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# Climate Change Risks and Consequences on Growth and Debt Sustainability in Africa

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## ABSTRACT

This paper argues that transitioning to a low-carbon economy for African countries is not an option but a necessity. The evidence suggests that average temperature in Africa has been rising steadily from the baseline of climatology prevailing between 1951 and 1980. Our preliminary findings suggest that real gross domestic product (GDP) growth would start declining for annual temperature higher than 0.7°C. Between 1990 and 2020, average temperature in Africa increased by about 0.03°C per annum, reaching a 1.3°C annual increase in 2020. About 45 African countries already registered annual temperature rise above 0.7°C in 2020, underscoring the seriousness of climate change induced risks for long term growth. If current trends persist, real GDP growth could decline by about 2 percentage points for an annual temperature change above 1.8°C which is expected to prevail by 2030 in Africa. In addition, frequency of major natural disasters tends to exacerbate political instability and conflict. Combined, these shocks have a direct effect on government fiscal position and subsequently on sustainability of debt. A 1 percent decline in real GDP growth could worsen the budget deficit by 0.3 percentage points, suggesting the impact of

*The Task Force on Climate, Development and the IMF is a consortium of experts from around the world utilizing rigorous, empirical research to advance a development-centered approach to climate change at the IMF. The Task Force believes it is imperative the global community support climate resilience and transitions to a low-carbon economy in a just manner, and the IMF's role in supporting a globally coordinated response is vital.*

*Task Force Working Papers support the Intergovernmental Group of Twenty-Four (G-24) in coordinating the positions of developing countries on international monetary and development issues as they relate to climate change. The Working Papers also support the Advocacy and Partnerships focus group of the V20 Group of Finance Ministers to help enable policies that promote financial stability for growth and development in response to the climate crisis.*

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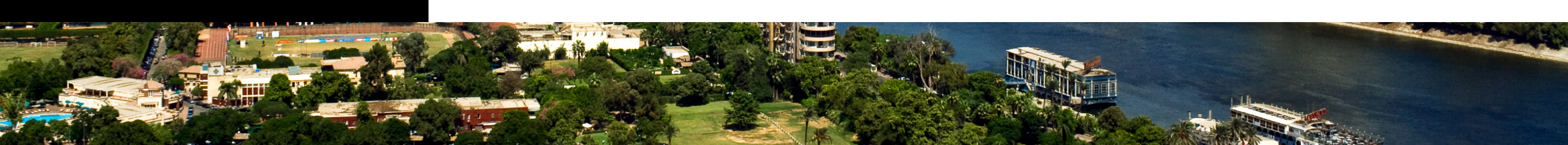
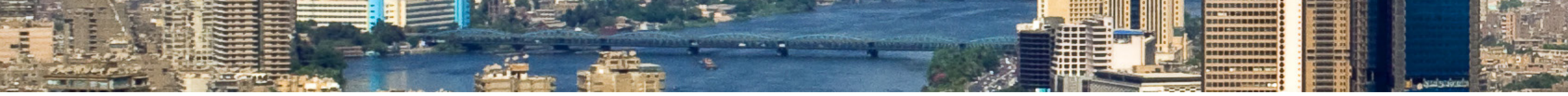




climate change could upend fiscal space significantly. Using a simple debt dynamics framework, the paper shows that the debt burden could increase 2.4 times due to climate change induced shocks. All African countries have signed the Paris Agreement, and many of them have submitted their Nationally Determined Contributions (NDCs) that contain targets for emissions reductions. Our modelling results show that carbon pricing could be an effective way of helping to meet the NDCs. However, carbon pricing (e.g., a carbon tax) would have negative impacts on energy-intensive industries and increase the prices of the goods and services they provide. There will also be job losses in these industries. The combined effect of these impacts could be reduction in GDP growth and real incomes. It is recommended that part of the revenues generated from the carbon tax could be used to address the negative impacts on vulnerable groups.

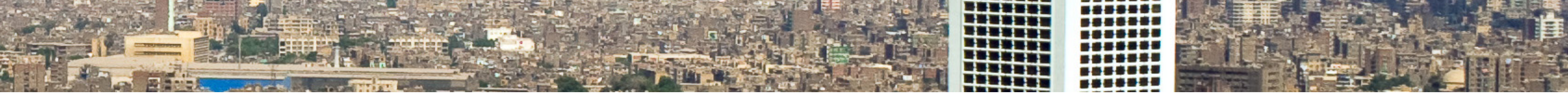
**Keywords:** Africa, climate change, climate impacts, debt sustainability, low-carbon economy

## INTRODUCTION

There is no denying that the international community is at the cusp of climate change-induced catastrophe that could be irreversible. The time is ticking for any meaningful action to make a difference. The transition to green energy sources is needed with urgency and scale to stem the risk of climate change related shocks. The main challenge is the enormous cost to the world economy which for centuries has relied on energy sources derived from fossil fuels, such as oil and gas, coal and others that polluted the environment through $CO_2$ emissions. A recent publication from the International Energy Agency (IEA) estimated in its 2021 World Energy Outlook[1] that over $30 trillion is needed up to 2030 for a green transition to take place effectively across the globe. Certainly, affordable technology in renewable energy sources is progressing rapidly, making the outlook to green transition hopeful. On the other hand, energy prices are rising despite diversified energy sources, partly due to ever rising energy demand as well as regulated energy markets largely driven by geo-political considerations.

Although Africa has contributed only 3.8 percent of total global emissions, it has borne the brunt of climate change. Annually, Africa loses $7 billion to $15 billion due to climate change (Adesina, 2021). This figure is expected to rise to $50 billion by 2040. The $100 billion per year climate financing pledged at the 21st United Nations Climate Change Conference (COP21) in Paris in 2015 has not yet materialized. Going into COP26 in 2021, the African

[1] IEA: https://www.iea.org/reports/world-energy-outlook-2021/executive-summary



Group of Negotiators had pushed for African climate mitigation and adaptation funding to be scaled up to $1.3 trillion per year by 2030, to be split evenly between adaptation and mitigation funding. This target was not achieved, although rich countries pledged to double adaptation funding by 2025, which would amount to about $40 billion per year. While this is an improvement on current funding levels, it is still insufficient to achieve an equal split between adaptation and mitigation. The current financing levels fall short of Africa's needs by $100 billion to $127 billion per year from 2020 to 2030. Some African countries are already spending more on climate adaptation than on health care and education.

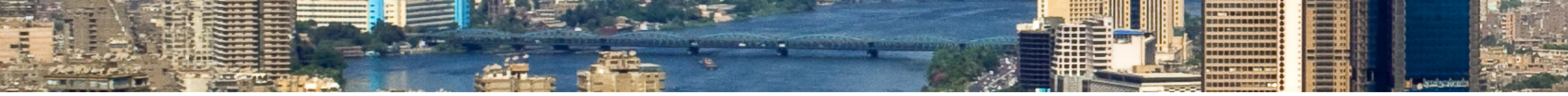
Four out of five people in the world without energy access live in Sub-Saharan Africa (SSA), impeding industrialization and development. Consequently, Africans must balance the need to combat climate change with an urgency to develop the continent's economies to alleviate hunger and poverty, among other UN Sustainable Development Goals (SDG). SDG7—affordable and clean energy—remains out of reach for half of Africa's people and is key to unlocking the other 16 goals. Development of transport and logistics as well as technology infrastructure is also vital. The evidence suggests that Africa contributes less than 3 percent of total global greenhouse gas (GHG) emissions yet suffers the most from climate change shocks. The main factors that exposed African countries to climatic shocks include the source of livelihood, which is predominantly from agriculture that, on average, employs over 55 percent of the work force and contributes close to 20 percent of GDP.[2] This suggests the low productivity pervading the sector where over 95 percent of farming relies on rain-fed agriculture and is prone to extreme weather variability. As a result, seven of the 10 most vulnerable countries to climate shock in the world are in Africa.

The African Economic Research Consortium (AERC)'s research[3] in this area shows that higher temperatures, coupled with reduced and/or variable rainfall, could lead to reduced agricultural output which will be transmitted to domestic prices and inflation. This can happen in several ways. First, the negative impact on agricultural productivity will contribute to food shortages, causing food prices to rise when there is an excess of demand over supply. This is more likely in countries where the foreign exchange reserve and fiscal space is very weak to establish buffer against severe drought, flood or other sources of crop failures, including locust attacks like those experienced recently in the Horn of Africa.

Second, climate shocks could translate into higher prices through trade as most African countries depend on primary commodities for their exports. Export contractions and likely import expansion could lead to weakening of exchange rates, therefore driving domestic prices upwards, especially in situations of fixed exchange rates regimes. Finally, droughts in the Horn of Africa will affect food prices and energy prices due to dependence on hydroelectricity generation. A combination of food and energy prices is a major supply shock on inflation. Monetary policy instruments in these countries do not have supply side instruments to mitigate these effects. Without any buffers on food or energy, these countries end up using

[2] https://www.afdb.org/en/cop25/climate-change-africa

[3] Asafu-Adjaye, et al (2022) "Macroeconomic consequences of climate change in Africa and policy implications" AERC Working Paper.



demand side instruments to dislodge the effects of a plateau of high prices and thus, plunge the economy into a short-term recession.

As Africa envisages building a climate shock resilient economy through industrial policies and other strategies of automation, the energy demand is likely to accelerate, therefore requiring a careful approach to mitigation and adaptation methods. Currently over 80 percent of Africa's energy consumption is generated from natural gas, coal and oil, which are fossil fuel based and contribute to greenhouse effects. The rest is accounted for by hydro, solar photovoltaic (PV), geothermal, solar thermal and biofuel that are green and renewable sources of energy.[4] In addition, close to 20 percent of African countries are exporters of oil on which their economy depends for foreign exchange earnings, government revenue and employment. Hence, transitioning to green and renewable energy sources will come at a heavy cost. It is also important to note that Africa's consumption of energy is the lowest in the world. The percentage of households that have access to electricity is less than 40 percent at the continental level, with the situation even worse in rural areas. It is difficult to imagine rural transformation without access to reliable and adequate energy.

