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Assessing physical climate risks for sovereigns

Focus on Asia

Key takeaways

- Physical risk refers to the potential damage caused by climate-related hazards. Physical risk can be acute if deriving from extreme weather events and hazards, or chronic if related to a more gradual effect of global warming. By affecting individual businesses, households and the broader economy, **climate risks could translate into financial risks and affect sovereign debt's pricing and sustainability.**
- Using models based on IPCC's climate scenarios, it is possible to assess countries' exposure to climate hazards at different time horizons. According to the scoring provided by our sovereigns' ESG data provider Verisk, t**he regions most exposed to physical risks by 2050 are Africa, Asia and the Americas. Europe is comparatively less exposed than other regions** but still faces significant risks, as it is currently the fastest-warming continent.
- In Asia, climate hazard risks are more significant in south and south-east Asia than in east Asia. Verisk's Climate Hazard index shows that **Singapore, Thailand, India, Indonesia and Sri Lanka face the highest risks by 2050 and 2080.** Meanwhile, **Japan, South Korea, Taiwan and China appear less at risk**, although a high temperature scenario would significantly increase their exposure to acute and chronic climate hazards by 2080.
- **To assess the medium to long term potential economic impact of physical risks in Asia**, we use two climate scenarios designed by the NGFS that capture the lowest and highest levels of physical risks. These scenarios show that **by 2050, Asia's GDP loss could reach between 10 and 16% compared to a baseline scenario, with south and south-east Asia being most affected.** The main climate-related economic impacts come from sea level rise, reduced labor productivity, increased energy demand and the impact of floods.
- Beyond exposure and vulnerability to climate hazards, it is also important to evaluate countries' capacity to adapt (readiness). According to the University of Notre-Dame's Global Adaptation Initiative (ND-GAIN) Index, **Singapore, South Korea, Japan, China and Malaysia have relatively low vulnerability and high readiness, while Afghanistan, Myanmar, Bangladesh, Pakistan, the Maldives and Bhutan are most vulnerable and least prepared.**
- Adaptation to climate change has a cost and could significantly impact public finances. **Some of the countries combining relatively high vulnerability and low readiness also face constraints on the fiscal side. This is notably the case for the Maldives, Sri Lanka, India, and Pakistan.** This could translate into lower credit ratings, as climate risks are being increasingly considered by ratings agencies, and could have an impact on sovereign bond yields and sovereign debt sustainability.
- While there are risks for sovereign debt investors stemming from the physical impact of climate change, there are also **investment opportunities linked to the necessary adaptation of countries.**

Climate-related physical risk and sovereign debt

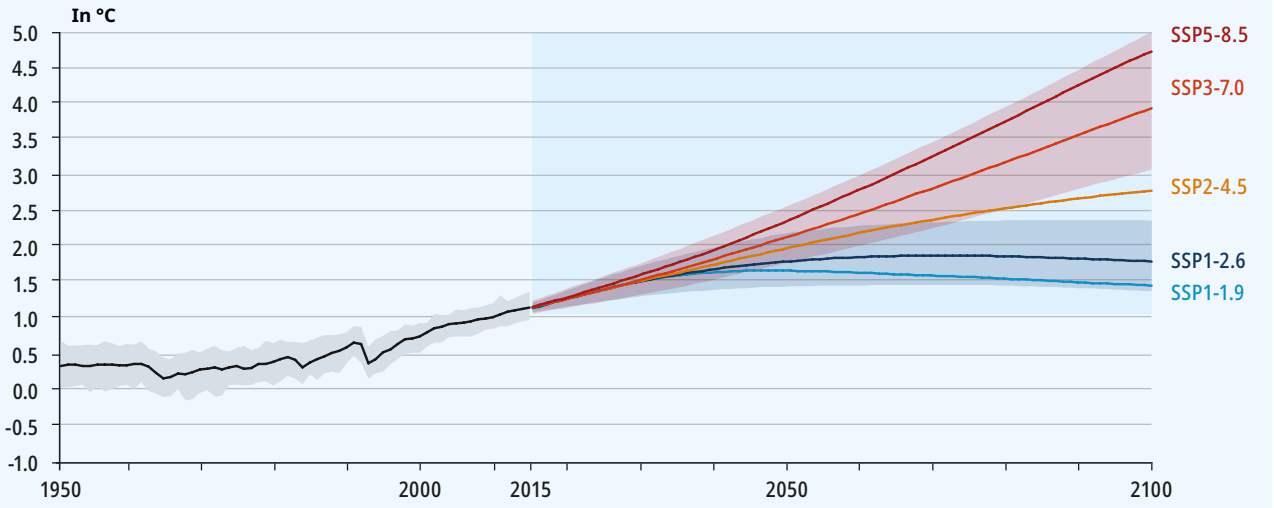
Physical risk refers to the potential damage caused by climate-related hazards. Physical risk can be acute, if derived from extreme weather events and hazards: floods, landslides, extreme temperatures, storms and hurricanes, droughts, wildfires; or chronic, if related to the more gradual effect of global warming: gradual increase of sea level, reduced crops harvesting, lower labor productivity due to higher temperatures, for instance.

