Enabling Adaptation

Sustainable Fiscal Policies for Climate Resilient Development and Infrastructure

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ABBREVIATIONS AND ACRONYMS

Acronyms	Definitions
AfDB	African Development Bank
ASEAN	Association of Southeast Asian Nations
BF	Blended Finance
BRD	Development Bank of Rwanda
CBD	Convention on Biodiversity
CDRI	Coalition for Disaster Resilient Infrastructure
CEPR	Center for Economic and Policy Research
CGFI	UK Centre for Greening Finance and Investment
CPI	Climate Policy Initiative
CRS	Creditor Reporting System
CGD	Center for Global Development
CGE	Computable General Equilibrium
CIV	Collective Investment Vehicle
D2D	Data-to-Deal
DAC	Development Assistance Committee of the OECD
DFI	Development Financial Institution
DIGNAD	Debt-Investment-Growth and Natural Disasters
ECDPM	European Center for Development Policy Management
EPDRS	Economic Development and Poverty Reduction Strategy
EMDEs	Emerging and developing economies
ESG	Environmental, social and governance
ESMS	Environmental and Social Management System
EU	European Union
FDI	Foreign Direct Investment
FI	Financial Instrument
GCA	Global Center on Adaptation
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Reduction and Recovery
GGCRS	Green Growth and Climate Resilience Strategy

Acronyms	Definitions
GGGI	Global Green Growth Institute
GIRI	Global Infrastructure Resilience Index
GIS	Geographic information system
GIZ	German Federal Development Agency
GNI	Gross National Income
GRO	Global Recovery Observatory
ICF	International Climate Finance
ICT	Information and Communication Technology
IDB	Inter-American Development Bank
IFC	International Finance Corporation
IIC	Inter-American Investment Corporation
IISD	Institute for Sustainable Development
IMF	International Monetary Fund
Intego	Rwanda's NDC Facility in RGF
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	UN International Panel on Climate Change
Ireme Invest	Rwanda's Climate Finance Facility / Green Bank funded by RGF and BRD
KPI	Key Performance Indicator
LDC	Least Developed Country
LIC	Low Income Country
LMIC	Low- and Middle-Income Countries
MDB	Multilateral Development Bank
MIC	Middle Income Country
MRV	Measurement, Reporting, and Verification
NAPA	National Adaptation Programme of Action
NbI	Nature-Based Infrastructure
NbS	Nature-Based Solution
NDC	Nationally Determined Contributions (to the Paris Agreement) under the UNFCCC
NGFS	Network for Greening the Financial System
NGO	Non-Governmental Organisation
NST	National Strategy for Transformation

Acronyms	Definitions
ODA	Official Development Aid
ODI	Overseas Development Institute
OECD	Organisation for Economic Co-operation and Development
PML	Probable Maximum Loss
PPP	Public Private Partnership
RCP	Representative Concentration Pathway
REMA	Rwanda Environment Management Authority
RGF	Rwanda Green Fund
RP	Return Period
RPDH	Resilient Planet Data Hub
RST	Resilience and Sustainability Trust of the IMF
S&P	Standard and Poor's
SCF	Stand-by Credit Facility
SDGs	UN Sustainable Development Goals
SLB	Sustainability-Linked Bond
SME	Small and Medium-sized Enterprise
SPV	Special Purpose Vehicle
SRAT	Systemic Risk Assessment Tool
TC	Tropical Cyclone
TCRs	Transnational Climate Risks
UN	United Nations
UNCTAD	United Nations Trade and Development
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEA	United Nations Environment Assembly
UNEP	UN Environmental Programme
UNFCCC	UN Framework Convention on Climate Change
UNIDO	UN Industrial Development Organisation
UNOPS	United Nations Office for Project Services
USD	United States (of America) Dollar(s)
WEF	World Economic Forum
WMO	UN World Meteorological Office
WRI	World Resource Institute

EXECUTIVE SUMMARY

Increasing investment in resilient, inclusive and sustainable infrastructure is vital to reduce the long-run impacts of climate change on economies and to spur development and poverty alleviation. The public sector plays a critical role in this respect, both as a financier of infrastructure, but also as a regulator, a catalyst and policy maker. This report takes the form of a compendium of key fiscal priorities, issues and considerations for climate resilient development, with a focus on infrastructure. The report was commissioned by the UN Environment Programme as part of an ongoing work on Sustainable Fiscal Policy.

The interplay between fiscal policy and adaptation is a large topic and we can only provide initial insights here as a primer. We consider five areas:

1. The synergies between debt sustainability and adaptation, and the needs and opportunities to change our approach to debt sustainability analysis to reflect this
2. The alignment of public expenditure and climate resilience goals
3. Blended finance and its role in mobilising private investment in adaptation
4. Aligning fiscal policy and wider public policy to mobilise investment in ways that are consistent with adaptation and nature goals
5. Investing in data as a public good to catalyse resilient investment

The report lays out the clear fiscal case for investment in inclusive, resilient and sustainable infrastructure – grey, green, blue and hybrid. Additional annual infrastructure investments of well over $1 trillion are needed until 2040 to achieve the SDGs, with more than 70% in emerging and developing economies (EMDEs). However, it is vital that new and existing infrastructure is resilient; according to the World Bank, disruption to infrastructure is already estimated to cost at least $390 billion a year across EMDEs. The extra cost of building resilience into these systems is only 3 percent of overall investment needs versus an overall net benefit of $4.2 trillion. Closing both the investment and resilience gap requires effective and aligned fiscal policy. Several authors have pointed to the significant fiscal benefits of such investments, both in terms of reduced costs of reconstruction and recovery, disruption to critical services and taxation, as well as well as for long term development, employment and growth.

The report also presents clear evidence of the false dichotomy between debt sustainability and investment in adaptation. Several countries note the difficulties of investing in adaptation given fiscal constraints and debt ceilings. Analyses presented in this report demonstrate the benefits of adaptation for debt sustainability. However, we also find that debt sustainability analyses currently do not fully account for physical climate risks and where adaptation is included, this is simplistic. We argue for a more thorough treatment of physical risks and adaptation within debt sustainability analyses, and exploration of the potential for a cost of capital reduction in sovereign financing where this is linked to adaptation.

Despite the fiscal win-wins of investing in adaptation, previous analyses commissioned by UNEP and conducted by the University of Oxford suggest that a relatively small fraction of fiscal expenditure is aligned with adaptation and resilience goals, and further that there is evidence that a large portion of fiscal expenditure may be pushing risks in the wrong direction. New analyses shown in this report demonstrates that the same holds true for nature-based solutions, which are an important part of adaptation and infrastructure investments. The report argues for greater integration of resilience and nature within sustainable budgeting approaches, project procurement and appraisal, and highlights the role of taxonomies in this respect, as well as the opportunities to leverage existing standards and frameworks.

Given the constraints on fiscal expenditure, there has been an increased focus on how countries can use fiscal policy – in particular, blended finance – to help mobilise more private investment into infrastructure. De-risking at an early stage (e.g., by means of co-financing) can help bring relevant adaptation projects off the ground and crowd in public finance. The extent to which public funds should be used in this way should be proportional to the societal benefit of a given project, its additionality, as well as its eventual commercial viability

Fiscal policy is most effective where it is aligned with and part of a wider policy and regulatory architecture. In this report, we give the example of Rwanda and detail the various elements of this architecture and how they work together to deliver both adaptation and transition finance. This begins with clear national targets and plans and a strong institutional and governance architecture and combines this with innovative sovereign financing and measures to align public finance with national plans. Private sector finance is mobilised through a blended finance architecture and developing enabling regulatory environment.

Finally, the report overviews the role of data and analytics in resilient development and infrastructure and the important role of the public sector in the provision of public goods of knowledge and information.

Recommendations

R1. Incorporate climate change and adaptation routinely into fiscal risk analysis and debt sustainability analyses, including analysing the benefits of adaptation for fiscal space, fiscal resilience and sovereign credit ratings.

R2. Explore if and how cost of capital for sovereign financing instruments could be reduced through investment in adaptation, including implementing appropriate disaster risk financing strategies and exploring the opportunities for labelled bonds and sustainability-linked sovereign finance for adaptation

R3. Development of an appropriate adaptation taxonomy (or integration of adaptation within a green taxonomy) that is aligned with national goals,

R4. Integrate adaptation within sustainable budgeting approaches, project procurement and project appraisal, and use sustainability budgeting approaches as a tool to identify where public expenditures could be more strongly aligned with national adaptation and nature goals.

R5. Develop investment plans for adaptation and infrastructure, aligned with national plans and goals, in collaboration with the private sector and civil society

R6. Identify roles of public and private finance as part of investment plans. Develop practical guidance for targeting projects for Blended Finance (and considering different structures vis a vis one another) that maximise the co-benefits from green infrastructure investment to society, including apportioning public funds between BF and other structuring approaches where private returns are too low to justify BF.

R7. Align blended finance allocations with adaptation taxonomies and develop context-appropriate additionality checks and make them mandatory for all grants and grant-equivalent portions of BF interventions so that efficiency is safeguarded. Make sure that relevant alternatives to any given project are being considered and that opportunity cost is kept low by picking the investment with the highest social value relative to its costs.

R8. Develop an appropriate institutional framework within the Ministry of Finance for mobilising and monitoring adaptation finance with clear national vision and goals.

R9. Conduct a diagnostic to identify gaps in policy, regulatory and financial architecture to mobilise adaptation action and finance.

R10. Develop policies and projects to address gaps in a way that engages with local people and communities for greater impact and sustainability and align policies and projects with broader development and poverty reduction agendas.

R11. Invest in physical climate risk data and tools as a public good, building upon existing platforms, such as the Resilient Planet Data Hub.

R12. Ensure risk analytics and macroeconomic modelling used within government decision making incorporate climate risks and take full account of climate extremes and their interlinkages with nature-related risks and the potential for cascading risks.

1. INTRODUCTION

Many countries around the world are grappling with the same conundrum – how to reach a level of economic activity that can support the needs of a growing population and achieve the sustainable development goals (SDGs), while tackling the triple challenges of adapting to an already changing climate (WMO, 2024), abating greenhouse gas emissions (Smith et al., 2024, 2023), and avoiding environmental degradation and biodiversity loss (Brondizio et al., 2019; Ceballos & Ehrlich, 2018; Malanoski et al., 2024). These challenges are particularly acute in many developing economies, facing some of the highest risks from climate change, fiscal constraints (or debt distress in some cases), an urgent need for infrastructure investment to power development, and a challenging macroeconomic environment for investment (Holland & Pazarbasioglu, 2024; UNDP, 2023).

This report takes the form of a compendium of key fiscal considerations for climate resilience development, with a focus on infrastructure. Infrastructure – grey, green[1], blue and hybrid – sits at the heart of the challenges noted above and is an area where public finance and public policy must play a critical role both in mobilising investment (public and private) and ensuring long-term resilience. These considerations are large topics, and we can only provide initial insights here as a primer for further research and action. We consider five areas:

1. The synergies between debt sustainability and adaptation, and the needs and opportunities to change our approach to debt sustainability analysis to reflect this
2. The alignment of public expenditure and climate resilience goals
3. Blended finance and its role in mobilising private investment in adaptation
4. Aligning fiscal policy and wider public policy to mobilise investment in ways that are consistent with adaptation and nature goals
5. Investing in data as a public good to catalyse resilient investment

The report addresses each topic through a combination of literature review, case studies and new analyses. We draw upon three country case studies in particular (a low income African economy, an climate-vulnerable upper-middle income Asian economy and an upper-middle income small-island state) as illustrations. While the analyses are preliminary, the paper presents a set of initial recommendations for governments in each of the five areas.

The following section introduces the role of infrastructure at the heart of the nexus between the SDGs and the triple challenges, and the links to government fiscal policy. The subsequent sections then address the five focus areas in turn. The final section concludes with a view to further research needs, particularly to inform future directions of promising developments: sustainability linked sovereign debt for adaptation and adaptation taxonomies.

1 Green infrastructure refers to the use of land-based natural systems as, or as a component of, an infrastructural system (Benedict & McMahon, 2006). Similarly, blue infrastructure describes aquatic ecosystems being harnessed as part of an infrastructural system. Lastly, grey infrastructure typically refers to human-engineered infrastructure which does not form part of a natural system. Approaches that integrate two or more these types are referred to as hybrid infrastructure, or specifically as blue-green, green-grey, and so on.

2. THE FISCAL CASE FOR RESILIENT INFRASTRUCTURE INVESTMENT

Investment in resilient and sustainable infrastructure presents a tremendous opportunity for inclusive pro-poor development; contributing to more than ninety-two percent (Thacker et al., 2021; UNEP, 2023b) of the sustainable development goals (SDGs), including through unlocking new jobs, trade, growth and access to water, energy, education and healthcare. Today around $2.9 trillion a year flows into infrastructure, with the most rapid growth across the ASEAN region (CPI, 2024). Yet, additional annual infrastructure investments of well over $1 trillion are needed globally until 2040 to achieve the SDGs, with more than 70% accruing to emerging and developing economies (EMDEs). Many developing economies in particular struggle to mobilise the finance required leaving a gap due to a variety of challenges (High-Level Expert Group on Scaling Up Sustainable Finance in Low- and Middle-income countries, 2024), with a foundational challenge being the lack of the fiscal space for public investment and the high cost of capital in EMDEs, both of which are related will be increasingly linked to the growing risks of physical climate change. In this report, we present an argument for how investment in climate resilient development, including resilient infrastructure, can be a core part of alleviating these challenges. There are multiple positive feedbacks between resilience and economic development (Hallegatte et al., 2020).

The Fiscal Case for Resilient Infrastructure Investment

Ensuring the resilience of new and existing infrastructure to climate today and in the future is vital to secure growth, jobs and prosperity across countries. Much of the current $2.9 trillion per year in investment noted above is not properly factoring in physical climate risks and might therefore lock-in adverse outcomes and damages to people for decades to come. Hallegatte et al. (2020) concludes that disruption to infrastructure costs at least $390 billion a year across emerging and developing economies; yet the extra cost of building resilience into these systems is only 3 percent of overall investment needs versus an overall net benefit of $4.2 trillion. Research by the World Bank and the University of Oxford estimates that more than 200,000 km of roads are currently exposed to climate-related hazards worldwide (Hall et al., 2019; Hallegatte et al., 2019). The costs of a failure of resilience fall most heavily on the poorest, leading to loss of income and access to basic services that can set back poverty alleviation (Weikmans, 2023). The costs of disruption to these assets can also strain fiscal budgets and reduce productivity, with knock-on effects for growth, investment and poverty alleviation. Ensuring quality, reliable, sustainable and resilient critical infrastructure is therefore seen by many countries as a core part of national security (Ranger et al., 2021). As Hall et al. (2016) note, getting infrastructure investment right is particularly important given the long life-span of infrastructure and the locking-in of direct and indirect impacts.

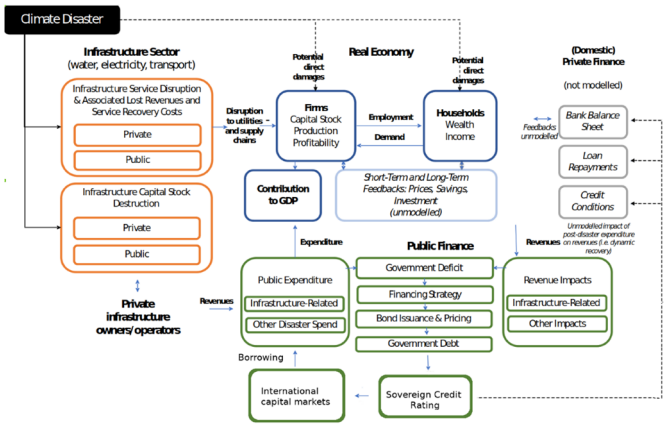

Figure 1: The relationship between climate shocks, the infrastructure sector, the real economy, and public finance. Source: N. Ranger

Figure 1 illustrates these linkages between climate risks, infrastructure and fiscal resilience. Damage to public infrastructure has a direct impact on government balance sheets as the public sector has to bear (most of) the costs of reconstruction and recovery. However, there is also a sizeable indirect and long-term fiscal effect, through the impacts of infrastructure disruption on firms and households, and the consequences for economic growth, social welfare costs and taxation revenues (as well as in extreme cases, the government having to act as an "insurer of last resort" to absorb costs).

Investing in resilient public infrastructure upfront, as well as putting in place regulatory and financing arrangements to ensure the resilience of private infrastructure, is therefore fiscally sound. While the positive growth dividends of adaptation and resilience investments should help to alleviate fiscal risks in the end, governments may need to increase taxes to recoup some of the initial public outlay (Godfrey et al., 2023). Yet, these come with substantial positive fiscal multipliers (Hallegatte et al., 2020). Moreover, several authors point to evidence that strategic investment in resilience and adaptation can help to lower the cost of sovereign debt over the medium- to long-term (Beirne et al., 2021; Buhr et al., 2018; Volz et al., 2020).

While our focus in this report is on infrastructure, these arguments hold more widely. Adapting to climate change is a critical priority for all countries, but even more so for highly climate-vulnerable ones (Aligishiev et al., 2022; Duenwald et al., 2022). It is well established that the cost of investing in adaptation and resilience is much lower than the returns in terms of potential avoided losses (Jha et al., 2013). Also, adaptation investments often generate further dividends in terms of induced economic development and social and environmental benefits (Aligishiev et al., 2022; Heubaum et al., 2022; Surminski & Tanner, 2016; Tanner et al., 2015). Bapna et al. (2019) find that investments in improved resilience generate high rates of return, with benefit-cost ratios ranging from 2:1 to 10:1, and in some cases even higher.

Green (or Nature-Based) Infrastructure

While the focus has often been on grey infrastructure, the benefits of green (and blue[2]) infrastructure have also become prominent in the dialogue and priorities of many countries. Broadly nature-based solutions (NbS) are defined as "actions to protect, conserve, restore, sustainably use and manage natural or modified [...] ecosystems that address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits" (Nature-Based Solutions for Supporting Sustainable Development, 2022). The key advantage of nature-based solutions is that they jointly address multiple dimensions of the crises at hand by leveraging synergies between the social, economic, and natural systems involved while minimising negative side-effects (Chausson et al., 2020; Key et al., 2022). While NbS cannot replace all grey infrastructure, if done well it is likely to be more cost-efficient than its engineered alternatives in certain areas such as flood protection (Bassi et al., 2021; Key et al., 2022; Malhi et al., 2020; Seddon et al., 2020, 2021).

Nature-based infrastructure (NbI) or green infrastructure, is a subgroup of NbS dedicated to the "protection, restoration, improved management or creation of natural and semi-natural ecosystems to provide services relevant to the functioning of infrastructure" (UNEP, 2023b). NbI and hybrid infrastructure additionally offer a wide range of potentially transformational benefits to the economy and the environment (UNEP, 2023b). NbI is unique in its ability to provide much needed infrastructure improvements and expansion in tandem with environmental sustainability (Rozenberg & Fay, 2019), and it does so up to 50% cheaper than traditional, grey infrastructure (Bassi et al., 2021). In fact, a recent report by UNEP concluded that NbI may be the only way through which countries can achieve mutual, synergistic progress on the SDGs, the Convention on Biological Diversity (CBD), and the Paris Agreement at the same time (UNEP, 2023b).

2 For simplicity, in this paper, blue infrastructure is wrapped into green infrastructure. For the different classifications of infrastructure, see footnote 1 above.

While grey infrastructure typically lacks the large-scale ecosystem benefits associated with NbI (UNEP, 2023b), building optimised green-grey hybrid infrastructure may prove preferrable, either as a transitory step before fully transitioning into NbI in the longer term or because existing NbI solutions are not by themselves sufficient to meet climate adaptation needs within the relevant timeframe (Dong et al., 2023; Reckner & Tien, 2023). For example, NbI solutions for coastal infrastructure, like mangrove belts around exposed coastal areas, are cheap and offer sizeable co-benefits, but they typically take relatively long to become effective and are somewhat limited in their protective capacity (Ihinegbu et al., 2023; Temmerman et al., 2023; van Hespen et al., 2023). Thus, it may be preferrable to combine them with pro-environmental, grey coastal structures such as breakwaters, seawalls, revetments, and groins that through reengineering can also function as habitats for marine life, or a combination of two spatially separated infrastructure types, one being a natural ecosystem and the other hardened structures (Kuwae & Crooks, 2021). Lastly, opting for coupled green-grey systems may also be appropriate, if stakeholders at the community level prefer them to pure NbI solutions (O'Donnell et al., 2021; Reckner & Tien, 2023).

