



United Nations
Economic Commission for Africa

CLIMATE SHOCKS AND SOVEREIGN BONDS IN AFRICA: UNDERSTANDING THE CLIMATE RISKS TO AFRICAN SOVEREIGN DEBT

Nadia S. Ouedraogo, PhD

3rd PUBLIC DEBT MANAGEMENT
CONFERENCE

October 3-4, 2024

Washington DC, United States

ideas
for a
prosperous
Africa



Ideas to Action

OUTLINE

**1. Introduction:
background and
context**

**2. Overview of
climate risks and
shocks in Africa**

**3. Overview of debt
levels and
composition in
Africa**

**4. Impact of climate
shocks on debt
trajectories:
Theoretical and
empirical study**

**5. Empirical
strategy**

**6. Estimations
Results**

**7. Conclusion and
policy implications**

INTRODUCTION

Need for Climate Finance

Africa requires USD 250 billion annually from 2020 to 2030 to meet its climate finance needs, but current funding covers only 12% of this requirement.

- Significant investment is needed to build resilience & mitigate the impacts of climate change, while avoiding the self-reinforcing "climate risk premium."

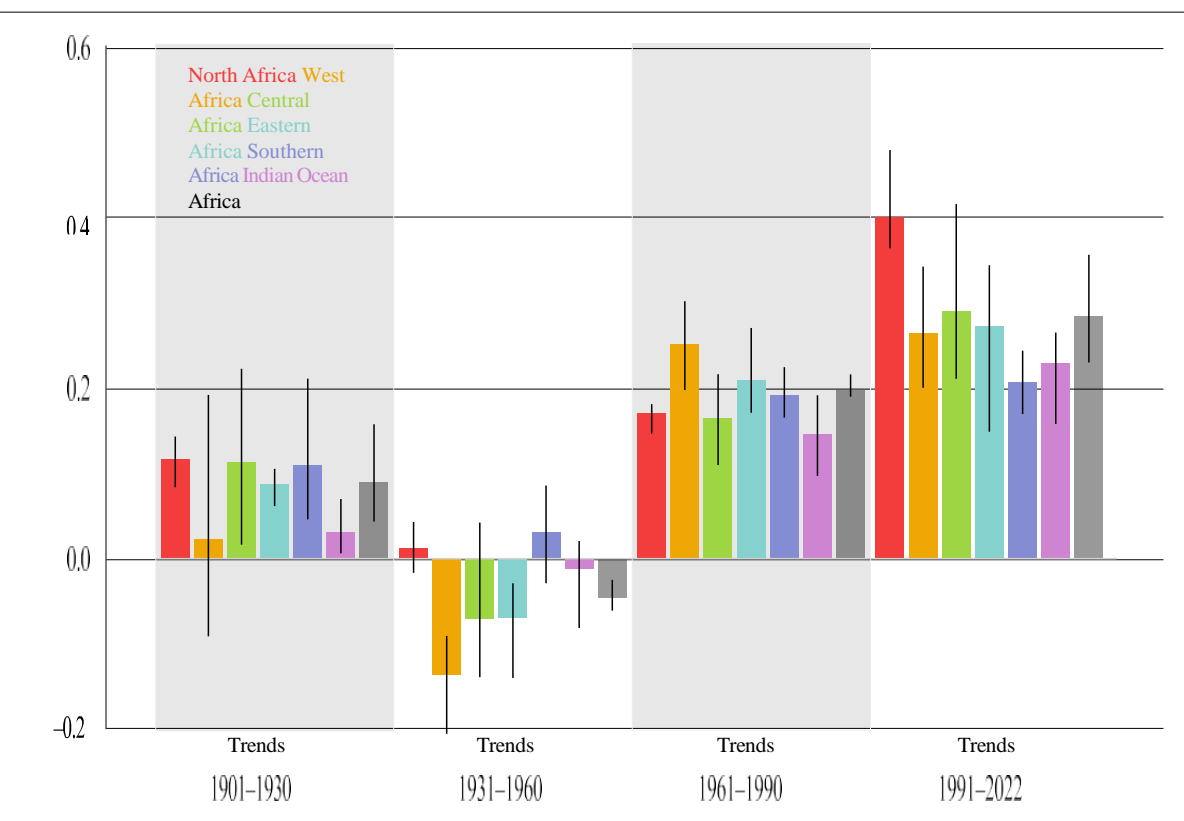
The Climate-Debt Loop

Poorer African countries risks: unable to finance necessary adaptation measures, leading to a cycle of increased vulnerability, deteriorating public finances, and escalating debt crises.

The Impact of Climate Change on Africa

- Warming Trends: Africa's warming rate is +0.3°C per decade, exceeding the global average (+0.2°C per decade). All subregions of Africa are experiencing a rise in temperature, with North Africa warming at +0.4°C per decade.

