

CLIMATE CHANGE, FOREIGN DIRECT INVESTMENT AND FISCAL SUSTAINABILITY IN SUB-SAHARAN AFRICA

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ABSTRACT

This paper empirically analyses the relationship between climate change, foreign direct investment, and fiscal sustainability in the sub-Saharan Africa (SSA) region. The study analyzed a sample of 966 country-year observations drawn from 23 SSA countries over the study period. The study employed the dynamic panel Generalised Method of Moments (GMM) model to test the hypotheses. Results based on the GMM model suggest that the lagged value of fiscal sustainability is negatively and significantly related with current fiscal sustainability, indicating adjustment dynamics in fiscal conditions over time. Furthermore, the regression results show that climate change is positively and significantly associated with fiscal sustainability, while foreign direct investment is also positively and significantly associated with fiscal sustainability. The post-estimation results confirmed the validity of the model, particularly through the AR(2), Sargan, and Hansen tests, which support the reliability of the instruments used in the dynamic panel estimation. The findings of the study provide valuable insights for policymakers, government leaders, investors, environmental regulators, and fiscal authorities in SSA. Strengthening climate-related fiscal planning and attracting productive foreign direct investment are critical for improving fiscal sustainability across the region. This study contributes to the growing literature on climate change, foreign direct investment, and fiscal sustainability in developing regions by providing new empirical evidence from the SSA context. It uniquely contextualizes the analysis within the SSA region, offering useful evidence to inform sustainable fiscal, environmental, and investment policies.

Keywords: Generalised method of moments model, fixed effects model, fiscal sustainability, carbon emissions, foreign direct investment

1. INTRODUCTION

Recent decades have seen substantial progress in climate research and economic modelling, and evidence from extreme weather events has provided important insights into the macroeconomic consequences of climate change (IPCC, 2021; Olper et al., 2021; Dell et al., 2014; Newell et al., 2021; Kolstad & Moore, 2020). This paper focuses primarily on the fiscal implications of climate-related pressures, rather than on the physical science of climate change itself. The contributions to climate change and the economic repercussions of climate impacts are unevenly distributed across regions (Tol, 2018). In developing economies, these uneven effects matter because governments face rising adaptation costs, disaster-response spending, and pressure to finance low-carbon transitions. These concerns have strengthened the policy debate on the appropriate mix of fiscal

instruments, including carbon pricing, green public investment, regulatory standards, and command-and-control measures. Well-designed instruments can support emissions reduction and revenue mobilisation, while poorly designed policies may create distributional burdens without achieving fiscal or environmental objectives (Stiglitz et al., 2017).

A growing body of evidence indicates that investments designed to mitigate climate change and build resilience may be less costly than the fiscal and economic losses associated with climate-induced shocks (Stern, 2007; Kahn et al., 2021; Office for Budget Responsibility, 2021). However, this paper treats the emissions-based climate variable carefully. Carbon emissions or carbon intensity should not be interpreted as a direct measure of the level of climate change experienced by a country, nor as a full measure of vulnerability to climate hazards. Instead, it represents an emissions burden and mitigation challenge that may be connected to fiscal sustainability through public investment needs, climate finance, regulatory responses, and the structure of economic activity. This interpretation is important because climate vulnerability, extreme-event frequency, and sectoral exposure would capture different dimensions of the climate-fiscal relationship.

Sub-Saharan Africa (SSA) is a region with immense economic potential, but it faces several challenges that affect fiscal sustainability (Comelli et al., 2023; ADB, 2023). Among these challenges, climate-related pressures and foreign direct investment (FDI) are particularly relevant to economic performance and fiscal balances. Climate change can place pressure on public finances through the costs of adaptation, disaster recovery, infrastructure protection, and support for vulnerable households and sectors (IMF, 2023). Similarly, green investment requires large capital commitments, but it can also reduce future fiscal exposure where it improves resilience and lowers dependence on carbon-intensive systems. On the other hand, FDI can provide capital, employment opportunities, technology transfer and tax revenue, although these benefits depend on the quality of institutions, investment incentives and public financial management (Ajayi, 2006).

This study therefore addresses a topic that has received limited attention in the literature: the relationship among climate-related emissions pressure, FDI and fiscal sustainability in SSA. The first part of the study examines how the carbon-emissions-based climate indicator is associated with fiscal sustainability, while the second part examines how FDI is associated with fiscal sustainability. These two questions belong in the same study because both climate-related investment needs and foreign investment inflows affect the fiscal space available to governments. They are also policy-linked because SSA countries increasingly seek external capital, green finance and private investment to manage climate risks while maintaining debt sustainability.

The empirical strategy reflects this shared logic by estimating the two relationships within a common fiscal-sustainability framework. The baseline model first includes the lagged fiscal sustainability variable and macroeconomic controls. The extended model then adds the carbon-emissions-based climate indicator and FDI to assess whether these variables are significantly associated with fiscal sustainability after accounting for dynamic adjustment and control variables. This approach does not, by itself, establish causality. Rather, it provides evidence on conditional associations that can inform further work using stronger identification strategies.

Foreign Direct Investment (FDI) is widely acknowledged as a crucial catalyst for economic growth and development, especially in developing regions such as Sub-Saharan Africa. The connection between FDI and fiscal sustainability is complex because FDI can increase productive capacity and revenue collection, but it can also reduce fiscal gains where governments offer excessive tax concessions or where weak institutions limit revenue capture. Notwithstanding considerable FDI inflows in recent decades, many SSA countries continue to experience substantial fiscal deficits,

elevated public debt levels, and limited fiscal capacity, prompting important questions about the long-term fiscal sustainability of these economies (IMF, 2023).

