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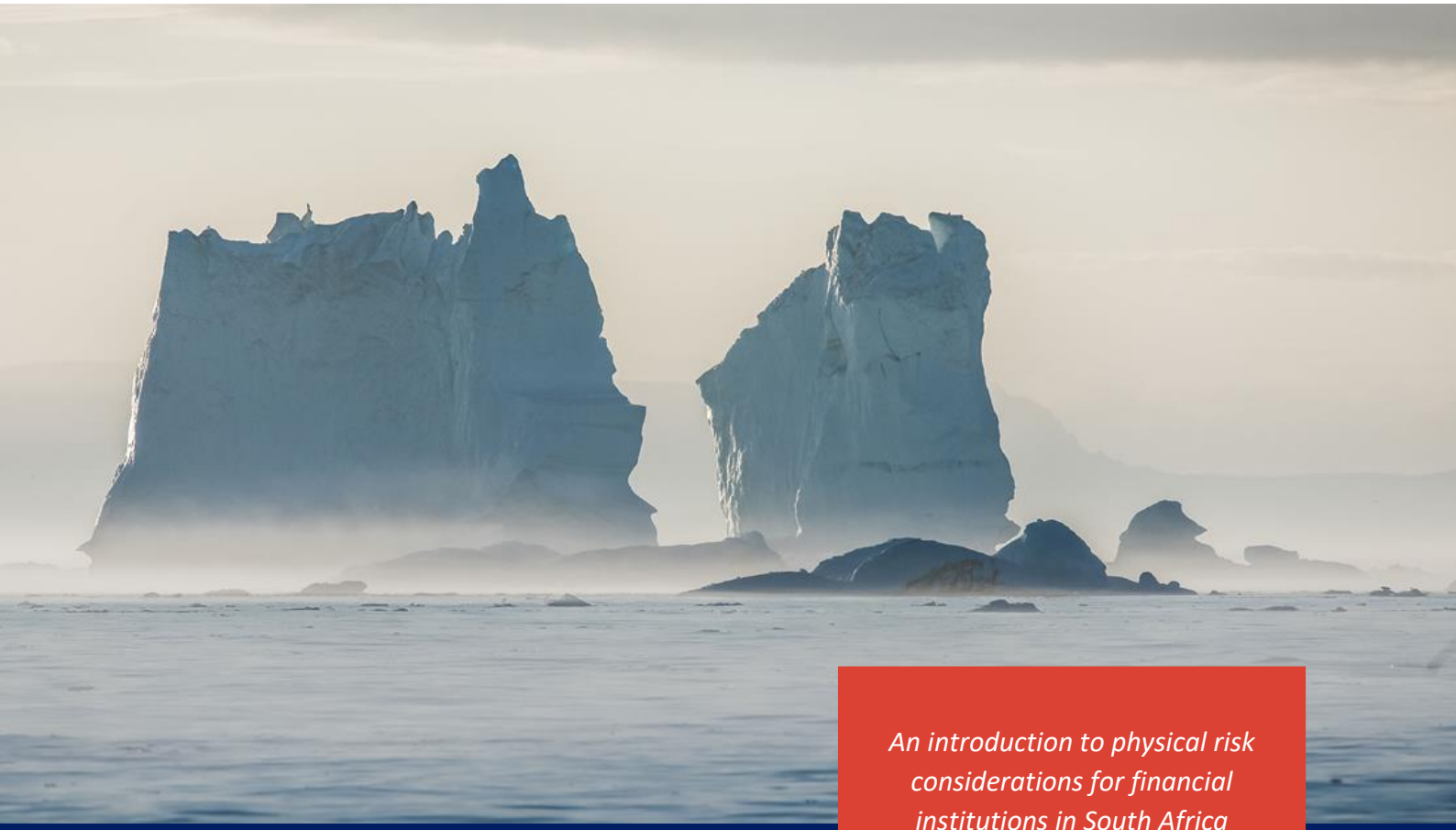

An introduction to physical risk considerations for financial institutions in South Africa

Physical Risk Assessment in TCFD Reporting

Vivid Economics

22/11/2021

Executive Summary

This report offers an introduction into the concept of physical risk and how it features in climate-related reporting for financial institutions.

Organisations are increasingly affected by the physical impacts of climate change, a trajectory which is likely to accelerate over the coming decades. Accordingly, financial markets are applying more pressure to assess and disclose the climate-related risks faced by companies and the financial implications of these risks. The Taskforce on Climate-Related Financial Disclosures (TCFD) has outlined a set of best-practice recommendations on reporting climate risks and opportunities, including both physical and non-physical factors associated with the transition to a low-carbon economy.

Financial institutions increasingly incorporate physical risk assessments into decision making, because climate change may affect future valuations of the companies in which they invest. Physical climate risks, which can be acute or chronic, impact on businesses and through multiple channels. These include, but are not limited to, disruptions to supply chains, asset damage or destruction, and impacts on human health, all of which can ultimately impact on the bottom line of businesses. These risks are of increasing concern to debt and equity holders, as not all hazards associated with climate change can be avoided through adaptive measures. The TCFD framework recommends that banks, asset owners and asset managers report on physical risk assessments at different time horizons and incorporate these assessments into future decision making.

The UN Intergovernmental Panel on Climate Change (IPCC) framework is the most widely used methodology for translating future projections of climate hazards into financial impacts. It is used by businesses, financial institutions, and governments to quantify physical risks at different time horizons. The framework conceptualises physical risk as function of the severity of climate hazards, vulnerability, and exposure. This report provides an introduction into how to use this, supported by a case study of its application in a South African context.

To assist users in conducting physical risk assessments, a list of data sources and assessment toolkits is provided. In addition, an initial assessment of data availability for analysis in the South African context is conducted. The intent of this section is not to provide an exhaustive list of available information, but to demonstrate that resources for physical risk assessment are freely available and to ease users into the process of assessing physical risk within their own organisations and portfolios.

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This document, and other outputs of the South Africa-UK PACT supported project: *Aligning South Africa's climate-related financial disclosure with global best practice* are available at: http://www.dnaeconomics.com/pages/sa_climate_disclosure/

