.60	0.61	0.62	0.62	0.62	0.62
Senegal	0.50	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Seychelles	0.80	0.80	0.80	0.80	0.80	0.80	0.79	0.79
Sierra Leone	0.46	0.45	0.46	0.47	0.47	0.48	0.48	0.48
Somalia	0.54	0.55	0.55	0.56	0.56	0.57	0.56	0.56
South Africa	0.71	0.72	0.72	0.72	0.73	0.74	0.73	0.71
South Sudan	0.41	0.41	0.40	0.40	0.40	0.39	0.39	0.39
Sudan	0.50	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Tanzania	0.52	0.52	0.52	0.53	0.54	0.55	0.55	0.55
Togo	0.51	0.51	0.52	0.52	0.53	0.54	0.54	0.54
Tunisia	0.73	0.73	0.74	0.74	0.74	0.75	0.74	0.73
Uganda	0.51	0.52	0.52	0.52	0.52	0.53	0.52	0.53
Zambia	0.56	0.56	0.56	0.57	0.57	0.58	0.57	0.57
Zimbabwe	0.58	0.58	0.59	0.59	0.60	0.60	0.60	0.59

F

Natural Resource Depletion dataset

see the website https://data.worldbank.org/indicator/NY.ADJ.DRES.GN.ZS for the complete explanation

Table F.1: Natural Resource Depletion dataset part 1

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Algeria	16.55	14.03	14.72	16.11	18.01	22.88	23.75	21.76	22.05	15.38	16.21
Angola	50.08	35.86	23.43	20.05	24.75	34.13	33.80	39.87	49.16	26.23	33.12
Benin	1.79	0.92	0.86	1.68	2.77	2.01	5.25	5.50	3.02	1.55	1.55
Botswana	3.27	1.71	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burkina Faso	0.03	0.01	0.03	0.01	0.02	0.03	0.09	0.00	0.32	1.03	3.19
Burundi	14.82	19.05	24.71	41.41	31.36	27.07	24.02	32.40	33.01	30.55	23.93
Cameroon	7.63	5.22	4.81	4.66	4.13	6.46	7.40	7.90	9.46	5.47	6.37
Cabo Verde	0.76	1.04	0.92	0.88	1.14	1.34	1.25	0.99	1.82	1.01	1.34
Central African Republic	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03
Chad	10.14	7.31	6.97	9.49	31.25	28.04	25.86	24.04	24.51	12.84	15.42
Comoros	1.40	1.27	1.38	1.66	1.24	1.30	1.27	1.58	1.72	1.75	1.59
Democratic Republic of the Congo	7.32	18.75	18.93	29.73	23.93	22.71	20.20	24.20	26.60	26.77	22.90
Djibouti	0.37	0.41	0.44	0.60	0.55	0.52	0.60	0.51	0.77	0.73	0.83
Egypt	5.46	4.51	5.22	6.69	8.18	10.25	10.48	9.34	11.04	6.29	6.66
Equatorial Guinea	102.89	99.86	96.82	93.78	90.75	87.71	54.15	50.32	50.43	33.26	48.40
Eritrea	2.05	2.24	3.17	2.05	1.35	1.22	1.25	1.61	1.99	1.94	1.84
Eswatini	4.90	4.25	2.62	3.81	2.90	3.22	2.33	2.47	1.59	0.01	0.03
Ethiopia	18.59	18.22	23.34	36.40	27.97	23.54	18.83	21.86	18.73	16.41	15.79
Gabon	40.62	26.16	24.55	20.83	22.25	29.64	29.53	31.00	33.48	22.61	29.63
