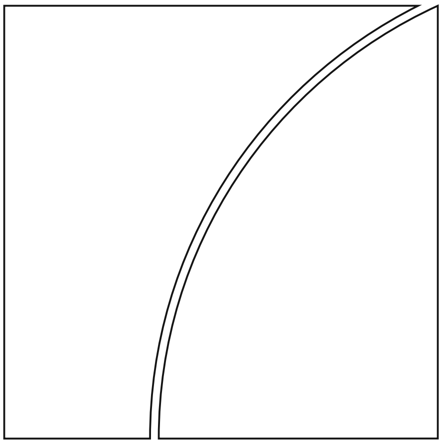

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# Climate change and central banking: macroeconomic challenges and evidence from Africa

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Keywords: central banking; physical risk; transition risk; climate-related shocks; BIS-climate modelling; African economies.

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# Climate change and central banking: macroeconomic challenges and evidence from Africa

Torsten Ehlers, Leonardo Gambacorta and Livia Pancotto*

## Abstract

Climate change is an important source of macroeconomic risk with direct implications for monetary policy and financial stability. Physical risks, including more frequent and severe weather events, disrupt production and damage infrastructure, generating supply and demand side pressures that affect output and inflation. Transition risks arising from climate policy, technological and market shifts can tighten financial conditions and alter relative prices, creating short-term adjustment costs, while influencing long-term growth prospects. These dynamics are particularly relevant in African economies, where climate shocks propagate rapidly through food and energy channels, reflecting greater sectoral exposure and more limited fiscal and insurance buffers. Drawing on simulations from the BIS-Multisector (BIS-MS) model and global evidence on weather disasters, this paper shows that climate-related shocks generate heterogeneous macroeconomic effects within policy-relevant horizons. Economies more exposed to energy-intensive and agricultural sectors – including several African countries – experience stronger inflationary pressures, deeper output contractions and larger policy rate adjustments. These findings highlight the importance of strengthening data and modelling frameworks to better account for climate-related risks in monetary policy and financial stability analysis.

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Keywords: central banking; physical risk; transition risk; climate-related shocks; BIS-climate modelling; African economies.

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# 1. Introduction

Climate change has become a structural challenge for the global economy, with visible macroeconomic implications. It directly affects central banks' core mandates through its impact on growth, inflation dynamics and financial conditions. Rising temperatures, more frequent extreme weather events, and uncertainty associated with the global transition towards a low-carbon economy generate risks that interact with traditional monetary and financial policy channels in complex and often non-linear ways.

The materialisation of physical risks – stemming from acute extreme weather events such as floods, storms and heatwaves, as well as from chronic shifts – can impair production capacity, damage infrastructure, disrupt supply chains and reduce labour productivity. Depending on the nature of the event, demand may also be affected. As a result, economic activity slows, while prices may rise in particular where demand is inelastic or supported by aid relief. For central banks, this complicates the assessment of climate-related shocks and may give rise to policy trade-offs between stabilising inflation and supporting economic recovery. Transition risks, arising from climate-related policy changes, technological advances and evolving market preferences, can also influence macroeconomic outcomes. Credible and orderly mitigation policies may stimulate investment, innovation and long-term productivity; delayed or abrupt adjustments, by contrast, can increase volatility, generate stranded assets and trigger shifts in financial valuations.

These risks are particularly relevant in Africa (IPCC (2022)). Many African economies are highly exposed to physical climate shocks due to their climatic conditions, reliance on climate-sensitive sectors such as agriculture and energy, and limited fiscal and insurance buffers. At the same time, the continent faces substantial challenges and opportunities associated with the net zero transition, including large investment needs in renewable energy, resilient infrastructure and new technologies. Transition policies and renewable energy investments in advanced economies also affect demand for critical minerals and fossil fuels, which are key exports for several African countries.

Understanding how climate-related risks propagate through the economy requires data and modelling approaches that incorporate sectoral interdependencies and the transmission of shocks through production networks. While standard macroeconomic frameworks provide useful benchmarks, they are not designed to capture these mechanisms in detail. Against this background, this paper combines simulations from the BIS-Multisector (BIS-MS) model with empirical evidence on the macroeconomic impact of weather disasters to examine how physical and transition-related shocks affect inflation, output and policy responses across economies, with a particular focus on Africa. These analytical advances are complemented by digital innovations that support more timely and transparent climate risk monitoring.

For central banks, integrating climate considerations into monetary policy, financial stability assessments and operational frameworks is not about expanding their mandates, but about safeguarding their effective fulfilment in a changing risk environment.[1] Climate-related shocks can influence inflation, output and financial conditions within policy-relevant horizons and therefore need to be taken into account in projections, risk assessments and supervisory practices. The relevance of these risks for macroeconomic outcomes and financial stability is reflected in the international policy agenda, including the work programmes of the Basel Committee on Banking Supervision (BCBS), the Financial Stability Board (FSB) and the Network for Greening the Financial System (NGFS).[2]

The remainder of the paper is organised as follows. Section 2 discusses why climate change matters for central banks, with a focus on the African continent, and outlines the main channels through which physical and transition risks affect financial stability, monetary policy and central bank operations. Section 3 examines the role of data and modelling, highlighting the need for improved analytical frameworks and drawing on recent BIS contributions. Section 4 describes how innovation and technology can strengthen climate risk monitoring and support central banks' analytical capacity. Section 5 concludes by summarising the key findings and policy implications.

## 2. Why climate change matters for central banks

Physical and transition risks give rise to shocks within policy-relevant horizons that interact with monetary policy, financial stability and central bank operations (Batten et al (2020); Talbot (2025)). As these risks intensify, understanding how climate-related shocks transmit through the economy and the financial system becomes important for assessing their implications for prices and financial stability (NGFS (2024b)).[3]

A growing empirical literature documents that climate-related shocks have persistent macroeconomic consequences. Temperature extremes reduce labour productivity and depress output (Dell et al (2012); Burke et al (2015); Colacito et al (2019); Szewczyk et al (2025)), while climate-related disasters can generate long-lasting reductions in gross domestic product (GDP) through capital destruction, lower total factor productivity (TFP) and disruptions to production networks (Hsiang and Jina (2014)). Recent work further suggests that extreme events account for a major share of the overall macroeconomic impacts of climate change and can lead to multi-decade losses in consumption and welfare, especially in more vulnerable economies (Bakkensen and Barrage (2026); Howard and Sterner (2025)). Evidence on transition risks points to similarly significant macroeconomic effects, including inflationary pressures arising from climate policy actions (Bettarelli et al (2025); Känzig (2025)).

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[1] While this paper focuses on the implications of climate change for central banks' core mandates, climate-related risks also have broader macroeconomic consequences, affecting public finances, labour markets and external balances, as discussed in Mitra et al (2025).

[2] The NGFS was established in 2017 as an initiative of eight central banks and, as of 2026, comprises 148 central banks and supervisory authorities worldwide, making it one of the largest international collaborative platforms on climate-related financial risks.

