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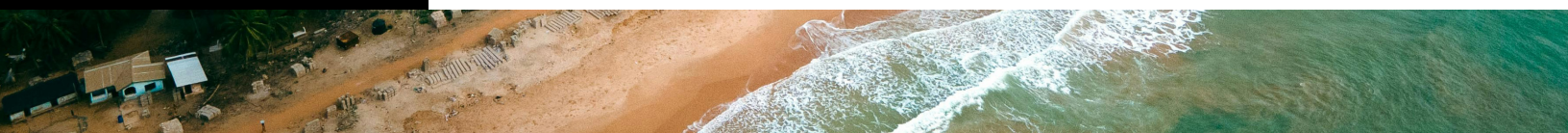
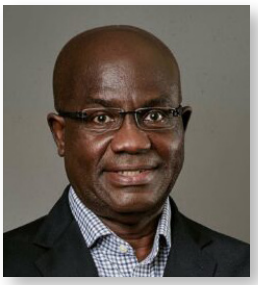
The Role of Climate-Positive Policies in Unlocking Finance for Inclusive Green Industrialization in Africa

JOHN ASAFU-ADJAYE AND GEORGE BAFFOUR AWUAH

ABSTRACT

As latecomers to industrialization, African countries have an opportunity to achieve their NDCs and drive sustainable and inclusive economic transformation through green industrialization. However, the lack of adequate financial resources is a significant constraint to accelerating the net-zero transition. As of May 2022, 45 African countries had submitted updated Nationally Determined Contributions (NDCs) with ambitious targets to reduce greenhouse gas emissions by 2030. However, many of the targets are conditional on countries receiving external financing. This study investigated the role of climate-positive policies and reforms in generating capital to help drive green industrialization. We found that undertaking regulatory reforms (e.g., removal of energy subsidies) can stimulate the flow of capital. Policy instruments such as carbon pricing (e.g., a carbon tax) can help countries to meet their NDCs and offset the spillover effects of other countries' environmental policies (e.g., the European Union's Carbon Border Adjustment Mechanism). Carbon pricing, however, may not be a one-size-fits-all policy instrument for all countries, particularly those with low carbon footprints and emissions. How successful it can be will depend on the extent to





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which a government can use part of the revenues generated in social protection schemes to address the adverse impacts on vulnerable households. Non-carbon pricing alternatives such as fuel taxes and carbon offset mechanisms could help to raise additional finance. Given its vast stocks of both green carbon (stored terrestrially) and blue carbon (stored in coastal and marine ecosystems), Africa can generate significant finance from the international carbon market. To do this, African governments must address several constraints, including limited infrastructure, poor governance, uncertain land tenure and limited capacity and awareness.

INTRODUCTION

Although Africa is responsible for less than 4 percent of total global greenhouse gas (GHG) emissions and bears the brunt of climate change, all 54 African countries have signed the 2015 Paris Agreement. As of May 2022, 45 African countries had submitted updated Nationally Determined Contributions (NDCs) with ambitious targets to reduce greenhouse gas emissions by 2030. At the inaugural Africa Climate Summit (ACS) in Nairobi in 2023, African leaders reaffirmed their commitment to lowering emissions and pursuing green growth strategies. In contrast to previous years when Africa highlighted its vulnerabilities to climate change, ACS 2023 saw leaders portray the energy transition as an opportunity to attract investments, create jobs and boost economic development. The Nairobi Declaration adopted at the summit called for "climate-positive investments to enable African countries to achieve middle-income status by 2050" (AU 2023).

These developments have occured against the backdrop of various challenges that the continent faces in its development agenda. Fiscal deficits resulting from the response to COVID-19 and the food and inflation crises arising from the Ukraine war are compounding African countries' debt burdens. Many African countries struggle to repay debts, while rising inflation is driving up interest rates worldwide and increasing the cost of debt servicing. African countries currently spend between 2 and 9 percent of their national budgets on responding to devastating climate-related extreme weather events (Associated Press 2023). The continent is estimated to lose between 5 and 15 percent of its projected gross domestic product (GDP) by 2050, with a projected climate adaptation cost of $10 billion to $30 billion annually by 2030 (AADFI 2023). To add to these challenges, recent research shows that transitioning to net zero could lead to high public debt levels (Maldonado and Gallagher 2022).

Access to external climate financing is crucial for nearly all African countries to achieve their NDCs. By 2030, Africa will require an estimated $2.8 trillion to meet its mitigation and adaptation needs. On an annual basis, the continent needs about $277 billion to transition to a low-carbon pathway (CPI 2022a). With about $29.5 billion annually in current climate finance inflows, Africa's climate finance gap comprises about 90 percent of its finance needs (CPI 2022b).

So far, the private sector has played a limited role in climate finance in Africa with a share of about 14 percent of total climate finance, compared to other regions like South Asia (37 percent), East Asia and the Pacific (39 percent) and Latin America and the Caribbean (49 percent) (AfDB 2023). The private sector can play a more prominent role in closing Africa's climate finance gap. There is an opportunity to use blended finance to de-risk private climate finance investment. Opportunities also exist to mobilize large capital pools like pension funds and sovereign wealth funds, estimated to hold $700 billion in African assets under management (CPI 2022b). Countries can also explore innovative instruments such as green bonds, green loans and sustainability-linked bonds.

With massive carbon stocks, 60 percent of the world's best solar resources and 39 percent of the global renewable energy potential (Ramalope et al. 2022), Africa can leverage its natural resources to finance the net-zero transition through carbon trading and other innovative policy instruments. According to the United Nations Economic Commission for Africa (UNECA), a global carbon price of $50 per ton of CO_2 equivalent (tCO_2e) can incentivize Africa to mobilize $30 billion annually (Pandey 2022). Financially viable carbon projects in Africa could generate an estimated annual return on investment of $2 billion (Koh et al. 2021).

Carbon trading will also be important in Africa's trade with the European Union (EU), which plans to implement its Carbon Border Adjustment Mechanism (CBAM) in 2026 and fully phase it in by 2034. The EU introduced the CBAM as part of the European Green Deal to prevent carbon leakage by imposing fees on imports based on GHG emissions during their production.[1] Other advanced countries such as the US, Japan, Canada and Singapore are also considering developing similar carbon border taxes.

HYPOTHESIS AND OBJECTIVES

As latecomers to industrialization, green industrialization presents an opportunity for African countries to achieve their NDCs and drive sustainable and inclusive economic transformation[2]. Lack of financial resources, however, constitutes a significant obstacle to investments needed to accelerate the transition towards a green economy and green industries[3]. In effect, despite the growing political commitment towards green industrialization and growth, most African countries have yet to harness the post-2015 momentum in climate and sustainability to accelerate sustainable structural transformation through green industrialization (UNECA 2016; AU 2015; Brahmbhatt et al. 2017). A recent analysis by the African Development Bank shows that the continent lags other regions in several dimensions of green growth, particularly in terms of the provision of green economic opportunities, including green employment, green trade and green investments (AfDB 2023)

[1] Carbon leakage refers to a situation in which, due to stringent climate policies in a country or region (e.g., the EU), companies move their production abroad to countries with lax policies, resulting in an increase in emissions outside the EU.

[2] We define green industrialization as industrial processes that are efficient in their use of natural resources and clean energy that help to minimize pollution and environmental impacts.

[3] Green finance is considered a primary driver of green investment, green innovation and green growth (Shah et al. 2023).

Meanwhile, whether stimulating the flow of climate finance or ensuring that such flows drive green industrialization, the lynchpin of green transition is establishing incentives and institutions. Consistent and coherent policy and regulation, combined with effective public institutions and political stability, make all the difference in creating credible incentives required to unlock green finance, both private and public. Similarly, a clear, credible and consistent policy, regulatory and institutional framework is at the heart of green structural transformations. Such a shift requires not just a marginal tweaking of current policy tools but a step-change in direction (Chukwu 2020; UNECA 2016).