Notwithstanding how promising NbI and hybrid solutions are, nature-based infrastructure remains underutilised for climate adaptation. One reason for this is a lack of financing, even though sustainable infrastructure offers potential to maximise the use of financial resources because of the synergies it exploits. For reference, an estimated US $484 billion is required annually by 2030 (UNEP, 2022) to meet global targets on climate change, biodiversity, and land degradation. Meanwhile, US $100 trillion need to be invested in infrastructure globally between 2016 and 2040 (UNEP, 2023b) across energy, transport, water, and IT. In EMDEs alone, the low-carbon infrastructure investment gap is estimated to reach US$15–30 trillion by 2040 (GCF, 2020; Prasad et al., 2022).

Seeing as these financing gaps overlap considerably in NbI, large societal savings are waiting to be made through efficiency gains. Moreover, infrastructure investments lock in development outcomes for decades to come, whether they be positive or negative, high or low carbon (Hall et al., 2016; Thacker et al., 2021). Such path-dependencies over the long-term underpin the public sector's mandate to carefully plan and coordinate the use of financial and policy levers to mobilise biodiversity finance, "including through appropriate fiscal policies, green financial products, investment in green infrastructure and other nature-based solutions, payment for ecosystem services, and high integrity carbon markets to incentivize private financial flows" (UNEP et al., 2023).

The Adaptation Financing Gap for Infrastructure

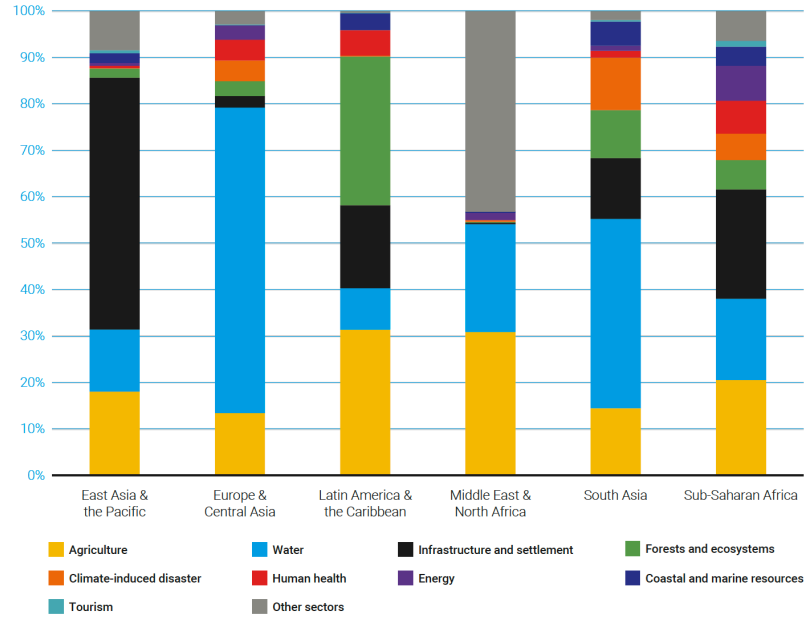

Figure 2: Sectoral distribution of adaptation finance needs (UNEP, 2023a).

Figure 2, which is reproduced from the UNEP Adaptation Gap report, clearly shows the adaptation financing gap in EMDEs, the important role of infrastructure and the scale of the financing gap to date (UNEP, 2023a). For sub-Saharan Africa, East Asia and Pacific, infrastructure accounts for the largest share or the adaptation finance gap. Moreover, the water sector, which greatly relies on infrastructure, lacks financing across all world regions, and especially so in South Asia and Europe and Central Asia.

3. FALSE DICHOTOMY OF DEBT SUSTAINABILITY AND ADAPTATION

Despite the clear economic and financial benefits of investing in resilient infrastructure and nature-based solutions, many developing countries struggle in the current macroeconomic environment and face binding fiscal constraints. As a result, many developing economies are at risk of falling into a climate investment trap. Barring major action, this can send the costs of climate damage and public debt spiralling and place countries at considerable risks.

Climate Investment Trap for Adaptation

The concept of a climate investment trap is well developed for mitigation (Ameli et al., 2021). Figure 3 illustrates an analogous vicious cycle for adaptation in EMDEs. In it, the blue cycle indicates how rising costs of climate-related disasters (Table 1, Volz et al., 2020) increase debt and in some cases lead to debt distress. This creates a poor investment environment and higher costs of capital for affected countries, which in turn constrains investment in climate adaptation (and mitigation). This, in turn, leads to greater climate vulnerability and still higher costs of climate-related disasters, further exacerbating debt sustainability and leading to a deteriorating investment environment. The red arrows indicate a further negative feedback loop based on rising emissions leading to increased transition risks and failure to capture green opportunities. Similarly, lower investment in infrastructure curtails growth and heightens debt sustainability challenges.

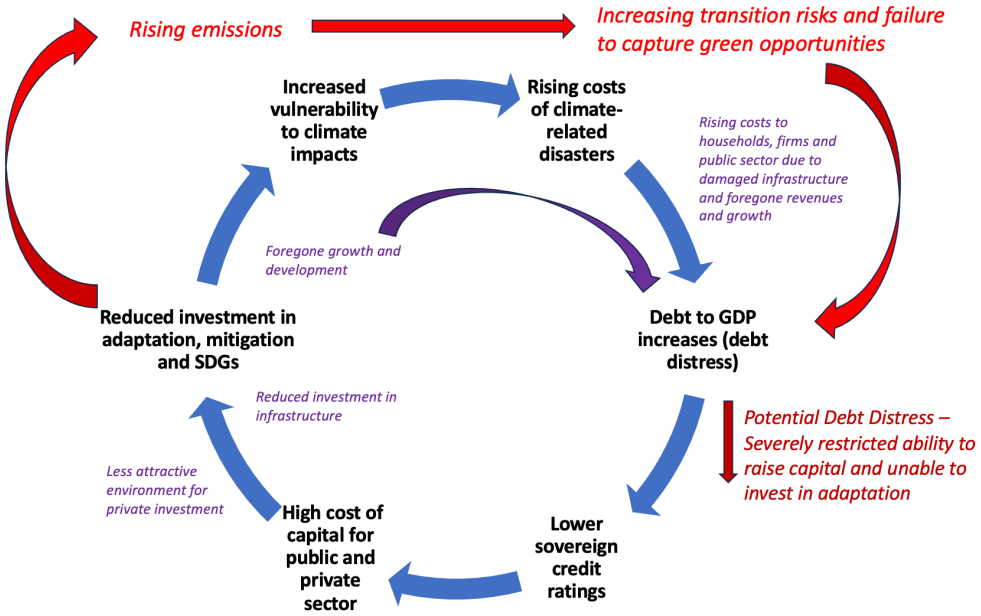

Figure 3: Vicious cycle leading to a climate-investment-trap (authors' compilation, analogous to Ameli et al., 2021).

Table 1: Macroeconomic impacts of climate change

		Physical impacts		
		From extreme weather events	From gradual global warming	Transition impacts
Demand	Investment	Damage to household and corporate balance sheets causes reduction of investment	Changes to household and corporate balance sheets affect investment	Effects on household and corporate balance sheets Growing demand for responsible investment Public investment push ("green new deal") "Crowding out" from climate policies
	Consumption	Loss of income and damage to household balance sheets reduce consumption	Effects on household income Wealth effects due to changes in property prices Effects on corporate balance sheets Effects on public finances	"Crowding out" from climate policies Changes of consumption patterns because of a shift in preferences or taxation (e.g. carbon taxes) Shifts in demand from migration or political instability Wealth effects due to share and bond prices Effects on public finances
	Trade	Disruption to import/export flows due to climate disasters	Changes to patterns and volumes of trade	Distortions from asymmetric climate policies Changes to patterns and volumes of trade
Supply	Labor supply	Loss of hours worked due to climate hazards	Loss of hours worked due to extreme heat Labor productivity effects of climate change Migration effects	"Stranded labor" Migration effects
	Natural capital		Loss of arable land, biodiversity loss, water stress	Climate policies may constrain/restrict the use of land or ecosystem services
	Energy, food, and other inputs	Food and other input shortages (e.g. through supply chain disruptions)		Changes to the energy supply through decarbonization policies and new renewable energy sources
	Capital stock	Damage due to extreme weather	Loss of productive assets Diversion of resources from productive investment to adaptation capital	Stranded assets Diversion of resources from productive investment to mitigation capital
	Technology	Diversion of resources from innovation to reconstruction and replacement	Diversion of resources from innovation to adaptation capital	Technology may become stranded Uncertainty about the rate of innovation and adoption of low-carbon technologies

Source: Volz et al. (2020) based on the taxonomy of Batten et al. (2018).

Adaptation for Debt Sustainability

It is vital that countries are able to break the climate investment trap. Klusak et al. (2023) show the substantial potential impact of climate change on sovereign credit ratings and, consequently, the growing cost of capital faced by countries globally. Across 109 countries, they estimate that climate change could increase the annual interest payments on sovereign debt by US$45–$67 billion even under strong mitigation scenario (RCP 2.6), and this rises to US$135–$203 billion under a weak mitigation scenario (RCP 8.5). Kling et al. (2018) find that, controlling for macroeconomic factors, climate vulnerability has increased debt costs for a subgroup of 25 climate-vulnerable developing countries by 1.17 percentage points (equivalent to USD 40 billion in additional interest payment). Böhm (2022) finds that higher temperature anomalies lower sovereign bond performances for 54 emerging economies.

How can we break the debt trap for the most climate-vulnerable countries and enable investment in adaptation? In the short term, the cycle can be broken by measures to reduce debt to unlock adaptation (e.g., a debt-for-adaptation swap), align public finance with adaptation goals, and increase the mobilisation of private and international climate finance. The fiscal and society benefits are clear. The following analyses demonstrate how investments in insurance (Box 1) and adaptation (Box 2) can offset the increasing challenges to debt sustainability posed by climate change. Based on disaster risk and macroeconomic modelling for one upper-middle income small-island state, Box 1 shows how investment in flood insurance can substantially decrease debt to GDP ratios in a warming climate, making the case for adaptation spending from a fiscal perspective. Box 2 shows how investing in adaptation today can significantly reduce future losses and economic impacts of extreme events in a larger upper-middle income Southeast Asian economy.

Box 1: Assessing the Fiscal Implications of Climate Shocks – Small-Island State

Figure 4 plots the results of a debt sustainability analysis for an upper middle income small-island state. The graph shows the time evolution of ensembles of trajectories of the debt-to-GDP ratio under different scenarios. For each scenario, we generated 2,000 different trajectories, each with a completely different catalogue of catastrophes. For clarity, we don't plot all the trajectories but instead show the time evolution of the 84th and 16th percentiles.

The losses from each catastrophe have been estimated using granular asset-level data collected, covering the most relevant sectors and infrastructure of the country. The black line represents the baseline scenario. The blue lines show the time evolution of the percentiles in a scenario without hurricanes. The red lines represent the time evolution of the percentiles with hurricanes considered. The green lines illustrate a scenario with hurricanes and insurance, where 50% of the losses are covered for return periods greater than 1 in 50 years.

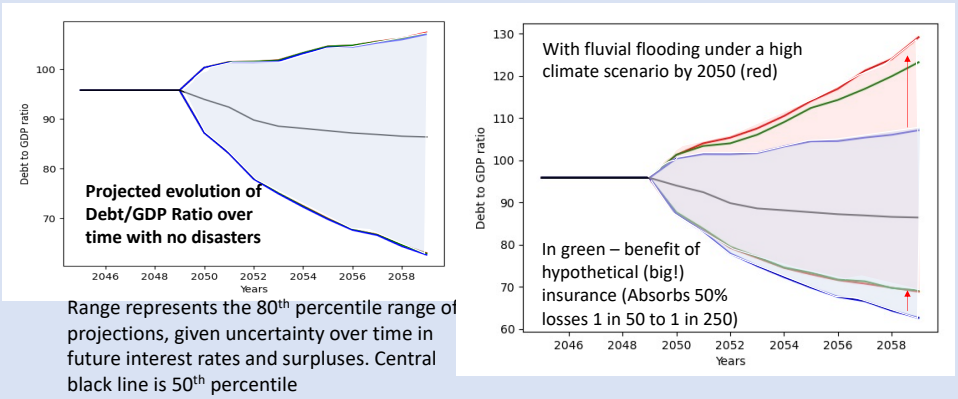

Figure 4: Projection of debt to GDP ratio under varying scenarios of flood risk and climate insurance.

Box 2: Adaptation and Sovereign Credit Ratings – Southeast Asian Economy

Using data from the Resilient Planet Data Hub (RPDH, 2024) and a sovereign credit rating model developed by Klusak et al. (2023), we explore the impact of extreme events on the sovereign credit ratings of a large upper middle income Southeast Asian economy. Scenarios were developed for flood and tropical cyclone (TC) events, considering direct damages to built-up areas and indirect impacts (transport disruption for flooding and power disruption for TCs). We consider three different scenarios:

1. Risk from a 1-in-500-year event in today's climate
2. Risk from a 1-in-500-year event in 2050 under a high emissions (RCP 8.5) scenario
3. Risk from a 1-in-500-year event in 2050 under a high emissions (RCP 8.5) scenario with additional investments in adaptation (improved building codes and infrastructure resilience, and increased insurance penetration).

Incorporating damage estimates from these acute risks into a sovereign credit rating model, we estimate the potential sovereign credit rating downgrade and associated increase in probability of default and increased cost of debt. A 1-in-500-year flood in today's climate could lead to a one notch downgrade in the credit rating. The same event in 2050, under a high emission (RCP 8.5) scenario, could lead to a downgrade of three notches. The credit rating would fall from investment to sub-investment grade. Investing in adaptation today can significantly reduce future losses and economic impacts of extreme events.

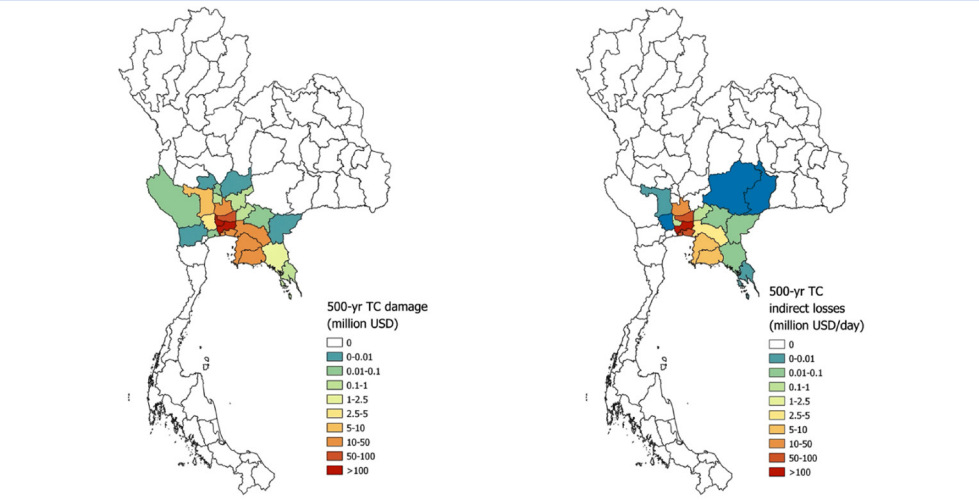

Figure 5: The direct (left) and indirect (right) impact of a 1-in-500 tropical cyclone (TC) event in today's climate.

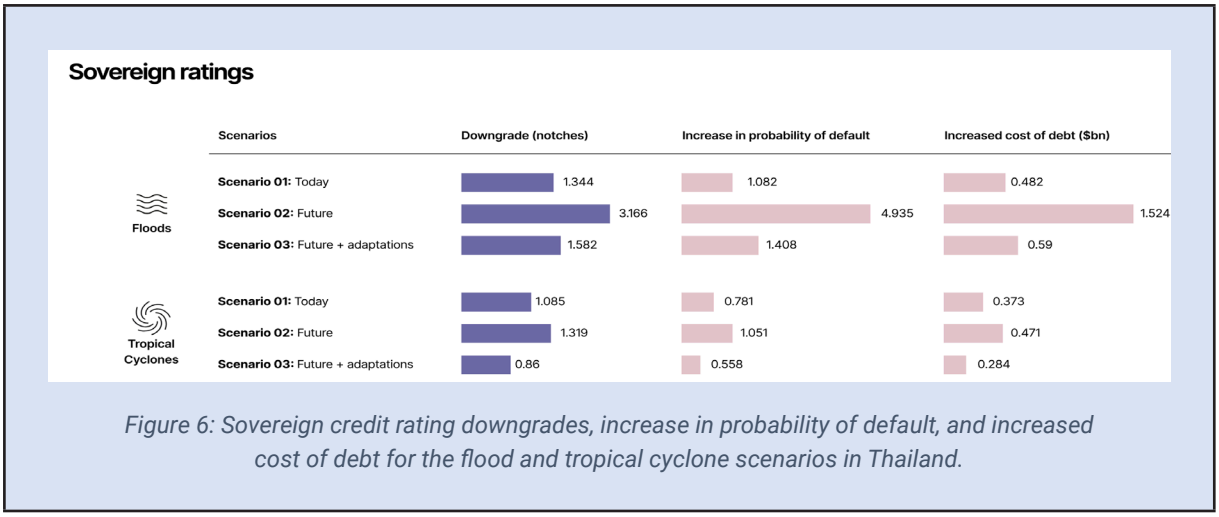

Figure 6: Sovereign credit rating downgrades, increase in probability of default, and increased cost of debt for the flood and tropical cyclone scenarios in Thailand.

Integrating Climate Risks and Adaptation into Debt Sustainability Analysis

A further challenge faced by countries is the lacking integration of climate change into debt sustainability analysis (DSA). The established IMF approach to DSA in developing countries has long been criticised on several grounds (Guzman & Heymann, 2015). We argue that it places excessive constraints on public investment in productive capital. Current DSAs treat all investment the same – as a public expenditure – and fail to recognise that many investments in capital (human, physical, natural) generate growth (and fiscal multipliers) and thereby lower debt to GDP over the long-term. Previous research has clearly demonstrated the green fiscal multipliers associated with mitigation (O'Callaghan et al., 2023). The analyses presented in Box 1 and 2 suggest that the same holds for adaptation. Investing in adaptation is pro-growth and therefore, needs to be treated differently within DSA and the related metrics used by Ministries of Finance, the IMF and credit ratings agencies to set debt ceilings and assess sovereign credit risks.

Today, very few DSAs fully integrate physical climate risks and even fewer adaptation and the models used in DSA do not capture all the risks (Box 3). The lack of integration of climate adaptation into DSAs, and subsequently sovereign credit ratings, not only impacts on governments ability to raise capital, but also suppresses private investment across the economy. Barring integration of adaptation in DSAs, neither the public or private sector can internalise the positive externalities from adaptation investment and the lack of these returns on investment further disincentivises investment. The vicious cycle deepens.

To demonstrate how climate adaptation can be integrated within DSA, we take the case of a low-income African economy (Box 4). In this analysis, we calibrate one of the IMF's own macroeconomic models used for DSAs – the DIGNAD model – to the country and use it to simulate the potential impacts of physical climate shocks (and earthquakes) on debt sustainability (measured by debt to GDP ratio). The analysis then demonstrates the substantial benefit of investing in risk reduction and adaptation. Refining and integrating such modelling within DSAs could be transformative in supporting countries to make vital investments in adaptation. Through integration into credit ratings, it can help create positive incentives for private investment as well.

