Emerging Markets Investors Alliance
Actionable Intelligence for Responsible Investing

Carbon Transition Initiative

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PHYSICAL CLIMATE RISK IN EM

www.eminvestorsalliance.org

CARBON TRANSITION INITIATIVE ISSUE BRIEF #1

- This Issue Brief addresses **physical climate change risk** from the perspective of emerging markets investors.
- Climate change affects many countries. However **emerging markets are both more vulnerable to climate-related hazards and less prepared to cope** with their effects.
- The risks associated with climate change **do not appear to be reflected in valuations** of most financial markets.
- Climate risk indices suggest that **Nigeria, Pakistan, India and Philippines are particularly vulnerable to physical climate risk**, among the major EM and frontier markets. Poland, Chile, Brazil and Russia appear relatively less vulnerable.
- This brief is the first in our **Carbon Transition Initiative**, a series of 12 webinars on the impact of climate change and carbon transition on emerging markets. It accompanies our webinar on the topic in January 2021.

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PHYSICAL CLIMATE RISK IN EM

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I. INTRODUCTION

Climate change introduces a range of risks for investors in emerging markets, affecting both countries and corporates, across a range of asset classes. In this Brief, we explore the physical effects of climate change and the relative exposure of key frontier and emerging markets to these risks.

Physical climate risks can take the form of a multitude of hazards, both acute and chronic, including storms, flooding, drought and rising sea levels. Climate itself is inherently uncertain, making it difficult to predict the specific impacts of climate change. However the scientific evidence is clear: physical climate risks are expected to have an increasingly adverse impact on a wide range of assets and economic actors including countries, households, companies and financial institutions.

Investors -- like policymakers and the broader public – appear increasingly aware of climate risks. However there is mixed evidence that asset prices reflect these risks. Countries with higher climate vulnerability do appear to carry higher borrowing costs. And yet, research has found limited evidence that climate risk is yet being priced into corporate securities such as equities.

Physical climate risk affects all countries, to varying degrees, but emerging markets are likely to be disproportionally affected. They are also likely to be less prepared to cope with and recover from them, due to weaker institutional frameworks, a lack of financial resources and limited adaptation measures. Based on our review of several country risk models, Nigeria, Pakistan, India and Philippines look particularly vulnerable to these risks, among major emerging and frontier markets.

There are a range of institutions available to investors and policymakers for guidance on physical climate risk and preparedness. TCFD has emerged as a leading framework for climate risk assessment, while NGFS has produced a series of guidelines for central banks and financial institutions. UNEP produces an annual Adaptation Gap assessment, while a number of other institutions promote climate preparedness, including the Global Commission on Adaptation, the Climate Vulnerable Forum and the Coalition for Climate Resilient Investment (CCRI).

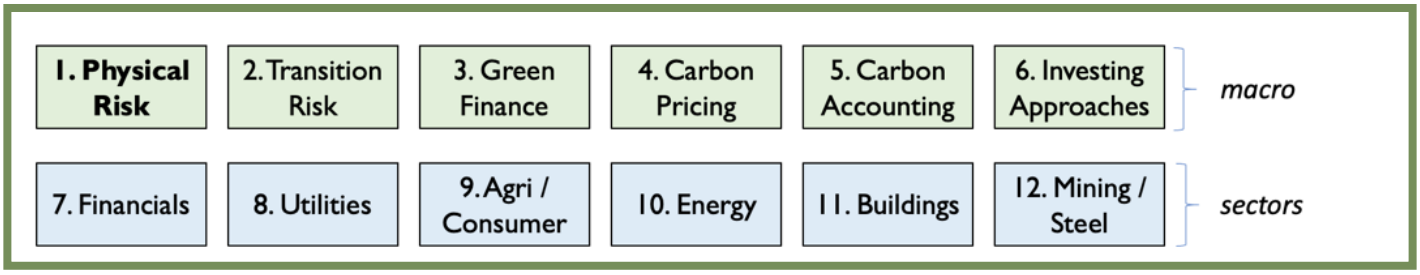
This Issue Brief is part of the Emerging Markets Investors Alliance **Carbon Transition Initiative**, a series of webinars and briefs covering a range of issues related to climate and emerging markets investing. For more information see www.eminvestorsalliance.org.

The Emerging Markets Investors Alliance enables institutional emerging market investors to support good governance, promote sustainable development, and improve investment performance in the governments and companies in which they invest. The purpose of Alliance Issue Briefs is to educate investors on issues of importance, highlight best practices and suggest ways to engage companies and governments.

II. BACKGROUND: THE CARBON TRANSITION INITIATIVE

This brief is the first in a series of publications by the Emerging Markets Investors Alliance on the impact of climate change and the transition to a low carbon economy in emerging markets (EM). The Alliance is exploring this issue through its **Carbon Transition Initiative**, a series of webinars featuring policy experts, accompanied by issue briefs. Through this series we address on the impact of climate and the low carbon transition on EM countries, industries and companies. We also identify institutions available to the investment community to help assess and manage climate and transition-related risks.

FIGURE 1
Emerging Markets Investors Alliance's Carbon Transition Initiative



Source: Emerging Markets Investors Alliance

III. PHYSICAL CLIMATE RISK IN EMERGING MARKETS

Rising temperatures are expected to cause accelerating impacts on natural systems. **Physical climate risk** refers to the investment risks arising from these impacts. While inherently hard to predict, climate change is expected to bring a range of effects including more severe weather, higher sea levels and drought. The longer-term impact of climate change on countries is a function of both these physical impacts and the degree of climate adaptation and resilience measures that have been taken.

Physical climate risk represents a major challenge for all countries. However, **emerging markets are likely to be particularly affected by the impacts of climate change**, compared with developed countries, for two reasons:

1. The direct physical effects of climate are likely to be more acute in developing countries, many of which already face exposure to heat stress, flooding, drought and other climate-related factors.

2. Many EMs are less prepared to cope with and recover from climate effects, due to a lack of adaptation measures taken, limited financial resources and weaker institutions.

Climate scenarios and hazards

The impacts of climate change can take a variety of forms, many of which are in evidence today. In its final Taxonomy report[1], the EU Technical Expert Group on Sustainable Finance identified 30 potential climate hazards, grouped into 4 categories related to temperature, wind, water and solid mass (Figure 2). Of these, it is floods, droughts, higher temperatures and rising sea levels that are the most widely anticipated climate hazards, based on their frequency that they are mentioned in the country NDC (Nationally Determined Contributions) reports submitted as part of the Paris Agreement[2] (Figure 3).