A review of the literature on Africa's legal and regulatory readiness for the transition to a green economy, however, points to pervasive and unsustainable fossil fuel subsidies, with only a few mandatory environmental regulations such as taxes and standards, despite some progress in the design and implementation of relevant legislative and regulatory reforms (AfDB and GGGI 2021). For instance, as Chukwu (2020) notes, while some African countries have green growth strategies, few have been translated into policies with clear incentives and penalties. Fossil fuel subsidies in some 30 sub-Saharan African countries totalled about $75 billion in 2015, constituting about 5 percent of regional GDP (Brahmbhatt et al. 2017). Among North African countries, fossil fuel subsidies as a share of GDP is even larger (Black et al 2023). Adoption and implementation of environmental taxes across African countries have been slow, such that they contributed minimally to total tax revenue (Occhiali 2024; Mpofu 2022). The pervasive fossil fuel subsidies and inadequate environmental fiscal taxes, when combined with new green policies, create an incoherent market framework environment that is likely to impede the attraction of domestic and foreign capital, both private and public, and investment towards greener production and consumption (Shah et al. 2023; AfDB and GGGI 2021).

Our working hypothesis is that climate-positive policies are key to unlocking green finance to drive green industrialization in Africa and accelerate the net-zero transition. Climate-positive policies are needed to address various market failures, such as environmental externalities, and to promote green investments.[4]

From the foregoing, the study has two key objectives:

- To investigate how environmental-related taxes and policies (e.g., fossil fuel subsidy reform) can influence the inflow of climate-related development finance to Africa. This includes exploring how environmental-related taxes and policies can influence the effect that climate-related development finance has on industrialization.
- To explore the potential of climate-positive policies such as carbon pricing to help countries meet their NDCs and raise green capital to fund the net-zero transition.

The remainder of the report is organized as follows: Section 3 provides brief details of the empirical strategies and data used in the analysis. In Section 4, we present and discuss the results, including the effects of climate-positive policies, such as environmental-related taxes, on the flow of finance to Africa. The discussion also includes the effects of

[4] We define a climate-positive policy as one that promotes energy efficiency and low-carbon use. Implementation of such a policy leads to reduced GHG emissions.

climate-positive policies such as carbon pricing on African economies. Section 5 discusses non-traditional carbon pricing mechanisms such as fuel taxes and carbon offset mechanisms. Section 6 concludes with the summary and policy recommendations.

METHODOLOGY AND DATA

We analyzed the effects of climate-positive policies on the flow of green finance to Africa in two stages: (i) analysis of the effects of environmental-related taxes and policy reforms on green capital flows to Africa, and (ii) investigation of how climate-positive policies affect African economies, including the macroeconomic, sectoral and environmental impacts. Each of these is discussed below.

Effects of Environmental-Related Taxes and Policy Reforms on Green Finance

In this stage, we used the two-step system of the Generalized Method of Moments (GMM) estimation strategy to examine the effect of environmental-related (or green) taxes and fossil fuel subsidies on climate-related development finance flow. We used unbalanced panel data that spans 2000 to 2021 for a sample of 49 African countries[5] and estimated the following model borrowing from previous empirical literature (Robertsen et al., 2015; Doku et al., 2021) with modifications to allow testing of our hypothesis:

$$lnCRDF_{it} = \beta_0 + \beta_1 lnCRDF_{it-1} + \beta_2 Environmental\ tax\ and\ policy_{it} + \beta_3 Controls_{it} + \upsilon_t + \gamma_i + \varepsilon_{it}$$

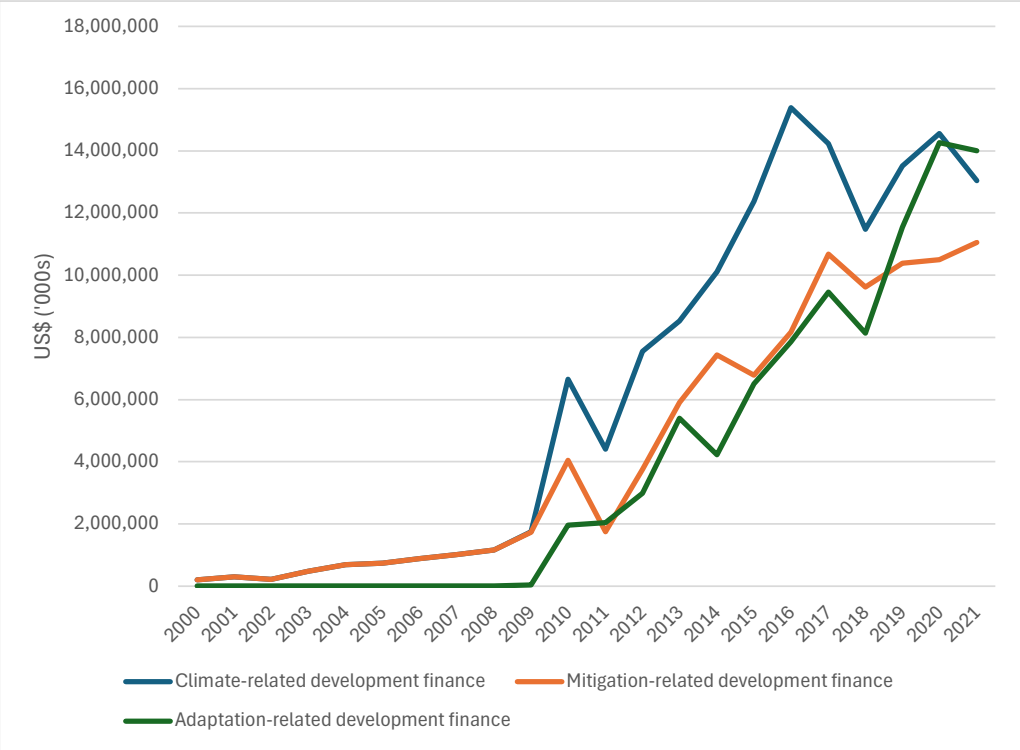
Here, the dependent variable is Climate-related development finance [CRDF]—comprising adaptation-related development finance and mitigation-related development finance, which is a proxy for green finance. The independent variables of interest are environmental tax revenue and fossil fuel subsidy [Environmental tax and policy]—measured on a per capita basis and as % of GDP, and used as proxies for environmental taxes and fossil fuel subsidy reforms.

Drawing on existing literature (Robertsen et al., 2015, and Doku et al., 2021), we include variables such as population, GDP per capita, foreign aid, climate change readiness, and governance as controls. We present a summary of all variables used, including descriptive statistics and a correlation analysis of the key variables, here and in Appendix 1.

Figure 1 shows trends in climate-related development finance to Africa for the period 2000 to 2021, while Figure 2 shows the distribution in 2021. The data show that although climate-related development finance to Africa has been growing it has been unevenly distributed, with

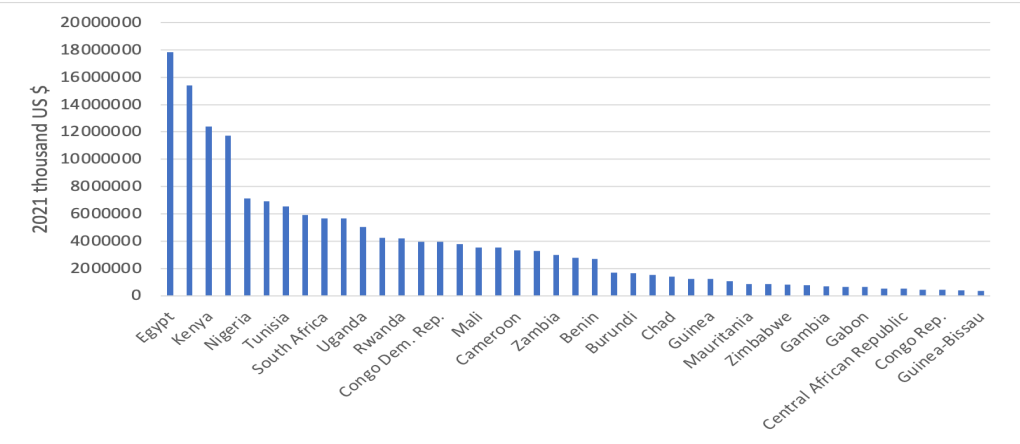
[5] Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Egypt, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

FIGURE 1 Trends in Climate-Related Development Finance, 2000-2021



Source: Authors' illustration based on OECD data.