Gambia, The	13.20	12.19	12.88	15.58	12.33	11.34	7.02	8.08	8.44	9.91	8.97
Ghana	2.35	2.61	3.76	6.42	2.61	2.69	2.80	3.10	3.24	3.36	3.09
Guinea	8.48	8.29	9.61	13.26	10.60	15.26	9.38	8.70	9.28	8.94	9.14
Guinea-Bissau	12.27	11.49	12.85	18.25	14.41	13.66	13.49	16.81	16.24	17.41	14.99
Cote d'Ivoire	0.47	0.33	0.67	0.80	1.25	2.74	4.96	3.78	4.24	2.27	1.69
Kenya	3.34	3.17	3.77	5.14	4.16	4.08	2.96	3.63	3.64	3.71	3.01
Lesotho	2.71	2.50	3.21	3.83	2.81	2.67	2.46	3.62	4.03	4.48	3.06
Liberia	20.18	20.85	29.03	42.96	24.29	23.99	20.42	24.26	23.88	23.95	20.05
Libya	16.63	16.26	15.89	15.53	19.64	22.23	22.74	21.24	23.35	16.56	17.83
Malawi	10.34	10.11	5.87	8.74	6.46	6.88	6.83	7.99	8.72	7.09	6.06
Madagascar	3.35	2.84	3.57	5.31	6.25	5.58	5.76	6.50	5.86	6.99	5.80
Mali	4.99	4.83	7.15	5.09	3.75	2.89	6.26	6.71	5.89	7.28	6.57
Mauritania	0.06	1.14	1.19	0.06	1.68	5.52	13.68	14.26	14.50	6.77	10.22
Mauritius	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05
Mozambique	6.43	5.28	4.99	4.72	2.48	1.55	1.27	1.13	1.41	0.91	1.21
Niger	0.02	0.03	0.02	0.02	0.08	0.18	0.24	0.29	0.24	0.20	0.28
Namibia	0.50	0.54	0.55	0.77	0.65	0.91	1.93	4.45	1.66	1.47	1.61
Morocco	0.03	0.01	0.01	0.01	0.11	0.17	0.32	0.40	0.77	0.16	1.04
Nigeria	13.18	8.37	5.49	6.63	8.16	10.23	7.59	6.95	7.74	4.38	6.68
Republic of the Congo	65.21	52.17	49.46	38.46	41.55	44.68	45.67	38.58	41.75	27.91	35.07
Rwanda	4.70	5.04	6.02	8.51	6.57	5.54	4.95	5.77	7.76	6.55	5.82
Sao Tome and Principe	2.88	3.11	3.34	4.11	3.14	2.81	2.63	3.52	3.52	3.51	3.96
Senegal	0.11	0.10	0.12	0.13	0.06	0.09	0.10	0.12	0.19	0.17	0.16
Seychelles	0.01	0.01	0.02	0.01	0.02	0.04	0.04	0.06	0.19	0.50	0.38
Sierra Leone	14.32	8.00	8.37	12.77	11.13	10.06	8.55	10.26	9.64	9.89	8.58
Somalia	11.88	12.34	12.81	13.28	13.74	14.21	14.67	15.14	15.61	16.07	16.54
South Africa	1.97	2.71	2.51	1.44	2.68	2.67	3.03	3.76	7.02	2.69	4.02
South Sudan	10.60	9.37	9.50	11.01	10.32	10.73	10.02	10.80	11.53	8.41	8.90
Sudan	10.60	9.37	9.50	11.01	10.32	10.73	10.02	10.80	11.53	8.41	8.90
Togo	5.98	5.78	6.13	8.59	5.90	6.48	7.36	8.87	9.94	9.84	8.27
Tanzania	0.18	0.48	0.95	0.96	0.68	0.58	0.91	0.81	0.18	0.64	1.32
Tunisia	2.89	2.07	2.05	1.62	1.94	3.02	3.26	4.89	7.79	5.71	4.68
Uganda	12.26	12.86	14.56	21.33	15.61	14.34	13.56	16.46	16.71	9.62	8.24
Zambia	9.15	6.50	7.48	10.40	9.92	9.69	11.86	13.55	9.10	8.58	9.98
Zimbabwe	4.85	4.41	6.20	8.07	9.51	9.21	14.12	22.65	37.13	6.19	5.82