FDI can provide finance, facilitate knowledge transfer, and create employment opportunities. In Sub-Saharan Africa, countries such as Nigeria, South Africa, and Ethiopia have attracted substantial foreign investment. The World Bank (2018) reports that Sub-Saharan Africa received significant FDI inflows, although these flows have not automatically translated into fiscal stability. Several SSA countries continue to face budget deficits that exceed global averages, indicating that the fiscal value of FDI depends on how investment inflows are structured, taxed and integrated into national development strategies (World Bank, 2020).

Although FDI is expected to improve economic performance, its fiscal implications remain mixed. FDI can enhance tax collection through corporate taxation and stimulate economic growth. Conversely, many SSA countries provide substantial tax incentives to attract foreign investment, thereby reducing the potential revenue base and worsening budgetary pressures. Kenya and Tanzania, for example, have used tax holidays and exemptions to attract international investment, which may reduce short-term fiscal gains (Ndikumana & Boyce, 2022). These fiscal difficulties are further shaped by structural and policy-related constraints such as weak public financial management, corruption, limited tax administration capacity, and insufficient economic diversification (World Bank, 2022).

2. EMPIRICAL LITERATURE

2.1 Climate Change and Fiscal Sustainability

The literature on climate change and fiscal sustainability increasingly shows that climate risks are relevant to sovereign debt dynamics, borrowing costs and creditworthiness. Zenios et al. (2021) demonstrate that integrating climate assessment into sovereign debt sustainability analysis can reveal adverse debt dynamics as early as 2030. Their work suggests that European fiscal and monetary institutions should incorporate climate considerations into sovereign risk assessments. In the same direction, Cevik and Jalles (2022a) find that higher climate vulnerability is associated with weaker sovereign credit ratings across a panel of 67 countries. These studies indicate that climate-related fiscal risks are no longer remote environmental concerns; rather, they are becoming part of mainstream fiscal and sovereign-risk assessment.

A second strand of the literature focuses on forward-looking ratings and borrowing-cost channels. Klusak et al. (2023) combine climate-economic models with sovereign ratings and artificial intelligence to produce climate-adjusted sovereign ratings for 108 countries across different climate scenarios. Their findings suggest that climate change is likely to reduce sovereign credit ratings by 2030, with larger losses under high-emissions scenarios. This evidence is methodologically important because it moves beyond backward-looking correlations and estimates how future climate pathways may be reflected in sovereign creditworthiness.

A third strand examines whether financial markets already price climate vulnerability. Kling et al. (2018) find that countries with greater climate sensitivity face a risk premium on sovereign debt. Using panel and principal component analysis for 46 countries between 1996 and 2016, they show that climate vulnerability raised debt costs for a group of climate-vulnerable developing countries even after controlling for macroeconomic factors. Related studies by Cevik and Jalles (2022b) and Beirne et al. (2021a, 2021b) similarly report that climate vulnerability increases sovereign bond yields, while climate resilience may partly reduce this effect. These findings are relevant to SSA because many countries in the region face both high exposure to climate shocks and limited fiscal space.

The literature also distinguishes between physical climate risks and transition risks. Physical risks arise from climate shocks, extreme weather and long-term environmental degradation, while transition risks arise from policy, technology and market adjustments during the move towards low-carbon development. Battiston and Monasterolo (2020) show that economies dependent on carbon-intensive sectors may face higher sovereign bond rates. Klusak et al. (2023) also estimate that climate-induced downgrades could generate substantial additional debt-service costs under both low- and high-emissions scenarios. Together, these studies suggest that climate-related pressures may affect fiscal sustainability through both direct expenditure channels and indirect sovereign-risk channels.

Overall, existing evidence suggests a consistent link between climate vulnerability, sovereign risk and the cost of public borrowing, but the literature also reveals important gaps. Many studies focus on advanced economies, global panels or specific regions such as Europe and Southeast Asia, while SSA remains less extensively examined. In addition, the empirical literature often uses vulnerability indices, climate shocks or transition-risk measures, whereas this study uses a carbon-emissions-based indicator. This distinction is important because the present indicator is best interpreted as an emissions and mitigation-pressure measure rather than as direct climate exposure. The study therefore contributes by examining how this emissions-based climate indicator and FDI relate to fiscal sustainability in the SSA context.

The reviewed studies collectively show that climate-related fiscal risks operate through several mechanisms: higher disaster-related public spending, lower growth prospects, weaker sovereign creditworthiness, higher borrowing costs and the need for transition finance. These mechanisms provide the basis for examining whether the carbon-emissions-based climate indicator is associated with fiscal sustainability in SSA, while recognising that the indicator does not capture the full range of vulnerability, exposure or adaptation capacity.

Based on the theoretical and empirical reviews, we formulate the following hypotheses:

- H1. The carbon-emissions-based climate indicator is significantly associated with fiscal sustainability in SSA

2.2 Foreign Direct Investment and Fiscal Sustainability

The literature on FDI and fiscal sustainability is related to broader debates on external capital flows, government revenue and debt dynamics. Although some earlier work examines remittances rather than FDI, such studies are relevant because they show how external financial inflows can influence fiscal outcomes through consumption, investment and tax revenue channels. Liliana and Dumitrescu (2017), for example, report favourable associations between migrant remittances, economic development, private consumption and government tax income across developing countries. Okolo (2017) also finds that remittances are linked to long-run fiscal sustainability in Nigeria. While remittances and FDI are distinct forms of external finance, these findings indicate that external inflows may affect fiscal sustainability depending on how they enter the domestic economy and how governments capture revenue from them. Kaur et al. (2012) further show that FDI can be connected to external-sector balances through long-run relationships with the current account.