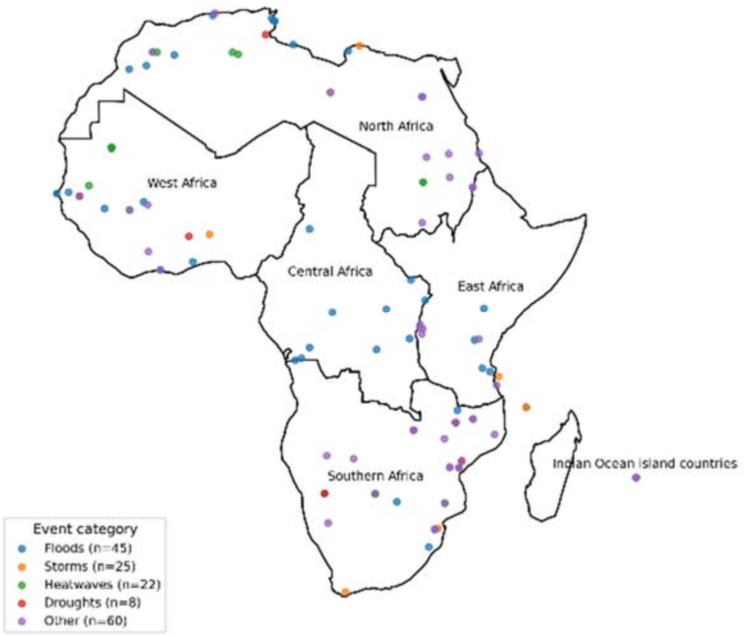
[3] An increasing number of central banks are taking, or considering, actions related to climate change, ranging from enhanced risk assessment and disclosure to adjustments in operational frameworks and policy implementation. The scope of these actions varies across jurisdictions and over time, reflecting differences in mandates, legal constraints, available instruments and the degree of public and political consensus.

## 2.1 Africa's macroeconomic exposure to climate-related risks

Africa faces a notable macroeconomic exposure to climate change despite contributing only a small share of global greenhouse gas emissions. The continent accounts for around 3% of cumulative global $CO_2$ emissions and less than 4% of global annual emissions (IEA (2022, 2023); IPCC (2022)). Yet data show it is warming faster than the global average and experiencing more frequent extreme weather events, including droughts, floods and heatwaves (Graph 1). These developments have already generated substantial macroeconomic costs, with recurrent climate shocks leading to sizeable output losses (up to 2–5% of GDP in some countries), alongside significant fiscal pressures linked to disaster response and recovery (WMO (2024, 2025a)). The impact in Africa is particularly macro-relevant given the high exposure of several economies to climate-sensitive sectors such as agriculture, food production and hydropower.

Extreme climate-related events in Africa (2024)

Graph 1



Eighteen hazard events are aggregated into five groups: floods; storms (including tropical and extra-tropical cyclones, thunderstorms, snowstorms and dust storms); heatwaves; droughts; and a residual category ("other") including less frequent hazards such as cold waves, wildfires and other weather-related events.

Sources: WMO Extreme Events Dashboard 2024; authors' elaboration.

Climate shocks, therefore, tend to translate more directly into persistent macroeconomic and financial pressures across the continent. Limited adaptive capacity and resource constraints slow recovery and intensify pressures on public finances (Fonjong et al (2024)). Recurrent disruptions to food production and energy supply contribute to inflation volatility, while constrained fiscal space limits the scope for countercyclical responses. Together, these structural features increase the likelihood that physical risks translate into lasting macroeconomic instability, with direct implications for monetary and financial stability.

In addition to physical risks, African economies are exposed to transition-related shocks arising from global climate policies and shifts in energy and commodity markets. Large investment needs for the green transition, especially in the energy sector, interact with underdeveloped domestic capital markets and limited access to long-term financing, increasing reliance on external funding and heightening vulnerability to global financial conditions (OECD (2025)). These features can amplify the macroeconomic and financial spillovers of transition dynamics, even in the absence of aggressive domestic mitigation policies.

## 2.2 Channels of transmission

The macroeconomic effects of climate-related shocks materialise through several transmission channels that are directly relevant to central banks' activities. These channels shape how physical and transition risks propagate through the economy and the financial system, with implications for financial stability and the conduct of monetary policy (Table 1).

Impact of climate-related risks on central banks' activities

Table 1

| **Dimension** | **Channel of transmission** | **Key implications** |
|---|---|---|
| Financial stability | Banks' balance sheets and asset valuations | Integrate climate factors into supervision and stress testing |
| Monetary policy | Prices and output | Account for climate shocks in projections and policy models |
| Central bank operations | Collateral, credit operations and asset purchases | Adjust operational frameworks to reflect these risks |

Sources: Authors' elaboration.

### Financial stability

Climate-related shocks can weaken the financial conditions of households, firms and sovereigns, thereby increasing credit risks and affecting the stability of financial institutions. By amplifying macroeconomic volatility, these shocks can further undermine financial stability.[4] The effects of physical shocks, such as extreme weather events, tend to be larger and more persistent in economies with low resilience and limited insurance coverage – a configuration typical across many African financial systems – contributing to weaker repayment capacity and higher credit risk (Noy (2009); Raddatz (2009); Acevedo et al (2020)). Higher credit risk can translate into tighter borrowing conditions and reduced access to credit, particularly for smaller firms (Brown et al (2021)). Uninsured catastrophe losses are associated with more pronounced macro-financial effects, as domestic balance sheets must absorb a larger share of the shock (von Peter et al (2024)). Moreover, climate change can also generate non-linear and correlated shocks that standard risk assessment frameworks may not fully capture, underscoring the need for more advanced approaches to reflect its complexity (Campiglio et al (2018)).

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[4] To evaluate the impact of climate change on financial institutions and overall financial stability, several central banks have enhanced their analytical frameworks by including climate scenario exercises and supervisory stress tests, often in coordination with prudential authorities (UNEP FI (2024)). Where supervisory mandates apply, climate considerations are being integrated into governance expectations, risk management and disclosure frameworks, in line with existing prudential toolkits.

Transition risks may also impact financial stability when shifts in policy, technology or market expectations alter the profitability and valuations of carbon-intensive sectors. These adjustments can change risk premia and the cost of capital for emission-intensive firms, give rise to stranded assets and trigger abrupt valuation losses (Ehlers et al (2022); Dong et al (2025)). Such developments have implications for the value of banks' credit and investment exposures and can propagate through financial networks when exposures to climate policy-relevant sectors are concentrated, possibly leading to system-wide stress (Battiston et al (2017)).

## Monetary policy

From a monetary policy perspective, climate change introduces supply and demand side shocks that alter inflation dynamics and complicate the calibration of interest rate policy. The optimal monetary policy response depends on several factors that are generally difficult to assess in real time, such as: (i) the type, severity and persistence of a given shock; (ii) the concentration and level of economic activity at the location where it occurs; and (iii) the economy's vulnerability, including insurance coverage and fiscal capacity. The most immediate impact of acute physical risk shocks tends to materialise in the form of supply shocks (eg destroyed capital, reduced labour or a loss in productivity), but demand effects may be equally important, reflecting income losses, displacement of people, reconstruction needs or limited insurance and fiscal space to offset negative impacts (NGFS (2024b)). Transition policies can also affect inflation dynamics by shifting relative prices and production costs, thereby generating temporary upward pressure on inflation as firms and households adjust (McKibbin et al (2020)).

These channels complicate inflation forecasting, affect the formation of expectations and increase headline inflation volatility, especially in low-income and commodity-dependent economies – including many in Africa – where food and energy carry greater weight in the consumption basket (NGFS (2024d)). Evidence from past disaster episodes shows that such shocks have prompted heterogeneous monetary policy responses across countries, underscoring the practical relevance of these inflation/output trade-offs for central banks (Cantelmo et al (2024)). As climate-related shocks become more severe, frequent or persistent, accounting for their effects becomes increasingly important for monetary policy calibration (Talbot (2025)).[5]

## Central bank operations

Climate risks also have implications for central bank operations, including credit operations, collateral frameworks and the management of central bank portfolios. Physical risks can disrupt payment systems, cash distribution and market functioning, while more severe events may compromise operational continuity (NGFS (2024b)). Transition risks can affect the valuations of assets held on central bank balance sheets or accepted as collateral, particularly where exposures are concentrated in carbon-intensive sectors or jurisdictions.