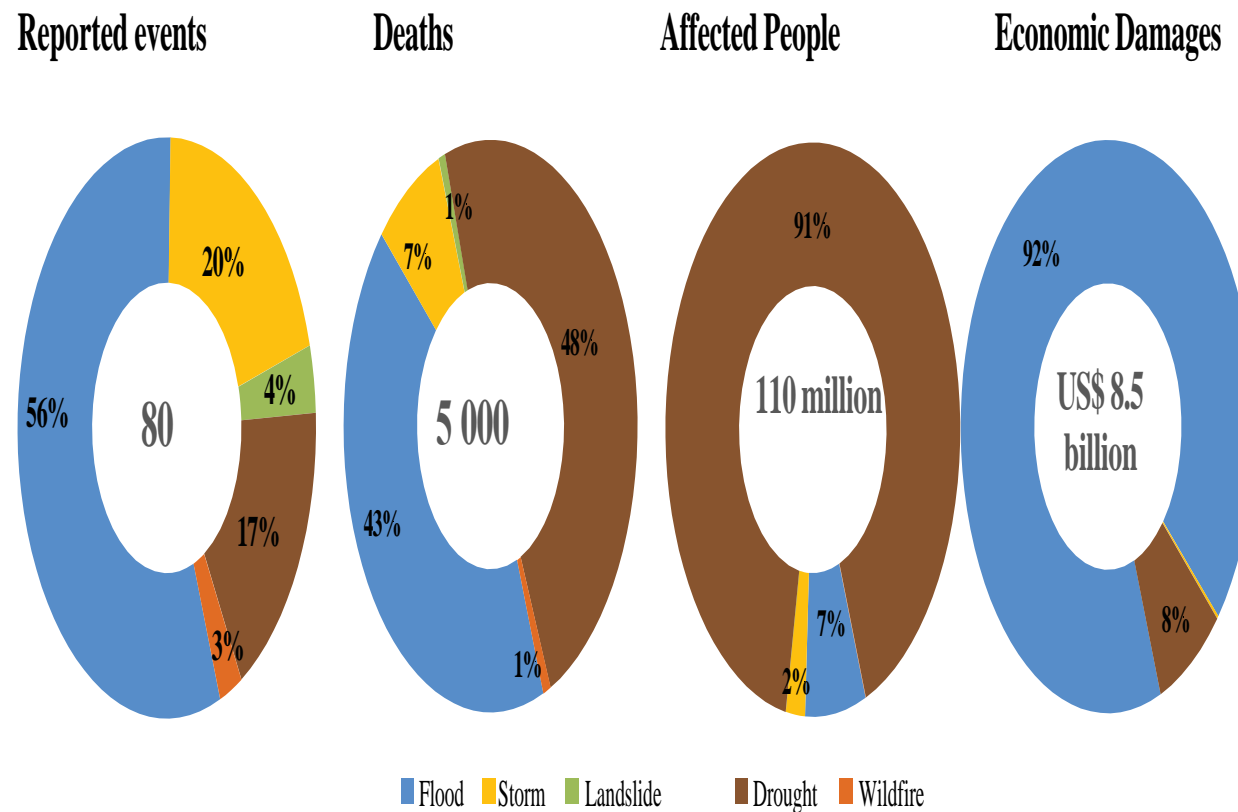
Fig 1. Trends in the area average temperature in °C/decade for the 6 African subregions: over 1901–1930, 1931–1960, 1961–1990, and 1991–2023.



Source: WMO, 2024

Note: The trends were calculated using different datasets, including observational datasets (HadCRUT5, NOAA GlobalTemp, GISTEMP, and Berkeley Earth) and reanalysis (JRA-55 and ERA5). The black vertical lines indicate the range of the six estimates.

Fig2: Weather-, climate- and water-related disasters in Africa in 2022.