1. Introduction to physical risk

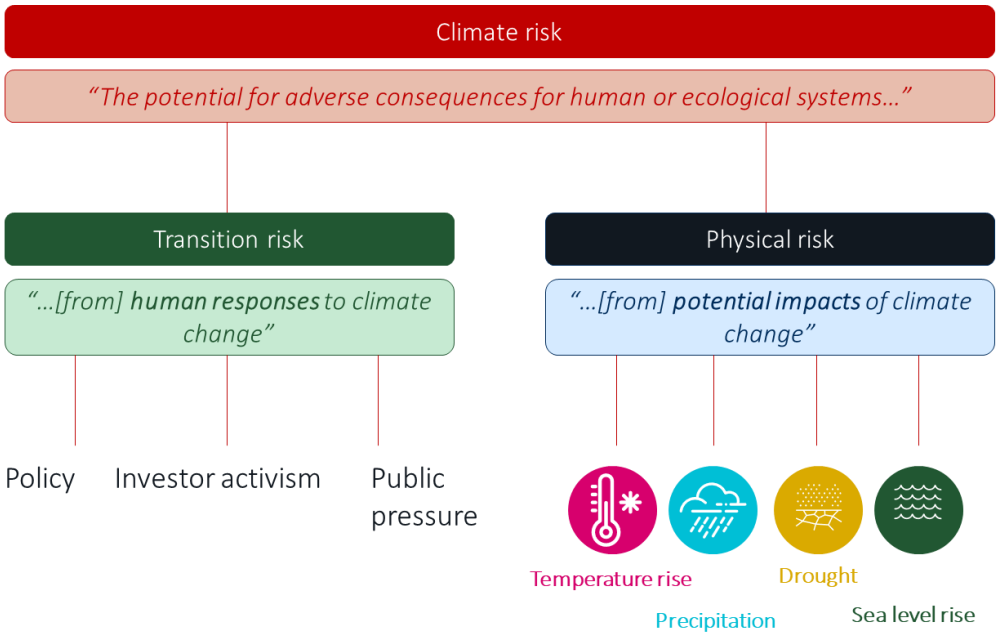
1.1. What is physical risk?

Companies and their investors are increasingly exposed to risks associated with climate change. The IPCC defines climate risk as follows:

> *"[Risk is] the potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from **potential impacts** of climate change as well as **human responses** to climate change. Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species."*[1]

While transition risk – the primary focus of this phase of the South Africa-UK PACT programme – arises from **human responses** to climate change (through policy action), physical risk relates to the **potential impacts** of climate hazards, as described above. The relationship between these two sources of risk is summarised in Figure 1.

Figure 1: Physical and transition risk



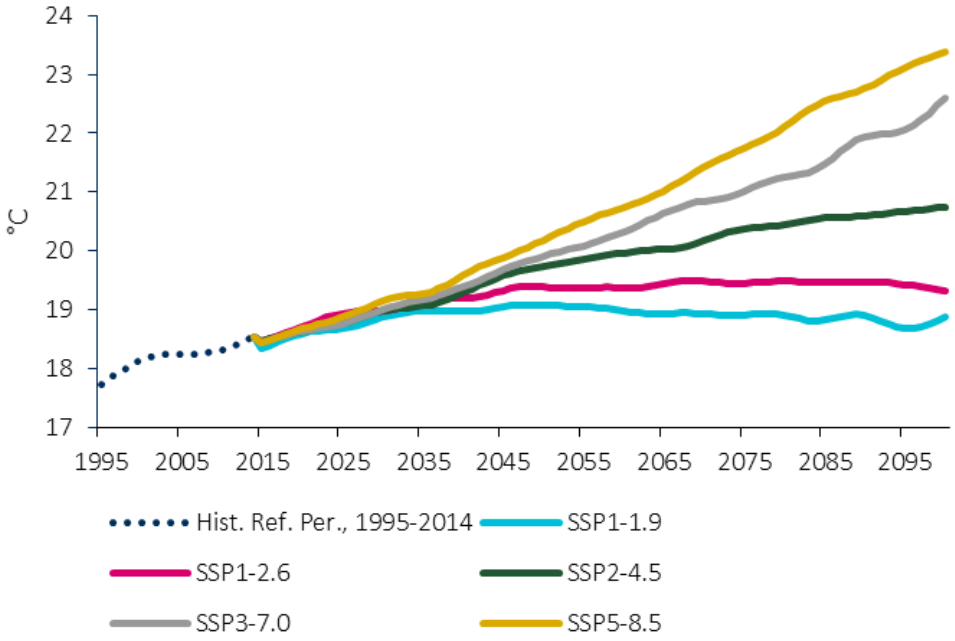
[1] IPCC (2021), The concept of risk in the IPCC Sixth Assessment Report: a summary of cross-Working Group discussions, https://www.ipcc.ch/site/assets/uploads/2021/02/Risk-guidance-FINAL_15Feb2021.pdf, last accessed 2021-11-19.

Source: Vivid Economics, based on IPCC (2021)

1.2. Why is South Africa affected by physical risk?

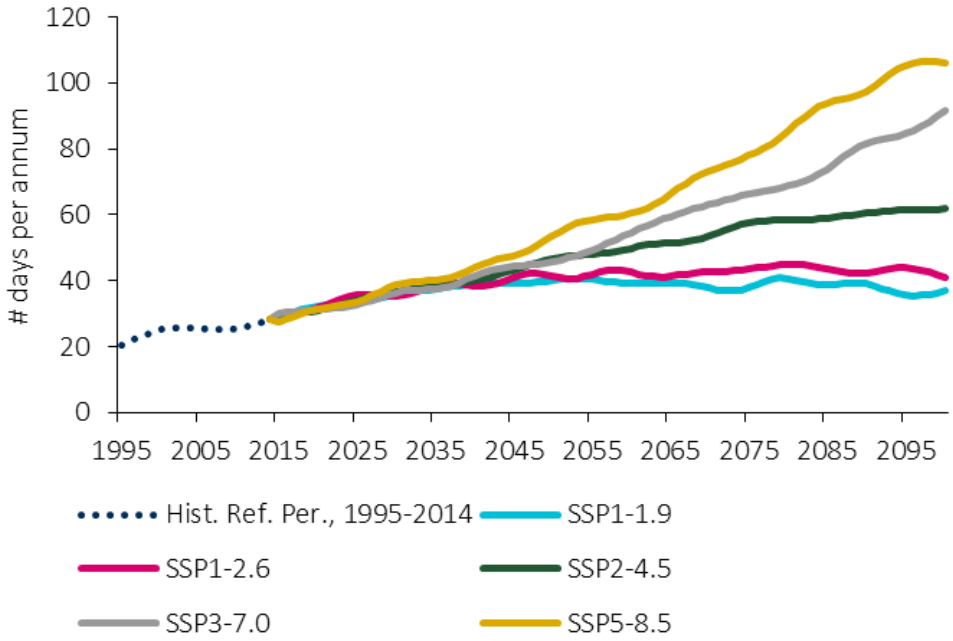
South Africa is highly exposed to the effects of rising temperatures and drought. According to the IPCC's shared socioeconomic pathways (SSPs), a basket of climate scenarios widely used in physical risk assessments, South Africa is likely to suffer a mean temperature increase of up to 5°C between 2014 and 2100, depending on the climate scenario considered. Figure 2 provides a range of possible temperature pathways implied by the SSPs, while Figure 3 shows that drought incidence is also likely to increase (proxied by days exceeding 35°C). It is important to recognise the figures below only show averages at the national level. Climate risks will differ between South Africa's regions, some of which may also experience irregular or extreme rainfall patterns, or consequences related to rising sea-levels along the coastline.

Figure 2: Temperature pathways for South Africa



Source: IPCC SSPs, sourced through World Bank Climate Change Knowledge Portal, https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-projections, last accessed 2021-11-19.