Studies have shown that rural electrification in Africa is not an easy fit even when there is strong government commitment. Most households cannot not afford to be connected to the grid and even if they do through some government subsidizes, they sparingly consume electricity because they cannot afford the bills because their income flows are low and erratic. The median price of electricity in 2021 in Africa is over 30 percent higher than the world average. In some African countries, the difference is over 200 percent. This simply suggests the need for a relatively cheaper and abundant source of energy to realize Africa's economic transformation. Certainly, many African countries have potential for hydro, wind and solar energy because of the geography.

This study uses a combination of econometric modelling, debt dynamics analysis and computable general equilibrium (CGE) modelling to explore the effects of climate change on growth, debt and sectoral output in Africa and address policy implications. The rest of the paper is organized as follows. Section 2 presents the challenges of climate change and its effect on economic growth, political stability and conflict and fiscal deficit. Section 3 uses the effect from reduced real GDP growth and budget deficit to estimate debt trajectories. Section 4 explores the transition to low-carbon economy, while Section 5 concludes.

## CLIMATE RISKS AND SHOCKS IN AFRICA: OVERVIEW

### Real GDP Growth and Rising Temperature in Africa

One of the indicators of climate change that causes extreme weathers, such as drought, flooding and other shocks is a rise in average temperature over time. Figure 1 below presents trends in the change in average temperature for the period 1990-2021.

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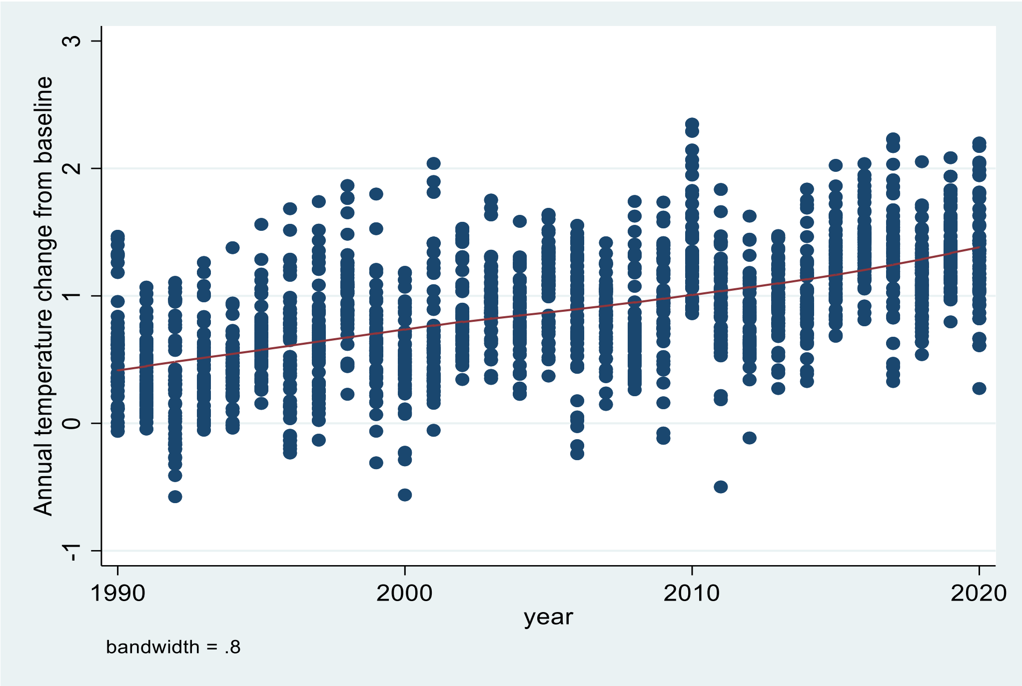
[4] https://www.statista.com/statistics/1275969/main-sources-of-electricity-generation-in-africa/

**FIGURE 1** Average Temperature Change in Degree Centigrade in Africa




**Source:** Authors' computations based on data from FAOSTAT.

**Note:** the annual temperature change is computed from the climatology that prevailed during 1951-1980.

Average temperature has been rising rapidly and steadily in Africa crossing the 1°C mark in 2010. If the situation continues untamed, the disruptions that could follow on the economy could be significant. We also note that there is significant heterogeneity across countries in their exposure to rising temperature. The literature that assesses the impact of climate change on real GDP growth in Africa is limited, though growing. For example, Baarsch et al. (2020) reported that, due to unequal exposure to climate-induced shocks, long-term growth in Africa could create different convergence clubs, further aggravating inequalities in the continent. Their results suggest that up to 15 percent of GDP per capita growth could be lost due to climate induced risks. Also, Abidoye and Odusola (2015) found that for the period 1960-2009, rise in temperature beyond 1C could lead to reduction in real GDP growth by about 0.67 percentage points. In this study, we update this literature using the most recent data (1990-2021) and decomposing real GDP growth into cyclical and long-term component. The linear model we estimated is specified as follows:

$$g_{it} = \alpha + \beta T_{it} + \theta T_{it}^2 + \gamma X_{it} + \vartheta_i + \varphi_t + \varepsilon_{it} \quad (1)$$

Where $g_{it}$ stands for real GDP growth, $T_{it}$ for annual change in temperature from baseline, and its square ($T_{it}^2$) and $X_{it}$ are control variables that include political stability and quality of institutions. The error terms control for time-variant and time-invariant unobserved factors. Equation (1) was estimated using a fixed-effects panel data regression method and results are reported in Table 1 below.

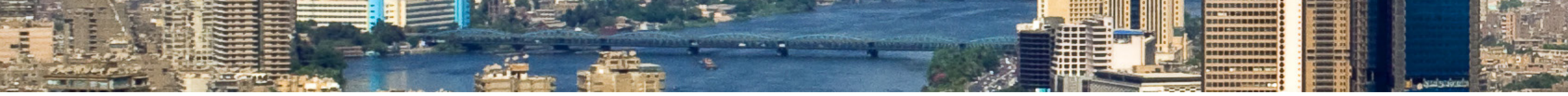


**TABLE 1** Effect of Temperature Change on Real GDP Growth in Africa, 1990-2021

| Dependent variable | Real GDP growth | Cyclical Real GDP growth | Long term real GDP growth |
|---|---|---|---|
| Lag Change in temp | 0.0321 | 0.0337 | −0.00167 |
| | (1.74) | (1.99)* | (−0.30) |
| Lag Change in temp$^2$ | −0.0264** | −0.0248** | −0.00157 |
| | (−3.00) | (−3.01) | (−0.60) |
| Constant | 0.0544*** | 0.000511 | 0.0539*** |
| | (4.41) | (0.04) | (14.53) |
| Political economy controls | Yes | Yes | Yes |
| Country and year fixed effects | Yes | Yes | Yes |
| N | 1062 | 1062 | 1062 |

**Source:** Authors' calculations.

**Notes:**

1. Real GDP growth is decomposed into cyclical and long-term component using the Hodrick-Prescott filter.
2. Temperature data reflects annual change in degrees from the baseline of climatology prevailing during 1951-1980. Political economy control factors include: rule of law, political stability and macroeconomic stability (inflation ). From column 1 and 2, real GDP growth would start declining for annual temperature changes starting at 0.7 degree centigrade.
3. t-statistics in parentheses: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

According to the table, real GDP growth responds negatively to a rise in temperature beyond a certain level. Most importantly, climate shock generally is highly correlated with the cyclical component of GDP growth rather than the long-term trend, which suggests that part of the volatility observed in growth emanates from climate-induced shocks. Column 2 of Table 1 suggests that a 0.7°C rise in annual temperature could lead 2 percentage points decline in real GDP growth, undermining positive shocks, such as commodity price booms, and amplifying negative shocks. It may have to be noted that the relationship between rise in temperature and real GDP growth reinforce each other, hence identification of the causation requires specifying structural econometric model. To reduce some potential endogeneity issues, the regression reported in Table 1 used one year-lagged annual change in temperature in degree centigrade. The working hypothesis is that rising temperature causes extreme weather such as drought, floods and other forms of natural disasters that could disrupt livelihoods and affect economic activities.

Figure 2 clearly shows that, in 2020, nearly 45 countries in Africa experienced annual temperature rise above the threshold of 0.7°C. Computations show that the annual average trend has been 0.03°C on average, and Africa is expected to hit 1.8°C rise in average change in temperature by 2030.

It is also feasible to identify an indirect channel. Natural disasters also tend to increase competitions for resources, such as water and fertile land among communities, creating conditions for political instability and conflict. In this regard, the risk of climate change induced risk poses a significant threat to the long-term development of Africa.

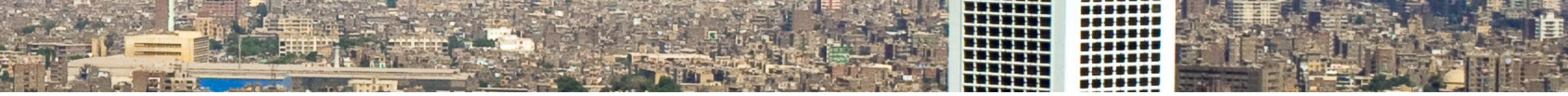
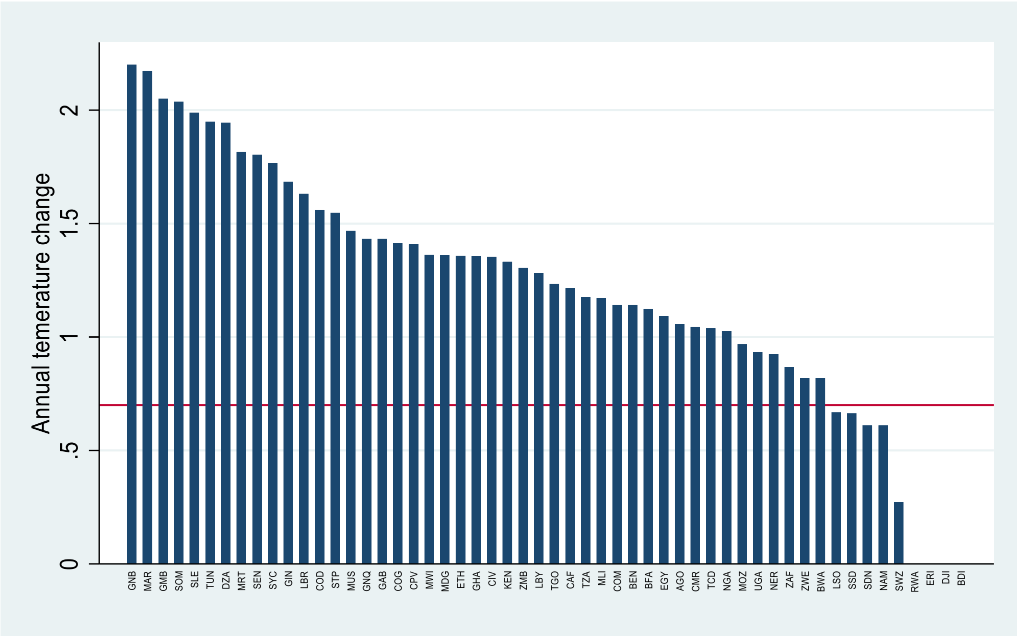


**FIGURE 2** Average Annual Change in Temperature by Country in Africa, 2020




**Source:** Authors' calculations.

**Note:** The figure presents by country annual change in average temperature in 2020 and marks the threshold of 0.7 degree centigrade beyond which real GDP growth starts to decline. List of country abbreviations in Annex A.

