

Riding the wave of physical risks

A compendium of tools and service providers
for investors in Asia

About AIGCC

The Asia Investor Group on Climate Change (AIGCC) is an initiative to create awareness and encourage action among Asia's asset owners and financial institutions about the risks and opportunities associated with climate change and low carbon investing.

AIGCC provides capacity for investors to share best practice and to collaborate on investment activity, credit analysis, risk management, engagement and policy. With a strong international profile and significant network, AIGCC represents the Asian investor perspective in the evolving global discussions on climate change and the transition to a greener economy. AIGCC has over 50 members from 13 markets representing over US\$26 trillion in assets under management.

Authors

Alice Martin
Director, Moribus Advisory
www.moribusadvisory.com

With contributions from Jane Ho (jane.ho@aigcc.net) & Firdaus Anuar (firdaus.anuar@aigcc.net).

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- Planetrics
- S&P Trucost
- South Pole
- SwissRe
- The Climate Service (TCS)
- Willis Towers Watson
- VE-RISK AIR

Contact

 info@aigcc.net

 www.aigcc.net

 [@AIGCC_Update](https://twitter.com/AIGCC_Update)

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Introduction

Asia is on the frontline of global warming. The combination of low-lying, densely populated coastal areas, a dependence on natural resources and agriculture, high levels of poverty and inadequate resources to adapt means that Asian societies and economies are extremely vulnerable to the physical risks of climate change.¹

With the region already experiencing significant climate variability and extreme weather events, continued global warming means that heat extremes will continue to increase, fire weather seasons will lengthen and intensify, precipitation levels will grow (including average and heavy rainfall events) whilst distribution will decrease, and sea levels will continue to rise with increasing coastal area loss and shoreline retreat.²

The increasing frequency and severity of climate-related hazards present significant financial risks to the region, in the present and future. The Asia economy could lose 26.5% of its GDP by 2048 if no action on climate change is taken, with Indonesia, Malaysia, the Philippines, Singapore and Thailand potentially facing the loss of more than seven times their 2019 GDP by 2050.³ The cost of real estate and infrastructure damage from a 100-year flood in Tokyo could more than double to \$14.2 billion in 2050 without additional adaptation and there could be a 7-12% decrease in labour productivity across regions exposed to rising heat and humidity levels.⁴

The imperative for investors to integrate physical climate risk exposures into investment analysis and stakeholder engagement has never been greater.

The financial impacts of inaction present substantial investment risk. The TCFD recommendations have increased awareness and understanding of the need to understand and manage climate risks, and there are increasing expectations from financial industry regulators across the globe on how fiduciaries should be managing these exposures and enabling resilience to ensure future economic stability and growth opportunities.⁵ There is also significant upside to be gained by investors through the massive investment opportunities present across the region, presuming that climate risk factors are embedded into asset, supply chain and infrastructure design.

Physical climate risks can be mitigated by investors to an extent through the implementation of resilience and adaptation strategies, however, the first necessary step is the identification and assessment of current exposures.

Evaluating physical risk exposures requires data that translates climate science into tangible impacts across diverse assets and geographies. Tools and data need to be robust, grounded in scientific evidence, with clear methodologies and usable alongside existing company disclosures and other risk management and portfolio analytics tools and systems to ensure risks and opportunities can be holistically assessed across investments.

There are an increasing number of service providers and analytical tools that support the assessment of physical climate risks and enable the quantification of the potential financial impacts on the risk and return profiles of investments. AIGCC has produced this guide to highlight the advances in tools available for investors in the Asian region alongside their key features and planned developments. Building on the work undertaken by UNEP FI⁶, the guide evaluated 18 fee for service providers available in September 2021 that offer tools and analytics covering Asian companies and geographies. A summary of these products and several case studies showcasing outputs are provided throughout this guide. It is worth noting that there has been significant growth in this industry with new service providers coming to market regularly and frequent updates made to existing tools.

The tools that have been profiled in this guide are designed for a variety of purposes including portfolio assessment, security selection, strategic and tactical asset allocation, risk management and regulatory reporting. Some offer top-down portfolio level assessments, while others offer bottom-up asset level analysis. This guide is useful for investors at the beginning of their climate risk journey, and also for those who are more advanced – to screen and determine relevant tools that fit in their investment process, to conduct deep dive analyses and develop investor action and engagement plans.

The guide summarised key features of the available tools using a systematic review framework, with the following key provided to help investors navigate the different elements offered.

1. ADB, 2012, [Climate Change in Asia and the Pacific: how can countries adapt? Highlights](#).

2. IPCC, 2021, [Sixth Assessment Report – Regional fact sheet – Asia](#).

3. SwissRe, 2021, [The economics of climate change: impacts for Asia](#).

4. McKinsey Global Institute, 2020, [Climate risk and response in Asia](#).

5. NGFS, 2021, [Origin and purpose](#).

6. UNEPFI, 2020, [Charting a new climate](#) and UNEPFI, 2021, [The climate risk landscape: a comprehensive overview of climate risk assessment methodologies](#).

