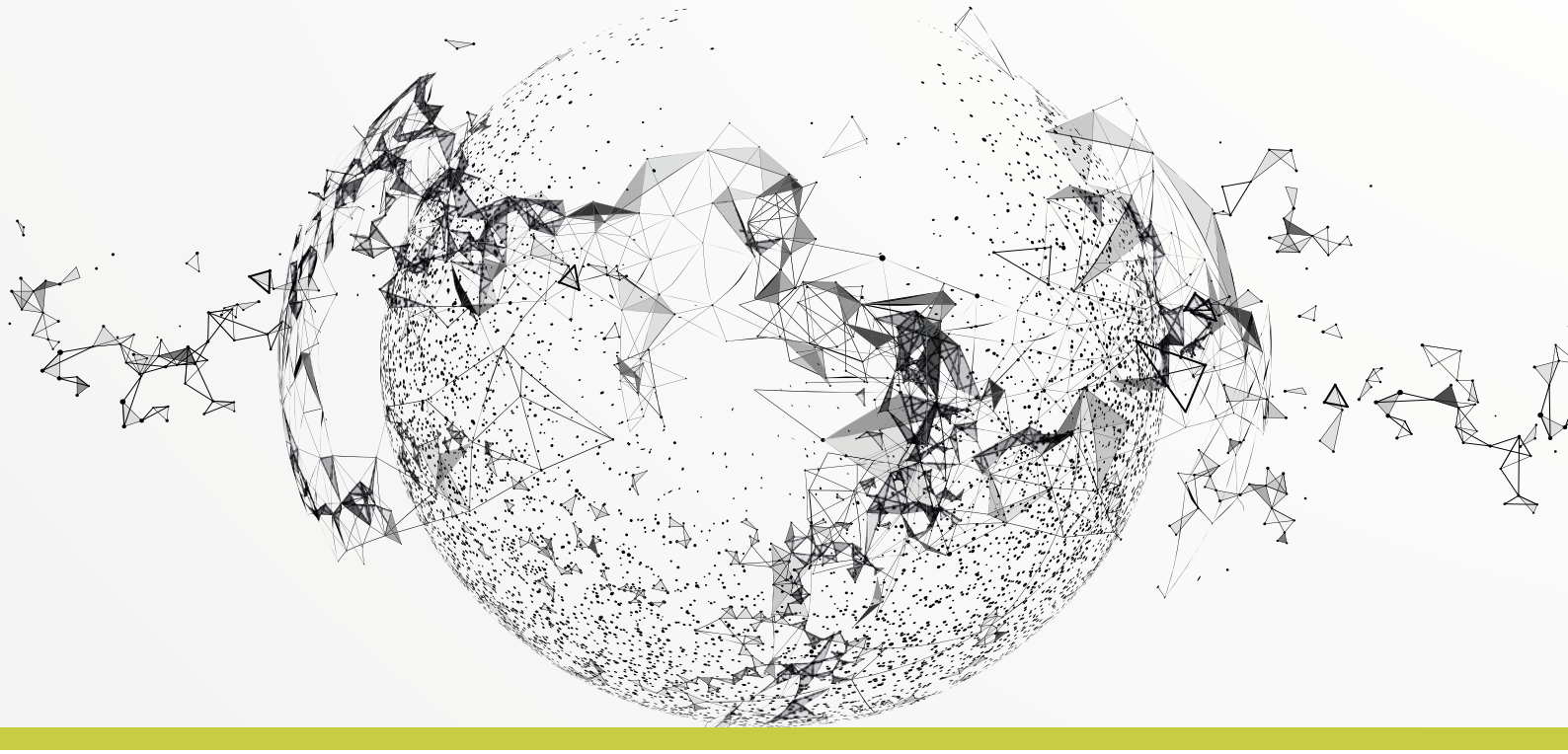
Risk Information Exchange

GLOBAL RESILIENCE INDEX INITIATIVE
A COMMON LANGUAGE OF RISK

TOWARDS A CLIMATE-RISK DATA ARCHITECTURE:

common and open risk metrics to align finance with climate-resilient development goals

Discussion paper



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On behalf of the Global Resilience Index Initiative (GRII) and Risk Information Exchange (RiX)

Acknowledgements

This report was prepared by the United Nations Office for Disaster Risk Reduction (UNDRR) and the Centre for Greening Finance and Investment (CGFI) as an input to the development of the Global Resilience Index Initiative (GRII) and Risk Information Exchange (RiX) and on behalf of the partners to those initiatives, including the Insurance Development Forum (IDF), the Coalition for Disaster Resilient Infrastructure (CDRI), the Coalition for Climate Resilient Investment (CCRI) and the Global Earthquake Model (GEM) Foundation.

The discussion paper has been written by a team comprising Jenty Kirsch Wood (UNDRR), Nicola Ranger and Benedikt Signer (CGFI). We thank colleagues including Ana Gonzalez Palaez, Julie Calkins, Jimena Alvarez, Diana Jaramillo Araujo, Mark Bernhofen, Rowan Douglas, Jim Hall, Nick Moody Nicholas Savvakis and Matthew Wright for review and inputs. Any errors remain those of the authors. We also wish to thank colleagues that have contributed to the development of the tools presented and by extension this publication, including Matt Foote, Frankie Brown, Vitor Silva, John Schneider, Paul Henshaw, Stuart Fraser, Dickie Whitaker, Andrew Maskrey, Loretta Hieber-Girardet, Andrew Spezowka, Hamish Patten, Rashmin Gunasekera, Alastair Norris, Claire Souch, James Lay, Jon Gascoigne, Conor Meenan, Roberto Rudari, Gabriel Bernal, Matt Jones, Jane Toothill, Judith Ellison, Michael Mullan, Raghav Pant, Jasper Vershuur, Tom Russell, Tim Fowler, Carlos Sanchez, Ben Caldecott, Olivier Mahul and Kamal Kishore for inputs to the development of GRII. Support to the authors from the German Government (BMZ), the UK Natural Environment Research Council (NERC), the Foreign and Commonwealth Development Office (FCDO), the Insurance Development Forum (IDF) and the World Bank is gratefully acknowledged. The views expressed are those of the authors and do not necessarily represent those of their institutions or their funding organizations.

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Coalition for Climate Resilient Investment

CDRI Coalition for Disaster Resilient Infrastructure

IDF Insurance Development Forum

CGFI UK Centre for Greening Finance & Investment

GEM GLOBAL EARTHQUAKE MODEL working together to assess risk

UNDRR UN Office for Disaster Risk Reduction

Contents

EXECUTIVE SUMMARY 4

1. INTRODUCTION 7

2. THE NEED FOR GLOBAL, OPEN AND COMMON CLIMATE RISK AND RESILIENCE METRICS 11

The Global Resilience Index Initiative (GRII) **13**

UNDRR's Risk Information Exchange (RiX) **14**

3. THE NEED FOR COMMON RISK METRICS 16

Climate-related financial disclosures (and wider sustainability disclosures) **16**

Current approach to metrics 17

How common risk metrics could enable progress 19

Infrastructure financing **22**

Current approach to metrics 23

How common risk metrics could enable progress 23

Stress testing and scenario analysis **26**

Current approach to metrics 28

How common risk metrics could enable progress 28

Fiscal resilience and sovereign financing instruments **30**

Current approach to metrics 31

4. CONCLUSION: TOWARDS GLOBAL, OPEN, AND COMMON RISK METRICS 34

Executive summary

Mobilizing the trillions of dollars of finance needed for climate change adaptation and resilience will require a new climate-risk data architecture to provide globally consistent, open baseline datasets on climate risk and resilience metrics as a global public good. The common language of greenhouse-gas emissions (tonnes of carbon) enables climate mitigation action at scale. This agreed architecture and approach means that from local to global level a common understanding is in place. Upon this governments, corporates and civil society can set targets and plans, monitor progress transparently and consistently, price the externality, and establish markets to encourage activity. This same standardization does not yet exist in the climate-resilience agenda. Adaptation and resilience are missing a common language – the common and open resilience metrics to help create a shared understanding and baseline for addressing climate risk in financial terms. The objective of this discussion paper is to demonstrate how such a common language could work and show progress to date.

Such comparable metrics will help bring finance for resilience to scale through full consideration and integration of physical risk considerations into private and public finance flows. In the absence of such common metrics, it is harder for decision makers to fully integrate physical climate risk into decisions and align investments with climate-resilient development goals, as outlined in Article 2.1c of the Paris Agreement. For example, it is difficult to robustly and transparently compare the benefits of two investments for resilience, to set verifiable targets, and for financial institutions to begin to integrate physical climate risks into their decisions over capital allocation and risk pricing. With a common language of risk and resilience, new forms of financial products can be designed and markets established to help mobilize the trillions of investment required for adaptation and resilience.

Two new complementary initiatives are working towards the establishment of such a new climate-risk data architecture. The Global Resilience Index Initiative (GRII) provides globally consistent risk and resilience data and metrics openly and transparently; aggregating the best available data from multiple sources across people, planet and prosperity dimensions and combines this with new analytics to capture systemic risks, such as infrastructure systems and supply-chain disruptions. UNDRR's Risk Information Exchange (RiX) works bottom-up with national governments and other stakeholders to collect and aggregate geospatial and wider data to help fill gaps in a currently spotty global risk-data landscape. The initiatives are complementary in that RiX, in addition to strengthening risk-data ecosystems at national level, also feeds better data in the tailored, analytical tools being developed by the Global Resilience Index Initiative (GRII) as a platform to develop common and open risk and resilience metrics. Investing in systematic data collection and aggregation to enable quality data that is comparable across all continents with regards to hazard, exposure, vulnerability and climate change risk is a global common good with significant utility across the public and private sectors.

These initiatives are working together to enhance the open data environment on climate and disaster risk. Such initiatives can only be strengthened if the wider ecosystem continues to take action to fill the current data divides, and to make more and better data accessible and interoperable. Users of climate risk metrics across the economy will benefit from the growth of such public-good initiatives to help address current challenges in integrating climate risk in financial decisions. Four use cases of improved climate-risk data are discussed in this paper:

i. Climate-related financial disclosure by asset owners and asset managers, highlights how common and open risk metrics can support effective and comprehensive disclosure of physical climate risks by financial institutions, in line with the Task Force for Climate Related Disclosures guidelines and wider sustainability standards.

ii. Infrastructure financing considers how such data can help enhance the measurement, disclosure and monitoring of physical climate risk in infrastructure investments and, in turn, enable investments in enhancing physical resilience and avoid or reduce new risk.

iii. Climate stress testing for banks considers the importance of common risk metrics to help inform central bank stress-testing simulations

iv. Fiscal resilience and sovereign disaster risk financing considers how improved risk metrics can help governments shift from qualitative assessment of climate-related fiscal risks to a more empirical and quantitative approach.

The GRII and RiX are two initiatives that contribute to expanding the open data architecture that will help achieve these goals. Ideally these initiatives can crowd in further collaborations to enhance the open-data environment on climate and disaster risk. This will not compete with private sector model and data providers, but help develop an innovative industry, able to draw on the latest publicly financed research undertaken at universities. This briefing paper can act as a call to action for further collaboration to enhance current approaches and tools. At the same time, raising the open-source baseline quality tools like the GRII can also encourage private sector innovators to increase public-private collaboration - in support of the 2015 Paris Agreement and UN Sustainable Development Goals.

Take aways from use cases for the design of a common, open climate-risk data architecture

Disclosure

- Country or regional and sector average common risk metrics could provide a high-level screening of risk as a proxy where detailed data is not available.
- Open data indirectly raises the ambition of high-level data providers, by articulating the gap between common metrics and proprietary asset-level outputs, thereby incentivizing increased investment in filling data gaps and providing high-quality information.
- Baselining through a third-party independent source could help provide a more level playing field. If more risk is assessed in a comparable way through objective, free, accessible and common metrics, investors will have greater confidence in adaptation-investment needs and opportunities. This would help identify the materiality of risks by hazard across sectors and locations, providing comparability at a high level and pointing to a need for higher-resolution, asset-level analysis.
- Providing a benchmarked set of exposure and risk data and damage functions could provide a basis for risk quantification.

Infrastructure financing:

- Funds find it difficult to assess projects when standards are fragmented. Common metrics would facilitate a high-level screening and detailed assessment of portfolios and projects.
- Open and comparable metrics would help fund managers compare exposure or performance of different assets, and develop a trusted aggregated portfolio view.
- Accessible and trusted asset-level data, or reliable comparable global data sets as proxies, would make it easier for investors and fund managers to assess especially unlisted entities; this will become more important over time, e.g. with the implementation of green taxonomies.

Stress testing and scenario analysis:

- A standard set of baseline data on physical climate-related hazards and risks could support financial institutions in their climate scenario analysis. This could help develop a common data standard for reporting of physical risks in financial institutions' regulatory or stress-testing returns.
- A benchmark set of risk layers, damage functions and proxies as a protocol reference set at agreed temporal and spatial resolution could serve as a baselining approach between different data vendors and enabling a common language across financial institutions and regulators.
- Common risk metrics could provide the tools to financial authorities to assess the effects of physical risks as part of their own top-down modelling, especially considering systemic and spill-over risks that are not fully captured within currently available data.
- As a microprudential tool, common metrics and standard calibration values could inform setting quantification methods. As a macroprudential tool, it could inform setting exposure limits and capital buffers to prevent concentrations of risk within systems, and coupled dependencies to understand risk spill-over between the real economy and financial institutions

Fiscal resilience and sovereign financing instruments

- Open-source common risk metrics empower actors, especially in emerging economies, to consider physical climate risk systematically in policy making and risk assessments.
- Easily accessible metrics can help decision-makers identify key risk transmission channels and material risks to guide in-depth climate-related fiscal risk assessments and interventions.
- An independent, open and transparent source of widely accepted risk information can provide an engagement tool with various national financial decision-makers and help support the design of new types of financial instruments to better manage risks and mobilize financing for resilience.