Figure 3 presents the correlation between the number of major natural disasters recorded in Africa every year since the 1990s and incidence of conflict and political instability. Countries that suffered frequent natural disasters also exhibited high incidence of violence and political instability. This is an important channel through which economic activity could be disrupted by climate change induced natural disasters. Preliminary correlations showed that a 1 percent increase in per capita $CO_2$ emissions is correlated with around 0.75 percent increase in natural disasters further solidifying the link between natural disasters and climate change.

In addition, the correlation between a country's emission of $CO_2$ per capita and annual temperature change is positive and significant (Figure 3). This is indicative of reinforcing processes where higher $CO_2$ emissions go hand-in-hand with rise in the average temperature, which has detrimental effect on long-term growth beyond a certain threshold.

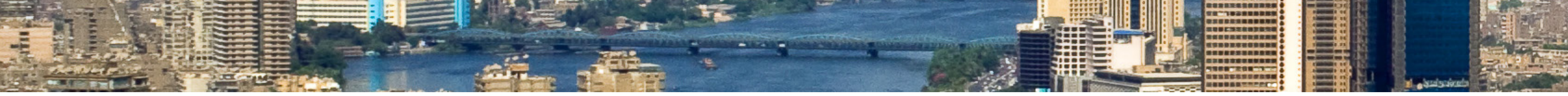
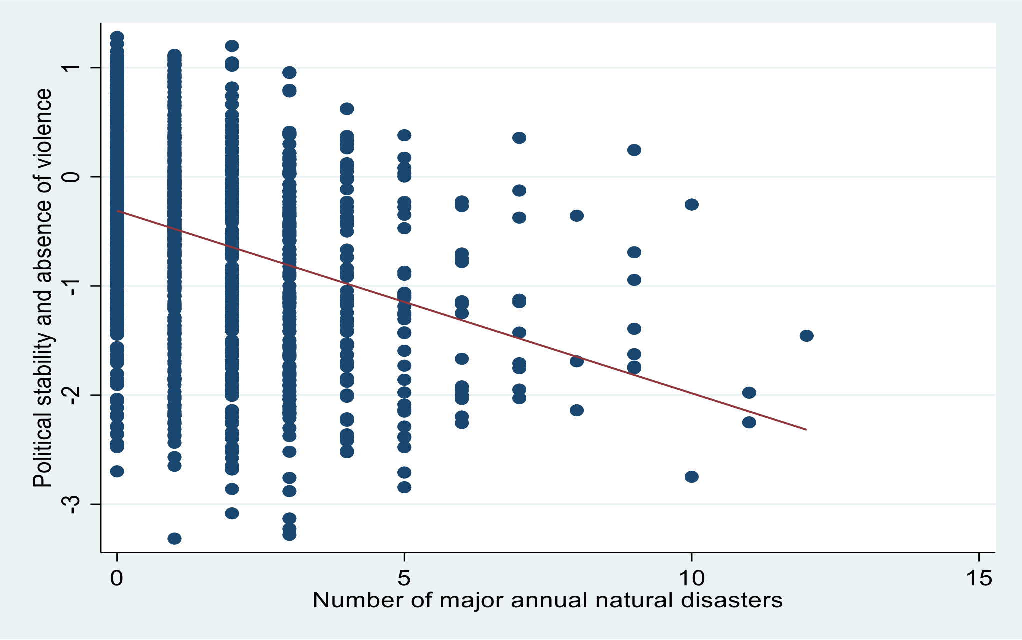
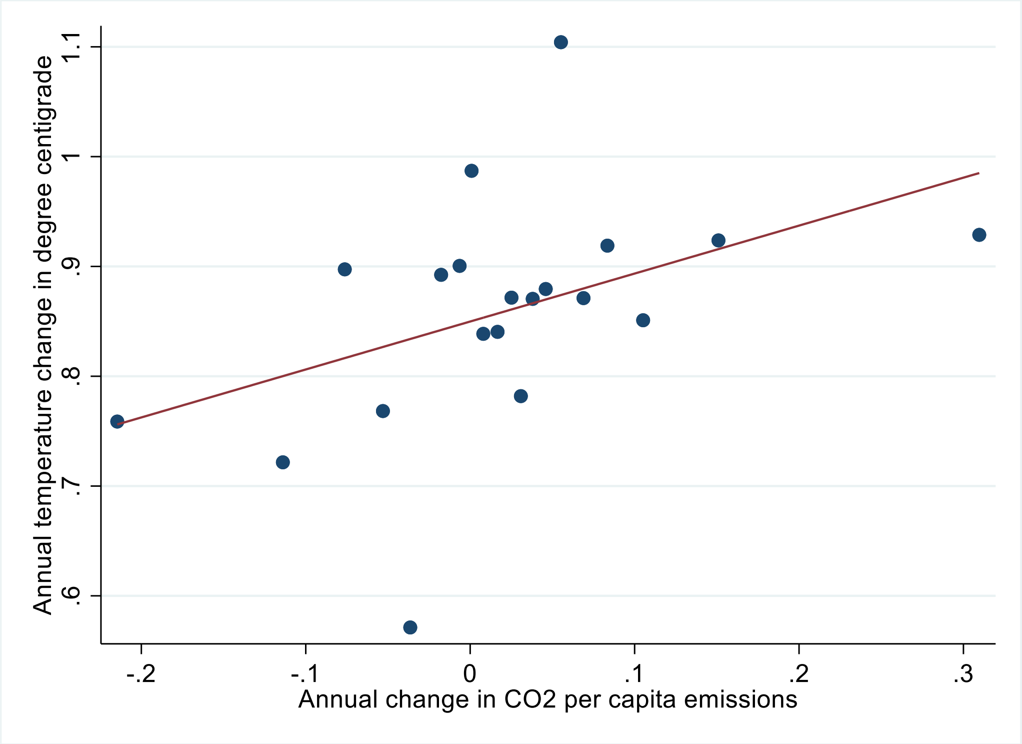


**FIGURE 3** Number of Major Natural Disasters and Political Instability/Conflict in Africa



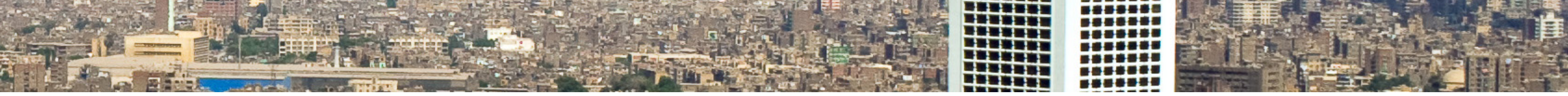

**Source:** Authors' computations based on data from World Development Indicators

**FIGURE 4** Bin-scattered Diagram on the Correlation of Annual Temperature Change and $CO_2$ per capita Emissions in Africa




**Source:** Authors' calculations.

**Note:** Figure 2 controls for economic structure (share of manufacturing and agriculture in GDP), energy consumption and political economy factors.



# CLIMATE SHOCKS ON DEBT TRAJECTORIES

## Methodology: Understanding Debt Dynamics

In this section, a simple debt dynamics model is used to motivate the discussion on designing an optimal debt management strategy. Consider the following well-known definition of debt dynamics:[5]

$$D_t = (1 + r)D_{t-1} - PB_t \qquad (2)$$

Where $D_t$ is total debt stock in either local or international currency, $r$ is the average interest rate on the debt and $PB_t$ is total primary balance of the government budget that requires current financing. Deficits in government budget add to the debt stock, while surpluses reduce it. Dividing through $GDP_t$, and rearranging we get:

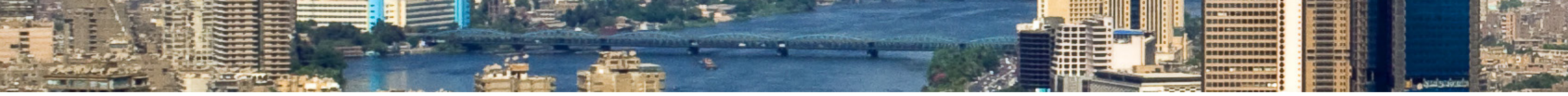
$$d_t = \frac{1+r}{1+g} d_{t-1} - pb_t \qquad (3)$$

Where $g$ is growth in nominal GDP and small letters indicate same variables as share of GDP.

Equation 3 is basically an identity, but the dynamic specification provides rich information on conditions for the stability of debt overtime. In addition, some of the drivers of debt, particularly that of external debt, have interesting features that allow decision makers to plan and understand better the path of debt. For instance, interest rate, especially for external debt, is quasi-exogenous. Some of which could be concessional, as is often the case and beyond the control of the policy makers. On the other hand, the cost of borrowings from the capital market tends to be influenced by credit rating agencies whose assessment of the country's credit worthiness depends on that considers global economic conditions as well as the opportunities afforded and perception of risks in the country, hence partly endogenous. GDP growth rate is endogenous shaped by economic fundamentals, institutions and policy except for transitory shocks. Government budget is policy-driven where spending and revenue mobilizations are shaped by public administration, and intertemporal consumption preferences of the government, including the discount rate for current spending. Impatient and short-sighted governments tend to accumulate debt rapidly compared with those that have long-term perspectives.