In response, central banks are assessing how to integrate climate considerations into established risk management practices. This involves reviewing collateral eligibility and haircuts under different climate scenarios (ECB (2025)), integrating

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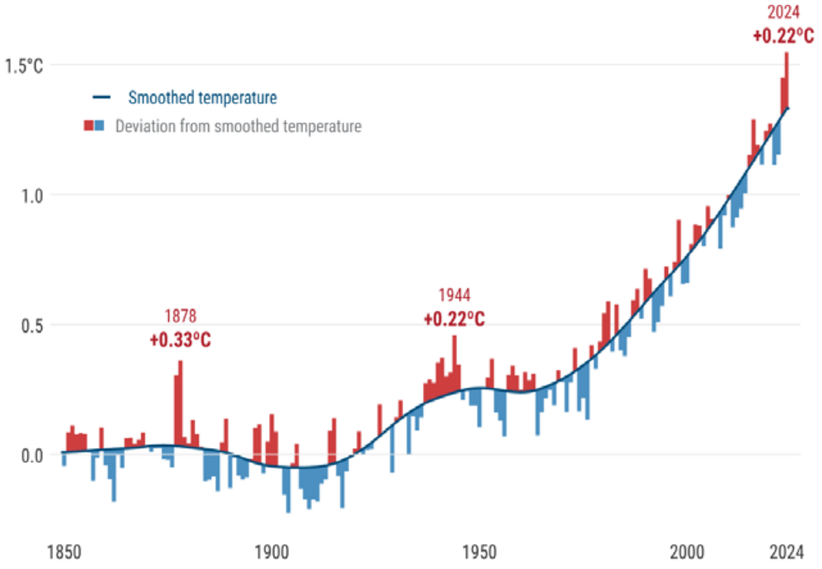
[5] Drawing on Villeroy de Galhau (2024)'s framework, Talbot (2025) argues that climate shocks tend to be more persistent, salient and uncertain, increasing the likelihood of inflation/output trade-offs that are difficult for monetary policy to "look through".

climate-related metrics into the management of own portfolios and asset purchase programmes and strengthening the resilience to physical hazards (Lagarde (2021); Schoenmaker (2021); Siegert and Talbot (2025)). Beyond these adjustments, central banks' efforts are also focused on strengthening climate-related taxonomies and improving the quality of climate-related statistics. Central bank communication on climate change represents an additional channel through which central banks may shape expectations and influence market perceptions of climate-related risks (Campiglio et al (2025)).

## 2.3 Physical and transition risks: macroeconomic impact and effects on inflation

Physical risks are gaining macroeconomic importance as global temperatures and climate extremes intensify and deviate from historical norms. Scientific evidence shows a marked acceleration in warming, with 2024 being the first calendar year to exceed 1.5°C above pre-industrial levels and the warmest year in the last 175 years (Graph 2).[6] Although temporary, this breach signals that temperature thresholds linked to more frequent and severe physical extremes may soon be crossed on a sustained basis.[7] There have also been unprecedented levels of atmospheric moisture, heightening the likelihood of extreme rainfall, flooding and tropical storm intensification. Economic losses from natural disasters amounted to approximately $320 billion in 2024 – about 0.3% of global GDP – with only 43% of losses insured (Swiss Re Institute (2025)).

Physical risks are on the rise globally Graph 2



Relative to the 1850–1900 average.

Source: Copernicus (2025).

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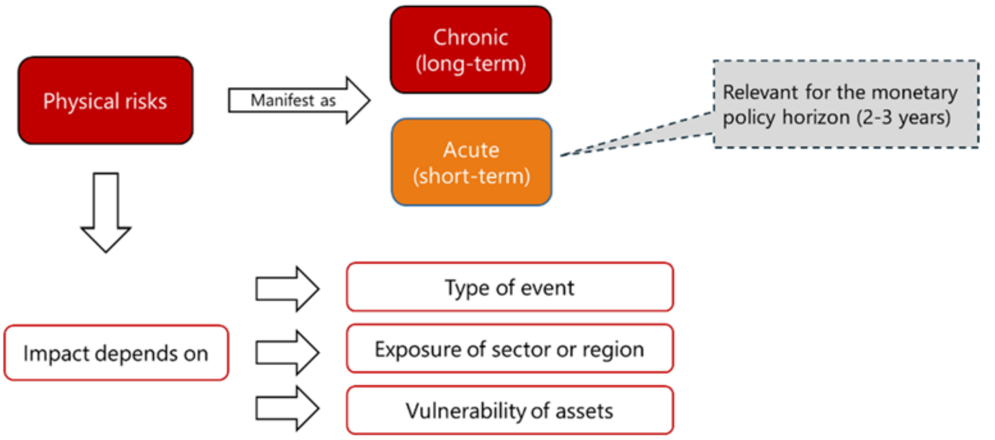
[6] Graph A1 in the appendix reports long-term temperature anomalies in Africa over the period 1990–2024, showing a sustained rise in near-surface air temperatures that has intensified in recent decades.

[7] The World Meteorological Organization estimates a 70% probability that the five-year average global temperature will exceed 1.5°C by 2029, up from 47% in the 2024–28 outlook (WMO (2025b)).

Physical risks manifest as either acute events or chronic climatic changes, each with distinct macroeconomic implications (Graph 3). Acute events – such as floods, storms, wildfires and heatwaves – disrupt production, transport and energy systems, causing immediate output losses and contributing to inflationary pressures. Chronic climate shifts, such as rising temperatures, changing precipitation patterns and increasing water scarcity, affect agricultural yields, labour productivity, power generation and the long-run composition of output. The macroeconomic impact varies across countries, reflecting differences in exposure, economic structure and the availability of insurance and fiscal buffers (NGFS (2024a)), with effects typically larger and more persistent in emerging market and developing economies (Nguyen et al (2025)). Impacts also depend on the type of event and interactions among hazards, as compounded events can amplify losses and complicate impact assessment. Financial channels may further magnify these effects when balance sheets weaken or credit conditions tighten, while trade and financial network linkages can transmit shocks across regions.

Physical risks: long-term changes and acute events Graph 3



Empirical evidence confirms the material macroeconomic consequences of physical risks. Natural disasters trigger severe short-term output losses, with persistence arising mainly when events coincide with institutional fragility or political instability (Cavallo et al (2013)). Global evidence further shows that weather disasters can generate substantial and, in some cases, long-lived GDP losses (also depending on the nature of the event and the country-specific characteristics), while their inflationary effects, typically concentrated in food prices, are mitigated by fiscal capacity and insurance mechanisms (Ehlers et al (2025)).

Disasters can also impact inflation. In general, these effects tend to be stronger and more persistent for food and housing-related prices (Parker (2018); Ehlers et al (2025)). Harvest disruptions lead to sizeable and long-lasting increases in global food prices and weaken real activity (De Winne and Peersman (2023); Peersman (2022)). Temperature shocks reduce output and employment while modestly increasing inflationary pressures, with effects that are stronger during periods of extreme heat (Ciccarelli et al (2024)).[8] Droughts are particularly inflationary in low-income, food-dependent economies, reflecting fragile supply conditions and limited

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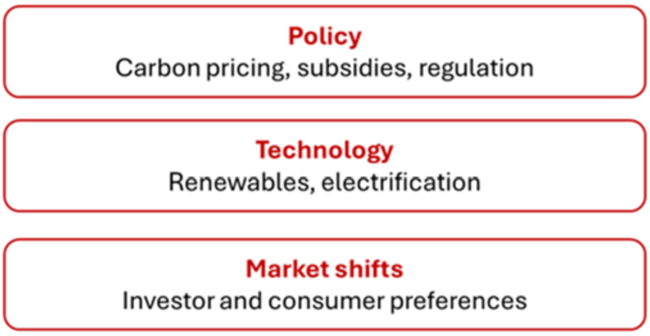
[8] Baleyte et al (2024) analyse a century-long monthly data set for European economies and show that hot temperature anomalies act as supply shocks, lowering industrial production and raising inflation, with the frequency of large anomalies increasing over time.

buffering capacity (Kabundi et al (2022)). Beyond acute events, chronic climatic stresses, most notably water scarcity, can constrain agricultural and industrial output and increase price volatility, with effects that are typically more persistent in economies with high water dependence and limited adaptive capacity (Frost et al (2025)).[9]

Transition risks give rise to macroeconomically relevant shocks as the shift to a low-carbon economy alters carbon pricing, regulation, technology and investment patterns (Graph 4). In the short term, these adjustments typically act as negative supply shocks, raising production costs, especially in energy-intensive sectors, and generating temporary inflationary pressures as relative prices shift and resources reallocate across the economy (Schnabel (2022)).[10] Empirical evidence confirms that carbon pricing measures can depress output and raise inflation in the near term, with effects shaped by policy design and household-firm responsiveness (Andersson (2019); Metcalf and Stock (2023)). Market-based transition shocks, such as increases in expected future carbon costs, also tighten financial conditions, reduce activity and modestly increase inflation (Känzig (2025)).

