Regional Workshop on Measuring Disaster Risks and Impacts

STATISTICS

Physical and Transition Risk Indicators: Definitions, Uses and Sources

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Climate change represents a new type of systemic risk, which we have characterized as a Green Swan. Unlike rare tail events, such as the Black Swans of the Global Financial Crisis, Green Swans are doomed to happen with certainty if not addressed by appropriate policies.

- BOLTON ET AL (2020)

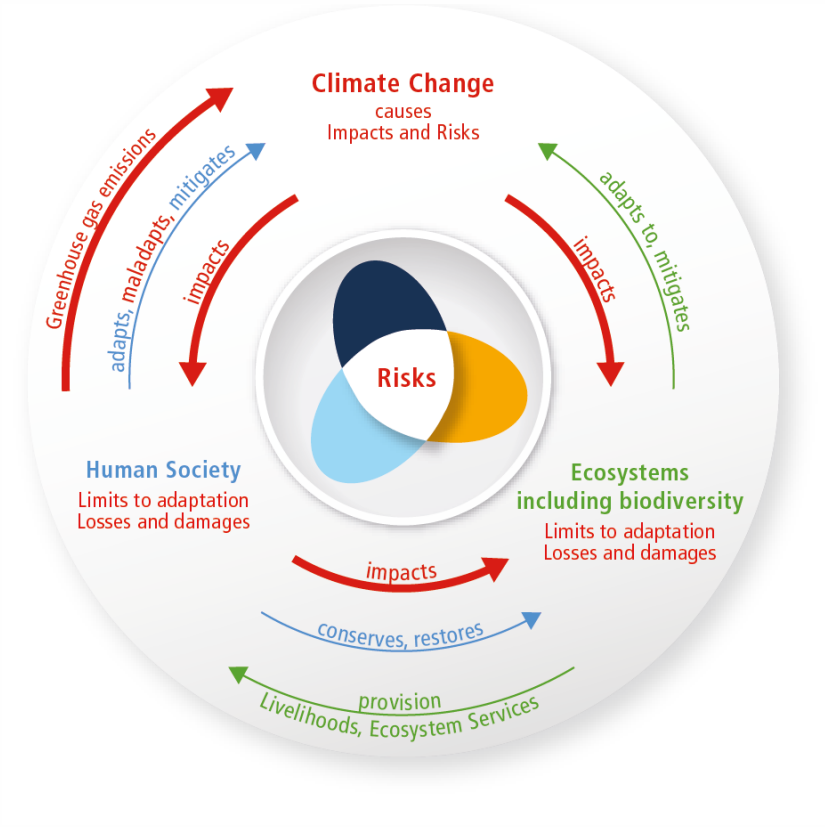
The Green Swan: Central Banking and Financial Stability in the Age of Climate Change

Outline

- Climate Risks
- Impacts of Climate Risks
- Physical Risks
- Transition Risks

Climate Risks

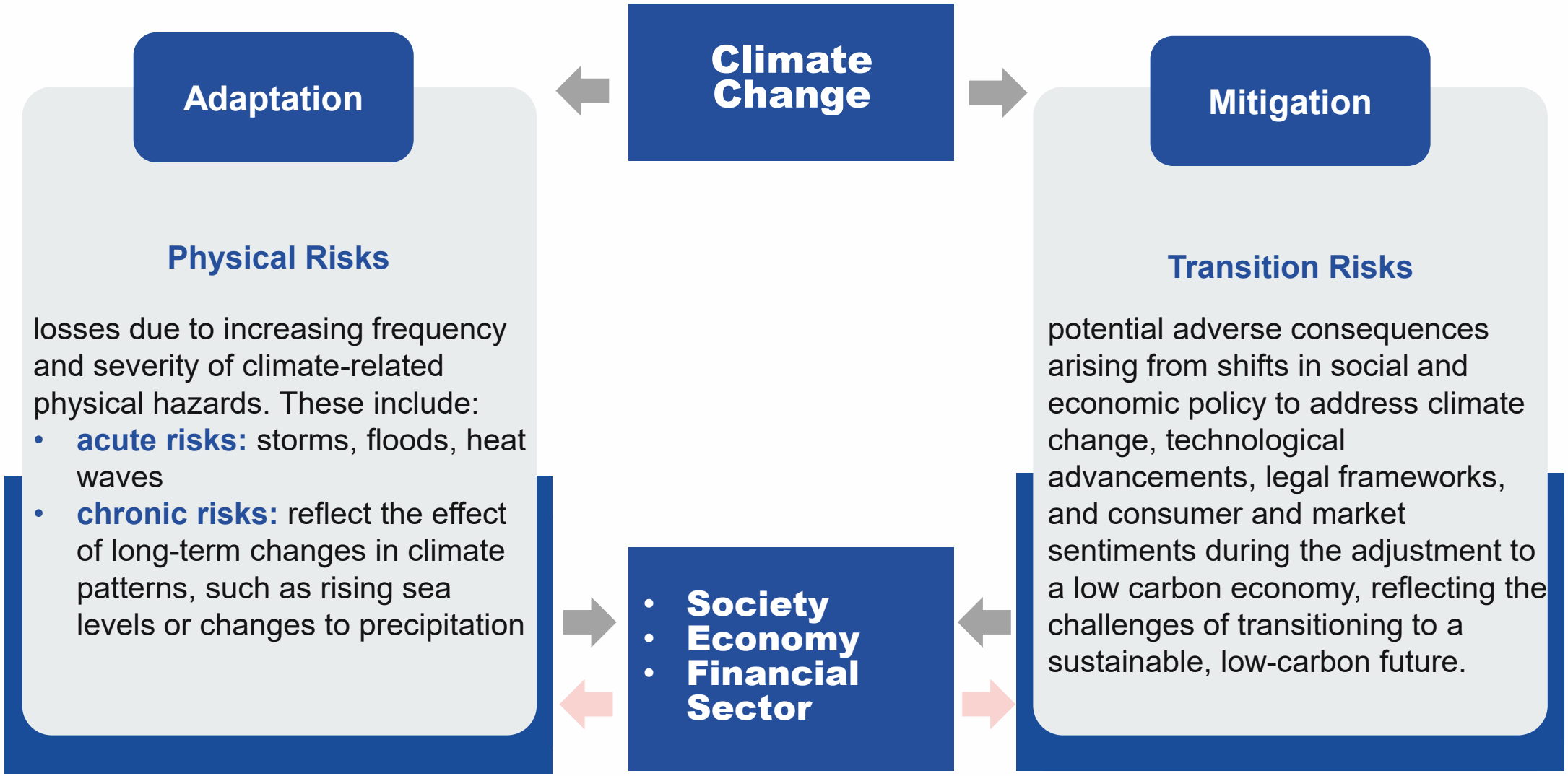
Climate Risk: What is it and what is it NOT?