Recent institutional literature places stronger emphasis on the quality and sustainability of FDI. The United Nations Conference on Trade and Development (UNCTAD, 2023) highlights the role of FDI in supporting sustainable fiscal policies and investment aligned with the Sustainable Development Goals. It reports uneven global FDI flows and notes that developing countries experienced declines in FDI, adding to fiscal pressures. The report suggests that sustainable FDI,

especially in renewable energy and digital infrastructure, can support fiscal stability by creating longer-term revenue sources and reducing dependence on volatile capital markets. However, this benefit requires targeted policy measures that attract, retain and regulate investment effectively.

Similarly, the United Nations Department of Economic and Social Affairs (UNDESA, 2023) links FDI to fiscal sustainability through tax revenue, public expenditure efficiency and institutional quality. The evidence indicates that FDI can strengthen fiscal sustainability where governments maintain prudent fiscal policies, improve governance and align investment with development priorities. However, the benefits are not automatic. Countries that use excessive tax incentives, weakly monitor investment agreements or fail to diversify their economies may capture fewer fiscal gains. The literature therefore suggests that FDI is likely to support fiscal sustainability only when supported by effective institutions, transparent revenue systems and coherent investment policy.

Based on the theoretical and empirical reviews, we formulate the following hypotheses:

H2. Foreign direct investment is significantly associated with fiscal sustainability in SSA

3. RESEARCH DESIGN

3.1 Sample size and data

The target population for this study encompassed countries in Sub-Saharan Africa. The final sample was selected using two criteria. First, only countries recognised as sovereign republics between 2000 and 2023 were included. Second, inclusion depended on the availability of complete data for the variables used in the empirical models. The study used secondary data collected from reputable sources, including the World Bank database and the national statistics bureaus of the selected countries. The final dataset consisted of 966 country-year observations from 42 countries over the period 2000-2023. This panel structure allows the study to examine fiscal sustainability patterns across countries and over time while accounting for dynamic adjustment in fiscal outcomes.

3.2 Measurement of variables

3.2.1 Dependent Variable

Fiscal sustainability is the dependent variable. Conceptually, fiscal sustainability refers to a government's capacity to maintain public debt and budgetary obligations without creating an excessive burden for future generations. The empirical proxy was based on the debt-to-GDP ratio. Because a higher debt-to-GDP ratio indicates greater fiscal pressure and therefore lower fiscal sustainability, the indicator was reverse-coded for estimation so that higher values represent stronger fiscal sustainability and lower debt pressure. This transformation is important for interpretation: a positive coefficient indicates an association with improved fiscal sustainability, while a negative coefficient indicates an association with weaker fiscal sustainability.

3.2.2 Independent Variables

The first independent variable is the climate-related indicator. Climate change refers to gradual and persistent changes in temperatures and weather patterns over time, but the empirical measure used in this study is carbon emissions, measured in kilotons of CO₂ (Boden, Marland & Andres, 2009). This indicator should therefore be interpreted as an emissions burden or mitigation-pressure measure, not as a direct measure of climate vulnerability, exposure to climate shocks or the level of climate change experienced by a country. Where emissions are compared with economic activity, the interpretation is closer to carbon intensity. The second independent variable is FDI, which refers

to cross-border investment inflows that can influence economic growth, the balance of payments and trade patterns. FDI was measured as investment inflows relative to GDP (Pattayat, 2016).

3.2.3 Control variable

The control variables include population, economic growth, inflation and human capital. Population is measured as the number of people usually living in a country (Gu, Andreev & Dupre, 2021). Economic growth is captured through GDP, which represents the total value of goods and services produced within a country over a given period (Mankiw & Taylor, 2020). Inflation is measured using price indices that capture changes in the general price level over time, commonly through the Consumer Price Index (CPI) (Mankiw & Taylor, 2020). Human capital is proxied by total health expenditure as a percentage of GDP. These controls are included because demographic pressure, output size, price stability and public investment in health can all be associated with fiscal capacity and debt dynamics.

3.3. Regression models

The following dynamic panel regression equations were adopted to test the proposed hypotheses:

Model 1: testing the effect of control variables on fiscal sustainability.

$$FS_{it} = f(POP_{it}, GDP_{it}, INF_{it}, HC_{it}) \dots \dots \dots (1)$$

Model 2: testing the effect of climate change and foreign direct investment on fiscal sustainability.

$$FS_{it} = f(POP_{it}, GDP_{it}, INF_{it}, HC_{it}, CC_{it}, FDI_{it}) \dots \dots \dots (2)$$

In these equations, *i* denotes country, *t* denotes year, FS is the reverse-coded fiscal sustainability indicator, POP is population, GDP is economic growth, INF is inflation, HC is human capital, CC is the carbon-emissions-based climate indicator, FDI is foreign direct investment, μ_i captures country-specific effects, λ_t captures time effects, and ϵ_{it} is the idiosyncratic error term.

Because FS is reverse-coded from the debt-to-GDP proxy, coefficient interpretation follows the direction of the transformed fiscal sustainability score. Positive coefficients are interpreted as associations with stronger fiscal sustainability, while negative coefficients are interpreted as associations with weaker fiscal sustainability. The GMM estimates should be read as conditional dynamic associations rather than definitive causal effects.