Hence, even though the decision to borrow is ultimately dependent on policy makers, not everything is under their control when it comes to its speed of accumulation and implications to the overall economy.

[5] Equation (2) presents an inter-temporal budget constraint for government budget and has been the basis of numerous analytical works to determine the 'maximum debt carrying capacity' of a country. Further details of this analytics could be found in Neil and Roffia (2003), Jarmuzek, Mariusz and Yanliang Miao, (2013) and Abiad and D. Ostry, (2005)



From Equation 3, some characterization of the dynamics of debt can be made. For example, if the economy grows ($g_t$) at the same pace as the cost of borrowing ($r_t$), then, debt burden grows by the full amount of the government budget deficit. The only way debt can be contained is if the government budget experiences a surplus or the budget is fully balanced (zero budget deficit). If the economy grows faster than cost of borrowing, or interest rate on the loan, then, the country can continue to run budget deficits without experiencing explosive debt trajectory. If the economy grows much less than the interest rate, then debt burden increases explosively, and the country needs to run a budget surplus not to buckle under the burden. Hence, economic contraction, caused for instance by significant shocks such as COVID-19 can aggravate debt-burden beyond the short-term. The solution, therefore, to the difference equation (2) that determines the time path of debt at any period *t* is given by:

$$d_t = \frac{\beta^t[d_0(1-\beta)+pb]}{1-\beta} - \frac{pb}{1-\beta} \quad (4)$$

Where $\beta = \frac{1+r}{1+g}$.

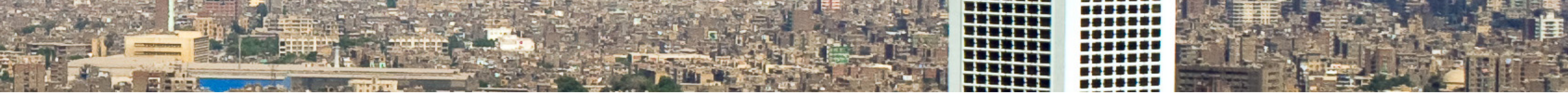
Equation 4 suggests that debt level at period $t$ is determined by pre-specified or pre-determined values involving average borrowing cost ($r$); projected, desired or historical trend in GDP growth ($g$) and initial stock of debt ($d_0$). We also note that for debt-dynamics to converge, it is necessary for $g > r$ or $\beta < 1$. For $\beta = 1$, debt grows out of control, hence $\beta \neq 1$. Equation 4 also can be used to solve for the equilibrium or 'steady-state' of debt.

Analytically, steady-state debt level or 'equilibrium' debt level is defined as a point where $d_t = d_{t-1} = d^*$ and is a function of 'historical' or 'desired' levels of GDP growth (say, obtained from growth strategies) and primary balance. At this equilibrium level, debt remains unchanged over time and can be regarded as 'stable.' In terms of Equation 4, it means the first term on the right-hand side converges to zero. This equilibrium or steady-state debt level, hence, is given by Equation 5:

$$d^* = -\frac{1+\bar{g}}{\bar{g}-\bar{r}} * \overline{pb} \quad (5)$$

In this set up, the primary balance plays a critical role in whether a country 'exits' debt in the long-term and become a net creditor. For example, if the growth rate of the economy in steady state is higher than the average interest rate paid on funds borrowed, then the country can afford to run into budget deficit without buckling under the burden of rising debt. In addition, if the government runs a budget surplus in the long-term, then clearly the economy can exit debt and become a net creditor.

Equation 5 has abstracted from two important dimensions that could significantly influence the behavior of the steady state debt level. First is the movement of foreign exchange rate and domestic prices which influence significantly future debt-servicing, hence sustainability of debt. External debt denominated in foreign currency will increase if the local currency depreciates in the course of time. On the other hand, inflation reduces the debt burden for



domestic debt (see details in the footnote).[6] The second important point is that Equation 5 abstracted is the permanent and transitory shocks that may affect interest rates, GDP growth and primary balance. The steady-state debt is determined by the expected values of the shocks as given in Equation 6.

$$E(d^*) = -\frac{\bar{p}+E(\varepsilon_t^p)}{\left(\bar{g}-\bar{r}+E(\varepsilon_t^r-\varepsilon_t^g)\right)} \qquad (6)$$

Using Equations 4 and 5, policy makers can build scenarios on the steady-state debt under certain assumptions on long-term or equilibrium values of primary balance and GDP growth rates. Figure 3 below illustrates that the steady-state debt-burden declines with GDP growth and increases with government budget deficit. Some of the lessons we could infer from Figure 3 is that the implications of GDP growth on steady-state debt level is non-linear. For example, protecting steady-state GDP growth from falling below 5 percent is very helpful in reducing the steady-state debt level. On the other hand, faster growth above 7 percent is less impactful on the steady-state debt level which implies better fiscal space even when running higher deficits. Similarly, variations in long-term primary balance deficit could affect the steady-state debt significantly. The faster the economy grows, then the lesser the impacts of primary balance deficit on steady-state debt burden. In addition, we can use Equations 4 and 5 to compute the time it takes for a country to reach the steady-state debt level from an initial debt stock. This is very useful for purposes of management of debt within a certain planning horizon.

As one would expect, Figure 6 shows that the higher the level of steady-state debt, the longer it takes to fully pay the debt from some initial level (in the example we took the initial external debt to GDP ratio of 57 percent which corresponds to that prevailed in Africa around 2020). On the right-hand side of the y-axis, Figure 6 mirrors the corresponding growth rate in GDP that is assumed to prevail for the computed steady-state debt-GDP ratio and the number of years it takes to fully pay the debt. In this case, the lower the GDP growth (the higher the steady-state debt-GDP ratio), the longer it takes for a country to clear its debt.

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6 Source: AfdB, 2019, "The state and dynamics of debt in Africa." Let both foreign and domestic debt are given in respective shares $\alpha^* = \frac{E_t D_t^*}{D_t}$ and 1 – *, and taking into account nominal foreign $i^*$ and domestic $i$ interest rates, exchange rates $E_t$, and domestic inflation $\pi_{t+1}$, debt growth can be decomposed according to the following equation:

$$d_{t+1} = \frac{D_{t+1}}{Y_{t+1}} = \frac{D_{t+1}}{Y_t(1+g_{t+1})(1+\pi_{t+1})} = \frac{\left(E_{t+1}D_{t+1}^* + \widetilde{D_{t+1}}\right)}{Y_t(1+g_{t+1})(1+\pi_{t+1})} = \frac{\left(E_{t+1}D_t^*(1+i^*) + \widetilde{D_t}(1+i)\right)}{Y_t(1+g_{t+1})(1+\pi_{t+1})}$$
$$= \frac{\left(E_t D_t^* \left({E_{t+1}}/{E_t}\right) + \widetilde{D_t}\right) + E_t D_t^* \left({E_{t+1}}/{E_t}\right) i^* + i\widetilde{D_t} + PD_{t+1}}{Y_t(1+g_{t+1})(1+\pi_{t+1})}$$
$$d_{t+1} - d_t \approx d_t \frac{\left(\alpha^* i^* \times \frac{E_{t+1}}{E_t} + (1-\alpha^*)i\right)}{(1+g_{t+1})(1+\pi_{t+1})} + d_t \frac{\alpha^* \left(\frac{E_{t+1}-E_t}{E_t}\right)}{(1+g_{t+1})(1+\pi_{t+1})} - d_t\left(\frac{g_{t+1}}{(1+g_{t+1})} + \frac{\pi_{t+1}}{(1+g_{t+1})(1+\pi_{t+1})}\right) + pd_{t+1}$$

In addition to the role of primary deficits, debt increases to the extent that domestic and foreign nominal interest payments, weighted by the respective shares of domestic and external debt, plus the contribution of exchange rate depreciation to the adjustment of the stock of external debt, exceed the sum of the contribution of domestic inflation and domestic real growth to the reduction in the stock of debt.