Source: https://www.ipcc.ch/

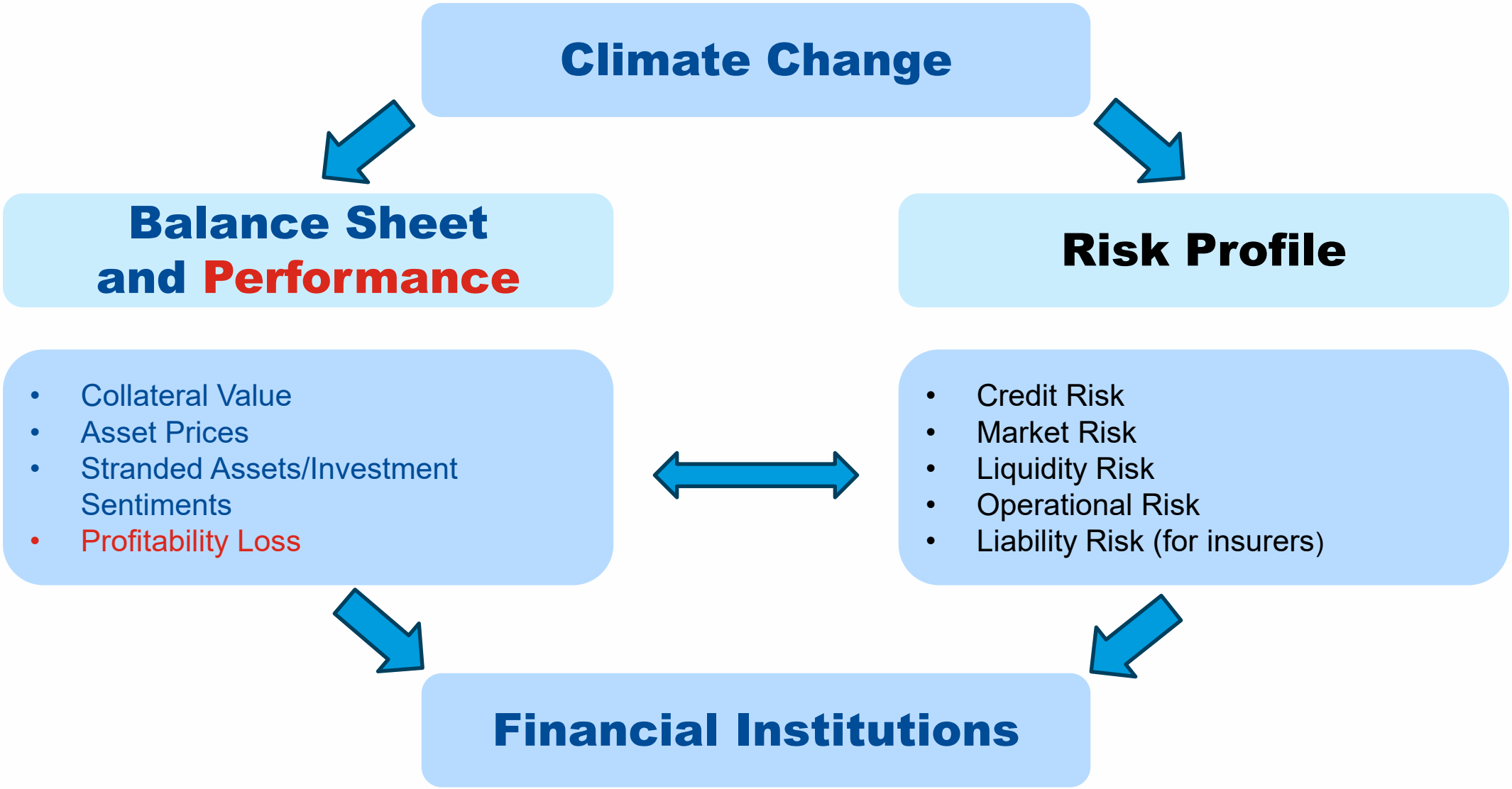
- According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), ***risk* is the potential for adverse consequences**.
- In the context of **climate change *impacts***, risks result from dynamic interactions between **climate-related hazards with the exposure and vulnerability to the hazards** (~ "physical risk").
  - **Hazard:** The potential occurrence of a physical event or trend.
  - **Exposure:** The presence in places and settings that could be adversely affected.
  - **Vulnerability:** The propensity or predisposition to be adversely affected.
- The IPCC revised **definition of risk clarifies and refines** previous definitions.
  - The "core" definition of *risk* is **"the *potential* for adverse consequences" – not only physical hazards.**
  - Risk should be used where **potential adverse consequences and the uncertainty** relating to those consequences are explicitly considered.
  - And to improve the ability for decision-makers to **understand and manage risk**.

Climate Risks: Physical and Transition Risks



Impacts of Climate Risks

Climate Change and Financial Institutions: Impact Channels



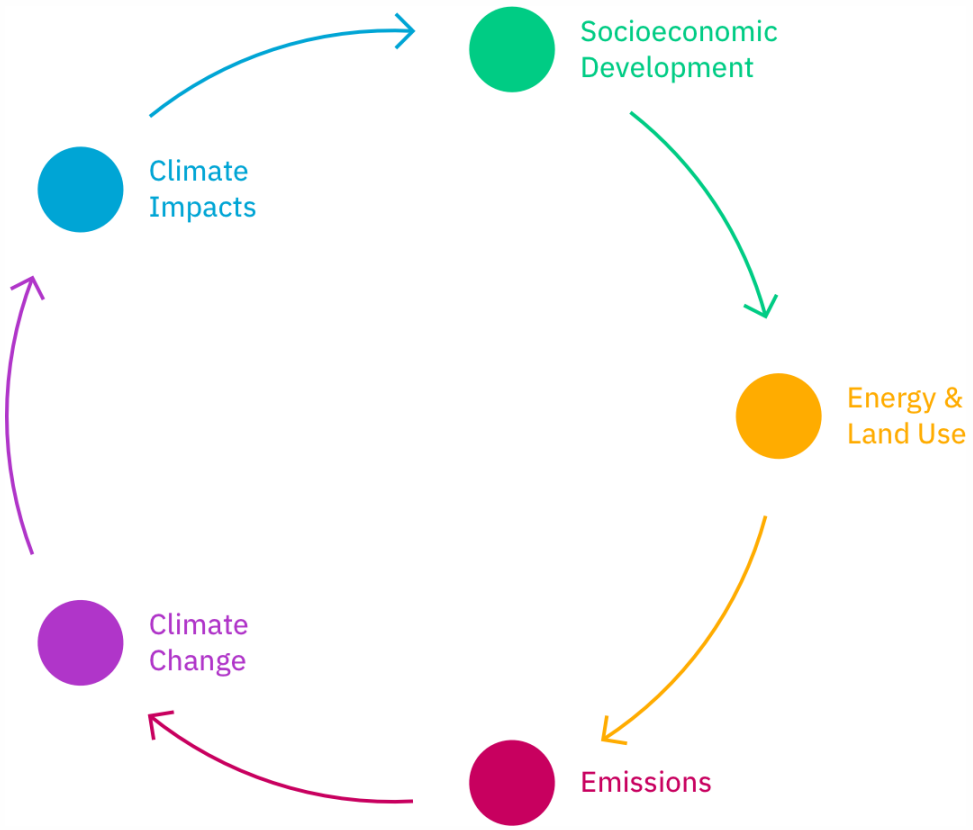
Interaction of Climate Risks with Financial Risks: Examples

Risks	Credit	Market	Operational
Transition	- Lower valuation of assets and collaterals; - Impaired loan portfolio due to stranded assets; - Higher expected default by carbon-intensive sectors	- Higher energy and commodity prices; - Higher transaction costs due to weakened macroeconomic conditions	- Higher reputational risks by investing in carbon-intensive sectors
Physical	- Higher expected default by climate-vulnerable sectors such as agriculture and tourism; - Lower valuation of properties in coastal areas due to increased risk of coastal erosion and coastal flooding	- Downgrade of credit ratings of borrowers including sovereigns due to extreme weather events	- Relocation of headquarters and data centers

What to do?

Minimizing the adverse impacts of Climate Change on the economy and the financial sector requires a *forward-looking risk assessment framework.*

What are Climate Change Scenarios? (I)

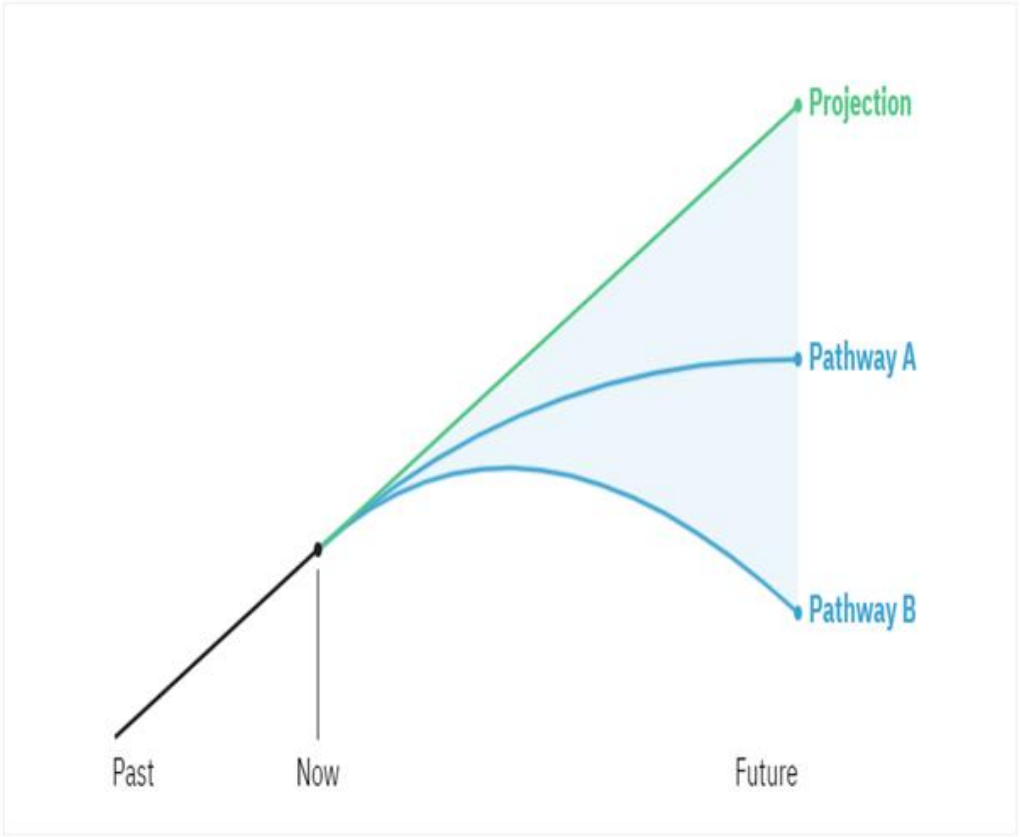


Source: https://climatescenarios.org/primer

- Climate change scenarios are not about predicting the future, but come in the form of **projections of what can happen or pathways of how to reach certain goals**.
- **Socioeconomics and climate change are inseparably intertwined.**
  - Socioeconomics define for example our land and energy needs,
  - which are closely linked to emissions.
  - Increased emissions lead to higher GHG concentrations,
  - which leads to climate change and its impacts.
  - Climate impacts close the cycle as they will also influence our socioeconomics.