Figure 3: Incidence of drought, proxied by number of days with temperatures in excess of 35°C



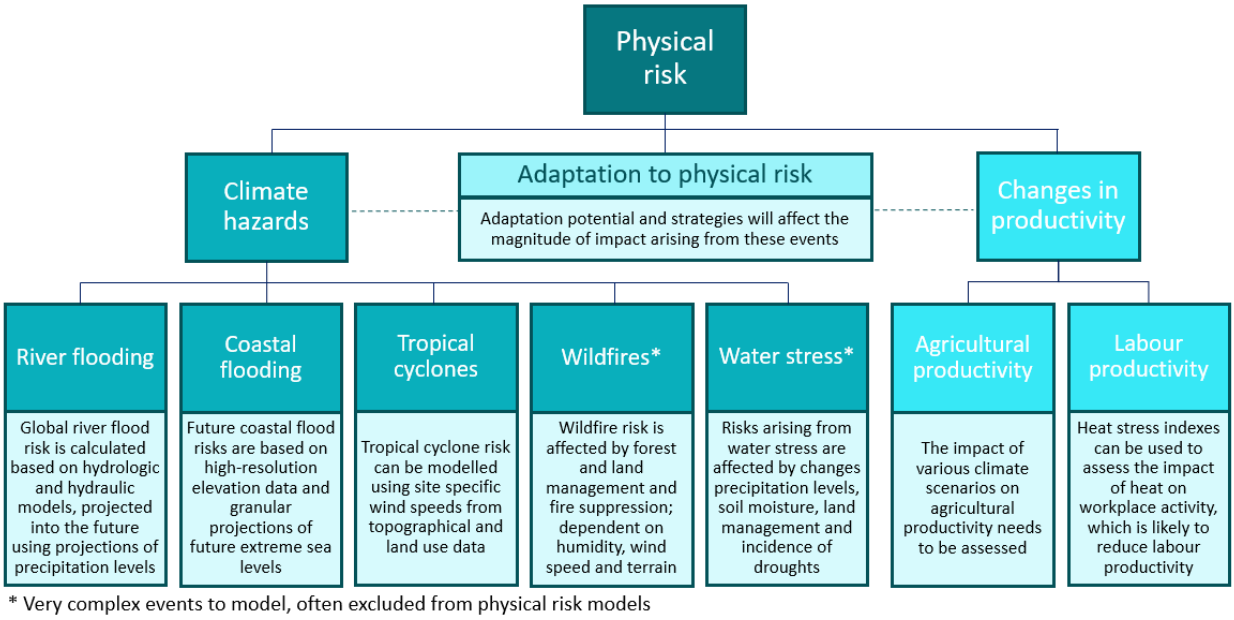
Source: IPCC SSPs, sourced through World Bank Climate Change Knowledge Portal, https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-projections, last accessed 2021-11-19.

Companies, financial institutions, and human communities will feel the impact of these risks through different channels. These are explored further below.

1.3. How do physical risks translate into financial losses?

Physical risks affect multiple economic sectors and can have adverse consequences for businesses, financial institutions, governments, and human communities. Figure 1 groups the potential impacts of climate change into four primary categories: rising temperatures, precipitation, drought, and temperature rise. There are several harmful consequences associated with these hazards, including flooding, wildfires, and water stress. These are summarised in Figure 4.

Figure 4: Channels of physical risk impact



Source: Vivid Economics

The impact of physical risks is affected by capacity of businesses, governments, and human communities to adapt to the effects of climate change. For example, governments or businesses may invest in floodwall construction or mangrove restoration projects, to protect coastal communities and building from flood risks associated with sea level rise. However, policymakers increasingly recognise that climate hazards have *already* caused damage to communities, businesses and infrastructure, and that adaptive measures cannot completely prevent this from worsening in the future.[2] This is known as "loss and damage" in climate policy circles and proved a bone of significant contention at COP 26 in Glasgow, where poorer countries demanded that industrialised nations do more to compensate them for the effects of the climate crisis.[3]

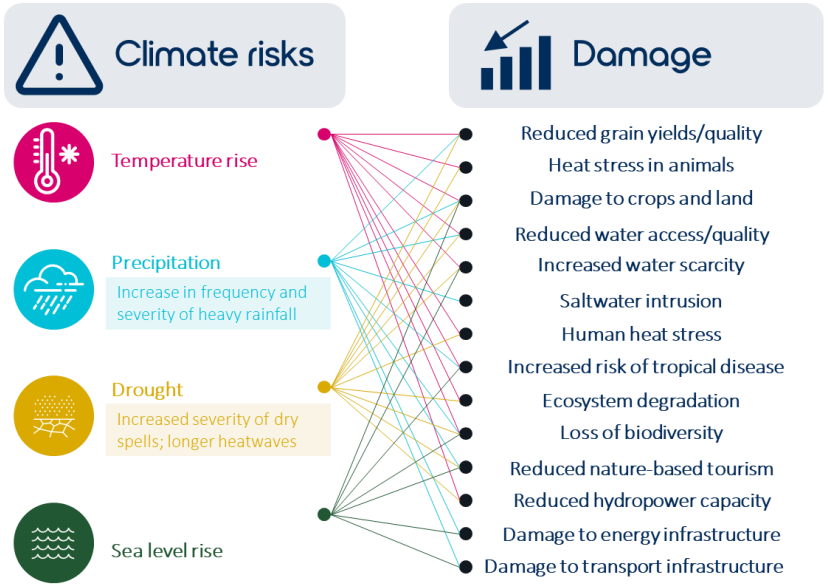
The limited capacity for adaptation means that climate hazards will translate into economic losses for businesses, governments, and human communities. Temperature rise, drought, precipitation, and sea level rise affect multiple economic sectors, causing damage to infrastructure, disruption to

[2] Byrnes and Surminski (2019), "Addressing the Impacts of Climate Change through an Effective Warsaw International Mechanism on Loss and Damage." https://www.lse.ac.uk/GranthamInstitute/publication/addressing-the-impacts-of-climate-change-through-an-effective-warsaw-international-mechanism-on-loss-and-damage/, last accessed 2021-11-22

[3] Carrington (2021), "What is loss and damage and why is it critical for success at Cop26?", https://www.theguardian.com/environment/2021/nov/13/what-is-loss-and-damage-and-why-is-it-critical-for-success-at-cop26, last accessed 2021-11-22.

supply chains and impacts on human health. A non-exhaustive map of these damage channels is provided in Figure 5.

Figure 5: Translating climate hazards to sources of damage



Note: sources of damage are illustrative and non-exhaustive
Source: Vivid Economics, based on IPCC (2021)

1.4. A note on terminology

Throughout this report, we refer to the "impact" of physical risk on financial institutions. For avoidance of doubt, this refers to the **monetary losses** associated with climate hazards, rather than physical damage to assets and buildings. Unless otherwise indicated, this refers to the **NPV impact** on **investment portfolios** (rather than on the financial institution's own operations), as these are more relevant for reporting purposes.