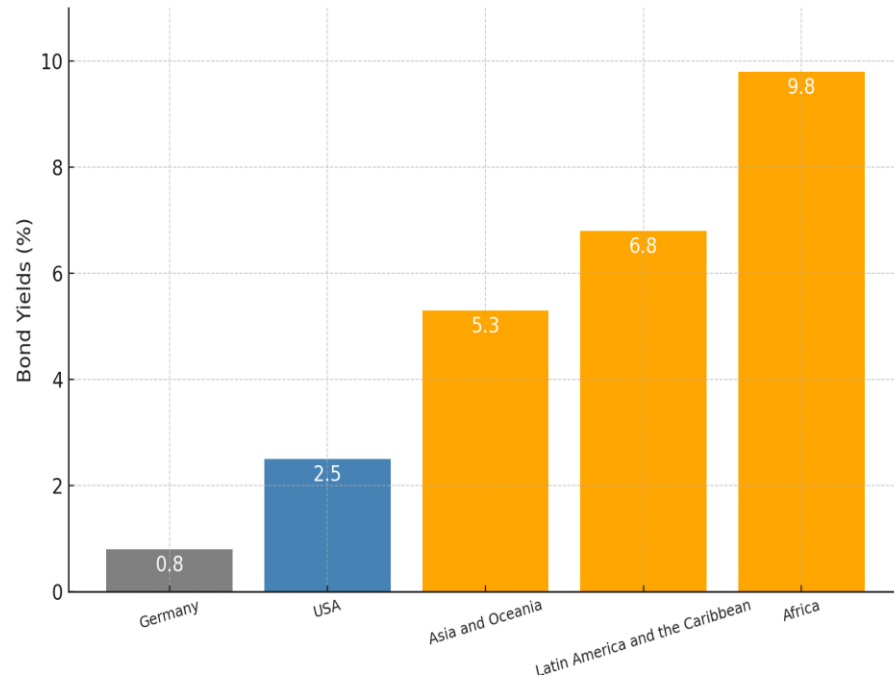


Source: Data as of June 2023 from EM-DAT

Note: The economic damages of some disaster occurrences are not presented in the figure due to data unavailability.

Africa's Debt Vulnerability

Fig 3: Borrowing Costs of Developing Countries Compared to Developed Ones

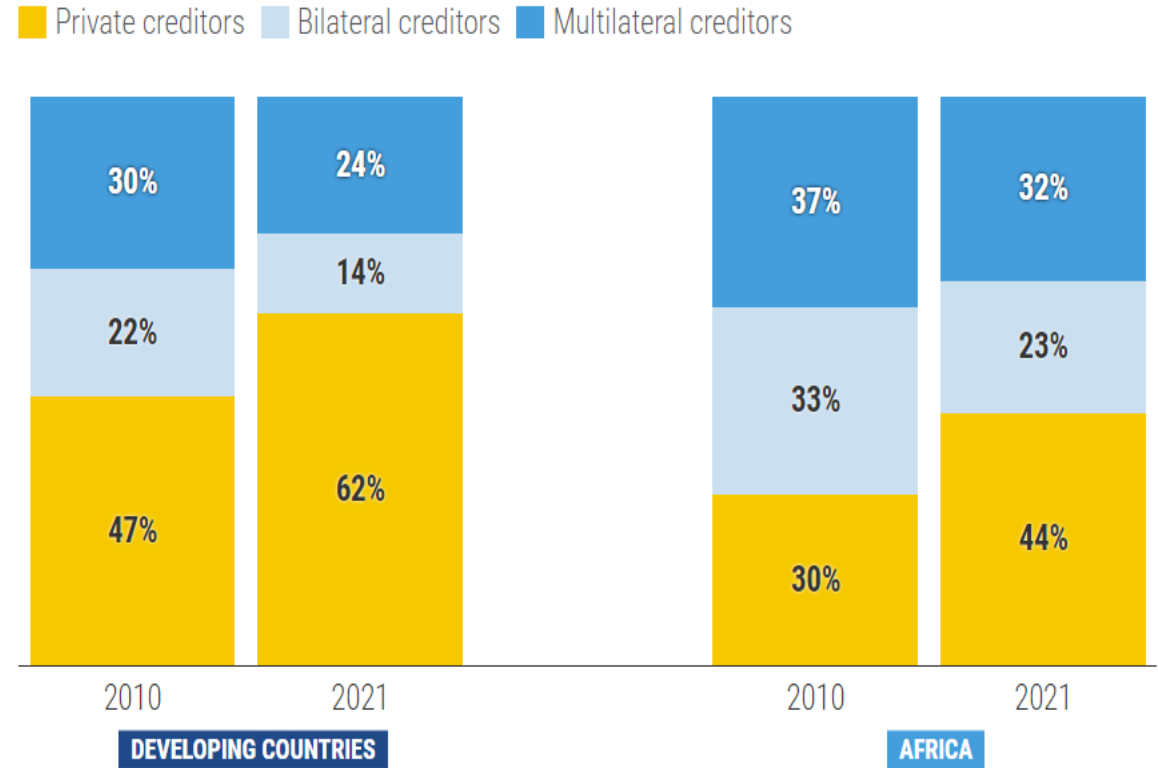


Source: UN GCRG-technical team calculations, based on Refinitiv data.

Note: Illustrative comparison of the average JPM EMBI Global Diversified USD bond yields per region with the 10-year bond yields of Germany and the United States from January 2020 to May 2024.