What are Climate Change Scenarios? (II)

Figure: Forward Looking Projections and Pathways



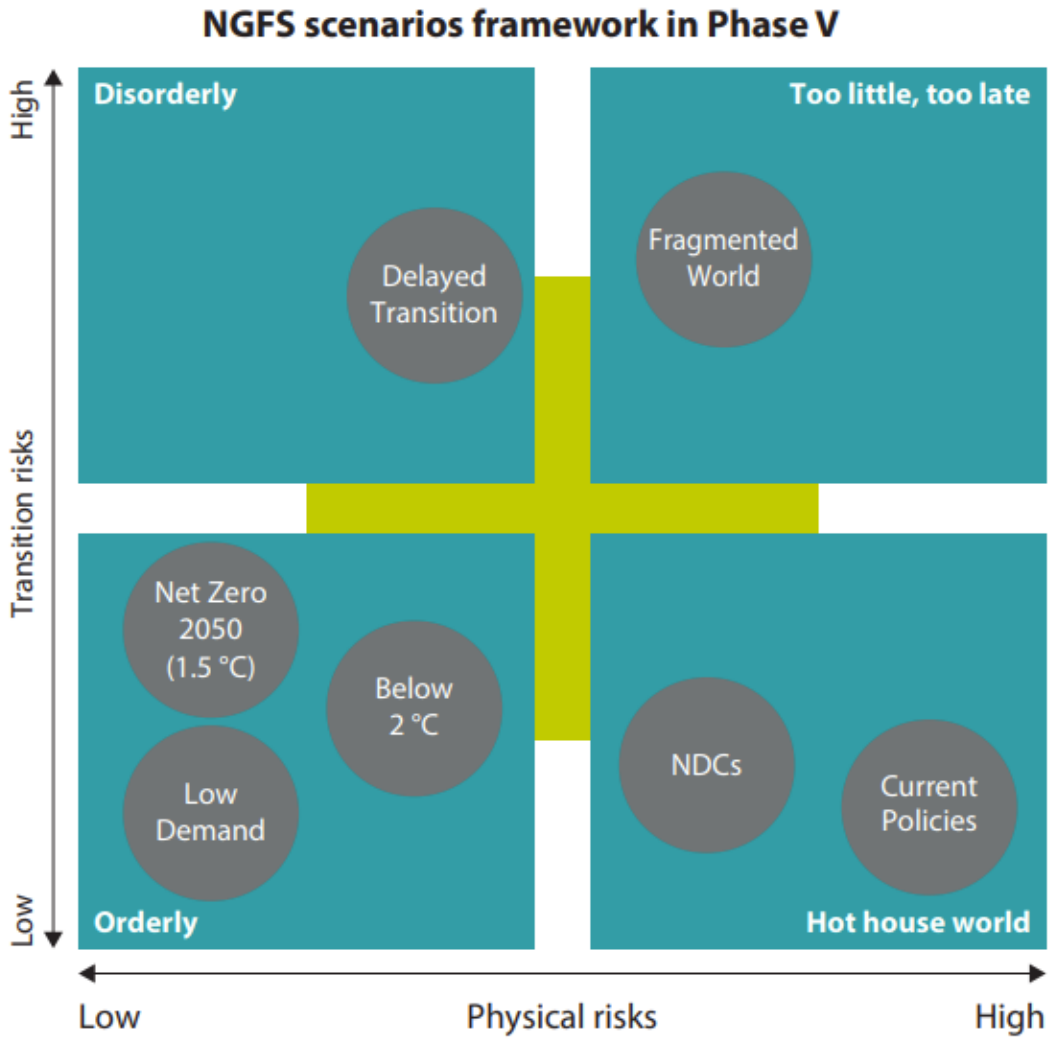
Source: https://climatescenarios.org/primer

The distinct nature of climate risks poses a challenge to **standard risk assessment approaches,** in that they are:

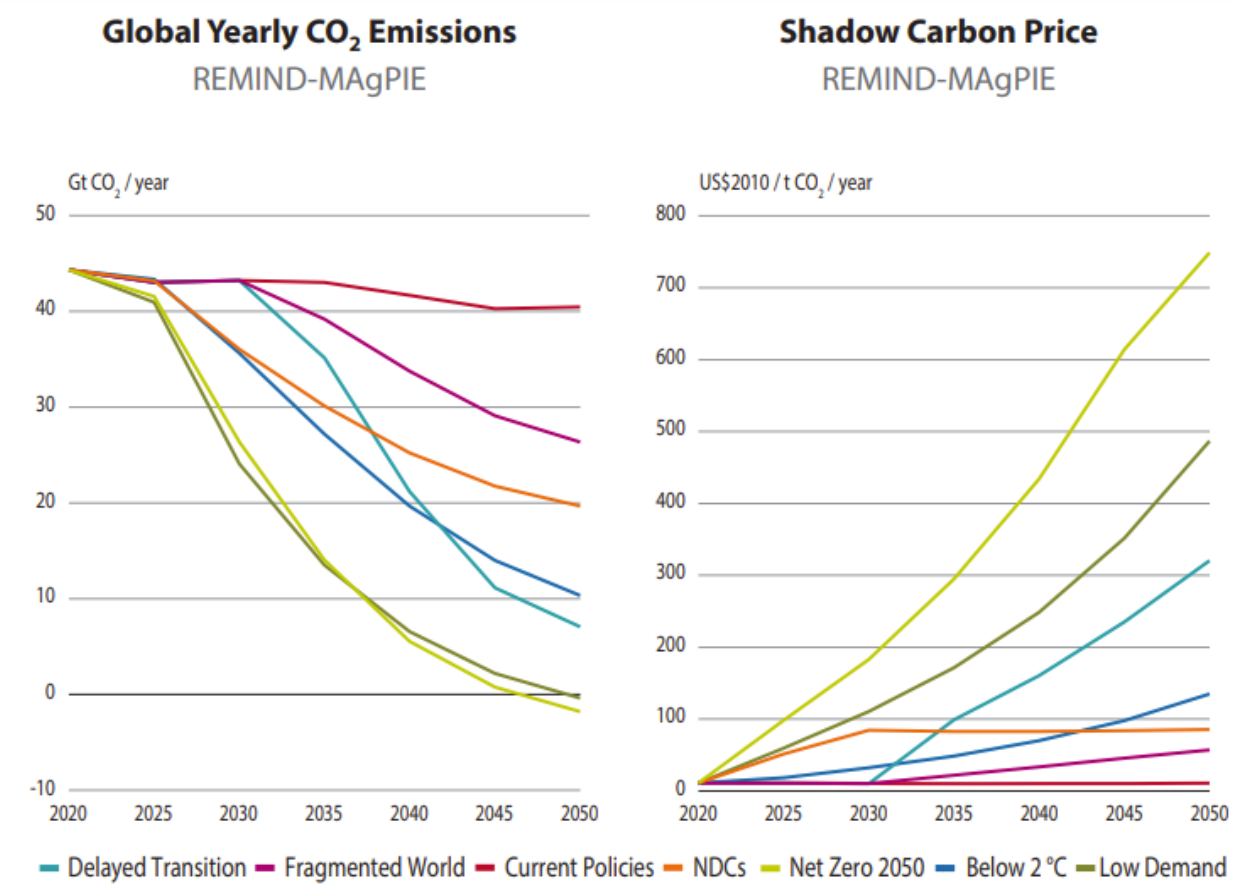
- **long time horizons with high uncertainty** about how policy and socioeconomic factors might evolve;
- **global and economy-wide** in nature; and
- complex, **varying from region to region and sector to sector**.

These **distinct characteristics are not captured** by risk assessment approaches that rely on top-down modeling and historical trends, are narrowly focused, and assume the structure of the economy and financial system remain unchanged.