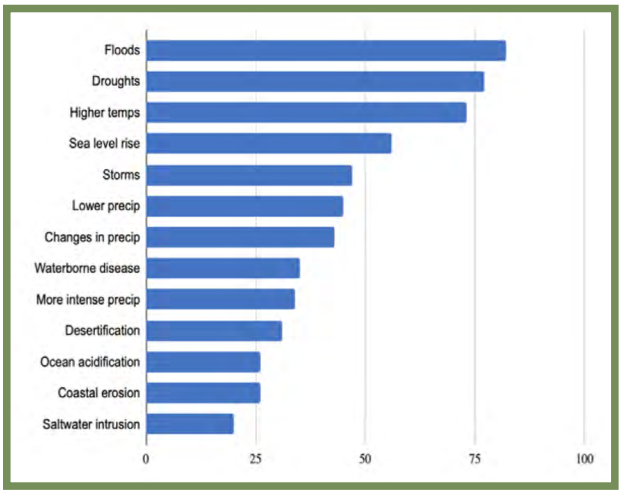
[01] Taxonomy: Final report of the Technical Expert Group on Sustainable Finance, EU Technical Expert Group on Sustainable Finance
[02] Aggregate effect of the intended nationally determined contributions: an update - Synthesis report by the Secretariat

FIGURE 2
Classification of Climate-Related Hazards

	Temperature-related	Wind-related	Water-related	Solid mass-related
Chronic	Changing temperature (air, freshwater, marine water)	Changing wind patterns	Changing precipitation patterns and types (rain, hail, snow/ice)	Coastal erosion
	Heat stress		Precipitation and/or hydrological variability	Soil degradation
	Temperature variability		Ocean acidification	Soil erosion
	Permafrost thawing		Saline intrusion	Solifluction
			Sea level rise	
			Water stress	
Acute	Heat wave	Cyclone, hurricane, typhoon	Drought	Avalanche
	Cold wave/frost	Storm (including blizzards, dust and sandstorms)	Heavy precipitation (rain, hail, snow/ice)	Landslide
	Wildfire	Tornado	Flood (coastal, fluvial, pluvial, ground water)	Subsidence
			Glacial lake outburst	

Source: EU Technical Expert Group on Sustainable Finance

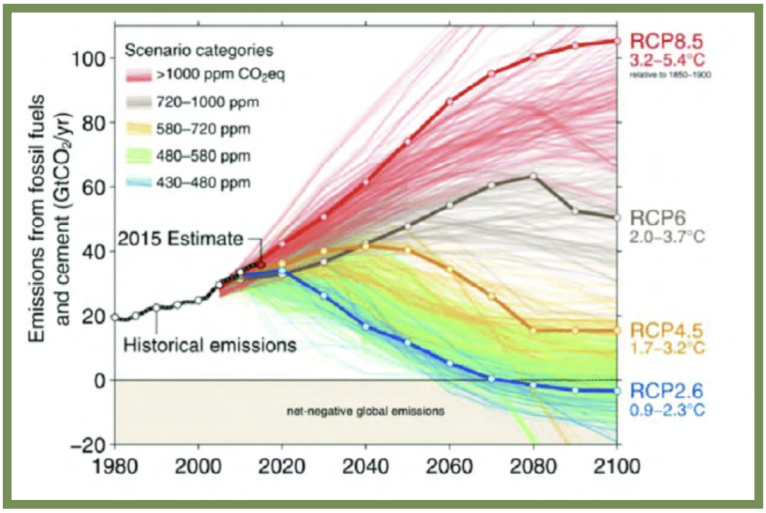
FIGURE 3
Climate hazards in the NDCs (# of parties mentioning)



Source: UNFCCC (2016)

The extent to which these hazards occur will be a function of the degree of climate change that occurs in the future. Due to the uncertainty over the course of climate change, any climate risk assessment involves evaluating potential pathways for the climate, economy and society. A range of models exist to aid with this assessment, evaluating scenarios for climate, land-use, energy systems and hazards. Underlying many of these models are the **Representative Concentration Pathways** (RCPs), which were released in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report and describe how different levels of greenhouse gas emissions might affect the world over the course of this century. The RCP8.5 scenario, associated with a 3.2-5.4C temperature increase from pre-industrial levels, is the pathway most consistent with observed emissions (Figure 4). Related climate scenarios include the Shared Socioeconomic Pathways (SSPs) and a forthcoming set of models known as the Coupled Model Intercomparison Projects (CMIP6).

FIGURE 4 RCP Climate Scenarios



Source: Neil Craik, University of Waterloo, Socio-Economic Data and Scenarios

Sector impacts of climate hazards

Climate hazards can damage physical and human capital directly as well as cause disruptions to economic activity and spillover affects to financial and political institutions. These effects vary across industry sectors. A framework produced for the Global Centre of Excellence on Climate Adaptation suggests that storms and floods are likely to have a high impact across industries, whereas other physical climate risks including extreme heat, precipitation and water stress will affect some industries more acutely than others[3]. On basis of this framework, industries exposed to the widest range of climate change globally appear to be utilities, materials, capital goods, apparel and autos (Figure 5).

The report, Climate risk and response: Physical hazards and socioeconomic impacts (McKinsey Global Institute, 2020) discusses many of these risks in detail. Examples of sector level risks include a reduction in productivity, destruction of infrastructure and disruption in the manufacturing sector and supply chains. In emerging markets, sectors such as tourism industry could be affected, and remittances could be disrupted.