Key:

Asset class:

Strategic Asset Allocation	Listed equities	Fixed income - corporate	Fixed income - sovereign	Real assets - property	Real assets - infrastructure	Commodities	Private equity
SAA	LE	FI-C	FI-S	RE	IN	CO	PE

Level of analysis:

	
Asset/facility level	Macro level
Bottom-up approach that maps the physical location of company assets and overlays these with climate-related impacts and hazard events.	Top-down approach either using macroeconomic indicators and/or sector level risk as inputs and overlays these with country/state level exposure to physical risks.

Coverage:

Coverage of company underlying assets/facilities has been assessed for listed equity and fixed income products using the following indices (based on index constituent coverage, not market capitalisation coverage):

- Listed equities – MSCI All Countries Asia including Japan Index
- Fixed income – J.P. Morgan Asia Credit Index Core (JACI)⁷

Access:

		
Web-based platform	API	Service provider output
Analysis is accessed via a web portal, allowing users to login and access/ conduct analysis on an as needs basis.	Data can be shared by the service provider via an automated electronic feed into your internal systems.	Analysis is accessed via outputs that are generated by the service provider.

Hazards:

						
Sea-level rise/coastal flood	Heat stress	Riverine flood	Water stress	Wildfire	Extreme wind	Hail
						
Precipitation	Snow	Electrical storms	Tornado	Hurricane/Typhoon	Landslide/subsidence	Drought

Climate scenarios:

The key scenarios utilised by service providers are the IPCC's Representative Concentration Pathways (RCPs) which provide greenhouse gas emission projections using different estimates of population size, economic activity, lifestyle, energy use, land-use patterns, technology and climate policy⁸. A number of service providers also offer coverage of the NGFS scenarios. The recently released IPCC Shared Socioeconomic Pathways will presumably be integrated into service provider analysis in the short-medium term.

Scenario	Summary
RCP 2.6	A stringent mitigation scenario that aims to keep global warming below 2°C above pre-industrial temperatures. It required emissions to start declining in 2020 and go to zero by 2100.
RCP 4.5	An intermediate scenario, where emissions peak by 2040 and then decline by 50% on 2050 levels by 2100. This scenario is expected to result in warming of more than 2°C by 2100.
RCP 8.5	A business as usual scenario without additional efforts to constrain emissions, resulting in very high greenhouse gas emissions and warming of more than 4°C by 2100.
NGFS - various	The Network for Greening the Financial System developed a series of scenarios to provide a common reference point for understanding how physical risk and climate policy and technology trends could evolve in different futures.

Physical and financial risk metrics:

Physical climate risk key metric	Metric that looks to quantify risk exposure of assets to various climate hazards and related impacts.
Financial impact key metric	Metric that looks to quantify the financial impacts to assets from climate hazards and related impacts.

7. Note when a service provider covers only corporate or sovereign issuers, the coverage assessment has been reweighted accordingly to exclude constituents not included in their asset class coverage.

8. IPCC, 2014, Climate Change 2014 Synthesis Report Fifth Assessment Report: Summary for Policymakers, https://ar5-syr.ipcc.ch/topic_summary.php

Service provider		BlackRock	Carbone4		Cross Dependency Initiative (XDI)			FutureProof	Iceberg Data Lab	ISS	Jupiter	Moody's ESG Solutions			MSCI	MunichRe	Ortec Finance		Planetrics	S&P Trucost	South Pole		SwissRe	The Climate Service	WTW		VERISK-AIR	
Name of product		Aladdin Climate Physical Risk Analytics	CIARA	CRIS	Single Asset & Cross Dependency	Large Site Analysis	TCFD	Multi Company Intelligence	Risk Metrics	Climate Impact	CSG & CSP	Real Assets	Corporate risk scores	Sovereigns and municipal bonds	Climate-VaR	Location Risk Intelligence Platform	ClimateMAPS	Climate PREDICT	Planetview	Physical Risk Solution	Screening Tool	In-depth analysis tool	Framework for assessing climate risk	Climanomics	HeatMapR	Climate Diagnostic & Property Quantified	AIR & Maplecroft	
Scenarios	2.0°C (RCP 2.6)				✓	✓	✓	✓		✓					✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			
	2.0°C (RCP 4.5)	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	3.0°C (RCP 6.0)			✓	✓	✓	✓	✓									✓	✓	✓	✓	✓	✓		✓	✓			
	>4.0°C (RCP 8.5)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Time horizons	Baseline / historical	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Near term (2025-2040)	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Medium term (2050)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Long-term (2100)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Physical hazards	Chronic	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Acute	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Risk analysis	Level of analysis	Asset	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
		Firm	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		Sector	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Country	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Impact Channel	Portfolio	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		Macroenvironment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		Supply chain	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		Operations and assets	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Method	Markets and customers	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		Physical Exposure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		Vulnerability indicators	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		Physical impact modelling	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Financial modelling	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Physical Hazard Type	Flood, coast	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Flood, inland		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Extreme weather	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Extreme heat	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Extreme precipitation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Landslide		✓	✓													✓	✓					✓	✓	✓	✓		
	Drought		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Water scarcity		✓	✓							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Wildfire		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Asset classes	Equity	✓		✓			✓	✓	✓	✓		✓		✓		✓	✓	✓	✓	✓	✓	✓	✓					
	Bonds, Corporate	✓		✓				✓	✓	✓		✓		✓		✓	✓	✓	✓	✓	✓	✓	✓					
	Bonds, Government	✓		✓					✓				✓				✓	✓	✓	✓	✓	✓	✓					
	Loans, Corporate	✓		✓	✓	✓	✓		✓		✓						✓	✓	✓	✓	✓	✓	✓					
	Loans, Project		✓		✓	✓	✓		✓		✓				✓		✓	✓	✓	✓	✓	✓	✓					
	Mortgages	✓	✓		✓		✓		✓	✓	✓	✓			✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		
	Real Estate / Real Assets	✓	✓		✓	✓	✓		✓	✓	✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Commodities		✓														✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
User inputs	Counterparty name	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Location	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Value of asset		✓	✓	✓	✓	✓	✓	✓		✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Characteristics of asset		✓		✓	✓	✓	✓	✓		✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Validity	Open source	✓			✓	✓	✓	✓	✓		✓				✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Peer-reviewed	✓			✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Source references	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outputs	Quantitative	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Semi-quantitative		✓	✓					✓	✓					✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Non-financial metrics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Financial metrics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		