Box 3: Physical Climate Risks, the DSA and Macroeconomic Modelling

There is a growing body of literature on the challenges and interpretation of macroeconomic models in the context of climate risks and climate policy. A commonly used tool for Ministries of Finance, World Bank and IMF staff in modelling the impact on shocks and stressors on debt sustainability is the Debt Sustainability Analysis (DSA) and more recently, the Sovereign Risk and Debt Sustainability Framework (SRDSF), alongside the IMF-World Bank Debt Sustainability Framework for Low Income Countries (LIC DSF) (IMF, 2022). These provide a standardised approach to conducting analyses of the risk of sovereign debt-related distress and public debt sustainability. There are several examples of climate change being incorporated into debt sustainability analyses using these frameworks, for example in Vanuatu (IDA-IMF, 2019).

The SRDSF and LICDSF (IMF 2022) include two aspects of relevance to understanding climate risks: (1) Medium-term risk assessment: under some criteria , the framework can include 'triggered' stress tests to capture specific risks facing countries that are not fully captured, including natural disasters; and (2) Long-term risk assessment: The long-term assessment covers risks of debt related stress that could materialise after 5 years. Climate change – or more specifically "the consequences of adaptation and mitigation investments to combat climate change" are one of four modules and are scenario-based and constructed back on the assumptions entered by users. The inclusion of climate change within the SRDSF (and the LIC DSF) toolkit is relatively simple – capturing natural disaster impacts on medium timescales and adaptation and mitigation investments on slightly longer timescales (5 years+). Few of the transmission channels are captured at all in the standardised scenarios. The inclusion of climate change physical impacts is narrow and does not account for changing climate risk over time (albeit the timescale of the DSA is short relative to climate) or the potential for higher impact events. There are also questions over whether these tools are being fully used in practice. These challenges can undermine the relevance of debt sustainability analyses.

Modelling the impacts of climate change on fiscal risks and sustainability

To capture the intersection and feedbacks between the economy, climate impacts, government budgets and adaptation and mitigation investments fully requires some form of integrated assessment modelling; specifically, the coupling of a macroeconomic model with some representation (model or scenarios) of climate impacts, adaptation and mitigation. There are significant and well-known uncertainties in our projections of the implications of climate change for the macroeconomic variables utilised in DSAs, driven by both uncertainties in the trajectory of socioeconomic development globally (including climate mitigation policies, innovation and roll-out of new low-carbon technologies and behavioural changes) and the resulting national and global emissions, the response of the global climate, the impacts on natural, social and economic systems, and our societal responses to these (i.e. adaptation). The challenges in making such projections and their dependences are well documented, e.g. in the reports of the Intergovernmental Panel on Climate Change (IPCC). A further major source of uncertainty is prediction of the interaction with the economy at micro- and macro-levels, and the feedbacks across the financial system and government fiscal balances. The limitations of IAMs are well documented (Farmer et al., 2015; Stern, 2016; and Hepburn & Farmer, 2020). Firstly, such models present an incomplete picture of the impacts of climate change, including missing extreme weather shocks (Stern, 2016). In addition, several phenomena induced by climate change – such as migrations, crop yield shocks, and social instabilities in exposed regions – are missing, as are the potential for cascading and compounding risks or nonlinear effects (Hepburn & Farmer, 2020). The links between climate and ecosystems and natural resources (such as soil, water, forestry) are excluded (Dasgupta, 2021).

Ranger et al. (2022) highlight five key challenges in assessing physical climate risks that are currently missing from most macro-economic and fiscal modelling of the implications of climate change, and together lead to an underestimation of physical climate risks, even on the relatively short timescale of the standard debt sustainability analysis:

- Representing the current and future risks of climate extremes, such as hurricanes, droughts, and floods—or disaster scenarios—in the analysis.
- Fully accounting for uncertainties in climate and impact models to ensure that scenarios span the space of potential future climate outcomes.
- Representation of the indirect and cascading impacts of chronic and acute climate risks on households and firms and their macroeconomic impacts.
- Representing the financial sector adequately to capture both the level of resilience of the financial sector to shocks and the complex feedbacks that can amplify risks by prolonging reconstruction and recovery.
- Compounding scenarios of climate shocks with other shocks and stressors.

The choice of macroeconomic model can then have significant implications for the findings. Macroeconomic models are imperfect representations of the economy; different model assumptions and structures can lead to vastly different projected outcomes for the same inputs. In addition, different types of models have different strengths and weaknesses and are suitable for different applications. A further challenge for practitioners for the application of such models in understanding future potential climate risks, is there are few studies that have compared the performance of different models. It is important to note also that, as of today, many of the transmission channels are not captured even in the most sophisticated macro-economic and macro-fiscal models, and that current models do not provide a complete quantified picture of the scale and dimensionality of impacts of climate change on the economy or the government balance sheet.

[3] SRDSF replaces the MAC DSA (approved by IMF Executive Board in January 2021).

[4] PRGT eligible countries are eligible to use SRDSF when they have graduated from being IDA only and demonstrate substantial and durable market access based on one of the tests used for the purposes of assessing eligibility to use the Fund's concessional resources.

[5] The natural disaster test, for example, is applied to MAC countries that meet the following criteria: (i) two natural disaster events in a three-year window; (ii) cumulative economic loss of at least 5 percent of GDP caused by the natural disaster events in that window. The natural disaster events considered include: (i) climate-related (droughts, wildfires, glacial lake outburst); (ii) geophysical (earthquakes including tsunamis, volcanic activities, dry mass movements); (iii) hydrological (floods and landslides); (iv) meteorological (storms, and extreme temperature events such as cold and heat waves); (v) biological (epidemics and insect infestations); and (vi) extra-terrestrial (asteroid impact). Information about natural disaster events and economic costs are taken from EM-DAT database between 1980 and 2021.74. In addition, the test is also applied to MAC Small States identified in IMF (2016).

Table 2: Comparison of macroeconomic model types

	Dynamic Stochastic General Equilibrium **DSGE**	Computable General Equilibrium **CGE**	Stock Flow Consistent **SFC**	**Process based-Integrated Assessment Models**	**Aggregated Integrated Assessment Models**
Representation of the Economy	**Detailed** calibrated on sector data at country and regional level. Market-clearing prices, representative agents with forward-looking expectations. Finance treated as exogenous frictions	**Varied** Dynamic CGEs calibrated on granular sector data at country and regional level. Market-clearing prices, representative agents with forward-looking expectations. No finance	**Detailed** dynamic balance sheet assessment with endogenous shocks. Agents' heterogeneity and adaptive expectations. Out of equilibrium dynamics. Financial agents and markets, macro-financial feedbacks	**Aggregated** Ramsey-style long-term economic growth model, representative agents, market clearing prices. No finance	**Aggregated** Ramsey-style long-term economic growth model, representative agents, market clearing prices. No finance
Representation of Non-economic Systems	**No** Some models might embed GHG emissions from production	**No** Some models might embed GHG emissions from production	**Yes** Agriculture, energy	**Yes** Agriculture, land-use, energy, water and climate systems	**Limited** Climate system
Price of Carbon	**Exogenous/ assumed**	**Exogenous/ assumed**	**Endogenously generated**	**Marginal Abatement Cost**	**Social Cost of Carbon (SCC)**
Use for Cost Benefit Analysis	**No** Used to build economic intuition	**Yes**	**Yes** Comparison of policy costs (socio-economic, financial) and co-benefits	**No** Climate damages calculated separately	**Yes**
Geographic Resolution	**Global-Regional-Country**	**Regional-Country**	**Regional-Country**	**Global-Regional** Country available through additional downscaling	**Global-Regional**
Explicit Accounting for Carbon Budget	**No**	**No**	**No**	**Yes**	**No**
Sector Granularity	**Limited** Energy sector	**Yes** Full sectoral disaggregation of the economy	**Yes** For high/low-carbon, labor/capital intensive sectors in the economy	**Yes** Several energy intensive sectors and several technologies	**No**
Bibliography	*Xiao et al. (2022)*	*Babatunde, Begum and Said (2017) Carbone and Rivers (2017)*	*Caversasi and Godin (2015), Dafermos et al. (2017), Monasterolo and Raberto (2018), Dunz et al. (2021)*	*Calvin et al. (2013); McCullum et al. (2018); Rogeli et al. (2019); Kriegler et al. (2013)*	*Nordhaus (1993, 2018); Anthoff and Tol, (2014); Hope et al. (1993)*

Source: Monasterolo et al., 2022.

Several authors have argued that the current standard economic toolkit is not well suited for analysing the economic, fiscal and financial impacts of climate change. For example, in the last decade, research in macroeconomics and finance has extended to consider climate change and more complex risks, as well as their transmission channels and impact on the real economy. A particular challenge identified by Ranger et al. (2022) is the issue of compounding and cascading risks. Nature loss in particular can create cascading feedbacks. Johnson et al. (2021) estimate that, in a conservative scenario, a collapse in select nature services could result in a decline in global GDP amounting to $2.7 trillion in 2030, equivalent to over 3% of current world GDP. Ranger et al. (2024) show that losses of up to 12% of GDP are possible under some scenarios. In addition, climate-related stresses will build up and compound with localised shocks, cascading through global supply chains and the financial sector. This type of compounding multi-dimension risk represents a new type of risk for macroeconomic modelling, policy and regulation. It represents a structural change in the economy and its implications cannot be simply deduced by the sum of individual risks and transmission channels. Indeed, when risks interact, they can give rise to non-linear dynamics in the economy and financial systems, generating a prolonged out of equilibrium state of the economy. Individual "agents", people, firms, and investors, behave differently in these circumstances. Deep uncertainty about the out-comes makes decision making more difficult for individuals and policy makers. This, in turn, contributes to increase uncertainty for firms and investors. When agents are uncertain about the impacts of the complex shocks, and about the out-comes that will prevail, they cannot have perfect foresight. Risk averse firms will consequently delay the investment decisions, whereas risk averse banks will tighten firms' access to credit, by revising the cost of debt upward. This means that economic, monetary and fiscal policies aimed at restoring stability will be less effective because their economic signalling might be weaker in the face of the uncertainty. Considering these important feedbacks between the economy, the financial sector and policy are therefore critical (Battiston et al., 2021).

The World Bank (2022) noted that different models are appropriate for different decisions and wherever possible, multiple models should be used. Also, users must understand fully what is and what is not included in models, assumptions and scenarios in the context of the key risk transmission channels. Where there are (inevitably) gaps, practitioners should consider the use of complementary analyses – e.g. narrative scenarios – and sensitivity testing to ensure that the impacts of climate change adequately represented.

Sources: Volz and Ranger, 2023; Ranger et al., 2022.

Building Fiscal Resilience through Closing the Financial Protection Gap

Fiscal resilience can be strengthened both through investing in ex-ante risk reduction and through risk financing. Risk financing, including contingent credit, national disaster funds and risk transfer instruments such as insurance and catastrophe bonds, do not eliminate the impacts of disasters on people and assets, but do reduce the financial cost and impact. Risk financing is the ex-ante arrangement of financing to fund anticipatory or post-event response and recovery. By having risk financing in place, governments, businesses or households can access rapid and cost-effective financing in emergencies, accelerating recovery and reconstruction and so reducing the impacts on long run development. Risk financing can also be linked to cash-transfer or other social protection systems to help people and can create positive incentives for preparedness. As illustrated in the example in Box 1, sovereign risk financing, can significantly reduce the fiscal impacts of disasters and so reduce the impacts on debt sustainability. Across many emerging and developing countries, regional risk pools are in place that can offer even more cost-effective financial protection, through leveraging

international donor capital. Four regional risk pools currently exist: African Risk Capacity; the CCRIF in the Caribbean; the Southeast Asia Disaster Risk Insurance Facility (SEADRIF); and PCRAFI in the Pacific. Significant knowledge resources are available on risk financing, including guidance on the development of disaster risk financing strategies and risk layering approaches for financial instruments. We refer readers to the World Bank's Financial Protection Forum and the Global Shield against Climate Risks for more information.

Toward Sustainability-Linked Sovereign Finance for Adaptation

The improved fiscal resilience and debt sustainability of countries investing in adaptation implied through these examples, suggests a potential case for a lower cost of capital (coupon reduction) in sovereign financing that is clearly linked to adaptation. Use of proceeds bonds have been increasingly linked to adaptation; for example, research by the Global Centre for Adaptation found that around 16% of green bonds have an adaptation component (GCA, 2021). Could developing economies secure a 'greenium' for such bonds given the benefits of adaptation for cost of capital demonstrated in this report? Sustainability-linked sovereign finance – with form of performance-based coupon – could be another modality to ensure countries benefit from a direct cost of capital reduction for investing in adaptation. Research by the University of Oxford (Resendiz, Ranger et al, forthcoming) shows that such instruments are already present in private corporate bond markets, offering prospects of similar instruments for sovereigns. The fact that many of the countries in question are highly indebted could also increase interest in debt-swaps for adaptation, but the literature needs to first come to agreement about their associated risks, and clearly identify situations in which they are more or less likely to lead to desirable outcomes (High-Level Expert Group on Scaling Up Sustainable Finance in Low- and Middle-income countries, 2024).

Box 4: Fiscal Impacts of Earthquakes and Floods and Benefits of Adaptation Infrastructure Investment – Low Income African Economy

The Debt-Investment-Growth and Natural Disasters (DIGNAD) macroeconomic model, which is a dynamic general equilibrium (DGE) growth model of a real small open economy developed by the IMF (Aligishiev et al., 2023), is applied to demonstrate the fiscal implications of acute climate risks and potential benefits of adaptation infrastructure.

The model is calibrated to match the macroeconomic country profile estimates of a low income African economy. Two main public infrastructure investment options are considered: (i) standard, and (ii) adaptation infrastructure, which is more expensive than its counterpart but has a lower depreciation rate and higher rate of return on investment; all of these variables are adjusted in the model to align with previous literature (IMF, 2022a; Marto et al., 2018; Melina & Santoro, 2021). For each option, it is assumed that the government invests 1.0% of GDP into its respective infrastructure option for the first five years before the disaster occurs and uses the public domestic and external commercial debt to cover the fiscal gap.

In terms of disasters, four scenarios are produced for the impact estimates to be equivalent to the direct damages of (i) a 1-in-10 and (ii) 1-in-1000-year earthquake and (iii) a 1-in-10 and (iv) 1-in-1000-year return period (RP) flood events. These disaster events are based on the probable maximum loss (PML) curves from the Global Infrastructure Resilience Index (GIRI) platform, a fully probabilistic model which can estimate the economic vales of climate risks to infrastructure (CDRI, 2023). For the DIGNAD model, when a disaster occurs, it affects three main channels of the economy: (i) destroying the public infrastructure assets, (ii) destroying the private assets, and (iii) reducing the total factor productivity (Aligishiev et al., 2023). For simplicity purposes, regardless of the disaster severity, it is assumed that it will take one year for the government to recover its infrastructure to its pre-disaster level on all four scenarios.

Figure 7 demonstrates the impacts of earthquakes on the total public debt. Looking at the standard infrastructure investment option, at its peak year, the public debt could reach up to 63.7% of the country's GDP in a 1-in-10-year event and 70.6% in a 1-in-1000-year event. In comparison with the adaptation infrastructure investment option, the public debt could increase up to 63.6% in a 1-in-10-year event and 67.8% in a 1-in-1000-year event. This means that between 0.2% and 2.8% of the total public debt could be mitigated as a result of adaptation infrastructure investment. Similarly, Figure 8 illustrates the impacts of floods on the total public debt in Rwanda. For standard infrastructure investment, the public debt could reach up to 63.7% in a 1-in-10-year event and 63.9% in a 1-in-1000-year event. As for adaptation infrastructure investment, the public debt could increase to 63.6% in both 1-in-10 and 1-in-1000-year events, indicating that between 0.2% and 0.4% of the total public debt could be reduced by investing in adaptation infrastructure.

In addition to the above observations, it is worth highlighting again some initial parameters, for example these scenarios considering only the direct damages of disasters and, in the resilient option, the government investing only 1.0% of its GDP per year in the first five years in adaptation infrastructure. These factors suggest that the potential fiscal benefits of adaptation infrastructure investment could be significantly higher than observed in the proposed scenarios.

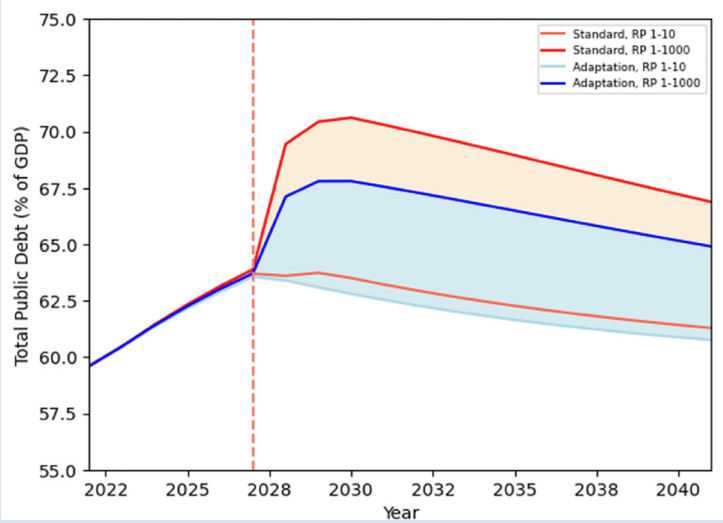

Figure 7: The impacts of earthquakes on total public debt in Rwanda.

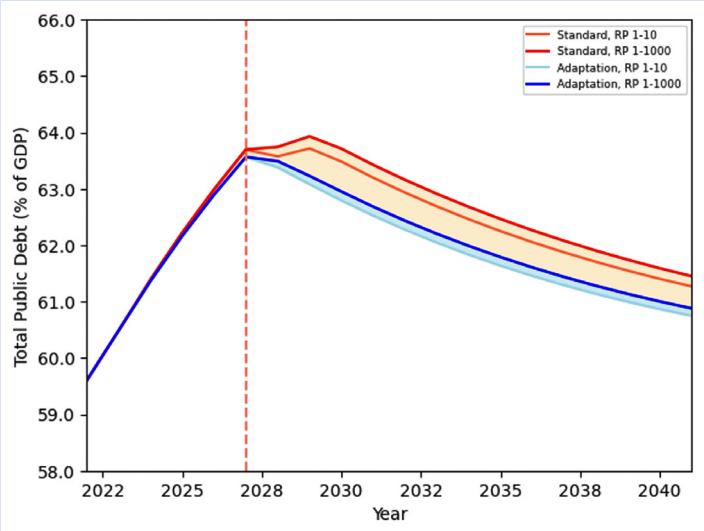

Figure 8: The impacts of floods on total public debt in Rwanda.

Recommendations

R1. Incorporate climate change and adaptation routinely into fiscal risk analysis and debt sustainability analyses, including analysing the benefits of adaptation for fiscal space, fiscal resilience and sovereign credit ratings.

R2. Explore if and how cost of capital for sovereign financing instruments could be reduced through investment in adaptation, including implementing appropriate disaster risk financing strategies and exploring the opportunities for labelled bonds and sustainability-linked sovereign finance for adaptation.

4. ALIGNING FISCAL EXPENDITURE AND ADAPTATION

While it is vital to create more fiscal space for adaptation investment, it is also essential to ensure existing public investment is aligned with adaptation and resilience goals. Frameworks such as Mullan and Ranger (2022) provide guidance and steps for the alignment of finance and investment with climate resilient development goals. Previous analysis supported by UNEP demonstrates the missed opportunities for governments to align fiscal policy with climate-resilient development. Sadler et al. (2024) demonstrate that only 10% of Covid-19 recovery spending was likely to enhance direct climate adaptation – though this rose to around 27% when potential indirect impacts were accounted for. Proportions were even lower in Africa at 10%. However, the study also found that nearly 28% of recovery spending could have negative impacts for adaptation, for example by locking-in non-resilient infrastructure.