Sector	Industry group	Storms and cyclones	Extreme rainfall and flood	Extreme heat	Variability in precipitation	Variability in temperature	Water stress	Sea-level rise	Other climate hazards
Consumer discretionary	Autos	H	H	H	M	H	M	H	AQ
	Durables/Apparel	H	H	H	M	H	M	H	AQ
	Media	H	H	L	M	M	M	H	
	Retailing	H	H	L	L	L	L	H	
Consumer staples	Retailing	H	H	L	L	L	M	H	
	Food, bev, tobacco	H	H	L	M	M	H	H	SD, OA
	House/personal	H	H	M	H	H	M	H	
Energy		H	H	M	M	H	M	H	PM
Financials	Banks	H	H	H	M	H	L	H	
	Diversified	H	H	L	L	L	L	H	
	Insurance	H	H	L	L	M	M	H	HS, L, W
Healthcare	Equip/svcs	H	H	M	M	L	M	H	W, H, AQ
	Pharma, biotech	H	H	H	L	H	M	H	
Industrials	Capital goods	H	H	H	M	M	H	H	
	Services	H	H	H	H	L	L	H	
	Transport	H	H	L	L	L	L	H	PM
Information technology	Semi-conductors	H	H	M	L	H	M	H	
	Software/services	H	H	H	L	L	L	H	
	Hardware	H	H	L	L	H	M	H	
Materials	Materials	H	H	H	H	H	H	H	
Real estate	Real estate	H	H	L	L	L	L	H	
Telecoms		H	H	L	L	L	L	H	
Utilities		H	H	H	H	H	H	H	W

FIGURE 5
Climate Risk Map for Global Sectors

H - High risk; M- Medium risk; L- Low Risk; AQ- Air quality degradation; SD- Soil degradation; HS- Hail storms. L- Landslides, W- Wildfires, PM- Permafrost melt, OA- Ocean acidification.

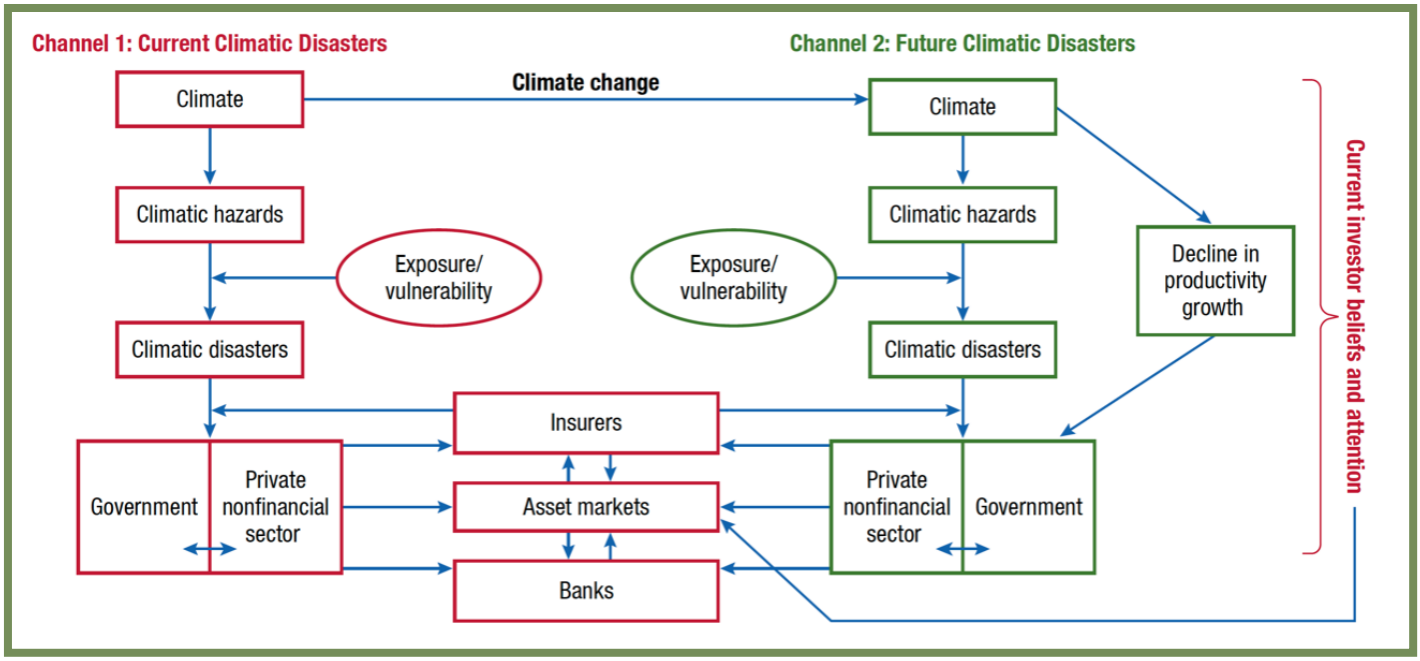
Source: EBRD and GGC

[03] Advancing TCFD guidance on physical climate risks and opportunities

Impacts on the financial system

The IMF has looked at the impact of physical climate risk on financial stability and notes that financial stability may be adversely impacted by climate change in two ways[4]. Firstly, the physical effects of climate change could affect households, firms, and governments through the loss of physical and human capital. Secondly, the value of assets exposed to a future increase in physical risk could decline, with potential knock-on effects to the financial system (Figure 6).