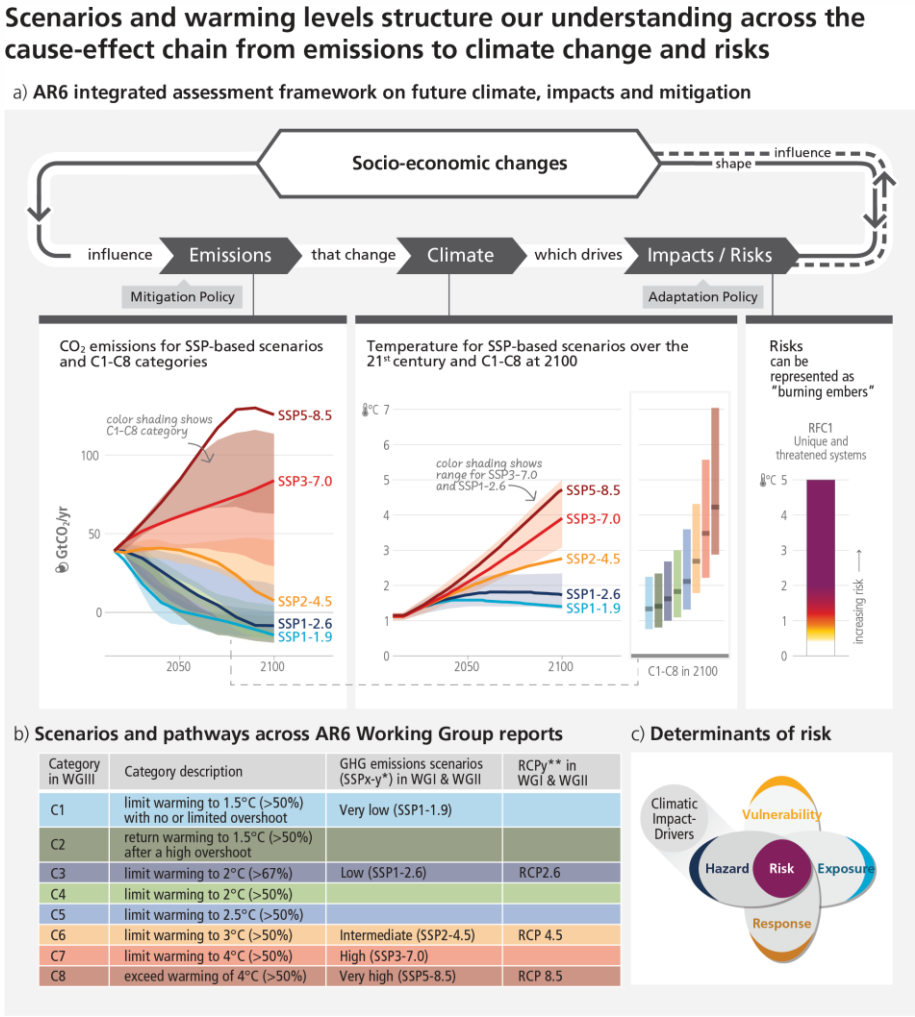
Climate scenarios



Scenario Analysis: NGFS Scenarios



Source: NGFS



Category in WGIII	Category description	GHG emissions scenarios (SSPx-y*) in WGI & WGII	RCPy** in WGI & WGII
C1	limit warming to 1.5°C (>50%) with no or limited overshoot	Very low (SSP1-1.9)	
C2	return warming to 1.5°C (>50%) after a high overshoot		
C3	limit warming to 2°C (>67%)	Low (SSP1-2.6)	RCP2.6
C4	limit warming to 2°C (>50%)		
C5	limit warming to 2.5°C (>50%)		
C6	limit warming to 3°C (>50%)	Intermediate (SSP2-4.5)	RCP 4.5
C7	limit warming to 4°C (>50%)	High (SSP3-7.0)	
C8	exceed warming of 4°C (>50%)	Very high (SSP5-8.5)	RCP 8.5

- Every climate scenario entails a unique array of assumptions (encompassing variables like CO2 emissions, policy ambition, policy responses, and others), covering a wide range of transition risk levels from low to high.

FSAP Climate Risk Analysis Framework

Stage 1
Climate risk diagnostics

Stage 2
Climate scenarios design

Stage 3
Bank stability assessment

C
R
A
M

Physical Risk Scenarios Transition Risk Scenarios

NEW: Climate Module

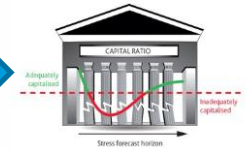
- High data granularity--geography of physical hazards and sectoral impact of carbon tax

Macro approach

Macro (& sectoral) scenario

Risk factors

Bank solvency stress test

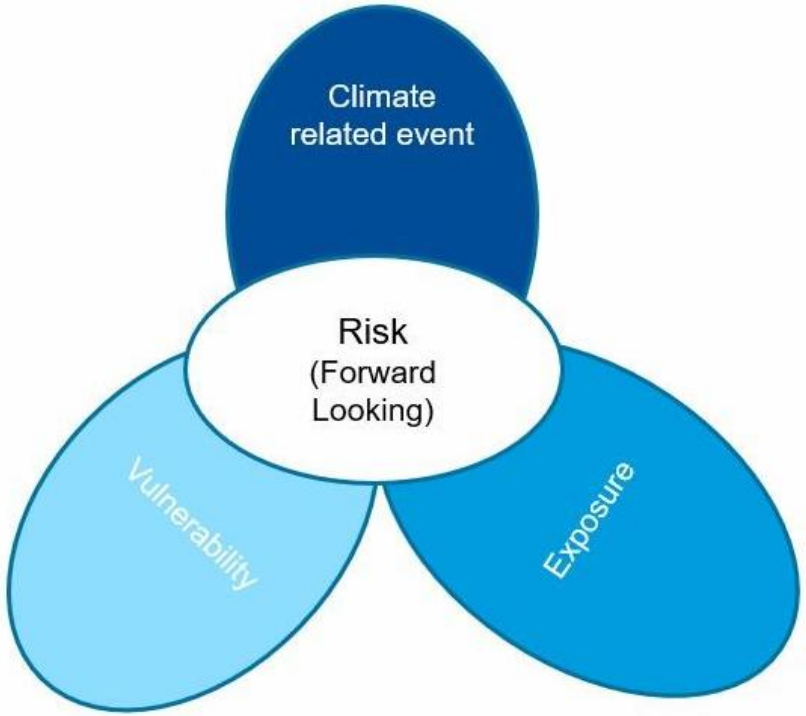


Corporate & household sensitivity analysis or stress test

Micro approach

Physical Risks

Physical Risk



Physical Risk refers to the physical impact of climate change. It affects the economy in two ways.

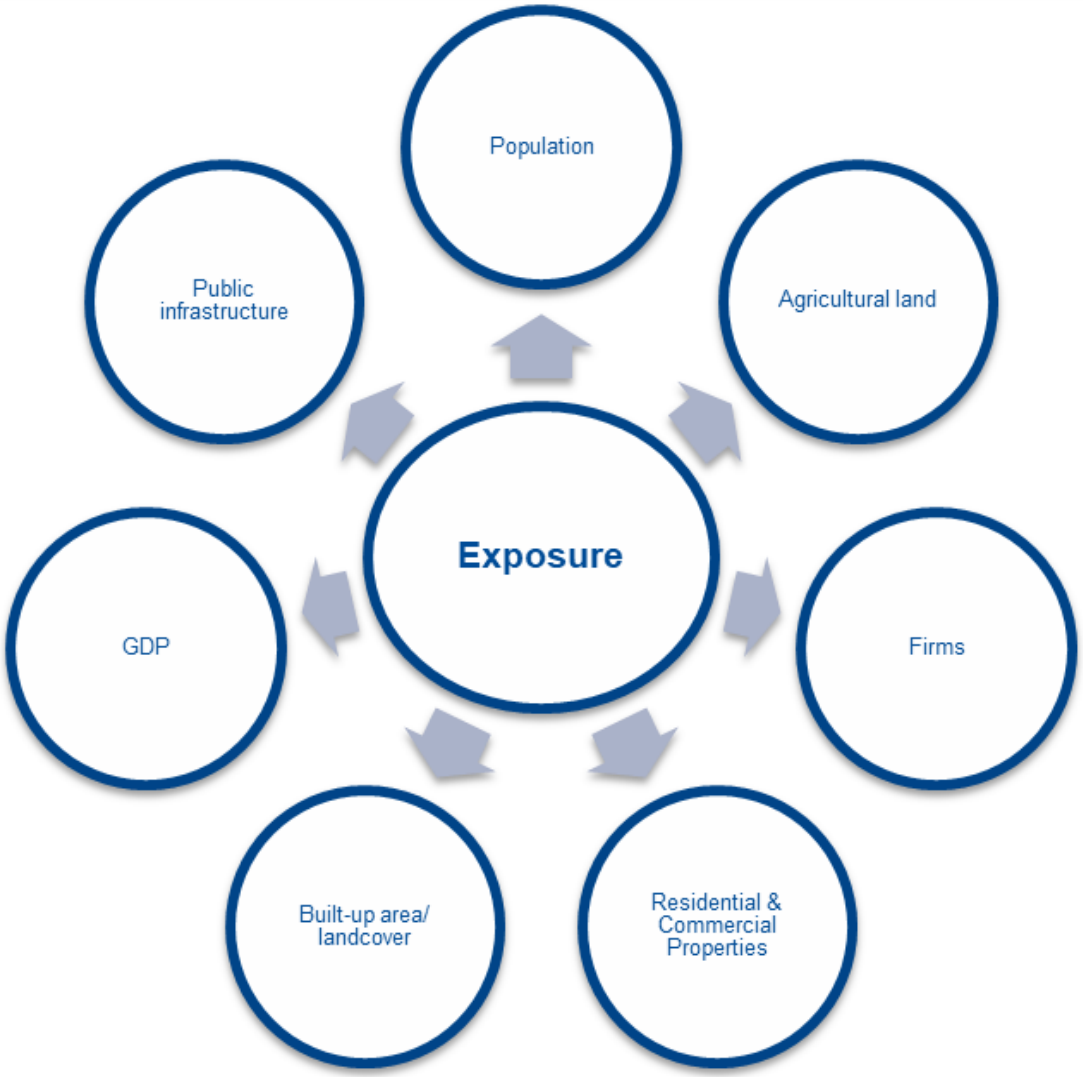
- **Acute impacts** from extreme weather events (such as storms, floods, heat waves etc.) can lead to business disruption and damages to property.
  - There is evidence that increased warming could also lead to persistent longer-term impacts.
  - These events can increase underwriting risks for insurers and impair asset values.
- **Chronic impacts**, particularly from increased temperatures, sea levels rise, and precipitation, may affect labor, capital, land, and natural capital in specific areas.
- In much of the business and financial literature, the term “physical risk” relates to those derived from the **hazard × exposure × vulnerability framework**.