Key drivers of transition risk

Graph 4



Over longer horizons, the macroeconomic effects of transition dynamics depend critically on timing and credibility. Well calibrated and predictable transition pathways can support investment, innovation and productivity growth, whereas delayed or abrupt transitions tend to heighten volatility and financial stability risks (Mangiante (2024); Bilal and Känzig (2025)). Inaction or insufficient progress in the transition ultimately increases macroeconomic losses by exacerbating physical damage and uncertainty about future policy paths (Table 2).[11]

[9] In Africa, observed and projected increases in hydrological variability and water scarcity have generated cascading impacts across agriculture, hydropower, industry and urban water supply, with persistent effects on output, prices and welfare, particularly in water-dependent economies with limited adaptive capacity (IPCC (2022)).

[10] In discussing the inflationary implications of the green transition, Schnabel (2022) distinguishes between three forms of inflation linked to climate policy: "greenflation", arising from the temporary increase in input costs during the transition; "fossilflation", reflecting the volatility and rising scarcity of fossil fuels as economies shift away from them; and "climateflation", resulting from the impact of more frequent and severe physical events on production costs and relative prices.

[11] For analyses of how policy credibility, inflation expectations and monetary-fiscal coordination influence transition dynamics, see Ferrari Minesso and Pagliari (2023) and Ferrari Minesso and Nispi Landi (2024).

## Macroeconomic impact of climate-related risks

Table 2

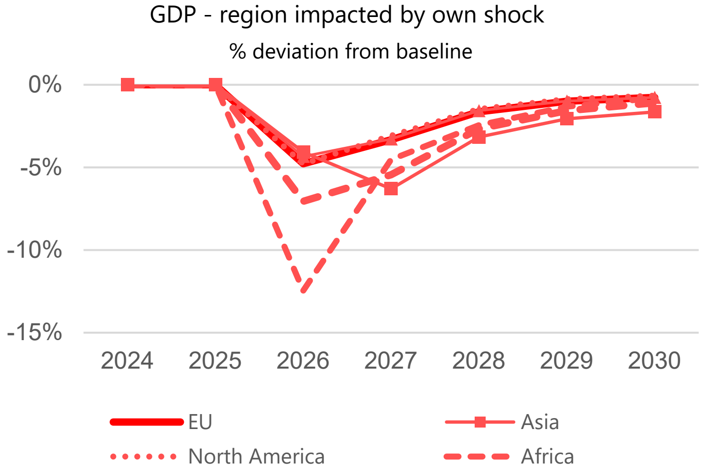
| Type | GDP (short-term) | GDP (medium- to long-term) | Inflation | Key considerations |
|---|---|---|---|---|
| Physical risks | ↓ due to disasters, infrastructure damage | ↓ if adaptation is weak | ↑ short-term; effect usually temporary | Heterogeneous effects; key roles of adaptation, fiscal capacity and insurance coverage |
| Transition risks | ↓ from higher production costs, stranded assets | ↑ under orderly transition (investment, productivity) | ↑ short-term<br>↓ long-term | Orderly and credible transition limits uncertainty; delays amplify instability |

Sources: Authors' elaboration.

Beyond historical evidence, forward-looking scenario analysis highlights how both physical and transition risks can give rise to significant macroeconomic effects across regions (Graph 5). For instance, a sequence of severe weather events can lead to large short-term GDP losses, with output declines reaching double digits in more vulnerable regions such as Africa (estimated to peak at around 12.5%).

## Climate-related risks affect regions differently

Graph 5



"Disaster and policy stagnation" is the reference scenario. It features successive region-specific extreme weather events in 2026–27 that trigger capital losses, productivity declines and global spillovers via trade and financial channels.

Source: NGFS (2025).

This reflects higher exposure to physical risks and limited shock-absorption capacity, with repercussions transmitted globally through trade and financial linkages. Transition outcomes also vary markedly: countries starting from less ambitious mitigation policies face steeper growth costs and higher investment requirements, particularly under abrupt or poorly coordinated pathways, whereas orderly transitions tend to produce more balanced adjustments (Graph 6).[12] In Africa, where fiscal space

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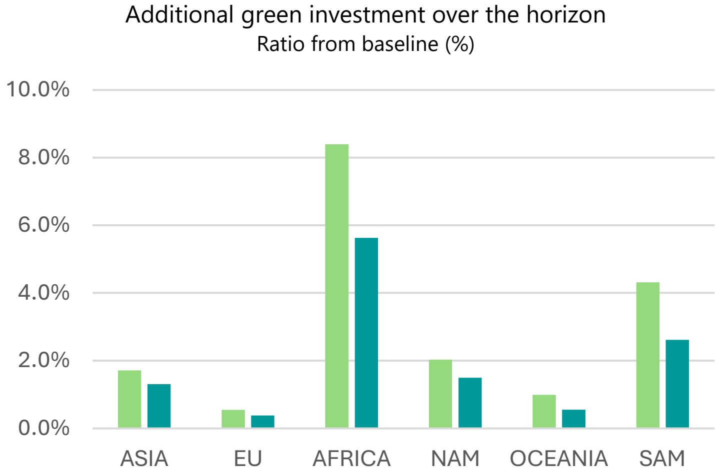
[12] See Graph A2 in the appendix for a representation of regional GDP impacts under alternative transition scenarios, as per the 2025 NGFS Short-term Climate Scenarios.

is constrained, the effectiveness of the required investment response depends critically on access to affordable international financing and risk-mitigation mechanisms (NGFS (2025)).[13]

Regional differences in green transition paths: green investment over the horizon

Graph 6



The "Highway to Paris" scenario assumes an orderly transition, while the "Sudden Wake-Up Call" reflects a delayed and abrupt transition. EU: European Union; NAM: North America; SAM: South America.

Source: NGFS (2025).

## 3. The importance of data and models

Quantifying climate-economic linkages remains challenging. Climate shocks are characterised by deep uncertainty, non-linear dynamics and interactions across physical, transition and financial systems. Their modelling requires input from multiple disciplines and the ability to account for persistent, state-dependent disturbances rather than one-off shocks.[14] Empirical work shows, for instance, that acute and chronic physical risks can propagate through production networks and regional spillovers in ways that standard macroeconomic frameworks struggle to capture (Botzen et al (2019)).

Traditional macroeconomic models were not designed to handle large supply side shocks, sectoral bottlenecks or structural transitions. Representative agent dynamic stochastic general equilibrium (DSGE) and semi-structural models typically assume small shocks, smooth adjustment and stable production technologies, leading them to underestimate non-linear responses to correlated sectoral shocks and to inadequately capture the spatial and distributive dimensions of climate impacts. Recent assessments, therefore, emphasise the need for modelling

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[13] For a discussion of how policy credibility, investor expectations and financing conditions shape the macro-financial effects of different transition pathways, see Monasterolo et al (2025).