1. Introduction

> "It is only in creating a market-wide, evidence backed, comparable and standardised approach on physical climate risk that the financial sector will be able to price climate risk, thus building finance sector resilience and helping to identify where and how our economy and society need to adapt to a changing climate"
>
> **JOINT STATEMENT BY THE GLOBAL COMMISSION ON ADAPTATION, THE TASKFORCE FOR CLIMATE-RELATED FINANCIAL DISCLOSURES, UNEPFI AND THE GLOBAL CENTRE ON ADAPTATION (2021)**

> "Strengthening the climate information architecture is paramount to promote transparency and global comparability of data and thus improve market confidence, safeguard financial stability, and foster sustainable finance"
>
> **INTERNATIONAL MONETARY FUND (2021)**

Institutions as diverse as the Global Commission on Adaptation, the International Monetary Fund (IMF), the United Nations Office for Disaster Risk Reduction (UNDRR), the Task-Force for Climate-Related Financial Disclosures (TCFD), the Global Centre for Adaptation and the Vulnerable Twenty (V20) Group have called for a common climate-risk data architecture as a foundation to underpin adaptation of our economy and society to climate change. This is equally important for financial decision makers and wider society. For civil society, firms and governments such information is essential to underpin adaptation decisions. For financial institutions, including banks, insurers, asset owners and asset managers, as well as public and international financial institutions (IFIs), climate-risk data is essential to inform investment decisions that support climate adaptation. Making such data more accessible, consistent and comprehensive is critical to scaling-up financing for adaptation and aligning financial flows with climate-resilient development goals.

This discussion paper was prepared to showcase the need for – and the benefit of having – a globally consistent, open *baseline* dataset of climate risk and resilience metrics as a global public good to help mobilize finance for adaptation. The Glasgow Climate Pact agreed at COP26 included the call to double climate finance for adaptation. To date, estimated adaptation costs in developing countries are five to ten times greater than current public adaptation-finance flows, and the adaptation-finance gap is widening.[1] Scaling-up private finance is essential, to fill the financing gap,[2] yet today this accounts for only a minor share of global climate finance flows, particularly in the Global South.[3] For example, the private sector contributed only 14 per cent (USD 4.2 billion) of total climate finance in

[1] UNEP Adaptation Gap Report 2021, https://www.unep.org/resources/adaptation-gap-report-2021

[2] The private sector plays three important roles: internal adaptation (climate-proofing their own operations); financing adaptation and providing adaptation goods and services to others, such as drought-resistant seeds. https://www.climatepolicyinitiative.org/unlocking-private-sector-adaptation-finance/

[3] CPI 2021 Global Landscape of Climate Finance

Africa, despite a wealth of adaptation-investment opportunities with wider global benefits, such as sustainable agribusiness. Common baseline climate-risk metrics are an essential component to scaling-up effective public and private finance for adaptation.

Scaling-up private-sector action to build adaptation and resilience is urgent and relevant for all countries. Human action is creating greater and more dangerous risk, and pushing the planet towards existential and ecosystem limits. Accordingly, the UNDRR's Global Assessment Report in 2022 calls upon all countries to rework financial systems to account for the real costs of risk, particularly long-term risks, rework investment and insurance systems to incentivize risk reduction, and adapt national fiscal planning alongside wider societal measures to reduce risks.[4]

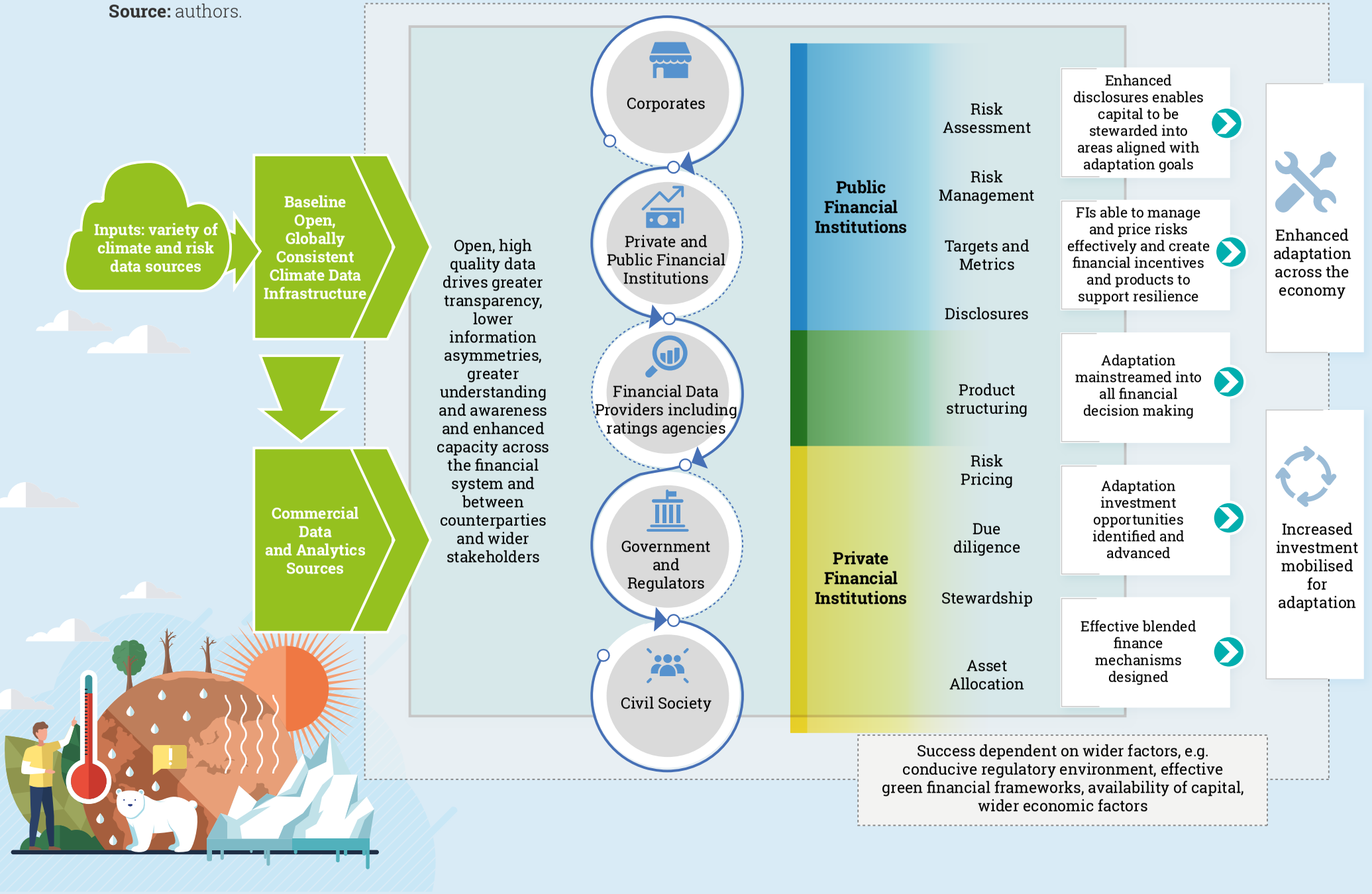
This is especially relevant to helping shift private finance flows, which are many times larger than public flows. By 2025, global assets under management are expected to reach $145 trillion.[5] This capital can either be deployed in ways that build resilience or undermine it. For example, total investment in infrastructure globally is projected to reach $3 trillion per year by 2025 – more than 60 times larger than all tracked, earmarked climate finance for adaptation. Such investments can lock in climate-related risks for decades, yet, in many parts of the world, buildings and infrastructure still do not meet minimum climate-resilient design standards. Global financial flows for agriculture are even larger. Moving from the billions to trillions needed for adaptation globally will require aligning the trillions of dollars of global public and private financial flows and investment with climate-resilient development goals, consistent with Article 2.1c of the Paris Agreement.

Yet we are a long way from integrating climate resilience into the financial system. For example, the TCFD 2022 Status Report found that physical climate risks are still not accounted for within financial decisions.[6] Data quality and data-gap problems[7] were cited as one explanation, alongside a perception that such risks are more remote. The Coalition for Climate Resilient Investment (CCRI) notes the need to close the gap in data and metrics to scale-up resilient investment.[8] More widely, the IMF explains that strengthening the climate information architecture is paramount to promoting transparency and global comparability of data, and thus improving market confidence, safeguarding financial stability, and fostering sustainable finance.[9]

Closing these gaps requires an open, globally consistent climate-risk data architecture to support enhanced adaptation across the economy and increased investment. Figure 1 sets out an illustrative Theory of Change for such a new architecture.

4 https://www.undrr.org/gar2022-our-world-risk
5 https://www.pwc.com/ng/en/press-room/global-assets-under-management-set-to-rise.html
6 TCFD Status Report 2022 (October 2022). https://www.fsb-tcfd.org/publications/
7 Assessments often require detailed information on the location of company assets, their nature (type, vulnerability, adaptations), the use of localized or regional climate models, and challenges with acute event attribution to climate change.
8 CCRI Risk and Resilience Report 2021. https://storage.googleapis.com/wp-static/wp_ccri/6dea3e47-ccri_riskandresilience_26.11.2021.pdf
9 IMF 2021. Strengthening the Climate Information Architecture. https://www.imf.org/en/Publications/staff-climate-notes/Issues/2021/09/01/Strengthening-the-Climate-Information-Architecture-462887

Figure 1: illustrative theory of change for an open, globally consistent climate-risk data architecture to support enhanced adaptation across the economic and increased investment.
Source: authors.



Section 1 of this paper sets out the case for building such a climate-risk data infrastructure. Section 2 introduces and draws upon learning from two major initiatives, the Global Resilience Index Initiative (GRII) and UNDRR's Risk Information Exchange (RiX) to showcase how a common climate-risk data architecture could work, and illustrate what can be achieved with currently available data. Section 3 then illustrates four areas where climate-risk data is required within the financial sector to draw out common elements to inform the design of such an open climate-risk data architecture. These case study areas were developed through consultations with private and public financial institutions (including asset owners, asset managers, national infrastructure banks, multinational banks and insurers), data and service providers (ESG data providers, physical climate-risk data providers, sustainability and engineering consultancies, ratings agencies) and related stakeholders (regulators, academia and the GRII partner institutions) and desk-based research. The case study areas were selected to provide a broad sweep of different use cases, though are not comprehensive. The final section draws conclusions on the characteristics of such a new climate-risk data architecture and proposes next steps, with a focus on the international community.

2. The need for global, open and common climate risk and resilience metrics

For climate change mitigation action, the consistent metric (or common language) of greenhouse-gas emissions enables the assessment, measurement and comparison of economic activities in terms of their impact (or externality) on the climate. This agreed architecture and approach means that from local to global level, a common understanding is in place. This common language is critical to unlocking action, including through setting measurable and verifiable targets, designing and implementing effective domestic and international policy, the development of markets, transparency in comparing action across companies, and stewardship by investors.

This same standardization does not yet exist in the climate-resilience agenda. Adaptation and resilience are missing a common language to unlock broad action. There are no comparable common and open resilience metrics to help create a shared understanding and baseline for addressing climate risk in financial terms. This is needed particularly to bring finance for resilience to scale through full integration of physical risk and resilience consideration in private-finance flows.

The absence of such metrics creates a constraint on adaptation action. It means, for example, that is difficult to robustly and transparently compare the benefits of two investments for resilience, to set verifiable targets, to price the externality and for financial institutions to begin integrating physical climate risks into their decisions on capital allocation and risk pricing.

Similar to GDP or tons of CO2 equivalent, resilience metrics should be underpinned by global open and transparent efforts to create a consistent and comparable dataset that becomes shorthand for understanding risk. This can support the global financial architecture required to move from billions to trillions of investment in climate adaptation across both developed and developing economies.

The need for this common language and set of metrics is well recognized. For example, the UNDRR's 2022 Global Assessment Report pointed to the need for a new risk language that cuts across sectors to break down asymmetries in understanding of risk across society – for example, between governments, civil society and financial institutions. This is essential to make adaptation plans, set targets and monitor progress across the economy. The TCFD promotes a common approach to measuring and valuing risk, which coupled with disclosure, ensures that different firms, assets or investments can be compared on a level playing field, and facilitates risk pricing that can act as an economic incentive for investing in resilience. This transparency in risk creates the discipline essential to supporting improved alignment with societal goals. It also unlocks the potential for new types of financial products for adaptation, including sustainability-linked bonds and loans for resilience, resilience-index-linked funds or debt-for-resilience swaps to mobilize investment.

Open risk data is not a replacement for commercial solutions, but instead acts as a public good in addressing important market failures and can accelerate progress across the entire ecosystem of data providers (See Figure 2):

- It works towards a level playing field in access to *baseline* metrics. The current uneven playing field, particularly between government, civil society, financial institutions and corporates – and those that can pay and those that cannot - reduces transparency and accountability of actors and creates information asymmetries that can lead to inequalities.
- Transparency on methodologies is important to ensure risk data is understood and used appropriately, so avoiding the potential for maladaptation.
- Open risk data creates a minimum standard that others can build upon and promotes transparency across providers. This increases data quality across the whole ecosystem.
- Through building upon existing established common standards for risk (e.g. for exposure data), the common metrics support and link groups working on climate resilience including, but not limited to, the humanitarian

sector, infrastructure investment, disaster-risk insurance, financial regulation and disclosure

- Global consistency in approaches ensures that metrics are comparable across countries, users and hazard types.