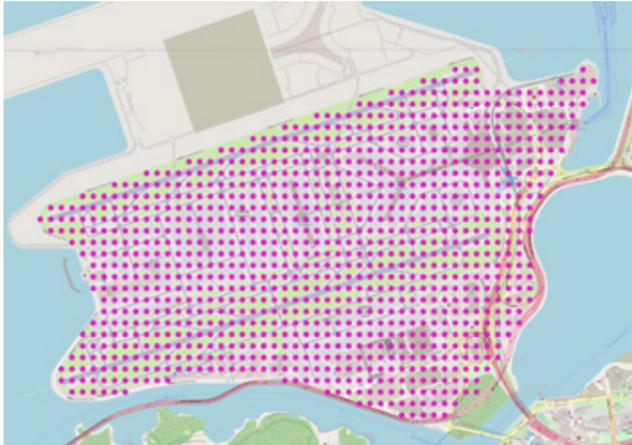
9. Validity refers to the service providers' approach to verifying and disclosing the methodology used to assess physical risk exposure.

BlackRock ¹⁰		
Tools offered	Aladdin Climate Physical Risk Analytics	
Asset class coverage	LE RE IN	FI-S
Summary	<ul style="list-style-type: none"> Provides economic and financial impacts of the physical risks of climate change at asset and portfolio level, in partnership with the Rhodium Group. Leverages econometric research to quantify the impact of probabilistic climate hazard projections on a range of social, economic and market outcomes. Identifies corporate revenue and operations risks by using an econometric model that combines macroeconomic conditions (GDP), with hazard damage, labour productivity and energy expenditure (based on heating and cooling costs). Real asset analysis also includes hazard impact on local economic activity. 	<ul style="list-style-type: none"> Similar to approach for RE, IN and LE, although fixed income – sovereign bonds are analysed at country level using projected change in GDP compared to a world without climate change.
Level of analysis		
Inputs required	<ul style="list-style-type: none"> LE: ISIN RE & IN: Asset location & type e.g. airport/toll road/retail property 	Country
Output format	<ul style="list-style-type: none"> Summary report that combines quantitative assessment of the portfolio's physical climate risk, including deep dives into key regions and drivers of risk, with qualitative analysis. Analytics integrated into Aladdin technology solutions with data delivery provided through flat files and visualisations provided in presentation slides. 	
Physical climate risk key metric	Climate risk score for relative risk of asset compared to peers.	
Financial impact key metric	<ul style="list-style-type: none"> Probabilistic quantitative results describing the physical climate risk and economic impacts - covering 5th, 13th, 50th, 87th, 95th percentiles which capture the range of outcomes due to uncertainty in the climate hazard projections and econometric modelling of each impact sector. Macroeconomic impact - reduction in GDP due to projected hazard impacts Combined metric that brings operating costs and revenue risk to corporate revenue total. Change in valuation of financial instrument due to climate risk. Change in probability of default for fixed income securities. 	
Asia coverage	<ul style="list-style-type: none"> LE: 95% (coverage mirrors benchmark) RE & IN: Global 	<ul style="list-style-type: none"> FI-S: Global
Access		
Climate scenarios	RCP 4.5 & RCP 8.5	
Time horizon	Decadal to 2100	
Hazard coverage & resolution	 30m ² 10km ² 25km ²	
Additional features offered/ in development	Additional features currently under development include updating the climate science in line with CMIP6, expanding hazard coverage to include inland flood and wildfire, expanding economic impact analysis for Asia to include additional sea level rise impacts, agriculture and mortality.	