FIGURE 6
Physical Climate Risk and Financial Stability

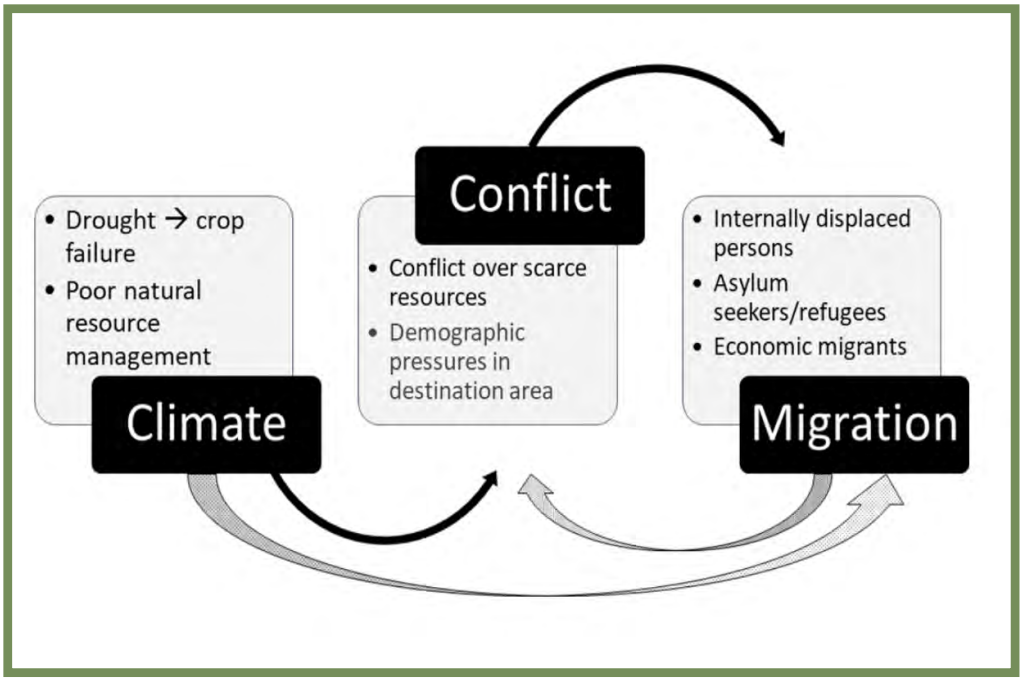


Source: IMF

Physical climate impacts can have adverse macro level implications on the balance sheets of countries, households, companies and financial institutions because of the immediate disruption to investments, economic growth, trade, government fiscal balances, debt sustainability, balance of payments and valuations on financial assets. In some emerging and frontier markets, climate-related disruptions could put further pressure on already fragile socioeconomic conditions, displacing people and exacerbating conflict (Figure 7), with negative feedback loops to macroeconomic variables and country balance sheets.[5]

[04] "Climate Change Physical Risk and Equity Prices", Chapter 5 of the April 2020 *Global Financial Stability Report*
[05] Climate change as a threat multiplier for human disaster and conflict: policy and governance recommendations for advancing climate security

FIGURE 7
Conceptual model of climate, conflict and migration



Source: Global Environmental Change. Climate, conflict and forced migration

Is Climate Risk priced in?

Like policymakers and the broader public – investors appear to be increasingly aware of climate risks. Evidence for this awareness can be seen in the proliferation of climate-related institutions, investor initiatives and evolving regulations mandating increased climate-related disclosure.

Despite this rising awareness, most studies indicate that financial asset prices do not reflect climate risks in a systematic way. In a policy brief[6], the research and advisory firm Climate Finance Advisors notes that

> ***"Investors engaged for this study seem to pay little attention to climate change risks in their investment practice… and seem unprepared to assess climate-related financial risks -- or view the potential for other financial impacts from climate risks as either too intangible to ascertain in terms of direct financial implications today, or manageable in the context of their overall portfolio exposure."***

The evidence for a systematic discount associated with physical climate risk is mixed. A study by Imperial College Business School and SOAS University of London[7] found that countries with higher climate vulnerability do appear to carry higher

[06] Understanding the Role of Climate Risk Transparency on Capital Pricing for Developing Countries, 2020
[07] Climate Change and the Cost of Capital in Developing Countries, 2018

borrowing costs. Using a basket of 48 countries, the study identified a 117bps higher cost of debt associated with climate vulnerability, partly offset by investments in preparedness. Another study, by the Asian Development Bank Institute[8], found that the premium on sovereign bond yields from rising climate risk vulnerability is 275bps for a high-risk group of countries, 155bps for ASEAN and 113bps for other emerging markets (Figure 8).

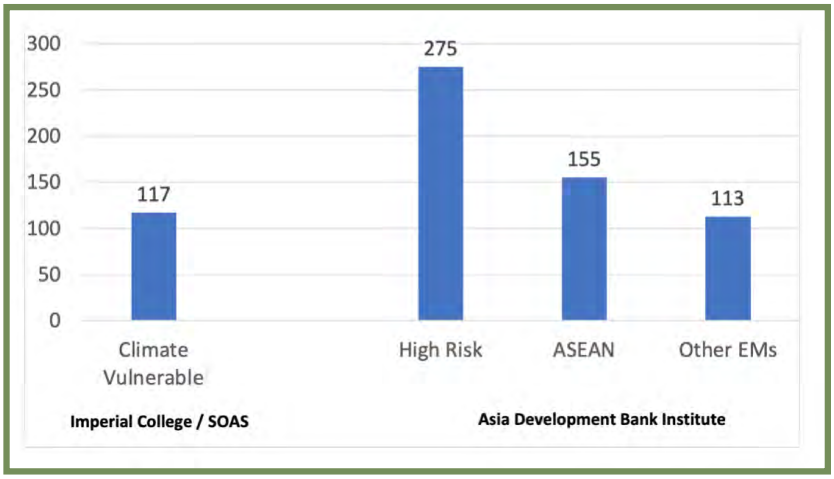


FIGURE 8
Increase in sovereign borrowing costs associated with climate risk (bps)

Source: Imperial College Business School/SOAS and ADBI

However, the Imperial College study also notes that, despite this link, no credit rating agency has yet downgraded a sovereign credit on the basis of climate risk:

> ***"The major rating agencies do not generally itemize climate risks in their published country assessments…capturing them in other areas". The paper adds: "If climate-related rating actions are taken in the future, as the agencies themselves have indicated is likely, these actions will almost certainly be negative."***

Turning to equity markets, the IMF notes that equity markets do not appear to assign any valuation discount to companies facing high or rising climate risks[9]. Their analysis suggests that market-implied equity returns "are consistent with a scenario with no further warming (possibly implying that climate risk is not being factored in)". This apparent mispricing may result from the difficulty that investors face in forecasting climate scenarios and impacts, particularly for companies with diverse geographic footprints. Going forward, we expect a rising focus on reflecting climate risk more comprehensively into valuations.