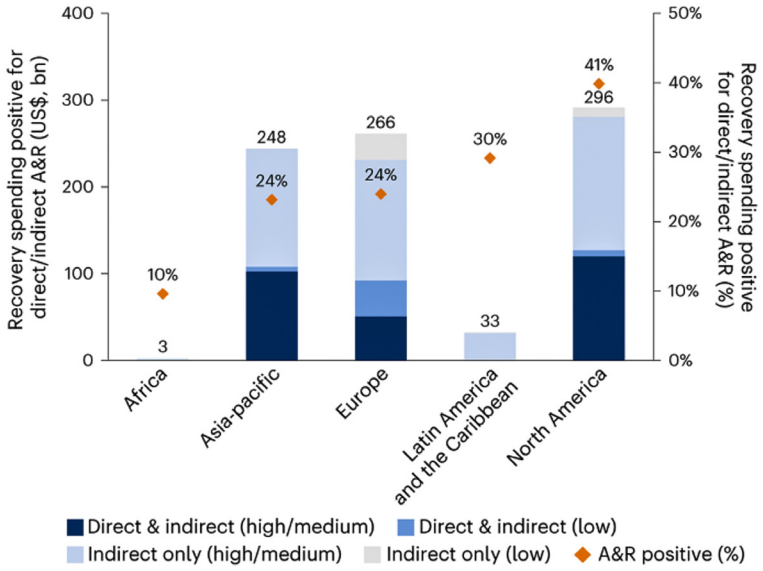

Figure 9: Recovery spending (US$, billion) by region, on policies that positively impact direct or indirect climate A&R, broken down by confidence level (Sadler et al., 2024).

New research conducted as part of this paper shows that the situation is even more difficult for nature-based infrastructure (Spacey Martín & Ranger, n.d.). The 2019 Global Assessment Report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) concluded that fourteen of the eighteen ecosystem services ('categories of Nature's contribution of people') that were assessed had declined since the 1970s (Brondizio et al., 2019). It further concluded that "nature across most of the globe has now been significantly altered by multiple human drivers, with the great majority of indicators of ecosystems and biodiversity showing rapid decline".

Estimates indicate that more than half of the world's GDP, equal to US$ 40 trillion, is moderately or highly dependent on nature and its services (World Economic Forum & PwC, 2020). Ranger et al. (2023) demonstrates the sizeable negative economic and financial impacts associated with this loss; totalling in excess of $7 trillion value at risk. Recent analysis by the UN Environment Programme found that investment in nature-based solutions must almost triple by 2030 to $542 billion if we are to meet global climate, land and biodiversity targets (UNEP, 2023c). In addition, to achieve global biodiversity goals, it is vital to curtail the nearly $7 trillion of financial flows that have a direct negative impact on nature, including $1.7 trillion of public funding to environmentally harmful subsidies.

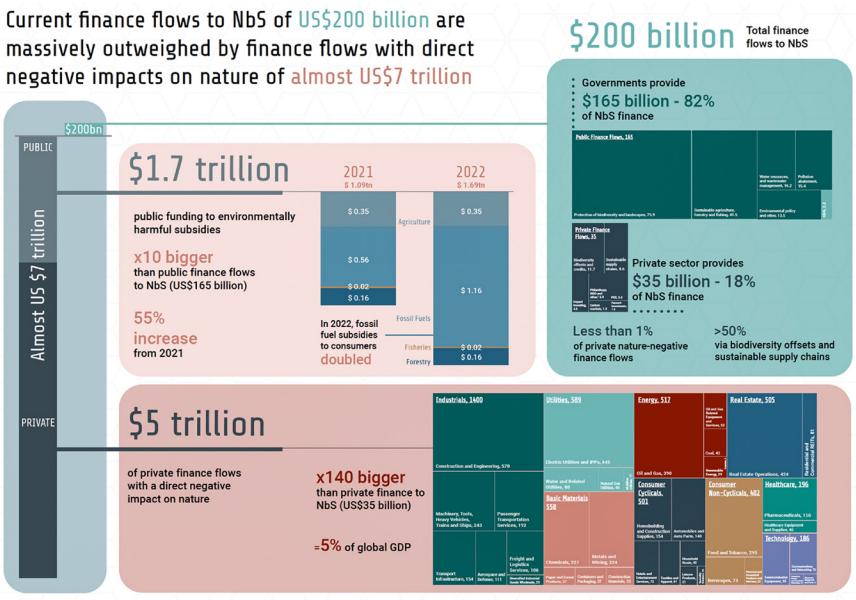

Figure 10: Current flows impacting nature (UNEP, 2023c).

Building upon the taxonomy of fiscal policies developed by the Global Recovery Observatory (GRO) and further refined in Sadler et al. (2024), we analyse the alignment of public expenditure during the COVID-19 response and recovery period that is nature-positive. Compiling and classifying over USD $17 trillion worth of fiscal spending over 42 policy archetypes and 293 sub-archetypes reveals that only 1.4% of spending had a net-positive impact on nature or biodiversity.

Even considering only the 20 most biodiverse countries according to the Global Biodiversity Index (Nash, 2022), only 2% of spending was nature-positive. Existing nature-positive activities included spending on green market creation, natural infrastructure and green spaces investment, and clean energy infrastructure investment. On the other hand, in Africa alone, 13% of the fiscal expenditure in response to COVID-19 had potentially a direct negative impact on nature and ecosystem services. Similarly, when isolating the four Least Developed Countries (LDC) in our sample, 25% of spending was considered to have a negative impact on nature (Spacey Martín & Ranger, n.d.).

The analysis reveals missed opportunities for securing positive impact by, for example, investing in improved agricultural land management practices, green worker retraining, and green job creation. These preliminary findings suggest that nature-related considerations need to be embedded in existing policy decision-making frameworks to secure otherwise missed opportunities and prevent avoidable losses.

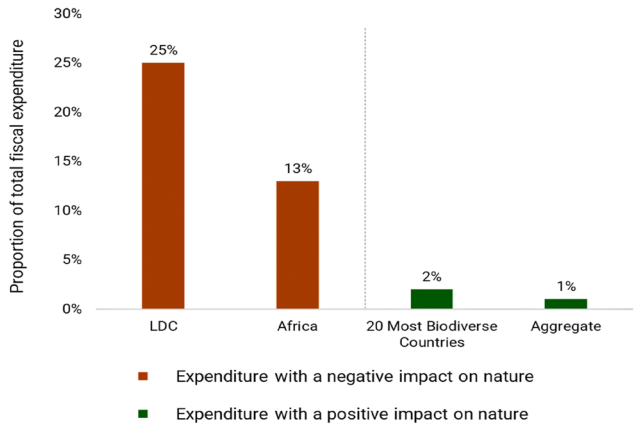

Figure 11: Proportion of COVID-19 fiscal expenditure with a positive and negative impact on nature. LDC covers all countries in our sample found on the official UN listing of LDCs (UNCTAD, 2024). The 20 most biodiverse countries are according to the Global Biodiversity Index (Nash, 2022).

Analyses such as these, however, can also help identify win-win opportunities for adaptation and nature. For example, the typology of fiscal policies developed in our analysis suggests that investments with specific adaptation & resilience considerations into agriculture, fishing, forestry, public green spaces and others can have significant nature-positive benefits as well. Equally investments into new sustainable housing or rural development programmes with adaptation & resilience considerations can still contribute to nature loss if nature is not fully considered at the intervention design stage. This, again, underlines the importance of approaching policy issues comprehensively, to ensure safeguards are in place to prevent losses.

This analysis also illustrates the power of nationally determined adaptation taxonomies as both a screening and monitoring tool for adaptation, including resilient infrastructure and nature-based solutions. Spacey Martín and Ranger (n.d.) identified already 25 adaptation taxonomies developed by both state and non-state actors. Such taxonomies can be aligned with national adaptation plans and goals to help guide both public and private investment, as well as to form a basis for the issuance of sovereign bonds and as screening criteria for blended finance facilities (discussed in subsequent sections). This leads to a clear recommendation for governments to develop taxonomies and link these to national plans, and complement these tools with frameworks to assess the alignment of expenditure on a project-by-basic basis, following for example frameworks such as Mullan and Ranger (2022) and the World Bank's Resilience Rating System (World Bank, 2021).

Recommendations

R3. Development of an appropriate adaptation taxonomy (or integration of adaptation within a green taxonomy) that is aligned with national goals,

R4. Integrate adaptation within sustainable budgeting approaches, project procurement and project appraisal, and use sustainability budgeting approaches as a tool to identify where public expenditures could be more strongly aligned with national adaptation and nature goals.

5. MAXIMISING THE IMPACT OF PUBLIC EXPENDITURE: MOBILISING PRIVATE INVESTMENT

Given the constraints on public resources for adaptation, there has been increased focus on breaking down barriers to investment and mobilising private funds. Blended finance (BF) has emerged as a key tool to jointly address four key investment barriers for climate finance in emerging markets: lack of scaled investable products for private investors, challenging risk-return profile, scarcity of flexible capital for production innovation, demonstration and scaling, and limited number of climate finance actors at the transaction and market levels (Gregory, 2023; OECD, 2023; Pande et al., 2023). A high-level review of existing blended finance facilities globally suggests that very few fully integrate adaptation as a core objective, even for infrastructure. This is surprising, given the public good nature of adaptation investments and the well-known barriers to private investment in adaptation and infrastructure. This section focusses on the role of BF in scaling private finance for adaptation-relevant infrastructure within the larger context of international development finance.

Mobilising Finance for Adaptation in the Infrastructure Sector

In this section, we use historical data from OECD (2024a) to explore the most common structures used to finance adaptation-relevant infrastructure through official development assistance (ODA) around the world. We then show the extent to which ODA interventions managed to mobilise commercial capital into this sector. The terms "mobilisation" or “leverage” are variably used to describe the “causal link between private finance made available for a specific project and an official intervention” (OECD, 2020, 2023). We use the OECD mobilisation survey for 2012–2021, as it contains the most comprehensive semi-disaggregated data available on the topic (see, e.g., Attridge & Engen, 2019).

Historically, only 14 percent of global blended climate finance has focused solely on adaptation, and only 14 percent of these investments were destinated for Sub-Saharan Africa (Ahairwe & Bilal, 2023; Convergence, 2024) – one of the most climate vulnerable regions globally (Adom, 2024). Contrary to these trends, grant resources including the grant-equivalent of BF interventions ought to be reserved for adaptation and development projects in the world’s poorest countries, especially considering that mitigation finance to developing countries shows little tangible impact on global emissions to date (Kenny, 2024)

Rather than an investment approach or an instrument, BF represents a structuring approach that strategically uses concessional capital and non-monetary assistance, most frequently from public or philanthropic sources, to mobilise additional commercial capital for sustainable development projects by engineering the risk-return profile to private investors’ advantage. Four archetypical structures of BF are briefly outlined in Box 5 below.

Broccolini et al. (2021) show that syndicated loans by multilateral development banks (MDBs), for example, can mobilize about seven dollars in bank credit over a three-year period for each dollar invested. Lu et al. (2024) find a positive link between co-financing and Chinese overseas infrastructure project outcomes; co-financed projects are significantly less likely to be cancelled or suspended. They are also more likely to have localized implementation and, where co-financed with international partners, have lower carbon emission intensity and lower biodiversity risk on average (Lu et al., 2024). These findings underscore the importance of collaborative finance approaches to developing infrastructure projects in the Global South. The following subsection analyses historical data on adaptation-specific infrastructure finance in developing countries to characterise typical traits of blended finance in this sector.

Box 5: Blended Finance Archetypes

Typical blended finance interventions, as depicted in Figure 10, often involve the use of concessional (i.e., below market terms) funds within the capital structure of a project (Panel A) to lower the overall cost of capital or to provide an additional layer of protection to private investors (see, e.g., Convergence 2024). Often, this protection is further formalised through loan arrangements in which debt to concessional partner(s) is subordinated, while commercial debt is prioritised as senior. Concessional investors may also provide credit enhancement through guarantees or insurance on below-market terms (Panel B), making the project's risk-return profile increasingly attractive for commercial investors (Attridge et al., 2023a).

Grant-funded technical assistance can also be an effective tool to strengthen a project's commercial viability, when direct provision of concessional funds to a project is not favoured by the providers (Panel C). Likewise, grant-funded project design can lower the cost of capital when it is often scarcest (Panel D), namely during the early, most uncertain stages of a project's lifespan (Convergence, 2023).

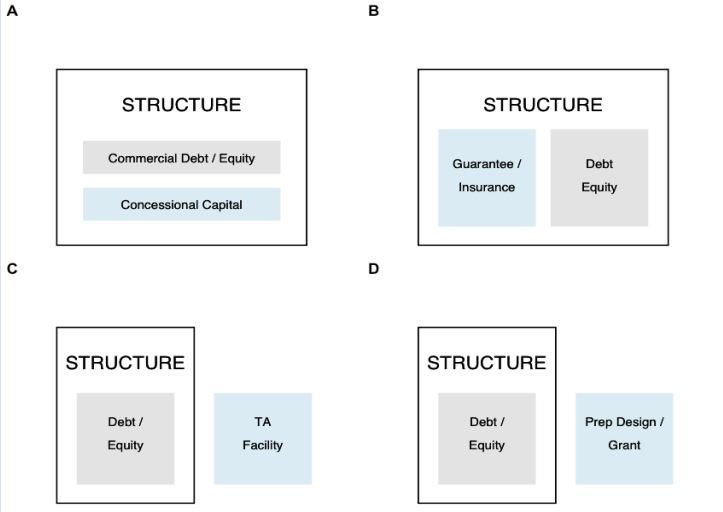

Figure 12: Archetypical blended financing structures and leveraging mechanisms (Convergence, 2024).

The use of external expertise at an early stage may also result in de-risking in the eyes of commercial investors, especially when it comes from a trusted or well-known source that investors have experience with. This non-monetary source of credibility helps to explain, in part, why so much of blended finance is implemented by high-level actors like MDBs and development finance institutions (DFIs), in addition to a few larger NGOs, Philanthropic enterprises, and dedicated investment funds (see, e.g., van Raalte & Ranger, 2023).

The OECD creditor reporting system (CRS) between 2010 and 2021 reveals that adaptation finance in infrastructure has increased drastically to almost 30 billion USD in 2020 – a tenfold increase relative to 2010. Debt finance has become the dominant financial instrument (FI) used in this area, accounting at times for up to two thirds of total commitments. Grant finance has also increased in its share, while equity and mezzanine finance remain largely insignificant. In fact, their shares are barely visible in the larger bar chart in Figure 13 below but zooming in reveals that Equity and Collective Investment Vehicles (CIV) have also grown significantly – or be it at several orders of magnitude below grants and debt – while Mezzanine FIs remain a fringe instrument in the adaptation-related infrastructure sector.

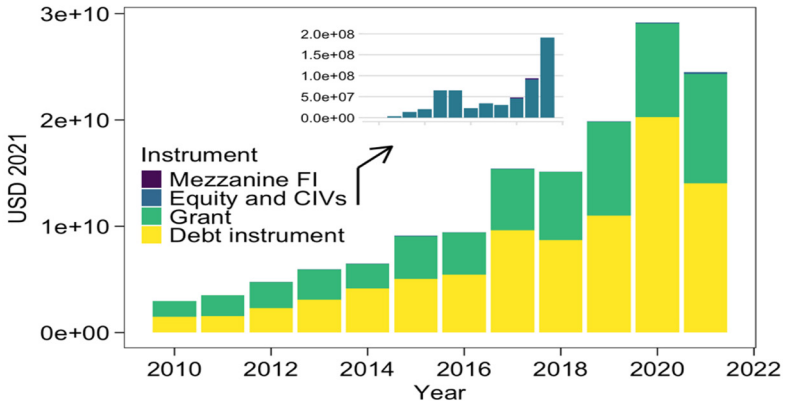

Figure 13: Adaptation finance in infrastructure, by instrument (data sourced from OECD, 2024a).

Another dataset provided by OECD-DAC enables us to explore the correlation between different provider types of concessional finance for adaptation-related infrastructure projects, and the amount of private capital leveraged as a result. Figure 14 below shows that the composition of leverage mechanisms differs slightly across types of concessional capital providers. Bilateral lenders – here mostly DAC members – rely on credit lines to a much larger extent than either international funds or multilateral development banks. They also rely more on shares in CIVs and simple co-financing, and less on syndicated loans than their multilateral counterparts. International funds predominantly use syndicated loans to mobilise private capital, while hardly using any co-financing.

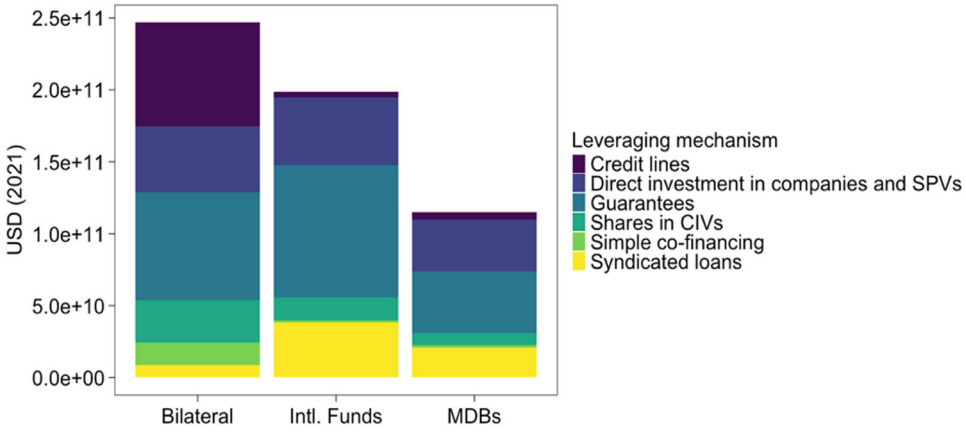

Figure 14: Leveraging amounts and mechanisms in adaptation finance 2012–2021, by provider type (data sourced from OECD, 2024b).

While the historical data shows that mobilisation into adaptation-finance for infrastructure has increased drastically between 2012 and 2021, it also shows a peak in private investment mobilisation in 2018, followed by a relative slowdown in 2019–2021. Considering the size of the remaining financing gap in adaptation, this loss of momentum warrants further attention.

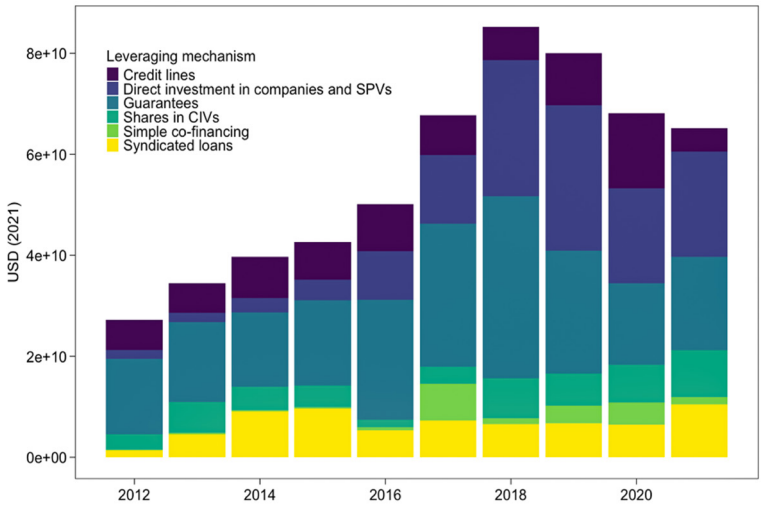

Figure 15: Leverage mechanisms in adaptation finance by year (Data: OECD, 2024b).

Geographically, this mobilised commercial capital has been unequally distributed. Figure 16 below maps the average of mobilisation per capita per year across the developing world. The dashed box indicates the limits of the tropics – the region of the planet where the adverse effects of climate change are most acute and the need for climate adaptation the highest. Notably, the countries receiving most additional capital for adaptation-related infrastructure through leverage, weighted by their population, lie outside this zone for the most part.

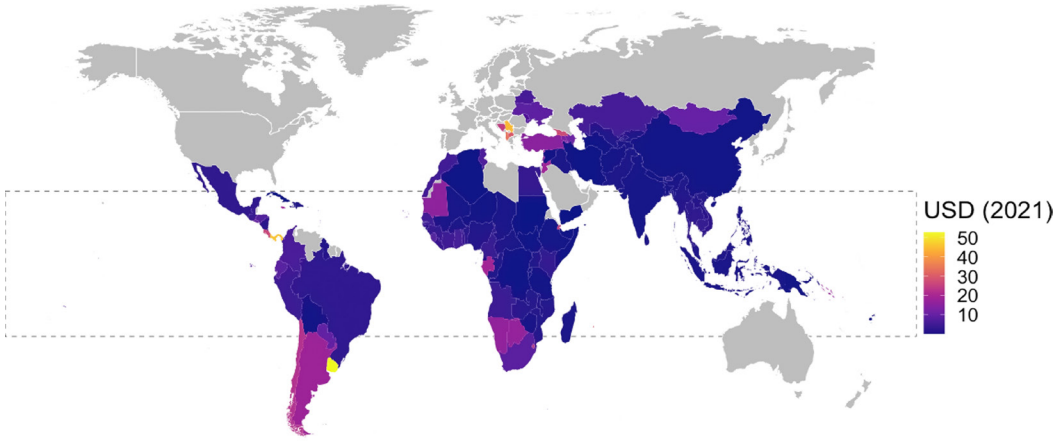

Figure 16: Per capita mobilised commercial capital into adaptation-related infrastructure finance, 2012–2021.