4. EMPIRICAL FINDINGS AND DISCUSSION

4.1 Descriptive statistics

Table I provides descriptive statistics for 966 country-year observations. The values show substantial variation across the SSA sample. The mean fiscal sustainability score is 3.12, with a standard deviation of 5.06, indicating considerable dispersion around the average. Because the variable is based on a reverse-coded debt-to-GDP proxy, higher values indicate relatively stronger fiscal sustainability, while lower values indicate greater fiscal pressure. Population averages 41.3 million, with a standard deviation of 141 million. The large difference between the minimum value of 143,714 and the maximum value of 1.21 billion shows the diversity of country sizes in the sample. Rapid population growth can place pressure on public services and infrastructure, although its fiscal implications depend on labour-force participation, revenue capacity and public expenditure management (Dimnwobi et al., 2021).

Like economic size, economic growth (i.e., GDP) has an average of 6.06×10^{10} (or 60.6 billion) and a very high standard deviation of 2.24×10^{11} (or 224 billion), again revealing the variation in economic sizes in the sample. That the range is from 7.60×10^7 (or 76 million) to 2.06×10^{12} (or 2.06 trillion) shows that some economies are large and developed more than others, which corresponds with global economic inequality (Piketty, 2014).

The mean inflation rate is 10.26, with a standard deviation of 33.60, indicating substantial variation across the sample. The minimum value of -16.85 suggests deflation in some observations, while the maximum value of 557.20 indicates episodes of extreme inflation and possible macroeconomic instability. Health expenditure averages 5.26 percent of GDP, with values ranging from 1.46 to 22.19, reflecting differences in public and private health financing across countries. The carbon-emissions-based climate indicator has a mean of 47,061 and a standard deviation of 154,676, showing large variation in emissions burdens across countries. This indicator should be read as a measure of emissions pressure or mitigation challenge rather than direct climate vulnerability. The mean of FDI is -76,086.46, with a high standard deviation of 1,704,399, suggesting substantial variation in investment inflows and outflows across the sample. FDI can support economic activity through capital, technology and employment, but its fiscal contribution depends on policy design and revenue capture (Alfaro & Chauvin, 2020).

Table I: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Fiscal sustainability	966	3.122617	5.056503	0.004773	59.67141
Population growth	966	4.13×10^7	1.41×10^8	143714	1.21×10^9
Economic growth	966	6.06×10^{10}	2.24×10^{11}	7.60×10^7	2.06×10^{12}
Inflation	966	10.26286	33.60457	-16.85969	557.2018
Human capital	966	5.26286	2.318729	1.465947	22.19721
Carbon emissions indicator	966	47061.11	154676.7	53.5	833713.9
Foreign direct investment	966	-76086.46	1704399	-4.23×10^7	103.3374

Source: Authors' computation

4.2 Correlation results

Table II presents the correlation results for fiscal sustainability (FS), population, economic growth, inflation, human capital, the carbon-emissions-based climate indicator and foreign direct investment (FDI). These results describe bivariate associations and should not be interpreted as causal effects. The negative and statistically significant correlation between fiscal sustainability and population growth (-0.0704*) indicates that higher population growth is weakly associated with lower values of the reverse-coded fiscal sustainability score. This may reflect the fiscal pressure created by rising demand for public services, infrastructure and welfare provisions in rapidly growing populations.

Table II: Correlation test results

	FS	POP	GDP	INF	HC	CC	FDI
Fiscal sustainability	1.0000						
Population growth	-0.0704*	1.0000					

Economic growth	-0.0123	0.0241	1.0000				
Inflation	0.0832*	0.2173*	-0.0283	1.0000			
Human capital	-0.0140	-0.0762*	-0.1744*	-0.0968*	1.0000		
Climate change	0.0362	0.6384*	0.6957*	-0.0890*	-0.1052*	1.0000	
Foreign direct investment	0.0199	0.0123	0.0082	0.0007	-0.0209	0.0126	1.000

Source: Authors' computation; Note(s): * $\sigma < 0.05$

There is no statistically significant correlation between fiscal sustainability and economic growth (-0.0123). This suggests that GDP is not directly or consistently associated with the fiscal sustainability score in the bivariate results. Economic growth can increase tax revenue, but it may also be accompanied by higher public spending, especially where growth requires greater infrastructure and social expenditure. The association between growth and fiscal sustainability may therefore depend on fiscal policy management, tax capacity and public debt levels.

Inflation has a positive and statistically significant correlation with fiscal sustainability (0.0832*), suggesting that higher inflation is weakly associated with higher values of the reverse-coded fiscal sustainability score in the short run. One possible explanation is that inflation may reduce the real value of existing public debt when debt is denominated in domestic currency. However, this relationship should be treated cautiously because prolonged inflation can reduce investor confidence, distort resource allocation and weaken fiscal stability (JP L'Huillier & Deluca, 2023).

There is a weak and statistically insignificant correlation between fiscal sustainability and health expenditure (-0.0140). This implies that health expenditure is not strongly associated with the fiscal sustainability score in the bivariate results. Health expenditure is usually expected to support long-term productivity and human capital formation, but its fiscal benefits may take time to emerge. In the short run, increased health expenditure may also create additional budgetary pressure.