FIGURE 2 The Distribution of Climate-Related Development Finance in 2021



Source: Authors' illustration based on OECD data.

Egypt, Morocco, and Kenya being the top three beneficiaries (Figure 2). At around $17.5 billion in 2021, the flow of development finance for climate action remains marginal compared to the funds needed. Before 2010, the flow of climate finance to Africa was primarily for mitigation purposes, with countries receiving adaptation funds only from 2010 onwards. While environmental-related tax revenue and environmental-related tax revenue per capita

have been increasing on average over the years, their share of GDP depicts a downward trend, pointing to the slow pace of green tax implementation. Finally, average fossil fuel subsidies in total and in per capita terms show significant volatility, often upended by global shocks and changes in global oil prices.

Effects of Climate-Positive Policies

In the second stage, we used computable general equilibrium analysis (CGE) to explore how climate-positive policies impact African economies. Here, we used the GTAP-E model developed by Burniax and Truong (2002) and revised by Corong et al. (2020) together with the GTAP-E Database Version 10. The GTAP-E model introduces an energy-environmental dimension to the standard GTAP model that enables the model to analyze energy, GHG issues and related policy issues.

The GTAP-E model is calibrated based on the GTAP 10 database and the extended energy balances compiled by the International Energy Agency (IEA). It has a base year of 2015. The database consists of 140 regions; for each region, carbon dioxide (CO2) emissions are distinguished by fuel type. We combined the 140 GTAP regions into 30 aggregates, comprising 30 countries/regions, including 25 African countries and five other countries/regions (see Appendix 2). The 57 GTAP commodity sectors were combined into six aggregates (see Appendix 3).

Compared to the original GTAP-E model, the revised version has several advantages that are useful for this study. First, the CO2 emissions are calculated using a bottom-up approach, which helps to ensure that emissions are proportional to the energy consumption of firms, households and the government and are sourced from both domestic and imported products. The carbon tax used in the revised model is a bloc-level variable that specifies both nominal and real rates and the relationship between them.

The theoretical structure of the revised GTAP-E model allows researchers to analyze policies using emissions accounting, emission permits and trading, carbon taxation, net revenues from emissions trading and changes in regional income. New arrays have been added to show CO2 emissions by region, commodity and use. The model assumes that emissions are proportional to usage. Therefore, the total emissions of the regions and commodities are calculated by summing the different uses. The region's actual emissions, emission quota and the bloc-level carbon tax rates (nominal and real) can be altered to examine the effects based on the policies being considered.

OVERVIEW OF THE CLIMATE-POSITIVE POLICIES AND THE CGE POLICY EXPERIMENTS

Following the 21st session of the Conference of the Parties (COP21) in Paris, 45 of 54 African countries have indicated in their NDCs that they plan to use climate-positive policies such as carbon pricing to help achieve their NDCs. South Africa was the first African country to implement a carbon tax in 2019, and other countries such as Egypt, Kenya, Ethiopia, Senegal, Burkina Faso and Côte d'Ivoire are considering schemes involving an emissions trading system (ETS) or carbon tax. Egypt is considering a national market for carbon trading, which

it says could later grow to serve the Arab and African regions, while Côte d'Ivoire is exploring carbon taxes and emissions trading for energy and agriculture.

The extent of African interest in applying carbon pricing or alternative means of regulating emissions can also be seen in the number of countries signing up for international initiatives. Morocco, Ethiopia and Côte d'Ivoire have joined the Carbon Pricing Leadership Coalition, a World Bank initiative to expand carbon pricing globally. Tunisia and South Africa receive technical assistance through the World Bank's Partnership for Market Readiness.

The purpose of a carbon price such as a carbon tax[6] or ETS[7] is to shift the burden of environmental damage back to those who are responsible for it and can reduce it. By making sure that the emitters account for external costs—the costs that the public pays for in other ways, such as damage to crops and health care costs from heat waves and droughts or property from flooding and sea level rise—putting a price on carbon helps to drive emissions down and foster investment in clean energies and low-carbon technologies.

In the policy experiments described below, we analyze how implementing a carbon price such as an ETS affects African countries and helps them to meet their NDCs and raise additional finance. We also consider how climate-positive policies implemented by advanced countries, such as the CBAM, affect African countries.

The CBAM will impose a levy on imported non-EU products that adjusts for the differences between the EU ETS price and the carbon price paid in the producing countries. It will come into force in 2026 after a three-year transition. The CBAM will initially apply to imported electricity, cement, aluminum, fertilizer, hydrogen and iron and steel products. In the long run, all products under the ETS may be included. Under the current proposal, the CBAM will apply to direct emissions, such as GHGs emitted during production. By the end of the three-year transition period, the European Commission will evaluate the process and decide whether to broaden its coverage to more products and services and cover indirect emissions, that is, GHG emissions from the electricity used to produce the goods and services.

Countries such as the United Kingdom and the US are considering climate-positive policies similar to the CBAM, and so we also consider the possible effects on African countries. We therefore undertake four policy experiments: (i) an African Union (AU) carbon tax, (ii) the EU CBAM, (iii) a combination of the CBAM and the AU carbon tax and (iv) a global carbon tax.

An AU Carbon tax

In this policy experiment, the AU is assumed to agree to implement a carbon tax of $10 per ton of CO_2 equivalent (tCO_2e) on its member countries.

[6] A carbon tax directly sets a price on carbon by defining a tax rate on GHGs or—more commonly—on the carbon content of fossil fuels.

[7] An ETS—sometimes referred to as a cap-and-trade system—caps the total level of GHG emissions and allows industries with low emissions to sell their extra allowances to larger emitters.

The CBAM

Here, the tariff equivalent of the EU CBAM (or carbon border tax rate) for a given export of goods and services is calculated based on the differences between the emissions taxes that would need to be paid in the EU and the emissions taxes paid in the exporting country. As indicated earlier, South Africa is currently the only African country with a carbon tax. Therefore, most African countries have a zero domestic emissions tax. Thus, the effective carbon border tax rate is \$88 per tCO_2e.

The AU Carbon Tax and the CBAM

In this scenario, we superimpose the CBAM on the AU carbon tax.

A Fuel Tax

This scenario assumes that African countries agree to implement a fuel tax of 10 percent.

RESULTS AND DISCUSSION

Effects of Environmental-Related Taxes and Policies on Finance Flows to Africa

Table 1 presents the GMM regression estimates of the effects of environmental taxes and fossil fuel subsidies on the flow of climate-related development finance. Models 1 and 2 are estimations for the effect of environmental taxes, measured in terms of revenue as a percentage of GDP and revenue per capita. On the other hand, Model 3 is an estimation for the effect of fossil fuel subsidies, measured on a per capita basis.

It can be inferred from the results that both environmental taxes and fossil fuel subsidies affect the flow of climate-related development finance in the short run. On the other hand, fossil fuel subsidies impede the flow of climate-related development finance in the short run. Over the long run, environmental taxes positively affect the flow of green finance, particularly where environmental taxes are measured in terms of revenue per capita. Conversely, the negative impact of fossil fuel subsidies on the flow of green finance fades out in the long run.

Besides the effects of green taxes and fossil fuel subsidies on green finance flow, there are some interesting results in Table 1 worth highlighting. First, previous levels of climate-related development finance flows positively influence future levels of flow. Second, climate readiness constitutes the most important (i.e., strongest) determinant of climate finance flow to African countries. Third, population and income levels positively drive the flow of climate finance, supporting concerns about the concentration of the flow of finance towards large and middle-income economies and the limited access among small and fragile economies. Finally, net ODA per capita has a positive effect on climate finance flow in both the short and long run, pointing to the role of existing ODA relationship (between donor and recipient) and donor priorities in influencing the flow of climate-related development finance.