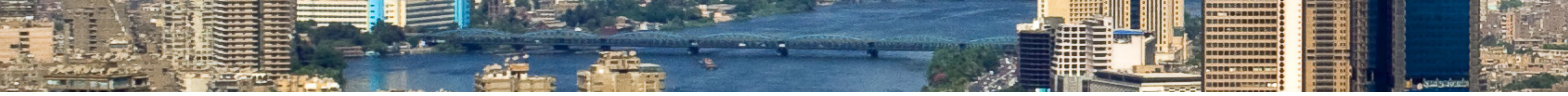
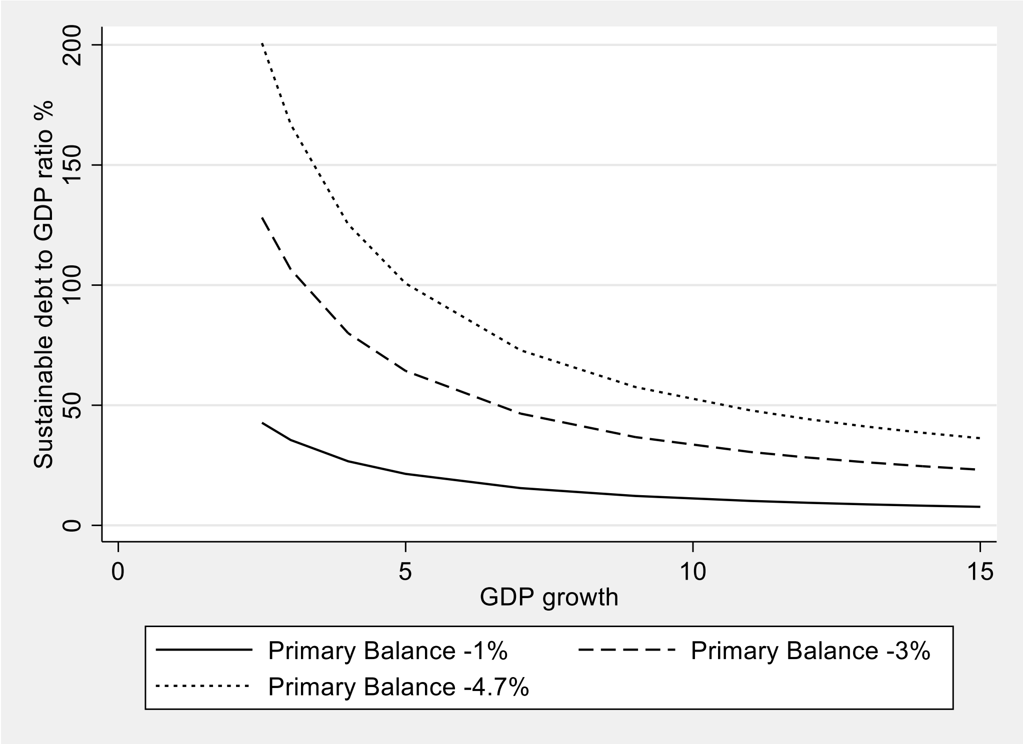
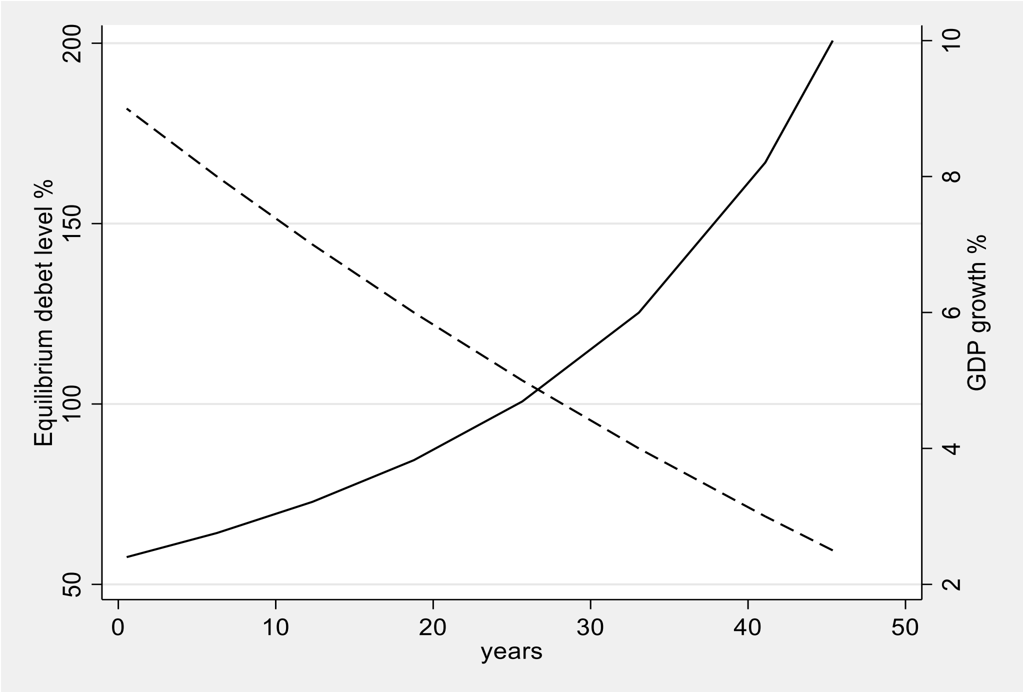


**FIGURE 5** Debt Burden and Real GDP Growth for Alternative Levels of Budget Deficit

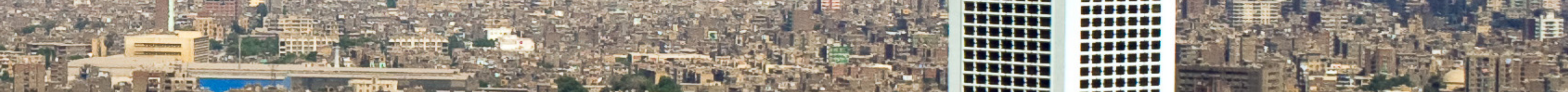



**Source:** Authors' calculations.

**FIGURE 6** Even When Debt is Sustainable, It Would Take Years to Clear Arrears with Sluggish Growth




**Source:** Authors' calculations.

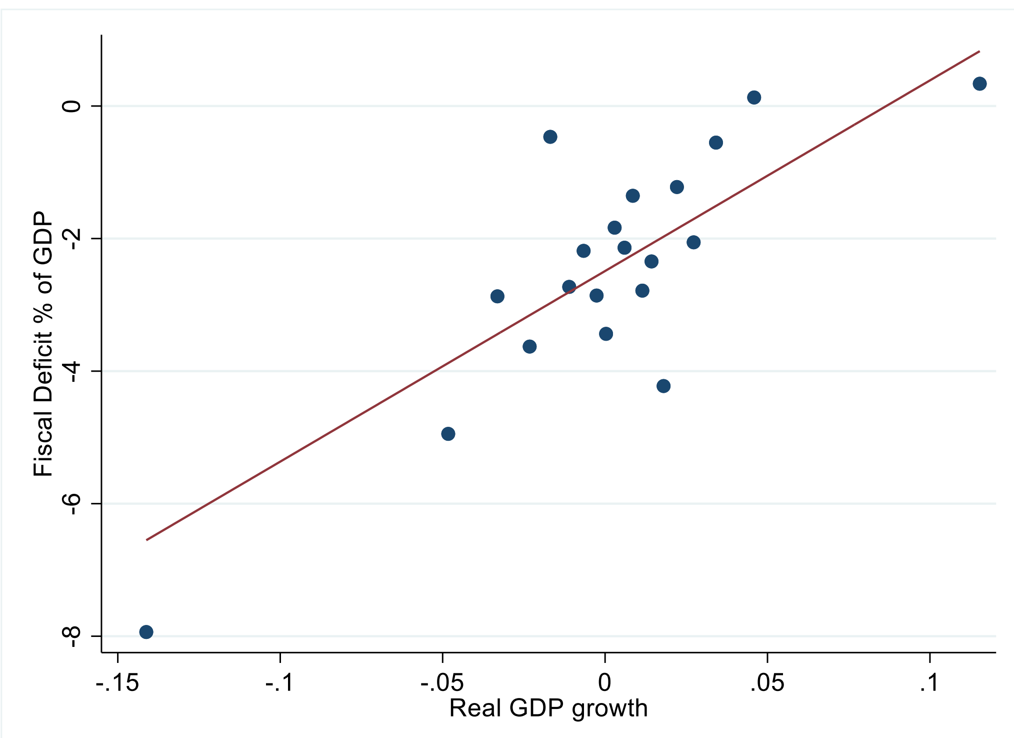


But the repayment years are not determined by the borrowing country. Often concessional loans stipulate a repayment period of 25 years, or 30 years, and non-concessional ones are of much shorter duration, often seven to 10 years. Hence, decision makers need to consider the ‘reasonable’ and ‘affordable’ steady-state debt-GDP ratio that is consistent with the stipulated repayment rate. For example, a country could afford to run a debt-GDP ratio of 150 percent for a 30-year loan by growing at a modest rate of 4 percent during this period. Faster growth means that the country could afford to run larger deficits and still manage to pay off its debt. For shorter term loans, such as that to be paid in about 10 years, the steady-state debt-GDP ratio could reach up to 70 percent provided the economy grows at 7 percent and so forth.

## Climate Change and the Debt Burden in Africa

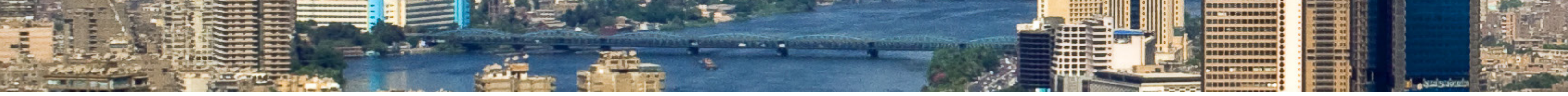
Using the above insights and results from Table 1, it is possible to assess the potential impact of climate-induced shocks on debt trajectories in Africa. As noted, a rise in temperature beyond 30°C could cost Africa 2 percentage point decline in real GDP growth. Similarly, the elasticity of budget deficit to real GDP growth computed from our data is around 0.3 percentage points as a share of GDP. Figure 7 presents robust and positive correlation between real GDP growth and fiscal deficit in Africa showing that growth losses would worsen fiscal deficit and vice versa.

**FIGURE 7** Correlation Between Fiscal Deficit and Real GDP Growth in Africa




**Source:** Authors’ calculations.

**Note:** The scatter diagram controls for political stability and institutional quality.



Putting these facts together, it is possible to evaluate the maximum debt burden beyond which a country could become insolvent. To give the order of magnitude, we first evaluate the debt-carrying capacity of African economy based on long-term growth achieved in the 'good times,' which stood around 5 percent (2000-2013). The average budget deficit (primary) during this period was around 2.8 percent of GDP. Noting that most African countries benefited for many years from concessional loans, real interest rate varied between 1 percent to 2 percent. Taking the lower bound of 1 percent real interest rate, the implied 'optimal' debt-burden would be around 73 percent of GDP. Now taking the shift in real GDP growth caused by climate change induced shocks and the budget deficit together, the debt-GDP ratio would increase to 175 percent of GDP. Such a scenario suggest how unattended climate change risk could easily increase the debt burden and undermine fiscal space badly needed for taking measures to contain greenhouse gas emissions.

## TRANSITION TO A LOW-CARBON ECONOMY: COST AND BENEFITS

This section analyzes what the transition to a low-carbon pathway means for Africa. The discussion starts with an analysis of historical trends of energy use and sources to assess how far Africa has been adjusting its sources of energy over the past decade and the potential for renewable energy. Next, we discuss the opportunities and challenges associated with the impending trading on a global carbon market. Following that, we discuss what the Just Energy Transition means for Africa, including an assessment of the costs of transitioning to low-carbon pathways.