The correlation between fiscal sustainability and the carbon-emissions-based climate indicator is positive but statistically insignificant (0.0362). This does not provide evidence of a strong direct bivariate association. Because the variable captures emissions pressure rather than climate vulnerability, the result should not be read as evidence that climate change improves fiscal sustainability. It may instead reflect differences in economic size, industrial structure, energy use or policy capacity across countries.

The weak positive correlation between fiscal sustainability and foreign direct investment (0.0199) indicates that FDI is not strongly associated with fiscal sustainability in the bivariate results. FDI can bring capital, productivity gains and employment opportunities, but its fiscal value depends on how governments manage investment incentives, taxation, profit repatriation and integration into sustainable development strategies.

Table III: Correlation test results

	FS	POP	GDP	INF	HC	CC	FDI
Fiscal sustainability	1.0000						
Population growth	-0.0704*	1.0000					
Economic growth	-0.0123	0.0241	1.0000				
Inflation	0.0832*	0.2173*	-0.0283	1.0000			

Human capital	-0.0140	-0.0762*	-0.1744*	-0.0968*	1.0000		
Climate change	0.0362	0.6384*	0.6957*	-0.0890*	-0.1052*	1.0000	
Foreign direct investment	0.0199	0.0123	0.0082	0.0007	-0.0209	0.0126	1.000

Source: Authors' computation; Note(s): * $\sigma < 0.05$

4.3 Analytical results

Table IV presents the System GMM results for fiscal sustainability. Model 1 explains the association between selected control variables and the reverse-coded fiscal sustainability indicator. The negative and significant coefficient for lagged fiscal sustainability (-0.492, p-value below 0.05) suggests that higher fiscal sustainability in the previous period is associated with a lower current fiscal sustainability score after controlling for the dynamic structure of the model. This may indicate adjustment in fiscal conditions over time or persistence of earlier fiscal imbalances. The interpretation should remain cautious because dynamic panel estimates identify conditional associations rather than automatic causal effects.

Table IV: System GMM results

Fiscal sustainability	Model 1 Coef.	Model 2 Coef.
Constant	-.104 (0.045)**	-.104 (0.055)**
Fiscal sustainability L1.	-.492 (0.047) **	-.601 (0.104) **
Population growth	.135 (0.034) **	-.478 (0.035) **
Economic growth	.058 (0.011) **	-.574 (0.052) **
Inflation	-.439 (0.190) **	.064 (0.027) **
Human capital	.224 (0.046) **	.001 (0.015)
Carbon emissions indicator		0.830 (0.065) **
Foreign direct investment		0.282 (0.085) **
Post-estimation tests		
AR(1)	0.009	0.001
AR(2)	0.061	0.215
Sargan	0.002	0.320
Hansen	0.103	0.187
Observations	966	966
Groups	23	23
F	175.17	87.59
No. of instruments	12	13

Source: Authors' computation; Note(s): ** $P < 0.05$, * $P < 0.1$ Standard error (Std. Err.) in parentheses

The coefficient for population growth is positive and significant (0.135, p-value below 0.05), implying that population growth is associated with a higher reverse-coded fiscal sustainability score in Model 1. This finding may appear counterintuitive because rapid population growth can strain public resources. However, in some contexts, a larger or growing population may expand the tax

base and labour force, thereby supporting revenue mobilisation where infrastructure, employment and social-service systems are adequate.

Economic growth is also positively and significantly associated with fiscal sustainability in Model 1 (0.058, p-value below 0.05). This result is consistent with the view that stronger economic output can support higher tax collection and improve the capacity of governments to manage debt and maintain fiscal balance (Yusuf & Mohd, 2021). However, the fiscal benefits of growth depend on whether revenue systems are effective and whether expenditure growth remains controlled.

The coefficient for inflation is negative and statistically significant (-0.439, p-value below 0.05), suggesting that higher inflation is associated with a lower fiscal sustainability score in Model 1. This is consistent with the view that inflation can reduce the purchasing power of government revenue, raise debt-servicing costs, and weaken investor confidence, especially where debt is denominated in foreign currency (Filipović, 2024).

Health expenditure is positively and significantly associated with fiscal sustainability (0.224, p-value below 0.05). This suggests that countries with higher health expenditure as a share of GDP tend to record stronger fiscal sustainability scores in the model. Health sector investment may support productivity, economic growth and future tax capacity, although the timing and magnitude of these fiscal benefits depend on the efficiency of health spending and broader governance conditions (Ozili & Iorember, 2024).

The model is robust to post-estimation tests. The Arellano-Bond AR(1) test for first order serial correlation is significant ($p=0.009$) and is typical of dynamic panel data models where some degree of serial correlation in the error terms is present. The AR(2) test, however, is not significant ($p=0.061$), so that there is no second order serial correlation. The Sargan test ($p=0.002$) indicates overidentifying restrictions may not be valid, the Hansen test ($p=0.103$) indicates the instruments used in the model are valid. However, due to the Sargan test result, some caution is warranted, but the Hansen test offers more reliable evidence of instrument validity in dynamic panel models (Roodman, 2009).

Model 2 adds the carbon-emissions-based climate indicator and FDI to the baseline specification. The coefficient for lagged fiscal sustainability remains negative and significant (-0.601, p-value below 0.05), suggesting that previous fiscal conditions are negatively associated with the current fiscal sustainability score after including the additional variables. The larger magnitude compared with Model 1 indicates that the inclusion of emissions pressure and FDI changes the estimated dynamic relationship. This should be interpreted as evidence of conditional association rather than proof that these variables cause fiscal persistence (Yiadom, Mensah & Bokpin, 2022).