Drawing on the results above, environmental taxes and fossil fuel subsidies, besides climate readiness, influence the flow of climate-related development finance. This indicates that

TABLE 1 GMM Estimates of the Effects of Environmental Taxes and Fossil Fuel Subsidies on Green Finance Flow

	(1)	(2)	(3)
Variables	**Dependent variable: Green finance**		
Short-run estimates			
Green finance (-1)	0.855***	0.851***	0.574***
	(0.0426)	(0.0445)	(0.171)
Environmental tax revenue as % of GDP	0.0735*		
	(0.0385)		
Environmental tax revenue per capita		0.0339*	
		(0.0196)	
Fossil fuel subsidy per capita			-0.0522*
			(0.0300)
Population	0.248***	0.251***	0.419**
	(0.0577)	(0.0636)	(0.203)
GDP per capita	0.120*	0.0836	-0.0533
	(0.0599)	(0.0601)	(0.112)
ODA per capita	0.398***	0.409***	0.295**
	(0.104)	(0.105)	(0.123)
Governance	-0.278	-0.292	0.102
	(0.196)	(0.186)	(0.197)
Climate readiness	1.964*	2.222*	3.220**
	(1.151)	(1.094)	(1.489)
Constant	-5.597***	-5.500***	-3.451**
	(1.463)	(1.502)	(1.675)
Long-run estimates			
Environmental tax revenue as % of GDP	0.508		
	(0.3366)		
Environmental tax revenue per capita		0.228*	
		(0.1344)	
Fossil fuel subsidy per capita			-0.123
			(0.0815)
GDP per capita	0.8249*		
	(0.4484)		
Population	1.713***	1.6865***	0.9831***
	(0.3051)	(0.2998)	(0.1247)
ODA per capita	2.7503**	2.7512***	0.6931
	(0.8730)	(0.8533)	(0.1878)***
Climate readiness	13.5571	14.936*	7.559**
	(8.647)	(8.4206)	(3.0591)

	(1)	(2)	(3)
Variables	**Dependent variable: Green finance**		
System GMM diagnostic test			
Year dummies	Yes	Yes	Yes
Observations	505	485	402
Number of countries	32	31	49
Instruments	22	21	18
Prop>AR(1)	0.000	0.000	0.002
Prop>AR(2)	0.679	0.691	0.573
Hansen p-value	0.294	0.351	0.444
Prob > F	0.000	0.000	0.000

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

enhanced environmental regulation and policy reforms can improve access to green finance among African countries.

Climate-related development finance constitutes the primary public source of finance for climate action and green growth in Africa. A recent study by Nchofoung et al. (2022) shows that the flow of climate-related development into Africa enhances industrialization. Currently, public finance is about six times greater than private finance (AfDB 2023); climate-related development finance is crucial for unlocking/catalyzing private finance. The inadequate flow of climate-related finance aside, the unequal distribution of climate finance across countries, with a concentration of flows towards middle-income countries. In contrast, low-income and vulnerable countries are underserved (Rickman et al. 2022). This is a major concern for policymakers in the region and rightly so. Meanwhile, the unequal distribution of finance is not limited to public sources. Private climate finance flows to Africa are "skewed toward a handful of African countries, comprising more than half of all financing inflows" (AfDB 2023). In 2019-2020, for instance, 56.2 percent of Africa's private climate finance inflows went to the continent's largest economies with more developed financial markets: Egypt, Kenya, Morocco, Nigeria and South Africa.

The analysis above offers insights into possible drivers of the confluence of international public and private flows into large middle-income countries and their divergence from small low-income countries—highlighting the importance of environmental taxes and fossil fuel subsidy reforms beyond climate readiness.

There is a general consensus among international financial institutions, multilateral development banks and international donors that environmental or green taxation is crucial in facilitating the transition to a green economy, possibly explaining the direct relationship between the application of fiscal policies and climate finance flow (IMF 2019; Pigato 2019;

Mpofu 2022). For developing African economies with increasing financial pressures and a degrading environment, green taxes are seen as an obvious solution—raising revenue while incentivizing businesses and consumers to adopt cleaner technologies and sustainable practices (Ben Youssef and Dahmani 2024).

While environmental taxes are increasingly becoming part of Africa's policy toolkit for green growth (Mpofu 2022; Ben Youssef and Dahmani 2024), their slow adoption and implementation reflects reflect practical institutional, administrative and political obstacles, including capacity constraints (lack of data and technical/analytical capacity) in effectively designing environmental taxes, consideration of revenue contribution potential over environmental impact, lack of institutional coordination—a challenge to harmonization of green taxes, perceived adverse impact on industrial growth and poverty reduction (Occhiali 2023; Mpofu 2022).

The effect of green taxes on industrial development is likely to vary across countries[8] (Abel et al. 2023; Ben Youssef and Dahmani 2024), suggesting the need for a cautious approach balancing environmental, economic and social considerations while tailoring green tax policies to prevailing local contexts.

In contrast to environmental taxes, fossil fuel subsidies cause market distortions, and for African economies, their removal can reduce the fiscal burden, enhance the transition to renewable energy and macroeconomic stability. For instance, in Nigeria, fossil subsidy reforms have been shown to increase renewable energy investments (Couharde and Mouhoud 2020). Importantly, there is consensus that fossil fuel subsidies are highly regressive, perpetuating inequality and discouraging investment in renewable energy and energy efficiency (Whitley 2015; Couharde and Mouhoud 2020).

As part of energy transition strategies, African countries have, over the past two decades, reformed fossil fuel subsidies to remove or reduce them or transfer them into RE sources—partly driving investments in renewables. Still, in 2022, fossil fuel subsidies in some 43 African countries amounted to $170 billion, constituting about 6 percent of regional GDP. A substantial part of these subsidies are in a number of countries such as Egypt, Algeria, Nigeria, and South Africa (OECD and IISD 2022). Thus, while these countries have made significant changes to their energy policies to enable renewable energy transition, they have at the same time maintained fossil fuel subsidies over time with frequent slight adjustments. Political economy constraints (i.e., special interests) coupled with a lack of institutional capacity to pursue more suitable policies underpin the persistence of subsidies (Whitley 2015; Couharde and Mouhoud 2020)

Still, where the dependence on fossil fuel is very high, the removal of subsidies is likely to have adverse distribution impacts on poor households, given the effect of such reforms on the price of other goods. In such contexts, complementary social safety net offers are crucial to protect the poor while correcting market distortions (Couharde and Mouhoud 2020).

[8] For instance, in contexts where populations are highly dependent on fossil fuels, green taxes have been found to be less effective at curbing environmental damage (Mpofu 2022).

Effects of Carbon Pricing

The results of the policy experiments are reported below for GDP, exports, terms of trade, welfare and CO_2 emissions.

EFFECTS OF AN AU CARBON TAX

An AU carbon tax leads to a contraction in GDP for countries that produce and export carbon-intensive commodities such as oil and gas. In Table 2, we observe contractions in the outputs of Nigeria (-0.5 percent), Central Africa (-0.2 percent) and South Africa (-0.2 percent). For the remaining African countries that mainly produce and export agricultural commodities, we observe positive effects on their GDP. The carbon tax increases the prices of energy-intensive products and services such as coal, gas and electricity, which causes private consumption expenditure to decline in all countries. This leads to declines in real income (measured by equivalent variation) in many countries. As can be seen in Table 2, the most affected countries include Nigeria ($1,030 million), South Africa ($549 million), Central Africa ($756 million) and Egypt ($279 million).

On the external side, many countries see a deterioration in their terms of trade, resulting in a decline in the exports of oil and gas producers (e.g., Nigeria, Cameroon, Central Africa), as well as agricultural exporters such as Kenya, Rwanda and Zimbabwe (Table 2, Column 3). The carbon tax results in a reduction in CO_2 emissions in all countries, ranging from -0.2 percent in Namibia to 13.5 percent in South Africa, which suggests that carbon pricing could be an effective means of reducing emissions to meet the NDCs.