Table F.2: Natural Resource Depletion part 2

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Algeria	18.22	16.32	14.89	14.14	8.98	7.74	9.29	12.58	11.05	7.60
Angola	32.78	29.43	24.72	18.59	10.95	17.09	21.67	26.61	24.07	16.46
Benin	1.29	1.54	1.01	0.75	0.71	0.72	0.79	0.76	0.57	0.57
Botswana	0.00	0.00	0.00	0.00	0.04	0.04	0.06	0.08	0.07	0.03
Burkina Faso	5.61	4.01	2.85	2.23	1.96	2.92	3.27	3.00	2.89	3.46
Burundi	25.09	17.48	17.67	17.44	15.50	19.07	18.43	13.40	13.09	13.77
Cameroon	7.43	7.69	6.87	6.55	5.44	5.23	5.85	5.61	5.07	4.05
Cabo Verde	1.55	1.16	0.87	0.78	0.79	0.82	0.82	0.69	0.64	0.67
Central African Republic	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.04	0.05	0.13
Chad	17.35	14.90	12.15	9.91	9.09	9.93	11.35	13.20	12.76	10.07
Comoros	1.63	1.92	1.84	1.97	2.45	2.49	2.35	1.54	1.48	1.59
Democratic Republic of the Congo	25.28	24.91	25.12	24.35	20.63	20.15	19.17	16.81	10.40	15.10
Djibouti	0.88	0.93	0.53	0.80	0.67	0.50	0.60	0.29	0.37	0.33
Egypt	8.83	7.79	7.13	6.28	3.03	2.33	4.18	5.58	4.29	2.30
Equatorial Guinea	44.53	46.36	37.84	33.85	19.89	17.91	24.18	27.17	25.25	16.37
Eritrea	2.06	2.37	2.49	2.42	2.81	4.00	3.56	2.78	3.07	3.03
Eswatini	19.00	9.09	7.92	7.37	6.05	6.35	6.77	6.07	5.60	5.07
Ethiopia	17.29	14.83	13.96	13.37	12.22	11.24	9.91	6.39	5.53	5.51
Gabon	31.97	31.99	25.07	17.94	9.84	9.12	13.12	14.90	13.97	10.11
Gambia, The	12.87	12.25	8.70	10.66	9.89	8.21	9.23	8.11	7.97	7.17
Ghana	4.57	5.90	6.04	5.37	5.70	6.69	6.62	2.77	2.86	3.08
Guinea	9.51	9.74	9.20	10.37	10.33	12.40	10.54	7.06	4.76	5.32
Guinea-Bissau	13.17	17.03	17.27	18.06	19.40	18.24	15.95	10.24	9.74	10.96
Cote d'Ivoire	3.08	2.05	1.53	0.75	0.59	0.71	0.88	1.04	1.08	0.85
Kenya	3.25	3.21	3.00	2.97	3.00	2.69	2.36	1.38	1.25	1.29
Lesotho	3.25	4.03	4.44	5.02	5.55	6.40	5.54	3.22	3.30	4.05
Liberia	18.93	20.43	19.08	21.07	21.13	21.38	22.04	16.08	15.96	18.39
Libya	3.81	17.42	10.03	3.76	1.92	1.40	3.91	6.49	7.75	1.28
Malawi	6.00	9.04	10.36	9.81	9.18	10.99	7.11	5.29	4.31	4.16
Madagascar	5.71	6.67	6.69	7.34	8.92	9.10	7.85	5.12	4.84	5.81
Mali	7.60	10.12	7.30	6.37	6.68	7.91	6.93	6.76	6.99	7.93
Mauritania	9.43	9.00	6.91	5.51	2.68	3.21	3.46	0.91	0.98	0.98
Mauritius	0.07	0.05	0.04	0.04	0.01	0.02	0.00	0.00	0.00	0.00
Mozambique	1.66	1.78	1.84	0.33	0.27	0.50	0.76	0.85	0.54	0.35
Niger	0.90	1.48	2.95	1.84	0.61	0.68	0.83	1.06	0.51	0.35
Namibia	1.54	1.36	0.94	1.31	1.59	2.17	2.50	1.06	1.24	1.58
Morocco	1.22	0.27	0.22	0.16	0.13	0.14	0.17	0.19	0.10	0.08
Nigeria	8.63	7.10	5.17	3.66	1.49	1.27	2.61	3.80	3.29	1.59
Republic of the Congo	41.83	31.07	20.70	16.67	10.00	11.30	22.35	30.49	30.05	20.99
Rwanda	5.97	5.79	5.89	5.87	5.52	5.72	5.63	4.42	3.70	3.95
Sao Tome and Principe	3.81	3.89	3.31	3.00	3.42	3.27	3.16	2.34	2.05	1.96
Senegal	0.16	0.18	0.15	0.13	0.11	0.11	0.13	0.13	0.10	0.14
Seychelles	0.57	1.58	0.63	0.40	0.46	0.96	0.46	0.87	0.98	0.96
Sierra Leone	8.91	7.63	6.25	7.02	8.90	12.33	10.88	7.58	6.75	7.49
Somalia	17.01	17.47	17.94	18.40	18.98	19.65	18.81	11.80	10.79	11.52
South Africa	4.68	3.80	3.70	2.71	1.26	1.67	1.80	1.94	2.05	2.12
South Sudan	52.42	2.30	5.50	16.88	8.48	6.35	6.77	6.07	5.60	5.07
Sudan	10.19	1.83	2.36	1.38	0.78	0.85	0.72	0.46	2.65	3.40
Togo	11.85	15.42	11.26	9.39	8.35	6.42	5.98	3.95	3.84	4.30
Tanzania	2.56	2.15	1.61	1.04	0.97	1.22	1.06	0.84	0.98	1.03
Tunisia	4.67	4.92	4.01	3.32	1.89	1.51	1.61	1.78	1.42	0.93
Uganda	9.30	10.89	10.87	10.55	10.99	12.93	12.41	9.03	8.18	8.52
Zambia	7.67	4.93	4.43	2.96	1.87	1.92	3.28	4.35	1.32	5.60
Zimbabwe	6.66	5.36	4.61	5.14	4.58	4.68	5.91	2.78	4.09	4.11