Acute impacts from extreme weather events can lead to business disruption and damage to property. There is some evidence that increased global warming could also lead to persistent longer-term impacts on the economy. These events can increase underwriting risks for insurers, possibly leading to reduced insurance coverage in some regions, and potentially impair asset values. Chronic impacts, particularly from increased temperatures, may affect labor, capital, land, and natural capital in specific areas. By affecting individual businesses, households and the broader macroeconomy, **climate risks could translate into financial risks and affect sovereign debt's sustainability**.

Assessing countries/regions exposure to physical risk

The Intergovernmental Panel on Climate Change's (IPCC) climate scenarios provide a solid basis to assess countries' exposure to physical risk at different time horizons through the projected change in global mean temperature.

Figure 1. Change in temperature according to the IPCC scenarios



Projected global mean temperature change compared with the period 1850-1900. Source: IPCC.

The IPCC uses a set of five socio-economic scenarios (SSP - Shared Socioeconomic Pathways) in its sixth report (AR6). These scenarios correspond to possible evolutions towards different models of society, which are broken down into several GHG emission trajectories:

- **SSP1: Sustainability** – Taking the Green Road (Low challenges to mitigation and adaptation)
- **SSP2: Middle of the Road** (Medium challenges to mitigation and adaptation)
- **SSP3: Regional Rivalry** – A Rocky Road (High challenges to mitigation and adaptation)
- **SSP4: Inequality** – A Road Divided (Low challenges to mitigation, high challenges to adaptation)
- **SSP5: Fossil-fueled Development** – Taking the Highway (High challenges to mitigation, low challenges to adaptation)

Using the Shared Socioeconomic Pathways based on IPCC's climate scenarios, it is possible to assess countries' exposure to climate hazards at different time horizons. According to the scoring provided by Verisk, the regions most exposed to physical climate risks by 2050 are Africa, Asia and the Americas, in both moderate and high temperature increase scenarios. Europe is comparatively less exposed than other regions in both scenarios but still faces significant risks, as it is currently the fastest-warming continent.

Figure 2. Climate hazard index scores by region, scenario and time horizon

Moderate temperature increase scenario

	2030	2050	2080
Africa	6.17	4.86	3.96
Asia	7.13	5.79	4.93
Americas	7.26	5.71	4.82
Oceania	7.64	6.94	5.74
Europe	8.26	7.98	7.59

High temperature increase scenario

	2030	2050	2080
Africa	5.77	4.96	2.86
Asia	6.83	4.87	3.44
Americas	6.94	4.96	3.86
Oceania	7.64	6.13	4.17
Europe	8.26	7.63	6.66

Verisk Scores from 0 (high risk) to 10 (low risk).
Moderate temperature increase scenario: SSP2-4.5; high temperature increase scenario: SSP5-8.5.

Verisk Climate hazard indices

The indices assess the degree to which locations are exposed to a range of chronic and acute climate hazards. Indices have been calculated using the Shared Socioeconomic Pathways (SSP) 2-4.5 and 5-8.5, which represent respectively the middle and the upper boundary within the range calculated by CMIP6*, based on the IPCC climate scenarios. There are 3 different horizons (2030, 2050, 2080) for each scenario.

Acute Climate Hazards:

- Extreme High Temperature Index
- Extreme Precipitation Index
- Heatwave Hazard Index

Chronic Climate Hazards:

- Chronic Change in Temperature Index
- Chronic Change in Precipitation Index
- Chronic Change in Wind Speed Index
- Temperature Variability Index
- Precipitation Variability Index

* Coupled Model Intercomparison Project Phase 6, a global research program on climate modeling.

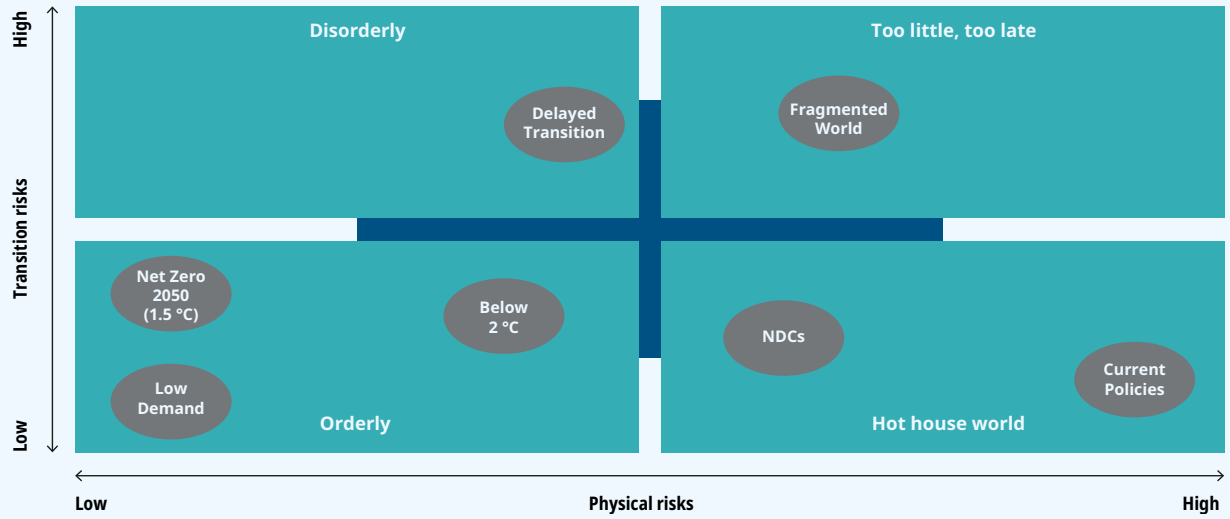
The economic impact of climate-related physical risk

The economic impact of climate change is challenging to model given the uncertainty on the global temperature trajectory, the changing patterns of extreme events and the complex interactions and location specificities involved. There are continuous developments to improve macroeconomic models, and results can be quite different depending on the methodologies used. There is however agreement on the fact that climate change will increase extreme weather events and modify the economic environment.