Fig 4: Creditor composition of external debt

in the developing world and countries in Africa

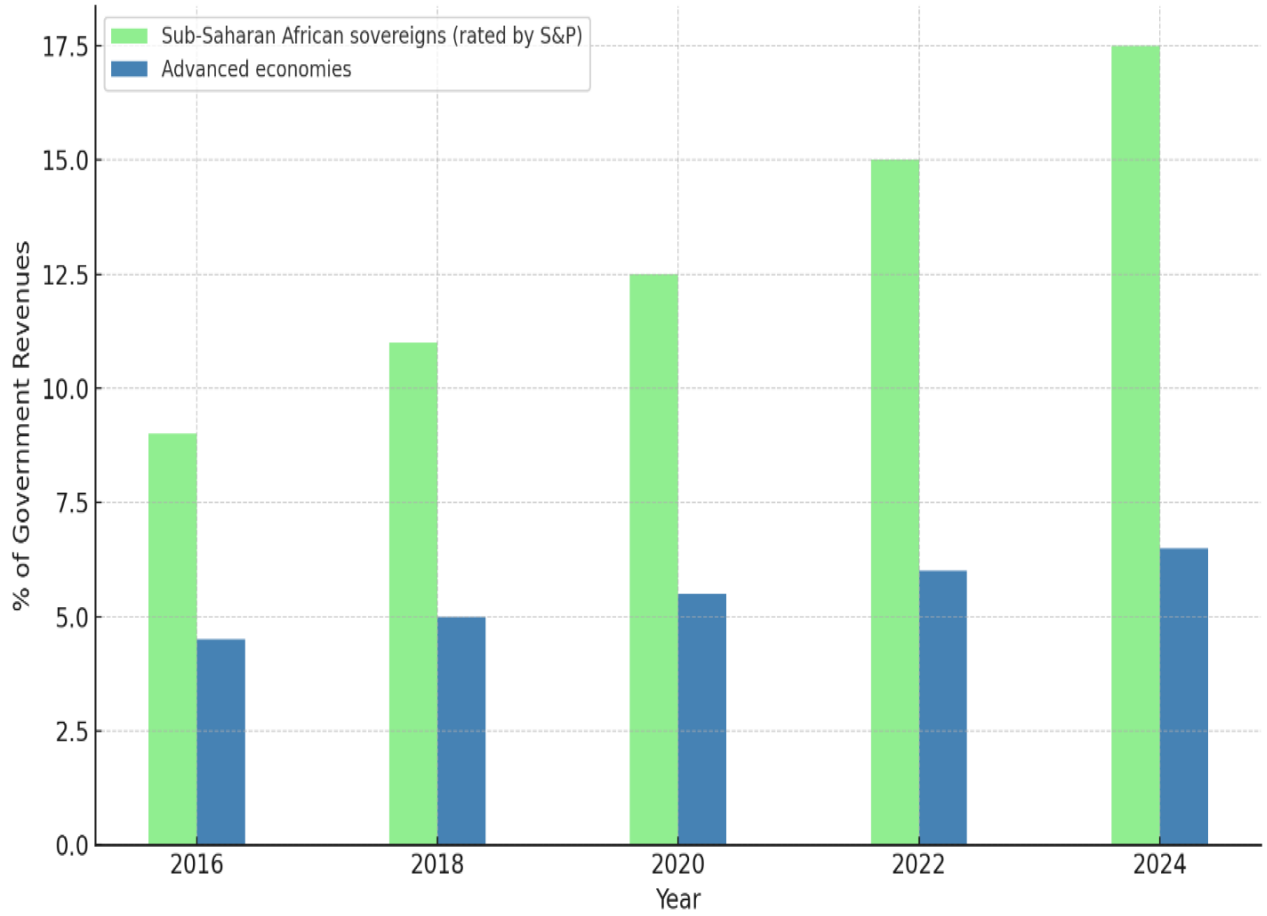


Note: External Public and Publicly Guaranteed (PPG) debt.

Source: UN Global Crisis Response Group calculations, based on World Bank International Debt Report 2022.

Africa's Debt Vulnerability (Cont)