TABLE 2 Effects of the AU Carbon Tax

Country	GDP (%)	Welfare (US$ mil.)	Total Exports (%)	CO_2 emissions (%)
Egypt	0.20	-279	0.17	-7.3
Morocco	0.36	-72	-0.58	-3.0
Tunisia	-0.07	-101	0.02	-7.2
Cameroon	0.13	-28	-0.25	-1.5
Côte d'Ivoire	0.43	16	0.34	-1.5
Ghana	0.60	-21	0.65	-1.9
Guinea	0.37	-7	0.10	-2.4
Nigeria	-0.45	-1,030	-0.74	-3.2
Senegal	0.48	7	-0.80	-4.1
Central Africa	-0.23	-756	-0.53	-1.9
Ethiopia	0.70	62	-0.70	-2.4
Kenya	0.61	50	-0.81	-2.4
Rwanda	0.17	-10	-0.52	-2.1
Tanzania	0.52	22	-0.22	-1.7
Uganda	0.24	-28	-0.70	-2.1

Country	GDP (%)	Welfare (US$ mil.)	Total Exports (%)	CO_2 emissions (%)
Malawi	-0.09	-14	-0.16	-2.5
Mauritius	0.26	-5	-0.03	-4.3
Mozambique	1.32	58	-0.27	-1.6
Zimbabwe	0.19	-16	-0.73	-6.3
Botswana	0.52	-3	0.43	-5.9
Namibia	0.21	-10	0.37	-0.2
South Africa	-0.16	-549	0.61	-13.5

Note: Central Africa includes the Central African Republic, Gabon and Angola.
Source: Compiled by the authors based on GTAP-E simulations.

EFFECTS OF THE CBAM

The imposition of the CBAM leads to depressed external demand for African exports with high carbon content. As a result, there is a worsening in countries' terms of trade, leading to various flow-on effects. First, GDP declines in countries that depend on the exports of energy-intensive products to the EU. Table 3 shows that the countries with large declines include Guinea (4 percent), Nigeria (2 percent), Mozambique (3 percent) and Botswana (4 percent). The decline in the terms of trade results in export declines in nearly all countries. This leads to household income losses, resulting in significant welfare losses in most countries. The worst affected countries include Nigeria ($3 billion), Central Africa ($2 billion), Namibia ($1.1 billion) and Egypt ($416 million). The countries least affected by the CBAM are Senegal, Ethiopia and Kenya, whose exports are dominated by agricultural commodities.

TABLE 3 The Effects of the CBAM

Country	GDP (%)	Welfare (US$ mil.)	Total Exports (%)	CO_2 emissions (%)
Egypt	-0.17	-416	-1.01	-0.1
Morocco	-0.06	-189	-1.01	0.8
Tunisia	-0.96	-276	-2.67	-1.7
Cameroon	-0.11	-34	-0.66	0.3
Côte d'Ivoire	-0.16	-25	-1.04	0.8
Ghana	-0.24	-154	-0.78	-0.4
Guinea	-3.98	-183	-4.77	-2.7
Nigeria	-1.90	-2,845	-2.90	0.6
Senegal	0.53	31	-1.41	-0.6
Central Africa	-1.84	-2,006	-2.58	-0.9
Ethiopia	0.64	62	-0.92	0.6
Kenya	0.45	40	-0.83	0.5
Rwanda	-0.50	-28	-1.43	0.4
Tanzania	-0.10	-65	-1.07	-0.1

Country	GDP (%)	Welfare (US$ mil.)	Total Exports (%)	CO_2 emissions (%)
Uganda	-0.40	-78	-1.45	0.3
Malawi	-0.56	-21	-0.4	0.1
Mauritius	0.05	-3	-0.57	0.3
Mozambique	-2.52	-230	-4.98	-3.1
Zimbabwe	-0.72	-40	-1.07	-1.0
Botswana	-4.09	-351	-2.23	2.0
Namibia	-0.90	-1,123	-0.29	-14.3
South Africa	-0.17	-416	-1.01	-0.1

Note: Central Africa includes the Central African Republic, Gabon and Angola.
Source: Compiled by the authors based on GTAP-E simulations.

EFFECTS OF THE CBAM PLUS THE AU CARBON TAX

The results in Table 4 show that an African carbon tax moderates the adverse impacts of the CBAM. However, preliminary analysis showed that an African carbon tax of $10 per ton of CO_2e would need to be increased substantially to significantly moderate the CBAM's adverse effects. For example, combining the CBAM with a carbon tax of $20 per ton of CO_2e reduces the GDP losses. Egypt's GDP decline of -0.17 percent under the CBAM reduces to -0.05 percent under the CBAM plus an AU carbon tax of $20 per ton (Table 4). Welfare losses are also moderated. For example, in Mozambique, welfare losses decline from $230 million under the CBAM to $127 million when the CBAM is combined with the AU carbon tax.

As can also be expected, export losses are less when the CBAM is combined with the AU carbon tax. For example, Nigeria's export decline is 2.9 percent under the CBAM (Table 3), but when combined with the AU carbon tax, this reduces to 2.0 percent (Table 4). Total reductions in CO_2 emissions are also greater when the CBAM is combined with an African carbon tax. For example, in Tunisia, CO_2 emissions decline by 1.7 percent under the CBAM (Table 3). However, when combined with the AU carbon tax, they decline by 15.4 percent (Table 4).

TABLE 4 Effects of the CBAM and an AU Carbon Tax of $20 Per Ton CO_2e

Country	GDP (%)	Welfare (US$ mil.)	Total Exports (%)	CO_2 emissions (%)
Egypt	-0.06	-729	-0.01	-13.5
Morocco	0.26	-198	-1.07	-6.9
Tunisia	-0.80	-320	-1.84	-15.4
Cameroon	-0.21	-73	-0.28	-3.2
Côte d'Ivoire	-0.34	-92	-0.38	-4.0
Ghana	-0.44	-243	0.36	-5.1
Guinea	0.29	-8	0.14	-0.3
Nigeria	-1.84	-2607	-2.09	-5.9

Country	GDP (%)	Welfare (US$ mil.)	Total Exports (%)	CO_2 emissions (%)
Senegal	0.92	57	-0.85	0.2
Central Africa	-1.56	-1964	-2.24	-4.6
Ethiopia	0.61	35	-0.64	-5.0
Kenya	0.67	49	-1.08	-4.8
Rwanda	-0.31	-29	-1.18	-4.6
Tanzania	0.55	47	-0.50	0.4
Uganda	0.22	-22	-0.77	0.6
Malawi	-0.14	-12	-0.08	-0.4
Mauritius	0.08	-23	-0.42	-8.2
Mozambique	-0.92	-127	-4.78	-6.7
Zimbabwe	-1.43	-101	0.03	-13.8
Botswana	-3.67	-351	-1.67	-11.8
Namibia	0.31	25	0.37	-0.2
South Africa	-1.40	-2216	0.56	-23.7

Note: Central Africa includes the Central African Republic, Gabon and Angola.
Source: Compiled by the authors based on GTAP-E simulations.

THE ROLE OF NON-TRADITIONAL CARBON PRICING MECHANISMS

Incentive-compatible policy pricing mechanisms such as carbon pricing have the potential to help African countries meet their NDCs and raise additional revenue to finance the transition.[9] However, carbon pricing instruments such as an ETS or carbon tax may not be a one-size-fits-all approach for reducing emissions for two reasons. First, as shown here, a carbon tax can potentially have adverse welfare impacts, especially on low-income and vulnerable households. How successful it can be will depend on how much a government can use part of the revenues generated from the carbon tax in social protection schemes to address the negative impacts on these groups. Second, it may not be appropriate for economies with low-carbon footprints that lack sources of carbon value, typically industrial-scale GHG emissions.

The implementation of carbon pricing mechanisms in Africa also faces several challenges. An ETS or carbon tax can be administratively burdensome and require a complex institutional architecture. Such systems also require enforcement capacity, a challenge in several African countries. For example, they would require a comprehensive monitoring, estimation and reporting framework. South Africa is the only country that has established such systems to date.

[9] As shown here, the amount of CO_2 emissions reduction that countries can achieve will depend on the size of their tax and how often they increase it.

A carbon price is considered an "explicit" pricing instrument because it directly prices the pollutant. However, the notion of carbon pricing can also include "implicit" forms, namely instruments that indirectly price GHG emissions, such as removing fossil fuel subsidies, fuel taxes or vehicle emissions surcharges. Other forms of implicit carbon pricing also include offset mechanisms that serve to put a price on carbon in the broader sense. We discuss two pricing mechanisms below: a fuel tax and a carbon offset.