In an exploratory scenario analysis of the vulnerability and readiness of 135 countries to climate change over the next 30 years, **S&P Global Ratings** (2022 study) found that physical climate risks could expose 3.3%, 4%, and 4.5% of world GDP to losses by 2050 under the respective climate pathways RCP2.6 (Paris Agreement), RCP4.5 (current policies), and RCP8.5 (high GHG emissions scenario), assuming no adaptation and all risks materialize simultaneously. The assessment finds that **regional impacts from climate hazards are most pronounced in South Asia (10%-18% of GDP at risk)** and is high for Central Asia, Middle East and North Africa, and Sub-Saharan Africa.

The Network for Greening the Financial System (NGFS) has developed climate scenarios to inform analysis and guide policy. The NGFS's long-term climate scenarios are a set of forward-looking pathways designed to explore how the global economy and financial system might evolve under different levels of climate policy ambition and physical climate impacts up to 2100. To reflect the uncertainty inherent to modelling climate-related macroeconomic and financial risks, the NGFS scenarios use different models, and explore a wide range of scenarios across regions and sectors.

Figure 3. NGFS scenarios framework:

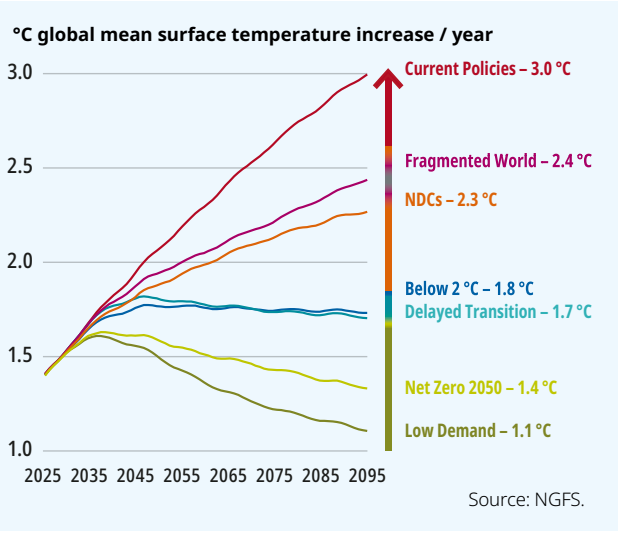


Positioning of scenarios is approximate, based on an assessment of physical and transition risks out to 2100.
Source: NGFS Climate Scenarios for central banks and supervisors - Phase V.

- Orderly scenarios assume climate policies are introduced early and become gradually more stringent. Both physical and transition risks are relatively subdued.
- Disorderly scenarios explore higher transition risks due to policies being delayed or divergent across countries and sectors.
- Hot house world scenarios assume that some climate policies are implemented in some jurisdictions, but globally efforts are insufficient to halt significant global warming. The scenarios result in severe physical risk including irreversible impacts.
- Too-little-too-late scenarios assume that a late and uncoordinated transition fails to limit physical risks.

Differences in assumptions across scenarios result in different temperature pathways, which correspond to varying carbon emission and carbon price trajectories.

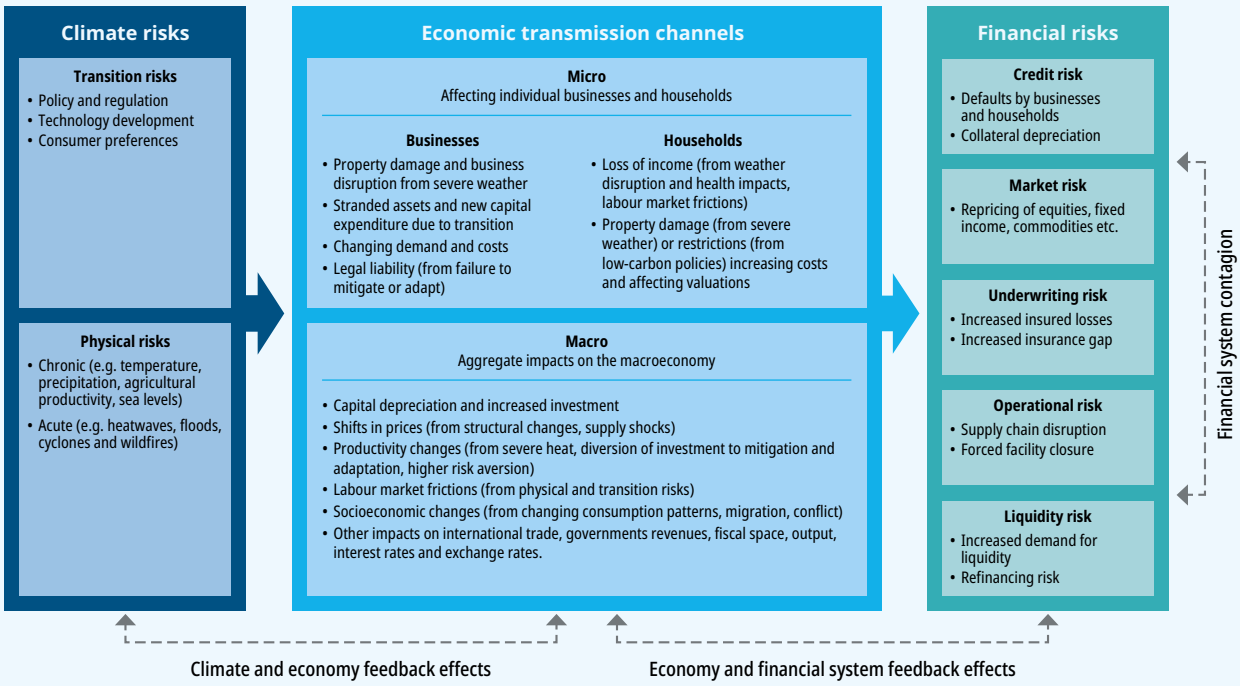
Figure 4. Global temperature pathways according to the NGFS' scenarios