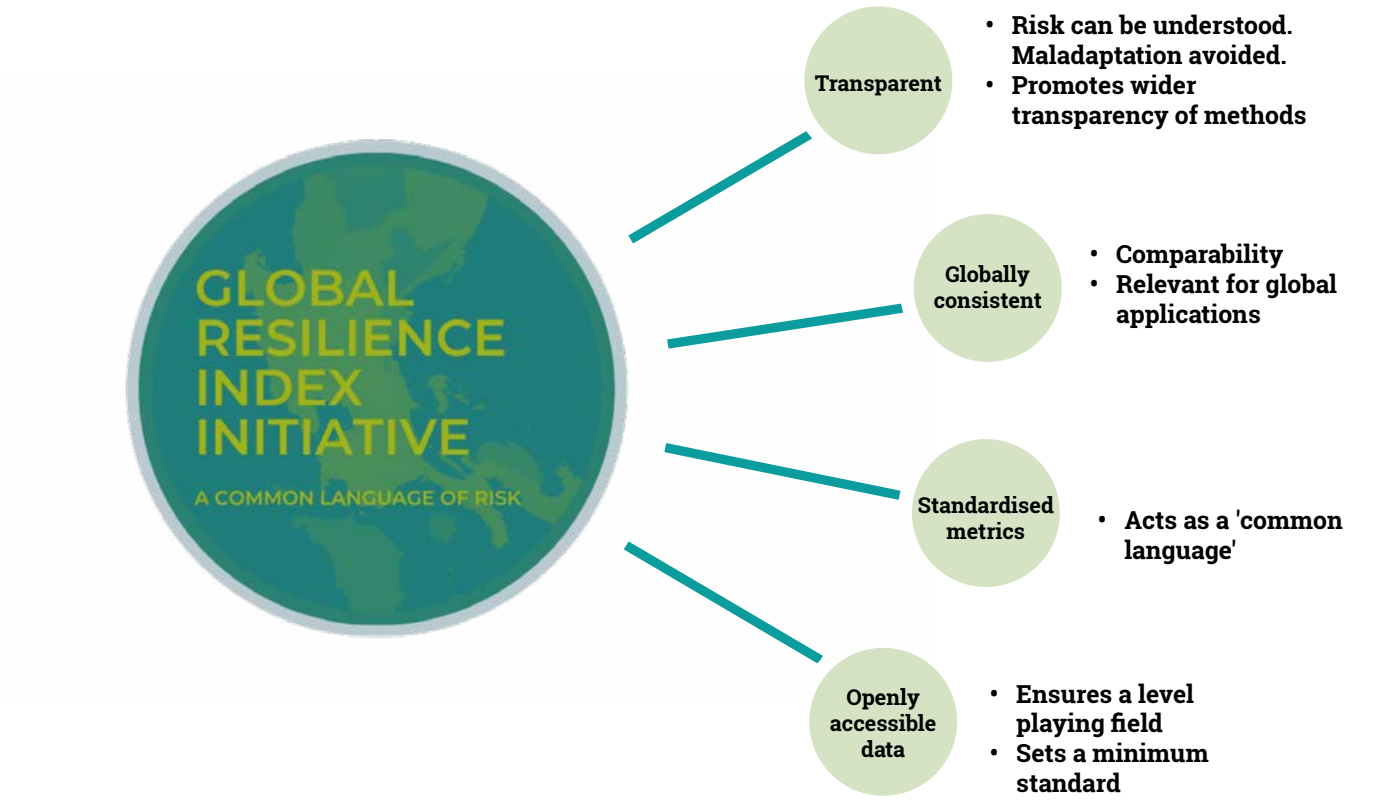
Such metrics can help sectors across the global economy quantify the value of building climate resilience – and the costs of doing nothing.

For the financial sector, common metrics will make it easier to measure risk, aggregate risk measures across a portfolio, disclose the information to regulators, investors and customers, and ultimately take well-informed decisions to reduce financial risk and increase (societal) resilience. They will enable asset owners to aggregate and compare portfolio risks across locations and hazards. They will unlock the development of new types of financial products, underpin blended finance instruments, and enable risk-based pricing that can incentivize adaptation.

At sovereign level, they will help governments better quantify risk to people, social services and physical assets, and assess risk-management investments. They will also allow governments to take informed decisions on what risk to reduce, to transfer, or to retain.

In recent years, a number of initiatives have emerged that either fully or partially meet such a system as described above, with criteria of transparency, openness, global consistency and standardization. Of these, the two introduced below have the ambition to meet each of these criteria and provide high-quality, open and consistent data globally. These two are used as examples within the following section to illustrate how such initiatives can support users in aligning finance and investment with climate-resilient development goals.

Figure 2: Summary rationale for baseline climate-risk data



THE GLOBAL RESILIENCE INDEX INITIATIVE (GRII)

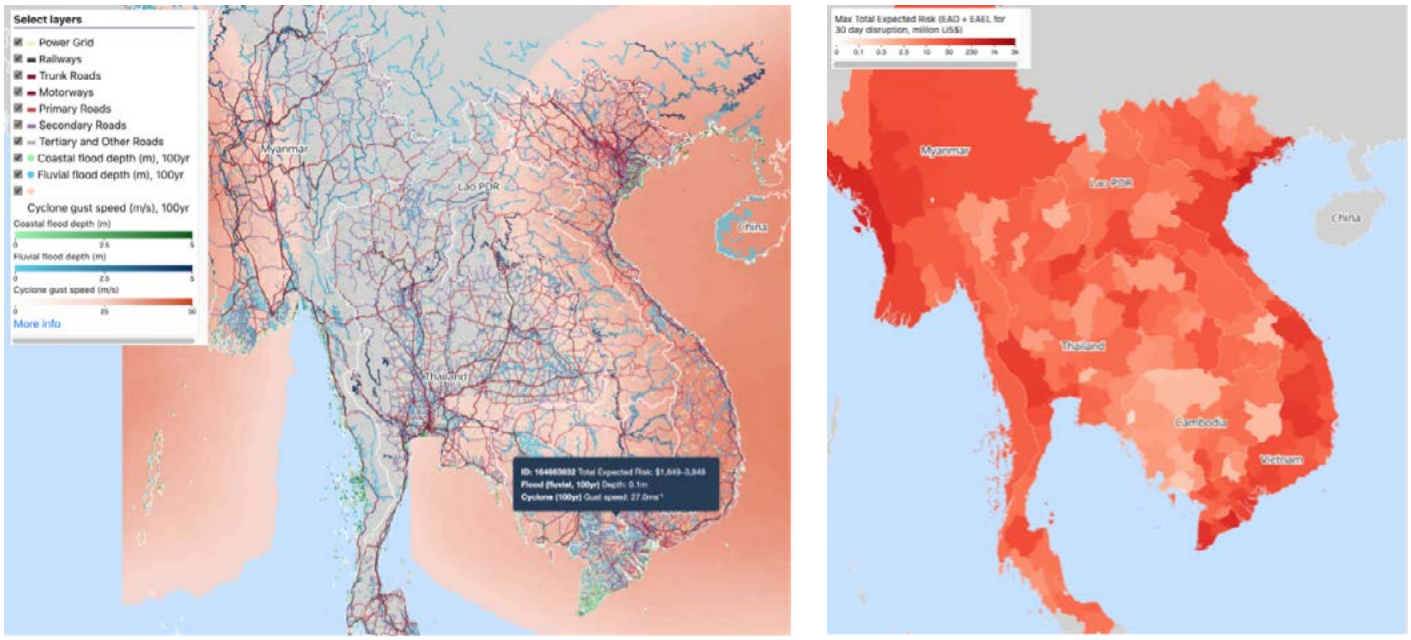
The Global Resilience Index Initiative (GRII) was launched at COP26 as a public-private initiative.

GRII aims to deliver the first open, globally consistent physical climate-risk and resilience data and information architecture designed to enable financial institutions, governments, civil society organizations and international organizations to assess risks, and mobilize finance and investment aligned with climate-resilient development goals, in line with Paris Article 2.1c. GRII has a global focus to support the mobilization of finance and investment for adaptation and resilience in emerging and developing economies. GRII also enables greater transparency on the impacts of financial flows to begin to shift capital toward activities that support climate-resilient development. Figure 3 shows an example of the type of resilience data GRII will provide.

As explained by Mark Carney at COP26: *"Discipline and transparency over alignment will also play a critical role for climate-resilient development. GRII can play an important role by creating a shared understanding of mounting physical climate risks. In turn, this will help close the insurance protection gap and direct investment and aid to where they are needed the most."*

GRII is an open collaborative initiative, rather than just a data product. GRII was conceived and established by a core group of six partner institutions and convened by the Insurance Development Forum (IDF) under a mandate provided by Mark Carney, UN Special Envoy for Climate Action: the UK Centre for Greening Finance and Investment (UKCGFI), the Coalition for Climate Resilient Investment (CCRI), the Coalition for Disaster Resilience Infrastructure (CDRI), the UNDRR, the IDF and the Global Earthquake Model (GEM). It operates with the support of three high-level champions: Mark Carney, Mami Mizutori (UNDRR) and Eric Anderson (Aon).

Figure 3: COP26 Prototype for SE Asia: illustrating combination of data at asset-level data and analytics, admin 1 resolution mapping and higher resolution hazard information.



Source: *Oxford Programme for Sustainable Infrastructure Systems, University of Oxford*

Unlike standard physical risk indices, GRII provides both asset-level and sub-national data, fully transparent and open, based on catastrophe-risk-modelling approaches of the insurance industry, coupled with best-in-class environmental science and engineering. It takes a people-planet-prosperity approach, including data and models of nature, biodiversity and social vulnerability factors, alongside infrastructure, economic activities and economic systems.

GRII is supported by a wide range of contributing technical organizations that share data, analytics and expertise, including the University of Oxford (the Oxford Sustainable Finance Group and Oxford Programme for Sustainable Infrastructure Systems), the Insurance Development Forum's Global Risk Modelling Steering Group (RMSG), the Centre for Disaster Protection, Fathom, JBA, GIRI, NASDAQ, OASIS, Willis Towers Watson, Aon, and the World Bank. The ambition is to expand these technical collaborations over time to build the climate-risk data ecosystem.

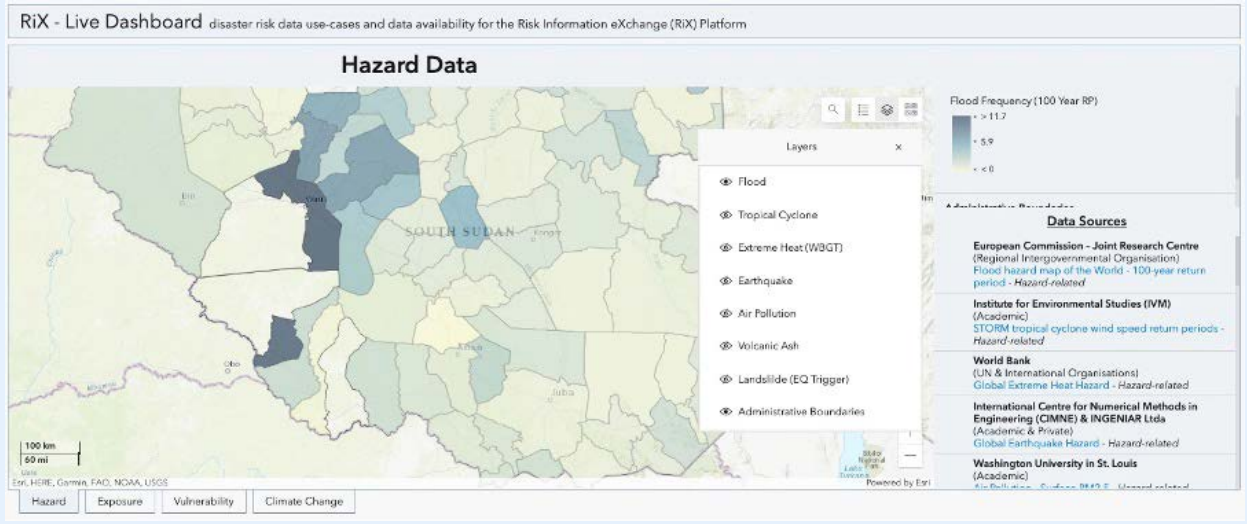
UNDRR'S RISK INFORMATION EXCHANGE (RIX)

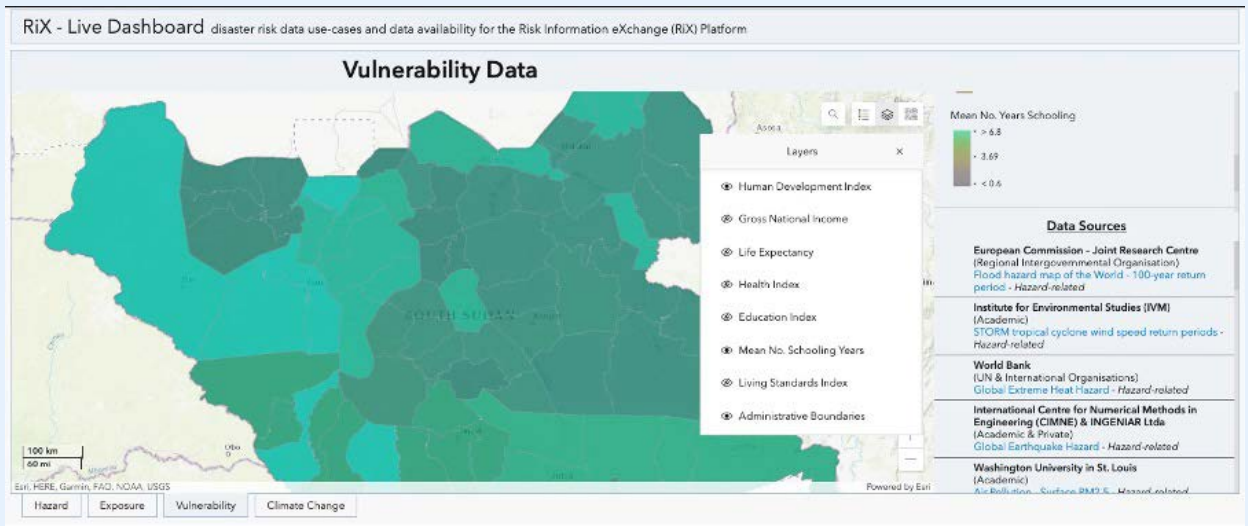
UNDRR's RiX aggregates risk data across traditionally siloed climate change, humanitarian and development networks. Open data and risk information is an essential element of sustainable development. An open-access platform, RiX builds on national efforts and connects them to relevant regional and global initiatives tracking risk. RiX does not duplicate existing risk and climate data. Instead it aggregates risk information and synthesizes data sources into a common platform accessible to all development and humanitarian actors. In contrast to GRII, it focuses on aggregating global, regional and nationally generated risk information for use at country level, with the goal of scaling-up across countries over time. While its focus is on geospatial data to visualize risk layers, it also includes non-spatial data like national adaptation plans.