2. Physical risk reporting for financial institutions

2.1. Why is physical risk relevant to financial institutions in South Africa?

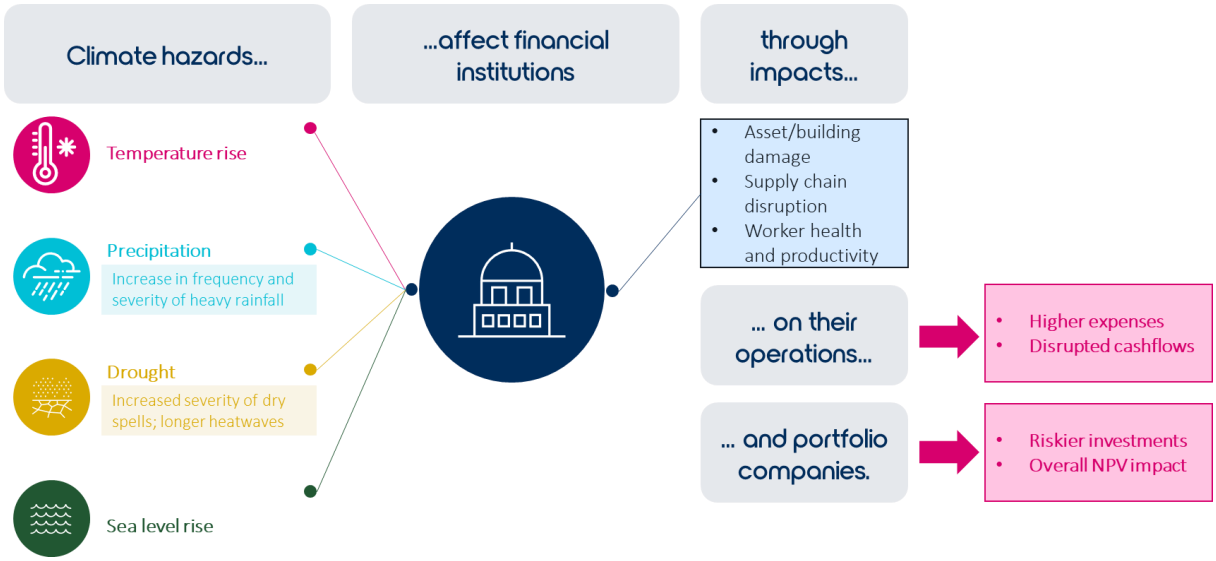
Physical risks can induce monetary losses through multiple channels including damage to infrastructure or assets, disruptions to supply chains and impacts on human health or productivity. Climate hazards may ultimately translate into monetary losses for financial institutions through the effect they have on their own operations and, more importantly, the companies that they finance.

Where these issues affect the operations of a financial institution, its translation into monetary losses is straightforward. The bank or asset manager pays money to address damage to its buildings or loses money through supply chain disruptions and weaker productivity. In South Africa, rising temperatures may increase the frequency of vector-borne diseases, as well as expenses on water and air conditioning. These factors may affect the running costs, or workforce health (and hence productivity) of financial institutions in the future.

When climate hazards affect portfolio companies, how these translate into monetary losses for financial institutions is more complex. Investees exposed to these hazards will become riskier investments in the future. From the perspective of the financing bank or asset owner, this means their valuation may decrease in net present value (NPV) terms. For financial institutions, this directly impacts on risk management, cashflow planning and general investment strategy. In South Africa, for example, increased incidence of drought impacts the risk profile of investments in agriculture and other water-dependent industries, while investments on the coastline may become riskier due to sea level rise.[4]

Figure 6 summarises how physical risk affects financial institutions in monetary terms.

Figure 6: The impacts of physical risk on financial institutions



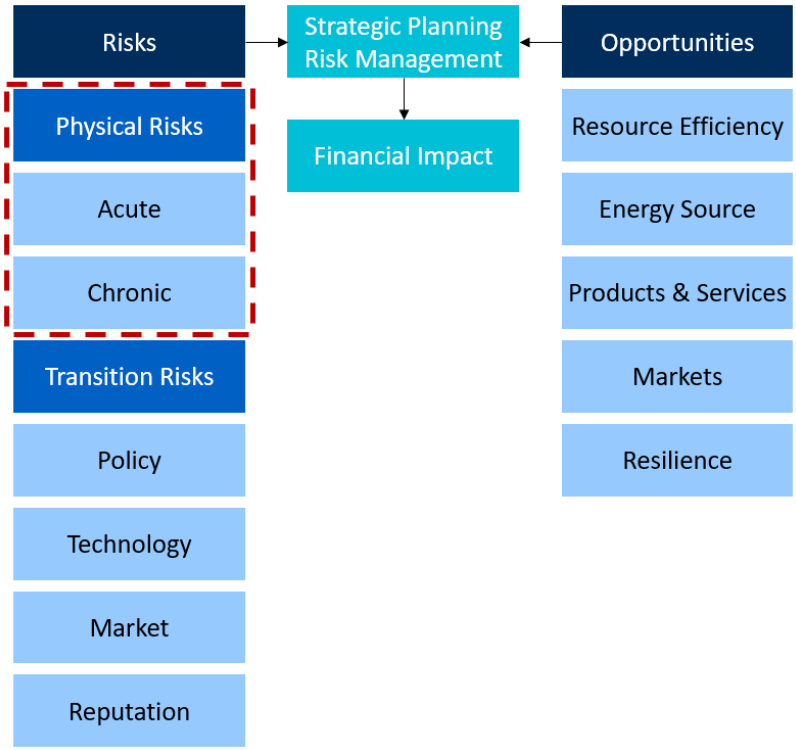
Source: Vivid Economics, based on IPCC (2021)

[4] Projections of the severity and frequency of hazards at different time horizons can be sourced from the World Bank Climate Change Knowledge Portal. See https://climateknowledgeportal.worldbank.org/, last accessed 2021-11-2021.

2.2. Physical risk and the TCFD

The Taskforce on Climate-Related Financial Disclosures (TCFD) recommends that financial institutions report on the projected impacts of physical risk at different time horizons.[5] The TCFD's framework for physical risk, summarised in Figure 7, helps companies to identify all the impacts the climate change may have on their operations. This in turn allows them to develop informed climate risk management strategies, minimise the financial impact of risks, and maximise the benefits of any opportunities.

Figure 7: TCFD risk and opportunity classification framework



Source: Vivid Economics, based on TCFD 'Recommendations of the Task Force on Climate-related Financial Disclosures', https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf. Last accessed 2021-10-25.