Source: NGFS.

The NGFS demonstrated in a 2024 study that negative impacts from severe weather events are not limited to the destruction of output, capital, and real estate but extend to the broader economy because supply, demand, and financial channels amplify and propagate the effects of the initial shock. The indirect costs of extreme weather events include economic losses from unusable infrastructure, lower investment and consumption demand due to declines in wealth, disrupted trade flows, and uncertainty about future climate events.

Figure 5. Transmission channels: Climate risks to financial risks



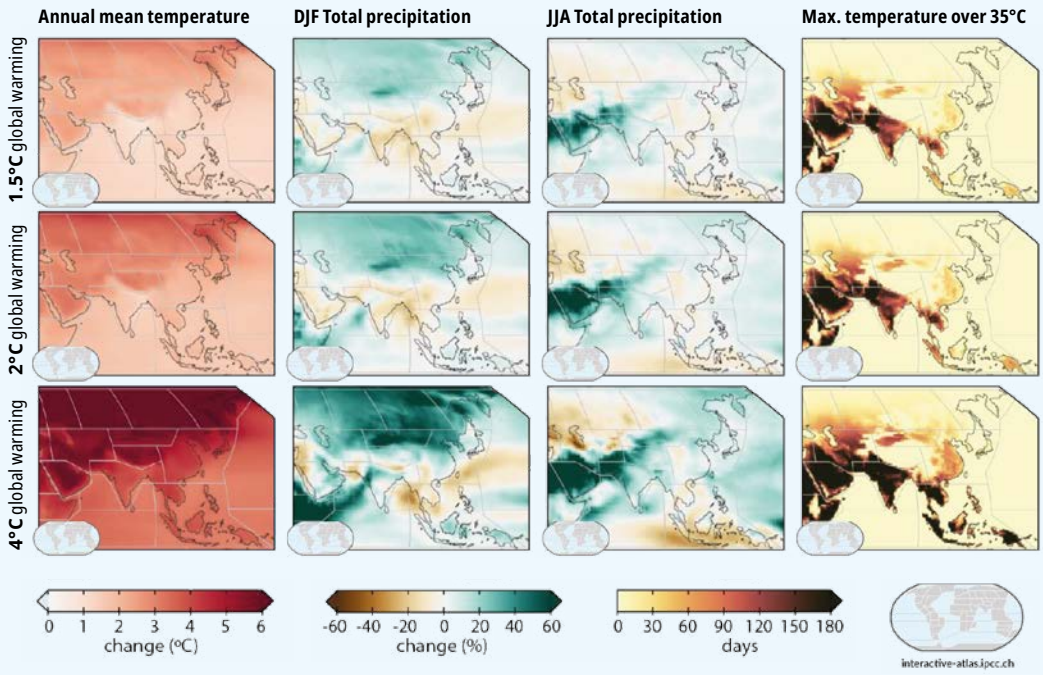
Source: NGFS long-term scenarios for central banks and supervisors.

Focus on Asia

Exposure to climate change and potential economic impact

According to the IPCC and other scientific analysis, Asia will be significantly exposed to climate hazards, even in a moderate temperature increase scenario. Higher mean and extreme temperatures and a change in the precipitation pattern will trigger an increase in extreme weather-related events and affect economic activity in the continent.

Figure 6. Expected change in mean temperature and precipitation in Asia according to various climate scenarios by the IPCC



Zooming in to country level, risks are more significant in south and south-east Asia than in east Asia. Verisk's Climate Hazard index shows that **Singapore, Thailand, India, Indonesia and Sri Lanka face the highest risks in 2050 and 2080**, both in a moderate and in a high temperature increase scenario (see ranking below). Meanwhile, **Japan, South Korea, Taiwan and China appear less at risk** although a high temperature scenario would significantly increase their exposure to acute and chronic climate hazards by 2080, notably for China and South Korea.