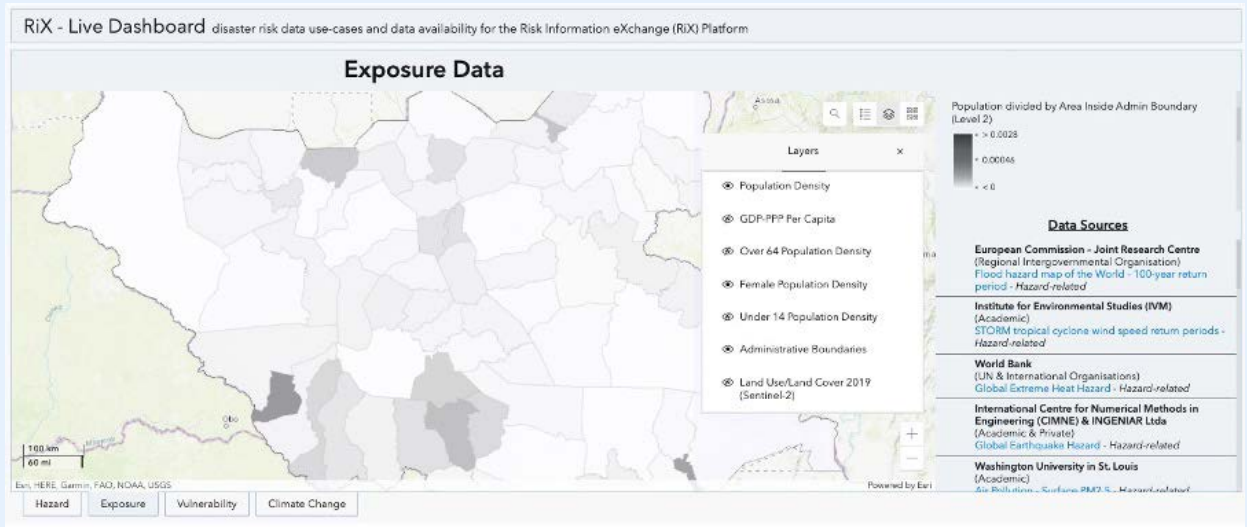
UNDRR's Risk Information Exchange (RiX) aggregates open-source information for sharing risk data among global and national end-users such as government ministries and departments, including disaster management and civil protection agencies, sector planners, and finance and investment officials; United Nations, bilateral and other multilateral organizations; NGOs and INGOs; researchers; and the private sector.

To improve risk knowledge and contribute to efforts to strengthen national risk-data ecosystems, RiX facilitates linkages between the providers and generators of risk information with end-users at country level, laying a foundation for continuous improvement in the visibility and use of risk information. Improving risk knowledge is fundamental to achieving the Sendai Framework and Paris Agreement, and contributing to national development and investment plans.

Figure 4 shows RiX downscaled aggregated risk data in South Sudan: *Disasters occur when hazard risk is combined with exposure and underlying vulnerability. The images show sub-national flood risk (a hazard) and population density for the same area (a proxy indicator for exposure), combined with average years of schooling achieved (a proxy indicator for tracking potential vulnerability). Increasing the accessibility and quality of such data, which currently is often scattered or hard to access in one place, can help government and other actors apply science-based quality information to inform decision making. It can also improve the base data quality for models and other tools (*https://rix.undrr.org*)*







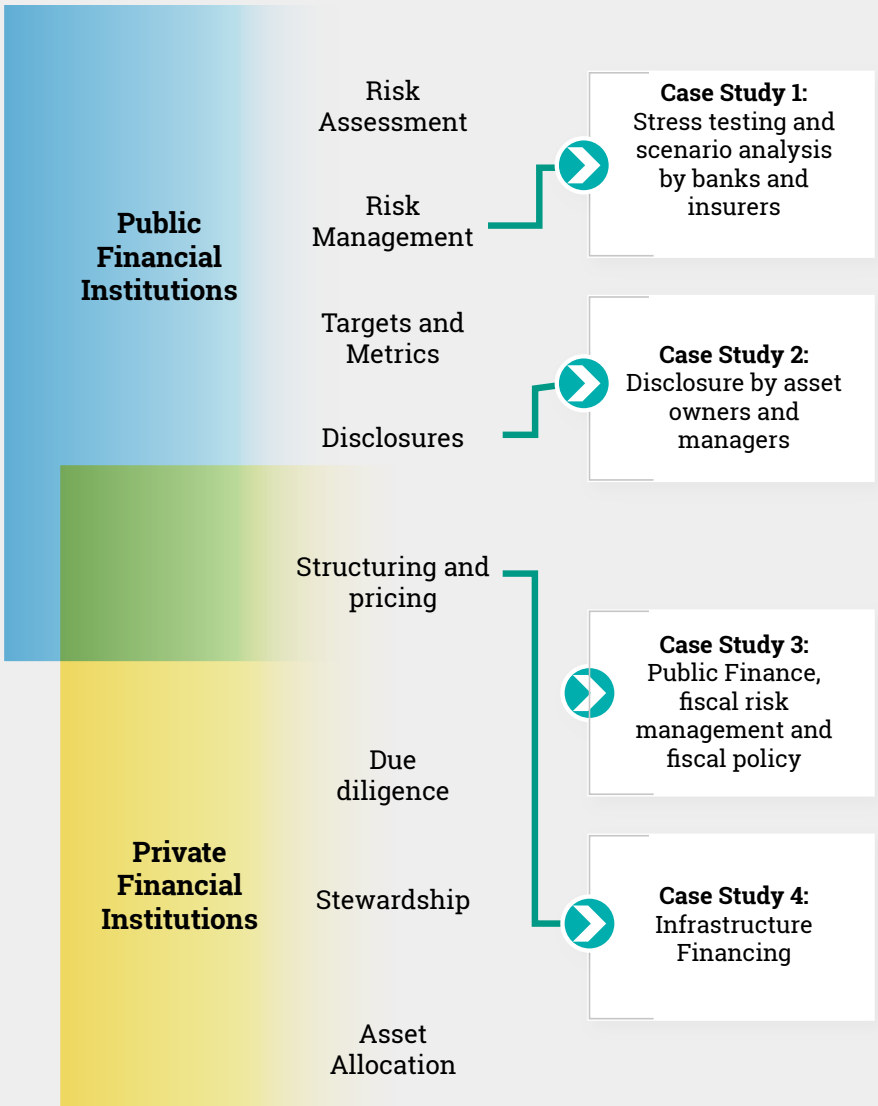
3. The need for common risk metrics

This section outlines findings from consultations with users of climate-risk metrics on the status of the use of such data today, the needs and challenges, and the lessons for the design of a new public-good initiative. Four specific use cases are discussed: (i) climate-related financial disclosure by asset owners and asset managers, (ii) infrastructure financing, (iii) climate stress testing for banks, and (iv) public policy and finance, with a focus on fiscal resilience. The selection of use cases is designed to give a wide range of perspectives, but is not comprehensive. The use of such a public good can be much broader, including, for example, risk-based financial instruments.

CLIMATE-RELATED FINANCIAL DISCLOSURES (AND WIDER SUSTAINABILITY DISCLOSURES)

Several jurisdictions, including the G7 countries, have mandated the disclosure of climate-related financial risks in alignment with the recommendations of the Task Force for Climate Related Financial Disclosures (TCFD). For many of these jurisdictions, this includes requirements for listed companies, financial firms and funds to disclose detailed information concerning the assessment, governance

Figure 4: Illustration of use cases considered in this report



and management of climate-related financial risks.[10] The recent 2022 TCFD Status Report found that all regions have significantly increased their levels of disclosure over the past three years. For fiscal year 2021 reporting, 80 per cent of companies disclosed in line with at least one of the 11 recommended TCFD disclosures. Europe remains the leading region for disclosure, at 60 per cent on average across the 11 recommended disclosures, 24 per cent higher than Asia Pacific as the next highest region. Over 60 per cent of asset managers and over 75 per cent of asset owners surveyed indicated they currently report climate-related information to their clients and beneficiaries, respectively. Based on the TCFD survey, 90 per cent of investors and other users incorporate climate-related financial disclosures in financial decision-making, and 66 per cent of these indicated such disclosures factor into the way they price financial assets. In addition, based on a literature review, there is a growing body of evidence that climate-related risks are beginning to affect prices for certain types of assets.

The growing adoption of TCFD[11] (and similar guidelines) reflects the increasing recognition of the materiality of climate financial risks and the need to address information asymmetries that create a barrier to risk management at the micro level and avoid their accumulation at macro level. For example, the TCFD recommendations emphasized that *"the disclosure of organizations' forward-looking assessments of climate-related issues is important for investors and other stakeholders in understanding how vulnerable individual organizations are to transition and physical risks and how such vulnerabilities are or would be addressed"*.

More broadly, across many jurisdictions, individual corporates, asset managers and financial firms (commercial banks, asset owners, insurers and asset managers) are required to disclose all sustainability-related financial information that is material to an entity for its investors and creditors, i.e. affecting the value of assets and investments, as well as reporting on non-financial risks. Climate-related disclosures are one part of broader ESG disclosures. The UN Principles for Responsible Investment set out a commitment by all signatories to incorporate environmental, social and governance (ESG) issues in all investment analysis and decision making.[12]

CURRENT APPROACH TO METRICS

The disclosure of the financial exposure of a corporate entity, asset or portfolio to physical climate risk enables investors and creditors to assess climate risk to their portfolio and act to manage these risks. Progress has been challenged by the lack of transparent, asset-level data, the multitude of standards and the diversity of approaches between firms.

The current TCFD guidance on quantification of physical climate risks includes metrics and targets (See Table 1). These are annual average loss (AAL), value at risk (VAR), critical physical thresholds and the proportion of unique sites or lines exposed to relevant climate impact. To calculate such metrics ideally requires reporting at the asset or firm level, and detailed analyses based on multiple data sources; in absence of this (or as a first step), analyses are conducted on the basis of sector averages or geography. To assess risk, asset-level data needs to be combined with climate hazard and vulnerability data, which is often obtained from commercial data vendors.

[10] To date, jurisdictions that have mandated climate-related financial disclosures aligned with the recommendations of the TCFD, include Brazil, the European Union, Japan, Hong Kong, New Zealand, Singapore, Switzerland, and the United Kingdom.

[11] https://www.fsb-tcfd.org/

[12] https://www.unpri.org/about-us/what-are-the-principles-for-responsible-investment

Table 1: Snapshot of TCFD data approach

		TCFD summary guidance (EBRD, IIGCC)	Currently available to varying quality through data vendor
Scope	**Hazards**	Storms, extreme rainfall, extreme heat, heatwave, flood, drought and wildfire, cyclones, variability in precipitation and temperature, water stress, sea-level rise, land degradation + other industry-relevant or localized hazard across value chain	Data providers using different risk indicators e.g. coastal inundation as sea-level rise, wind as storm, precipitation rate as floods
	Timeframes	For 2020-2040 - probabilistic For 2040-2100 - scenario-based analysis	Probabilistic analysis from 2020 to 2100 for RCP 2.6 and 8.5
	Scale	At least country or city of business and supplier facilities, rated by criticality. Asset-level where possible, in respect of model downscaling limits	Different levels by provider – high level or asset level Regional climate models resolutions to between 5 and 50km Hazard layer resolutions vary between 5 and 250 metres.
	Scenarios	RCPs 2.6 and 8.5 as best (2C) and worst (4C) case	
	Direct - Indirect	Direct - damage and loss of real assets, disruption to chain, supply-chain costs and lost hours Indirect - insurance cost, energy cost, regulatory change, legal liability, market change, debt cost, social licence to operate	Supply chain seems to be the most difficult of direct impacts
Disclosure	**Metrics - Outputs**	Data - climate overlain with business -> Recent and historic impacts -> AAL -> # of sites and business lines exposed to the relevant climate impact -> VAR -> Identification of critical thresholds	AAL Annual damage assuming multi-hazard insurance VAR and %VAR Each data vendor has developed risk ratings and hotspot maps based on VAR Failure probability Productivity loss
	Adaptation measures	Now and future defences, retrofits, relocations, or other adaptations	Adjusted risk profile
	Strategy, policy, and advocacy	Supply-chain risk-management strategy with engagement Engagement with government and local stakeholders on resilience	

Market participants report a proliferation of metrics, protocols, data tools and approaches. This diversity and the resulting challenges create a barrier to accurately capturing the potential impact of physical climate change on investments, to evaluating firms adaptation targets and plans, and comparing adaptation opportunities in a systematic way. The existence of different data vendors creates important choice and fosters innovation, but can create confusion for investors and asset managers in multiple ways. First, related to the outputs from different data providers. Recent papers by UNEP

FI,[13] the UK Green Building Council and others have identified and compared physical climate-risk data providers, indicating trade-offs in turnaround time, cost and detail in choosing between a more high-level screening and an asset-level deep assessment (which can then be aggregated up to country or sector). Providers specialize in one or the other, but not both, and using modelling outputs requires trusting the capability of the provider, since the finer methods are opaque. Secondly, related to the method and aggregation. Multiple data providers will provide different results with divergences that are complicated to explain. There is little supervision or authoritative guidance on best practice. The evaluator is the investor and so comfort in communicating outputs also plays into data-provider choice and overall approach to disclosure. Finally, a lack of comparability and standards is creating difficulties for asset managers. In the current commercial landscape, asset managers are able to access climate data and pull input data. It is the failure coefficients and calculations behind the damage functions that are proprietary and without benchmarks, requiring trust in the data vendor due to low method transparency.

Despite this, consultations suggest that institutional investors are beginning to use physical risk data to assess financial risks and keep a diversified portfolio. Asset managers are motivated to undertake resilience-building activities within their role, to address risk for investor confidence by disclosing the risks they face and how they are managing these. The typical asset manager journey to determine the material exposure of an entity or multiple entities within a portfolio to physical climate risk involves a number of steps that would benefit from open, comparable resilience metrics, including helping to identify materiality of risks by hazard across sectors.

Initiatives like the International Sustainability Standards Board (ISSB) of the International Financial Reporting Standards Foundation (IFRS) and the TCFD, are working across the sector to harmonize approaches. There is also an active debate on whether standardized metrics could help to improve quality and reduce greenwashing. Frameworks are also being developed to guide integration of physical climate-risk assessment into investment decision-making. As part of this, basic common metrics are needed and can act as a bridge to more sophisticated commercial modelling outputs. While there are differences in needs between different financial firms, there are common challenges. For example, a set of benchmarked damage functions at a high level could provide sector averages, a proxy that could provide a very high-level screening of risk. Similarly, a set of proxies for the built environment could provide agreed characteristics of e.g. heat and wind thresholds.