G

International protocols dataset

Table G.1: International protocols part 1

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
number active protocolos	3	3	3	4	4	4	4	4	4	5	5	5	6	7
Algeria	0	0	0	2	3	3	3	3	3	3	3	3	4	4
Angola	0	0	0	0	0	0	0	0	0	0	0	1	2	2
Benin	0	0	0	1	2	2	3	3	3	3	3	3	4	4
Botswana	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Burkina Faso	0	0	0	0	0	0	0	1	1	2	4	4	5	6
Burundi	0	0	0	1	1	1	1	1	2	2	2	2	3	3
Cameroon	0	1	1	3	3	3	3	3	3	3	3	3	4	4
Cape Verde	0	0	0	0	0	0	0	0	1	1	1	1	2	2
Central African Republic	1	1	1	2	2	2	2	2	2	2	2	2	3	3
Chad	0	0	0	0	0	0	0	0	0	1	2	2	3	3
Comoros	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Democratic Republic of the Congo	1	1	1	2	2	2	2	2	2	2	3	3	4	4
Djibouti	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Egypt	1	1	1	3	3	3	3	3	4	4	4	4	5	6
Equatorial Guinea	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Eritrea	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Eswatini	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Ethiopia	0	0	0	1	1	1	1	1	1	2	2	2	3	3
Gabon	0	0	0	0	0	0	1	2	2	3	3	3	4	4
Gambia	1	1	1	1	1	1	1	2	2	2	2	2	3	3
Ghana	1	1	1	2	2	2	2	2	4	4	4	4	5	5
Guinea	0	1	1	2	2	2	2	2	2	2	2	2	3	6
Guinea-Bissau	0	0	0	0	0	0	0	0	0	0	2	2	3	3
Ivory Coast	0	0	0	1	1	1	1	1	1	1	1	1	2	2
Kenya	1	1	1	1	1	1	1	1	1	1	2	3	4	4
Lesotho	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Liberia	0	1	1	1	1	1	1	1	1	1	1	1	2	2
Libya	0	0	0	1	1	1	1	1	1	1	1	1	2	2
Madagascar	1	1	1	2	2	2	2	2	2	2	2	2	3	3
Malawi	0	0	1	2	2	2	2	2	2	2	2	2	3	3
Mali	0	0	0	1	1	1	1	3	3	3	3	3	4	4
Mauritania	0	0	0	2	2	2	2	2	2	2	2	2	3	3
Mauritius	1	1	1	1	1	1	1	1	1	1	1	1	3	4
Morocco	2	2	2	3	3	3	3	3	3	3	3	3	4	5
Mozambique	0	1	1	2	2	2	2	2	2	2	2	2	3	3
Namibia	0	0	0	0	0	0	0	0	0	0	1	1	2	2
Niger	1	1	1	3	3	3	3	4	4	4	4	4	5	5
Nigeria	1	1	1	2	2	2	2	3	3	3	3	3	5	5
Republic of the Congo	1	1	1	2	2	2	2	2	2	2	3	3	4	4
Rwanda	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Congo	0	0	0	1	1	1	1	2	2	2	2	2	3	3
São Tomé and Príncipe	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Senegal	2	2	2	3	3	3	3	3	4	4	4	4	6	6
Seychelles	1	1	1	2	2	2	2	2	2	2	2	2	3	5
Sierra Leone	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Somalia	0	0	0	0	0	1	2	2	2	2	2	2	3	3
South Africa	2	2	2	2	2	2	2	2	2	2	2	3	4	4
South Sudan	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Sudan	0	0	1	2	2	2	2	2	2	2	2	2	3	3
Tanzania	1	1	1	2	2	2	2	2	2	2	2	2	3	4
Togo	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Tunisia	1	2	2	3	3	3	3	4	4	4	4	4	5	6
Uganda	0	0	0	0	0	0	0	1	2	2	2	3	4	5
Zambia	1	1	1	1	2	2	2	2	2	2	2	3	4	5
Zimbabwe	0	1	1	2	2	2	2	2	2	2	2	2	3	3