Figure 7. Climate hazard index scores by country, scenario and time horizon

Moderate temperature increase scenario

	2030	2050	2080
Singapore	7.03	3.05	2.61
Thailand	5.78	3.06	2.26
India	5.89	3.36	2.65
Indonesia	6.33	3.40	2.68
Sri Lanka	7.04	3.76	2.63
Pakistan	6.05	4.30	3.17
Bangladesh	7.06	4.39	2.81
Philippines	6.90	4.43	3.46
Malaysia	7.00	4.48	3.09
Vietnam	6.95	4.92	2.75
Hong Kong	7.54	7.12	5.15
China	7.72	7.22	6.57
Taiwan	7.65	7.31	6.75
South Korea	7.81	7.53	7.16
Japan	7.94	7.57	7.11

High temperature increase scenario

	2030	2050	2080
Thailand	5.49	2.29	1.79
India	6.05	2.74	1.87
Indonesia	6.11	2.81	2.01
Singapore	7.00	2.86	2.08
Bangladesh	7.06	2.93	1.95
Sri Lanka	6.94	3.02	2.13
Pakistan	5.49	3.19	2.38
Vietnam	6.93	3.26	2.16
Hong Kong	7.32	3.27	2.86
Malaysia	6.88	3.30	2.18
Philippines	6.76	3.52	2.18
China	7.57	6.63	4.73
Taiwan	7.58	6.66	5.04
South Korea	7.72	7.03	3.98
Japan	7.87	7.11	5.94

Verisk Scores from 0 (high risk) to 10 (low risk); sorted on 2050 scores (from highest to lowest risk).
Moderate temperature increase scenario: SSP2-4.5; high temperature increase scenario: SSP5-8.5.

Among the different types of climate hazards, Asia is more vulnerable to floods, sea level rise and storms. Drought is less of an issue compared to other parts of the world, while risks of heatwaves are significant mostly for India and Pakistan.

Figure 8. Sovereigns most exposed to different types of physical risks according to Fitch Ratings

Heatwaves & wildfires	Drought	Storms	Floods & landslides	Sea level rise
India	Egypt	Bahamas	Vietnam	Vietnam
Oman	Jordan	Philippines	Panama	Netherlands
Nigeria	Saudi Arabia	Mexico	Philippines	Maldives
UAE	Tunisia	Japan	Thailand	Bahamas
Autralia	Qatar	China	Indonesia	Bangladesh
Benin	Turkmenistan	Dominican Rep.	India	Seyshelles
Chad	Iraq	Vietnam	Taiwan	Bahrain
Iraq	North Macedonia	Jamaica	Aruba	Macao
Pakistan	Uzbekistan	Korea	Bangladesh	Philippines
Saudi Arabia	Israel	Barbados	Gabon	UAE
Kuwait	Nicaragua	United States	Pakistan	Japan
Paraguay	Guatemala	Laos	China	Thailand

Sorted by most exposed first and alphabetical if equal rank. Asian countries highlighted in blue.
Source: Fitch Ratings – Global Sovereigns: exposure to climate risk.

To assess the medium to long term potential economic impact of physical climate risks in Asia, we focus on two among the seven scenarios designed by the NGFS that capture the lowest and highest levels of physical risks: Net Zero 2050 and Current Policies.

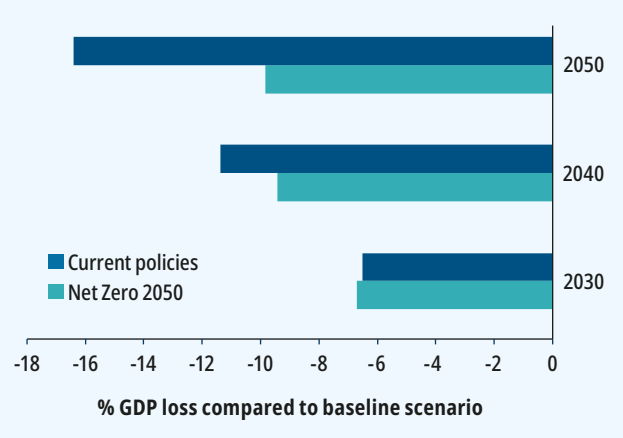
The NGFS describes these scenarios as follows:

- **Net Zero 2050** limits global warming to 1.5 °C through stringent climate policies and innovation, reaching global net zero CO2 emissions around 2050.
- **Current Policies** assumes that only currently implemented policies are preserved, leading to high physical risks.

Based on these climate scenarios, the NiGEM[1] macro-economic model provides estimates of the impact of physical risks on economic indicators for different time horizons, up to 2050. While the impact of chronic risks will gradually rise over time, the frequency of acute weather events has already increased.

It is noteworthy that the percentage of GDP change under each scenario is modelled relative to the underlying assumptions used in the base case. Therefore, the impacts from each scenario will vary in line with other non-climate related macro-economic drivers.