Fig 5: Government Interest Expenditure as % of Government Revenues



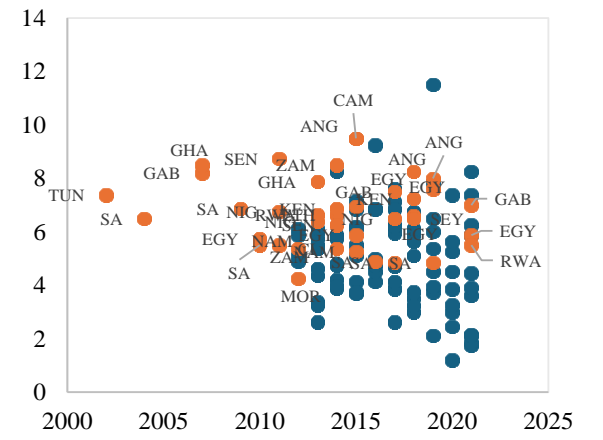
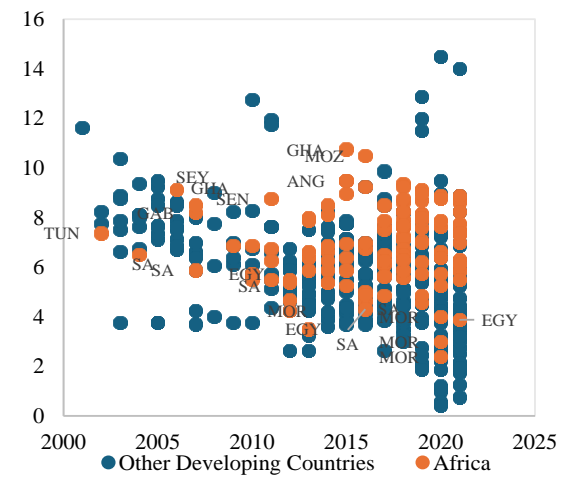
Source: Data from S&P Global Ratings (Sovereign Risk Indicators), 2024

Bond yields in Africa (2022-2023)

| | | |
|---------------------------|-----------------------------|-------------|
| Top 3 | Tunisia | 27.9 |
| | Egypt | 12.5 |
| | Nigeria | 11.5 |
| Regional aggregate | Africa | 11.6 |
| Bottom 3 | Morocco | 6.1 |
| | United Republic of Tanzania | 4.4 |
| | Cameroon | 3.5 |
| Reference point | United States of America | 3.1 |

Note: Exclusion of countries in default or preemptive restructuring. Average JPM EMBI Global Diversified USD bond yields.
Source: UN Global Crisis Response Group calculations, based on Refinitiv.

Figure 6: Coupon rates on Eurodollar bond issuance across countries (2001-2021) **Figure 7: Coupon rates on 10-year Eurodollar bond issuance across countries (2002-2021)**



Source: adapted from ECA, 2022
Notes: The sample comprises bonds with simple coupon structures (fixed, flat trading and floating) for comparability. Other developing countries include 48 countries from EAP, ECA, SA, LAC and Middle East. The data are obtained from Bloomberg data (downloaded in January-February 2022). Coupon rates on 10-year Eurodollar bond issuance across countries (2002-2021) The sample comprises bonds with simple coupon structures (fixed, flat trading and floating) for comparability. Other developing countries include 35 countries from EAP, ECA, SA, LAC and Middle East. The data are obtained from Bloomberg data (downloaded in January-February 2022). African countries are in red, other developing countries in blue.

Objective of the study

The study aim: enhance the understanding of how climate risks influence the cost of borrowing and the creditworthiness of nations

Provide insights for better identification and management of sovereign climate risk.

We investigate the relationship between climate change vulnerability and resilience and their effects on sovereign bond yields and spreads in African countries

We employ **GMM** to address **potential endogeneity** and measurement errors in the panel dataset.

Additionally, sensitivity analyses using the **2SLS, FGLS, Random Effects Models, and PQFM** methods are conducted to control for unobserved heterogeneity, heteroskedasticity, and capture effects across different quantiles.

The novelty of the paper: address the dearth of research on this topical issue and to produce new research findings, with a particular focus on African countries.

Theoretical and empirical study

Building on foundational work on integrated assessment models (IAM) (Nordhaus, 2019), a body of literature has emerged, examining both the direct and indirect effects of climate on sovereign debt.