Fuel Tax

As the name suggests, a fuel tax imposes a positive price on a carbon-emitting fuel source, while fossil fuel subsidies impose a negative price on carbon. Fossil fuel subsidies have been criticized for distorting the true price of fossil fuels and incentivizing the inefficient use of carbon-intensive forms of energy, which in turn may undermine the effectiveness of emissions reduction efforts. According to the IEA, in 2022, global subsidies for fossil fuel consumption exceeded $1 trillion for the first time, double those in 2021 (IEA 2022). In 2022, Senegal's fuel and electricity subsidies were about 4 percent of its GDP, while Nigeria spent $10 billion on fuel subsidies (Reuters 2023).

In this policy experiment, we impose a 10 percent tax on fuel and other oil products. Except for Egypt, Tunisia and Côte d'Ivoire, impacts on GDP are negligible in most countries (Table 5). Furthermore, the welfare impacts in these two countries are relatively more severe than in other African countries. However, the fuel tax leads to a reduction in the exports of nearly all countries.

TABLE 5 Effects of a 10% Fuel Tax

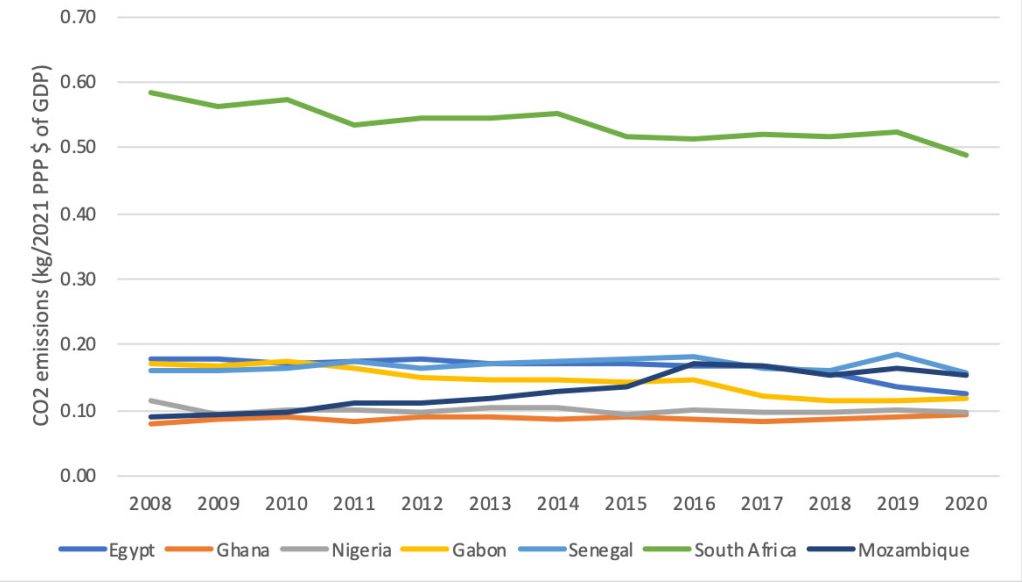
Country	GDP (%)	Welfare (US$ mil.)	Total Exports (%)	CO_2 emissions (%)
Egypt	-0.23	-167	-0.49	1.0
Morocco	-0.20	-74	0.56	1.5
Tunisia	-0.02	29	-0.09	1.0
Cameroon	0.01	31	0.09	3.9
Côte d'Ivoire	-0.33	-64	1.00	2.5
Ghana	0.17	56	-0.27	0.0
Guinea	0.00	1	-0.02	0.4
Nigeria	0.13	182	-0.25	2.1
Senegal	0.55	68	-0.12	0.3
Central Africa	0.22	399	-0.31	2.2
Ethiopia	0.05	22	-0.12	0.4
Kenya	-0.07	-17	0.13	0.7
Rwanda	0.05	2	-0.05	0.4
Tanzania	-0.01	0	0.01	0.0
Uganda	0.04	6	-0.05	0.5
Malawi	0.53	24	-0.88	3.3

Country	GDP (%)	Welfare (US$ mil.)	Total Exports (%)	CO_2 emissions (%)
Mauritius	0.02	3	-0.03	0.0
Mozambique	0.16	23	0.17	-0.2
Zimbabwe	0.61	84	-0.82	1.4
Botswana	0.26	76	-0.14	1.9
Namibia	0.46	60	-0.33	3.3
South Africa	-0.15	180	0.39	1.2

Note: Central Africa includes the Central African Republic, Gabon and Angola.
Source: Compiled by the authors based on GTAP-E simulations.

Except for the more industrialized or fuel-exporting countries, the fuel tax implementation results in slow (or no) growth in CO_2 emissions in most African countries. Viewed against the backdrop that growth in per capita CO_2 emissions in most African countries has been trending downwards or has remained flat over the last decade (see Figure 3), this implies that imposing fuel taxes or removing fossil fuel subsidies could help raise climate finance. Table 4 shows that a fuel tax is less effective in reducing emissions than a carbon tax because it targets only one energy source. However, it could be used as a prelude to a carbon tax. To avoid a situation of multiple taxation, a carbon tax would subsume all forms of climate-positive taxes.

FIGURE 3 Growth in Per Capita CO_2 Emissions for Selected African Countries, 2008-2020



Source: IMF (2024).

Carbon Offset Mechanisms

While traditional carbon pricing mechanisms tend to apply mainly at the national or regional level, numerous international mechanisms, such as carbon offset mechanisms, also serve

to put a price on carbon. These include the existing approaches under the Kyoto Protocol, such as the Clean Development Mechanism (CDM), those contemplated under Article 6 of the Paris Agreement and Results-Based Climate Finance (RBCF) projects, such as the UN's Reducing Emissions from Deforestation and Forest Degradation (REDD+).[10] In the Paris Agreement, REDD+ has a stand-alone article, Article 5 (UNFCCC 2015), which indicates broad international political backing for the scheme.

A *carbon offset* broadly refers to a reduction in GHG emissions—or an increase in carbon storage (e.g., through land restoration or planting trees)—used to compensate for emissions elsewhere. It is a transferable instrument certified by governments or independent certification bodies to represent an emissions reduction of 1 tCO_2 or an equivalent amount of other GHGs. Carbon offsets occur when a polluting company buys a carbon credit to compensate for the GHGs emitted. The money can then fund climate action elsewhere to remove the same amount of carbon from the atmosphere or prevent carbon emissions. There are two main types of carbon offset markets—mandatory (or compliance) and voluntary offset markets. Compliance markets are created and regulated by mandatory national, regional or international carbon reduction regimes.

On the other hand, voluntary markets function outside of compliance markets and enable companies and individuals to purchase carbon offsets on a voluntary basis with no intended use for compliance purposes. In some instances, compliance offset market credits may be purchased by voluntary, nonregulated entities. However, unless explicitly accepted into the compliance regime, voluntary offset market credits are not allowed to fulfill compliance market demand. Given that regulatory obligations drive the demand for compliance offset credits, the prices of such credits tend to be higher than offset credits issued solely for the voluntary market.

To date, however, African countries have had limited participation in carbon offset schemes compared to other regions. For example, the global share of African CDM projects in 2014 was only 3 percent (Röttgers and Grote 2014). African countries face several challenges in participating in carbon markets. First, private investors perceive Africa as having a high level of risk because of limited infrastructure, poor governance, uncertain land tenure and limited capacity and awareness. In addition to corruption, land tenure probably represents the most serious governance concern. More than 90 percent of Africa's rural land is generally undocumented (Byamugisha 2013), and less than 2 percent of Africa's tropical forest land is legally owned or designated for use by forest communities or indigenous groups.

Second, lack of finance constrains African countries. Schemes like the CDM and REDD+ employ a performance-based approach with payments made after the emissions reduction. Saddled with fiscal challenges, many countries find it challenging to pre-finance projects without assistance from multilateral development agencies. Finally, the United Nations Framework Convention on Climate Change (UNFCCC) requires that participating countries have a credible system for measurement, reporting and verification to quantify emissions

[10] RBCF is a form of climate finance where the provider of climate finance releases funds to the recipient upon its implementation of a pre-agreed set of climate change actions.

reductions and removals. However, African countries often lack the technology and expertise to accurately measure and report their carbon stocks.