Figure 9. Impact of physical risks on Asia's GDP according to two NGFS transition scenarios



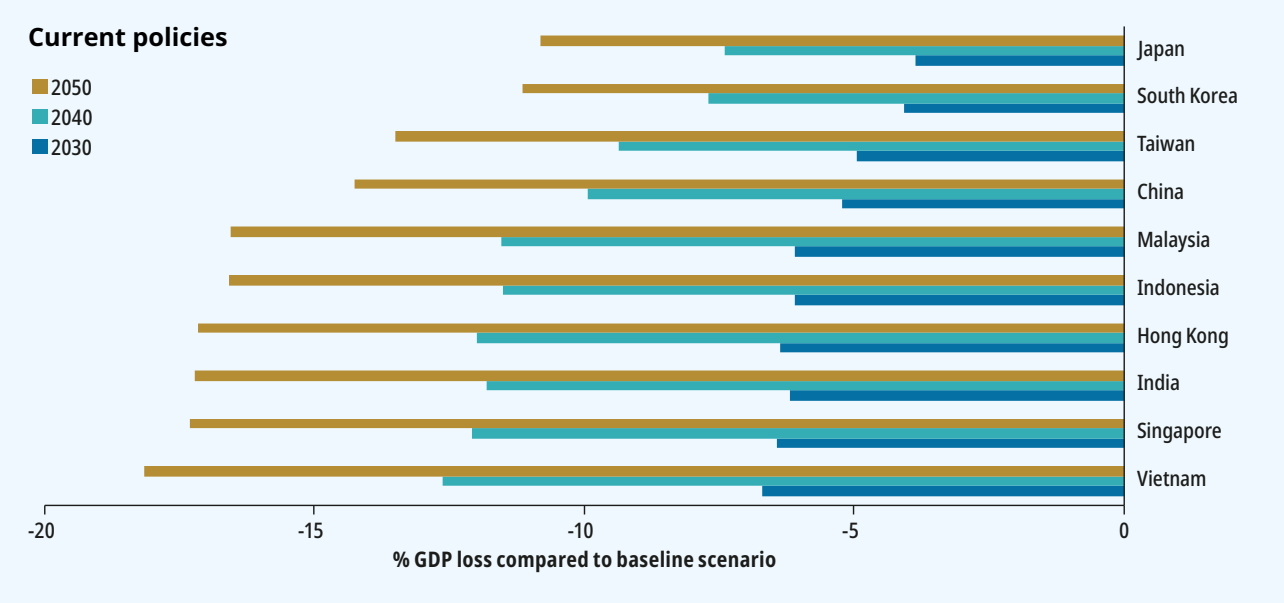
Impact on GDP: % difference from baseline scenario, based on 2017 GDP in PPP; for each scenario and time horizon, we calculate the average of the NiGEM macroeconomic model's results, based on the inputs of the NGFS modelling framework (three different Integrated Assessment Models)

Asia includes China, Hong Kong, India, Indonesia, Malaysia, Singapore, South Korea, Taiwan and Vietnam, which are modelled individually + the rest of emerging & developing Asia countries (IMF definition), which are modelled as a group

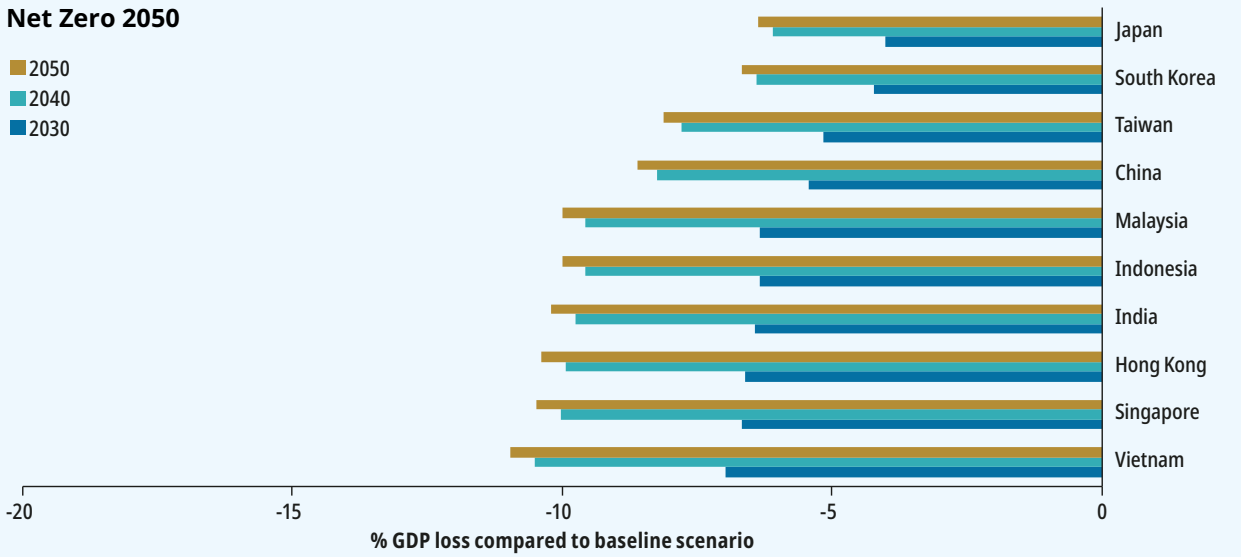
Source: NGFS

The main climate-related risks for the region's economy are sea level rise, reduced labor productivity, increased energy demand (to cope with heat waves) and the impact of floods. Other affected areas are agriculture, fisheries and forestry, as nature and biodiversity will be impacted by climate change.