Climate-related event: the potential occurrence of climate-related physical or transition related events or trends that may cause loss and damage.

Exposures: the presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Vulnerability: the propensity or predisposition to be adversely affected and encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Exposure Data



- "Reduce the number of affected people globally"
  - **Projections of urban, rural, and total population** consistent with the SSPs(*) at 30 arcseconds resolution; Jones and O'Neill (2016), and Gao (2017).
  - But people can flee from hazards, even at short notice if given an early warning.

"Reduce direct economic loss in relation to GDP"

- **Projections of GDP** consistent with the SSPs at 5 arcminutes resolution; Murakami et al. (2021).
- GDP proxies capital stocks, but capital-output ratios are not standardized.

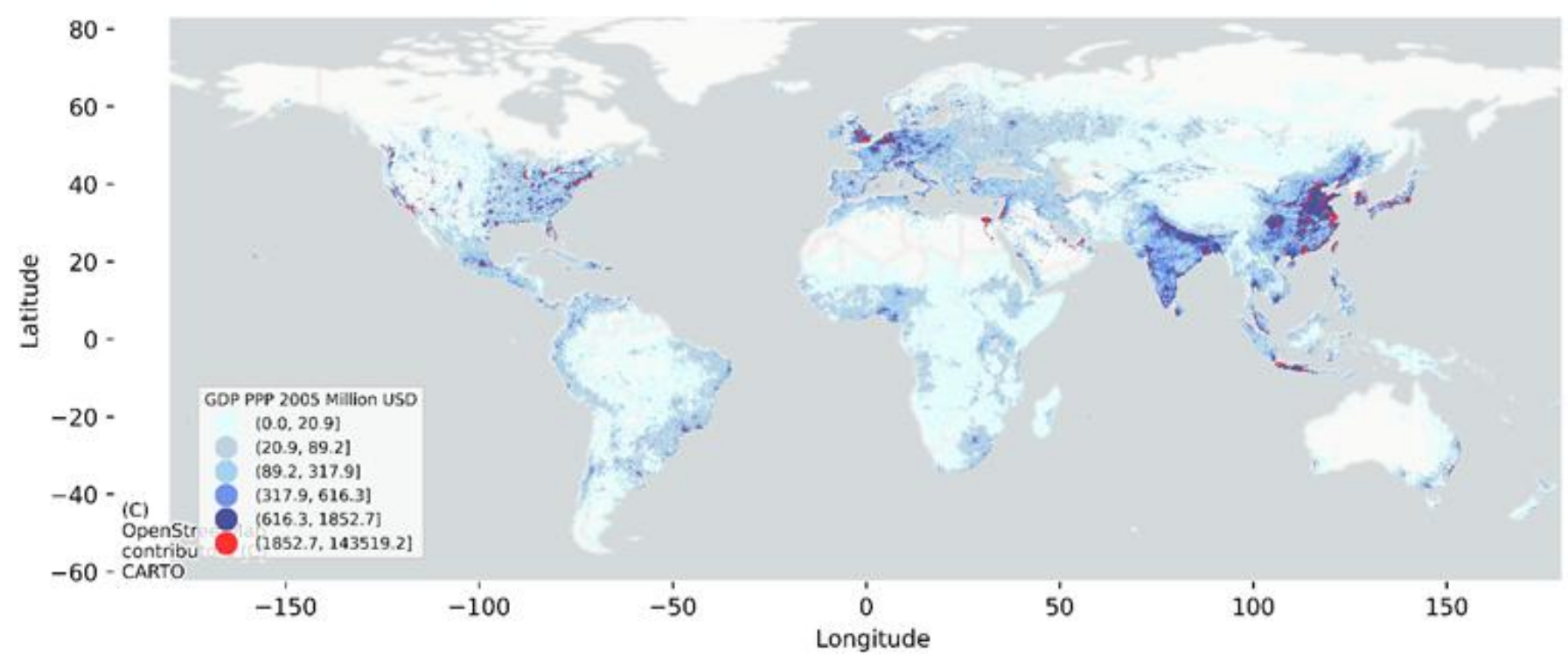
"Reduce disaster damages to critical infrastructure and disruption of basic services"

- **Projections of urban (and rural) land** consistent with the SSPs at 30 arcseconds resolution; Gao and O'Neill (2020), and Gao and Pesaresi (2021).
- Urban land proxies built-up area, rural land proxies agriculture and forestry land.

(*) SSPs = Shared Socioeconomic Pathways.

Exposures – An example

- Murakami et al., (2021) - downscaled GDP projections under all five SSPs at 5 arcminutes for 2010-2100 (10-years intervals).



Source: Murakami D, Yoshida T and Yamagata Y (2021) “Gridded GDP Projections Compatible With the Five SSPs (Shared Socioeconomic Pathways)”. Gridded GDP under SSP2 in 2040. GDP has been grouped by the following percentiles [0, 50, 75, 90, 95, 99, 100].

Hazard data and tools (public)

- Available publicly available risk and hazard data platforms. Most use same underlying hazard data sets and models but may provide different aggregations for the end-user. Example:

  - **INFORM** (flood, cyclone, storm, drought)
    - No future projections
    - Country and subnational level
    - [Source: EC-JRC]

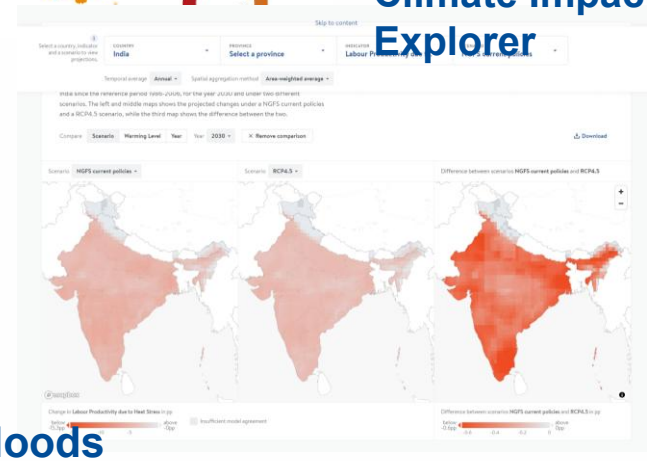
  - **Climate impact explorer** (flood, wildfire, heatwave)
    - RCP projections
    - Country+ gridded
    - [Source: NGFS+Potsdam Institute for Climate Impact Research+ETH Zürich]

  - **Aqueduct Floods** (floods)
    - SSPs and RCPs
    - [Source: WRI, Aqueduct floods]

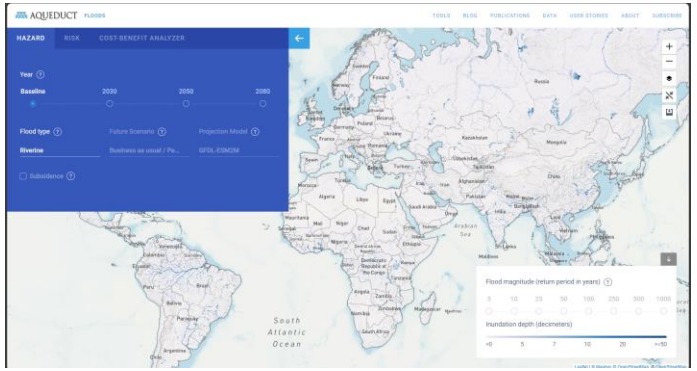
  - **Others**: Notre Dame GAIN Index, ThinkHazard!, FAO, World Bank CCKP