South America is particularly interesting in this respect. Uruguay receives about 50 USD per capita, and Argentina and Chile – two other relatively rich countries in the region – also receive larger shares of mobilised capital than countries further north. Central America, too, receives relatively high amounts, as do some of the states located in the Balkans.

In terms of cumulative mobilisation per capita in 2012–2021, 6 of the top ten receiver countries were in Europe. Montenegro had the highest mobilisation per capita out of any country at about 1500 per capita. Panama (3), Costa Rica (8), and Uruguay (9), some of the richer countries in Latin America, received the most mobilisation on the continent. Jordan (10), the only country in the top ten outside Europe and Latin America, received less than a sixth of Montenegro's per capita mobilisation. In contrast, the eleven countries at the bottom of the distribution received less than a US dollar per capita. They included Sudan, Cuba and Equatorial Guinea, all of which received less than a cent per capita in mobilised capital.

The unequal distribution of mobilised private capital for adaptation-relevant infrastructure finance is also apparent in Figure 17 below, which shows how total mobilisation in this sector in 2012–2021 correlates with some other potentially relevant factors.

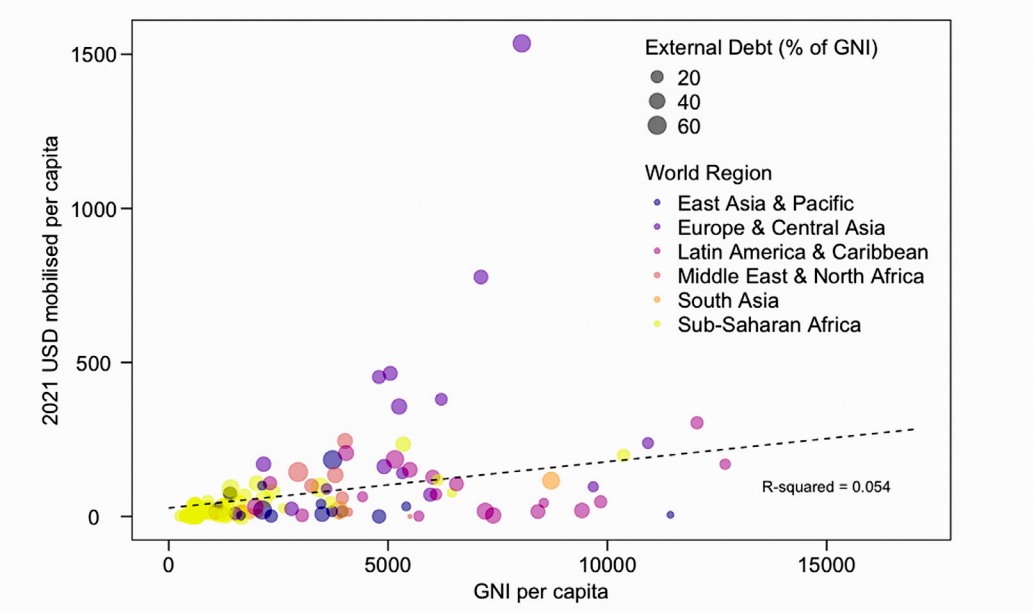

Figure 17: Correlation of mobilised funds, GNI per capita, and External Debt (Data: OECD, 2024b; World Bank, 2022).

The cluster of yellow shows that Sub-Saharan African countries receive much less of the capital mobilised than, say, their Middle Eastern or Latin American counter parts, while also having lower income per capita. On average, European and Central Asian nations receive the most USD per capita in mobilised capital. While some of these trends can be explained by adverse investment environments and weak financial markets (e.g., in Cuba or Sudan), the broader trend across SSA is less easily attributed (see Prasad et al., 2022 for an analysis of structural barriers). There is a clear bifurcation in the graph, where on the one hand European and Central Asian countries' share of mobilised capital grows exponential relative to their GNI per capita. On the other hand, it seems that the relationship between Gross National Income (GNI) and mobilisation per capita follows a linear trend for the rest of the sample – a trend that, by itself, explains more than five percent of the underlying variation in mobilisation. Either way, mobilisation per capita is shown to be monotonously increasing in GNI per capita, which is in line with the literature.

While it should not be interpreted as a causal statement, this illustrative result shows that the geographic inequality is reinforced by an apparent trend, by which relatively richer countries obtain more mobilised capital than lower-income countries (LIC). Adding S&P sovereign credit ratings and a country's external debt to the regression does not have significant effects on these results, suggesting that the unequal apportioning of mobilised capital cannot simply be explained away by concerns over solvency or sovereign credit ratings alone. These results show that we are still in need for a better approach to effectively deploy blended finance in the poorest countries (Attridge & Engen, 2019; Gratcheva et al., 2024; Kenny, 2021; Pande et al., 2023) as part of the larger poverty-climate nexus (Lankes et al., 2024).

The Economics of Maximising the Impact of Public Funds

Given that the concessional funds used in blended finance are a scarce and (predominantly) public resource, their use should be targeted according to both socioeconomic efficiency and equity considerations. Warner (2013) provides a static and highly stylised framework for of public investment decisions, which Pegon (2023) applies to identifying ("targeting") suitable projects for BF interventions. For BF to achieve increased capital mobilisation, enhance a project's impact, and deliver risk-adjusted financial returns to investors in an efficient way then, any given project should fulfil the following three pre-requisites:

1. Positive externality: Net social returns are positive and exceed private returns.
2. Financial Additionality: Private returns without blended finance are lower than the risk-adjusted return threshold at which financiers choose to invest.
3. Opportunity cost efficiency: there is no other available use of public resources that would yield a higher ratio of social returns to costs over the same project time horizon.

They are jointly visualised in the project space depicted in Figure 18 below where any potential project can be located as a point in two dimensions. For projects that lie on the 45-degree line, private returns equal social returns. Projects below the line exhibit positive externalities to society. The dashed horizontal line is the level or risk-adjusted private returns at or above which a project is "bankable" (i.e., interesting to private investors without need for additional interventions or de-risking). The shaded rectangular area immediately below this line delineates the operating space where blended finance is socially desirable and efficient, conditional on the existence of alternative projects to its right.

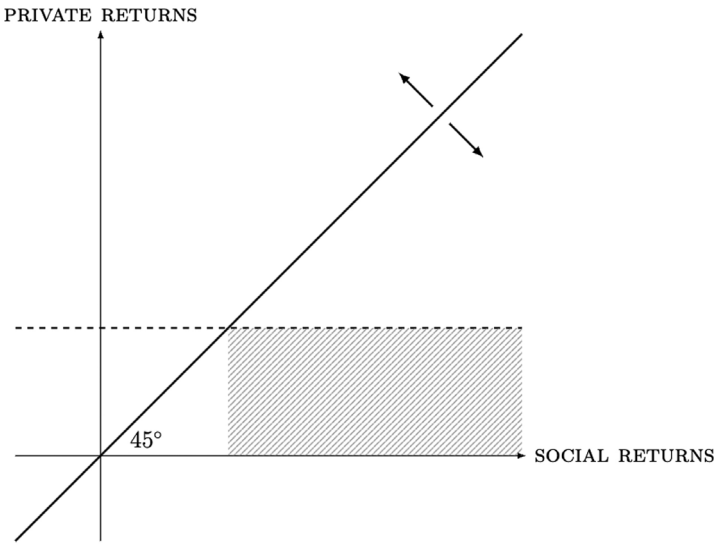

Figure 18: A conceptual framework for targeting blended finance (based on Warner, 2013).

If a project does not exhibit a positive externality for society, there is no case for the use of public capital to begin with. Likewise, it is hard to justify using concessional capital to subsidise commercial investors, if they had invested in the project to the same extent without it (Kenny, 2019a).

Whether or not a given project would be bankable without involving concessional capital, though, is a counterfactual that is hard to pin down in practice. Assuming efficient allocation of market capital to the most promising projects is bound to ignore the presence of one or more market failures – including the positive externality in prerequisite 1 – that are likely to

persist barring further intervention (see Attridge et al., 2023b on strategies for market building; and Stern et al., 2022 for climate related market failure overlap). EMDEs are particularly prone to multiple market failures which explains the "deep-seated financing gap for Climate Change mitigation and adaptation" (IMF, 2022b) in these markets and offers a rationale for the creation of dedicated asset classes to tackle their unique challenges (IFC, 2023; Lankes & Robins, 2023; NGFS, 2023).

On the other hand, targeting blended finance at projects that have proven positive externalities and remain underfunded will almost certainly be less than optimal unless there is a clear pathway to financial maturity. By its very nature, blended finance is intended to help projects overcome financial and structural barriers to market entry with the understanding that, once financial maturity has been reached, the project will be able to attract enough commercial capital to operate by itself (den Heijer & Coppens, 2023).

Likewise, targeting projects based on their potential leverage can prove difficult ex ante and should follow a probabilistic understanding of (financial) additionality (Carter et al., 2021) instead of binary classification as either additional or not (Carter et al., 2021; Kenny & Yang, 2020; Winckler Andersen et al., 2021). The third prerequisite encapsulates opportunity cost which is particularly relevant because concessional finance is so scarce and there are relatively few projects to choose from, some of which may nonetheless have crucial impact on social welfare (Kenny, 2019b).

Going beyond the static model for targeting blended finance depicted in Figure 18 (Flammer et al., 2024; Pegon, 2023; Warner, 2013), uninternalized learning spill-overs and cooperation problems between investors over time may play a role in determining of a project's future bankability, independent of whether other market failures have already been resolved (Waidelich et al., 2023). In any case, if the public good characteristics of a given project dominate its commercial viability, blended finance may be less suited and purely public provision or long-term subsidisation of private provision (as in PPPs) may be more appropriate from a societal perspective (den Heijer & Coppens, 2023).

Practical Steps

Countries and their international partners need to produce more evidence on the financial additionally of public investment to better understand how to target public investment most cost effectively for adaptation.

While they are firmly rooted in fundamental economic theory, the guidelines presented above do not easily translate into practicable, tangible policy action. That is mainly because some of the concepts used throughout the framework are well-defined in theoretical terms (e.g., additionality, opportunity cost, etc.) but difficult to measure in an applied setting. To provide some actionable guidance, nonetheless, consider that the main issue with assessing the additionality of a marginal unit of mobilised capital lies in the lack of a credible baseline which it can be compared to.

Hence, it can only be an improvement if international donors, MDBs, as well as recipient countries and local stakeholders work together to achieve a higher level of transparency and data sharing in the international development finance space. Disaggregated data, beyond the level currently available through OECD DAC for example, could enable researchers to apply causal inference methods capable of establishing a credible counterfactual and, in that way, to estimate the additionality of mobilised capital (Flammer et al., 2024).

Policy makers should focus on carefully selecting for blended finance projects in sectors that can credibly hope to achieve financial maturity once blending has successfully helped them to lift off the ground. Screening for commercial viability in addition to assessing the public benefits of a project early on can help differentiate effectively between projects that could benefit from blended finance from those that would be better served by direct subsidy or grant finance. Depending on the country context in question, such screening might already go a long way to scope the landscape of relevant projects and, thereby, improve the efficiency of blended finance as well as setting the agenda for public adaptation spending more generally.

A key question in this area is whether a given adaptation strategy can produce enough private returns to warrant the use of blended finance strategies, or whether derisking alone is not sufficient to crowd in private funding - in which case purely public options should be considered commensurate to the co-benefits to society one would expect from the adaptation strategy, relative to its alternatives. All of this also underlines the need for more disaggregated, publicly and freely accessible data on the number, volume, and efficiency of blended finance interventions.

Recommendations

R5. Develop investment plans for adaptation and infrastructure, aligned with national plans and goals, in collaboration with the private sector and civil society

R6. Identify roles of public and private finance as part of investment plans. Develop practical guidance for targeting projects for Blended Finance (and considering different structures vis a vis one another) that maximise the co-benefits from green infrastructure investment to society, including apportioning public funds between BF and other structuring approaches where private returns are too low to justify BF.

R7. Align allocations with adaptation taxonomies and develop context-appropriate additionality checks and make them mandatory for all grants and grant-equivalent portions of BF interventions so that efficiency is safeguarded. Make sure that relevant alternatives to any given project are being considered and that opportunity cost is kept low by picking the investment with the highest social value relative to its costs.

6. ALIGNING FISCAL AND WIDER POLICY

The earlier sections explored the role of public expenditure and blended finance in adaptation. To address the fiscal challenges and opportunities for adaptation and nature-based solutions, countries must deploy the full fiscal toolkit, including innovative financing models and incentives, guided by and aligned with a broader policy and financial and sector regulatory enabling environment. This section draws heavily on the example of Rwanda, as one of the leading states among EMDEs that is taking steps to deploy its full policy and fiscal toolkit in a coherent and coordinated way to mobilise finance and action on sustainability (Figure 19). Our goal in developing this case study is to begin to draw out key elements that can form a diagnostic framework that can be used by other countries. Further work is required to fully develop and test this diagnostic framework through applications to other contexts.

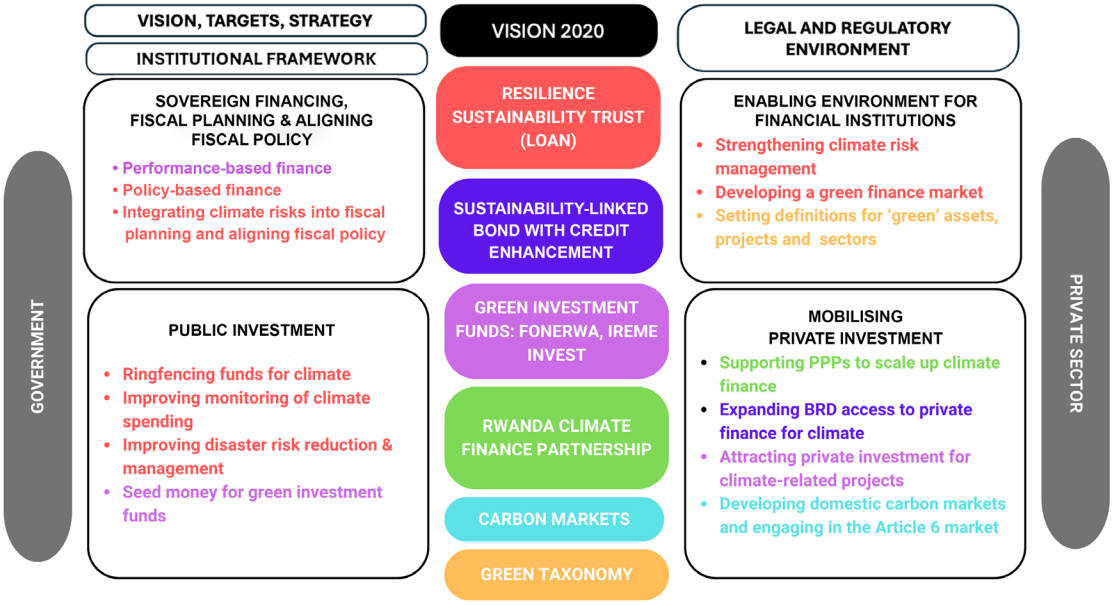

Figure 19: Overview of Rwanda's climate finance measures and initiatives. Colours of text relate to different instruments.

Background: The Starting Point for Policy Innovation in Rwanda

Rwanda has experienced several climate disasters over the past years and represents the 32nd most vulnerable country to climate change (and the 88th most ready) globally (ND-GAIN, 2023). The World Bank's Rwanda Country Climate and Development Report estimates that the country's "GDP levels can drop by 5–7% below baseline in multiple years by 2050, with negative impact on private consumption, exports and government revenues" (World Bank, 2022a).

Rwanda has a long history of sustainability policies, including being one of the first countries in the world to ban single use plastics in 2008. In the face of the climate risks the country is exposed to, Rwanda has committed to become a "climate resilient, low carbon economy by 2050", under its revised Green Growth and Climate Resilience Strategy (Government of Rwanda, 2022). Rwanda was also the first African country to submit Nationally Determined Contributions (NDC) with updated climate targets to the UN Framework Convention on Climate Change (UNFCCC) in 2020. The NDC elicits a 5.7 USD billion financing need for mitigation measures, and a further 5.3 USD billion in needs for adaptation, whilst setting the aim to reduce

emissions by up to 38% by 2030 (WRI & UNCC, 2024). This implies investments representing 7 percent of GDP on yearly basis (IMF, 2023).

The Revised NDC plan (2020) draws on Rwanda's 2011 Green Growth and Climate Resilience Strategy to set adaptation and resilience priorities. The priority sectors for adaptation include water, agriculture, land and forestry, human settlements, health, mining and cross-cutting (Government of Rwanda, 2020a, pp. 50-55).

Vision, Institutions and Law: Building from Vision 2020

Several authors have pointed to the importance of establishing clear national goals and targets to catalyse adaptation action (e.g., Ranger et al., 2023). In 2000, Rwanda's development plan Vision 2020 ignited an all-around, climate-sensitive revision of the national policy landscape. The Vision recognised climate change as a key cross-cutting area (alongside gender and ICT), making the mainstreaming of climate change mandatory across all sectors of economic development (Munyazikwiye & Michaelowa, 2022). Since Vision 2020, climate change has been integrated in the subsequent development plans, the Vision 2050 as well as the national strategy for transformation. Today, climate change considerations are incorporated in all planning and budgets submitted by districts and sectors to the Ministry of Economic Planning and Finance (MINECOFIN). Some of the key policies and legislation addressing climate change in Rwanda since 2000 include:

- 2006: National Adaptation Program of Action (NAPA)
- 2011: The Green Growth and Climate Resilience Strategy (GGCRS)
- 2013-2018: The second Economic Development and Poverty Reduction Strategy (EDPRS 2)
- 2016: Nationally Determined Contribution (NDC)
- 2017-2024: National Strategy for Transformation (NST1)
- 2018: Rwanda Law on Environment
- Vision 2050
- 2019: Environment and Climate Change Policy
- 2020: revised Nationally Determined Contribution (NDC)
- 2022: Revised Green Growth and Climate Resilience (GGCRS). National Strategy for Climate Change and Low Carbon Development
- 2023: National Carbon Market Framework

A key part of the success in Rwanda is the Institutional Framework. The Rwanda Environment Management Authority (REMA) monitors the progress of climate change policies, while MINECOFIN and the Ministry of Environment issue an environment and climate change budget statement to monitor investments in climate change. Additionally, a Rwanda country office for the Global Green Growth Institute (GGGI) was established in 2012 in Kigali, to assist access to climate finance. Rwanda has sought to enhance its climate readiness and spur private investment in climate through multiple domestic policy initiatives over the past five years. These recent policy initiatives and their trade-offs will be described in the following (Box 6, meanwhile, summarises the caveats and trade-offs apparent in the Rwandan case study).

Box 6: IMF, Debt Sustainability and the RST in Rwanda

The IMF has highlighted some potential drawbacks of Rwanda's ambitious climate agenda, including the risk of weakening debt sustainability. Additionally, the NDC is seen to potentially jeopardise investments in other development areas (e.g., social protection, education, health) given that the share of public spending is envisaged to gradually decline relative to GDP. As such, the IMF recommends increasing the fiscal space, doubling efforts to mobilise private finance and advancing reforms under the RSF (IMF, 2023).