[14] For a comprehensive overview of data sources, models and scenarios used in country-level climate-macroeconomic analysis, see Mitra et al (2025).

frameworks that better incorporate uncertainty, long-horizon dynamics and interactions between the climate and economic systems (NGFS (2024c)).

Progress in macro climate modelling increasingly relies on hybrid approaches that integrate physical climate modules with macroeconomic structures, commonly known as integrated assessment models (IAMs). In general equilibrium IAM models – either computable general equilibrium (CGE) or DSGE models – this integration is usually achieved through damage functions that map physical climate impacts into economic variables, such as productivity or GDP growth. Macroeconomic outcomes are therefore highly sensitive to damage function specifications (Weitzman (2012)). For instance, explicitly accounting for extreme weather events can substantially increase estimated economic damages (Howard and Sterner (2025)), while models focusing solely on temperature changes may underestimate risks relative to those incorporating additional stressors such as droughts, floods or extreme winds. Although many IAM models remain relatively simple and small-scale, recent methodological advances, including machine learning-based global solvers, enable more accurate representations of climate dynamics, tipping points and spatial heterogeneity (Fernández-Villaverde et al (2025)).

A complementary class of IAMs, often referred to as "cost-effectiveness models", comprises large-scale frameworks that combine multiple modules to identify cost-effective solutions for key economic variables (eg energy investment, carbon tax) required to achieve exogenously specified policy objectives (eg net zero carbon emissions by a given date). These models typically span many sectors and regions and rely on a large number of assumptions, giving rise to complex interdependencies across sectors and regions. Solving them is computationally demanding due to their high dimensionality, strong non-linearities and multiple sources of uncertainty.

Finally, improving the availability and granularity of climate-related data is important for strengthening modelling frameworks. Because many non-linear climate effects originate at highly local or sectoral levels, significant data gaps remain, particularly for emissions, energy use, supply-chain linkages and asset-level vulnerabilities. More comprehensive and comparable data sets are critical for quantifying exposure to physical and transition risks and for calibrating the macro-sectoral and network-based models increasingly used by central banks. Ongoing efforts by statistical authorities and central banks to expand climate-related data collections, therefore, play a key role in bridging climate science and macroeconomics and ultimately enabling more robust forward-looking policy analysis.

## 3.1 The BIS Multisector model

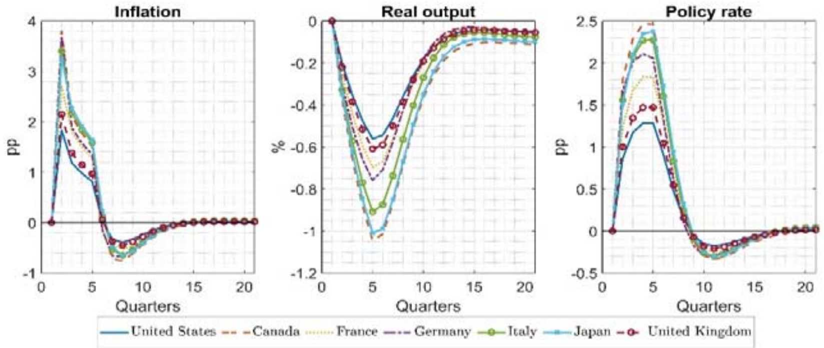
The BIS Multisector (BIS-MS) model, developed by Burgert et al (2025a), is a structural multi-country, multi-sector DSGE model designed to analyse how climate- and energy-related shocks propagate through production networks and across borders. Built on detailed global input-output (I-O) linkages covering more than 80 economies and 18 sectors, the model captures sectoral interdependencies, trade spillovers and energy-cost transmission mechanisms that are often omitted in standard macroeconomic models. Its flexible structure allows the analysis of both temporary shocks and persistent structural changes, including alternative transition pathways, while explicitly accounting for monetary policy responses.

### 3.1.1 Temporary carbon-intensive energy price shock

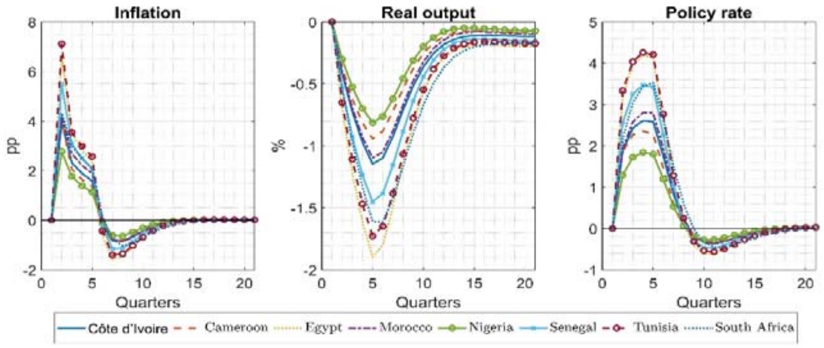
A first shock analysed by the model is a temporary carbon-intensive energy price shock. Graph 7, panel A, reports the impulse responses of inflation, real output and the policy rate for the G7 economies following a temporary 25% increase in carbon-intensive energy prices, originating in the manufacturing and mining sectors and calibrated as an exogenous shock. Across countries, the shock generates a common pattern: an initial, short-lived spike in inflation, a contraction in real activity and a

Macroeconomic responses to a temporary energy price shock Graph 7

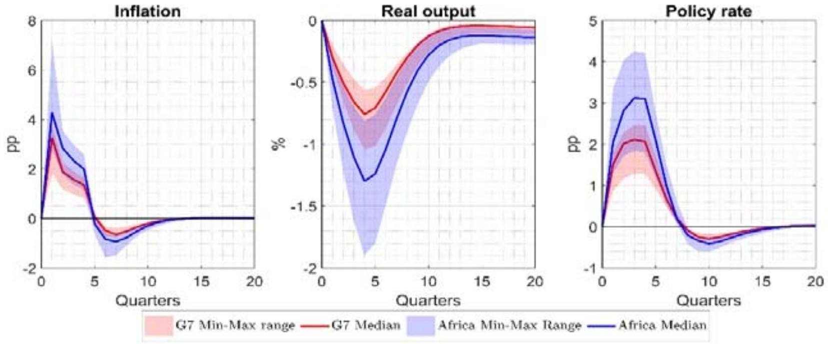
Panel A. G7 economies



Panel B. Selected African countries



Panel C. Comparison: G7 vs Africa



Panels A and B report impulse response functions of inflation, real output and the policy rate following a temporary 25% increase in carbon-intensive energy prices, originating in the manufacturing and mining sectors, for the G7 economies and selected African countries, respectively. Panel C compares the median responses and cross-country dispersion across the two groups. Simulations are based on the BIS-MS model.

temporary monetary policy tightening. The same simulation for eight African economies, shown in panel B, displays a qualitatively similar transmission pattern but with larger magnitudes. While the timing of adjustment is broadly comparable with that observed in the G7, the inflation, output and policy rate responses are more pronounced and exhibit wider cross-country dispersion, as illustrated in panel C. These differences reflect higher energy intensity and stronger pass-through of energy costs into production across the selected African economies. Overall, this exercise and the cross-regional comparison highlight the value of network-based models for assessing the macroeconomic impact of climate-related shocks, as they capture structural heterogeneity across countries and support policy-relevant analysis.

Differences across and within the two groups of countries can be traced to their underlying production structures. In the BIS-MS model, the energy price shock originates in upstream carbon-intensive sectors and propagates through intermediate input linkages across global production networks. This mechanism is illustrated in Graph 8, which relates the peak responses of inflation, output and the policy rate to countries' exposure to energy-intensive sectors. Economies in which the manufacturing and mining sectors account for a larger share of production costs experience stronger macroeconomic effects. This evidence confirms the key role of I-O structures in shaping the transmission of climate-related supply shocks (Burgert et al (2025b)).