INFORM

Climate Impact Explorer

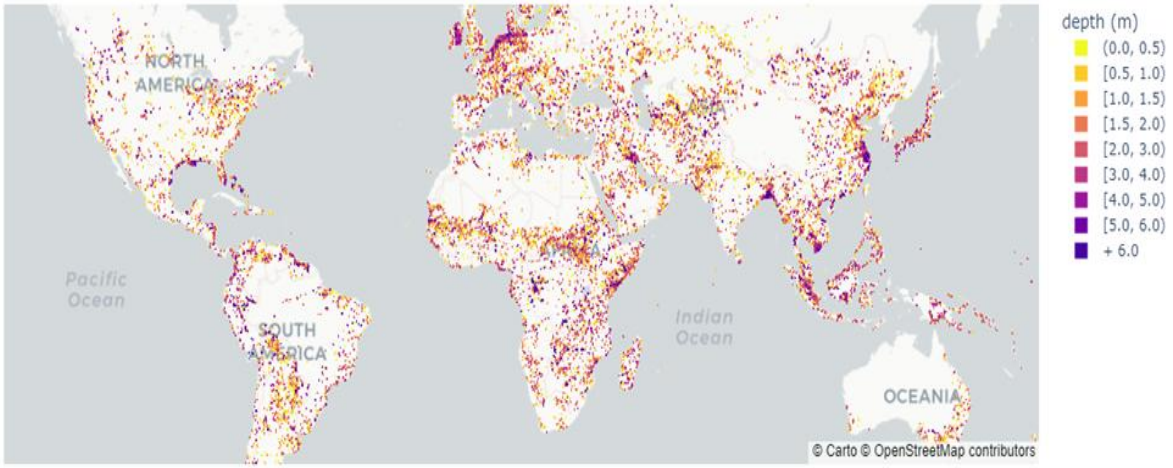


Aqueduct Floods



Hazards Data: Floods and TCs

- **Floods (river and coastal) depth and fraction flooded by return periods**.



Note: Jupiter flood depth: mean depth meters for 1-in-500 year in 2040 under SSP2 RCP 4.5 (only positive values are reported).

- **Maximum 1-minute sustained wind speed at 10 meters above ground level by return period**.

Note: Grids that consider tropical cyclones simulations in wind parameter estimates from Jupiter.

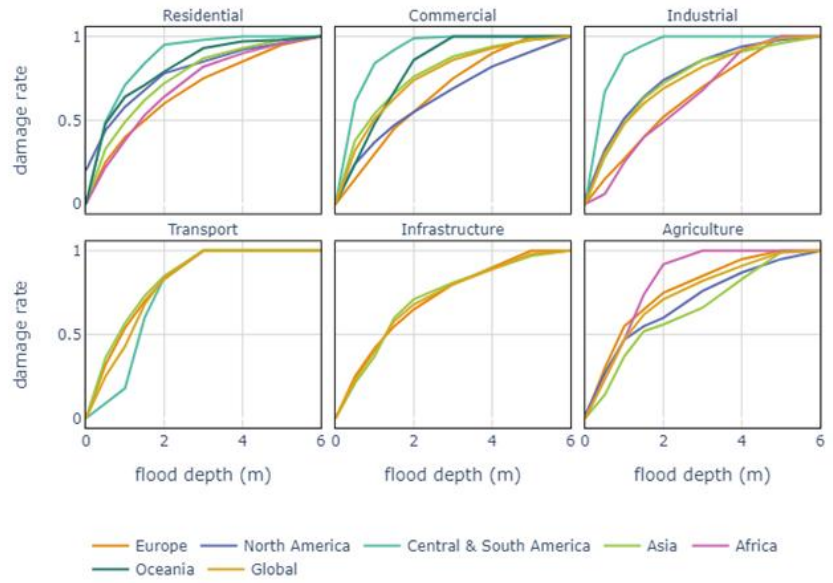
Vulnerability data

- Vulnerability information (damage function) and resources vary by peril, sectors, and region of interest.
- Examples of global vulnerability data:
  - **Tropical cyclone**: the functions of Eberenz et al. (2021) combines wind speed to **property damage**. Calibrated for different regions, recognizing differences in building vulnerabilities across the globe.
  - **Flood**: the European Commission Joint Research Centre's flood depth-damage functions relate flood depth to damage per asset or land use class.
  - **Drought**: FAOSTAT vulnerability of agricultural capital stock.

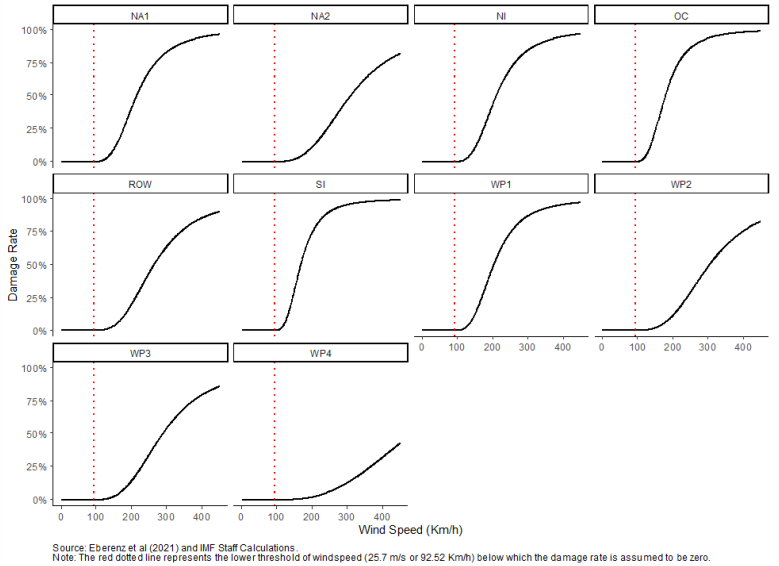
- Given the sensitivity of catastrophe risk models to vulnerability functions, it is critical that selected vulnerability curves are appropriate for the **specific country context**, and that they are adjusted if required.
- Often not available at a global scale.

Vulnerability: Floods and TCs damage functions – Implementation Example

- Huizinga, de Moel, and Szewczyk (2017)
- For each GDP grid: Divide the exposure into built-up and non-built-up based on Copernicus Global Land Operations "Vegetation and Energy" (CGLOPS-1).
  - For built-up areas: Combine the residential, commercial, and industrial damage functions, by equally weighting.
  - For non-built-up areas: Consider agriculture and infrastructure damage functions.



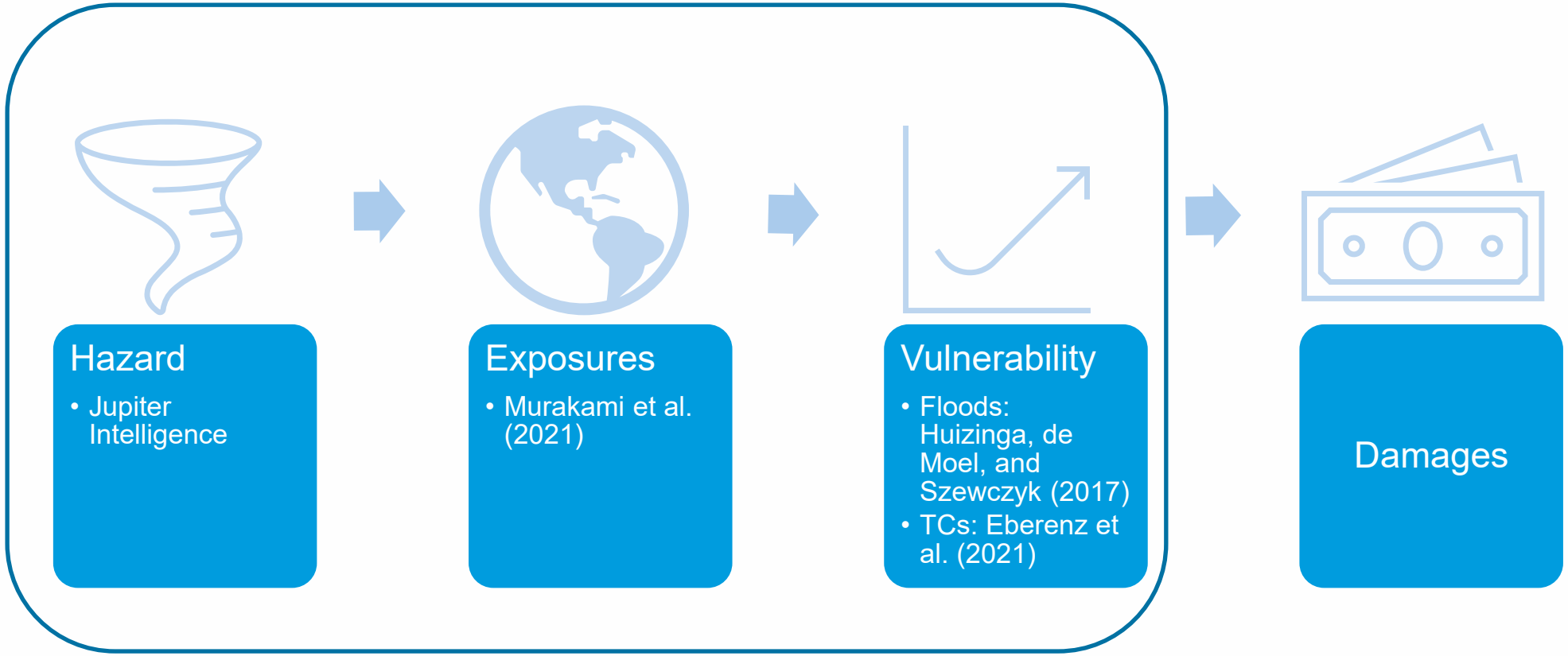
- Eberenz et al. (2021)
- Regionally calibrated damage functions (sigmoidal).
- No directly wind-induced damage is expected for low wind speeds.
- Calibration for countries in a region.