HOW COMMON RISK METRICS COULD ENABLE PROGRESS

- Country or regional and sector average common risk metrics could provide a high-level screening of risk as a proxy where detailed data is not available, with some guardrails around communicating a high-level estimation.
- Open data indirectly raises the ambition of high-level-data providers, by articulating the gap between common metrics and proprietary asset-level outputs, thereby incentivizing increased investment in filling data gaps and providing high quality information.
- Baselining through a third-party independent source could help provide a more level playing field. If more risk is assessed in a comparable way through objective, free, accessible and common metrics, investors will have greater confidence in adaptation-investment needs and opportunities. This would help identify materiality of risks by hazard across sectors and geography, providing comparability at a high level and pointing to a need for targeted granular and asset-level analysis (rather than exploratory analysis).
- Providing a benchmarked set of exposure and risk data and damage functions could provide a basis for risk quantification, upon which asset owners and fund managers can engage with asset managers on their plans for the holding.

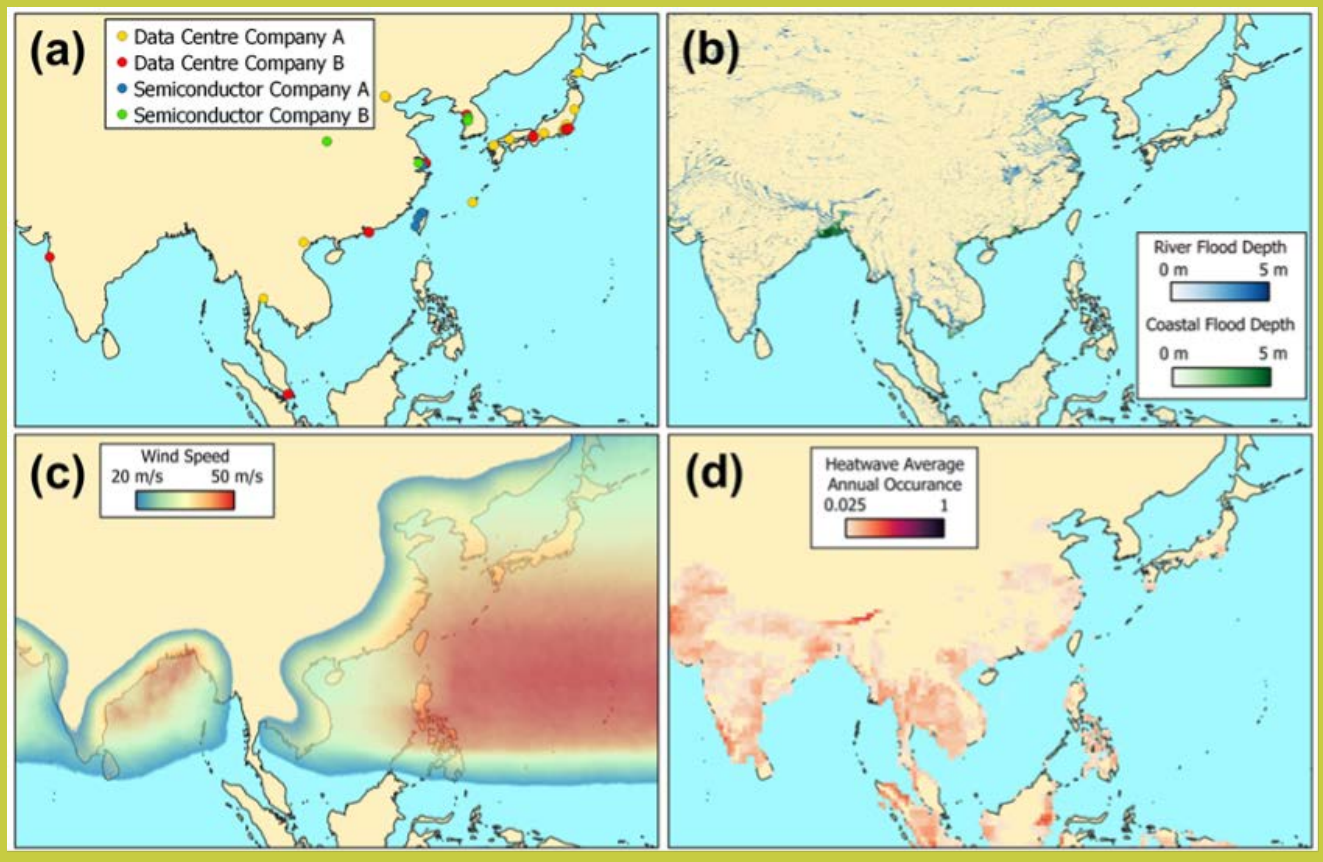
[13] The Climate Risk Landscape

Box 1: Climate-related financial disclosure case study – Impax Asset Management

Pricing the physical risks of climate change broadly remains difficult and limited across listed equity markets, but investors such as Impax Asset Management are working to improve this given its increasing importance. The following case study, developed in collaboration with the Centre for Greening Finance and Investment, demonstrates the application of GRII data within physical climate-risk assessment as part of analyses to support the preparation of Impax's TCFD-aligned disclosures.

Physical climate risk is assessed to four companies relevant to Impax Asset Management - two data-centre operators and two semiconductor manufacturers - with a particular focus on the assets owned and operated by these companies in the Asia-Pacific (APAC) region. These industries were identified as being particularly susceptible to physical climate risks and where new data was required to fill gaps in existing approaches. Data centres are vulnerable to extreme heat, evidenced by the impacts felt by an important data-centre operator in London during the European heatwave of July 2022.[14] The semiconductor manufacturing process is water-intensive, and thus manufacturing facilities are notably exposed to water-related risks. The facilities analysed are also geographically concentrated in specific areas in the region, meaning a catastrophic event could have systemic impacts on supply chains.[15]

Box 1: Figure 1. (a) Impax asset-level data. (b) GRII fluvial and coastal flood maps. (c) GRII tropical cyclone wind-speed maps. (d) GRII heatwave average annual occurrence maps

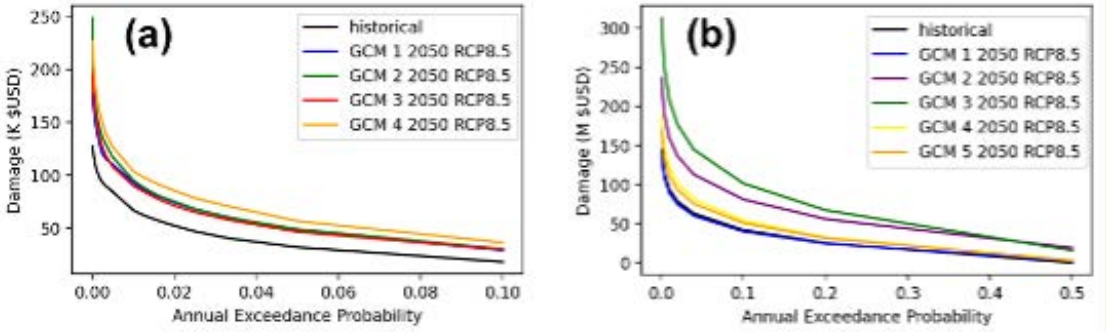


[14] https://www.wired.co.uk/article/data-centers-climate-change

[15] McKinsey Global Institute. 2020. Climate risk and response: physical hazards and socioeconomic impacts. https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/climate%20risk%20and%20response%20physical%20hazards%20and%20socioeconomic%20impacts/mgi-climate-risk-and-response-full-report-vf.pdf

Risk to the four companies' assets is assessed using GRII data (Figure 1) for four climate hazards: tropical cyclones, river floods, coastal floods and heatwaves, both for the present day and in 2050 for a high-emission (RCP8.5) scenario. Exceedance probability curves (Figure 2) are calculated for each asset at risk, as well as risk metrics Average Annual Loss (AAL) and, for heatwaves, Average Annual Exposure (AAE), by combining GRII hazard information and vulnerability information based on disclosures. These risk metrics are also aggregated to company level, to give company-level risk (Figure 2c). Asset values are taken from company disclosure or are estimated based on industry data.

Figure 2. (a) Tropical cyclone exceedance probability curve for a Japanese data centre. (b) River flood exceedance probability curve for a Chinese semiconductor manufacturer. (c) Company-level risk metrics



(c)

		Data Centre Company A	Data Centre Company B	Semiconductor Company A	Semiconductor Company B
River Flooding *AAL $USD*	Historical	681 K	19 K	7,528,189 K	97,741 K
	2050 RCP8.5	621 K (-9%)	31 K (+63%)	1,954,442 K (-23%)	116,827 K (+20%)
Coastal Flooding *AAL $USD*	Historical	0	0	157,996 K	74,850 K
	2050 RCP8.5	0	2 K	163,949 K (+4%)	143,503 K (+92%)
Tropical Cyclone *AAL $USD*	Historical	252 K	218 K	36,659 K	8,772 K
	2050 RCP8.5	568 K (+125%)	423 K (+94%)	59,752 K (+63%)	19,593 K (+123%)
Heatwaves *AAE % Assets*	Historical	1.2	0.9	0.7	0.5
	2050 RCP8.5	10.7 (+792%)	14.8 (+1544%)	9 (+1186%)	9.5 (+1800%)

Results from the physical risk assessment indicate that river flooding is currently the most material risk to both semiconductor manufacturing companies and data-centre company A, while tropical cyclone risk is the most material risk for data-centre company B. Future increases in risk for all companies will be greatest for heatwaves.

This analysis demonstrates the relevance of acute risks such as flooding and tropical storms for any company reliant on physical assets. It also highlights the magnitude of future changes in exposure to extreme heat. This is of particular importance to data-centre companies, whose thermal operating ranges will be stretched by future climate change. Impax Asset Management will use this information to contextualize the adaptation and resilience plans of these companies, and to deepen its understanding of how physical risk may express itself in these industries, contributing to their ability to understand and price these risks in the future. The demonstration case shows the importance of openly available, transparent and globally consistent risk and resilience metrics as an input to risk assessment.

Source: *Centre for Greening Finance and Investment and Impax Asset Management*

INFRASTRUCTURE FINANCING

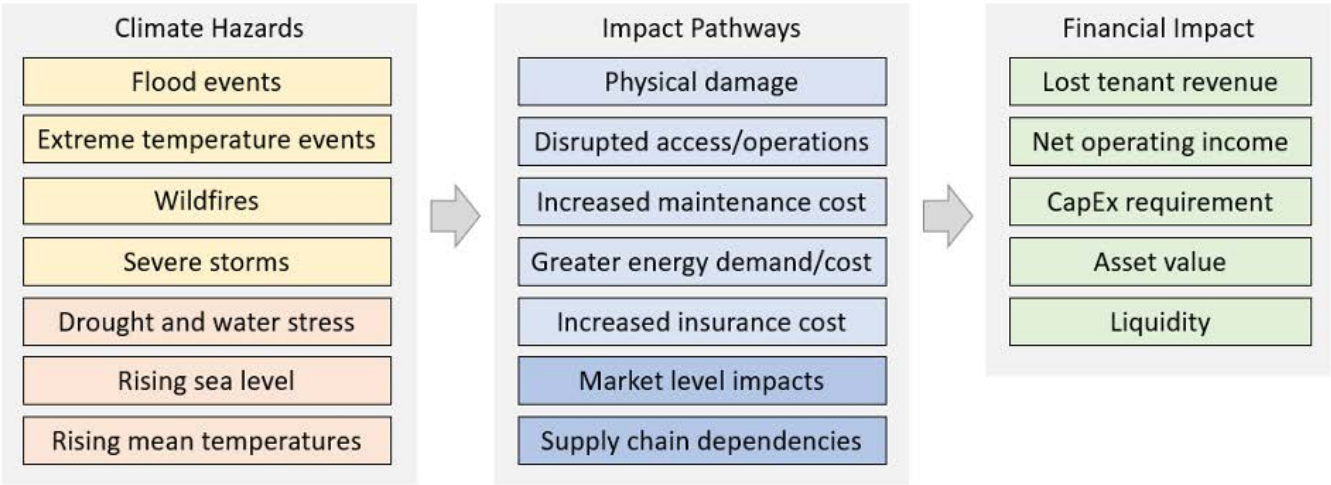
Infrastructure is one of the most important asset classes for adaptation and resilience. Firstly, the resilience of infrastructure is critical to national prosperity. Infrastructure services are essential for economic development and for raising and maintaining people's quality of life. Yet millions of people, especially in low- and middle-income countries, are facing the consequences of unreliable electricity grids, inadequate water and sanitation systems, and overstrained transport networks, and these systems will come increasingly under strain due to damages and disruption related to physical climate risks.[16] Research by the World Bank estimated that with fewer disruptions and reduced economic impacts, the overall net benefit of investing in the resilience of infrastructure in developing countries alone would be $4.2 trillion over the lifetime of new infrastructure. Secondly, these are long-lived assets and so decisions taken today can influence risk for decades or more.

Our consultations with users of climate-risk data viewed infrastructure financing from the viewpoint of assets owner and asset managers as well as procurer-investors in large public infrastructure. Based on these consultations, multiple pathways were identified through which physical climate risk can generate financial impacts for infrastructure financiers (Figure 5).

Different stakeholders have different interests and needs when engaging with physical risk data:

- *Asset owners* such as pension funds are concerned with continued performance and return based on fund requirements at the due-diligence stage, and periodic monitoring of risks.
- *Asset managers* support the performance of the asset and ongoing risk management.
- *Asset operators or tenants* enable and maintain the performance of the asset, with responsibility for meeting the required service level or output.
- *The State* as procurer, issuer-investor, owner, and operator for purely public infrastructure, shares all needs in asset management and operation.
- Regulators that are establishing and enforcing service standards, stability and output needed for the public, require the information to assess and evaluate the investment plans and risk-management practices for infrastructure.