Table G.2: International protocols dataset part 2

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
number active protocolos	9	9	10	10	11	11	11	11	11	11	13	13	13
Algeria	5	6	8	8	9	9	9	9	9	9	9	11	12
Angola	3	3	3	4	5	5	6	6	6	6	6	6	8
Benin	6	6	7	9	9	9	10	10	11	11	13	13	13
Botswana	4	4	6	7	9	9	9	9	9	10	11	11	11
Burkina Faso	7	7	8	8	8	9	9	9	9	9	11	13	13
Burundi	3	3	3	7	7	7	7	8	9	9	10	11	11
Cameroon	6	7	7	8	8	8	8	9	10	10	11	11	12
Cape Verde	3	5	6	6	6	7	7	7	7	7	7	9	13
Central African Republic	3	5	6	6	6	6	6	6	6	6	6	6	8
Chad	5	5	6	7	7	8	8	8	8	8	11	11	11
Comoros	6	7	7	7	8	8	9	9	9	9	9	9	9
Democratic Republic of the Congo	6	8	9	10	10	10	10	10	10	10	10	13	13
Djibouti	4	5	5	6	6	6	6	6	8	9	12	12	12
Egypt	9	9	10	10	10	10	10	10	10	10	11	12	12
Equatorial Guinea	2	3	3	5	5	5	7	7	7	9	10	10	10
Eritrea	2	3	5	5	5	5	5	6	6	6	6	11	11
Eswatini	1	2	4	5	5	5	5	5	5	5	5	7	9
Ethiopia	5	5	5	6	6	6	7	7	7	7	9	10	10
Gabon	4	4	5	6	8	8	8	8	8	8	9	9	10
Gambia	6	6	7	9	9	9	9	11	11	11	12	12	13
Ghana	7	8	9	9	9	9	9	9	9	11	13	13	13
Guinea	8	9	9	10	10	10	11	11	11	11	12	12	12
Guinea-Bissau	3	5	7	7	7	7	7	7	7	7	7	9	10
Ivory Coast	6	7	8	9	9	9	9	9	9	10	12	12	12
Kenya	7	7	7	8	8	9	10	10	10	10	11	13	13
Lesotho	1	3	4	4	4	4	6	6	6	8	10	10	10
Liberia	2	2	2	2	3	3	3	4	7	8	12	12	12
Libya	2	2	3	3	3	4	5	7	8	9	10	11	12
Madagascar	3	3	4	5	5	8	8	9	9	10	11	12	12
Malawi	6	6	7	8	8	8	8	9	9	9	9	9	9
Mali	7	8	9	9	9	9	10	10	11	11	13	13	13
Mauritania	4	4	8	8	10	10	10	10	10	10	10	13	13
Mauritius	6	7	8	8	8	8	8	10	10	10	12	13	13
Morocco	5	8	9	9	9	9	9	9	10	10	11	11	11
Mozambique	3	5	5	8	8	8	8	8	8	8	9	11	11
Namibia	3	6	6	8	8	8	9	9	9	10	10	12	12
Niger	5	7	8	8	9	9	9	9	9	9	10	10	12
Nigeria	8	8	8	9	9	9	9	10	10	10	13	13	13
Republic of the Congo	6	8	9	10	10	10	10	10	10	10	10	13	13
Rwanda	2	2	3	3	5	5	6	6	6	6	10	11	12
Congo	3	3	5	5	6	7	8	8	8	8	8	8	9
São Tomé and Príncipe	2	2	2	2	3	5	5	7	7	7	7	7	10
Senegal	8	9	10	10	10	10	10	11	11	11	13	13	13
Seychelles	7	7	7	8	8	8	8	8	9	9	9	11	11
Sierra Leone	3	5	5	6	6	6	7	7	7	7	8	9	10
Somalia	4	4	4	4	4	4	4	4	5	5	5	5	5
South Africa	5	5	6	10	10	10	10	10	11	11	13	13	13
South Sudan	1	1	1	1	1	1	1	1	1	1	1	1	1
Sudan	5	5	7	7	7	7	7	7	7	7	8	10	12
Tanzania	5	5	7	8	8	9	10	10	11	11	13	13	13
Togo	3	5	8	8	9	9	9	9	9	9	13	13	13
Tunisia	8	9	10	10	10	10	10	10	10	11	12	12	12
Uganda	7	7	7	8	8	9	10	10	11	11	12	12	12
Zambia	8	8	9	9	9	9	9	9	9	9	9	9	11
Zimbabwe	5	6	6	7	7	7	7	7	7	7	7	7	7