[08] Feeling the Heat: Climate Risks and the Cost of Sovereign Borrowing, 2020
[09] Chapter 5: "Climate Change: Physical Risk and Asset Prices"

IV. EM COUNTRIES AND PHYSICAL RISK

Country physical risk indices

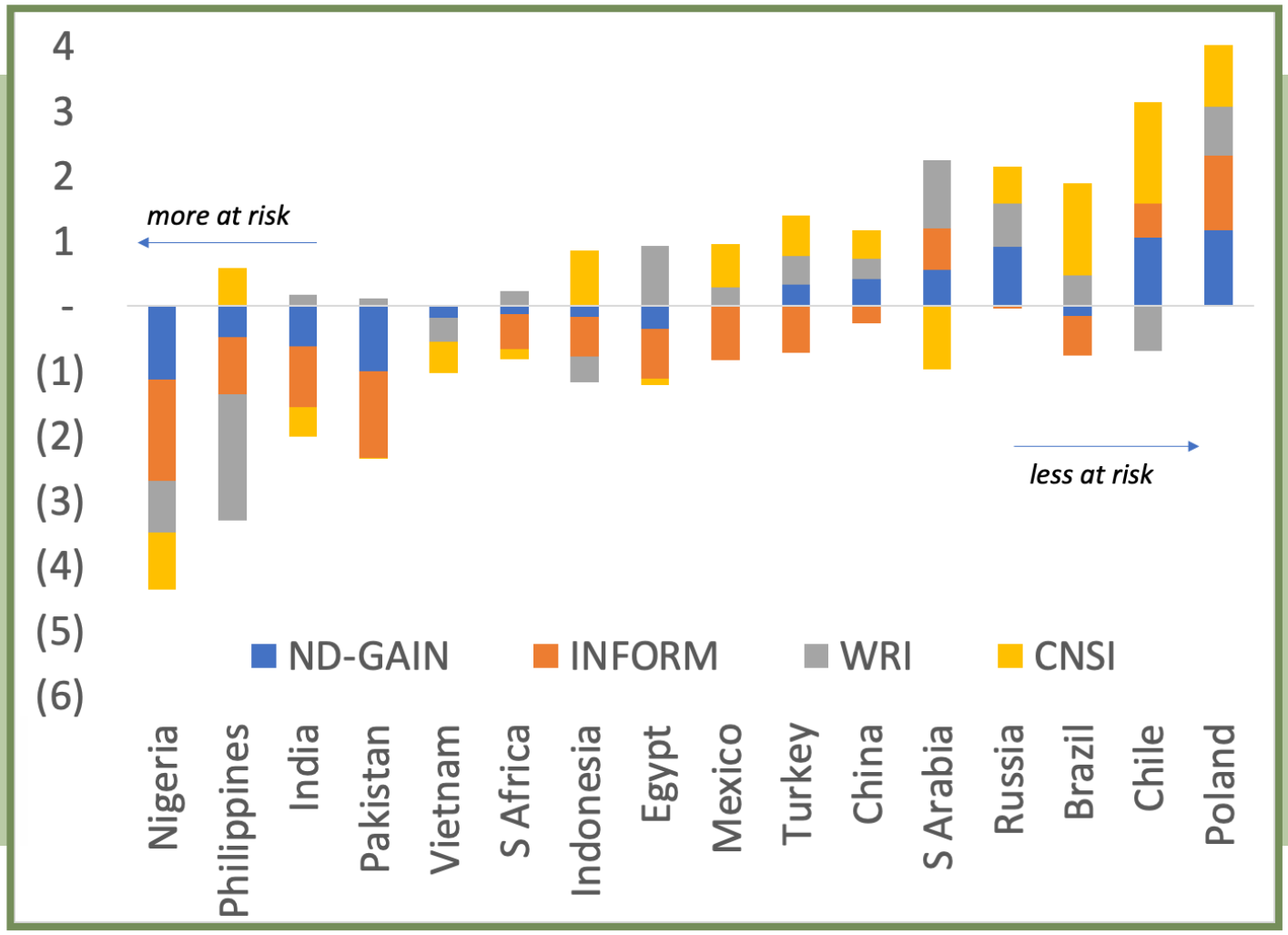
We next turn to the question of which emerging markets could be most affected by climate risks. To address this, we examined 5 public domain physical risk indices. These are: the Notre Dame Global Adaptation Index (ND-GAIN), the INFORM Risk Index, the WorldRiskIndex (WRI), the Climate & Nature Sovereign Index (CNSI) and the Global Climate Risk Index (CRI). All 5 indices, described in the Appendix, seek to measure the relative vulnerability of countries to physical risks, using a variety of data inputs. Two of these (ND-GAIN and CRI) focus exclusively on climate risk and adaptation, while climate is a component of two others (WRI and CNSI), alongside other natural and man-made hazards such as earthquakes and war.

We reviewed the relative performance on these indices of 16 large emerging and frontier markets: Brazil, Chile, China, Egypt, India, Indonesia, Mexico, Nigeria, Pakistan, Philippines, Poland, Russia, Saudi Arabia, South Africa, Turkey and Vietnam. The countries in this group are intended to be a representative basket of "relevant" emerging markets, consisting of the 10 largest members of the MSCI Emerging Markets index by equity market capitalization, excluding the two most developed EMs (Korea and Taiwan), and augmented by the 6 largest frontier equity markets by population.

We averaged the performance of each country on 4 indices[10] to come up with a combined EM vulnerability ranking for the 16 countries. The results are displayed in Figure 9. We find that the most vulnerable countries to physical risks on this basis are Nigeria, Pakistan, India and Philippines. Those countries least exposed to these risks are Poland, Chile, Brazil and Russia.

[10] Each index was normalized across all countries and its z-scores were averaged (equal weighted) across the first 4 indices. We excluded the CRI from this aggregation, due to its narrow focus on historical weather-related damages.

FIGURE 9
Ranking of 16 EM and frontier markets countries on 4 physical risk ranking indices



Source: ND-GAIN, INFORM, WRI an CNSI

A glance at this chart makes it clear that these risk indices do not always give consistent results, and in some cases deliver widely varying verdicts on the vulnerability of certain countries. Nigeria ranks poorly on all 4, and Poland ranks well on all 4, but for other countries the index rankings diverge. Chile, Brazil, Egypt, Indonesia, Saudi Arabia and Turkey are countries that rank higher-risk on some models and lower-risk on others.

The divergence results from the varied purpose and construction of each index. Of the 4, only ND-GAIN attempts to measure forward-looking climate risk specifically. The CNSI index considers other natural impacts such as biodiversity as well as transition risk, while INFORM and WRI consider vulnerability to natural disasters more broadly. The report *Adaptation Metrics: Current landscape and evolving practices*[11], provides a detailed discussion of different approaches to measuring vulnerability to climate risk. In the Appendix we provide further details on the construction of all 5 indices.