10. BlackRock acquired the Rhodium Group in mid 2021, with Rhodium's Climate Risk Service now being offered through BlackRock's Aladdin platform.

Carbone4		
Tools offered	Climate Impact Analytics for Real Assets (CIARA)	Climate Risk Impact Screening (CRIS)
Asset class coverage	IN RE CO	LE FI-C FI-S
Summary	<ul style="list-style-type: none"> Assesses the exposure of assets and portfolios to climate-related physical risks through the assessment of key hazards, and production of an overall risk score. Covers 100 infrastructure asset types. 	<ul style="list-style-type: none"> Captures the risk due to the increase in intensity and frequency of climate related hazards and assesses climate risk as a function of location specific climate hazards and sector specific vulnerability. Climate hazard ratings combine information on a direct hazard with the risk-aggravating context to capture indirect hazards e.g. biodiversity migration and loss, air quality degradation, urban heat island intensification. Utilises publicly available information on sectoral and geographic distribution of fixed assets or revenues depending on the sectoral capital intensity. Sectoral vulnerability is assessed for 60 sectors through analysis of CAPEX, OPEX and revenue metrics covering 13 underlying factors. Sovereign analysis assesses country exposure to hazards (population and land exposure), GDP impacts from hazards and adaptive capacity (disaster preparedness and current GDP) to produce a net vulnerability risk metric.
Level of analysis		
Inputs required	Asset location, value of investment, type, year of construction/year of last retrofit (for real assets)	ISIN & weight in portfolio
Output format	Risk scoring at portfolio and asset level (in the reference and future periods), asset vulnerability, key hazards per asset, evolution of key climate hazards between reference and future periods.	Dashboard provides high level portfolio and benchmark scores and risk measures, identification of most at risk companies and distribution of risk across sectors and companies within the portfolio.
Physical climate risk key metric	Risk score (0-1) at portfolio and asset level, and level of expected change in climate hazard characteristics.	Climate risk rating = direct climate hazard rating (location), risk aggravating context rating (location), gross vulnerability rating (asset type) and adaptability rating (asset specific) (note adaptability rating only included for sovereign analysis)
Financial impact key metric	Under development	
Asia coverage	On demand	<ul style="list-style-type: none"> LE: 58% (underlying detail not provided) FI: 31% (underlying detail not provided)
Access		
Climate scenarios	RCP 4.5, RCP 6.0 & RCP 8.5	
Time horizon	2050 & 2100	
Hazard coverage & resolution	 12km ²	 National level
Additional features offered/ in development		

The Cross Dependency Initiative (XDI)	
Tools offered	XDI Platform – Easy XDI, Adapt XDI, XDI Large Site, Cross Dependency, Regional Economic Exposure, Company TCFD physical risk, Multi-company intelligence, XDI Masterplan, XDI Globe & residential mortgage portfolios.
Asset class coverage	LE RE IN
Summary	<ul style="list-style-type: none"> • EasyXDI offers an on demand physical risk assessment that integrates detailed analysis of building characteristics, while Adapt XDI offers the on demand physical risk assessment plus an adaptation analysis. • Single site level analysis includes micro-testing of a large area around the asset at 5m resolution across all hazards and asset types to ensure localised risks are also factored in. • XDI large site analysis enables mapping of multiple points and/or multiple types of assets across a large site e.g. hospitals. • XDI Cross Dependency analysis links an asset to critical local infrastructure e.g. roads, rail, power, communications, water, to quantify integrated risk and enable resilience management. • Regional economic analysis provides a long-range view of productivity loss, business disruption levels and economic retardation resulting from extreme weather and climate change across a region. • TCFD physical risk report produced for multiple asset portfolios and companies, that provides investment and engineering grade data on physical risk to a company's assets and benchmarks the company against its peers. Also for multiple assets, the Multi-company Intelligence Report provides a high level, aggregated climate risk analysis on a portfolio of companies. • XDI Masterplan is used for medium to large scale land use planning, to pre-test the climate resilience of real assets at the planning stage for various asset types (with over 100 types covered). • Analysis of residential mortgage portfolios in partnership with Climate Valuation. • XDI Globe offers a visualisation tool for analysing results on all assets at site, company or portfolio level. This analysis includes upstream critical infrastructure, including power, water and access. Results can be aggregated into heat maps for different KPI's, hazards and time points. • Company asset analysis includes those that are owned and leased.
Level of analysis	
Inputs required	<ul style="list-style-type: none"> • LE: ISIN • RE & IN: Asset location, value, type & characteristics
Output format	Outputs available in a variety of formats - reports, maps, data files and the dashboard on the platform interface. Data outputs for portfolios or single assets can be produced at high level aggregated insights down to detailed sub asset componentry.
Physical climate risk key metric	Climate adjusted hazard level insights, severity return frequency tables, synthetic vulnerability curves , with the ability to drill down into the hazards and vulnerability of individual assets.
Financial impact key metric	Annual Average Loss, Total Technical Insurance Premiums, Percentage of Value at Risk (% of loss due to physical damage the company asset base could experience), climate adjusted valuations, LVR risk, failure probability (unavailability of asset for a period), productivity loss, Insurability Rating (FEMA), Number and percentage of high risk properties and average annual risk per hazard.
Asia coverage	<ul style="list-style-type: none"> • LE: 63% (incl. underlying assets, 96% at HQ level); with stronger coverage for Japan and lower coverage for China. • RE & IN: Global
Access	 
Climate scenarios	RCP 2.0, RCP 4.5, RCP 6.0 & RCP 8.5
Time horizon	Annual out to 2100
Hazard coverage & resolution	 5km ² 5m ² 30m ² 5km ² 5km ² 5km ² 30m ² 30m ² 30m ²
Additional features offered/ in development	<ul style="list-style-type: none"> • Adapt XDI allows users to customise the asset type and test adaptation measures, providing an opportunity to develop an optimal resilience pathway using cost benefit analysis and net present value. • XDI partner with Baringa to offer a transition analytics service.