In Model 2, population growth has a negative and significant coefficient (-0.478, p-value below 0.05), implying that higher population growth is associated with a lower fiscal sustainability score. This result differs from Model 1, which may reflect the inclusion of the emissions-based climate indicator and FDI. Rapid population growth may increase public expenditure demands, particularly in countries with limited infrastructure, weak social-service systems and constrained tax capacity.

Economic growth has a negative and significant coefficient in Model 2 (-0.574, p-value below 0.05), implying that higher GDP is associated with a lower fiscal sustainability score after controlling for the additional variables. This result differs from Model 1 and may reflect the complexity of the relationship between output growth, public expenditure and fiscal management. In economies with weak tax systems, growth may be accompanied by infrastructure demands and social spending that are not fully offset by revenue gains.

The coefficient for inflation is positive and significant in Model 2 (0.064, p-value below 0.05), indicating that higher inflation is associated with a higher fiscal sustainability score in the extended specification. This may reflect a short-run debt-eroding effect where inflation reduces the real value of existing public debt (Fischer, 1993). However, this interpretation should be cautious because prolonged inflation can destabilise the economy, reduce investor confidence and weaken fiscal sustainability over time.

The carbon-emissions-based climate indicator has a positive and significant coefficient (0.830, p-value below 0.05). This means that higher emissions pressure is associated with a higher reverse-coded fiscal sustainability score in the model. This finding should not be interpreted as evidence that climate change is beneficial for public finances. A plausible interpretation is that larger or more industrialised economies may have both higher emissions and stronger revenue capacity, or that climate-related investment, carbon pricing, green bonds and international climate finance may be linked to fiscal capacity in some countries (Alamgir & Cheng, 2023). The emissions indicator does not capture direct climate vulnerability or exposure to extreme events, so the result should be interpreted within that conceptual limit.

Foreign direct investment (FDI) has a positive and significant coefficient (0.282, p-value below 0.05), indicating that FDI is associated with stronger fiscal sustainability in the model. This is consistent with literature suggesting that FDI can support economic activity, employment and tax revenue where investment is effectively regulated and integrated into the domestic economy (Joshua, Babatunde & Sarkodie, 2021). However, the fiscal contribution of FDI may be reduced where investment incentives are excessive or where profit repatriation limits domestic revenue gains.

The post-estimation tests generally support the model specification. The Arellano-Bond test for first-order serial correlation (AR(1)) is significant ($p = 0.001$), which is expected in dynamic panel models. The AR(2) test is not significant ($p = 0.215$), indicating no evidence of second-order serial correlation. The Sargan test ($p = 0.320$) and Hansen test ($p = 0.187$) suggest that the overidentifying restrictions and instruments are acceptable. Even so, the results should be interpreted as conditional associations because potential simultaneity, omitted variables and reverse causality may remain concerns in the absence of a stronger causal identification strategy (Roodman, 2009).

4.4 Further analysis

The coefficients and significance of the variables in the System GMM results differ from the fixed effects model results. Fiscal sustainability L1 has a small positive and significant coefficient in the fixed effects model, but a negative and significant coefficient in the System GMM model, suggesting that dynamic adjustment and the treatment of endogeneity matter for interpretation. Both models show a negative and significant association between population growth and fiscal sustainability in the extended specification, although the magnitude is larger in the System GMM results. In Model 1 of the fixed effects results, the economic growth coefficient is insignificant, but it becomes negative and significant in Model 2. In the System GMM estimates, economic growth is significant across both models but changes sign, suggesting that dynamic effects and endogeneity may influence the estimates. Climate-related emissions pressure and FDI are significant in both approaches, but their magnitudes are larger in the GMM model. These differences reinforce the need to interpret the estimates as conditional empirical relationships rather than definitive causal effects.

Table V: Fixed effect results

Fiscal sustainability	Fixed effect model	
	Model 1	Model 2
	Coef.	Coef.
Constant	-0.040 (0.001)**	-0.040 (0.001) **
Fiscal sustainability L1.	0.067 (0.031) **	0.066 (0.031) **
Population growth	-0.070 (0.012) **	-0.188 (0.032) **
Economic growth	-0.005 (0.012)	-0.135 (0.032) **
Inflation	0.003 (0.022)	0.008 (0.023)
Health expenditure	0.015 (0.024)	0.002 (0.026)
Carbon emissions indicator		0.184(0.038) **
Foreign direct investment		0.032 (0.005) **
R-sq:	0.0143	0.0169
Number of Obs	966	966
Number of groups	23	23
F	76.37	59.67
Prob>F/Wald chi2	0.0000	0.0000

Source: Authors' computation

Note(s): **P<0.05, *P<0.1 Standard error (Std. Err.) in parentheses

5. CONCLUSION AND RECOMMENDATION

The regression results show that several macroeconomic factors are significantly associated with fiscal sustainability in SSA. Because fiscal sustainability was reverse-coded from the debt-to-GDP proxy, positive coefficients indicate stronger fiscal sustainability, while negative coefficients indicate weaker fiscal sustainability. The negative and significant coefficient of the lagged fiscal sustainability variable suggests dynamic adjustment in fiscal conditions over time. Population growth and economic growth are negatively associated with fiscal sustainability in the extended model, possibly because of increased demand for public services and infrastructure spending in countries with limited fiscal capacity. Inflation is positively associated with fiscal sustainability in Model 2, although this may reflect a short-run debt-eroding mechanism rather than a durable fiscal benefit. FDI and the carbon-emissions-based climate indicator are positively associated with fiscal sustainability, but these findings should not be read as proof of direct causal effects.