### Trends in emissions and energy production

Figure 8 shows that Africa emissions are relatively low compared to other countries and regions. For example, in 2019, emissions for the largest emitter on the continent, South Africa, was 226 $MtCO_2$ compared to 5,256 $MtCO_2$ for the US and 10,490 $MtCO_2$ for China. Africa's emissions are low due to the lower level of economic activity compared to other regions and because most of the population lacks access to electricity and clean cooking solutions.

Currently, Africa produces only 4 percent of global GDP and about 6 percent of global energy. However, Africa's population could grow significantly in the future and, by 2100, more than a quarter of the world's population could be living on the continent. This could put upward pressure on global emissions depending on the energy transition pathways that countries choose. However, African countries have signalled their intensions to contribute to lowering global emissions. Following COP23 in 2015 in Paris, all 54 African countries have signed the Paris Agreement and submitted ambitious Nationally Determined Contributions (NDCs), while most of them have ratified their NDCs.

Figure 8 shows trends in energy production by source for Africa in the period 2010 to 2019 for natural gas, crude oil, hydro, solar PV and wind. The data show a meteoric rise in the production of energy from renewables such as solar and wind. Over the past decade, the

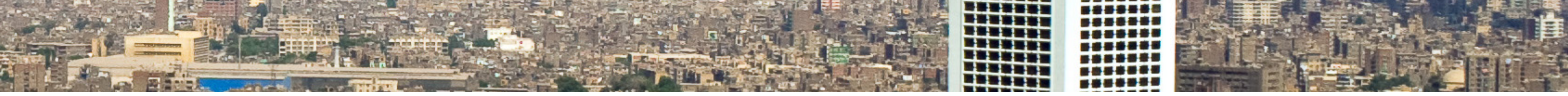
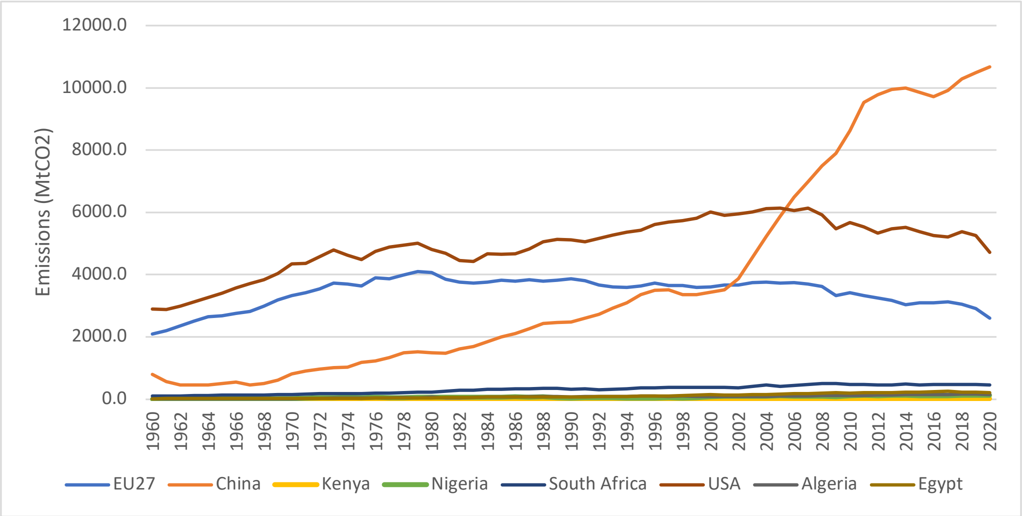


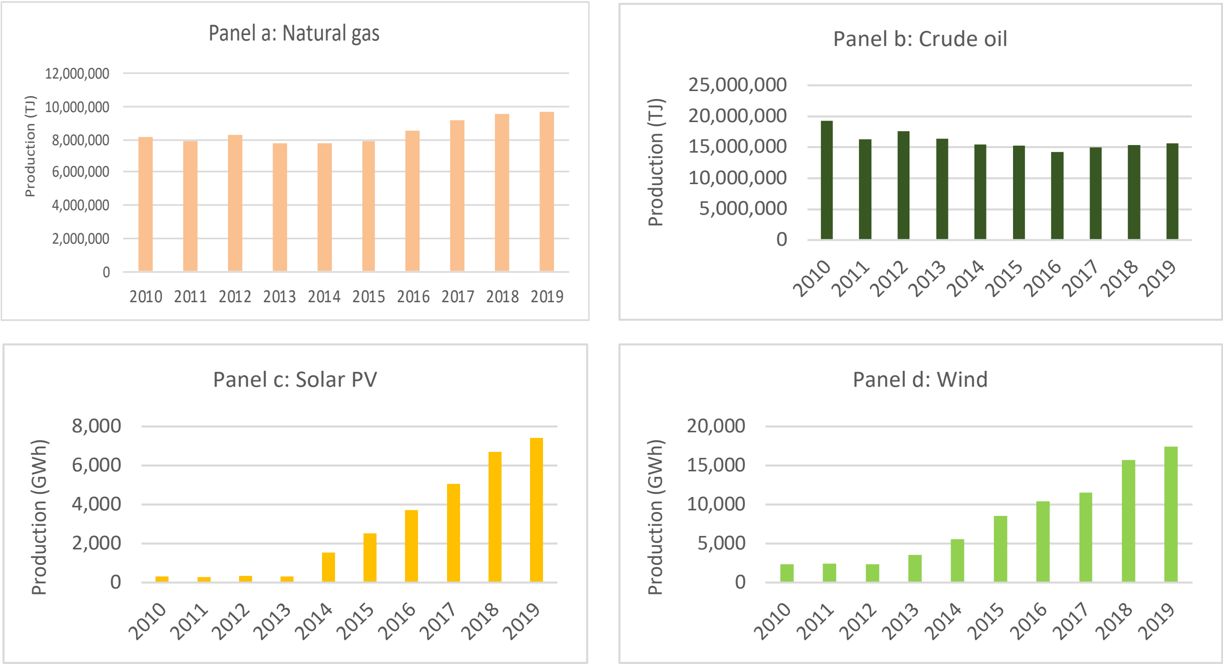
**FIGURE 8** Carbon Dioxide Emissions for Selected Countries, 1960-2020



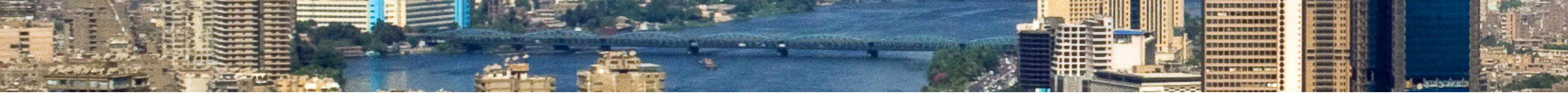

**Source:** Andrew and Peters (2021).

take up of solar PV has increased by twenty-fold while that of wind energy has increased by nearly seven-fold. On the other hand, production of crude oil fell by 19 percent in this period. These results show that, to some extent, African countries have gone cleaner. And judging from their NDCs, many of them have shown ambitions to embrace a low-carbon economy. We discuss below that the transition may not be as easy and that challenges will have to be addressed.

**FIGURE 9** Africa's Energy Production by Source, 2010-19

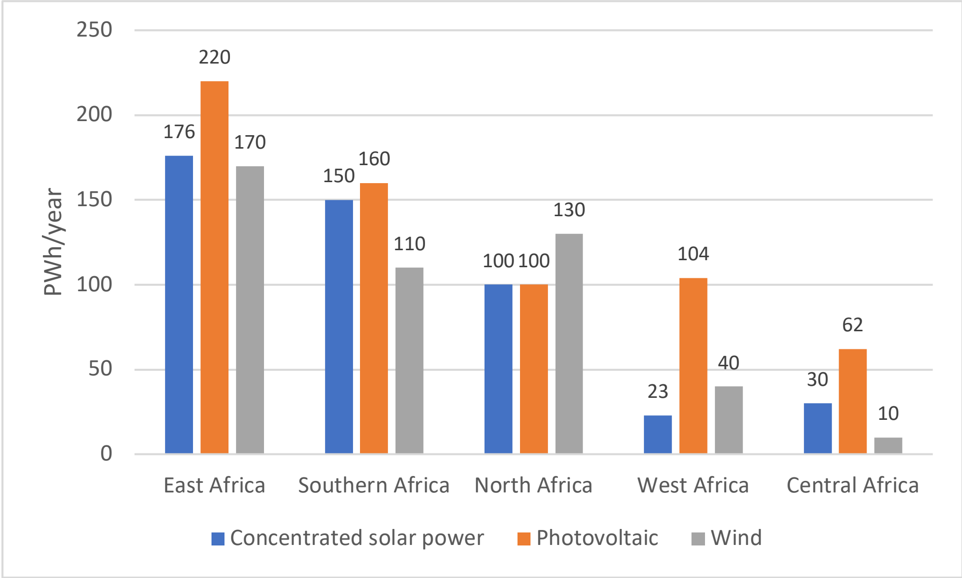



**Source:** IEA (2021).



Africa has abundant supplies of renewable energy that could be leveraged in the global carbon market. According to the International Renewable Energy Agency, Africa's total energy potential for concentrated solar power (CSP), PV and wind energy is about 1,585 petawatt hours (PWh) per year, broken down as follows: CSP, 479 PWh; PV, 640 PWh; and wind, 460 PWh (see Figure 8). For both CSP and PV, East Africa has the highest potential (176 PWh for CSP and 220 PWh for PV), followed by Southern Africa (150 PWh for CSP and 160 PWh for PV). North Africa has potential of about 100 PWh for both CSP and PV. West Africa is endowed with good PV potential (104 PWh) but limited CSP potential (30 PWh) because of less direct irradiation and higher "solar fluctuations" (IRENA, 2014). Central Africa has relatively low potential for either CSP or PV compared with the other regions.