A few comments on some of the divergences:

- **Saudi Arabia** ranks worst of the group on the CNSI index, but among the best on the other 3 indices. This divergence is due to the country's particularly weak scores on 2 elements that the CNSI measures but the others do not: carbon mitigation efforts and water management. By contrast, Saudi scores well on the other indices due to its high-quality infrastructure and lower risk on many of the physical exposures that those indices target (rising sea levels, earthquakes). Aside from CNSI, none of these models account for the risks stemming from Saudi Arabia's oil dependency.

- **Egypt** ranks well on WRI and poorly on the others, especially INFORM. Its good score on WRI is a result of lower exposure to many (non-climate related) natural hazards such as floods, earthquakes and cyclones, although it scores similar to the EM average in terms of adaptation and coping ability. Its poor score on WRI is a result of weak governance and institutions.

- **Mexico** scores well on CNSI due to strong scores on biodiversity and natural capital, and reasonably good scores on adaptation, partly offset by water stress and transition risk. Like Egypt, it scores poorly on INFORM, due to a high exposure to physical and human hazards.

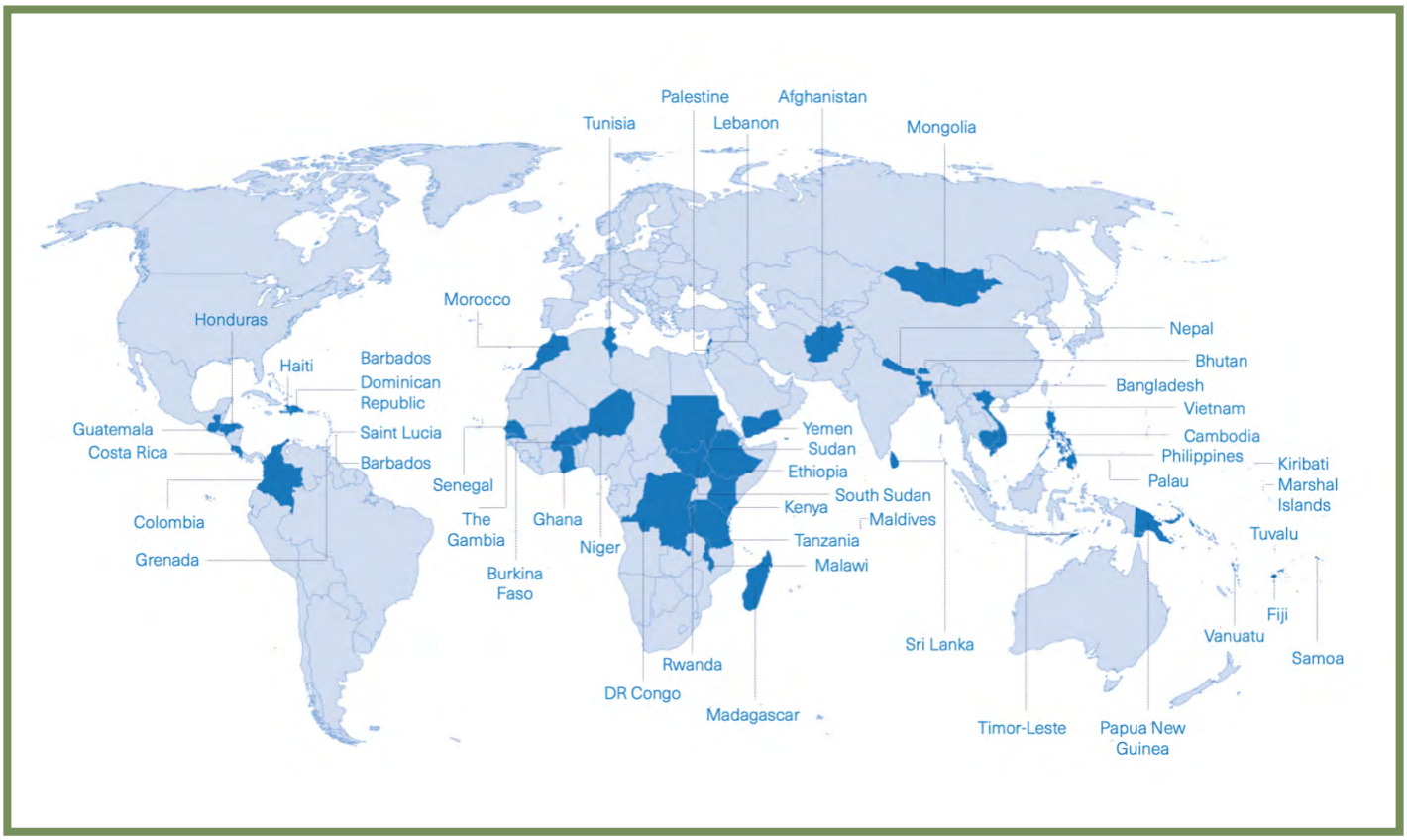
Given the uncertainty of climate risk, it is unsurprising that such indices do not always speak with a common voice on country risks. These are at best a starting point for investors to consider the kinds of hazards that could influence investment returns.

[11] Published by Global Commission on Adaptation as a companion to its 2019 flagship report

Climate Vulnerable Forum

Another framework for identifying vulnerable countries is the membership of Climate Vulnerable Forum (CVF), a partnership of 48 countries vulnerable to a warming planet established in 2009. These are mapped out in Figure 10 and include many emerging and frontier markets including Bangladesh, Colombia, Kenya, Morocco, Philippines, Sri Lanka and Vietnam. Given the self-selecting nature of this group this should not be treated as a comprehensive list of climate-vulnerable countries, and it bears noting that 3 of the 4 most vulnerable countries on our ranking above are not currently members of the CVF.

FIGURE 9
Members of the Climate Vulnerable Forum



Source: CVF, Imperial College/SOAS

V. POLICY RECOMMENDATIONS

In the face of climate uncertainty, there are a number of steps that policy makers in emerging markets can take to prepare for the future. In a policy brief[12], Climate Finance Advisers proposes a framework for developing countries to enhance preparedness and adaptation. Although these recommendations were directed to development agencies, they can be applied with equal merit to the countries themselves. Such recommendations can serve as the basis for engagement by investors when investigating steps towards climate adaptation and resilience.