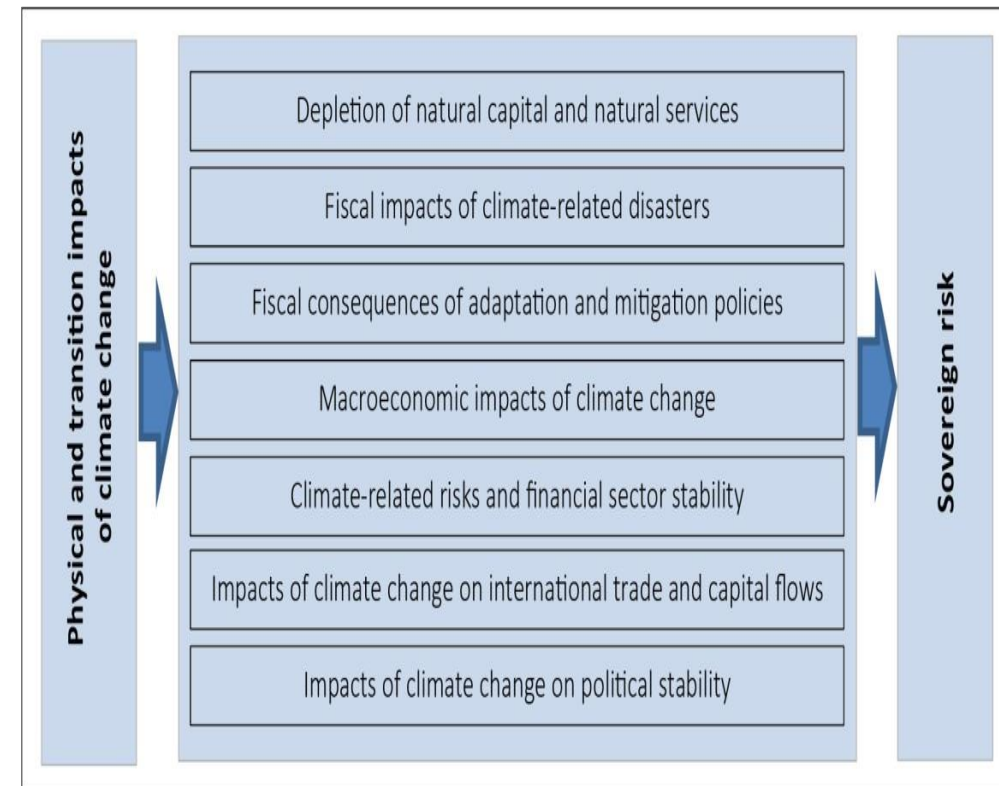
Kling et al. (2018) employed a POLS methodology and PC analysis to estimate a linear model that explained sovereign bond yields based on control variables, climate vulnerability, and social preparedness measures for the V20 Group. Vulnerability to climate risks has led to an average increase of 1.17% in the sovereign cost of debt for climate-vulnerable developing countries over the last decade.

Cevik and Tovar-Jalles (2020a; 2020b) employed an OLS, probit and logit and a 2SLS approach with IV. A panel of 67 countries over 1995-2017. A 1% increase in climate change vulnerability results in a 0.23% decline in creditworthiness. Conversely, an improvement of 1% in climate change resilience is associated with a 0.09% increase in the sovereign credit rating.

Mallucci (2020) investigated the impact of disaster risk and climate change on financial vulnerabilities in 7 Caribbean countries, a combination of scenario analysis and econometric modeling for the period 1980 to 2019. In a scenario where the frequency of high-category disaster events increases by 29.2% and their intensity rises by 48.5%, the study estimated that debt-to-GDP ratios could decline by at least 12%, reflecting reduced

fiscal capacity.

Transmission channels of climate change risk to Sovereign risk



Source: Adapted from Volz et al., 2021

Empirical strategy

List of countries included in the panel

| | | |
|-------------|-------------|--------------|
| Algeria | Gabon | Nigeria |
| Angola | Ghana | Rwanda |
| Benin | Ivory Coast | Senegal |
| Cameroon | Kenya | Seychelles |
| Congo, Rep. | Mauritius | South Africa |
| Egypt | Morocco | Tanzania |
| Ethiopia | Mozambique | Tunisia |
| | Namibia | Zambia |

Analyze the impact of climate change metrics (vulnerability and readiness) on the cost of government borrowing expressed as both sovereign bond yields and sovereign risk premium, several sources are used to construct a panel dataset of annual observations covering 23 African countries over 2002–2020.



Dependent variables: government bond yields and spreads as measured by foreign-currency-denominated government bond yields and spreads vis-à-vis the U.S. benchmark, from Bloomberg.



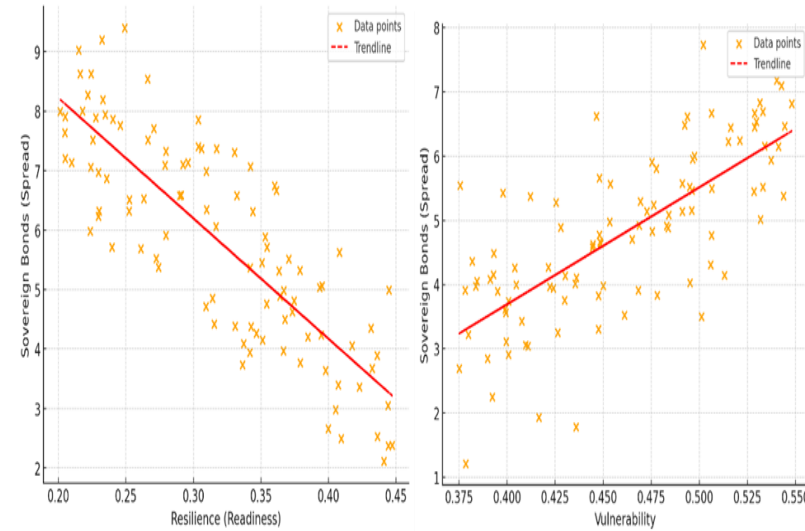
Explanatory variables: vulnerability and resilience to climate change, as captured by the Notre-Dame Global Adaptation Initiative (ND-GAIN) indices. These indices reflect a country's overall susceptibility to climate-related disruptions and its capacity to manage the impacts of climate change