Figure 10. Economic impact of climate risks on countries that are modelled individually, under the two extreme scenarios (Current policies and Net Zero 2050)



1. National Institute Global Econometric Model



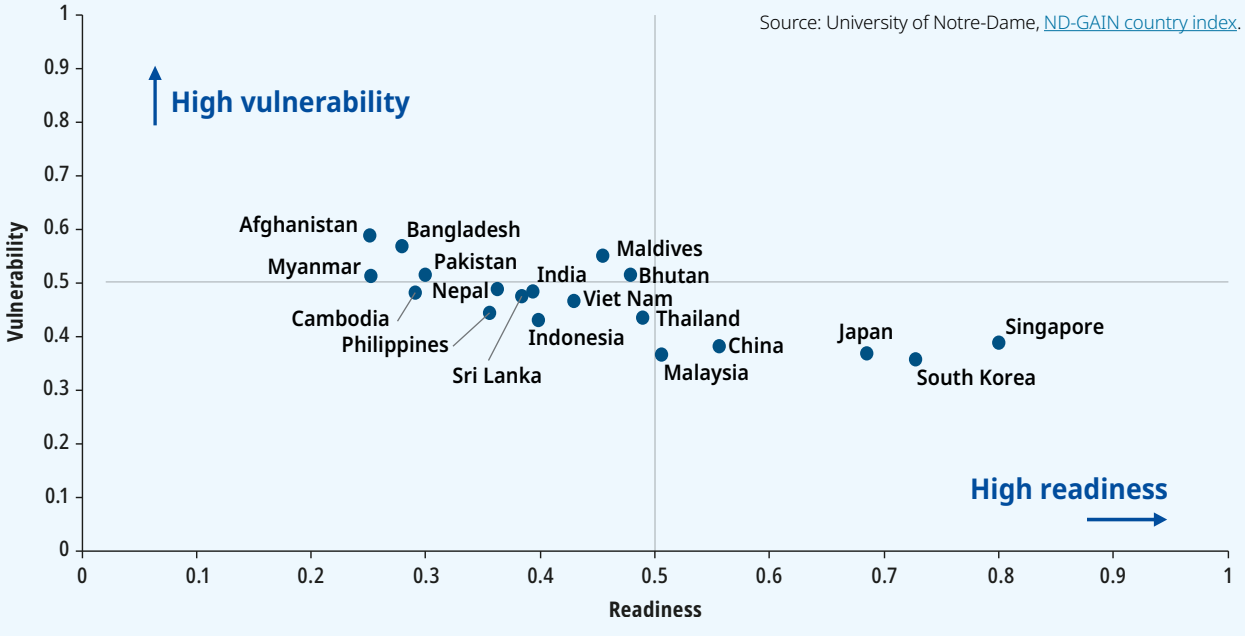
Impact on GDP: % difference from baseline scenario, based on 2017 GDP in PPP; for each scenario and time horizon, we calculate the average of the NiGEM macroeconomic model's results, based on the inputs of the NGFS modelling framework (three different Integrated Assessment Models). Source: NGFS.

Vulnerability and readiness

Beyond the physical exposure to climate hazards, it is also important to evaluate a country's sensitivity to such risks (population and proportion of the economic activity potentially affected) and its economic, social and institutional ability to prepare and adapt.

The University of Notre-Dame's Global Adaptation Initiative (ND-GAIN) developed a tool that scores countries on their sensitivity and capacity to adapt, as well as their readiness to leverage investment into adaptation action (this involves not only an economic capacity but also effective governance and social capacity). The ND-GAIN Country Index uses 45 indicators to rank over 180 countries annually based on their level of vulnerability, and their readiness to successfully implement adaptation solutions.

Figure 11. Asian countries vulnerability to readiness plot



The countries in the quadrant at the bottom right of the chart – Singapore, South Korea, Japan, China and Malaysia - have relatively low vulnerability and high readiness according to the index. On the other hand, **Afghanistan, Myanmar, Bangladesh, Pakistan, the Maldives and Bhutan – in the top left quadrant – are the most vulnerable and least prepared.** This could translate into lower credit ratings as climate risks are being increasingly considered by ratings agencies. This could lead to higher borrowing costs while these countries need to finance their adaptation.

ND-Gain Country Index

The index is composed of two key dimensions of adaptation: vulnerability and readiness.

Vulnerability

Measures a country's exposure, sensitivity and capacity to adapt to the negative effects of climate change. ND-GAIN measures overall vulnerability by considering six life-supporting sectors – food, water, health, ecosystem service, human habitat, and infrastructure.

- **Exposure:** Degree to which a system is exposed to significant climate change from a biophysical perspective. It is a component of vulnerability independent of socio-economic context. Exposure indicators are projected impacts for the coming decades and are therefore invariant overtime in ND-GAIN.
- **Sensitivity:** Extent to which a country is dependent upon a sector negatively affected by climate hazard, or the proportion of the population particularly susceptible to a climate change hazard. A country's sensitivity can vary over time.
- **Adaptative capacity:** Availability of social resources for sector-specific adaptation. In some cases, these capacities reflect sustainable adaptation solutions. In other cases, they reflect capacities to put newer, more sustainable adaptations into place. Adaptive capacity also varies over time.

Readiness

Measures a country's ability to leverage investments and convert them to adaptation actions. ND-GAIN measures overall readiness by considering three components – economic readiness, governance readiness and social readiness.