Figure 5: Climate hazard pathway to financial impact on infrastructure investment



[16] Hallegatte, Stephane; Rentschler, Jun; Rozenberg, Julie. 2019. Lifelines : The Resilient Infrastructure Opportunity. Sustainable Infrastructure;. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/31805 License: CC BY 3.0 IGO

CURRENT APPROACH TO METRICS

Infrastructure financing includes assessments and decisions involving physical climate change as a material risk at several points, as outlined below and in Figure 5. Notably, many infrastructure owners and private companies are currently not obliged to disclose risk under TCFD or related frameworks. Consultations suggest that physical-risk quantification is most relevant in the due-diligence and investment-monitoring phases:

- **Due diligence**
  - In initial asset screening, the fund manager will consider elements of climate risk in determining fit to fund. This includes, for example, assessing the risk of operational outages, weak points in operations, and forward-looking resilience.
  - Due diligence will utilize both quantitative assessments and qualitative judgement, for example the use of quantitative tools and direct engagement with the asset manager or directly with the operator. Basic tools are, for example, the UK planning permission which includes a Climate Change Risk Assessment (CCRA) aligned to the Equator Principles[17] due-diligence framework. This sets out that CCRA for built projects include consideration of relevant climate-related physical risks as defined by TCFD. Open-source tools are also used to look at likely risk for a 1:200 or 1:1000 event. Some pension funds are designing exclusion criteria based on resilience (risk) and alignment to Paris, which requires easier access to comparable and trusted asset-level data.
- **Monitoring**
  - Fund managers assess their overall portfolio for performance and risk; for example, screening investments' risk rankings. In the best case, they then engage with the asset manager to disclose the risk management, voting behaviour and plans for increasing resilience and Paris alignment of this holding. Asset managers and operators are queried by fund managers but, practically, fund managers find it difficult to compare exposure or performance, or trust aggregated portfolio views. They rely on sensible proxies where data is available, e.g. map against an equivalent listed entity.
  - It is most challenging to access data and information about unlisted infrastructure assets. With an unlisted direct investment into renewables for example, a fund manager monitoring performance and risk will use proxies in the form of a physical asset proxy and a matched listed company where disclosure data is available.

Consultations suggest that historically physical climate-risk assessment has been mostly a box-ticking exercise, but this is beginning to change. Efforts to develop new tools and approaches, and to convene and generate best practice, for example by the CCRI,[18] are laying the groundwork to embed physical risk in investment decision-making more robustly. In addition, infrastructure resilience standards are being developed. Further, infrastructure investors expect that the EU and UK Green Taxonomy could help to accelerate the integration of climate risk in new project development, with the CCRA aligned with the 'do no harm' screening principle. Data providers are developing capability to screen projects to these requirements.

HOW COMMON RISK METRICS COULD ENABLE PROGRESS

- Funds find it difficult to assess projects when standards are fragmented and the projects themselves can exhibit high variability in their profiles. Common metrics would facilitate a high-level screening and detailed assessment of projects.
- Open and comparable metrics would help fund managers compare exposure or performance of different assets, and develop a trusted aggregated portfolio view.
- Accessible and trusted asset-level data, or reliable comparable global datasets as proxies, would make it easier for investors and fund managers to assess especially unlisted entities; this will become more important over time, e.g. with the implementation of green taxonomies.

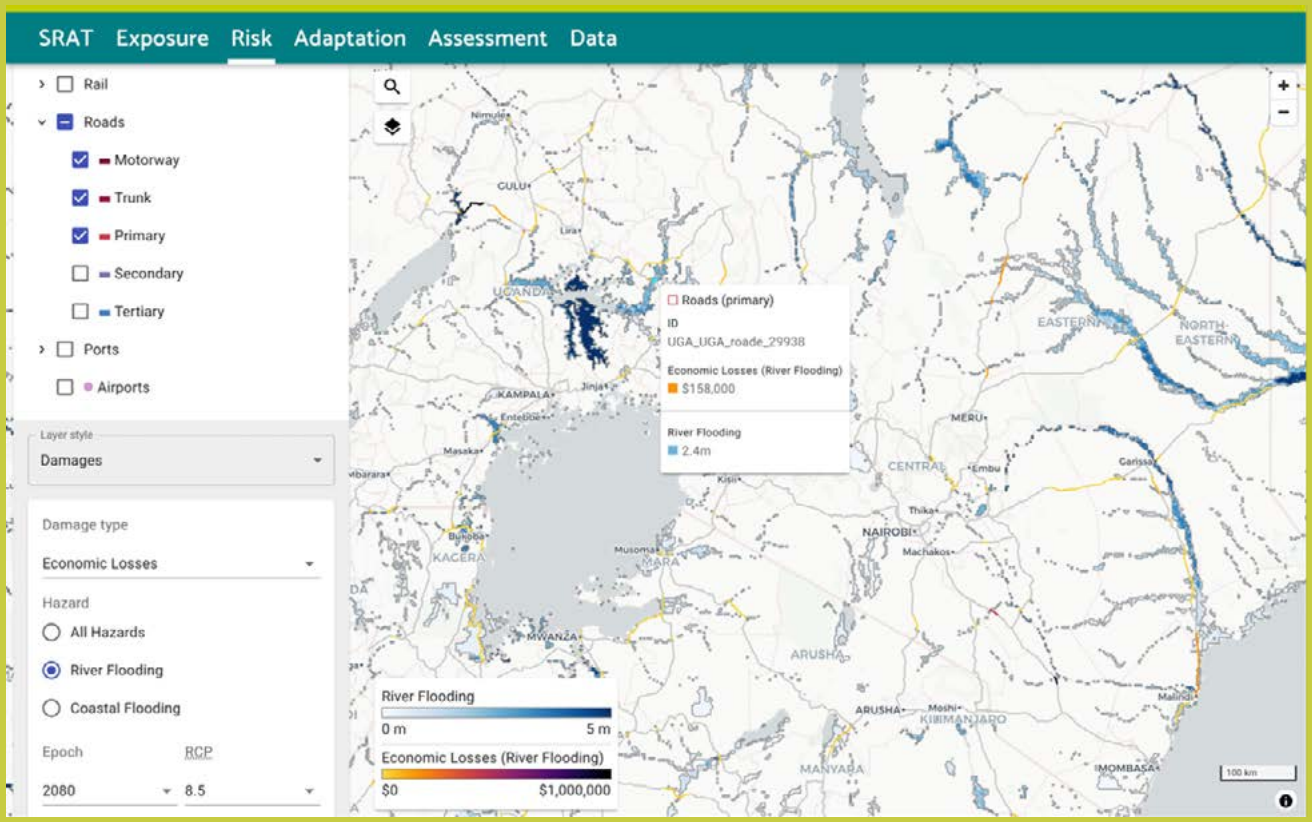
[17] The Equator principles document identifies OS tools and data sources useful for assessing risk
[18] Coalition for Climate Resilient Investment CCRI

Box 2: Resilience metrics for infrastructure investment

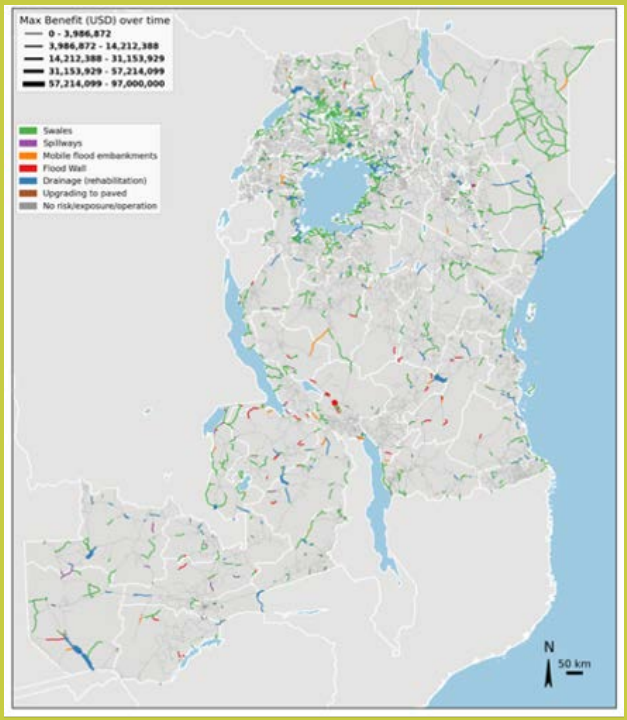
At the core of GRII is an infrastructure risk-analytics model that allows financiers and other decision-makers to assess the physical risks to individual infrastructure assets as well as the benefits of investing in resilient infrastructure systems. The model was developed by the Oxford Programme for Sustainable Infrastructure Systems (OPSIS), one of the technical contributors to GRII. The following case study demonstrates an application of the infrastructure systems model (the Systemic Risk Assessment Tool, SRAT) underpinning GRII to an assessment of transport infrastructure resilience options across Kenya, Tanzania, Uganda and Zambia.[1] The project seeks to understand the magnitudes and locations of exposures, damages, economic disruptions and risks from climate-related hazards to strategic road and railway network links. This in turn can inform financial decisions, for example to assess and price physical climate risk for new infrastructure investments and assess the economic costs and benefits of adaptation.

The analysis estimates a potential increase in cumulative direct damage risks for road and rail assets from flooding across all climate scenarios from $ 41 million a year in the current baseline to about $ 82-131 million a year by 2080. Further analysis shows that indirect economic risks to trade flows due to disruptions of key transport linkages might grow from $ 0.16 million a day in the current baseline to about $ 4.2 million a day by 2080 across all climate scenarios.

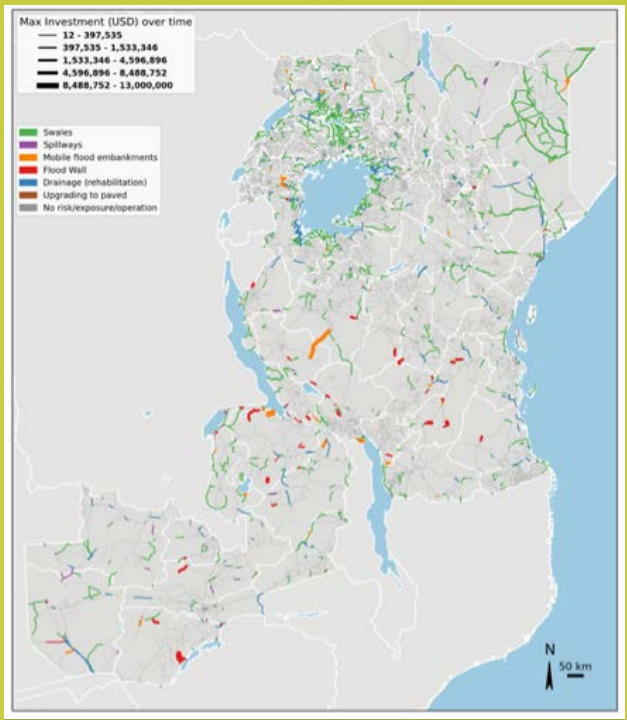
The tool is available here: https://east-africa.infrastructureresilience.org/



GRII allows users to access these physical risk and resilience metrics for infrastructure. These data, and the wider SRAT tool, can then inform analyses of the effectiveness of adaptation options; as illustrated below for river flooding of roads: (a) net present value (NPV) of maximum benefits due to avoided risks and the (b) NPV of maximum costs or investments needed over an implementation timeline, resulting in (c) a benefit-cost ratio (BCR) of optimal adaptation options.

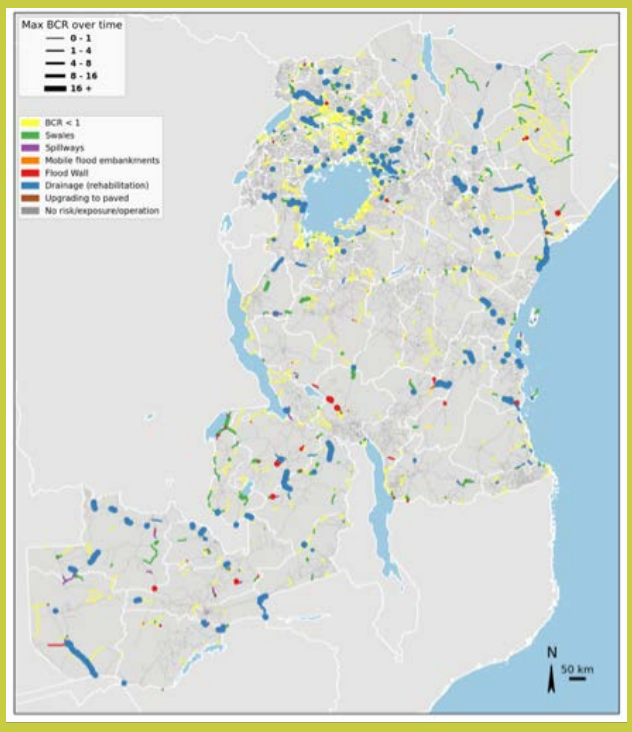


(a)



(b)

Source: *Oxford Programme for Sustainable Infrastructure Systems, supported by the UK Foreign, Commonwealth, and Development Office project: 'Decision Support Systems for Resilient Strategic Transport Networks'.*



(c)

STRESS TESTING AND SCENARIO ANALYSIS

Climate scenario analysis and climate stress testing are accelerating globally. For example, most of the over one hundred supervisors (64 per cent) that are members to the NGFS have already implemented, or are in the process of implementing, climate-related risks assessments.[19] The objectives of climate scenario exercises range from assessing microprudential, macroprudential and economic risks, to developing capabilities both internally and within the broader financial sector. More broadly, bank stress testing is designed to test the resilience of banks and the banking system overall to shocks. This involves modelling the impact of hypothetical adverse macroeconomic and financial market scenarios on bank profitability and balance sheets.

Quantifying the climate risk posed to banks' balance sheets remains challenging, as climate impacts play out across short, medium and long-term horizons. A recent report by the European Central Bank (ECB)[20] finds that financial stability risks from climate change are both concentrated in sectors, locations and firms, and vary over the next decades given strongly path-dependent risks. The capacity of climate change to trigger feedback loops and non-linearities between the real and financial sectors further complicates quantification. Losses suffered by the financial system could cause reduced lending by banks and reduced coverage by insurers, which could in turn lead to contraction of the real economy, suggesting that climate risk may represent a systemic risk to the banking sector.