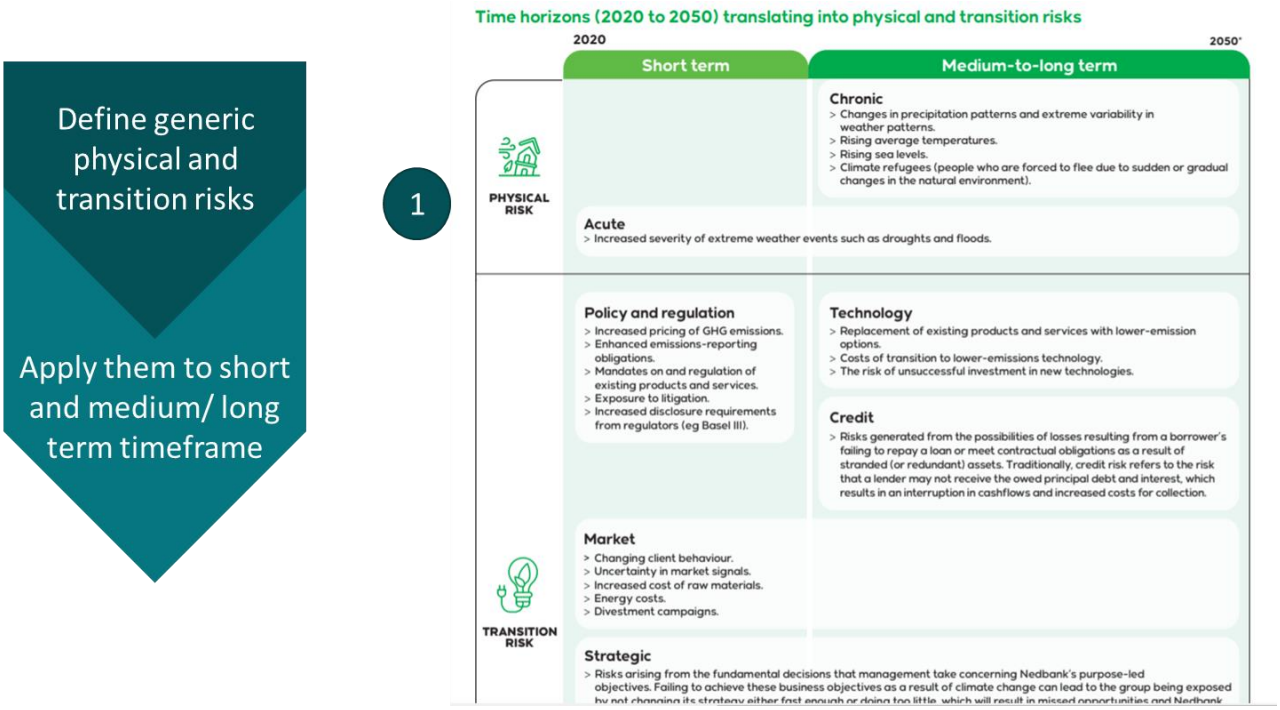
The TCFD classifies physical risks as "acute" or "chronic", to differentiate their potential impacts on assets, companies, or portfolio valuations. Acute physical risks are event-driven, e.g., cyclones and floods, and are mostly a short-term concern. Their impacts are concentrated in the period around the occurrence of the event. Chronic physical risks are associated with changes in climate patterns, e.g., sea level rise and recurring heat waves, and are a medium to long-term concern. They

[5] The TCFD was established by the Financial Stability Board "to develop recommendations for more effective climate-related disclosures that could promote more informed investment, credit, and insurance underwriting decisions." https://www.fsb-tcfd.org/. Last accessed 2021-11-16.

change fundamental features of environments, but at a slower pace than acute risks. As Figure 6 shows, all physical risks may imply future monetary losses for financial institutions, particularly by changing the risk profile of investment portfolios.

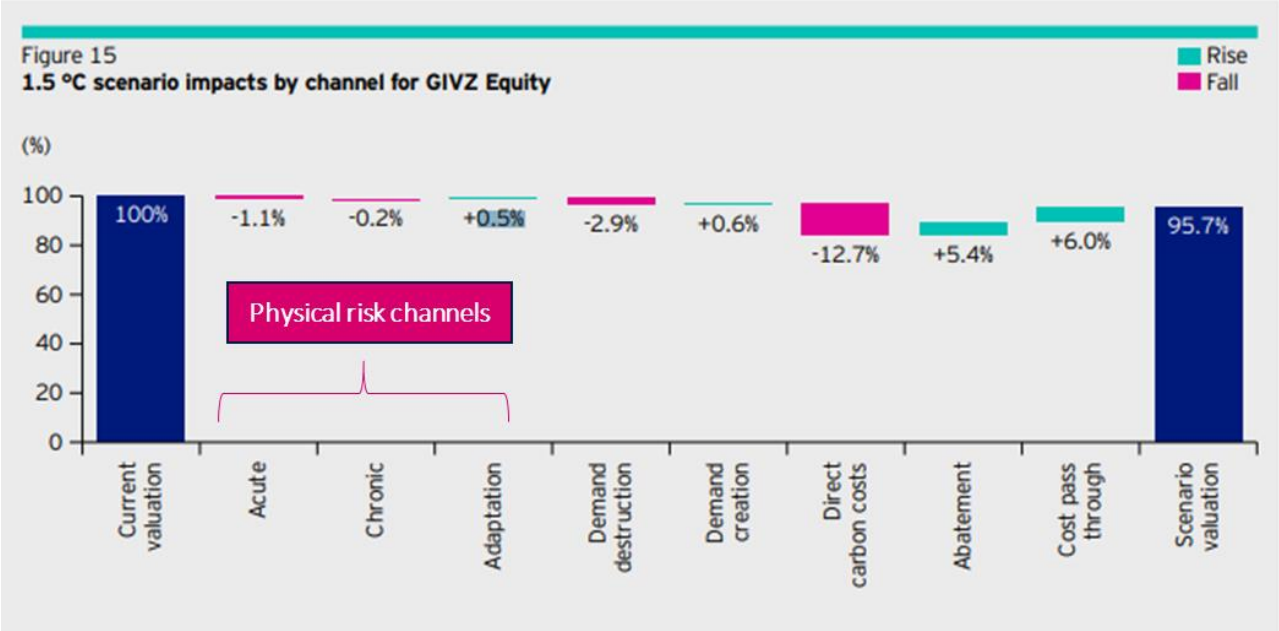
The TCFD recommends that financial institutions report on the materiality of physical risks, across different climate scenarios and time horizons. In practice, however, there is significant variance in how financial institutions report for TCFD. In South Africa, Nedbank's recent TCFD report includes broad, qualitative commentary on how physical risk affects their portfolio (see Figure 8). In contrast, international asset manager Invesco quantifies the impact of acute and chronic physical risks, as well as adaptive measures, on their overall portfolio valuation to 2050 under different climate scenarios. The Invesco disclosure relies on numbers produced by the Planetrics model, which was also used for the transition risk outputs of the South Africa-UK PACT programme. These outputs are shown in Figure 9.

Figure 8: Nedbank TCFD reporting on physical risks



Source: Nedbank TCFD Report (2020), https://www.nedbank.co.za/content/dam/nedbank/site-assets/AboutUs/Information%20Hub/Integrated%20Report/2021/2020%20Nedbank%20Group%20TCFD%20Report%20(single-page)(1).pdf, last accessed 2021-10-25.