1. **Build climate-risk management systems**. Investors cite many barriers to integrating climate risk into investment decisions including data, metrics, taxonomies and informational challenges. These elements form critical pieces of an investor's climate-risk management toolkit and are necessary to manage and reduce climate-related risks and capture opportunities.
   Steps towards this goal include:
   a. Promote the application and integration of existing climate-related taxonomies and methodologies
   b. Scale and apply common climate-risk and resilience metrics
   c. Develop climate risk identification guidance for resilient investment in specific sectors/ industries
   d. Promote the application of climate-related warning scenarios

2. **Integrate climate risk/resilience into financial policy and regulation**. Financial system governance bodies within developing countries can and will play a key role in ensuring that climate considerations – including risks posed by physical impacts from climate change – are addressed locally within domestic policies, regulations, and enabling. The domestic policy and regulations that promote resilience and sustainability within those countries will support the investments, but also the economic resilience of those economies. And this in turn can help developing countries improve their resilience overall and strengthen their ability to adapt to climate change.
   Steps include:

[12] *Understanding the Role of Climate Risk Transparency on Capital Pricing for Developing Countries*

a. Accelerate Network for Greening the Financial System (NGFS) guidance to support policymakers/regulators to undertake climate-related scenario analysis

b. Map our transition and physical risk transmission channels within the economy

c. Adopt climate risk frameworks and action plans for regulated entities

d. Ensure that climate-related risks and resilience opportunities are integrated into NDC plans

e. Support the adoption of a price on carbon

3. **Develop financial instruments.** Some financial instruments can help developing countries enhance their resilience and reduce vulnerability, helping share risks across different types of investors and filing financing gaps which may be present as a result of real or perceived riskiness of an investment. These include risk transfer mechanisms (insurance), risk sharing mechanisms (structuring) and incentives tied to resilience/adaptation outcomes. Resilience Bonds, adaptation-linked loan guarantees and other incentives could play a role here.

VI. INSTITUTIONS ADDRESSING PHYSICAL RISK, ADAPTATION AND RESILIENCE

TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES (TCFD)

The Financial Stability Board (FSB) -- an international body that monitors and makes recommendations about the global financial system -- established the Task Force on Climate-related Financial Disclosures (TCFD) to develop recommendations for more effective climate-related disclosures. In 2017, TCFD released its final report with recommendations for helping businesses disclose climate-related financial information. Although these were aimed at businesses, climate-related risk has increasingly the subject of governmental reporting disclosure requirements, many of which are based on the TCFD framework. Several national governments formally support the TCFD.

The TCFD's core recommendations center around four themes: Governance, Strategy, Risk Management and Metrics & Targets. Taken from a sovereign perspective, the **Governance** theme encourages countries to disclose oversight of climate-related risks/opportunities. **Strategy** asks countries to assess the importance of climate change to their national security and interests, and to disclose their exposure to climate-related risks/opportunities, including through forward-looking scenario-based analysis. **Risk Management** asks countries to report on how they integrate their process for identification, assessment and management of climate risks and opportunities into their existing governance frameworks. **Metrics and Targets** encourages national reporting to include climate-related metrics and to set targets aligned with the material risks/ opportunities identified through the process.

NETWORK FOR GREENING THE FINANCIAL SYSTEM (NGFS)

NGFS is a group of central banks and supervisors fostering the development of environment and climate risk management in the financial sector, and the mobilization of mainstream finance to support a low carbon transition. It supports the TCFD recommendations and encourages companies to disclose in line with the recommendations. In line with TCFD, the NGFS has also identified scenario analysis

as an important tool to help central banks and supervisors assess the impacts of climate change on the macroeconomy, the financial system and financial firms.

NGFS's report for Central Banks on climate risks recommends: (i) integrating climate-related risks into financial stability monitoring and micro-supervision, (ii) integrating sustainability factors into own-portfolio management, (iii) bridging data gaps, (iv) building capacity and encouraging knowledge sharing, (v) achieving robust and internally consistent climate and environment-related disclosure, and (vi) supporting the development of a taxonomy of economic activities.

UNEP / ADAPTATION GAP REPORT

The 2015 Paris Agreement established a global goal of "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change". Reflecting the need for a global perspective on adaptation, the United Nations Environment Programme (UNEP) produces an Adaptation Gap Report (AGR) to inform policymakers and the public on the status and results of global adaptation efforts. The recently-released 2020 report argues that:

- **Climate adaptation is now widely embedded in policy and planning** across the world, but levels of engagement and the quality of instruments are vastly different from country to country
- Analysis of adaptation planning paints a **mixed picture** in terms of achieving stated objectives.
- **Additional adaptation finance is critical to enhance adaptation planning and implementation** and limit climate damages, particularly in developing countries. annual adaptation costs in developing countries alone are currently estimated to be in the range of US$70 billion, with the expectation of reaching US$140–300 billion in 2030 and US$280–500 billion in 2050.
- Implementation of adaptation actions is growing worldwide but **there is still very limited evidence of climate risk reduction**. The Global Adaptation Mapping Initiative identified almost 1,700 articles detailing adaptation actions worldwide, a third of which were in early stages of implementation and only 3 per cent of which were in the stage of risk reduction.

  However, there is clear evidence of a rise in implementation.

Reviewing the overall progress made towards this global goal on adaptation is one of four adaptation-related functions of the UNFCCC Global Stocktake, which will take place every five years starting in 2023, with data collection and input due to begin during 2021.

A number of other institutions have been established to explore issues around physical risk and adaptation, promote awareness and recommend best practices. These include:

- **Global Commission on Adaptation**. The Commission was launched in 2018 by the UN Secretary General and is supported by 20 convening countries with the mandate to encourage the development of measures to manage the effects of climate change through technology, planning and investment. The managing partners of the Commission are the Global Center on Adaptation and World Resources Institute. The Commission's flagship report argues that "investing $1.8 trillion globally in five areas from 2020 to 2030 could generate $7.1 trillion in total net benefits."
- **Global Center On Adaptation (GCA)**, hosted by the Netherlands, GCA is a self-described "solutions broker for adaptation action" and is establishing a worldwide network of innovation hubs for climate adaptation in Africa, Asia and the Americas. It hosts a number of adaptation-related events including a digital Climate Adaptation Summit on January 25-26, 2021.
- **Climate Vulnerable Forum (CVF)**. The CVF was established in 2009 as an international partnership of countries highly vulnerable to a warming planet. Chaired by Bangladesh, the CVF has launched the initiative "Midnight Survival Deadline for the Climate" to call all nations to deliver on their commitments under the Paris Agreement
- **Coalition for Climate Resilient Investment (CCRI)**. Launched at the UN Climate Action Summit in 2019, the CCRI aims to support national decision-making, project valuation and investment appraisal and financial innovation.