Table G.3: International protols dataset part 3

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
number active protocolos	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Algeria	12	12	12	12	12	12	12	12	12	13	13	13	13	13
Angola	9	9	9	9	9	9	10	10	10	10	11	11	11	11
Benin	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Botswana	11	12	12	12	12	12	12	12	12	13	13	13	13	13
Burkina Faso	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Burundi	11	11	11	11	12	12	12	12	12	12	12	12	12	12
Cameroon	12	12	13	13	13	13	13	13	13	14	14	14	14	14
Cape Verde	13	13	13	13	13	13	13	13	13	13	14	14	14	14
Central African Republic	8	10	10	10	10	10	10	10	10	11	11	11	11	11
Chad	11	11	13	13	13	13	13	13	13	13	14	14	14	14
Comoros	10	11	11	11	11	11	11	11	11	12	12	12	12	12
Democratic Republic of the Congo	13	13	13	13	13	13	13	13	13	13	14	14	14	14
Djibouti	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Egypt	12	12	12	12	12	12	12	12	12	12	13	13	13	13
Equatorial Guinea	10	10	10	12	12	12	12	12	12	12	12	13	13	13
Eritrea	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Eswatini	9	9	9	9	9	11	13	13	13	14	14	14	14	14
Ethiopia	10	10	10	11	11	11	11	11	11	11	12	12	12	12
Gabon	11	13	13	13	13	13	13	13	13	14	14	14	14	14
Gambia	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Ghana	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Guinea	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Guinea-Bissau	10	12	12	12	12	12	12	12	12	12	12	13	13	13
Ivory Coast	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Kenya	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Lesotho	11	12	12	12	12	12	12	12	12	12	13	13	13	13
Liberia	12	13	13	13	13	13	13	13	13	13	13	14	14	14
Libya	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Madagascar	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Malawi	9	9	11	12	12	12	12	12	12	12	13	13	14	14
Mali	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Mauritania	13	13	13	13	13	13	13	13	13	13	14	14	14	14
Mauritius	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Morocco	12	12	12	12	13	13	13	13	13	14	14	14	14	14
Mozambique	11	11	12	13	13	13	13	13	13	13	13	14	14	14
Namibia	12	12	12	12	12	12	12	12	12	13	13	13	13	13
Niger	12	12	12	12	12	12	13	13	13	14	14	14	14	14
Nigeria	13	13	13	13	13	13	13	13	13	13	14	14	14	14
Republic of the Congo	13	13	13	13	13	13	13	13	13	13	14	14	14	14
Rwanda	12	12	12	12	12	12	12	12	12	13	13	13	13	13
Congo	12	13	13	13	13	13	13	13	13	13	14	14	14	14
São Tomé and Príncipe	10	11	11	11	11	11	13	13	13	14	14	14	14	14
Senegal	13	13	13	13	13	13	13	13	13	14	14	14	14	14
Seychelles	11	12	12	12	12	12	12	12	12	13	13	13	13	13
Sierra Leone	10	10	10	10	10	10	10	10	10	13	13	13	13	13
Somalia	5	5	7	11	11	11	11	11	11	12	12	12	12	12
South Africa	13	13	13	13	13	13	13	13	13	14	14	14	14	14
South Sudan	1	1	1	1	1	1	2	5	5	6	6	6	6	6
Sudan	12	12	12	12	12	12	12	12	12	12	13	13	13	13
Tanzania	13	13	13	13	13	13	13	13	13	13	13	14	14	14
Togo	13	13	13	13	13	13	13	13	13	13	14	14	14	14
Tunisia	12	12	12	12	12	12	12	12	12	13	14	14	14	14
Uganda	12	13	13	13	13	13	13	13	13	14	14	14	14	14
Zambia	11	11	11	11	12	12	12	12	12	13	13	13	13	13
Zimbabwe	7	7	8	8	8	12	13	13	13	13	14	14	14	14

Table G.4: Sources and definitions for international protocols

United Nations Statistics Division Participation in selected international environmental agreements		
Date of release:		3/31/20
Coverage:		194 countries and areas
Unit:		Year
Definitions & Technical notes:	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	http://www.basel.int/
	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	https://cites.org/eng
	Convention on Biological Diversity (CBD)	http://www.cbd.int/
	Convention on the Conservation of Migratory Species of Wild Animals (CMS)	http://www.cms.int/en
	Kyoto Protocol	http://unfccc.int/kyoto_protocol/items/2830.php
	Montreal Protocol on Substances that Deplete the Ozone Layer	http://ozone.unep.org/
	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)	http://www.ramsar.org/
	Paris Agreement	https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	http://www.pic.int/
	Stockholm Convention on Persistent Organic Pollutants	http://chm.pops.int/
	United Nations Convention on the Law of the Sea	http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm
	United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD)	https://www.unccd.int/convention/about-convention
	United Nations Framework Convention on Climate Change	http://unfccc.int/2860.php
	Convention Concerning the Protection of the World Cultural and Natural Heritage (UNESCO World Heritage Convention)	http://whc.unesco.org/en/conventiontext/
Sources:	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	https://www.basel.int/default.aspx
	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	https://www.cites.org/eng/disc/parties/chronolo.php
	Convention on Biological Diversity (CBD)	https://www.cbd.int/information/parties.shtml
	Convention on the Conservation of Migratory Species of Wild Animals (CMS)	http://www.cms.int/en/parties-range-states
	Kyoto Protocol	https://treaties.un.org/
	Montreal Protocol on Substances that Deplete the Ozone Layer	https://ozone.unep.org/treaties/montreal-protocol
	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)	https://www.ramsar.org/sites-countries
	The Paris Agreement	https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	http://www.pic.int/Countries/Statusofratifications/tabid/1072/
	Stockholm Convention on Persistent Organic Pollutants	http://chm.pops.int/Countries/StatusofRatifications/PartiesandSignatoires/tabid/4500/Default.aspx
	United Nations Convention on the Law of the Sea	http://www.un.org/depts/los/reference_files/chronological_lists_of_ratifications.htm
	United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD)	https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-10&chapt
	United Nations Framework Convention on Climate Change	http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php
	World Heritage Convention	http://whc.unesco.org/en/statesparties/

H

Linear Regression Result

CRI (Climate Readiness Index)