Figure 9: Invesco TCFD reporting on physical risks



Source: Invesco TCFD Report (2019), https://www.invesco.com/emea/en/country-splash.html?src=%2Femea%2Fen%2Finvesco-insights%2Finsights%2Finvesco-climate-change-report-2019.html, last accessed 2021-10-25.

3. Assessing the materiality of physical risk

3.1. The IPCC risk framework

According to the IPCC, there are three core drivers of physical risk:

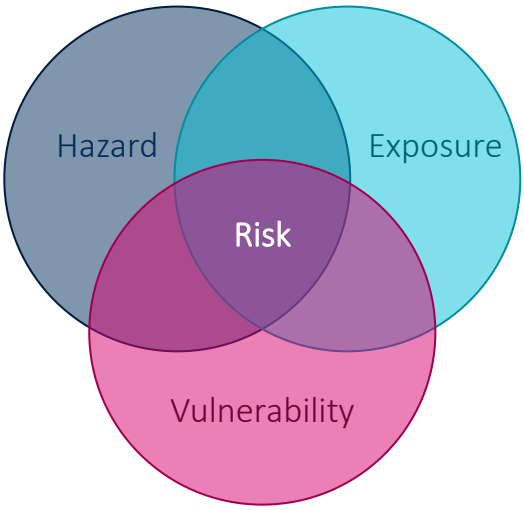
- **Hazards**: these flow directly from temperature increase, drought, precipitation, and sea level rise. These include both acute risks, e.g., rarer hurricanes becoming more frequent and chronic risks, e.g., gradual decreases in crop yields as temperatures rise.
- **Exposure**: this is determined by the location of a business activity, asset, or human settlement, and whether this coincides with increased likelihood of climate hazards. For example, coastal settlements and buildings will become increasingly exposed to risks associated with rising sea levels.
- **Vulnerability**: according to the IPCC's 2001 Synthesis Report,[6] vulnerability "is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change,

[6] IPCC (2001), Synthesis Report, https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_TAR_full_report.pdf, last accessed 2021-11-22.

including climate variability and extremes." Vulnerability is determined, in part, by the capacity of industries and governments to adapt to the effects of climate change.

The IPCC framework is summarised in Figure 10:

Figure 10: Physical risk is a function of hazard, exposure, and vulnerability



Note: while the IPCC refers to 'climate risk' in the linked report, it is referring primarily to physical risk (rather than transition risk).
Source: IPCC 'Determinants of Risk: Exposure and Vulnerability', https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap2_FINAL-1.pdf. Last accessed 2021-10-25.

Based on the IPCC framework above, UNEP-FI have proposed a four-step methodology by which financial institutions can quantify physical risk impacts at different time horizons. This methodology, or a variant of it, tends to be used in best-practice physical risk disclosures in TCFD reporting. Unless otherwise stated, the steps below relate to quantifying the impact of physical risks on portfolio NPVs, through the impact it has on investee companies.

- **Step 1: Vulnerability assessment.** The financial institution must assess how vulnerable its portfolio companies are to physical risk. There is no "one size fits all" approach to assessing vulnerability, but factors to consider may include:
    - Whether company assets, such as buildings, are exposed to climate hazards, such as flooding and water scarcity
    - Dependence on infrastructure (such as roads or rail), which may be damaged or disrupted by climate hazards
    - Whether the company's labour force may suffer deleterious health effects (such as heat stress or malaria) from climate change in the future

- The capacity for adaptation in the company's sector, and across the different geographies in which it operates

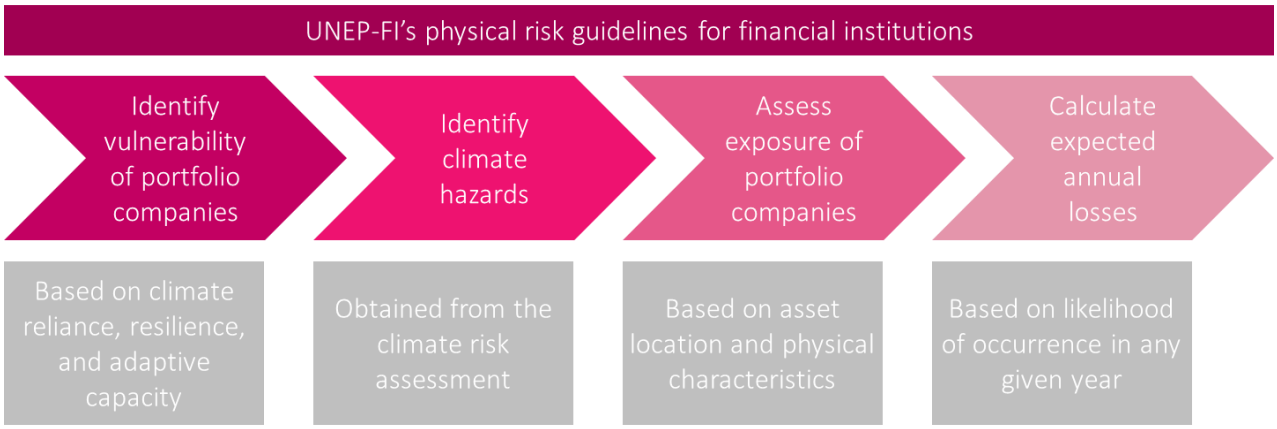
- **Step 2: Identify Climate Hazards**. With each potential vulnerability, there are a range of climate hazards which can drive physical impact. For example, sectors which are vulnerable to infrastructure damage must consider hazards such as floods, wildfires, landslides, and more. It is best practice to consider a range of climate hazards and their acuteness, using **scenario analysis**. Off-the-shelf scenario providers, such as NGFS, provide freely available projects of rainfall, temperature rise and sea level rise at different time horizons. These providers are listed in Table 1.

- **Step 3: Exposure Assessment**. After identifying which climate hazards are relevant to portfolio companies, the financial institution must determine the materiality of these risks. Given that the acuteness of risk is location-specific, it is useful to assess exposure at high levels of spatial granularity. For example, the financial institution may want to consider the location of their counterparties in agriculture and how they map to granular predictions of future drought incidence. Table 1 provides a non-exhaustive list of open source and proprietary data sources which offer exposure assessments for company assets at high levels of spatial granularity. Regional or national assessments of exposure are acceptable for disclosures, but less preferable to detailed spatial assessments.

- **Step 4: Loss Assessment**. With an understanding of vulnerability, hazards and exposure, the financial institution can make an educated assessment of how physical risk can impact on portfolio NPV at different time horizons. As with the vulnerability assessment, there is no "one size fits all" approach to incorporating this assessment into disclosures. High-level, qualitative assessments are acceptable for TCFD disclosures, which involve extracting the key takeaways from climate scenarios and how these impact on the portfolio (see Nedbank's disclosure in Figure 8). Best practice disclosures tend to quantify these impacts for different portfolios (see Invesco's disclosure in Figure 9). One possible approach to this calculation is to multiply the expected financial losses associated with each risk by the predicted probability of each risk materializing each year. Expected loss projections will be driven primarily by the chosen climate scenarios, which can project distinct trajectories of relevant climate inputs, e.g., average daily temperatures, sea level rise, and annual precipitation.