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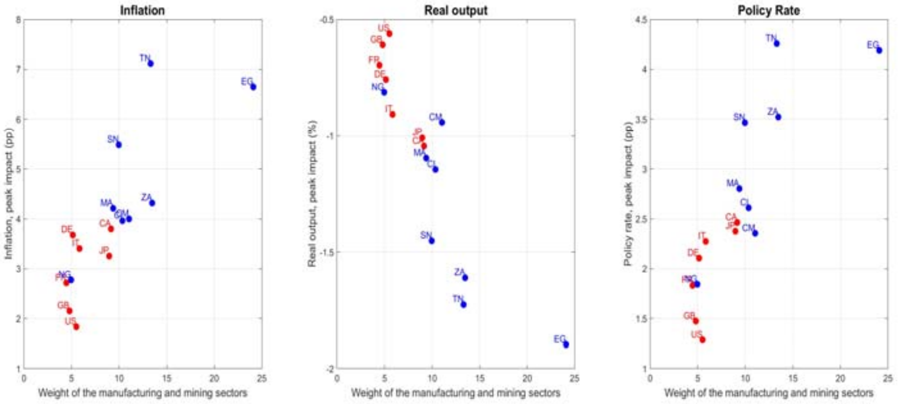
Peak macroeconomic responses and exposure to energy-intensive sectors

Graph 8



This graph shows how the peak responses of inflation, real output and the policy rate relate to the weight of energy-intensive sectors in the BIS-MS model. The x-axis reports an I-O-based measure of exposure, computed as the mining sector's weight plus 0.1 times the manufacturing sector's weight in intermediate production (see Table A1 in the appendix). Each dot represents a country, with red markers denoting G7 economies and blue markers denoting the African economies. The simulation is based on a temporary 25% increase in carbon-intensive energy prices.

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## 3.1.2 Temporary productivity shock in the agricultural sector

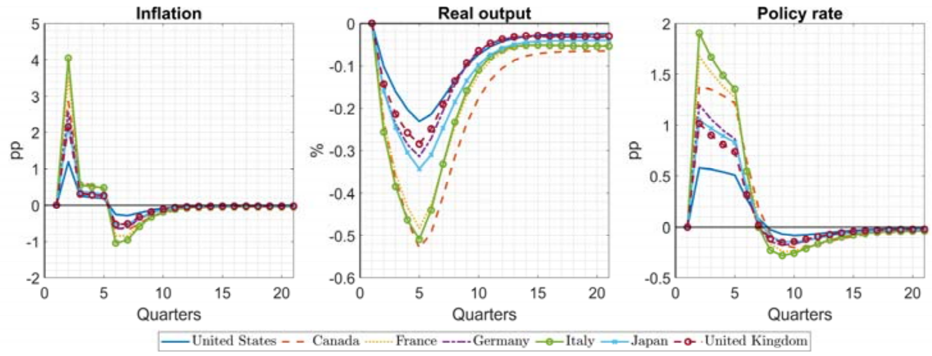
As a second simulation, the BIS-MS model is used to evaluate the effects of a temporary 25% negative productivity shock in the agricultural sector, thereby capturing an alternative channel through which climate-related disturbances may affect the macroeconomy. Graph 9 reports the corresponding impulse responses for inflation, real output and the policy rate for the G7 economies (panel A) and the selected African countries (panel B), with panel C comparing median responses and dispersion across the two groups.

The negative productivity shock raises marginal costs in the agricultural sector and, through I-O linkages, transmits cost pressures to downstream industries. Inflation rises as higher production costs feed into aggregate price dynamics. At the same time, real activity contracts, as lower productivity and higher costs reduce profitability and real purchasing power. Central banks respond by raising policy rates.

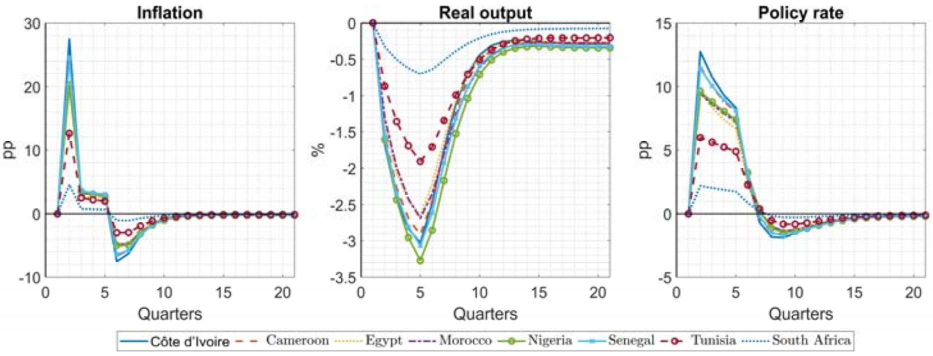
Macroeconomic responses to a temporary shock in the agricultural sector

Graph 9

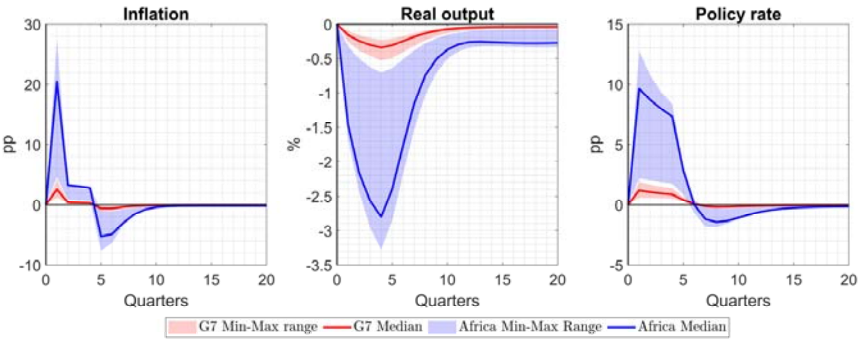
Panel A. G7 economies



Panel B. Selected African countries



Panel C. Comparison: G7 vs Africa



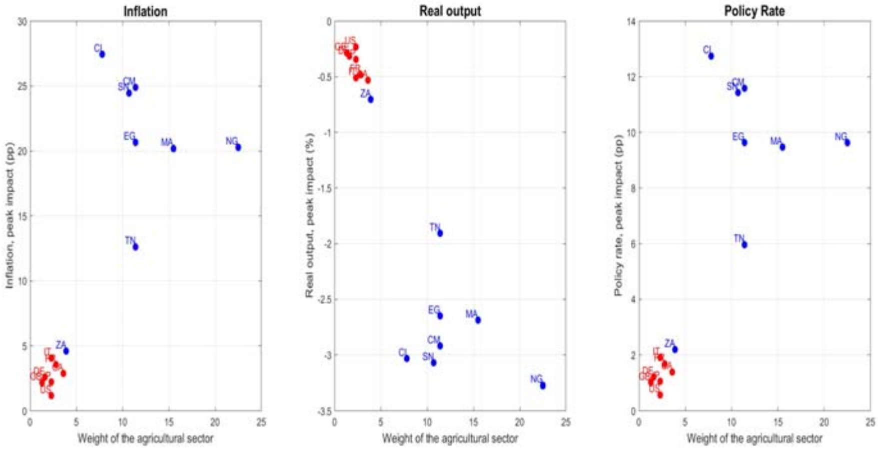
Panels A and B report impulse response functions of inflation, real output and the policy rate following a temporary 25% negative productivity shock in the agricultural sector for the G7 economies and selected African countries, respectively. Panel C compares the median responses and cross-country dispersion across the two groups. Simulations are based on the BIS-MS model.