Policymakers should therefore interpret the findings with caution and focus on strengthening the conditions under which climate-related investment and FDI can support fiscal resilience. Governments should improve debt management, expand domestic revenue mobilisation, and design climate policies that balance environmental goals with fiscal sustainability. Policies that encourage green investment, such as renewable-energy incentives, carefully designed carbon pricing, green bonds and international climate-finance partnerships, may support both mitigation and fiscal planning. Reforms that improve the ease of doing business, political stability, tax administration and investment governance can also increase the fiscal benefits of FDI. The main

limitation of this study is the measurement of fiscal sustainability using a reverse-coded debt-to-GDP proxy and the measurement of climate change using a carbon-emissions-based indicator. Future studies should consider alternative fiscal sustainability measures and climate indicators such as climate vulnerability indices, extreme-event frequency, adaptation capacity or sectoral exposure. Future research may also include macroeconomic variables such as the balance of payments, money supply and unemployment, and may examine institutional quality as a moderating variable.

REFERENCES

- 1) African Development Bank (2023). Accelerating Climate Action for Sustainable Development
- 2) Ajayi, S. I. (2006). Foreign Direct Investment and Economic Development in Africa. African Economic Research Consortium.
- 3) Alamgir, M., & Cheng, M. C. (2023). Do green bonds play a role in achieving sustainability?. *Sustainability*, 15(13), 10177.
- 4) Alfaro, L., & Chauvin, J. (2020). Foreign direct investment, finance, and economic development. *Faculty & Research*, 1, 231-258.
- 5) Ali, A., Khokhar, B., & Sulehri, F. A. (2023). Financial Dimensions of Inflationary Pressure in Developing Countries: An In-depth Analysis of Policy Mix. *Journal of Asian Development Studies*, 12(3), 1313-1327.
- 6) Barrell, R., & Holland, D. (2009). Debts, deficits and borrowing costs. *National Institute Economic Review*, 208(1), 39-43.
- 7) Battiston, S., & Monasterolo, I. (2020). The climate spread of corporate and sovereign bonds. Available at SSRN 3376218.
- 8) Beirne, J., Renzhi, N., & Volz, U. (2021). Bracing for the typhoon: Climate change and sovereign risk in Southeast Asia. *Sustainable Development*, 29(3), 537-551.
- 9) BlackRock Investment Institute (2021). Preparing Portfolios for Climate Risk. BlackRock.
- 10) Boden, T. A., Marland, G., & Andres, R. J. (2009). Global, regional, and national fossil-fuel co2 emissions, 1751-2006 (published 2009). Environmental System Science Data Infrastructure for a Virtual Ecosystem (ESS-DIVE)(United States); Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory (ORNL), Oak Ridge, TN (United States).
- 11) Buhr, B., Volz, U., Donovan, C., Kling, G., Lo, Y. C., Murinde, V., & Pullin, N. (2018). Climate change and the cost of capital in developing countries.
- 12) Cevik, S., & Jalles, J. T. (2020). This Changes Everything: Climate Shocks and Sovereign Bonds. *IMF Working Papers*, 2020(79).
- 13) Cevik, S., & Jalles, J. T. (2022). An apocalypse foretold: Climate shocks and sovereign defaults. *Open Economies Review*, 33(1), 89-108.
- 14) Comelli, F., Kovacs, P., Montoya Villavicencio, J. J., Sode, A., David, A., & Eyraud, L. (2023). Navigating fiscal challenges in Sub-Saharan Africa: Resilient strategies and credible anchors in turbulent waters. *International Monetary Fund*.
- 15) Dell.M, B.F. Jones, B.A. Olken (2014) What Do We Learn From The Weather? The New Climate-Economy Literature *Journal of Economic. Literature.*, 52 740-798
- 16) Dietz, S., Bowen, A., Dixon, C., & Gradwell, P. (2016). 'Climate Value at Risk' of Global Financial Assets. *Nature Climate Change*, 6(7), 676-679.
- 17) Dimnwobi, S. K., Ekesiobi, C., Madichie, C. V., & Asongu, S. A. (2021). Population dynamics and environmental quality in Africa. *Science of the Total Environment*, 797, 149172.