The UNEP-FI process is summarised in Figure 11.

Figure 11: The UNEP-FI methodology for financial institutions



Source: Vivid Economics, based on UNEP FI 'Charting a New Climate: State-of-the-art tools and data for banks to assess credit risks and opportunities from physical climate change impacts', https://www.unepfi.org/publications/banking-publications/charting-a-new-climate/. Last accessed 2021-10-25.

3.2. Portfolio-level analysis

Portfolio-level physical risk assessments can be constructed by aggregating asset-level assessments or through applying sector averages. A bottom-up analysis is more accurate; however, this is often not feasible due to a lack of data. This does not preclude broader portfolio analysis. Vulnerability and hazards are often assessed at the sector or subsector level, considering regional or economic attributes. For example, drought exposure may not vary significantly between agricultural properties in single drainage basin. In this case, asset-level location data is unnecessary beyond property size estimates.

The sector aggregate approach is a perfectly suitable starting point for financial institutions beginning the disclosure journey. The margin for error is lower in highly diversified portfolios or where exposure is relatively even between sectors. In these cases, asset-level inaccuracies are likely to average out across the portfolio in general. This approach is less accurate for portfolios where investments are highly concentrated in a small number of companies, which may not be representative of their broader sector. For example, a mortgage portfolio which is heavily concentrated in the hilly portion of a city will have a lower level of flood exposure but a higher level of landslide exposure than a portfolio which is evenly dispersed across hillside and valley properties. Although these examples may not be common, investment managers should conduct reasonable due diligence on segments of the portfolio where asset-level data is not available and openly disclose all assumptions where necessary.

4. Case Study: applying the UNEP-FI methodology in practice

The Standard Bank Group (SBG) conducted a trial analysis of various physical risk assessment tools, noting key insights and limitations when quantifying physical risk in a largely Africa-based portfolio.[7] SBG relied upon several key criteria in determining the appropriateness of each tool for TCFD-compliant risk reporting as well as regular portfolio stress testing. These criteria include:

1. **Data considerations:** The way each risk assessment toolkit handles input data is unique, with some being more flexible than others. Some toolkits map companies to industries internally, while others allow for users to provide industry classifications themselves. In diverse portfolios, additional flexibility for classification overrides is beneficial. Many physical risk toolkits also rely on detailed asset-level location data to quantify exposure. Sourcing such data is often difficult or impossible due to client data confidentiality rules. This can be particularly problematic for toolkits which store or process data externally.
2. **African coverage:** The lack of up-to-date and spatially granular physical risk data covering the African continent remains a significant issue in physical risk assessment for portfolios with significant exposure on the continent. SBG note this as a general limitation for physical risk assessments across its assets in Africa, but certain scenario toolkits provide regional climate projections while others provide only a single continental one.
3. **Focus on portfolio vs. transactional risk:** Many risk assessment toolkits include up-to-date climate scenario pathways, but some are designed with an intent to be used in pre-transaction screening while others are tailored for portfolio analysis.

With the physical risk assessment tools appropriately ranked, SBG conducted a pilot analysis for a single agricultural subsector: sugar. Because SBG is a major investor in South African agriculture, it is exposed to physical risks including future increases in drought and higher average temperatures. These may harm crop yields on the farms they finance, potentially driving down revenues for farmers and the food companies which rely on their crops to manufacture their own products. SBG sourced segmented financial information including gross revenues and cost of goods sold, separated by both product and geography. Then, based on regional climate projections, they were able to estimate a range of potential sugarcane production output and associated prices within each region under each scenario and time horizon. The process of this analysis is summarised in Figure 12.

[7] This case study is drawn from the September 2020 United Nations Environment Programme Finance Initiative (UNEP FI) report "Charting a New Climate: State-of-the-art tools and data for banks to assess credit risks and opportunities from physical climate change impacts". Five additional case studies examine physical risk assessment pilots by banks across a range of investment sectors. The report is available for download at https://www.unepfi.org/publications/banking-publications/charting-a-new-climate/ (last accessed 2021-10-25).

One key drawback of this analysis was a lack of geographic granularity in both asset and climate-related data. The reliability of these types of forecasts depends largely on accurate model calibration, and hence sourcing reliable yield and price projection data is of paramount importance. The climate projections were too coarse to capture significant climate differences across regions and subregions.

Despite the data granularity issues, SBG was able to estimate a range of potential changes in agricultural production and revenue associated with climate change. The exercise additionally provided a valuable opportunity for relevant staff training, identified key data gaps, and left SBG well situated to expand its physical risk assessment going forward.

Figure 12: Case study of applying the UNEP-FI methodology

Identify asset vulnerability	Identify climate hazards	Identify asset exposure	Calculate expected annual losses
• Sugar assets comprise of cane farms (including real estate and land), milling and refining facilities, some starch sub-sector investments • Cane farms rely on amenable climate conditions (focus on heat, precipitation) • Milling and refining facilities rely on habitable working conditions • Supply chain relies on infrastructure security to transport raw materials and final goods	• Higher temperatures impact cane yields and labor productivity • Drought can reduce yields significantly • Extreme events, e.g., wildfires and storms were not considered in this pilot analysis (infrastructure security thus out of scope)	• Two scenarios: 2°C and 4°C • Two time horizons: 2020s and 2040s • Assets located in six Southern African countries • Regional climate projections were used to estimate ranges of sugarcane production output and associated prices under each scenario • External data was used to precisely locate processing facilities but exact crop plantation boundaries were not available	• The results "yielded an interesting range of potential changes in production output and price variations", and identified the data needs required for accurate calculations • Final outputs identified the significant potential from the analysis once models have been able to be calibrated to regional Africa-specific yield and price data forecasts

5. Data Sources

This section offers a non-exhaustive summary of data sources that South African financial institutions can use in physical risk disclosures. Three summary tables are provided:

Table 1 provides a sample of physical risk datasets and tools. These data sources are meant to be combined with internal information on asset locations and values to allow users to conduct their own physical risk assessment. The focus is on free-to-use datasets with global or African coverage. Different datasets cover different physical hazards, and these differences are captured within the table. A legend for these icons is below. Agricultural yield impact implicitly includes several of the other physical risks including heat, flooding, and drought. However, it is frequently modelled explicitly and for that reason is noted independently here.


Heat


Flooding


Sea level rise


Drought


Cyclones


Wildfire


Agricultural yield impact

Table 2 summarises proprietary toolkits that financial institutions can use for automated risk assessments, rather than modelling these internally. They typically combine user-provided data on assets with internal climate datasets and modelling to project future risks. The advantage of these end-to-end toolkits is that they reduce the amount of work on the part of the assessor significantly. However, they are generally commercially licensed products.