The magnitude of the responses differs markedly across country groups. Compared with the G7 economies, African countries display larger and more heterogeneous movements in inflation, output and the policy rate. This reflects the larger weight of agriculture in production structures and final demand across many African countries. Where agriculture accounts for a sizeable share of value added and intermediate inputs, a sector-specific productivity shock propagates more strongly through the I-O network, resulting in more pronounced aggregate effects.

Also in this case, cross-country differences closely track sectoral exposure. Graph 10 relates peak macroeconomic responses to the share of agriculture in production costs (Table A1 in the appendix). Economies with larger agricultural input shares experience stronger inflationary pressures and deeper output contractions, alongside tighter monetary policy responses. In the G7, where agriculture represents only a small fraction of production costs, aggregate effects remain limited. By contrast, in several African economies the larger role of agriculture amplifies shock transmission, contributing to both the stronger average impact and the wider dispersion of responses across countries.

Peak macroeconomic responses and exposure to the agricultural sector

Graph 10



This graph relates the peak responses of inflation, real output and the policy rate to the weight of the agricultural sector in the BIS-MS model (see Table I). Each dot represents a country, with the red markers denoting G7 economies and the blue markers denoting the African economies. The simulation is based on a temporary 25% sectoral productivity shock to agriculture.

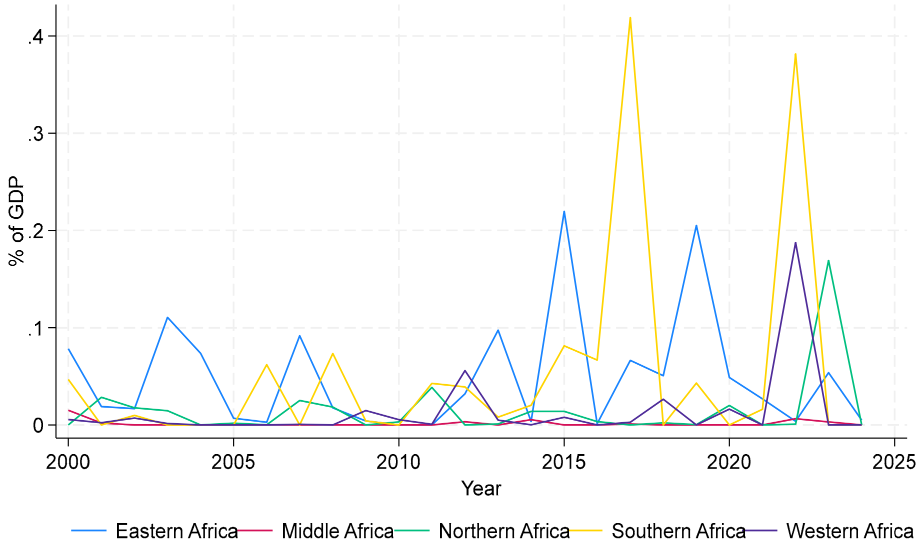
## 3.2 Macroeconomic impact of weather disasters

Ehlers et al (2025) develop a complementary empirical framework to quantify the macroeconomic effects of physical climate risks using harmonised global data. The authors compile a panel data set for 2000–24 that combines macroeconomic indicators with standardised measures of disaster-related damage (from the EM-DAT International Disaster Database) across seven types of weather events: droughts, floods, heatwaves, storms, wildfires, cold waves and landslides.[15] Using local projection methods, the framework traces the dynamic responses of output and prices to different hazards, enabling systematic comparisons across countries and event types.

Applying this framework to African economies reveals substantial heterogeneity in the macroeconomic impact of weather disasters across sub-regions (Graph 9). The estimates indicate that southern and eastern Africa experience larger and more volatile disaster-related GDP losses, with several pronounced spike years over the past decade reflecting successive severe events.[16] By contrast, other regions show more muted average effects. These patterns align with differences in exposure to climate hazards, economic structure and shock absorption capacity, and illustrate how physical climate risks can translate into uneven macroeconomic impacts within the continent.

Average annual damages from weather disasters

Graph 11



Source: Ehlers et al (2025).

## 4. Innovation and technology for climate-risk analysis

As climate-related risks grow more complex and data-intensive, central banks require timely, granular and reliable information to support macroeconomic analysis, financial stability monitoring and early warning systems. Traditional data sets are often incomplete, backward-looking or poorly suited to capturing non-linear climate dynamics, particularly for physical risks and supply chain exposures. These data limitations are especially pronounced in many African economies, where local and

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[15] www.emdat.be/.

[16] Consistent with this evidence, the IPCC assessments identify eastern, especially the Horn of Africa, and southern Africa as climate hot spots characterised by recurrent droughts, heat extremes and compound events that generate large and volatile economic losses (IPCC (2022)).

sectoral gaps constrain the assessment of climate risks and their macro-financial transmission. In addition, because climate impacts often originate at highly local levels but propagate systemically, effective assessment requires data that are both granular and comparable across jurisdictions. Addressing these data gaps has therefore become a core prerequisite for effective climate-risk assessment by central banks (Nefzi et al (2025)).

Against this background, the BIS Innovation Hub has launched a set of data-driven, technology-enabled initiatives, in collaboration with partner central banks, to strengthen climate risk monitoring and analysis. Among these, three projects demonstrate how advanced digital tools can bolster central banks' analytical capacity by addressing key data gaps. Project **Danu** uses digital twin simulations to assess the economic impact of extreme weather events by integrating climate, geospatial and socioeconomic data, enabling forward-looking stress analysis of physical risks. Project **Gaia** applies artificial intelligence (AI) and natural language processing to extract climate-relevant indicators from corporate disclosures, improving the consistency and comparability of transition risk data. Project **Symbiosis** leverages big data and AI to map Scope 3 supply chain emissions, strengthening transparency regarding indirect transition exposures. These tools are designed to be adaptable across jurisdictions and can support central banks, including those operating in data-constrained environments, in developing more robust climate risk monitoring frameworks and early warning capabilities.[17]

## 5. Conclusions

In a context of intensifying physical risks and evolving transition dynamics, this paper has examined the macroeconomic implications of climate change, with a particular focus on Africa. Drawing on structural multi-sector model simulations and empirical evidence on weather disasters, and complemented by a discussion of recent advances in climate risk monitoring, it has assessed how climate-related shocks can affect economic outcomes through sectoral structures and across regions, and why these effects matter for central banks within policy-relevant horizons.

Three main conclusions emerge.

First, climate-related shocks can generate sizeable and heterogeneous macroeconomic effects that are directly relevant to central banks' mandates. The BIS-MS simulations show that temporary shocks originating in energy-intensive and climate-sensitive sectors lead to inflationary pressures and output contractions, giving rise to potential policy trade-offs. Moreover, as the model-based comparison between the G7 and selected African countries indicates, the magnitude of these responses is closely related to countries' production structures and sectoral exposure. Complementing this evidence, the disaster-based analysis documents substantial GDP losses from extreme weather events and pronounced regional heterogeneity across African sub-regions. These findings underscore the importance of incorporating climate-related shocks into macroeconomic projections and risk assessment, supported by analytical frameworks that account for sectoral interdependencies and cross-country heterogeneity.

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[17] See Table A2 in the appendix for a more comprehensive overview of completed and ongoing BIS Innovation Hub climate-related projects and collaborative initiatives.

Second, climate-related risks interact with structural vulnerabilities in ways that amplify macroeconomic instability, particularly in climate-exposed and fiscally constrained countries. Economies with high reliance on climate-sensitive sectors and limited fiscal and financial buffers are generally more exposed to both physical shocks and transition dynamics. In Africa, where production structures and energy systems are often highly climate-dependent, these structural features can heighten sensitivity to extreme weather events and global transition adjustments. Moreover, the interaction between physical risks and delayed transition pathways may increase macroeconomic volatility over time.