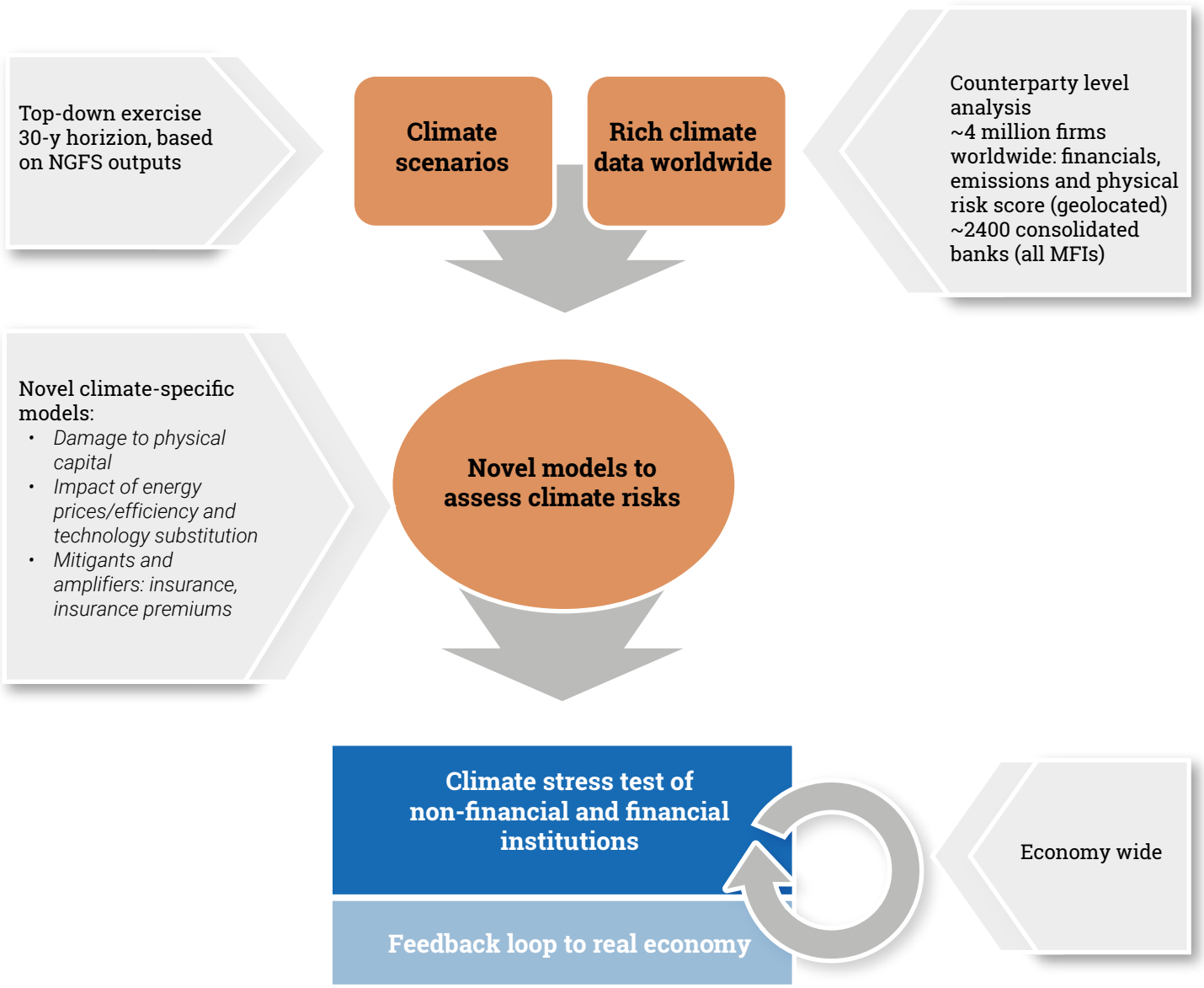
Climate-risk stress testing involves modelling the future impact of several path scenarios varying the rate and degree of both planet warming and policy action, which relate to physical and transition risk respectively, with the resulting macroeconomic impacts on labour, inflation, interest rates and GDP as a function of, for example, stranded and damaged assets, supply-chain disruption and lower agricultural productivity. From the perspective of central banks and bank regulators, stress tests have the potential to support both risk measurement and risk management. This means quantifying the impact on banks and the banking system, as well as pointing toward the prudential policy needed to ensure adequate resilience of the banks and the wider banking system. Microprudential policy requires bottom-up analyses and disclosures, while macroprudential policy requires more top-down modelling to assess and manage systemic risk across the banking and wider financial system. Systemic risk is challenging to assess given its association with cascading impacts within and across systems and sectors (e.g. ecosystems, health, infrastructure and the food sector).[21] Figure 6 shows the main approach to stress testing taken by the ECB.

[19] Central Banks and Supervisors Network for Greening the Financial System (NGFS) (2021) Scenarios in Action: a progress report on global supervisory and central bank climate scenario exercises. https://www.ngfs.net/sites/default/files/medias/documents/scenarios-in-action-a-progress-report-on-global-supervisory-and-central-bank-climate-scenario-exercises.pdf

[20] ECB 2021 Climate-related risk and financial stability

[21] Briefing note on systemic risk | UNDRR

Figure 6 Main elements of the ECB economy-wide climate stress test[22]



Source: *ECB*

Notes: NGFS: Network for Greening the Financial System; MFIs: monetary financial institutions.

[22] ECB (2021) Occasional Paper Series: ECB economy-wide climate stress test: Methodology and results. https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op281~05a7735b1c.en.pdf

CURRENT APPROACH TO METRICS

Climate stress testing and scenario analyses requires a range of data and scenarios. The NGFS scenarios are increasingly becoming a reference for analysing climate risks to the economy and financial system. Alongside such scenarios, analyses require macroeconomic and indexed risk data, as well as detailed sectoral and counterparty-level vulnerability and risk information. The NGFS 2022 Final Report on Bridging Data Gaps[23] concluded that gaps in climate-related data encompass several dimensions: availability (e.g., coverage, granularity, accessibility), reliability (e.g., quality, auditability, transparency) and comparability. In some instances, relevant data is not available. In other instances the data exists but lacks the appropriate granularity, cannot be verified or is of poor quality. Finally, in some cases available data sources cannot be compared or are not consistent. Two of the four headline recommendations of the report called for the development of well-defined and decision-useful metrics and methodological standards and the better use of existing data sources and tools, including concerning physical climate metrics.

A recent report by the Financial Stability Board[24] highlights the lack of data on entities' exposures to acute physical risks as a key challenge to assessing physical climate-related financial risks. Data that does exist lacks either sufficient granularity for an accurate assessment of risks, or consistency with data provision from supervisors and vendors not comparable across sectors and locations. These data gaps are particularly severe in the case of financial sector exposures to firms with complex, multi-national supply chains and in emerging markets or developing economies where hazard data can be less available. The FSB's roadmap notes the importance of filling these gaps in a way that both emphasizes cross-sectoral and international consistency, and is coordinated, for example, with the development of disclosure standards and taxonomies. Research by the World Bank similarly identifies particular gaps in complex and cascading risks and the implications of acute physical climate risks for the macroeconomy and financial sector.[25]

Consultations suggest that as a microprudential tool, common metrics could inform setting reporting standards and disclosures; sector averages at country or regional scale are an important first step to counterparty-level analysis. For macroprudential policy, common metrics that can support the identification of more complex, cascading macroeconomic risks add significant value.

HOW COMMON RISK METRICS COULD ENABLE PROGRESS

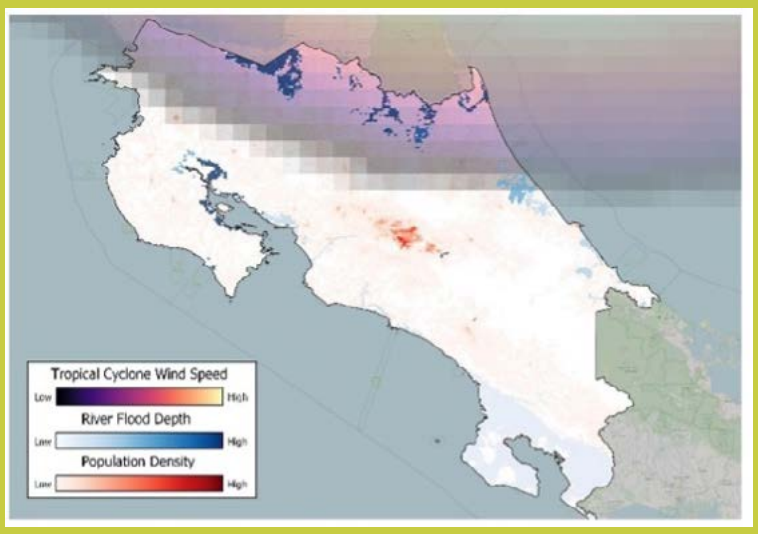
- A standard set of backstopped data on physical climate-related hazards and risks could support financial institutions in their scenario analysis. This could help develop a common data standard for reporting of physical risks in financial institutions' regulatory or stress-testing returns.
- A benchmark set of risk layers, damage functions, and proxies as a protocol reference set at agreed temporal and spatial resolution could serve as a baselining approach between different data vendors and enable a common language across financial institutions and regulators.
- Common risk metrics could provide the tools to financial authorities to assess the effects of physical risks as part of their own top-down modelling, especially considering systemic and spill-over risks that are not fully captured within currently available data.
- As a microprudential tool, common metrics and standard calibration values could inform setting quantification methods. As a macroprudential tool, it could inform setting exposure limits and capital buffers to prevent concentrations of risk within systems and coupled dependencies to understand risk spill-over between the real economy and financial institutions

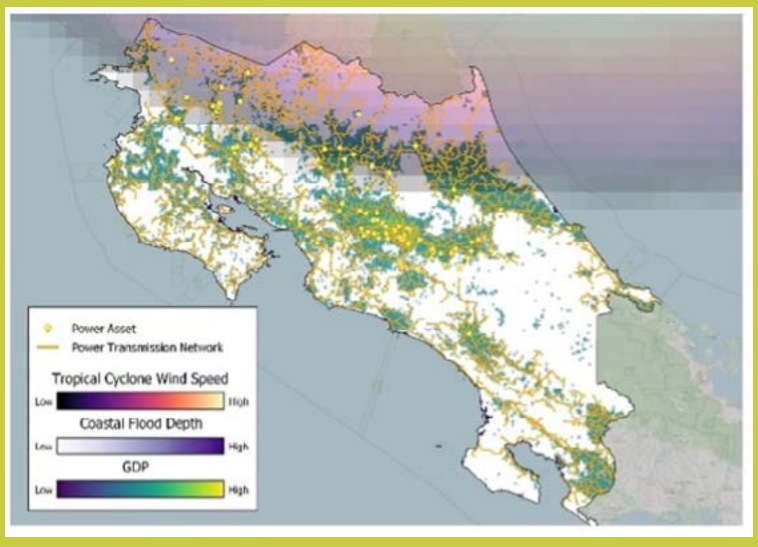
[23] NGFS 2022 https://www.ngfs.net/sites/default/files/medias/documents/final_report_on_bridging_data_gaps.pdf
[24] FsB (2021) FSB Roadmap for Addressing Climate-Related Financial Risks.
[25] Ranger, N; Mahul, O; Monasterolo, I. 2022. Assessing Financial Risks from Physical Climate Shocks : A Framework for Scenario Generation. World Bank. https://openknowledge.worldbank.org/handle/10986/37041

Box 3: Climate stress testing through GRII's people, planet and prosperity lens

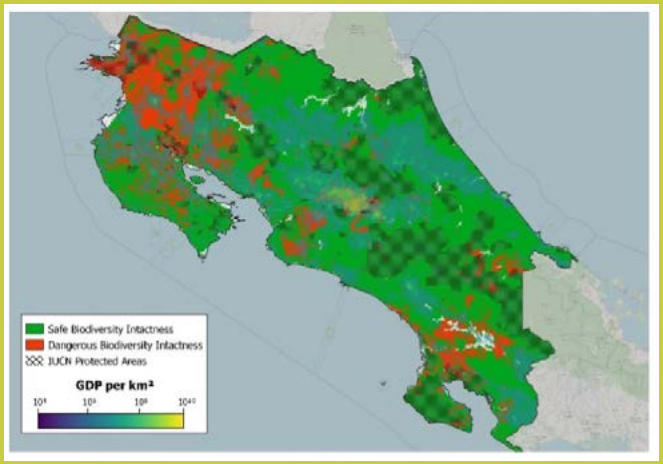
GRII provides data to feed into micro and macro-level analyses of both physical climate financial risks and nature-related financial risks. In this case study, we demonstrate this for Costa Rica. Costa Rica is highly vulnerable to hydrometeorological extreme events with over 1.3 million people being affected from 1980 to 2017[1] and over two thirds of GDP and population exposed to several risks.[2] The government projects the impacts of extreme events on infrastructure will reach 0.7-2.5 per cent GDP in 2025.[3] The country has strong adaptation plans, which respond to flood, drought and tropical cyclone risks. GRII provides data on these key hazards, as well as population, economic and critical asset exposures.

(a) Mapping population exposure to flooding and tropical cyclones; (b) Mapping economic assets exposure to flooding and tropical cyclones





Hazards like flooding and tropical cyclones result in both direct damages to infrastructure and buildings, and indirect losses to the economy. Asset-specific and hazard-specific damage functions from GRII can estimate the level to which an asset might be impaired leading both to production loss (e.g. reduced electricity production) as well as reconstruction costs. Production loss will affect firms directly, probably reducing cash flows, and potentially affecting the equity valuation and probabilities of default. Local banks lending to these firms, therefore, might see an increase in unexpected losses, which in turn dampens the ability of these local banks to provide financing to rebuild damaged assets. Indirect economic impacts might impair transportation routes and transmission lines for electricity (due to high wind speeds or flooding), which disrupts services in other parts of the economy and could affect wider macroeconomic variabilities, including employment, interest rates and GDP. The data provided by GRII to identify the key risk transmission channels can be used by financial-sector institutions to develop scenarios and then assess the financial risk implications both at a micro-level and to the overall resilience of the national financial system. The need for these type of assessments has been highlighted by the Climate Working Group of Costa Rica's Financial Supervisory Council (CONASSIF) and its four superintendencies across the financial system (SUGEF, SUGESE, SUGEVAL, SUPEN), and by the Central Bank of Costa Rica.



Nature-related risks are rising up the agenda of central banks and related supervisory entities across the financial system. In Costa Rica, the leadership of SUGESE (insurance regulator) has made breakthroughs on the need to apply insurance-based risk quantification across the economy. Mapping areas with greater biodiversity loss using GRII can help identify regions that may be affected by a decline in key ecosystem services. This could include impacts from a decrease in natural flooding defence or an increase in water stress (also relevant for cooling of power plants), which could also lead to GDP impacts at national level, increasing pressure on inflation with macro-financial risks spreading.