Some of the caveats outlined by the literature take issue with the IMF's RST. Chief among the concerns aired is that the RST prioritises climate finance over other development necessities. It represents additional funding, however there is a trade-off regarding other key development areas, as funding is directed to climate finance rather than poverty reduction, for instance (Wainer, 2023). RST funding is granted upon the fulfilment of stringent conditions including governance and income-based criteria, strong climate credentials and the need for an existing IMF financing and a nonfinancial IMF programme (e.g., the Policy Coordination Instrument) excluding around70 % of emerging and developing economies. Heavily indebted MICs may face particular challenges in accessing RST funding (Vasic-Lalovic et al., 2023).

Lastly, Wainer (2023) notes that the RST could well be seen as a tool for foreign agents to exert influence over Rwanda's domestic policy sphere. RST-based funding nearly triples the number of IMF programme conditions for some countries, and naturally increases IMF's policy influence over LMIC governments.

Sovereign Finance & Aligning Fiscal Policy: Resilience Sustainability Trust

As noted in previous sections, the creation of fiscal space and the alignment of fiscal policy and national adaptation goals are foundational steps in adaptation. In Rwanda, the Resilience and Sustainability Trust provided an important opportunity for both.

In December 2022, Rwanda became the first low-income country and the first African nation to receive Resilience and Sustainability Trust (RST) funding from the IMF (through the Resilience and Sustainability Facility). The RST is the result of a G20 decision to re-channel 100 USD billion worth of IMF Special Drawing Rights to support vulnerable developing economies to respond to external shocks. It channels concessional finance to LMICs. Rwanda's receipt of RST funding was preceded by the creation of institutional foundations for operationalising climate finance measures, notably through the creation of the Green Economy Department within the Ministry of Finance.

The initial RST arrangement consisted of a 319 USD million grant for the duration of 36 months (IMF, 2023), under the conditions of a 10-year grace period, 20 years maturity and 0.5 percent concessional funding (source: personal communication). Following the second programme review in December 2023, the IMF approved a new Stand-by Credit Facility (SCF) arrangement for 14 months. This came with an additional, immediate disbursement of around 49.49 USD million for the RST, and a further 89.35 USD million under the SCF (IMF, 2023).

The RST loan is fully directed to climate resilience and aims to "generate tangible changes in public financial management, including protecting climate-spending in the context of fiscal consolidation" (Wainer, 2023). More specifically, the key action areas under the RST/RSF funding include (Wainer, 2023; emphases added):

1. strengthening and institutionalizing **monitoring and reporting** of climate-related spending;

2. integrating climate risks into **fiscal planning**;

3. improving the sensitivity of **public investment management**, to climate-related issues;

4. strengthening climate-related risk management for financial institutions and developing a **green finance market**;

5. strengthening the **disaster risk reduction and management** strategy and operations.

Each of these action areas together contribute to the alignment of fiscal policy and public finance with climate resilience goals, as well as the setting of an enabling policy environment for financial market development. Rwanda's RSF funding has also enabled the 'Rwanda Climate Finance Partnership', which facilitates PPPs to scale-up climate finance (IMF, 2023).

Sovereign Financing (Performance-Based): Sustainability-Linked Bond issued via the Bank of Rwanda to Catalyse Private Investment

Sovereign finance was further charged up through the issuance of a new form of financial instrument that linked finance with specific outcomes. In September 2023, the Development Bank of Rwanda (BRD) launched a Sustainability-Linked Bond (SLB) on the Rwanda Stock Exchange – making it the first national development bank to issue a SLB globally. The SLB is designed to bolster Rwanda's development policy objectives, such as increasing women-led business loans and financing for affordable housing (Alatabani et al., 2023). The bond was targeting 30 billion RWF (24.8 USD million), with a seven-year maturity. Closed on October 13th in 2023, the bond was oversubscribed with demand from over 100 different investors.

Rwanda's SLB had several unique features which made it successful. Firstly, the bond benefited from a 10 USD million credit enhancement funded through a World Bank loan, which helped collateralise the bond and mobilise private sector capital (Alatabani et al., 2023). Additionally, the SBL was designed with a lower, step-down coupon (in contrast to other SBLs issued globally), to incentivise the borrower "to set meaningful targets" (Alatabani et al., 2023).

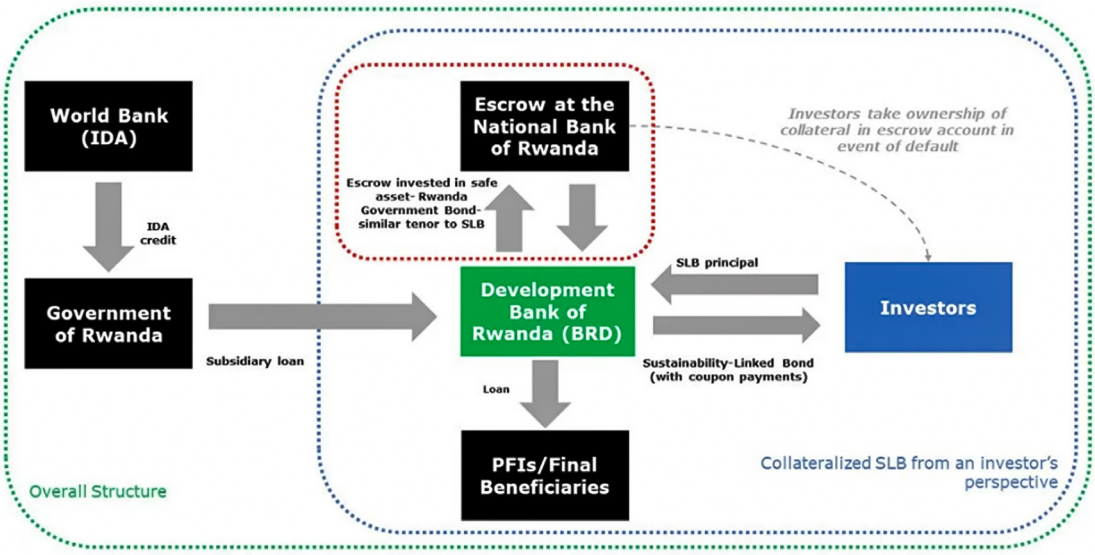

Figure 20: Bond Structure and Transaction Details (Replicated from Alatabani et al., 2023).

Furthermore, Rwanda's SLB is linked to key performance indicators around the country's sustainable economic development objectives (Government of Rwanda, 2020b). As such, rather than issuing a bond for specific projects, the BRD aims to meet KPIs around sustainable development, which entitles it to lower interest repayments. More specifically, the set KPIs focus on "increasing environmental, social, and governance (ESG) compliance in the local financial sector, boosting funding to women-led projects from the current 15 percent to 30 percent of BRD's portfolio, and financing 13,000 affordable housing projects by 2028" (Alatabani et al., 2023). The SLB allowed BRD to successfully shift away from government dependency and expand and diversify its sources for funding. Additionally, the bond mitigates risks regarding foreign exchange fluctuations by raising funding in Rwandan Francs (Alatabani et al., 2023).

Mobilising Private Investment: National Climate Change Fund & Green Bank

Public finance was leveraged to mobilise private finance through a well-structured financial architecture. Rwanda has spurred public and private investment for climate adaptation in part because it is among the first countries in Africa to adopt the African Development Bank's recommendations (AfDB, 2021) to establish national, country-driven Climate Finance Facilities (CFFs or "Green Banks"). CFFs are dedicated, catalytic financial institutions designed to address domestic market gaps, take ownership of climate finance and crowd-in private investments in low carbon and resilient projects (CPI, 2024).

The Rwanda Green Fund (RGF, formerly known as FONERWA) was established by the Government of Rwanda in 2012. It became operational after 2013 with the aid of UK-provided seed money worth GBP 22.5 million. As of 2024, RGF has mobilised 247 USD millions for 47 projects, and its mandate is to "invest in public and private projects with the potential to create transformational change, build an ecosystem to incubate, accelerate and provide growth capital to high-impact green ventures and play a catalytic role to attract climate finance and green investment" (Rwanda Green Fund, 2024). In 2021–2022, RGF launched a NDC facility called Intego with seed capital of 25 million Euros to support public sector initiatives on climate change adaptation and mitigation, implemented by the NDC facility beneficiaries (Rwanda Green Fund, 2022).

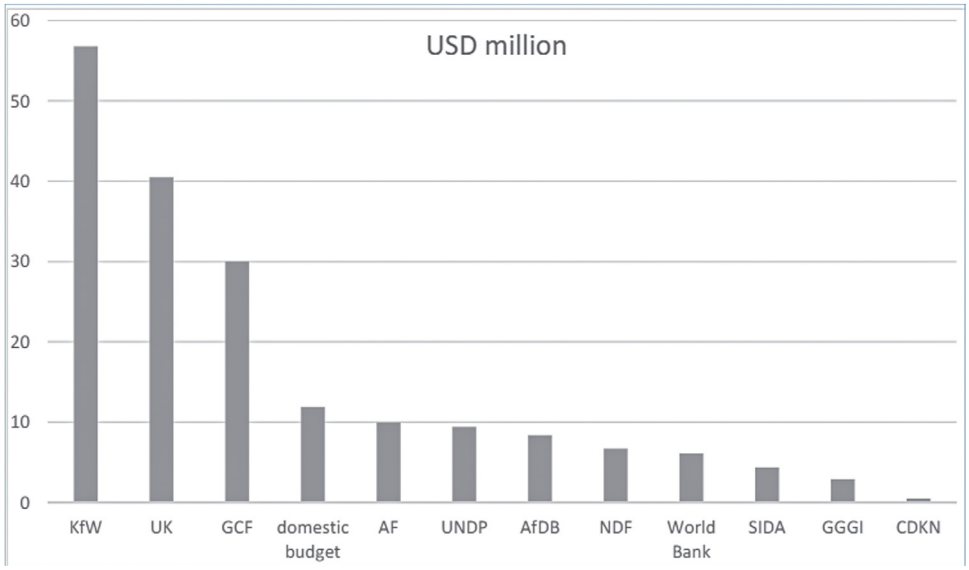

Figure 21: Rwanda Green Fund funding sources in USD million (Munyazikwiye & Michaelowa, 2022).

Rwanda has also a CFF, named Ireme Invest, aimed at spurring private sector engagement in climate adaptation. Ireme was launched in 2022 during COP27, with an initial investment from the government, worth 104 USD million. Today, the facility is fully capitalised with 240 USD million, originating from development partners.

Ireme Invest's key role is to provide concessional finance to small and medium sized enterprises (SMEs) which dominate the private sector landscape in the country. SMEs have long been neglected by the traditional banking sector, which remains focused on large enterprises and operates with high interest rates without mainstreamed 'green investment' considerations.

As such, the investment facility operates as a "one stop shop" for green investment in the country. It has two key components; (1) a project preparation facility (located at the RGF) which offers equity and grants, combined with project support, and (2) a credit facility (located at the Development Bank of Rwanda) which offers concessional loans and credit guarantees. Priority sectors covered by Ireme Invest include clean energy, smart mobility, sustainable cities, climate smart agriculture, and waste & circular economy.

Setting the Enabling Environment for Finance: Green Taxonomy

The final component of the architecture is the sustainable finance framework, within which the green taxonomy plays an important role. Rwanda is also in the process of developing a Green Taxonomy, with the support of the *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) on behalf of the German Federal Ministry for Economic Cooperation and Development. The Green Taxonomy White Paper was published in December 2023, and suggests that the development of the taxonomy will be gradual. In the first instance, a green taxonomy with environmental and climate objectives will be created with focus on four key sectors: agriculture, energy, construction and transportation. At a later stage, the taxonomy is envisaged to expand to a sustainable taxonomy including social objectives.

Furthermore, the taxonomy will initially prioritise climate change mitigation objectives, "with the additions of climate change adaptation where possible"(Government of Rwanda, 2023b). Nevertheless, the White Paper points to some indicative options for the development of adaptation objectives, including (1) generic criteria drawing on vulnerability assessment and risk reduction (as in South Africa and EU taxonomies), (2) a whitelist of activities most closely related to adaptation (e.g., NbS, ecosystems restoration, stormwater systems), and (3) agriculture activities related to adaptation as in the Colombian and Mexican taxonomies (Government of Colombia, 2022; Government of Mexico, 2023).

The key objectives of the Rwandan taxonomy are (Government of Rwanda, 2023b, emphases added):

1. to develop standardised **definitions for sustainable economic activities** and sustainable investments to attain priority environmental and sustainability goals;

2. to **increase the country's attractiveness to responsible investors**, including those pursuing impact-investing strategies in the domestic and international arena;

3. to support the growth of **domestic sustainable finance markets**, and to enable **tracking and reporting of public expenditures and private investments** addressing specific sustainability issues based on categories that are technically sound and aligned with international best practices.

Mobilising Investment in Nature: Expanding Engagement in Carbon Markets

A future direction under consideration is how to embed nature more strongly within this architecture. Rwanda has been expanding its engagement in the Article 6 market backed by the UN. It has so far signed cooperation agreements with Singapore and Kuwait. Additionally, in 2023, Rwanda adopted the UN-created 'corresponding adjustment' tool to ensure that carbon dioxide cuts are not double counted by companies buying carbon credits and countries where projects are implemented. Subsequently, the Swiss carbon registry platform Gold Standard issued over 54 thousand Article 6-aligned credits for Atmosfair – a German non-profit with a cookstove project in Rwanda, which has been backed by the Rwandan government (Pilling & Bryan, 2023).

Furthermore, Rwanda launched a carbon market framework at COP28 in December 2023 (Government of Rwanda, 2023a). The country seeks to create a domestic cap-and-trade system, and to increase transparency and standards of the domestic carbon market to reflect the requirements of the international carbon market (Yin & Gupte, 2023). The scope of the framework is the international carbon market in the broad sense. It covers Articles 6.2, Article 6.4, independent carbon standards (the Voluntary Carbon Market – VCM), ongoing initiatives such as the Standardized Crediting Framework (SCF), and Article 6.8, which is a non-market approach (Government of Rwanda, 2023a).

Significant lessons can be learnt from the Rwanda experience, yet further work is needed to fully evaluate the impacts of the case and learn from other cases. Such analyses can be used to build a diagnostic framework and set of best practice principles for government to approach setting an enabling environment for green fiscal policy for adaptation.

Recommendations

Based on the analysis of Rwanda the following initial conclusions can be drawn on the steps that governments can take:

R8. Develop an appropriate institutional framework within the Ministry of Finance for mobilising and monitoring adaptation finance with clear national vision and goals.

R9. Conduct a diagnostic to identify gaps in policy, regulatory and financial architecture to mobilise adaptation action and finance.

R10. Develop policies and projects to address gaps in a way that engages with local people and communities for greater impact and sustainability, and align policies and projects with broader development and poverty reduction agendas.

7. INVESTING IN DATA AS A PUBLIC GOOD

An Open-Data Architecture for Adaptation

Achieving each of the milestones outlined in this report requires data. Data and tools to understand physical climate risks and the benefits of adaptation are critical for integrating climate into DSAs, setting adaptation targets and plans, managing risks and for informing investment decisions on mobilizing finance for adaptation and resilience in both the public and private sector. Providing this data as a public good can be a critical enabler of adaptation across both the public and private sector. Kirsch-Wood et al. (2022) review the use cases for climate data across an economy and construct a theory of change for public investment in open data to support the mobilisation of adaptation finance and societal resilience and adaptation (Figure 22). Several examples of public and private initiatives are available that attempt to fill this need, including the UN Office for Disaster Risk Reduction (UNDRR) Risk Information Exchange, the Resilient Planet Data Hub (see Box 7), and OS-Climate. As noted in Box 3 it is also vital to ensure that the models used in risk assessment are appropriate and include all the relevant risks in order to inform robust adaptation strategies.

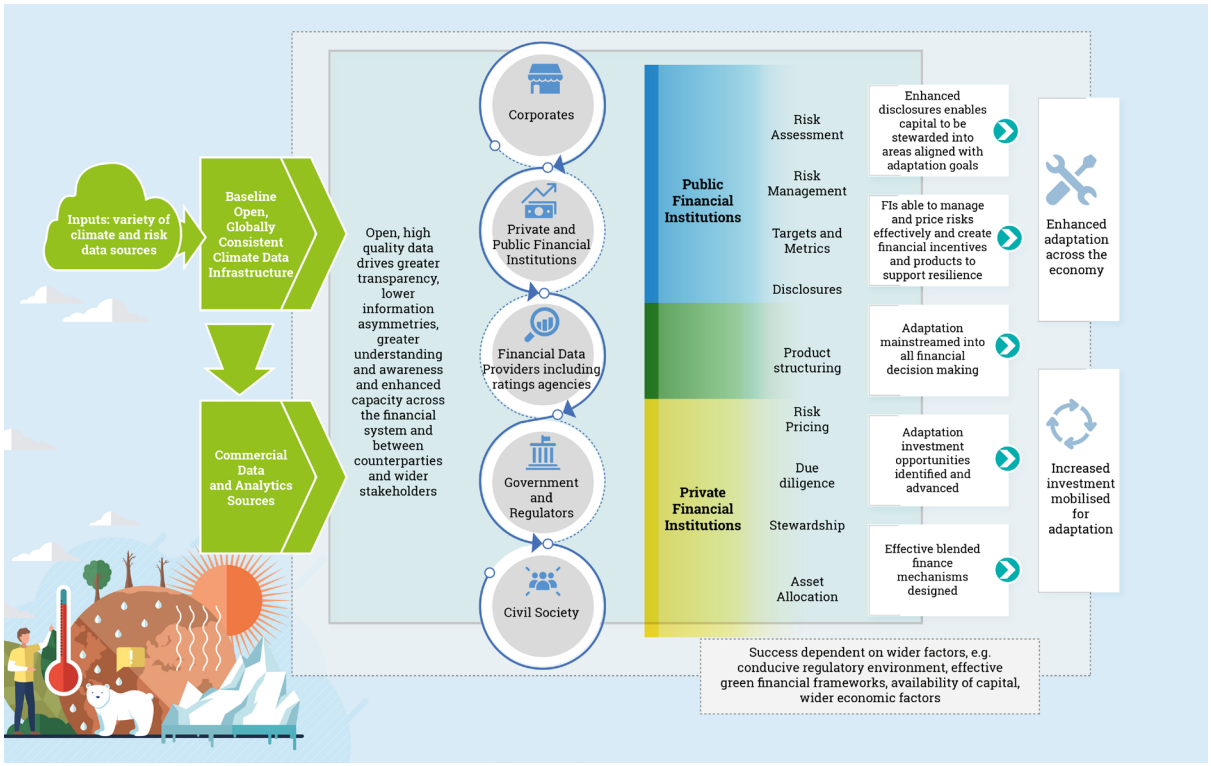

Figure 22: Theory of change for how open climate data architecture can support adaptation (Kirsch-Wood et al., 2022)

Recommendations

R11. Invest in physical climate risk data and tools as a public good, building upon existing platforms such as the Resilient Planet Data Hub.

R12. Ensure risk analytics and macroeconomic modelling used within government decision making incorporate climate risks, and take full account of climate extremes and their interlinkages with nature-related risks and the potential for cascading risks.

Box 7: Resilient Planet Data Hub – application to infrastructure investment

The Resilient Planet Data Hub serves as an example of how sophisticated data-analytical tools can be made available publicly to policy makers and other stake holders and inform policy making in a streamlined fashion (see Box 6), specifically during the policy formulation and scoping, monitoring, and evaluation stages of the policy cycle. It, and other platforms like it (consider, e.g., Boxes 1, 2, and 3 above), can be leveraged to target the use of scarce resources towards those policy priorities that yield the biggest return to society, through projects that offer the largest co-benefits (or "positive externalities") in line with the emerging targeting framework for blended finance from Section 3.

The Resilient Planet Data Hub was developed as a collaboration between the UN Office for Disaster Risk Reduction (UNDRR), the Insurance Development Forum and technical partners including the University of Oxford, to provide fully open, globally consistent and high-quality information to governments, financial institutions and civil society organisations to help strengthen risk management and mobilise finance for adaptation.

The Resilient Planet Data Hub (RPDH, 2024) provides data and tools that can help infrastructure investors understand and manage their physical climate risks. Together with the UK Centre for Greening Finance and Investment (CGFI), a case study was developed exploring how RPDH tools and data could be used to inform investors in East Africa about where to invest in climate-resilient transport infrastructure. In the current climate, one might expect average yearly flood damages to transport infrastructure of about US$ 40 million. By 2080, these average annual losses could more than triple due to climate change in a high emission (RCP 8.5) scenario (see Figure 24).