VII. KEY READINGS

Adapt Now: A Global Call for Leadership on Climate Resilience, Global Commission on Adaptation, 2018

Adaptation metrics: current landscape and evolving practices, Background paper for the global commission on Adaptation, UNEP DTU Partnership

Advancing TCFD guidance on physical climate risks and opportunities, Four Twenty Seven and Acclimatise for the collaboration between the EBRD and the Global Centre of Excellence on Climate Adaptation, 2019

Changing Course: A comprehensive investor guide to scenario-based methods for climate risk assessment, in response to the TCFD, UN Environment – Finance Initiative, Vivid Economics and Carbon Delta, 2019

Climate Change and the Cost of Capital in Developing Countries, Imperial College Business School and SOAS University of London, 2018

Climate Change as a Threat Multiplier for Human Disaster and Conflict, The Hague Institute for Social Justice, 2015

Climate Change Physical Risk and Equity Prices from Global Financial Stability Report, International Monetary Fund, 2020

Climate risk and response: Physical hazards and socioeconomic impacts, McKinsey Global Institute (2020)

Climate change as a threat multiplier for human disaster and conflict: policy and governance recommendations for advancing climate security. The Hague Institute for Global Justice

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VIII. APPENDIX: DETAILS OF PHYSICAL RISK INDICES

Numerous indices assessing the exposure of countries to climate risk have been developed by governments, the private sector and civil society. See the Adaptation Metrics report for more details.

FIGURE 11 Country Physical Risk Indices

NAME/YEAR	ORGANIZATION	# INDICATORS	TYPES OF INDICATORS	DESCRIPTION	HIGHEST/LOWEST RISK COUNTRIES
ND-GAIN Index 2018	Notre dame university	45	Vulnerability of food, water, health, ecosystem service, human habitat, and infrastructure; & ability to leverage investments and convert them to adaptation actions	Vulnerability to challenges caused by climate change and readiness to implement solutions	Top: Nigeria, Pakistan and India. Bottom: Poland, Chile and Russia
INFORM Risk Index 2021	European Commission	50	Vulnerability of individuals and households to crisis, coping capacity (institutional strength) & exposure to natural and human hazards	Risk from humanitarian crises and disasters that could overwhelm national response capacity	Highest: Nigeria, Pakistan and India; Least: Poland, Saudi Arabia and Chile
WorldRiskIndex (WRI) 2020	Bündnis Entwicklung Hilft	28	Disaster risk based on vulnerability and exposure to 5 natural hazards: earthquakes, cyclones, droughts and sea-level risk	a) Country's exposure to natural hazards; b) the population's susceptibility and capacity for coping and adaptation	Highest: Philippines, Nigeria and Chile. Lowest: Saudi Arabia, Egypt and Poland
Climate & Nature Sovereign Index (CNSI) 2020	WWF / NinetyOne	90	Biodiversity & natural capital; Physical risk-atmospheric, water & agriculture; transition risk; financial & socio-economic resilience	Nature- and transition-risk exposures, climate risk and the economic and financial impacts	Highest: Saudi Arabia, Nigeria, Vietnam; Lowest: Chile, Brazil, Poland
Global Climate Risk Index (CRI) 2020	Germanwatch	4	Fatalities and monetary losses from extreme weather events.	Direct impact of past extreme weather events.	Highest: Pakistan, Chile, India; Lowest: Turkey, Brazil, Nigeria

[27] 2019 Informe de Desarrollo Sustentable, Grupo México
[28] Mejor Práctica, Grupo México

The Notre Dame Global Adaptation Index (ND-GAIN) was developed and is maintained by the University of Notre Dame as part of the Notre Dame Environmental Change Initiative, which also maintains an Urban Adaptation Assessment. Of the indices examined in this report, ND-GAIN perhaps comes closest to focusing on forward-looking climate risk. The ND-GAIN index measures a country's a) vulnerability to climate disruption and b) readiness to leverage private and public investment for adaptive actions. 45 core indicators for 192 UN countries are compiled from to 2018, on vulnerability and readiness.

The **INFORM Risk Index**, a collaboration between the Inter-Agency Standing Committee (IASC) of the UN General Assembly and the European Commission, measures country-level risk of a humanitarian crisis, combining 54 indicators along 3 parameters: hazard & exposure, vulnerability and coping capacity.

The **World Risk Index (WRI)** measures disaster risk on 28 indicators for 171 countries along 5 parameters: exposition, vulnerability, susceptibility, lack of coping and lack of adaptation. WRI attempts to capture the threat from, or exposure to, key natural hazards and the rise in sea level caused by climate change, as well as social vulnerability in the form of the population's susceptibility and their capacity for coping and adaptation. The index was developed by the United Nations University Institute for Environment and Human Security (UNU-EHS) and is maintained by the Institute for International Law of Peace and Armed Conflict at Ruhr University Bochum.

The **Climate & Nature Sovereign Index (CNSI)**, developed by WWF and the investment firm NinetyOne, covers nature- and transition-risk exposures, as well as climate risk, and makes explicit the economic and financial links to them. Many of CNSI's indicators are based on modelling from the CMIP5 IPCC climate model ensemble, rather than older climate models. The index is broader than others considered here, with more inputs (nearly 100 indicators) and a more holistic perspective that in addition to climate risk considers natural capital impacts and transition risk.

FInally, the **Global Climate Risk Index (CRI)**, by Germanwatch, an independent development and environmental organisation, considers quantified impacts of historical extreme weather events – including both fatalities and economic losses that occurred, based on data from Munich Re. The CRI differs from the other indices considered here in being exclusively backward-looking. In the briefing paper for the 2020 index, the authors acknowledge that the index represents "one piece in the puzzle" of climate-related impacts. CRI focuses on extreme weather events but not slow-onset processes such as rising sea-levels. In addition, the index is based on past data and "should not be used as a basis for projections of future climate impacts".

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