Source: Eberenz et al (2021) and IMF Staff Calculations.
Note: The red dotted line represents the lower threshold of windspeed (25.7 m/s or 92.52 Km/h) below which the damage rate is assumed to be zero.

A Multi-Country Study of Forward-Looking Economic Losses from Floods and Tropical Cyclones

Economic losses due to physical risk: The interaction of Hazard, Exposure and Vulnerability



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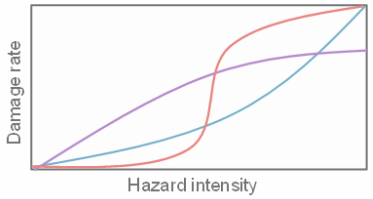
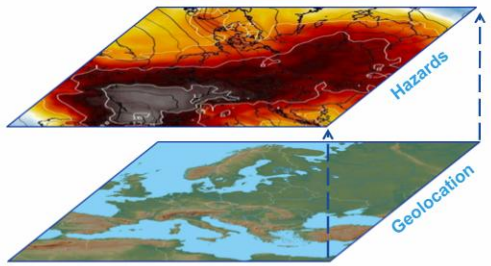
Forward looking damages



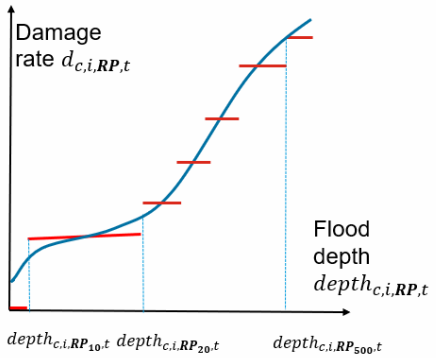
Damage rate
(location level)

- Damage functions by regions
- Geolocational hazards data (by location and return period)

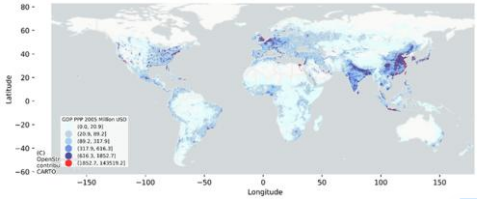


Expected damage rate
(location level)

- Calculate expected annual damage rate based on the damage rates by return period



Gridded GDP



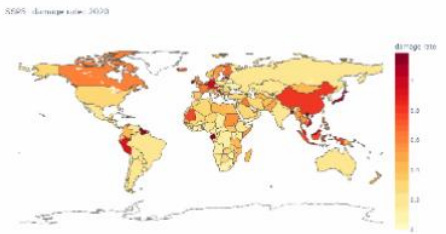
Aggregation
(country level)

- Aggregate locations damage rates at the country level by linking to GDP exposure

Analysis

- Country level damage rate
- Absolute change
- Relative change

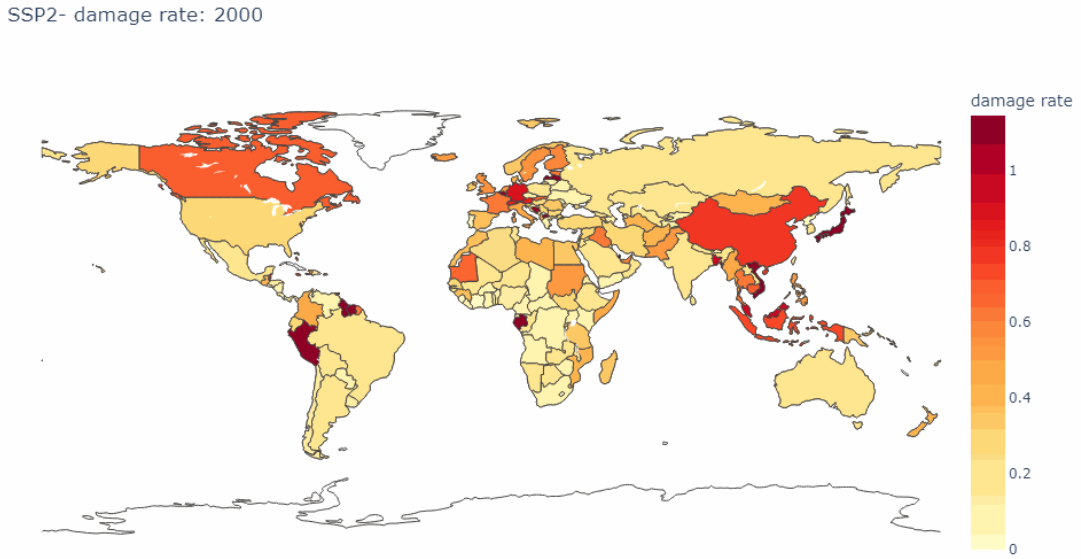
Country damage rates



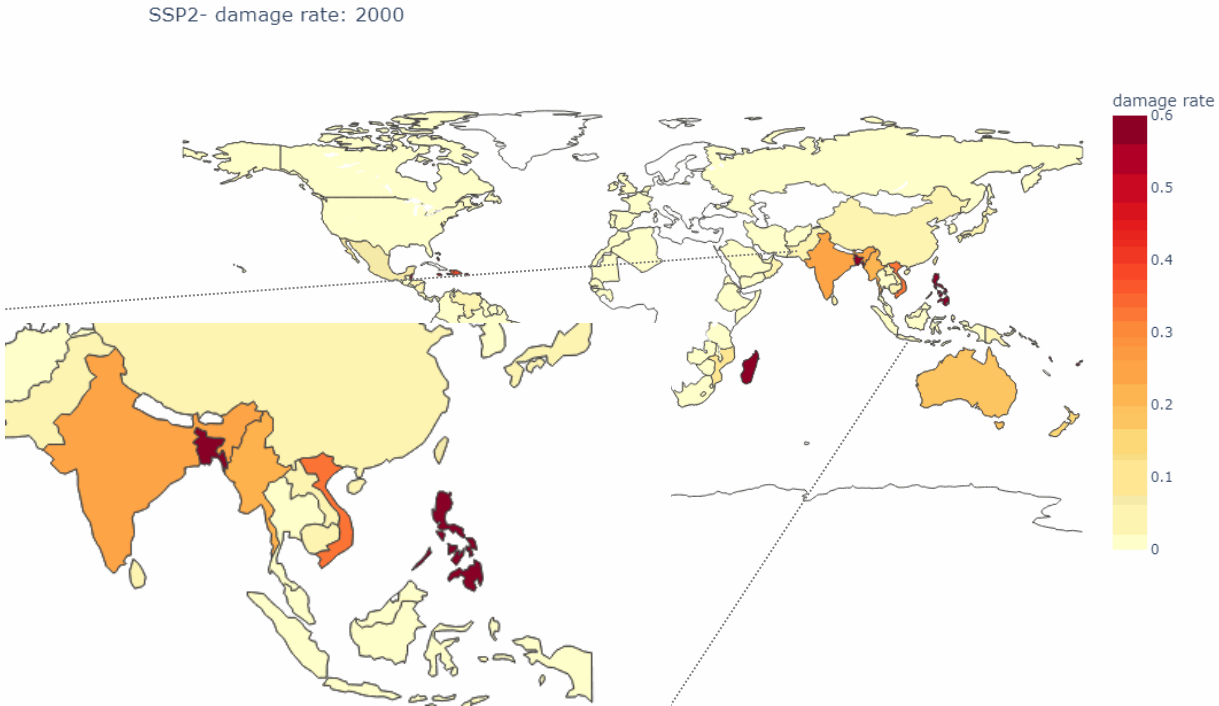
Damage rates: SSP2

- Among the largest projected damage rates for flood are found in: South America (GUY), Africa (GAB), and East Asia (BGD, VNM, JPN).
- For Tropical Cyclones, the largest damage rates are in the Caribbean (BHS, BRB), South and Southeast Asia (BGD, MMR, VNM, PHL), Eastern Africa (MDG, MUS, COM), and Oceania (FJI, VUT).