Hong Kong Airport - Infrastructure																																											
Provider	The Cross Dependency Initiative (XDI)																																										
Asset class	Infrastructure																																										
Process	<p>The physical climate risk analysis used hypothetical assets (based on XDI's 'Simple House' archetype) at 100 m resolution in order to capture all relevant hazards at the site. Note that resolution as high as 5m is available subject to hazard/location.</p> <p>For the site being analysed, XDI undertook the following steps:</p> <ul style="list-style-type: none"> • Establish a hypothetical asset grid over the site at a site-appropriate resolution of 100 m. Note that grid points which fell within water bodies were not analysed (hazards that can be measured within water bodies include extreme heat and extreme wind). • Using XDI's Climate Risk Engines, analyse climate-related failure and damage risks at each grid point, under RCP 8.5 and RCP 2.6, to identify the spatial distribution of climate risks across the site. 																																										
																																											
	<ul style="list-style-type: none"> • XDI's coastal inundation modelling has taken sea defences into account. Riverine flooding analysis is based on third party flood maps, with the location of the airport falling into an inner island watercourse flood zone. • VAR% is the technical insurance premium of an asset, expressed as a percentage of its replacement cost. MVAR% is the maximum VAR% value reached up until a stated point in time e.g. the MVAR% for 2050 is the maximum VAR% that occurred in any year up to and including 2050. • For each analysed asset and for each year, heat failure probability is the probability (commonly expressed in percentage terms) of asset failure due to its heat threshold being exceeded. Note that in XDI's analysis extreme heat is considered a 'failure only' hazard, so no asset damage results (and therefore no Total Insurance Premium and VAR% figures) are computed for it, based on the assumption that a component (or a whole asset) can fail to function for a period of time, but can later resume normal functioning without requiring replacement. This does not affect VAR however can translate into a productivity loss metric, which is an additional metric XDI can provide. 																																										
Results	<p>Maximum Value-at-Risk (MVAR%) - 2030, 2050 and 2100</p> <p>The top MVAR% tables below list the highest MVAR result under each hazard for the RCP 8.5 and RCP 2.6 emission scenarios.</p> <p>Hong Kong Airport top MVAR% results 2030</p> <table border="1"> <thead> <tr> <th></th> <th>Riverine flooding</th> <th>Coastal inundation</th> <th>Forest fire</th> <th>Extreme wind</th> <th>Soil movement</th> <th>Surface water</th> </tr> </thead> <tbody> <tr> <td>RCP 8.5</td> <td>1.49%</td> <td>7.13%</td> <td>0%</td> <td>0%</td> <td>0.05%</td> <td>1.49%</td> </tr> <tr> <td>RCP 2.6</td> <td>1.47%</td> <td>4.83%</td> <td>0%</td> <td>0%</td> <td>0.05%</td> <td>1.47%</td> </tr> </tbody> </table> <p>Hong Kong Airport top MVAR% results 2050</p> <table border="1"> <thead> <tr> <th></th> <th>Riverine flooding</th> <th>Coastal inundation</th> <th>Forest fire</th> <th>Extreme wind</th> <th>Soil movement</th> <th>Surface water</th> </tr> </thead> <tbody> <tr> <td>RCP 8.5</td> <td>1.87%</td> <td>25.29%</td> <td>0%</td> <td>0%</td> <td>0.05%</td> <td>1.87%</td> </tr> <tr> <td>RCP 2.6</td> <td>1.69%</td> <td>14.23%</td> <td>0%</td> <td>0%</td> <td>0.05%</td> <td>1.69%</td> </tr> </tbody> </table>		Riverine flooding	Coastal inundation	Forest fire	Extreme wind	Soil movement	Surface water	RCP 8.5	1.49%	7.13%	0%	0%	0.05%	1.49%	RCP 2.6	1.47%	4.83%	0%	0%	0.05%	1.47%		Riverine flooding	Coastal inundation	Forest fire	Extreme wind	Soil movement	Surface water	RCP 8.5	1.87%	25.29%	0%	0%	0.05%	1.87%	RCP 2.6	1.69%	14.23%	0%	0%	0.05%	1.69%
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Hong Kong Airport top MVAR% results 2100

	Riverine flooding	Coastal inundation	Forest fire	Extreme wind	Soil movement	Surface water
RCP 8.5	4.26%	28.10%	0%	0.01%	0.05%	4.26%
RCP 2.6	2.14%	15.25%	0%	0.01%	0.05%	2.14%

- For both RCP emission scenarios, coastal inundation is by far the most significant hazard across all years, reaching ~28% MVAR by 2100.
- Riverine flooding is the next most significant hazard.
- The top MVAR% figures for riverine flooding and coastal inundation increase between 2030 and 2100 under both RCP scenarios.