Third, strengthening international cooperation and leveraging technological innovation are important in improving the assessment of climate-related risks. Given the global nature of climate change, the data, analytical tools and expertise required to evaluate its macro-financial implications benefit from cross-border collaboration. Initiatives such as the NGFS and the BIS Green Swan work illustrate how coordinated efforts among central banks, academia and the private sector can advance understanding and promote greater consistency in analytical approaches.[18] Enhanced convergence in data standards, modelling practices and scenario design can further improve comparability across jurisdictions. At the same time, technological innovation provides opportunities to strengthen analytical capacity. The use of AI to extract climate-related information, supply chain emission mapping and advanced simulations of weather-related disruptions can improve the granularity and timeliness of risk assessment. Developing robust data infrastructures and scalable analytical tools can play a key role in integrating climate-related risks into policy frameworks in data- and capacity-constrained environments, including many African economies.

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[18] www.bis.org/events/green_swan_2024/overview.htm.

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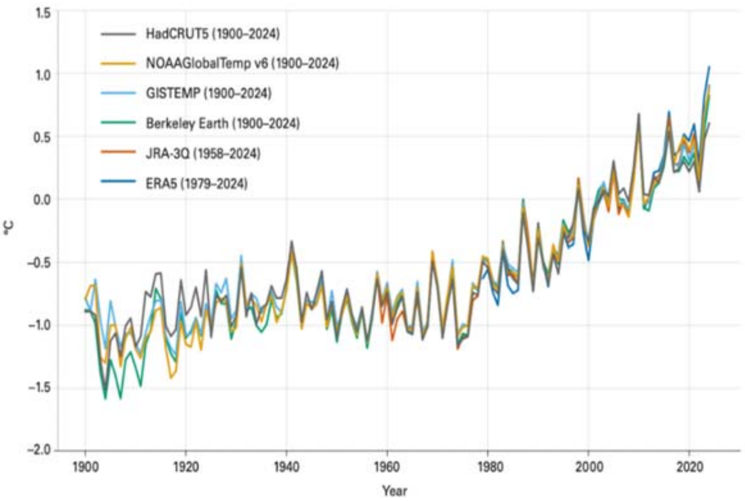
# Appendix

This appendix provides supplementary background material supporting the discussion and analysis in the main text. It includes additional climate indicators for the African continent (Graph A1) and further evidence from 2025 NGFS short-term climate scenario exercises (Graph A2). Table A1 reports the sectoral weights used in the two BIS-MS-based simulations, while Table A2 offers a brief description of the ongoing and completed BIS Innovation Hub projects related to climate change and green finance.

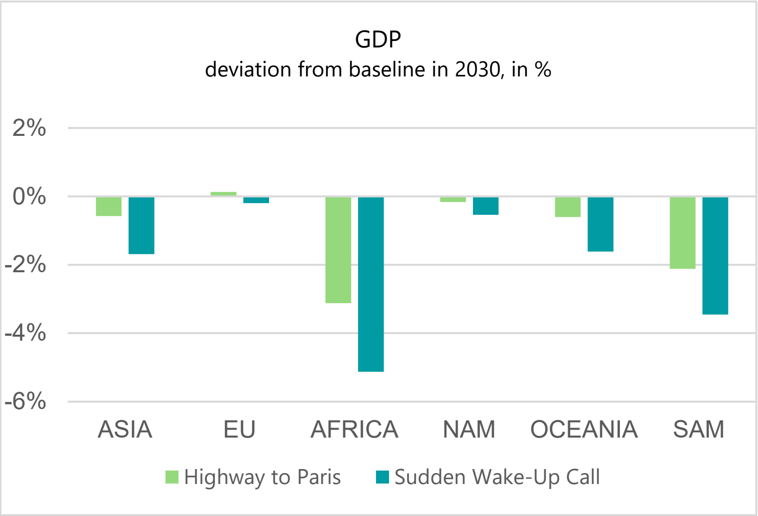
## Long-term temperature anomalies in Africa (1990–24) Graph A1



Relative to 1991–2020 average.

Source: WMO (2025a).

## GDP impacts by regions under alternative transition pathways Graph A2



The “Highway to Paris” scenario assumes an orderly transition, while the “Sudden Wake-Up Call” reflects a delayed and abrupt transition.

Source: NGFS (2025).

## Sectoral weights in production costs

Table A1

| Country | Manufacturing (%) | Mining (%) | Agriculture (%) |
|---|---|---|---|
| Cameroon | 29.4 | 8.1 | 11.4 |
| Canada | 30.5 | 6.1 | 3.6 |
| Côte d'Ivoire | 29.5 | 7.4 | 7.8 |
| Egypt | 36.9 | 20.4 | 11.4 |
| France | 25.6 | 1.9 | 2.8 |
| Germany | 31.4 | 2 | 1.6 |
| Italy | 32.4 | 2.6 | 2.3 |
| Japan | 43.6 | 4.6 | 2.3 |
| Morocco | 40.8 | 5.3 | 15.5 |
| Nigeria | 16.6 | 3.3 | 22.5 |
| Senegal | 33.6 | 6.6 | 10.7 |
| South Africa | 31.7 | 10.3 | 3.9 |
| Tunisia | 44.1 | 8.9 | 11.4 |
| United Kingdom | 21 | 2.7 | 1.3 |
| United States | 23.1 | 3.2 | 2.3 |

This table reports the shares (in per cent) of manufacturing, mining and agriculture sectors in countries' production costs, based on the I-O structure used in the BIS-MS.

## BIS Innovation Hub climate and green finance projects (as of January 2026)

Table A2

| Name | Stage | Description |
|---|---|---|
| Genesis 1.0 | Completed | The Innovation Hub's first green finance project executed in conjunction with the Hong Kong Monetary Authority to explore the use of digital technologies – including blockchain, smart contracts, the internet of things and digital assets – to support green finance applications.<br>Project Genesis 1.0: prototype digital platforms for green bond tokenisation |
| Genesis 2.0 | Completed | Assessed the technical feasibility of digitising green bonds with attached carbon forwards (also known as mitigation outcome interests, MOI). Two prototypes were developed to track, transfer and settle digitised MOI using blockchain, smart contracts and other related technologies.<br>Genesis 2.0: smart contract-based carbon credits attached to green bonds |
| Viridis | Completed | Explored the integration of regulatory data with external climate data sources through a new platform designed to help financial authorities assess climate-related financial risks, their impact on financial institutions and financial stability, and the actions needed to mitigate them.<br>Project Viridis: a climate risk platform for financial authorities |
| NGFS Data Directory 2.0 | Almost completed | Provides a centralised directory of reliable and consistent climate-related data to support financial authorities and institutions in assessing their exposure to climate-related risks.<br>NGFS Data Directory: a growing resource for climate risk data |
| Gaia | Phase 1 completed | Developed with the Deutsche Bundesbank and the European Central Bank, Gaia Phase 1 explored AI-driven text extraction to generate scalable data for applications in money and finance, with a focus on climate-related financial risks. In collaboration with the Bank of Spain, the project integrated large language models into an application for extracting climate risk information from unstructured disclosures. |
|  | Phase 2 ongoing | Gaia Phase 2 builds on the initial prototype by developing a robust and scalable data-extraction pipeline that keeps pace with rapid advances in AI. The project expands to additional use cases and relies on widely available technologies to ensure reliability, adaptability and ease of deployment across central banks.<br>Project Gaia: enabling climate risk analysis |
| Symbiosis | Completed | Addresses information gaps related to climate and nature risks through targeted and simplified AI methods in supply chains.<br>Project Symbiosis: AI and big data technologies for supply chain sustainability disclosure |
| Danu | Ongoing | Leverages digital twin technology to monitor emerging risks to financial stability.<br>Project Danu: monitoring emerging risks by leveraging digital twin technology |