Damage rate SSP2, 2000-2100
(%) Percentage



Damage rate SSP2, 2000-2100
(%) Percentage



Source: IMF staff calculations

Transition Risks

Transition Risk and its Importance

- **Transition risk** – Risk on the financial sector and the economy due to changes in climate policy, technological advances, legal framework, and consumer and market sentiment while transitioning to a lower carbon future.

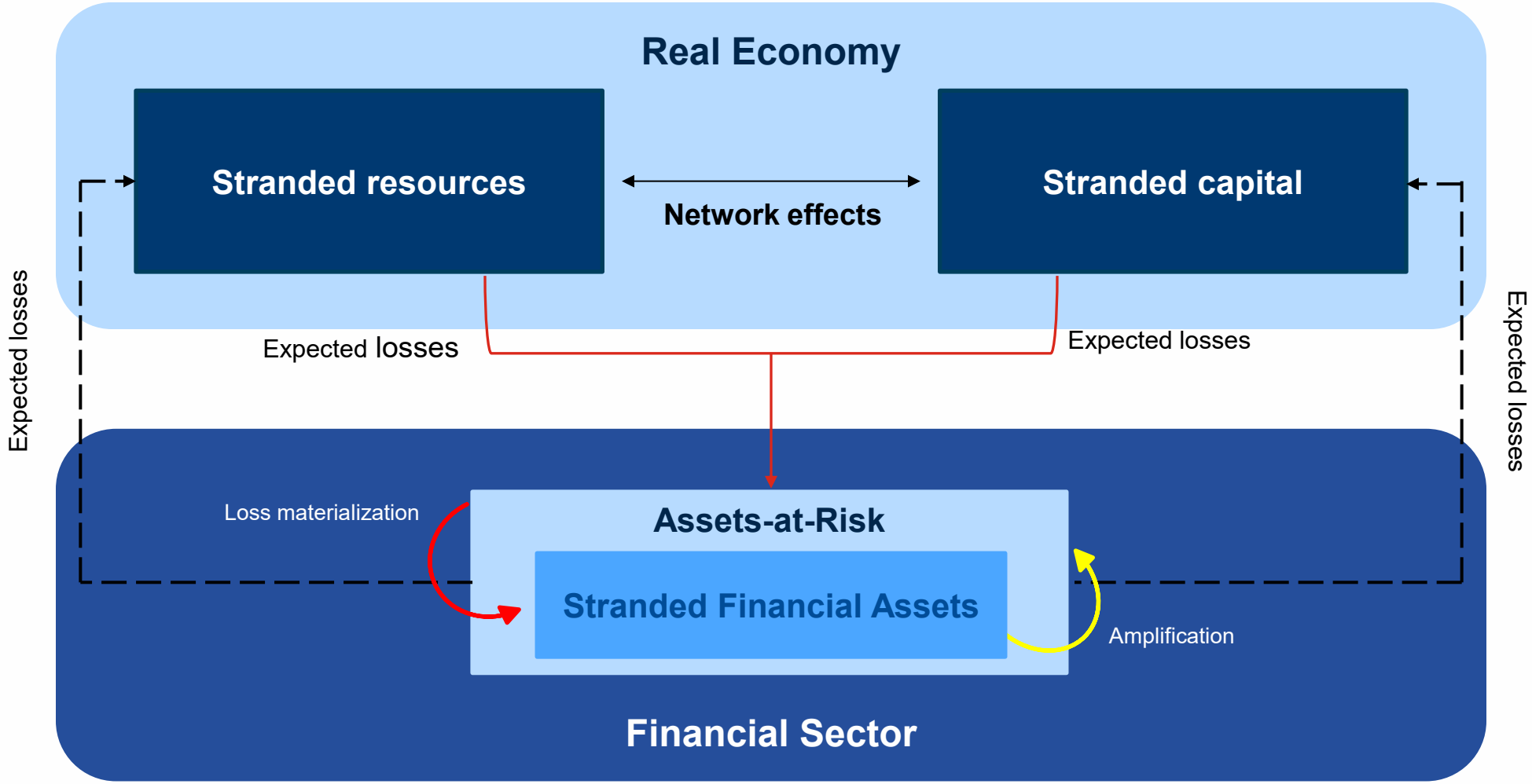
- These can include;
  - higher energy costs from **carbon taxation** or **emissions cap schemes** or **subsidies**;
  - reduction in the market value of emission-intensive assets (also known as **stranded assets**);
  - expenses for research and development of **green technologies**;
  - and **regulatory and reporting** requirements (BIS, 2021a).

- Transition risk can manifest through **assets becoming stranded, loss of market access, reduced return on investments, job market implications, reputational damage, and potential financial distress**.

- Depending on the nature, speed, and focus of these changes, transition risks may pose **varying levels of economic and financial risks** to different sectors and economies

- For the financial sector, transition risk is a major concern—as the costs outlined above could lead to significant losses on financial assets, including loans and securities investments.

Mapping Transition Risk to the Financial Sector: Stranded Assets & Assets at Risk



Transition Risk and its Importance

IMF | MACROECONOMIC CLIMATE INDICATORS DASHBOARD

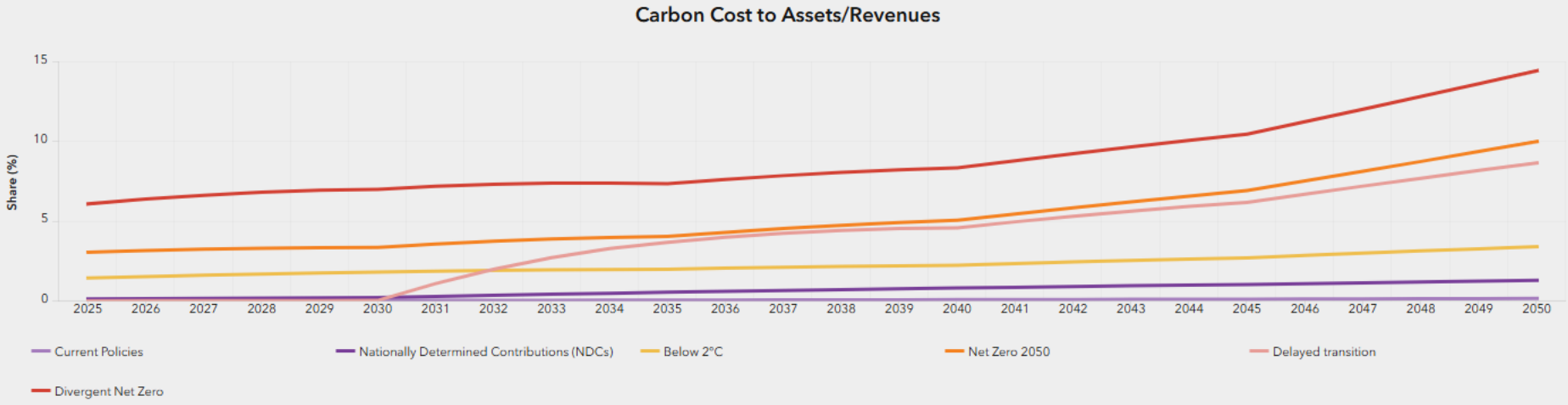
INDICATORS | COUNTRIES | ACCESS DATA | TOOLS | LEARN MORE

Transition Risk Indicators: Firms at Risk

Carbon Cost to Assets/Revenues in Disclosing Firms

Carbon taxes are one of the leading tools being considered to incentivize a transition to a low-carbon economy. Carbon Cost to Assets/Revenues indicator gives an indication of how high these taxes could be in comparison to revenues/assets of the disclosing firms along the transition to 2050 under six different Network for Greening the Financial System (NGFS) Phase 3 scenarios.

Indicator: Carbon Cost to Revenu... | Country/Region: Emerging and Developi... | Sector: All | Type of Emissions: Scope 1 | Assumption: Constant Assets/Revenues



Sources: ICE Data Services, Orbis (Bureau Van Dijk), Network for Greening the Financial System (NGFS); IMF staff calculations.

Thank you!

Financial Corporations Sector