Reform of legal systems so that they recognize and secure customary tenure rights as ownership rights would enable indigenous and local communities to claim property rights to forest land and benefit from performance-based payments.

CARBON FARMING

Another form of carbon offset scheme that can help smallholder farmers in Africa earn additional income from the sale of carbon credits is carbon farming (or regenerative agriculture). Carbon farming involves implementing farming practices that help mitigate climate change by reducing soil carbon loss and enhancing soil carbon sequestration. The European Commission (2021, p. 4) defines carbon farming as

> *"a green business model that rewards land managers for taking up improved land management practices, resulting in the increase of carbon sequestration in living biomass, dead organic matter and soils by enhancing carbon capture and/or reducing the release of carbon into the atmosphere, in respect of ecological principles favorable to biodiversity and the natural capital overall."*

The first carbon farming project implemented in Africa was the Kenya Agricultural Carbon Project, which involved 60,000 farmers on 45,000 hectares to support more productive, sustainable and climate-friendly farming (World Bank 2014). The project issued its first carbon credits in 2014 under the Verified Carbon Standard for sequestering soil carbon through sustainable agricultural land management (SALM) practices. The credits represent a reduction of 24,788 metric tCO_2e, equivalent to emissions from 5,164 vehicles in a year. So far, the project's results indicate that SALM can help increase farmers' yields by up to 15-20 percent. These productivity gains from greater soil fertility help counteract the effects of increasingly extreme weather conditions. Also, by sequestering more carbon in the soil, SALM helps mitigate climate change. By 2017, the project had generated carbon credits estimated at about $600,000.

As noted, African countries have submitted ambitious emissions reduction targets in their NDCs. One way they can achieve those targets is to scale up carbon farming. For example, India has significantly invested in carbon farming. In July 2022, its government adopted a bill to amend the Energy Conservation Act of 2001 and establish a nationwide voluntary carbon credit trading scheme, with trading scheduled to start in 2023. To scale up carbon trading in Africa, governments need to improve the incentives for technology adoption by smallholder farmers. There is also the need to build the capacity of smallholder farmers to implement SALM practices.

SUMMARY AND POLICY IMPLICATIONS

African leaders have committed to the net-zero transition and have set ambitious emissions reduction targets in their NDCs. As latecomers to industrialization, Africa can leapfrog to low-carbon pathways by leveraging its abundant renewable energy resources and massive carbon stocks. Doing so would enable countries to achieve their NDCs and foster sustainable and inclusive economic development.

We have shown in this paper that undertaking climate-positive regulatory reforms can stimulate the flow of capital to drive green industries. For example, we showed that removing fuel subsidies and introducing environmental taxes is positively associated with the inflow of climate-related development finance.

Policy instruments such as carbon pricing compel households and firms to internalize the external costs of their polluting activities, reducing their GHG emissions. They also incentivize firms to find innovative ways to mitigate their emissions. In this regard, we investigated the effects of a carbon tax on African economies. The tax raises the prices of goods and services produced with carbon-intensive inputs and reduces GDP for countries dependent on such commodities. In contrast, countries producing agricultural products are not much affected.

Given that African countries mainly depend on fossil fuels for their energy needs, the tax increases the price of electricity. It also leads to job losses in energy-intensive industries (not shown here). The net result is a decline in welfare in all countries. Because the demand for electricity is price inelastic, and poorer households spend a higher percentage of their income on it, we infer that they would be worse off than wealthier households. On the other hand, our analysis showed that a carbon tax could effectively reduce GHG emissions to help meet the NDCs.

We also analyzed the spillover effects of climate-positive policies in advanced countries on African countries. Here, we examined the effects of the EU's CBAM. We found that the policy adversely impacts the GDP and welfare of many African countries, with more significant impacts on countries whose exports to the EU are dominated by carbon-intensive products. Because the carbon border tax rate reflects the difference between the emissions taxes that would need to be paid in the EU and the emissions taxes paid in the exporting country, the adverse effects of the tax are somewhat moderated if an African carbon tax is in place. However, the African carbon tax rate has to rise substantially for it to have an appreciable offsetting effect.

Carbon pricing may not be a one-size-fits-all policy instrument for African countries. In particular, it may not be appropriate for less industrialized countries with low carbon footprints and emissions. We considered non-carbon pricing alternatives such as fuel taxes and carbon offset mechanisms. Although not as effective as a carbon tax in reducing emissions, we showed that these could be used as a precursor to a carbon tax.

Given its vast stocks of both green carbon (stored terrestrially) and blue carbon (stored carbon in coastal and marine ecosystems), Africa can generate significant finance from the international carbon market. There are also good prospects for African smallholder farmers to earn extra income from selling carbon credits through carbon farming (or regenerative agriculture). However, African countries' participation in carbon offset markets has been limited so far. Countries face various constraints, including limited infrastructure, poor governance, uncertain land tenure and limited capacity and awareness.

The results of this study have several implications for African governments, the African Union, the EU and MDBs such as the World Bank and the International Monetary Fund (IMF), which are discussed below.

African governments should consider implementing climate-positive policies to help shift their economies toward low-carbon pathways to achieve their NDCs. Large, industrialized countries can consider carbon pricing mechanisms, while less industrialized economies can consider the removal of fuel subsidies or imposition of fuel or other environmental taxes. In either case, there is a need to establish social protection schemes using some of the revenues to address the adverse impacts on low-income and vulnerable households.

African governments can enhance their countries' participation in international carbon markets by introducing land tenure reforms and addressing internal governance issues, especially corruption and the rule of law. There is also a need to improve legal, policy and regulatory frameworks to attract investors. More importantly, countries need to enhance the capacity of their private and public sectors to develop bankable climate change projects.

The AU can help accelerate the energy transition by promoting regional collaboration. Deeper regional collaboration on energy resource-sharing and investment can help to maximize the benefits of Africa's renewable energy resources and enhance energy access while also improving regional energy security. Regional collaboration will also help scale up renewable energy development on the continent and equip African countries to participate in the global carbon market. Additionally, regional collaboration to establish a regional carbon tax or ETS would be a viable path to proceed, given the administrative and capacity challenges in some countries.

The EU and other advanced countries contemplating policies similar to the CBAM should consider setting aside part of the revenues generated to provide technology transfer and capacity building to assist developing countries in implementing green industrialization policies to accelerate the net-zero transition. To address the adverse impacts of such policies, especially on least developed countries (LDCs), there should be a longer phase-in period. The adverse impacts can also be mitigated by limiting the scope of the CBAM to direct emissions. Including indirect emissions would be a challenge for many countries are not in direct control of the emitters.

Multilateral funders such as the IMF and the World Bank can promote green industrialization and help accelerate the energy transition by taking various actions. For example, the IMF can accelerate the decision to reallocate unused Special Drawing Rights (SDRs) for climate

finance. This would create the opportunity to significantly increase resources that can be lent to governments and the private sector to address climate risks and enhance development. The IMF and the World Bank could also accelerate reforms of the Debt Sustainability Framework (DSF) to account for "positive" debt, such as debt on green growth-producing assets like infrastructure investments for renewable energy, clean technologies and clean transportation that would accelerate the energy transition across the continent.

Some countries would need to finance their NDCs through debt instruments, which could adversely affect their debt sustainability. The IMF and World Bank can help address the issue by helping to scale up innovative instruments such as green finance, debt-for-climate swaps and climate-linked debt.