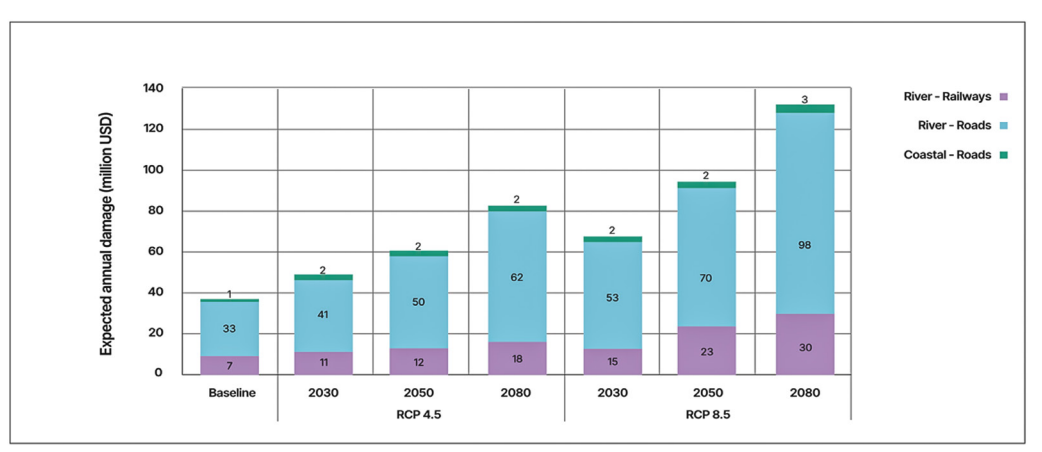

Figure 23: Expected annual flood damages to transport infrastructure in Kenya, Uganda, Tanzania, and Zambia (Hickford et al., 2023).

Investing in climate-resilient infrastructure from the outset has the potential to significantly reduce future climate-related losses. However, investors need the appropriate tools and data to inform the financing of climate-resilient infrastructure. The East Africa Systemic Risk Assessment Tool (SRAT, 2023) allows infrastructure investors to both assess risks to transport infrastructure as well as explore different options for adaptation. 23 shows how the SRAT tool can help infrastructure investments explore different adaptation options and their benefit (in terms of avoided damages) for a railway line in Tanzania. The tool shows that investing in mobile flood embankments for this specific section of railway line could lead to avoided damages exceeding US$ 11 million.

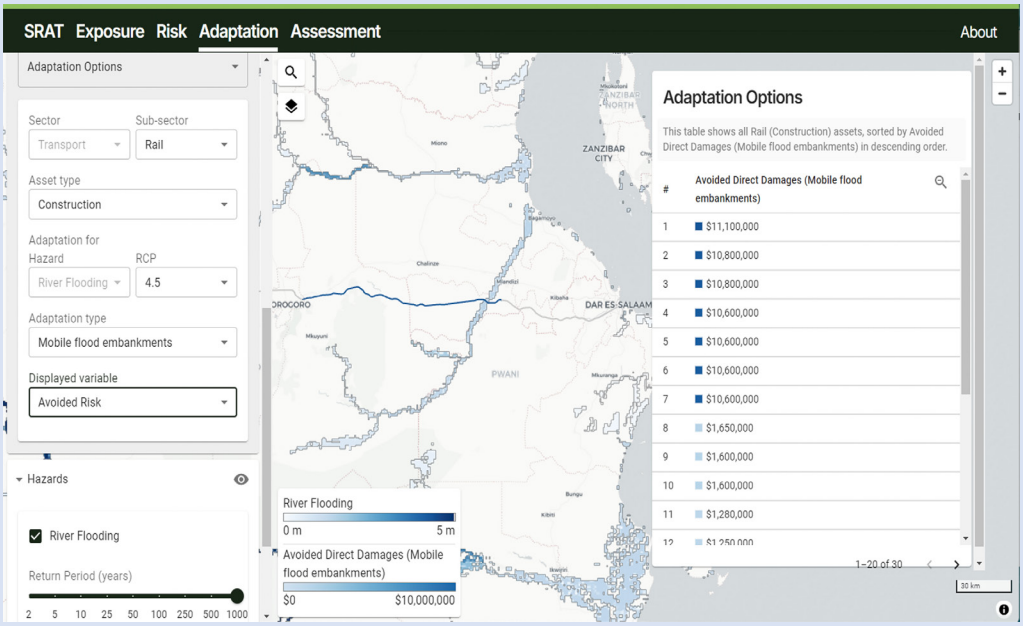

Figure 24: The East Africa Systemic Risk Assessment Tool adaptation options appraisal functionality.

By providing investors with the data, analytics, and tools to assess climate risk and explore different options for managing that risk, we can provide an evidence-base to help increase the flows of finance towards adaptation and resilience.

8. CONCLUSIONS

This report has identified several priorities and recommendations that are common across contexts and may prove transformative in the transition towards more resilience and nature-positive growth in EMDEs. The clear link between sovereign debt and adaptation shows that investments in adaptation and nature-based solutions both enhance fiscal resilience and deliver environmental and societal co-benefits, potentially freeing up more finance for the SDGs. It is also clear that targeting LICs for investment in adaptation offers the clear value for money despite the inherently higher market risk.

Recommendations R1–R12 at the end of each section above offer practical guidance for policy makers, based on the research presented and reviewed in this report. Policy practice will need to evolve in tandem with a dynamic research agenda that can fill in the gaps in what we know to date. Therefore, we close this report with a call to action for researchers in government, international organisations, universities and elsewhere, as well as funding organisations. The following five steps emerge as crucial avenues to further enable transformative finance in adaptation infrastructure.

1. The link between African nations' sovereign risk and their potential for adaptation and resilience needs to be replicated in different countries. A better understanding of how it evolves would enable analysts to offer better guidance on whether financial instruments like debt swaps should (not) be considered in a given economy's context.

2. Linking national adaptation goals and strategies, to taxonomies and national investment plans

3. To define meaningful key performance indicators for fiscal strategies in the adaptation space, adaptation-specific taxonomies of fiscal expenditure are necessary. The preliminary work presented in this report (Spacey Martín & Ranger, n.d.) could be expanded both in scope and precision and applied to wider public investment, sovereign financing and the allocation of blended finance.

4. Despite the popularity of Blended Finance, its economic rationale remains understudied. Further delineating the opportunities and limits of blended finance, especially with regards to the adaptation's public good nature, is clearly necessary.

5. Sustainability linked bonds for adaptation, like the one established in Rwanda, could become a blueprint for countries that already boast a comparable institutional landscape, including a climate finance facility (green bank) and proactive governments. Identifying contexts where this is most promising and defining effective ways to garner political support for institutionalisation in these places, should become a focus point.

References

Adom, P. K. (2024). *The Socioeconomic Impact of Climate Change in Developing Countries* [CGD Working Paper]. Center for Global Development. https://www.cgdev.org/sites/default/files/socioeconomic-impact-climate-change-developing-countries-next-decades.pdf

AfDB. (2021). *Potential for Green Banks & National Climate Change Funds in Africa* [Scoping Report]. African Development Bank. https://www.afdb.org/en/documents/potential-green-banks-national-climate-change-funds-africa-scoping-report

Ahairwe, P. E., & Bilal, S. (2023). *Mobilising (European) Development Finance for Climate Adaptation and Resilience* [Research Paper]. ECDPM and cascades. https://www.cascades.eu/publication/mobilising-european-development-finance-for-climate-adaptation-and-resilience/

Alatabani, A., Verma, N., & Navarro, M. (2023). How Rwanda's inaugural Sustainability-Linked Bond broke new ground in leveraging private capital. *World Bank Blogs*. https://blogs.worldbank.org/en/psd/how-rwandas-inaugural-sustainability-linked-bond-broke-new-ground-leveraging-private-capital.

Aligishiev, Z., Bellon, M., & Massetti, E. (2022). *Macro-Fiscal Implications of Adaptation to Climate Change* (Staff Climate Note 2022/002). IMF. https://www.imf.org/en/Publications/staff-climate-notes/Issues/2022/03/16/Macro-Fiscal-Implications-of-Adaptation-to-Climate-Change-512769

Aligishiev, Z., Ruane, C., & Sultanov, A. (2023). *User Manual for the DIGNAD Toolkit* (IMF Technical Notes and Manuals TNM/2023/03). IMF. https://www.imf.org/en/Publications/TNM/Issues/2023/06/05/A-User-Manual-for-the-DIGNAD-Toolkit-531886

Ameli, N., Dessens, O., Winning, M., Cronin, J., Chenet, H., Drummond, P., Calzadilla, A., Anandarajah, G., & Grubb, M. (2021). Higher cost of finance exacerbates a climate investment trap in developing economies. *Nature Communications*, *12*(1), 4046. https://doi.org/10.1038/s41467-021-24305-3

Attridge, S., & Engen, L. (2019). *Blended finance in the poorest countries: The need for a better approach.* [ODI Report]. ODI. https://odi.cdn.ngo/media/documents/12666.pdf

Attridge, S., Getzel, B., & Gilmour, A. (2023a). *A. National Development Banks: An untapped opportunity to mobilise the private capital and build the markets needed for a net-zero world* [Policy Brief]. ODI.

Attridge, S., Getzel, B., & Gilmour, A. (2023b). *National Development Banks: Building markets for a net-zero world* [Policy Brief]. ODI. https://cdn.odi.org/media/documents/National_Development_Banks_-_building_markets_for_a_net-zero_world_2607.pdf

Bapna, M., Brandon, C., Chan, C., Patwardhan, A., & Dickson, B. (2019). *Adapt Now: A Global Call for Leadership on Climate Resilience*. Global Center on Adaptation and World Resources Institute. https://gca.org/wp-content/uploads/2019/09/GlobalCommission_Report_FINAL.pdf

Bassi, A. M., Bechauf, R., Casier, L., & Cutler, E. (2021). *How Can Investment in Nature Close the Infrastructure Gap? An estimate of how much nature-based infrastructure can save costs and create value relative to traditional grey infrastructure.* [NBI Report]. International Institute for Sustainable Development and United Nations Industrial Development Organization. https://nbi.iisd.org/wp-content/uploads/2021/10/investment-in-nature-close-infrastructure-gap.pdf

Beirne, J., Renzhi, N., & Volz, U. (2021). Feeling the heat: Climate risks and the cost of sovereign borrowing. *International Review of Economics & Finance*, *76*, 920–936. https://doi.org/10.1016/j.iref.2021.06.019

Benedict, M. A., & McMahon, E. T. (2006). *Green infrastructure: Linking landscapes and communities*. Island Press.

Broccolini, C., Lotti, G., Maffioli, A., Presbitero, A. F., & Stucchi, R. (2021). Mobilization Effects of Multilateral Development Banks. *The World Bank Economic Review*, *35*(2), 521–543. https://doi.org/10.1093/wber/lhz049

Brondizio, E. S., Settele, J., Diaz, S., & Ngo, H. T. (Eds.). (2019). *The global assessment report on biodiversity and ecosystem services*. IPBES. https://doi.org/10.5281/zenodo.6417333

Buhr, B., Volz, U., Donovan, C., Kling, G., Lo, Y., Murinde, V., & Pullin, N. (2018). *Climate Change and the Cost of Capital in Developing Countries*. UN Environmental Programme, Imperial College Business School Centre for Climate Finance and Investment, and SOAS University of London. https://wedocs.unep.org/bitstream/handle/20.500.11822/26007/Climate_Change_Costs.pdf?sequence=1&isAllowed=y

Carter, P., Van de Sijpe, N., & Calel, R. (2021). The elusive quest for additionality. *World Development*, *141*, 105393. https://doi.org/10.1016/j.worlddev.2021.105393

CDRI. (2023). *Global Infrastructure Resilience—Capturing the Resilience Dividend* (1st ed.). CDRI Secretariat. https://doi.org/10.59375/biennialreport.ed1

Ceballos, G., & Ehrlich, P. R. (2018). The misunderstood sixth mass extinction. *Science*, *360*(6393), 1080–1081. https://doi.org/10.1126/science.aau0191

Chausson, A., Turner, B., Seddon, D., Chabaneix, N., Girardin, C. A. J., Kapos, V., Key, I., Roe, D., Smith, A., Woroniecki, S., & Seddon, N. (2020). Mapping the effectiveness of nature-based solutions for climate change adaptation. *Global Change Biology*, *26*(11), 6134–6155. https://doi.org/10.1111/gcb.15310

Convergence. (2023). How is Technical Assistance Used in Blended Finance? *Convergence News*. https://www.convergence.finance/news-and-events/news/7cgtqRftJDM5JMaabC4J3d/view

Convergence. (2024). *Blended Finance*. https://www.convergence.finance/blended-finance

CPI. (2024). *Green Banks and National Climate Change Funds (NCCFs)*. CPI. https://www.climatepolicyinitiative.org/gca-africa-adaptation-finance/actors/green-banks-and-national-climate-change-funds-nccfs-2/

den Heijer, C., & Coppens, T. (2023). Paying for green: A scoping review of alternative financing models for nature-based solutions. *Journal of Environmental Management*, *337*, 117754. https://doi.org/10.1016/j.jenvman.2023.117754

Dong, X., Yi, W., Yuan, P., & Song, Y. (2023). Optimization and trade-off framework for coupled green-grey infrastructure considering environmental performance. *Journal of Environmental Management*, *329*, 117041. https://doi.org/10.1016/j.jenvman.2022.117041

Duenwald, C., Abdih, Y., Gerling, K., Stepanyam, V., Agoumi, L., Al Hassan, A., Anderson, G., Baum, A., Andaloussi, M. B., Chen, C., Sakha, S., Saksonovs, S., Saliba, F., & Sanchez, J. (2022). *Feeling the Heat: Adapting to Climate Change in the Middle East and Central Asia* (Departmental Paper DP/2022/008; International Monetary Fund Middle East and Central Asia Department). IMF. https://www.imf.org/en/Publications/Departmental-Papers-Policy-Papers/Issues/2022/03/25/Feeling-the-Heat-Adapting-to-Climate-Change-in-the-Middle-East-and-Central-Asia-464856

DRFIP&NGFS. 2022. Physical Climate Risk Assessment: Practical Lessons for the Development of Climate Scenarios with Extreme Weather Events from Emerging Markets and Developing Economies. https://www.ngfs.net/sites/default/files/media/2022/09/02/ngfs_physical_climate_risk_assessment.pdf

Farmer, J.D., C. Hepburn, P. Mealy, and A. Teytelboym. 2015. A Third Wave in the Economics of Climate Change. *Environmental Resource Economics*, 62, 329-357.

Flammer, C., Giroux, T., & Heal, G. M. (2024). *Blended Finance* (SSRN Scholarly Paper 4770779). https://doi.org/10.2139/ssrn.4770779

GCF. (2020). *Tipping or turning point: Scaling up climate finance in the era of COVID-19* (Green Climate Fund Working Paper 3). Green Climate Fund. https://www.greenclimate.fund/document/tipping-or-turning-point-scaling-climate-finance-era-covid-19

Godfrey, N., Heckwolf, A., Averchenkova, A., Bob, W., Bhattacharya, A., & Stern, N. (2023). *Strengthening the Role of Ministries of Finance in Driving Climate Action: A Framework and Guide for Ministers and Ministries of Finance*. The Coalition of Finance Ministers for Climate Action. https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2023/06/Strengthening-the-role-of-Ministries-of-Finance-in-driving-climate-action.pdf

Government of Colombia. (2022). *Taxonomía Verde de Colombia*. Government of Colombia. https://www.taxonomiaverde.gov.co/webcenter/portal/TaxonomaVerde

Government of Mexico. (2023). *Taxonomía Sostenible de México*. Government of Mexico. https://www.gob.mx/shcp/documentos/taxonomia-sostenible-de-mexico?state=published

Government of Rwanda. (2020a). *Updated Nationally Determined Contribution*. UNFCCC. https://unfccc.int/sites/default/files/NDC/2022-06/Rwanda_Updated_NDC_May_2020.pdf

Government of Rwanda. (2020b). *Vision 2050*. https://www.minecofin.gov.rw/fileadmin/user_upload/Minecofin/Publications/REPORTS/National_Development_Planning_and_Research/Vision_2050/English-Vision_2050_Abridged_version_WEB_Final.pdf

Government of Rwanda. (2022). *Revised Green Growth and Climate Resilience*. https://www.rema.gov.rw/fileadmin/user_upload/Rwanda_Green_Growth___Climate_Resilience_Strategy_06102022.pdf

Government of Rwanda. (2023a). *Rwanda National Carbon Market Framework*. REMA. https://www.rema.gov.rw/fileadmin/user_upload/Rwanda_National_Carbon_Market_Framework_updated_1_.pdf

Government of Rwanda. (2023b). *Rwanda's Green Taxonomy* [White Paper]. https://www.minecofin.gov.rw/index.php?eID=dumpFile&t=f&f=86157&token=d71147b50abd9777735ff3debaf7a2caf98e717e

Gratcheva, E., Natalucci, F., & van Oorschot, C. (2024, March 15). Addressing barriers to climate investments in EMDEs. *OMFIF*. https://www.omfif.org/2024/03/addressing-barriers-to-climate-investments-in-emdes/

Gregory, N. (2023). *Taking Stock of MDB and DFI Innovations for Mobilizing Private Capital for Development* (Policy Paper 290; CGDev). Center for Global Development. https://www.cgdev.org/sites/default/files/taking-stock-mdb-and-dfi-innovations-mobilizing-private-capital-development.pdf

Guzman, M., & Heymann, D. (2015). The IMF Debt Sustainability Analysis: Issues and Problems. *Journal of Globalization and Development*, *6*(2), 387–404. https://doi.org/10.1515/jgd-2015-0034

Hall, J. W., Mullan, M., Pant, R., Paszkowski, A., Rozenberg, J., Sheng, F., Stenek, V., Thacker, S., Väänänen, E., Vallejo, L., Veldkamp, T. I. E., van Vliet, M., Wada, Y., Ward, P., Watkins, G., & Zorn, C. (2019). *Adaptation of Infrastructure Systems* [Background Paper for the Global Commission on Adaptation]. Environmental Change Institute, University of Oxford. https://gca.org/wp-content/uploads/2020/12/GCA-Infrastructure-background-paperV11-refs_0.pdf

Hall, J. W., Tran, M., Hickford, A. J., & Nicholls, R. J. (Eds.). (2016). *The Future of National Infrastructure: A System-of-Systems Approach* (1st ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781107588745

Hallegatte, S., Rentschler, J., & Rozenberg, J. (2019). *Lifelines: The Resilient Infrastructure Opportunity*. The World Bank. https://doi.org/10.1596/978-1-4648-1430-3

Hallegatte, S., Rentschler, J., & Rozenberg, J. (2020). *The Adaptation Principles*. World Bank. https://openknowledge.worldbank.org/entities/publication/2dc19238-096a-5907-89c2-d4b99e6cb4d3

Heubaum, H., Brandon, C., Tanner, T., Surminski, S., & Roezer, V. (2022). *The Triple Dividend of Building Climate Resilience: Taking Stock, Moving Forward* [WRI Working Paper]. https://doi.org/10.46830/wriwp.21.00154

Hickford, A., Blainley, S., Pant, R., Jaramillo, D., Russel, T., Preston, J., Hall, J., Young, M., & Glasgow, G. (2023). *Decision support system for resilient strategic transport networks in low-income countries* (Final Report HVT/043; High Volume Transport Applied Research Programme). DT Global. https://transport-links.com/wp-content/uploads/2023/10/final-report-decision-support-systems-for-resilient-strategic-transport-networks-in-low-income-countries.pdf

High-Level Expert Group on Scaling Up Sustainable Finance in Low- and Middle-income countries. (2024). *High-Level Expert Group on scaling up sustainable finance in low- and middle-income countries mandated by the European Commission: Final Recommendations*. European Commission. https://international-partnerships.ec.europa.eu/document/download/b5b4ed83-ff82-4684-b301-bf5e4dcd1f28_en?filename=hleg-final-recommendations-april-2024_en.pdf

Holland, A., & Pazarbasioglu, C. (2024, January 24). *How to Ease Rising External Debt-Service Pressures in Low-Income Countries* [Blog]. IMF. https://www.imf.org/en/Blogs/Articles/2024/01/24/how-to-ease-rising-external-debt-service-pressures-in-low-income-countries

IFC. (2023). *Creating Efficient Capital Markets in Africa* [Factsheet]. IFC. https://www.ifc.org/content/dam/ifc/doc/2023-delta/fig-factsheet-capital-markets-2023.pdf

Ihinegbu, C., Mönnich, S., & Akukwe, T. (2023). Scientific Evidence for the Effectiveness of Mangrove Forests in Reducing Floods and Associated Hazards in Coastal Areas. *Climate*, *11*(4), Article 4. https://doi.org/10.3390/cli11040079

IMF. (2022a). *Building Resilience to Natural Disasters and Climate Change: A Model Application to Timor Leste* (IMF Staff Country Reports Issue 308). IMF Asia and Pacific Department. https://www.elibrary.imf.org/downloadpdf/journals/002/2022/308/article-A001-en.xml

IMF. (2022b). *Global Financial Stability Report, October 2022: Navigating the High-Inflation Environment* [Global Financial Stability Report]. International Monetary Fund. https://www.elibrary.imf.org/display/book/9798400219672/9798400219672.xml

IMF. (2023). *Rwanda: 2023 Article IV Consultation, Second Reviews Under the Policy Coordination Instrument and the Arrangement Under the Resilience and Sustainability Facility, Requests for the Modification of End December 2023 Quantitative Targets, Rephasing of Access Under the Resilience and Sustainability Facility, and Request for an Arrangement Under the Standby Credit Facility* (IMF Staff Country Report 23/422; p. 1). https://elibrary.imf.org/openurl?genre=journal&issn=1934-7685&volume=2023&issue=422&cid=542581-com-dsp-crossref

Jha, A. K., Stanton-Geddes, Z., & World Bank (Eds.). (2013). *Strong, safe, and resilient: A strategic policy guide for disaster risk management in East Asia and the Pacific*. The World Bank.