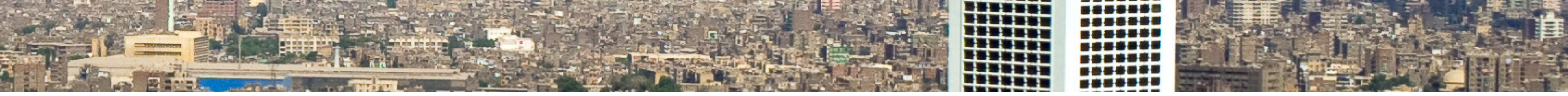
**FIGURE 10** Africa's Renewable Energy Resources, 2013




**Source:** IRENA (2014).

## Carbon Trading

Africa currently accounts for around 2 percent of trading in the international carbon market. South Africa and North Africa get the bulk of Clean Development Mechanism (CDM) funds under the Kyoto Protocol. In June 2021, Gabon became the first African country to receive climate finance of up to $150 million over 10 years. During COP26, countries reached agreement on Article 6 of the 2015 Paris Agreement to pave the way for the establishment of a regulated international carbon market. It is likely that modalities and timelines will be announced at COP27. Africa needs to be ready to be a significant player in this global market given its massive carbon stocks. Many countries around the world currently have energy efficiency and renewable policies and over 50 national or sub-national governments have implemented carbon pricing (World Bank, 2019) in the form of carbon taxation or emissions trading schemes (ETS). A few African countries have shown interest in using carbon pricing to meet their NDCs. South Africa was the first to introduce a carbon tax in 2019 and other



countries such as Kenya, Ethiopia, Egypt and Côte d'Ivoire are considering schemes involving an ETS or carbon tax.

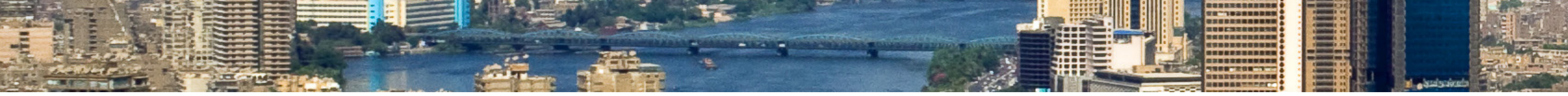
The main challenges of implementing carbon pricing (whether ETS or carbon tax) schemes in Africa include the fact that they can be administratively burdensome, and subject to their design, they can require a complex architecture of institutions. This is particularly the case for the ETS, making carbon tax systems relatively preferable from an implementation perspective. Such systems also require enforcement capacity, again something that is a challenge for several African countries. At a minimum, and subject to the design of the carbon pricing instrument, countries would most likely require a comprehensive monitoring or estimation and reporting framework for the emissions or inputs/outputs on which the price is imposed, a system that many African countries are still in the process of developing. Furthermore, although these schemes have the potential to generate revenue, they can also have regressive effects, particularly on low-income households, if not well-designed.

## The Just Energy Transition

The idea of a Just Transition is premised on the fact that the shift to low- or zero- carbon economies must be a shared global responsibility with the benefits being distributed fairly and that some communities should not be worse off as a result. In the case of SSA, most of the population do not have access to electricity and clean cooking solutions and must rely on biomass for household thermal energy. Going into COP27, Africa will make a strong case for natural gas to be part of its Just Energy Transition systems. This is because, to improve energy access, Africa cannot rely entirely on renewables due to their intermittency. Africa needs to combine renewables with natural gas to assure stability and energy security, as well as improve access and affordability. Given Africa's energy profile shown in Figure 9 above, even if Africa triples the use of gas-to-power, it will contribute less than 1 percent to global carbon emissions.

Another aspect of the Just Energy Transition is the cost involved. Estimates of adaptation and mitigation costs in the NDCs are just the direct costs. They do not include the 'adjustment' or indirect costs of transitioning to low-carbon pathways. For example, they do not include the costs of job losses in carbon-intensive sectors and possible stranded assets. A recent study by McKinsey estimates the cost of the net-zero transition to be equivalent to 6.8 percent of global GDP in 2021, rising to 8.8 percent from 2026 to 2030 (McKinsey, 2022). It also estimates that 200 million jobs could be created, but 185 million direct and indirect jobs could be lost. In the case of Africa, countries would need to invest 1.5 times or more compared to advanced economies as a share of GDP today to support economic development and build low-carbon infrastructure to enable a shift to net-zero greenhouse gas emissions. In developing regions, expenditures on energy and land would form a substantially larger share of national GDP: about 10 percent in Africa, India and some other Asian countries, and Latin America.

To get some further indication of the indirect costs of the low-carbon energy transition for African countries, we estimated the macroeconomic and sectoral impacts of using carbon pricing as an instrument to achieve the NDCs. We used South Africa, Nigeria and Egypt, who



are among the high African emitters, as examples. For this analysis, we used the GTAP-E model developed by Burniaux and Truong (2002) and revised by McDougall and Golub (2007), together with the GTAP-E Database Version 10.

South Africa's carbon tax is envisioned to be a fuel input tax, based on the carbon content of the fuel used, and will cover all stationary direct greenhouse gas emissions from both fuel combustion and non-energy industrial process emissions, amounting to approximately 80 percent of total emissions. The tax was implemented on June 1, 2019 at a rate of R120 ($7.46) per tonne $CO_2$e. On January 1, 2022, the finance minister announced an increase to R144 ($9) per tonne $CO_2$e. To uphold South Africa's NDCs, the rate will increase each year by at least $1 until it reaches $20. Since Nigeria and Egypt have not yet announced carbon pricing policies, we applied a tax of $9 as South Africa has just done. We also run another simulation with a higher tax of $20 per tonne $CO_2$e to investigate the effects of a further escalation of the tax.

Table 2 shows that the carbon tax leads a contraction in the GDP of Nigeria (-0.10 percent) and South Africa (-0.58 percent) but has a small positive effect (0.03 percent) on that of Egypt.

**TABLE 2** Macroeconomic Impacts of a $9 per tonne Carbon Tax

| Variable | Nigeria | South Africa | Egypt |
|---|---|---|---|
| GDP (percent change) | –0.10 | –0.58 | 0.03 |
| Private consumption (percent change) | –0.01 | –0.26 | –0.04 |
| Exports (percent change) | 0.18 | 0.71 | 0.36 |
| Imports (percent change) | –0.26 | –1.78 | –0.14 |
| Terms of trade (percent change) | –0.04 | –0.10 | –0.05 |
| Trade balance (US$ mil.) | 357.90 | 2888.28 | 308.15 |
| $CO_2$ emissions (percent change) | –2.78 | –13.21 | –6.79 |
| Welfare (based on EV, US$ mil.) | –44.06 | –805.83 | –125.11 |

**Source:** GTAP-E model simulations.

The tax leads to rises in the prices of energy-intensive products and services such coal, gas and electricity (see Table 4), which causes private consumption expenditure to decline in all three countries. This in turn leads to declines in real income (measured by equivalent variation) of $44 million, $805 million and $125 million, respectively, for Nigeria, South Africa and Egypt.

On the external side, Table 2 shows that exports increase faster than imports, resulting in trade balances of $357 million, $2,888 million and $305 million, respectively, for Nigeria, South Africa and Egypt. The results indicate that $CO_2$ emissions fall by 13 percent in South Africa, 7 percent in Egypt and 3percent in Nigeria (see Table 2), which suggest that carbon pricing could be an effective means of reducing emissions to meet the NDCs.

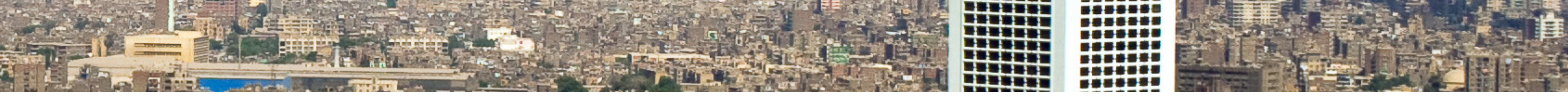


Table 3 shows that the tax results in improvements in the outputs of the agriculture and oil sectors, which result in declines in their prices as shown in Table 4. On the other hand, there are contractions in the outputs of coal, gas and energy-intensive industries and services.

**TABLE 3** Sectoral Impacts of a $9 per tonne Carbon Tax (% Change from Base Level)

| Sector | Nigeria | South Africa | Egypt |
|---|---|---|---|
| Agriculture | 0.01 | 0.10 | 0.06 |
| Coal | -8.38 | -6.20 | -9.25 |
| Oil | 0.18 | 0.53 | 0.06 |
| Gas | -0.51 | -4.11 | -9.28 |
| Oil products | -3.38 | -2.65 | -1.05 |
| Electricity | -2.72 | -12.78 | -2.59 |
| Energy-intensive industries | -1.83 | -1.32 | -0.73 |
| Other industries & services | -0.06 | -0.10 | 0.01 |

**Source:** GTAP-E model simulations.

**TABLE 4** Impacts of a $9 Carbon Tax on Product Prices (% Change from Base Level)

| Product | Nigeria | South Africa | Egypt |
|---|---|---|---|
| Agriculture | -0.17 | -0.20 | -0.09 |
| Coal | 14.22 | 30.24 | 24.56 |
| Oil | -0.05 | -0.67 | -0.20 |
| Gas | 10.69 | 5.54 | 20.91 |
| Oil products | 4.09 | 3.66 | 4.04 |
| Electricity | 4.63 | 13.37 | 5.03 |
| Energy-intensive industries | 0.55 | 0.33 | 0.30 |
| Other industries & services | -0.10 | -0.70 | -0.10 |

**Source:** GTAP-E model simulations.

The results for a carbon tax of $20 per tonne are shown in Table 5. It can be seen that whereas there is not much change in Egypt's GDP, those of Nigeria and South Africa decline by 0.25 percent and 1.29 percent, respectively. Private consumption declines by similar amounts in Nigeria and South Africa, while it increases slightly by 0.04 percent in Egypt. As was the case in the previous scenario, a carbon tax is advantageous for the external sector. A carbon tax of $20 per tonne carbon tax leads to an increase in exports and decline in imports, resulting in a doubling of the trade balance in all three countries. The $20 carbon tax also results in faster progress towards achieving the NDCs as $CO_2$ emissions decline by about 24 percent, 13 percent and 6 percent, respectively, in South Africa, Nigeria and Egypt. However, the $20 carbon tax intensifies the adverse welfare impacts on households due to the rapid rise in the price of utilities and products of carbon-intensive industries. In this scenario, welfare based on equivalent variation declines by $2,107 million in South Africa, $385 million in Egypt and by $131 million in Nigeria.