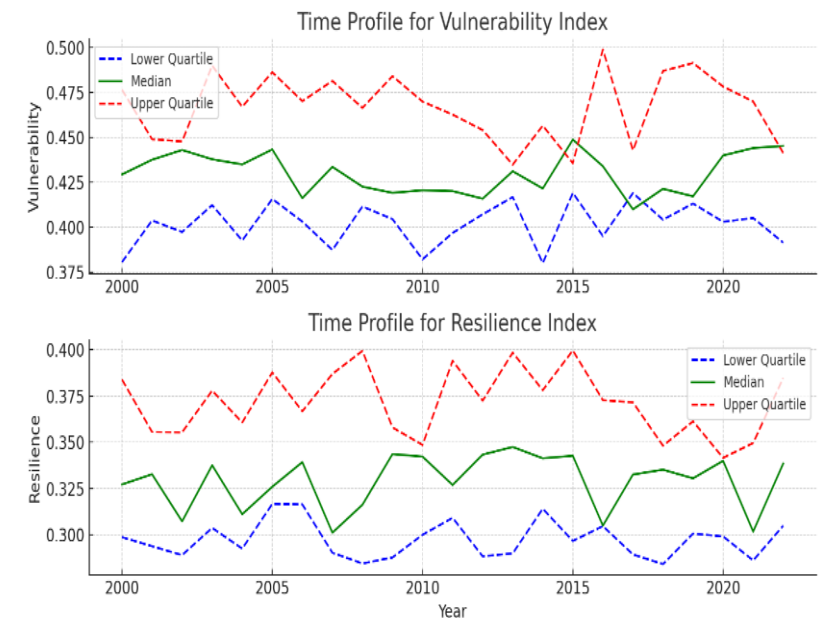
Set of control variables: *Debt and fiscal management, macroeconomic indicators, external sector indicators, & institutional framework measures (i.e., level and growth rate of real GDP, consumer price inflation, public debt-to-GDP ratio, budget balance-to-GDP ratio, international reserves as a share of GDP, & measures of institutional development-government effectiveness & bureaucratic quality).*

Preliminary estimations

Figure: Climate Change and Government Bond Spread



Source: ND-GAIN; Bloomberg; authors' calculations.



Empirical Study

We begin the empirical analysis with the standard **random effects model**.

we check the sensitivity of our baseline results by estimating the **static model with 2SLS estimator**. The 2SLS are used to address endogeneity concerns. This method helps correct for the bias that arises when independent variables are correlated with the error term

FGLS well-suited for panel data since it can handle both cross-sectional dependence and time-series correlations among the error terms as well as complicated error structures

FGLS particularly useful for understanding the relationships between variables like vulnerability, readiness, and bond yields or spreads in a way that captures the true underlying dynamics of the data.

Furthermore, we applied a **PQFM** to address unobserved heterogeneity and heterogeneous effects across the quantiles (percentiles) of the dependent variable's distribution while accounting for unobserved heterogeneity over time and across entities

Finally, we employed the **GMM approach**, as developed by Arellano and Bover (1995) and Blundell and Bond (1998), to estimate the dynamic version of our model.

Empirical Results

| | (1) Spread | (2) Yield | (3) Spread | (4) Yield |
|--------------------------|---------------------|---------------------|--------------------|---------------------|
| Vulnerability | 3.613*** (.872) | 4.362*** (.909) | | |
| Readiness | | | -3.057** (1.22) | -1.581* (.813) |
| GDP per capita | -.407 (.297) | -.259 (.173) | -.609*** (.204) | -.348*** (.071) |
| Inflation | -.008 (.02) | .002 (.011) | -.008 (.02) | .014 (.009) |
| Debt to GDP | .004 (.004) | .003 (.003) | .005 (.004) | 0 (.003) |
| Trade Openness | .002 (.007) | .004 (.006) | -.005 (.007) | -.006* (.004) |
| Reserve to GDP | -.254* (.142) | -.153*** (.043) | -.203** (.085) | -.159* (.095) |
| Growth Rate | -.031 (.046) | -.044** (.023) | -.092 (.077) | -.088 (.099) |
| Government Effectiveness | .709 (.721) | .468 (.451) | .74 (.595) | .187 (.316) |
| Regulatory Quality | -1.071** (.461) | -.763*** (.287) | -.535 (.601) | -.008 (.341) |
| _cons | 7.632*** (2.678) | 7.928*** (1.499) | 3.337*** (1.24) | 4.223*** (1.348) |
| Country effects | Yes | Yes | Yes | Yes |
| Year effects | Yes | Yes | Yes | Yes |

Robust standard errors are in parentheses

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

The primary analysis employs the Generalized Method of Moments (GMM) to address potential endogeneity and measurement errors in the panel dataset.