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APPENDIX 1: VARIABLES, DESCRIPTIVE STATISTICS AND VARIABLE TRENDS

DESCRIPTION OF VARIABLES AND DATA SOURCES

Variable	Measurement/Description	Source
Green finance	Climate-Related Development Finance (thousands of dollars)	OECD database.
Environmental taxes	Environmental tax revenue per capita	OECD database.
Fossil fuel Subsidy	Fossil fuel subsidy per capita	OECD, IEA, IMF
Population	Total population	World Bank
Per capita income	GDP per capita	World Bank
Foreign Aid	Net ODA per capita % of GNI)	World Bank
Vulnerability	ND-GAIN Vulnerability Index	Notre Dame Global Adaptation Initiative
Climate Readiness	ND-GAIN Readiness Index	Notre Dame Global Adaptation Initiative
Governance	Governance Index	World Bank
Industrialisation	Industry (including construction), value added (% of GDP)	World Bank
Trade openness	Trade (% of GDP)	World Bank
Natural resource rent	Total natural resources rents (% of GDP)	World Bank
FDI inflow	Foreign direct investment, net inflows (% of GDP)	World Bank

SUMMARY OF DESCRIPTIVE STATISTICS

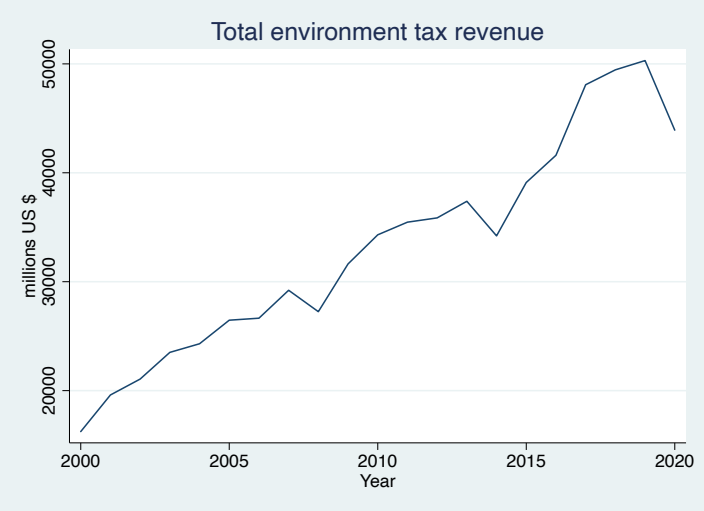
Variable	Obs	Mean	Std Dev	Min	Max
Green finance (log)	532	10.17	2.69	0.33	14.34
Environmental tax revenue per capita (2015 US$) (log)	569	3.12	1.67	-2.21	7.09
Environmental tax revenue (2015 US$) (log)	569	5.42	2.00	-1.02	9.95
Fossil fuel subsidy per capita (US$)	452	2.63	1.95	-5.22	7.11
Population (log)	569	16.12	1.53	11.37	19.15
GDP per capita(log)	569	7.35	0.99	5.78	9.73
ODA per capita (log)	566	3.79	0.87	-1.12	6.44
Climate vulnerability index	569	0.51	0.07	0.37	0.66
Climate readiness index	569	0.31	0.07	0.13	0.57
Governance index	549	-0.47	0.59	-1.85	0.87
Industrial value added (% of GDP)	927	26.24	12.16	4.43	86.67
Trade (% of GDP)	827	65.61	26.83	4.13	172.09
Total natural resources rents (% of GDP)	944	11.42	10.58	0.00	66.06
Foreign direct investment, net inflows (% of GDP)	935	4.03	7.47	-17.29	103.34

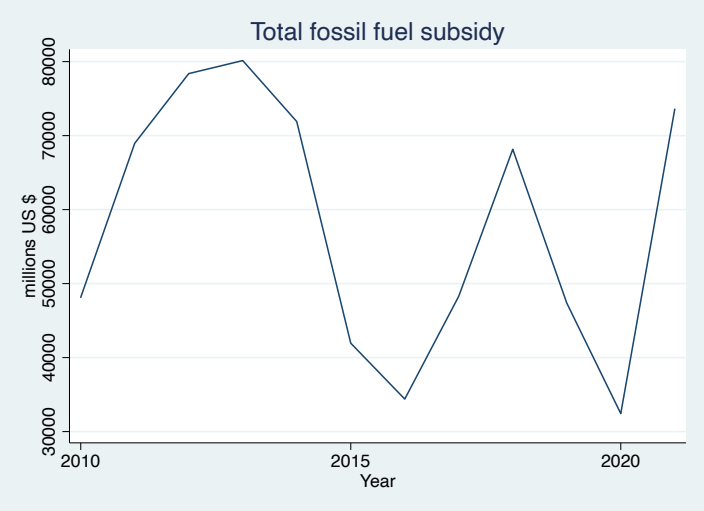
Source: Authors' calculations.

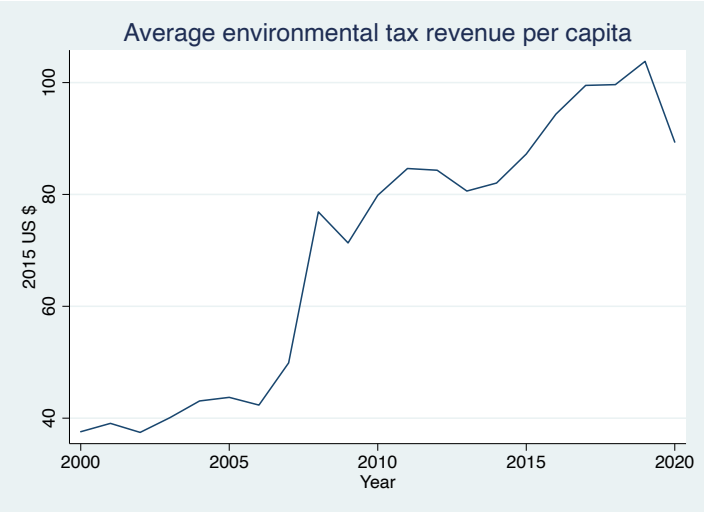
CORRELATION MATRIX FOR MODEL 1

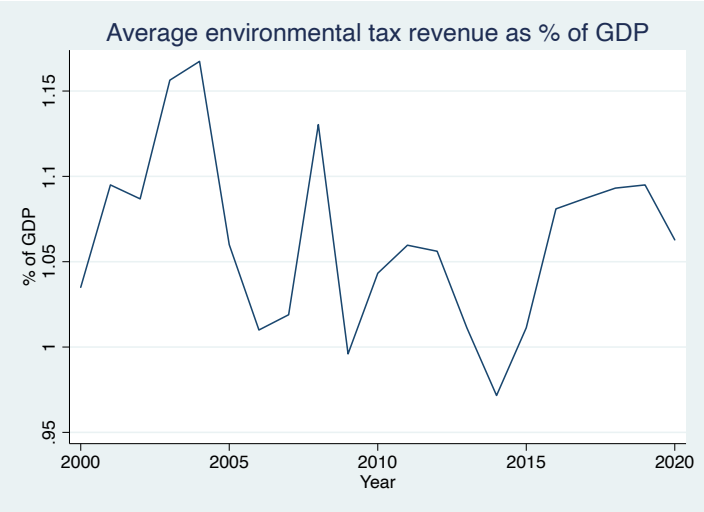
Variables	1	2	3	4	5	6	7	8
Green finance	1.00							
Environmental tax	-0.04	1.00						
Fossil fuel subsidy	0.13	0.18	1.00					
Population	0.47	-0.44	0.08	1.00				
GDP per capita	-0.07	0.57	0.34	-0.47	1.00			
Foreign aid	0.06	0.13	-0.17	-0.46	-0.00	1.00		
Climate vulnerability	-0.07	-0.33	-0.38	0.17	-0.81	0.10	1.00	
Climate readiness	0.06	0.51	0.18	-0.42	0.59	0.28	-0.58	1.00
Governance	0.01	0.44	0.07	-0.43	0.51	0.37	-0.45	0.60

Trends of key variables









APPENDIX 2: COUNTRIES AND REGIONS

African countries:	
Egypt	Kenya
Morocco	Rwanda
Tunisia	Tanzania
Benin	Uganda
Burkinafaso	Madagascar
Cameroon	Malawi
Cote d'Ivoire	Mauritius
Ghana	Mozambique
Guinea	Zambia
Nigeria	Zimbabwe
Senegal	Botswana
Central Africa	Namibia
Ethiopia	South Africa
Rest of Africa	
USA	
EU27	
China	
India	
Rest of the World	

Note: Central Africa includes the Central African Republic, Gabon and Angola.

APPENDIX 3: AGGREGATED SECTORS

1	Agriculture
2	Coal
3	Oil
4	Gas
5	Oil products
6	Electricity
7	Energy-intensive industries
8	Other industrial services