Kenny, C. (2019a). *Five Principles for Use of Aid in Subsidies to the Private Sector* (CGD Policy Paper 157). Center for Global Development. https://www.cgdev.org/publication/five-principles-use-aid-subsidies-private-sector

Kenny, C. (2019b). *Marginal, Not Transformational: Development Finance Institutions and the Sustainable Development Goals* (CGD Policy Paper 156). Center for Global Development. https://www.cgdev.org/publication/marginal-not-transformational-development-finance-institutions-and-sustainable

Kenny, C. (2021). *We Should Be Spending More of Available Aid in Poorer Countries, Not Less* (CGD Working Paper 564). Center for Global Development.

Kenny, C. (2024). *Does Mitigation ODA Reduce Emissions?* (CGD Note 359). Center for Global Development. https://www.cgdev.org/sites/default/files/does-mitigation-oda-reduce-emissions.pdf

Kenny, C., & Yang, G. (2020). *Measuring the Development Impact of the IFC and Development Finance* (CGD Working Paper 562). Center for Global Development. https://www.cgdev.org/sites/default/files/WP562-Kenny-IFC-Development-Outcomes-Full.pdf

Key, I. B., Smith, A. C., Turner, B., Chausson, A., Girardin, C. A. J., Macgillivray, M., & Seddon, N. (2022). Biodiversity outcomes of nature-based solutions for climate change adaptation: Characterising the evidence base. *Frontiers in Environmental Science*, *10*. https://doi.org/10.3389/fenvs.2022.905767

Kirsch-Wood, K., Ranger, N., & Signer, B. (2022). *Towards a Climate-Risk Data Architecture: Common and open risk metrics to align finance with climate-resilient development goals* [Discussion Paper]. Global Resilience Index Initiative. https://www.cgfi.ac.uk/2022/11/grii-report-nov22/

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. https://doi.org/10.1287/mnsc.2023.4869

Kuwae, T., & Crooks, S. (2021). Linking climate change mitigation and adaptation through coastal green–gray infrastructure: A perspective. *Coastal Engineering Journal*, *63*(3), 188–199. https://doi.org/10.1080/21664250.2021.1935581

Lankes, H. P., Macquarie, R., Soubeyran, É., & Stern, N. (2024). The Relationship between Climate Action and Poverty Reduction. *The World Bank Research Observer*, *39*(1), 1–46. https://doi.org/10.1093/wbro/lkad011

Lankes, H. P., & Robins, N. (2023). *Mobilising Private Capital for Climate Action and Growth in the Global South* [T20 Policy Brief]. G20. https://t20ind.org/wp-content/uploads/2023/07/T20_PolicyBrief_TF5_PrivateCapitalForClimateActionGrowth.pdf

Lu, Y., Springer, C., & Steffen, B. (2024). Cofinancing and infrastructure project outcomes in Chinese lending and overseas development finance. *World Development*, *175*, 106473. https://doi.org/10.1016/j.worlddev.2023.106473

Malanoski, C. M., Farnsworth, A., Lunt, D. J., Valdes, P. J., & Saupe, E. E. (2024). Climate change is an important predictor of extinction risk on macroevolutionary timescales. *Science*, *383*(6687), 1130–1134. https://doi.org/10.1126/science.adj5763

Malhi, Y., Franklin, J., Seddon, N., Solan, M., Turner, M. G., Field, C. B., & Knowlton, N. (2020). Climate change and ecosystems: Threats, opportunities and solutions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *375*(1794), 20190104. https://doi.org/10.1098/rstb.2019.0104

Marto, R., Papageorgiou, C., & Klyuev, V. (2018). Building resilience to natural disasters: An application to small developing states. *Journal of Development Economics*, *135*, 574–586. https://doi.org/10.1016/j.jdeveco.2018.08.008

Melina, G., & Santoro, M. (2021). *Enhancing Resilience to Climate Change in the Maldives* (IMF Working Paper WP/21/96). IMF. https://www.imf.org/en/Publications/WP/Issues/2021/04/23/Enhancing-Resilience-to-Climate-Change-in-the-Maldives-50293

Munyazikwiye, F., & Michaelowa, A. (2022). Chapter 10: The Rwandan approach to maximising benefits from international climate finance. In A. Michaelowa & A.-K. Sacherer, *Handbook of International Climate Finance* (pp. 242–254). Edward Elgar.

Nash, M. H. (2022, July 28). The 200 Most (& Least) Biodiverse Countries. *The Swiftest*. https://theswiftest.com/biodiversity-index/

Nature-Based Solutions for Supporting Sustainable Development, UNEP/EA.5/Res.5 (2022). https://wedocs.unep.org/bitstream/handle/20.500.11822/39752/K2200677%20-%20UNEP-EA.5-Res.5%20-%20Advance.pdf?sequence=1&isAllowed=y

ND-GAIN. (2023). *Rwanda Country Profile*. ND-GAIN Index. https://gain-new.crc.nd.edu/country/rwanda

NGFS. (2023). *Scaling Up Blended Finance for Climate Mitigation and Adaptation in Emerging Market and Developing Economies (EMDEs)* [Technical Document]. Network for Greening the Financial System.

O'Donnell, E. C., Gosling, S. N., Netusil, N. R., Ka Shun Chan, F., & Dolman, N. J. (2021). Perceptions of blue-green and grey infrastructure as climate change adaptation strategies for urban water resilience. *Journal of the British Academy*, *9s9*, 143–182. https://doi.org/10.5871/jba/009s9.143

OECD. (2020). *DAC methodologies for measuring the amounts mobilised from the private sector by official development finance interventions*. https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/DAC-Methodologies-on-Mobilisation.pdf

OECD. (2023). *Private Finance Mobilised by Official Development Finance Interventions: Opportunities and challenges to increase its contribution towards the SDGs in developing countries*. Development Co-operation Directorate, OECD Publishing. https://www.oecd.org/dac/2023-private-finance-odfi.pdf

OECD. (2024a). *Development finance standards* [Oecd.org/dac]. How We Measure and Collect Data. https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/#resources

OECD. (2024b). *Mobilised private finance for sustainable development*. Oecd.Org/Dac. https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/mobilisation.htm

Pande, V., Sivaprasad, D., Salleh, N., & Tan, D. (2023, October 12). How national-level blended finance can catalyse the climate transition in emerging markets. *World Economic Forum - Climate Change*. https://www.weforum.org/agenda/2023/10/blended-finance-climate-transition-emerging-markets/

Pegon, M. (2023). *Beyond Leverage Ratios: A Strategic Approach to Blended Finance* (IDB Invest). Inter-American Investment Corporation. https://www.idbinvest.org/en/publications/beyond-leverage-ratios-strategic-approach-blended-finance

Pilling, D., & Bryan, K. (2023, November 30). UN-based checks on carbon credits face critical test. *Financial Times*. https://www.ft.com/content/d19cc94d-f9d2-4183-b4ad-69ab944e9b13

Prasad, A., Loukoianova, E., Feng, A. X., & Oman, W. (2022). *Mobilizing Private Climate Financing in Emerging Market and Developing Economies* (Staff Climate Note 2022/007). IMF. https://www.imf.org/en/Publications/staff-climate-notes/Issues/2022/07/26/Mobilizing-Private-Climate-Financing-in-Emerging-Market-and-Developing-Economies-520585

Ranger, N.A., O. Mahul, and I. Monasterolo. 2022. *Assessing Financial Risks from Physical Climate Shocks: A Framework for Scenario Generation*. Washington, DC: World Bank.

Ranger, N., Alvarez, J., Freeman, A., Harwood, T., Paulus, E., & Sabuco, J. (2023). *The Green Scorpion: The Macro-Criticality of Nature for Finance: Foundations for scenario-based analysis of complex and cascading physical nature-related financial risks* [NGFS Occasional Paper]. Environmental Change Institute, University of Oxford. https://www.ngfs.net/sites/default/files/medias/documents/ngfs_occasional_paper_green-scorpion_macrocriticality_nature_for_finance.pdf

Ranger, N., Low, L. P., & Signer, B. L. (2021). *Financial Protection of Critical Infrastructure Services*. World Bank. https://www.financialprotectionforum.org/publication/financial-protection-of-critical-infrastructure-services

Reckner, M., & Tien, I. (2023). Community-Scale Spatial Mapping to Prioritize Green and Grey Infrastructure Locations to Increase Flood Resilience. *Sustainable and Resilient Infrastructure*, *8*(sup1), 289–310. https://doi.org/10.1080/23789689.2022.2148449

Rozenberg, J., & Fay, M. (2019). *Beyond the Gap: How Countries Can Afford the Infrastructure They Need while Protecting the Planet*. World Bank. https://hdl.handle.net/10986/31291

RPDH. (2024). *Resilient Planet Data Hub*. https://resilient-planet-data.org/

Rwanda Green Fund. (2022). *Refocusing Our Efforts, Expanding Opportunities: Annual Report 2021-2022* [Annual Report]. Rwanda Green Fund. https://greenfund.rw/sites/default/files/2023-06/RGF%20Annual%20Report%202022_HD-1.pdf

Rwanda Green Fund. (2024). *Who We Are*. Rwanda Green Fund. https://greenfund.rw/who-we-are

Sadler, A., Ranger, N., Fankhauser, S., Marotta, F., & O'Callaghan, B. (2024). The impact of COVID-19 fiscal spending on climate change adaptation and resilience. *Nature Sustainability*, *7*(3), 270–281. https://doi.org/10.1038/s41893-024-01269-y

Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *375*(1794), 20190120. https://doi.org/10.1098/rstb.2019.0120

Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., House, J., Srivastava, S., & Turner, B. (2021). Getting the message right on nature-based solutions to climate change. *Global Change Biology*, *27*(8), 1518–1546. https://doi.org/10.1111/gcb.15513

Smith, S., Geden, O., Gidden, M., Lamb, W. F., Nemet, G. F., Minx, J., Buck, H., Burke, J., Cox, E., Edwards, M., Fuss, S., Johnstone, I., Müller-Hansen, F., Pongratz, J., Probst, B., Roe, S., Schenuit, F., Schulte, I., & Vaughan, N. (2024). *The State of Carbon Dioxide Removal. 2nd edition*. https://doi.org/10.17605/OSF.IO/F85QJ

Smith, S. M., Geden, O., Nemet, G. F., Gidden, M. J., Lamb, W. F., Powis, C., Bellamy, R., Callaghan, M. W., Cowie, A., Cox, E., Fuss, S., Gasser, T., Grassi, G., Greene, J., Lück, S., Mohan, A., Müller-Hansen, F., Peters, G. P., Pratama, Y., … Minx, J. C. (2023). *The State of Carbon Dioxide Removal. 1st edition*. doi:10.17605/OSF.IO/W3B4Z

Spacey Martín, R., & Ranger, N. (n.d.). *The Impact of COVID-19 Fiscal Spending on Nature* [Unpublished manuscript]. Environmental Change Institute, University of Oxford.

SRAT. (2023). *Systemic Risk Assessment Tool*. https://east-africa.infrastructureresilience.org/

Stern, N., Stiglitz, J., & Taylor, C. (2022). The economics of immense risk, urgent action and radical change: Towards new approaches to the economics of climate change. *Journal of Economic Methodology*, *29*(3), 181–216. https://doi.org/10.1080/1350178X.2022.2040740

Surminski, S., & Tanner, T. (Eds.). (2016). *Realising the 'Triple Dividend of Resilience'*. Springer International Publishing. https://doi.org/10.1007/978-3-319-40694-7

Tanner, T., Surminski, S., Wilkinson, E., Reid, R. C. J., Rentschler, J., & Rajput, S. (2015). *The Triple Dividend of Resilience: Realising development goals through the multiple benefits of disaster risk management* (Working Paper 122524). Global Facility for Disaster Reduction and Recovery (GFDRR) at the World Bank and ODI. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/993161515193991394/the-triple-dividend-of-resilience-realizing-development-goals-through-the-multiple-benefits-of-disaster-risk-management

Temmerman, S., Horstman, E. M., Krauss, K. W., Mullarney, J. C., Pelckmans, I., & Schoutens, K. (2023). Marshes and Mangroves as Nature-Based Coastal Storm Buffers. *Annual Review of Marine Science*, *15*(Volume 15, 2023), 95–118. https://doi.org/10.1146/annurev-marine-040422-092951

Thacker, S., Adshead, D., Fantini, C., Palmer, R., Ghosal, R., Adeoti, T., Morgan, G., & Stratton-Short. (2021). *Infrastructure for Climate Action*. UNOPS.

UNCTAD. (2024). *UN list of least developed countries*. https://unctad.org/topic/least-developed-countries/list

UNDP. (2023, September 12). *Tight fiscal and financial constraints are driving growth-at-all costs, according to United Nations Development Programme collaboration with 95 countries* [Press Release]. UNDP. https://www.undp.org/press-releases/tight-fiscal-and-financial-constraints-are-driving-growth-all-costs-according-united-nations-development-programme-collaboration-95

UNEP. (2022). *State of Finance for Nature. Time to act: Doubling investment by 2025 and eliminating nature-negative finance flows.* United Nations Environment Programme. https://wedocs.unep.org/20.500.11822/41333

UNEP. (2023a). *Adaptation Gap Report 2023: Underfinanced. Underprepared. Inadequate investment and planning on climate adaptation leaves world exposed*. United Nations Environment Programme. https://doi.org/10.59117/20.500.11822/43796

UNEP. (2023b). *Nature-based Infrastructure: How natural infrastructure solutions can address sustainable development challenges and the triple planetary crisis*. UNEP. https://wedocs.unep.org/xmlui/handle/20.500.11822/44022

UNEP. (2023c). *State of Finance for Nature 2023: The Big Nature Turnaround - Repurposing $7 Trillion to Combat Nature Loss*. UNEP. https://doi.org/10.59117/20.500.11822/44278

UNEP, CBD, UNDP, World Bank, Finance for Biodiversity Foundation, & Finance Montreal. (2023). *Aligning financial flows with the Kunming-Montreal Global Biodiversity Framework* [High-level roadmap]. UNEP. https://www.unepfi.org/publications/high-level-roadmap-aligning-financial-flows-with-the-kunming-montreal-global-biodiversity-framework/

van Hespen, R., Hu, Z., Borsje, B., De Dominicis, M., Friess, D. A., Jevrejeva, S., Kleinhans, M. G., Maza, M., van Bijsterveldt, C. E. J., Van der Stocken, T., van Wesenbeeck, B., Xie, D., & Bouma, T. J. (2023). Mangrove forests as a nature-based solution for coastal flood protection: Biophysical and ecological considerations. *Water Science and Engineering*, *16*(1), 1–13. https://doi.org/10.1016/j.wse.2022.10.004

van Raalte, D., & Ranger, N. (2023). *Financing Nature-Based Solutions for Adaptation at Scale: Learning from Specialised Investment Managers and Nature Funds*. Global Center on Adaptation and Environmental Change Institute, University of Oxford.

Vasic-Lalovic, I., Merling, L., & Wu, A. (2023). *The Growing Debt Burdens ¬¬of Global South Countries: Standing in the Way of Climate and Development Goals*. CEPR. https://cepr.net/wp-content/uploads/2023/10/The-Growing-Debt-Burdens-of-Global-South-Countries_Standing-in-the-Way-of-Climate-and-Development-Goals-Lalovic-Merling-Wu.pdf

Volz, U. 2022. "On the Potential of Sovereign State-Contingent Debt in Contributing to Better Public Debt Management and Enhancing Sustainability Outcomes". *Journal of Globalization and Development* 13(2), 379-409.

Volz, U., Beirne, J., Ambrosio Preudhomme, N., Fenton, A., Mazzacurati, E., Renzhi, N., & Stampe, J. (2020). *Climate Change and Sovereign Risk*. SOAS University of London, Asian Development Bank Institute, World Wide Fund for Nature Singapore, and Four Twenty Seven. https://doi.org/10.25501/SOAS.00033524

Volz and Ranger, 2023 Climate Change, Fiscal Risks and Debt Sustainability. Working Paper

Waidelich, P., Krug, J., & Steffen, B. (2023). *Mobilizing Credit for Clean Energy: De-risking and Public Loan Provision Under Learning Spillovers* (Discussion Paper 23–040; ZEW Discussion Papers). ZEW - Leibniz Centre for European Economic Research. https://www.zew.de/publikationen/mobilizing-credit-for-clean-energy-de-risking-and-public-loan-provision-under-learning-spillovers

Wainer, A. (2023). *The Resilience and Sustainability Trust: Early Learning and Challenges from Costa Rica and Rwanda* (Policy Paper 301). Center for Global Development. https://www.cgdev.org/sites/default/files/resilience-and-sustainability-trust-early-learning-and-challenges-costa-rica-and-rwanda.pdf

Warner, A. (2013). *A Framework for Efficient Government Investment* (SSRN Scholarly Paper 2233761). https://papers.ssrn.com/abstract=2233761

Weikmans, R. (2023). *The normative foundations of international climate adaptation finance*. Cambridge University Press.

Winckler Andersen, O., Hansen, H., & Rand, J. (2021). *Evaluating financial and development additionality in blended finance operations* (Working Paper 91; OECD Development Co-Operation Working Papers, Vol. 91). OECD. https://doi.org/10.1787/a13bf17d-en

WMO. (2024). *State of the Global Climate 2023* (1347). World Meteorological Organisation. https://library.wmo.int/idurl/4/68835

World Bank. (2021). *Resilience Rating System: A Methodology for Building and Tracking Resilience to Climate Change*. World Bank. https://doi.org/10.1596/35039

World Bank. (2022). *World Development Indicators* [Data repository]. https://databank.worldbank.org/source/world-development-indicators

World Bank. 2022b. World Bank Group Macroeconomic Models for Climate Policy Analysis. EFI Note. Washington, DC: World Bank.

World Economic Forum & PwC. (2020). *Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy* (New Nature Economy Series). World Economic Forum. https://www3.weforum.org/docs/WEF_New_Nature_Economy_Report_2020.pdf

WRI & UNCC. (2024). *Rwanda*. Partnership in Action 2021. https://pia.ndcpartnership.org/country-stories/rwanda/

Yin, I., & Gupte, E. (2023, December 3). COP28: Rwanda unveils carbon policy framework for emissions trading, Article 6. *S&P Global Commodity Insights*. é