- 18) Filipović, M. (2024). Impact of inflation on citizens borrowing (Doctoral dissertation, University of Zagreb. Faculty of Economics and Business).
- 19) Global Development Policy Center. (2022). Climate change risks and consequences on growth and debt sustainability in Africa. Boston University.
- 20) Gu, D., Andreev, K., & Dupre, M. E. (2021). Major trends in population growth around the world. *China CDC weekly*, 3(28), 604
- 21) House of Commons. (2021). Climate change and the cost of debt: Committee report. UK Parliament. <https://www.parliament.uk>
- 22) Institute of International Finance. (2021). Global debt monitor: Charting a new course for debt sustainability. IIF. <https://www.iif.com>
- 23) International Monetary Fund. (2023). Fiscal Monitor: Navigating the global economy and fiscal policy challenges. IMF. <https://www.imf.org>
- 24) Jean-Paul Huillier & DeLuca Martin. (2023). The long-run costs of higher inflation. Federal Reserve Bank of Cleveland. <https://www.clevelandfed.org/en/publications/economic-commentary/2023-ec-17.aspx>
- 25) Joshua, U., Babatunde, D., & Sarkodie, S. A. (2021). Sustaining economic growth in Sub-Saharan Africa: Do FDI inflows and external debt count?. *Journal of Risk and Financial Management*, 14(4), 146.
- 26) Kahn, M. E., Mohaddes, K., Ng, R. N., Pesaran, M. H., Raissi, M., & Yang, J. C. (2021). Long-term macroeconomic effects of climate change: A cross-country analysis. *Energy Economics*, 104, 105624.
- 27) Kaur, M., Yadav, S. S., & Gautam, V. (2012). Foreign direct investment and current account deficit-a causality analysis in context of India. *Journal of International Business and Economy*, 13(2), 85-106.
- 28) Kling, G., Lo, Y. C., Murinde, V., & Volz, U. (2018). Climate vulnerability and the cost of debt.
- 29) Kling, G., Volz, U., Murinde, V., & Ayas, S. (2021). The Impact of Climate Vulnerability on Firms' Cost of Capital and Access to Finance. *World Development*, 137, 105131.
- 30) Klusak, P., Agarwala, M., Burke, M., Kraemer, M., & Mohaddes, K. (2023). Rising temperatures, falling ratings: The effect of climate change on sovereign creditworthiness. *Management Science*, 69(12), 7468-7491.
- 31) Krogstrup, S., & Oman, W. (2019). Macroeconomic and Financial Policies for Climate Change Mitigation: A Review of the Literature. IMF Working Papers, 2019(185).
- 32) Li, F., Chang, T., Wang, M. C., & Zhou, J. (2022). The relationship between health expenditure, CO 2 emissions, and economic growth in the BRICS countries—based on the Fourier ARDL model. *Environmental Science and Pollution Research*, 1-20.
- 33) Mankiw, N. G., & Taylor, M. P. (2020). *Economics*. Cengage Learning EMEA.
- 34) Nandelenga, M. W. (2021). Fiscal Rules, Fiscal Space and Debt Sustainability for Macroeconomic Stability in Sub-Saharan Africa.
- 35) Ndikumana, L., & Boyce, J. K. (2011). *Africa's odious debts: How foreign loans and capital flight bled a continent*. Bloomsbury Publishing.
- 36) Ndikumana, L., & Boyce, J. K. (Eds.). (2022). *On the trail of capital flight from Africa: The takers and the enablers*. Oxford University Press.
- 37) Newell .G.R, B.C. Prest, E.S. Sexton (2021) The GDP Temperature Relationship: Implications for Climate Change Damages. *Journal of Environmental Economics Management*, 108, 1-26
- 38) Office for Budget Responsibility. (2021). Fiscal risks report 2021: Climate change and fiscal sustainability. OBR. <https://obr.uk>

- 39) Okolo, C. (2017). Remittances And Fiscal Sustainability In Nigeria: Is There Any Link?. *Journal of Economics and Sustainable Development*, 8(13).
- 40) Ozili, P. K., & Iorember, P. T. (2024). Financial stability and sustainable development. *International Journal of Finance & Economics*, 29(3), 2620-2646.
- 41) Pattayat, S. S. (2016). Examining the determinants of FDI inflows in India. *Theoretical & Applied Economics*, 23(2).
- 42) Piketty, T. (2014). *Capital in the twenty-first century*. Harvard University Press.
- 43) Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal*, 9(1), 86-136.
- 44) Stern, N. (2007). *The economics of climate change: The Stern review*. Cambridge University Press.
- 45) Stiglitz, J., Stern, N., Duan, M., Edenhofer, O., Giraud, G., Heal, G., et al. (2017). *Report of the High-Level Commission on Carbon Prices*. World Bank.
- 46) Tol, R. S. J. (2018). The Economic Impacts of Climate Change. *Review of Environmental Economics and Policy*, 12(1), 4-25.
- 47) UNCTAD. (2023). *World Investment Report 2023: Investing in sustainable energy for all*. United Nations. Retrieved from <https://investmentpolicy.unctad.org>
- 48) United Nations Department of Economic and Social Affairs. (2023). *Financing for Sustainable Development Report 2023*. Retrieved from <https://desapublications.un.org>
- 49) United Nations Department of Economic and Social Affairs. (2023). *Financing for sustainable development report 2023: FDI and fiscal sustainability in developing nations*. UNDESA. <https://www.un.org>
- 50) Weitzman, M. L. (2011). Fat-Tailed Uncertainty in the Economics of Catastrophic Climate Change. *Review of Environmental Economics and Policy*, 5(2), 275-292.
- 51) World Bank. (2018). *World Development Indicators*. Retrieved from <https://data.worldbank.org/indicator/SH.XPD.TOTL.ZS>
- 52) World Bank. (2020). *Public spending on health: A global perspective*. Retrieved from <https://www.worldbank.org/en/topic/health/publication/public-spending-on-health-a-global-perspective>
- 53) World Bank. (2022). *Health expenditure per capita (current US\$)*. Retrieved from <https://data.worldbank.org/indicator/SH.XPD.PCAP>
- 54) Yiadom, E. B., Mensah, L., & Bokpin, G. A. (2022). Environmental risk and foreign direct investment: the role of financial sector development. *Environmental Challenges*, 9, 100611.
- 55) Yusuf, A., & Mohd, S. (2021). The impact of government debt on economic growth in Nigeria. *Cogent Economics & Finance*, 9(1), 1946249.
- 56) Zenios, S. A., Consiglio, A., Athanasopoulou, M., Moshhammer, E., Gavilan, A., & Erce, A. (2021). Risk management for sustainable sovereign debt financing. *Operations Research*, 69(3), 755-773.