- Coefficient: -0.2571
- Std. Error: 0.1214
- t-value: -2.12
- P>|t|: 0.035
- 95% CI Lower: -0.4955
- 95% CI Upper: -0.0186

The negative coefficient for CRI (-0.2571) indicates that as the Climate Readiness Index decreases, there is a decrease in the dependent variable (the response variable of your regression). This suggests that countries with lower climate readiness tend to have lower values of the dependent variable. The p-value (0.035) is less than the common significance level of 0.05, indicating that the coefficient is statistically significant.

lnCA (Natural Log of Climate Aid)

- Coefficient: -0.0222
- Std. Error: 0.0051
- t-value: -4.36
- P>|t|: 0.000
- 95% CI Lower: -0.0322
- 95% CI Upper: -0.0122

The negative coefficient for lnCA (-0.0222) suggests that an increase in the natural logarithm of climate aid is associated with a decrease in the dependent variable. In other words, as climate aid increases, carbon consumption tends to decrease. This coefficient is statistically significant (p-value: 0.000).

CRI*lnCA (Interaction Term between CRI and lnCA)

- Coefficient: 0.0352
- Std. Error: 0.0107
- t-value: 3.28
- P>|t|: 0.001
- 95% CI Lower: 0.0141
- 95% CI Upper: 0.0563

The positive coefficient for the interaction term CRI*lnCA (0.0352) indicates that the combined effect of climate readiness and climate aid is associated with an increase in the dependent variable. In simple terms, when both climate readiness and climate aid are higher, carbon efficiency tends to increase. This interaction term is statistically significant (p-value: 0.001). With this variable, it is clear that even though the lnCA is negative, the cumulative effect of lnCA is positive.

Year Dummy Variables (2007 to 2020)

- These variables represent different years compared to a reference year (possibly 2005 or another year).
- Positive coefficients (e.g., 0.1083 for ”year 2007”) suggest that, in those specific years, the dependent variable tends to be higher compared to the reference year.
- Negative coefficients (e.g., -0.1115 for ”year 2008”) suggest that, in those specific years, the dependent variable tends to be lower compared to the reference year.
- All year dummy coefficients have low p-values (p<0.05), indicating statistical significance.

Country Dummy Variables (e.g., Angola, Benin, Botswana, etc.)

- Each of these dummy variables represents a specific country compared to a reference country (possibly the base category).
- Negative coefficients (e.g., -0.1127 for ”Angola”) suggest that, compared to the reference country, the dependent variable is lower for that specific country.
- Positive coefficients (e.g., 0.1099 for ”Benin”) suggest that, compared to the reference country, the dependent variable is higher for that specific country.
- The country dummy coefficients have low p-values (p<0.05), indicating statistical significance.

cons (Constant/Intercept)

- Coefficient: 0.8972
- Std. Error: 0.0716
- t-value: 12.53
- P>|t|: 0.000
- 95% CI Lower: 0.7566
- 95% CI Upper: 1.0377

The constant term, or intercept (_cons), represents the estimated value of the dependent variable when all independent variables (CRI, lnCA, interaction terms, and dummies) are equal to zero or in their reference categories. In this case, it suggests the baseline value for the dependent variable.

The positive coefficient (0.8972) for the constant indicates the estimated value of the dependent variable when all predictors are zero or in their reference categories. This value is statistically significant ($p<0.05$).