Source: *Oxford Sustainable Finance Group*[26]

FISCAL RESILIENCE AND SOVEREIGN FINANCING INSTRUMENTS

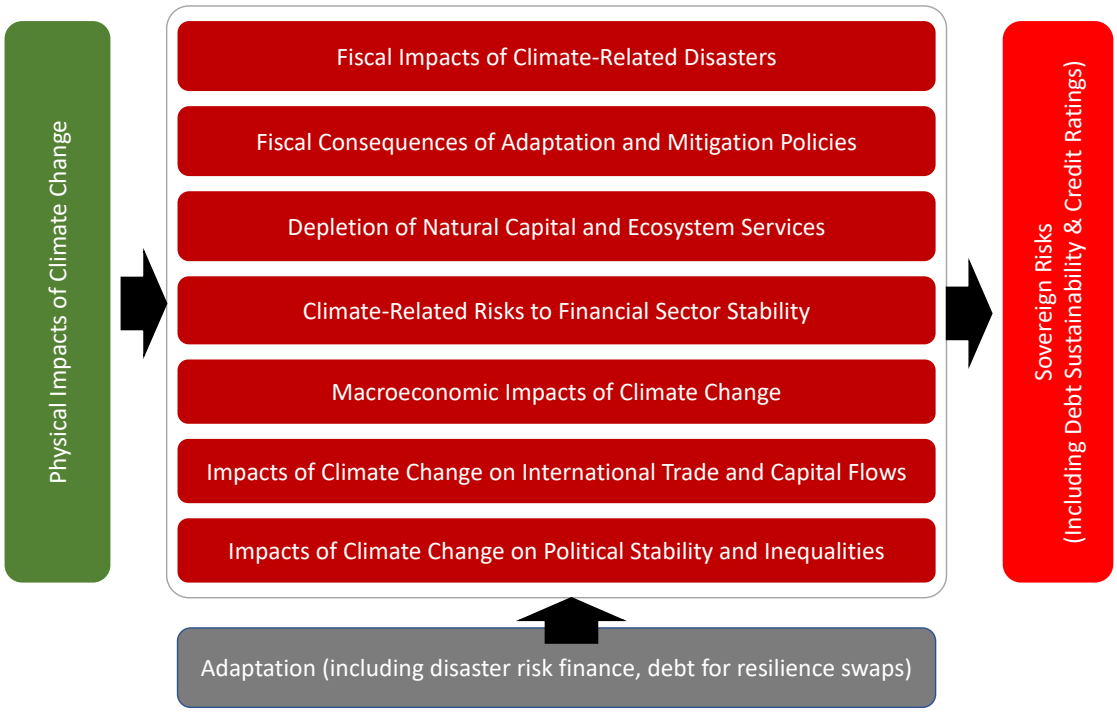
Climate risk and resilience data can support many types of public decisions, from public policy and regulation, public expenditure, fiscal and economic policy, public financial institutions, public financial management and sovereign disaster-risk financing and insurance. In this case, we focus on one particular application, fiscal resilience to climate-related shocks and the linkages to public debt management, sovereign credit ratings and sovereign financing instruments, including potential new innovations such as sustainability-linked bonds and debt-for-resilience swaps.

Public finances are exposed to financial risks from climate and environmental impacts through multiple channels (Figure 7). Sovereign climate risk creates a contingent liability to the government, for example, associated with increased expenditure (e.g. through its role in providing relief, recovery and undertaking reconstruction) and reduced revenue (e.g. through reduction in economic activity and subsequently reduced tax intake), or directly through de-risking activities (e.g. guarantees, public-private partnerships or backstopping private institutions).[27] For a high-impact event, these contingent liabilities can lead to large costs accruing to governments, which in some cases (e.g. highly vulnerable countries) can increase debt-to-GDP ratios and reduce sovereign credit worthiness. In some cases, this can result in risk contagion across regions and connected economies. Risk financing through hedging instruments spreads and pools risks. This lessens the variability of losses but does not directly reduce risk. New types of sovereign products have been proposed, to manage the risks through combining risk management and investment, such as sustainability-linked bonds for adaptation, and debt-for-resilience swaps.

[26] Sources: Instituto Meteorológico Nacional. (2021). Análisis de la mortalidad por eventos meteorológicos extremos en Costa Rica. Período 1980-2017. IMN; Deubelli, Teresa. "Hacia una infraestructura resiliente y sustentable: Un estudio de caso sobre la gobernanza de la resiliencia en la infraestructura crítica en Costa Rica." (2019); Contraloría General de la Republica (2018) Presión sobre la Hacienda Pública en un contexto de variabilidad y cambio climático: desafíos para mejorar las condiciones presentes y reducir los impactos futuros https://cgrfiles.cgr.go.cr/publico/docs_cgr/2017/SIGYD_D_2017015617.pdf; Gobierno de Costa Rica (2022). Reporte de avances en la implementación del PLAN NACIONAL DE DESCARBONIZACIÓN al 2021. https://dev.cambioclimatico.go.cr/wp-content/uploads/2022/02/Reporte-final-de-Descarbonizacion-Preview.pdf

[27] Bolton, P. et al 2020. The Green Swan: Central Banking and Financial Instability in the Age of Climate Change.

Figure 7 Channels of physical climate risk impact to government finances.[28]



Source: *Volz et al 2020*

CURRENT APPROACH TO METRICS

At country level, the annual Article IV consultations by the International Monetary Fund (IMF) are one anchor point of fiscal risk surveillance and monitoring. The IMF has recently started to integrate climate change in Article IV consultations with its member countries.[29] An increasing, however still minor, number of Article IV reports refer substantively to the role of climate change in increasing macroeconomic and fiscal risks. The World Bank is also active in supporting governments in assessing and managing climate-related financial risks, for example through its disaster-risk financing and insurance programme[30] and instruments such as the Global Risk Financing Facility.[31] Such risk assessment and monitoring, whether through the IMF, other international financial institutions or domestic fiscal-risk management, requires access to high-level, objective physical climate-risk metrics that can inform fiscal-risk assessments. Especially in developing countries, governments do not usually have the required access to commercial models, or the capability to assess, work with and customize commercially available data.

In assessing fiscal risks from climate change, governments often rely on qualitative assessments, with only a few governments having taken steps to quantify fiscal risks. Where governments are quantifying fiscal risks, they are often building on custom-built models or working with commercial model providers, but these are lengthy and complex undertakings. Especially in developing countries, these often require the support of development partners. Open and accessible climate-risk metrics could help accelerate progress and shift governments to begin to more systematically include baseline quantitative climate-related fiscal-risk assessments in their processes.

[28] Volz et al 2020, ADB report Climate Change and Sovereign Risk
[29] IMF Comprehensive Surveillance Review on Climate Change
[30] https://www.worldbank.org/en/programs/disaster-risk-financing-and-insurance-program
[31] https://globalriskfinancing.org/

Box 4: RiX Data Aggregation for Modelling of Cascading Effects of Shocks in Costa Rica

Using spatial computable general equilibrium (CGE) modelling, UNDRR is supporting the Government of Costa Rica to assess the interconnected and systemic impacts of disasters impacting households, water and sanitation, energy, telecommunications, public infrastructure, and agriculture. Data aggregation through the RiX can help governments and other stakeholders understand the quantity and quality of available disaster and climate change risk information available in a country. By improving the accessibility of open-source information it can also help foster the future innovation and collaborations on risk analytics.

Area of Interest	Physical Assets	Data availability				
		Geo-location	Replacement value	human occupancy or number of users	Vulnerability characteristics	Resolution of data
Housing – residential buildings	Dwellings					H
	Departments					H
Public Infrastructure (transport, education, health and government/public buildings)	Main roads					H
	Secondary roads					H
	Other roads					H
	Bridges					H
	Ports					H
	Airports					H
	Hospitals, clinics, medical centers					H
	Schools and educations infrastructure					H
	Government buildings					H
Energy Infrastructure	Electricity generation plants					H
	Transmission lines					H
	Distribution lines					H
	Substation					H
	Fuel stations					H
Telecommunication system infrastructure	Transmission towers					H
	Wireless antennas					N/D
	Telephone lines					N/D
	Optical fiber wires					N/D
Water and Sanitation Infrastructure	Water pipelines and pumps stations					H
	Sewage lines and pumps stations					H
	Treatment plants					H
	Dams (includes intakes, wells and springs)					H
	Storage tanks					H
Agriculture	Crops (coffee, banana, corn, flowers, beans, etc.)					N/D
	Agriculture infrastructure (buildings, warehouses. relevant machineries, etc.)					N/D

Legend	
	Data available in the required format
	Primary data available to compute/generate the required information.
H	High resolution of the data available
N/D	Resolution of the data is not specified/defined

Source: Ordaz Schroeder et al, UNDRR, 2022

Where governments do assess the potential cost of climate risks, this is usually focused on estimating the cost of physical damages. It rarely takes into account the economic and social cost of interrupted services from damaged assets, or more complex feedback. This is critical as it is typically these risks that have the largest macroeconomic impact. Moreover, risk models usually estimate risk under current hazard profiles and do not integrate future climate scenarios.

Sovereign credit and bond rating providers are increasingly integrating climate-adjusted economic variables and algorithms[32] to varying satisfaction by experts. Until recently, climate risk was treated in the 'AOB' category of risk in questions of sovereign credit ratings and, as it follows, the pricing of sovereign debt. Over the last five years, climate risk has started to be priced in to the cost of borrowing, but not yet systematically. Challenges to further looking at climate risk systematically include the lack of data and capability to embed systemic risk transmission, including particularly more-complex macroeconomic risks beyond direct damages. To date, data providers have tended to use similar data sources, but different (and not transparent) methodologies to construct metrics.

It is important to note that vulnerable sovereigns are paying a climate-vulnerability premium, and globally face risks of a downgrading cascade, which could worsen the sovereign debt crisis. For this reason, new types of financial instruments, such as sustainability-linked bonds for adaptation and debt-for-resilience swaps, have been proposed as opportunities both to mobilize financing to invest in adaptation and resilience, and reduce climate risks to government balance sheets. An example was the recent debt-for-nature or 'blue bond' in Belize, which acts to mobilize finance for nature recovery and nature-based solutions for resilience, and explicitly addresses hurricane risks[33].

HOW COMMON RISK METRICS COULD ENABLE PROGRESS

- Open-source common risk metrics empower actors, especially in emerging economies, to consider physical climate risk systematically in policy making and risk assessments.
- Easily accessible metrics can help decision-makers identify material risks by providing the *magnitude* of relevant risk-transmission channels to focus in-depth climate-related fiscal risk assessments and interventions.

An independent, open and transparent source of widely-accepted risk information can provide an engagement tool with various national financial decision makers, and help support the design of new types of financial instruments to manage risks and mobilize financing for resilience.

[32] Bennett Institute working paper 'Rising Climate, Falling Ratings'
[33] https://www.nature.org/content/dam/tnc/nature/en/documents/TNC-Belize-Debt-Conversion-Case-Study.pdf

4. Conclusion: towards global, open, and common risk metrics

Consultations with financial practitioners have highlighted several ways in which the development of global, open and accessible common climate-risk and resilience metrics could help inform financial decisions. Ultimately this will contribute to an improved understanding of climate and environmental physical risk across both developed and emerging markets. More broadly, providing a global common basis of understanding physical risks, will facilitate joined-up discussion and development of aligned policy and coordination between central banks, governments, corporates and regulators. It will also stimulate and enable innovation in both the public and private sector by reducing the 'risk-data divide' existing in countries, unlocking the ability to engage and build on risk data and analytics products. Open and common risk metrics can enable financial institutions to access data on physical risks for any point on earth, assess how it affects assets, and identify how these assets are interdependent via e.g. shared infrastructure, or are contained in feedback loops.

The 2022 TCFD Status Report showed that physical climate risk is still under-priced across the financial system; a clear sign that finance is currently not working for adaptation and resilience. Similarly, the consultations show across all four case-study areas, that while there has been substantial progress over the past five years, physical climate risks are still not assessed systematically, and significant challenges remain. The ability to access baseline, transparent and common risk metrics will help overcome such challenges. The consultations suggest that there is now a need for those 'writing the rule book' to pay more attention to quality of physical climate risk reporting, and to begin to agree on the kinds of benchmarks and standards that can lead to greater global comparability and trust in climate-risk analytics and the decisions made based upon it.

Access to third-party open-source common risk metrics would empower different actors to consider physical climate risk more systematically in risk assessments, and support improved risk monitoring and management across the financial system and beyond. Easily accessible metrics can help to constrain the boundaries of materiality and provide the magnitude of relevant risk-transmission channels to focus in-depth climate-related risk assessments and interventions. They would ensure comparability at a high level and the ability to identify where targeted granular and asset-level analysis is needed. In addition, an independent, open and transparent source of widely accepted risk information can provide an engagement tool with various national financial decision-makers, to increase understanding of climate risk and encourage both fiscal and corporate investment in climate-proofing, as well as unlock the development of new financial instruments and markets.

Investing in systematic data collection and aggregation to enable quality data that is comparable across all continents with regards to hazard, exposure, vulnerability and climate-change risk is a global common good with significant utility across the public and private sectors. Bottom-up initiatives such as UNDRR's Risk Information Exchange (RiX) that focus on closing the digital divide on risk knowledge by strengthening cooperation in data collection and aggregation with national governments and other stakeholders, can help fill gaps in a currently spotty global risk-data landscape. This work can help feed better data in the tailored, analytical tools being developed by initiatives such as the Global Resilience Index Initiative (GRII). Platforms like the GRII can create an improved baseline to foster further innovation and refinement.

Ideally these initiatives can crowd in further collaborations to enhance the open-data environment on climate risk. Such initiatives can only be strengthened if the wider ecosystem continues to take action to fill the current data divides, and to make more and better data accessible and interoperable. This briefing paper can act as a call to action for further collaboration to enhance current approaches and tools. At the same time, in raising the bar for open-source baseline quality, tools like the GRII can also foster private-sector innovators to up their game and to step-up public-private collaboration to improve risk analytics and to open up new business opportunities that also accelerate Paris Agreement and SDG achievement.

Risk Information Exchange

GLOBAL RESILIENCE INDEX INITIATIVE
A COMMON LANGUAGE OF RISK

UNDRR
UN Office for Disaster Risk Reduction

CGFI
UK Centre for Greening Finance & Investment