Table 3 provides an initial examination of data availability for conducting physical risk assessments in the South African context. The quality, coverage, and granularity of physical risk data, particularly detailed climate projections, tends to be lower for Africa than other parts of the world. This presents a challenge for assessing long-run physical risk in portfolios which are heavily concentrated on investments in Africa.

Table 1: List of physical risk datasets and tools

Provider	Tool	Description	Hazard	Time Period		Scenarios			Spatial Coverage	Licencing and Cost
				Historical / Current	Future Projections	<2˚C	2˚C	>2˚C		
Network for Greening the Financial System / Climate Analytics	NGFS CA Climate Impact Explorer	Country- or province-level projections of agricultural yields, temperature, precipitation, and extreme event exposure probability		✓	✓	✓	✓	✓	Global	Free to use
Network for Greening the Financial System	NGFS IIASA Scenario Explorer	Global and regional forecasts of temperature, energy demand, agricultural yield, etc.		✓	✓	✓	✓	✓	Global	Free to use
World Bank	Climate Change Knowledge Portal	Regional projections of temperature, precipitation, sea level rise, and more		✓	✓	✓	✓	✓	Global	Free to use
	Climate and Disaster Risk Screening Tools	Suite of project-level tools to generate qualitative risk reports		✓	✓	Unclear			Global	Free to use

Global Facility for Disaster Reduction and Recovery	ThinkHazard!	Broadly identify most relevant current climate hazards for areas		✓					Global	Free to use
Partnership for Resilience and Preparedness	PREPdata	Climate projections under two IPCC scenarios plus current infrastructure locations, cropland extent, etc.		✓	✓		✓	✓	Global	Free to use
Climate Analytics	Local SLR	Localised projections of sea level rise		✓	✓	✓	✓	✓	Global	Free to use
	RegioClim	Regional climate projections for all African countries for temperature and precipitation		✓	✓		✓		Africa	Free to use
	RegioCrop	Regional crop yield projections for all African countries			✓	✓	✓	✓	Africa	Free to use
University of Cape Town	Climate Information Platform	Observational climate data and downscaled projections under IPCC scenarios		✓	✓		✓	✓	Africa	Free to use

UNEP / UNISDR	Global Risk Data Platform	Covers past events, nation-level financial risk, exposure (population), hazard incidence		✓					Global	Free to use
World Resources Institute	Aqueduct Floods	Maps riverine and coastal flood risks under three IPCC scenarios		✓	✓		✓	✓	Global	Free to use
	Aqueduct Food	Cross-references water risk maps with agricultural data for management of water-related risks to food security		✓	✓		✓	✓	Global	Not yet released
	Aqueduct Water Stress	Projected indicators on water supply, demand, and stress		✓	✓		✓	✓	Global	Free to use
Climate Central	Coastal Risk Screening Tool	Coastal flood risk under many scenarios		✓	✓	✓	✓	✓	Global	Free to use
	Surging Seas Risk Finder	Pixel-level assessments of coastal flood risk		✓	✓	✓	✓	✓	US and Caribbean	Free to use
	Portfolio Analysis Tool	Quantify flood risk individually for all properties in a portfolio		✓	✓	✓	✓	✓	Global	Chargeable

Princeton Climate Analytics	Platform	High-resolution historical and current climate data		✓					Global	Chargeable
Ecolab	Smart Water Navigator	Quantifies water dependency in monetary terms		✓	Unclear				Global	Free to use
NOAA	Historical Hurricane Tracks	Visualise categorized storm paths since 1842		✓					Global	Free to use
Royal Netherlands Meteorological Institute	Climate Explorer	Compiles historical temperature and precipitation observations		✓					Global	Free to use
South African Environment Observation Network	South African Risk Vulnerability Atlas	Hundreds of contemporary climate, environment, and agriculture datasets		✓					South Africa	Free to use
Climate Impact Lab	Impact Map	Regional temperature projections		✓	✓	✓	✓	✓	Global	Free to use
International Research Institute for Climate and Society	Climate: Analysis, Monitoring, Forecasts	Suite of current and historical climate datasets including forecasts		✓	2-5 years only				Global	Free to use

Bloomberg	CMAP/MAPS	Precise physical site information on 11,000 firms in 200,000 locations	N/A	✓					Global	Chargeable

Table 2: List of comprehensive physical risk assessment toolkits

Provider	Toolkit	Description	Time Period		Scenarios			Spatial Coverage	Licencing and Cost
			Historical / Current	Future Projections	<2˚C	2˚C	>4˚C		
Planetrics	Planetrics	Fully customisable risk model which estimates asset- to portfolio-level climate valuation impact of both physical and transition risks	✓	✓	✓	✓	✓	Global	Chargeable
	PlanetView	Detailed climate risk dashboard generator backed by Planetrics model (not yet released)	✓	✓	✓	✓	✓	Global	Chargeable
Jupiter	ClimateScore Global	Localised metrics of physical risk	✓	✓	✓	✓	✓	Global	Chargeable
	ClimateScore Planning	Comprehensive suite of asset-level physical risk analysis applications	✓	✓	✓	✓	✓	Global	Chargeable
Swiss RE	CatNet	Browser-based risk tool which combines hazard, loss, exposure, and insurance information, focusing on catastrophes	✓	Unclear	Unclear			Global	Chargeable
	CatNet Premium	More powerful version of CatNet, modelling additional risks	✓	Unclear	Unclear			Global	Chargeable

MSCI Inc.	Climate Value-at-Risk	Integrated toolkit for estimating and disclosing financial risk directly	✓	✓	✓	✓	✓	Global	Chargeable

Table 3: Data availability survey for South Africa

IPCC Step	Field	Necessary Information	Example Data Source(s)
Vulnerability	Transportation infrastructure	Road network, port locations	PREPdata
	Energy security	Location of energy facilities and energy mix	PREPdata, NGFS Scenario Explorer
	Agricultural productivity	Localised cropland extents and yields	PREPdata, Climate Impact Explorer, RegioCrop, StatsSA
	Labor productivity	Earnings and hours by sector	StatsSA Quarterly Labour Force Survey
Hazard	Sea level rise	Localised risk projections	Local SLR, Coastal Risk Screening Tool
	Coastal flooding		SLR data sources plus CatNet® Premium, ThinkHazard, NOAA Hurricane Tracks
	Inland flooding		CatNet® Premium, ThinkHazard!
	Drought		Jupiter ClimateScore, Aqueduct Water Stress
	Wildfire		Climate Impact Explorer, ThinkHazard!, Jupiter ClimateScore
Exposure	Facility (building) locations	Precise locations of owned assets	Bloomberg CMAP/MAPS
	Presence and size of hazard insurance	Asset-level polices	Internal / Gap

	Client financials	Asset- or client-level EV, or debt + equity	Internal / Gap
	Loan or investment exposure	Drawn balances or equity stake	Internal / Gap

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