Table H.1: Linear Regression Results

Variable	Coefficient	Std. Error	t-value	P>|t|	95% CI Lower	95% CI Upper
CRI	-0.2571	0.1214	-2.12	0.035	-0.4955	-0.0186
lnCA	-0.0222	0.0051	-4.36	0.000	-0.0322	-0.0122
CRI*lnCA	0.0352	0.0107	3.28	0.001	0.0141	0.0563
year 2006	0.1099	0.0266	4.13	0.000	0.0577	0.1622
year 2007	0.1083	0.0240	4.51	0.000	0.0612	0.1555
year 2008	0.1115	0.0240	4.64	0.000	0.0644	0.1587
year 2009	0.0950	0.0241	3.94	0.000	0.0477	0.1424
year 2010	0.0961	0.0253	3.80	0.000	0.0464	0.1458
year 2011	0.1142	0.0261	4.38	0.000	0.0629	0.1654
year 2012	0.1137	0.0253	4.49	0.000	0.0640	0.1634
year 2013	0.1136	0.0253	4.49	0.000	0.0639	0.1633
year 2014	0.1085	0.0262	4.14	0.000	0.0571	0.1600
year 2015	0.0821	0.0249	3.29	0.001	0.0331	0.1310
year 2016	0.0706	0.0259	2.72	0.007	0.0197	0.1215
year 2017	0.0647	0.0261	2.48	0.013	0.0135	0.1159
year 2018	0.0646	0.0263	2.45	0.014	0.0129	0.1164
year 2019	0.0530	0.0270	1.96	0.050	-0.0001	0.1061
year 2020	0.0528	0.0270	1.96	0.051	-0.0002	0.1059
Angola	-0.1127	0.0416	-2.71	0.007	-0.1945	-0.0309
Benin	-0.5083	0.0270	-18.81	0.000	-0.5613	-0.4552
Botswana	-0.1067	0.0326	-3.28	0.001	-0.1707	-0.0428
Burkina Faso	-0.2129	0.0324	-6.58	0.000	-0.2764	-0.1493
Burundi	0.0276	0.0393	0.70	0.482	-0.0494	0.1047
Cameroon	-0.2927	0.0271	-10.78	0.000	-0.3460	-0.2394
Cape Verde	-0.4944	0.0275	-17.95	0.000	-0.5485	-0.4404
Central African Republic	0.1664	0.0291	5.72	0.000	0.1093	0.2235
Chad	0.0755	0.0323	2.33	0.020	0.0120	0.1390
Comoros	-0.0120	0.0365	-0.33	0.742	-0.0836	0.0596
Democratic Republic of the Congo	0.1898	0.0328	5.78	0.000	0.1254	0.2543
Djibouti	0.1208	0.0311	3.89	0.000	0.0598	0.1818
Egypt	0.0757	0.0392	1.93	0.054	-0.0012	0.1526
Equatorial Guinea	-0.2768	0.0488	-5.68	0.000	-0.3725	-0.1810
Eritrea	0.0766	0.0391	1.96	0.051	-0.0002	0.1535
Eswatini	0.1644	0.0290	5.67	0.000	0.1074	0.2213
Ethiopia	0.2002	0.0317	6.32	0.000	0.1380	0.2625
Gabon	0.1565	0.0292	5.36	0.000	0.0991	0.2138
Gambia	-0.4761	0.0281	-16.92	0.000	-0.5313	-0.4208
Ghana	-0.3837	0.0268	-14.30	0.000	-0.4363	-0.3310
Guinea	-0.1712	0.0286	-5.99	0.000	-0.2273	-0.1150
Guinea-Bissau	0.1014	0.0290	3.50	0.000	0.0445	0.1582
Ivory Coast	-0.2906	0.0274	-10.62	0.000	-0.3443	-0.2368
Kenya	0.1347	0.0304	4.43	0.000	0.0751	0.1944
Lesotho	0.1027	0.0320	3.21	0.001	0.0399	0.1655
Liberia	-0.0321	0.0309	-1.04	0.299	-0.0927	0.0285
Libya	0.0511	0.0410	1.25	0.213	-0.0295	0.1317
Madagascar	-0.0413	0.0317	-1.30	0.193	-0.1035	0.0209
Malawi	-0.0423	0.0279	-1.52	0.130	-0.0970	0.0124
Mali	-0.0879	0.0323	-2.72	0.007	-0.1512	-0.0246
Mauritania	0.1046	0.0296	3.54	0.000	0.0466	0.1627
Mauritius	-0.5538	0.0283	-19.56	0.000	-0.6094	-0.4982
Morocco	-0.4348	0.0302	-14.41	0.000	-0.4940	-0.3755
Mozambique	0.0489	0.0335	1.46	0.144	-0.0168	0.1147
Namibia	0.1624	0.0272	5.98	0.000	0.1091	0.2157
Niger	0.1211	0.0301	4.02	0.000	0.0619	0.1803
Nigeria	0.0955	0.0300	3.18	0.002	0.0365	0.1545
Republic of the Congo	0.0171	0.0321	0.53	0.594	-0.0459	0.0801
Rwanda	-0.1285	0.0279	-4.60	0.000	-0.1833	-0.0737
Senegal	-0.5266	0.0268	-19.62	0.000	-0.5793	-0.4739
Sierra Leone	-0.1422	0.0341	-4.18	0.000	-0.2090	-0.0753
South Africa	-0.0040	0.0332	-0.12	0.903	-0.0692	0.0611
Sudan	-0.0099	0.0462	-0.21	0.831	-0.1006	0.0808
São Tomé and Príncipe	0.1110	0.0292	3.80	0.000	0.0536	0.1684
Tanzania	-0.0915	0.0294	-3.11	0.002	-0.1492	-0.0337
Togo	-0.2675	0.0414	-6.46	0.000	-0.3488	-0.1862
Tunisia	-0.6046	0.0286	-21.11	0.000	-0.6608	-0.5483
Uganda	-0.0462	0.0276	-1.67	0.095	-0.1005	0.0080
Zambia	0.0676	0.0314	2.15	0.032	0.0059	0.1292
Zimbabwe	-0.0888	0.0281	-3.16	0.002	-0.1440	-0.0337
_cons	0.8972	0.0716	12.53	0.000	0.7566	1.0377