XDI risk rating scale:

C	High Risk = %VAR >1.0%
B	Moderate Risk = 0.2% < % VAR < 1.0%
A	Low Risk = % VAR <0.2%

In this analysis, a representative asset is classed as becoming “High Risk” if its VAR% for a given year exceeds 1%. This is based on the USA Federal Emergency Management Agency (FEMA) thresholds for government insurance schemes, which highlight properties in an (historic) 1-in-100 flood zone, also known as “Rating A Zones”. The number of High Risk properties is the sum of all assets for which the VAR% is above 1% in a given year. The number of Moderate Risk Properties is the sum of all assets for which the VAR% is between 0.2% and 1%. **Using this scale, Hong Kong Airport is classed as a High Risk asset under both RCP 2.6 and RCP 8.5 scenarios.**

Heat Failure Probability

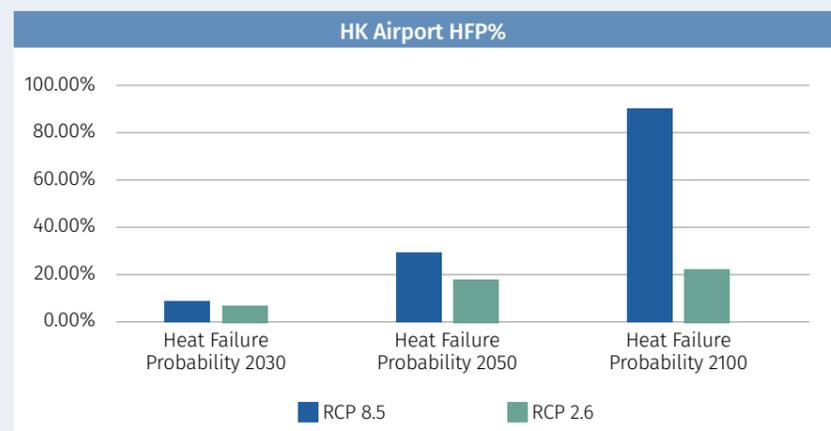
This section shows the top Heat Failure Probability (HFP%) results for this site under both RCP scenarios for the years 2030, 2050 and 2100. HFP refers to the risk of asset disruption due to extreme heat events. Note that for each RCP scenario, heat failure probability results are the same across all hypothetical assets, as these results only depend on:

- Heat threshold values - 99th percentile of maximum daily temperature (38.55°C for this site).
- Projected extreme heat event frequencies, which are the same for all assets within the same geographical area.

Hong Kong Airport heat failure probability % results

	Heat failure probability 2030	Heat failure probability 2050	Heat failure probability 2100
RCP 8.5	9.89%	30.62%	90.95%
RCP 2.6	7.88%	18.88%	24.16%

- Heat failure probability figures start at significant levels and increase sharply under both scenarios, by 2100 reaching as high as ~90% under RCP8.5 and ~24% under RCP2.6.



Futureproof

Tools offered	Risk Metrics																												
Asset class coverage	LE RE IN PE																												
Summary	<ul style="list-style-type: none"> • Combines econometrics regression techniques and machine learning to assess the financial impacts & prevalence of climate perils at asset, company and portfolio levels. • Model utilises a catastrophe modelling framework to calculate average annual loss, estimating asset-level financial impacts using machine learning on insurer claims and debt data, which allow asset specific projections for individual assets. • Company location information (exact addresses) is available to users for 50,000 companies globally, with the platform allowing the calculation of site-specific financial returns to investments in improving climate resilience. • Analysis includes insurance increase projections as well as repair and maintenance costs over time, for integration into discounted cash flow analysis of asset value. 																												
Level of analysis																													
Inputs required	<ul style="list-style-type: none"> • LE: ISIN • PE: Company name • RE & IN: Asset location 																												
Output format	Automated reporting template for single assets, companies and portfolios that provides estimated losses by year and location (at underlying asset/facility level). Includes a map view of assets using current risk and future change in risk, across individual perils and in aggregate across all perils.																												
Physical climate risk key metric	Frequency and severity of climate events that can impair asset value.																												
Financial impact key metric	Annual average damage in each year from the present until 2100 as % of asset value vs. national average, with loss breakdown by peril and time period.																												
Asia coverage	<ul style="list-style-type: none"> • LE: 44% (underlying detail not provided) • PE: 6,000 in Asia • RE & IN: Global 																												
Access																													
Climate scenarios	RCP 4.5 & RCP 8.5																												
Time horizon	Annually from present to 2100																												
Hazard coverage & resolution	<table border="1"> <tbody> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>30m²</td> <td>10m²</td> <td>6km²</td> <td>1km²</td> <td>6km²</td> <td>10m²</td> <td>6km²</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>6km²</td> <td>10m²</td> <td>6km²</td> <td>6km²</td> <td>6km²</td> <td>6km²</td> <td></td> </tr> </tbody> </table>								30m ²	10m ²	6km ²	1km ²	6km ²	10m ²	6km ²								6km ²	10m ²	6km ²	6km ²	6km ²	6km ²	
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6km ²	10m ²	6km ²	6km ²	6km ²	6km ²																								
Additional features offered/ in development	<ul style="list-style-type: none"> • Asset class coverage will be expanded to include fixed income – corporates and sovereigns by the end of 2021. • The tool also offers innovative coverage of residential and commercial mortgage-backed securities; however this is currently limited to the US. • Futureproof is considering expanding scenario coverage to RCP 2.6. 																												