The GMM results indicate that a 1-unit increase in vulnerability raises spreads by **3.6%** and yields by **4.4%**,

while a 1-unit increase in readiness reduces spreads by **3.1%** and yields by **1.9%**.

Sensitivity analyses using 2SLS, FGLS, Random Effects Models, and PQFM validate these findings. These methods help control for unobserved heterogeneity, heteroskedasticity, and capture effects across different quantiles.

The robustness of the GMM results, confirmed by alternative models shows that climate-vulnerable African countries, exhibiting low climate disaster managerial abilities in mitigating the climate challenges pay a higher risk premium on their sovereign debt.

Empirical Results (Cont)

| | (1) Spread | (2) Yield | (3) Spread | (4) Yield |
|--------------------------|---------------------|---------------------|--------------------|---------------------|
| Vulnerability | 3.613*** (.872) | 4.362*** (.909) | | |
| Readiness | | | -3.057** (1.22) | -1.581* (.813) |
| GDP per capita | -.407 (.297) | -.259 (.173) | -.609*** (.204) | -.348*** (.071) |
| Inflation | -.008 (.02) | .002 (.011) | -.008 (.02) | .014 (.009) |
| Debt to GDP | .004 (.004) | .003 (.003) | .005 (.004) | 0 (.003) |
| Trade Openness | .002 (.007) | .004 (.006) | -.005 (.007) | -.006* (.004) |
| Reserve to GDP | -.254* (.142) | -.153*** (.043) | -.203** (.085) | -.159* (.095) |
| Growth Rate | -.031 (.046) | -.044** (.023) | -.092 (.077) | -.088 (.099) |
| Government Effectiveness | .709 (.721) | .468 (.451) | .74 (.595) | .187 (.316) |
| Regulatory Quality | -1.071** (.461) | -.763*** (.287) | -.535 (.601) | -.008 (.341) |
| _cons | 7.632*** (2.678) | 7.928*** (1.499) | 3.337*** (1.24) | 4.223*** (1.348) |
| Country effects | Yes | Yes | Yes | Yes |
| Year effects | Yes | Yes | Yes | Yes |

Robust standard errors are in parentheses

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

Gros domestic product (GDP) per capita = A 1% increase in GDPpc leads to a decrease in spreads ranging from 0.6% to 0.11%

GDP per Capita= A 1% increase in GDP per capita results in a decrease in yields ranging from 0.4% to 0.11%, reflecting lower borrowing costs in wealthier economies.

Economic growth = A 1-unit increase in growth leads to a decrease in spreads ranging from 0.03% to 0.04% and a decrease in yields ranging from 0.04% to 0.03%..

Debt-to-GDP ratio = A 1% increase in the Debt ratio leads to an increase spread by 0.01% and marginally impacts yields by 0.007%, indicating a nuanced effect depending on other factors.

Current budget balance are mostly negative. A 1% deterioration in the budget balance (higher deficit as a percentage of GDP) leads to an increase in yields ranging from 0.014% to 0.03%.

International reserves are a negative impact on spreads. A 1% increase in international reserves to GDP is associated with a decrease in spreads ranging from 0.25% to 0.20%.

A 1-unit increase in **Government Effectiveness** leads to a decrease in spreads ranging from 0.14% to 0.51%,

Regulatory Quality significantly reduces both spreads and yields. A 1-unit increase leads to a decrease in spreads ranging from 1.07% to 0.53%

Policy Implications

Sound Fiscal and Monetary Policies: Control debt and deficits, stabilize inflation, and diversify the economy to reduce exposure to external shocks and lower borrowing costs.

- **Strengthen Governance and Regulations:** Improve transparency, public services, and regulatory quality to create a stable environment that boosts investor confidence.
- **Promote Trade Openness:** Facilitate trade liberalization, reduce barriers, and engage in global agreements to diversify risks and enhance economic stability.
- **Maintain Adequate Reserves:** Build sufficient reserves to buffer against financial crises and enhance creditworthiness.
- **Support Sustainable Growth:** Implement structural reforms and promote private sector development to strengthen fiscal stability and attract investment.
- **Integrate Climate Risk Management:** Incorporate climate risk analysis into public finances, establish fiscal buffers, and create disaster financing mechanisms to improve resilience, foster economic stability, and ensure sustainable growth.
- **Enhance Regional and International Cooperation:** collaborate with institutions like the African Development Bank and the World Bank to develop coordinated adaptation strategies and establish risk transfer mechanisms



United Nations
Economic Commission for Africa

Thank you Merci