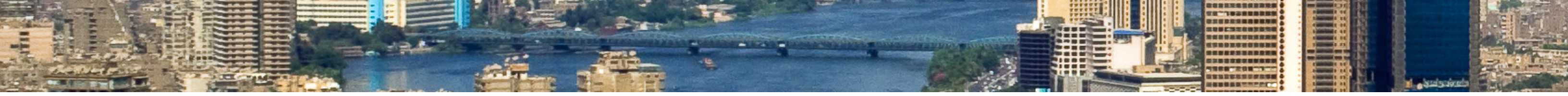


**TABLE 5** Macroeconomic Impacts of a $20 per tonne Carbon Tax

| Variable | Nigeria | South Africa | Egypt |
|---|---|---|---|
| GDP (percent change) | −0.25 | −1.29 | 0.04 |
| Private consumption (percent change) | −0.27 | −1.33 | 0.04 |
| Exports (percent change) | 0.43 | 1.47 | 0.78 |
| Imports (percent change) | −0.67 | −3.66 | −0.3 |
| Terms of trade (percent change) | −0.11 | −0.21 | −0.12 |
| Trade balance (US$ mil.) | 873.73 | 5941.62 | 661.73 |
| $CO_2$ emissions (percent change) | −6.39 | −24.03 | −13.45 |
| Welfare (based on EV, US$ mil.) | -130.88 | -2107.45 | -384.57 |

**Source:** GTAP-E model simulations.

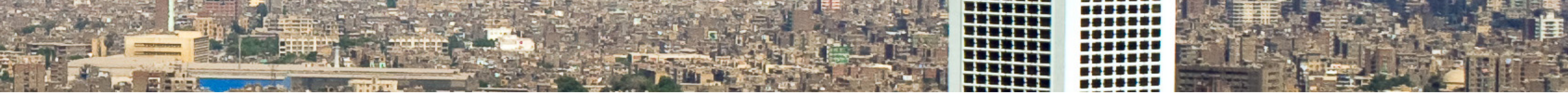
The foregoing results have two key implications for the design of carbon pricing schemes in Africa. First, the fall in the output of energy-intensive sectors will lead to job losses (not measured here). Therefore, there would be a need for retraining of workers for employment in other sectors. Second, the increased price of electricity and energy-intensive goods will have a greater impact on low-income households. The share of the income of low-income households spent on electricity and energy-intensive goods would be greater (given that electricity consumption is relatively price inelastic), leading to much more adverse effects on their welfare. Therefore, part of the revenues generated from the carbon tax could be used to address the negative impacts on these groups.

## CONCLUSIONS AND POLICY IMPLICATIONS

### Conclusions

Although Africa contributes less than 3 percent of total global GHGs, it suffers the most from climate change shocks. Our preliminary findings suggest that Africa's real GDP growth could decline by about 2 percentage points for a temperature change above 1.8°C. Projections by the Intergovernmental Panel on Climate Change (IPCC) indicate that the frequency and intensity of climate-related events such as natural disasters (i.e., droughts and floods) will increase in the coming decades. In this paper, we have shown that this could exacerbate political instability and conflict. These shocks combined could have a direct effect on government fiscal position and subsequently on sustainability of debt. For example, a 1 percent decline in real GDP growth could worsen the budget deficit by 0.3 percentage points, and this could increase the debt burden by 2.4 times.

All African countries have signed the Paris Agreement and have submitted their NDCs that contain targets for emissions reductions. Our modelling results indicate that carbon pricing could be an effective way of meeting the NDCs. However, carbon pricing (e.g., a carbon tax) would have negative impacts on energy-intensive industries and increase the prices of the goods and services they provide. There will also be job losses in these industries. The



combined effect of these impacts could be reduction in GDP growth and real incomes. From the modelling results, we infer that carbon pricing can have regressive effects, particularly on low-income households, if not well-designed.

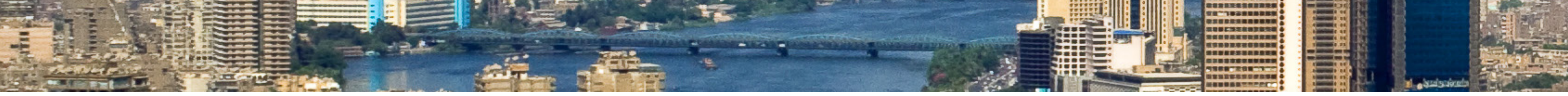
## Policy Implications

The study results have several implications for policy makers. First, Africa has significant stocks of renewable natural resources that could be leveraged in a future global carbon market to speed up economic transformation and improve the well-being of the people. However, significant foreign investment and technology is required to make this a reality. To attract the needed investment, African governments should develop a stable regulatory and policy environment and establish competitive pricing to promote mini-grid solutions and standalone systems.

Second, participation in international carbon markets and offset schemes (e.g., Reducing Emissions from Deforestation and Forest Degradation or the Clean Development Mechanism) requires a credible system for measuring, reporting and verifying emissions. However, many African countries have been unable to accurately measure and report the carbon sequestered in their forests. At COP27, Africa needs to push for more capacity building and technical assistance. Furthermore, improvements need to be made in forest governance and land tenure. In general, forest governance in Africa suffers from poor institutional capacity and performance and insecure or weak land and forest tenure by local communities. Less than 2 percent of Africa's forests are estimated to be legally owned or designated for use by local communities (Allen, 2011). Land tenure reforms are urgently needed to enable indigenous and local communities to claim property rights in forest land to benefit from payments from carbon trading and offset schemes.

Third, in the transition to low-carbon pathways, the world would need African resources. Although accounting for a small proportion of current global resources, Africa has a significant proportion of untapped mineral reserves: 30 percent of bauxite, 60 percent of manganese, 75 percent of phosphates, 85 percent of platinum, 30 percent of titanium and 60 percent of cobalt. There is, therefore, the need to ensure that sustainable techniques are used and fair employment practices are enforced.

Finally, several countries such as Burkina Faso, Côte d'Ivoire, Nigeria, Rwanda and Senegal have expressed an interest in advancing carbon pricing at a domestic level. There is also interest in carbon pricing at the regional level. For example, two new regional groups, the West African Alliance on Carbon Markets and Climate Finance (WAA), and the East African Alliance on Carbon Markets and Climate Finance (EAA), have expressed an interest in regional carbon pricing initiatives. This could lead to the implementation of a regional carbon tax or ETS. However, this would require significant regional collaboration and leadership. For example, regional collaboration would be required to amend and enhance legal frameworks to facilitate implementation and administration of the scheme. There would also be the need to build capacity and expertise to assess carbon pricing options and implement the mechanisms.



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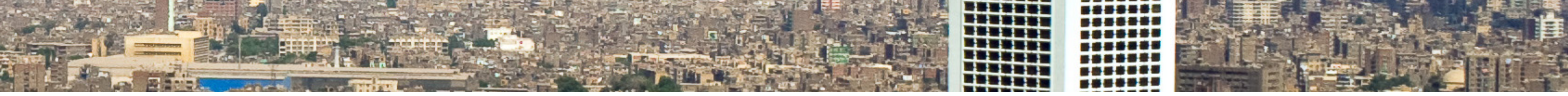


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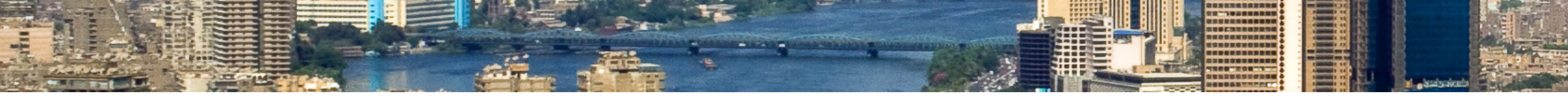

## ANNEX A

| | |
|---|---|
| **AGO** | Angola |
| **BDI** | Burundi |
| **BEN** | Benin |
| **BFA** | Burkina Faso |
| **BWA** | Botswana |
| **CAF** | Central African Republic |
| **CIV** | Côte d'Ivoire |
| **CMR** | Cameroon |
| **COD** | Democratic Republic of the Congo |
| **COG** | Republic of Congo |
| **COM** | Comoros |
| **CPV** | Cabo Verde |
| **DJI** | Djibouti |
| **DZA** | Algeria |
| **EGY** | Egypt |
| **ERI** | Eritrea |
| **ETH** | Ethiopia |
| **GAB** | Gabon |
| **GHA** | Ghana |
| **GIN** | Guinea |
| **GMB** | The Gambia |
| **GNB** | Guinea-Bissau |
| **GNQ** | Equatorial Guinea |
| **KEN** | Kenya |
| **LBR** | Liberia |
| **LBY** | Libya |
| **LSO** | Lesotho |
| **MAR** | Morocco |
| **MDG** | Madagascar |
| **MLI** | Mali |
| **MOZ** | Mozambique |
| **MRT** | Mauritania |
| **MUS** | Mauritius |
| **MWI** | Malawi |
| **NAM** | Namibia |
| **NER** | Niger |
| **NGA** | Nigeria |
| **RWA** | Rwanda |
| **SDN** | Sudan |
| **SEN** | Senegal |
| **SLE** | Sierra Leone |
| **SOM** | Somalia |
| **SSD** | South Sudan |
| **STP** | São Tomé and Príncipe |
| **SWZ** | Eswatini |
| **SYC** | Seychelles |
| **TCD** | Chad |
| **TGO** | Togo |
| **TUN** | Tunisia |
| **TZA** | Tanzania |
| **UGA** | Uganda |
| **ZAF** | South Africa |
| **ZMB** | Zambia |
| **ZWE** | Zimbabwe |