Iceberg Data Lab	
Tools offered	Climate Impact
Asset class coverage	LE FI-C FI-S RE IN PE
Summary	<ul style="list-style-type: none"> • Portfolio level assessment tool using a sector-based approach that incorporates company turnover by country and sector for over 450 sectors and 100 geographical areas. • Analysis includes operations and upstream/downstream suppliers, scored across 50 countries & incorporates country and company adaptability with each company getting a physical risk score. These physical risk scores are then aggregated at portfolio level to enable the identification of the most at risk sectors. • Physical risk is estimated by multiplying sector sensitivity by geographical vulnerability: <ul style="list-style-type: none"> - Sectoral sensitivity is estimated for 450 typical activities based on the scoring of 6 vulnerability factors including water dependency, temperature sensitivity, energy supply sensitivity, transport dependency, ecosystem dependency and risk related to fixed infrastructure. - Geographical vulnerability at country level covers extreme events including the increase in intensity & frequency of natural disasters and the impact these have on operations.
Level of analysis	
Inputs required	<ul style="list-style-type: none"> • LE & FI: ISIN & market value • RE, IN & PE: revenue & adaptation measures
Output format	<ul style="list-style-type: none"> • Identification of portfolio climate risk per sector across 4 levels of risk (high/significant/limited/low), relative to size of financial exposure • Outlines the sectors exposed to higher physical risks and analysis of the physical risk origin • Access to company level risk exposure analysis • Provides portfolio risk exposures vs. benchmark
Physical climate risk key metric	<p>Physical risk score (0-100) is based on a combination of 3 factors:</p> <ol style="list-style-type: none"> 1. Exposure - climate scenarios and activity location 2. Sensitivity - business activities and upstream/operations/downstream 3. Adaptability - adaptability of country and company (with a resilience factor able to be applied to monitor a company's climate strategy)
Financial impact key metric	
Asia coverage	<ul style="list-style-type: none"> • LE: 62% (with stronger coverage for Japan and India, and lower for China and Hong Kong) • FI-C & FI-S: 34% (with slightly stronger coverage for China, Singapore & India, and lower for Indonesia & Philippines) • RE, IN & PE: Global
Access	
Climate scenarios	The tool assesses current vulnerabilities to changes in physical risks from climate change as experienced today, based on the intrinsic current activity of the company, with no reference to future time periods.
Time horizon	Near term
Hazard coverage & resolution	<p>Analysis factors in the impacts from extreme events including the increase in intensity & frequency of natural disasters, rising sea levels and difficult working conditions and overlays these with the following:</p> <ul style="list-style-type: none"> • Water dependency • Transport dependency • Infrastructure dependency • Temperature sensitivity • Energy supply sensitivity • Ecosystem dependency <p>Geographic vulnerability and adaptive capacity (at country level)</p>
Additional features offered/ in development	<ul style="list-style-type: none"> • Transition risk analysis also provided. • Enhancing analysis of adaptability of country and company. • Expanding coverage of listed equities & fixed income – corporate & sovereign issuers.