- **Economic:** Captures the ability of a country's business environment to accept investment that could be applied to adaptation that reduces vulnerability.
- **Governance:** Captures the institutional factors that enhance application of investment for adaptation.
- **Social:** Captures the factors such as social inequality, ICT infrastructure, education and innovation that enhance the mobility of investment and promote adaptation actions.

Source: University of Notare Dame, ND-GAIN methodology.

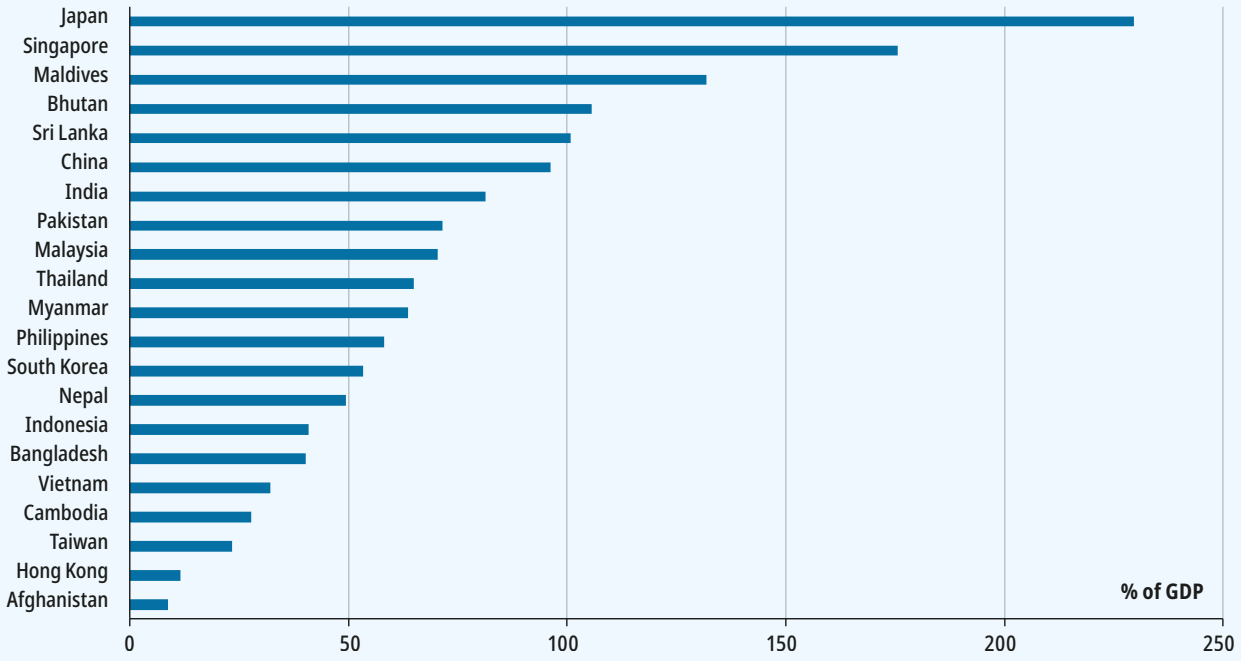
The cost of adaptation and of loss and damage will weigh on public finances

Adaptation to climate change has a cost and could significantly impact public finances. As Asia faces high climate risks, this could become a heavy burden for some countries with an already strained fiscal capacity.

The Asian Development Bank (ADB) in its Asia-Pacific Climate Report 2024 estimates that adaptation finance needed for Asia and the Pacific is in a range of US$102-431bn per year to 2030 (US$102bn based on sector modeling, and US$431bn based on submitted NDCs, National Adaptation Plans, adaptation communications, etc.). Meanwhile, total tracked adaptation commitments for the region amounted to US$34bn annually in 2021-2022, of which US$24bn was domestic expenditure (primarily in China). Private investment accounts for less than 1% of adaptation finance flow to developing Asia and the Pacific according to the ADB.

Some of the countries combining relatively high vulnerability and low readiness also face constraints on the fiscal side, due to already high debt levels. This is notably the case of the Maldives, Sri Lanka, India and Pakistan.

Figure 12. General government debt to GDP



2025 data (2024 for Afghanistan and Bhutan). Source: IMF.

Conclusion

Even with global mitigation and adaptation measures, it will be impossible to avoid loss and damage - unavoidable and irreversible impacts of climate change - in Asia. This will require the deployment of financial mechanisms to address more frequent and intense extreme weather events.

Overall, the financial burden of adaptation and loss and damage is a risk for the public finances of the least developed and most vulnerable countries of the region. **This could translate into lower credit ratings, as climate risks are being increasingly considered by ratings agencies, and could have an impact on sovereign bond yields and sovereign debt sustainability.**

The need to direct more financial flows towards the most vulnerable and least developed countries globally has been reiterated at COP29, where a New Collective Quantified Goal (NCQG) on climate finance was adopted. The goals are 1/ to **scale up financing for developing countries to at least US$1.3 trillion annually by 2035 from all sources**, and 2/ to mobilize at least US$ 300 billion per year by 2035, led by developed countries.

While there are risks for sovereign debt investors stemming from the physical impact of climate change, there are also investment opportunities linked to the necessary adaptation of countries. Most of them have national adaptation plans or equivalent frameworks, which need to be assessed case by case to check their credibility, relevance, deployment and monitoring.

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