ISS	
Tools offered	Climate physical risk analysis
Asset class coverage	LE FI-C
Summary	<ul style="list-style-type: none"> • Analysis maps the underlying asset locations for listed companies, overlays current and future exposure to 6 climate hazards and then assesses the impact of these on company productivity and sales to identify the value at risk. • Value at Risk model is based on an internal Economic Value Added model that calculates company economic performance, looking at potential future share prices and company performance. • The methodology quantifies operational risks by considering the costs of repairing assets damaged and the loss of income incurred by business interruption due to extreme climatic events. Operational risks also include the costs associated with the impact of heat stress on labour productivity. Market risks quantify the revenue at risk due to sea level rise, combined impact of droughts and heat stress on agricultural productivity, temperature induced decrease in labour productivity and the effect of extreme temperatures on human health - using a direct correlation between a reduction in GDP and a subsequent equal reduction in a company's revenues. • Analysis includes where companies have production facilities or where they generate revenue. When mapping company assets, ISS does not differentiate between companies owning or leasing assets - all are covered, however clients cannot access underlying asset location data.
Level of analysis	
Inputs required	ISIN
Output format	<ul style="list-style-type: none"> • Annual expected impact for each hazard for each company, aggregated up to portfolio level. • Outputs include four key scores for companies, a heat map visualisation tool and spreadsheets with underlying hazard information for each company. • A useful output is the assessment of management capabilities and action on climate change which may be helpful when assessing companies with significant value at risk and identifying priorities for engagement.
Physical climate risk key metric	<ul style="list-style-type: none"> • Physical risk management score - shows if the company has considered physical risk in their risk management strategies (using CDP reporting data). Scores are only provided for companies that report to the CDP and specifically disclose how they are affected by physical risks, what strategies are in place and how they expect the costs will affect their balance sheet. • Physical risk score (0-100) – measures the total financial risk of an issuer relative to the sector.
Financial impact key metric	<ul style="list-style-type: none"> • Financial risk - current exposure and by hazards (absolute and % of revenue) - measures the expected annual financial impact of physical risks on a company and is a sum of the cost of repairs, cost to productivity, loss from business interruptions and loss from market risk. • Value at Risk (absolute & %) – measures the expected percentage change in company share price.
Asia coverage	<ul style="list-style-type: none"> • LE: Physical risk score = 83%, Risk management score = 18%, VaR = 73% (with slightly stronger coverage for Japan and lower for China) • FI-C: Physical risk score = 25%, Risk management score = 4%, VaR = 20% (with stronger coverage for Singapore & Korea, and slightly lower for China & Hong Kong)
Access	
Climate scenarios	RCP 4.5 & RCP 8.5
Time horizon	Current & 2050
Hazard coverage & resolution	         <p>100km²</p>
Additional features offered/ in development	<ul style="list-style-type: none"> • Currently adding sovereign analysis, also developing VaR for transition risk and scenario analysis capability, as well as providing much more detailed explanations in the company and portfolio reports. • A net zero scenario is currently under development.

Jupiter		
Tools offered	Climate Score Global (CSG)	ClimateScore Planning (CSP)
Asset class coverage	RE IN	
Summary	<ul style="list-style-type: none"> A portfolio screening tool to assess overall exposure to various climate-related hazards. Utilises machine learning, land use and elevation data combined with satellite, air, land and ocean borne sensors alongside large scale climate models (approx. 5,600 metrics for each location) to provide detailed hazard information that enables the identification of loss drivers and key exposures at asset level, potentially including supply chain linkages (reliant on the client providing this data). 	<ul style="list-style-type: none"> CSP offers a deep dive climate risk analysis for a company's critical facilities/single site assessments. The tool uses high resolution modelling through dynamic/statistical downscaling and can take into account local conditions such as flood defence systems. CSP is typically used to support risk mitigation and resilience planning for high value, critical assets such as a major power plant or large commercial facility.
Level of analysis		
Inputs required	Asset location, value, occupancy type and number of floors.	Similar to CSG, with more details on the specific asset and operational features of the facility in question.
Output format	Data tables and visualisation tools/dashboards with heat mapping, bubble charts and graphs of climate risk parameters for assets and portfolios, covering present day climate risk exposures and future rates of change.	Similar to CSG, with more details on exposures, risks and downtimes of the facility in question to help address solutions around risk mitigation, supply chain and resiliency planning.
Physical climate risk key metric	Hazard risk metrics - each offered at multiple customisable return periods and peril thresholds that reflect the locations of the asset at risk, with regional scores and benchmarks.	
Financial impact key metric	Site specific losses (based on return period) and portfolio level Average Annual Loss (\$/%) from key hazards.	
Asia coverage	Global	Analysis undertaken on demand for any site globally.
Access		
Climate scenarios	RCP 2.6, RCP 4.5 & RCP 8.5 SSP1-2.6, SPP2-4.5 & SSP5-8.5	
Time horizon	5 year periods until 2070	
Hazard coverage & resolution	 90m ²	 3m ²
Additional features offered/in development	Next release of updates due in approx. Q1 2022 will include a water stress/scarcity metric, top down analysis through a corporate entity model and business interruption loss calculations.	

Moody's ESG Solutions						
Tools offered	Real assets		Corporate risk scores		Sovereign & municipal bonds	
Asset class coverage	RE IN PE		LE FI-C		FI-S	
Summary	<ul style="list-style-type: none"> Single asset or portfolio analytics tool with the ability to drill down into a detailed analysis of hazard exposure for individual assets. Asset activities that are sensitive to water and heat stress have sensitivity adjustments incorporated. Allows evaluation of supply chain facility exposure to hazards, however does not automatically include upstream or downstream supply chain dependencies. 		<ul style="list-style-type: none"> Assesses company exposure across operations (to hazards & socioeconomic risk), supply chain (source country & resource demand) and markets (country of sales & weather sensitivity). 		<ul style="list-style-type: none"> Determines the percent and total exposure of the population, GDP (Purchasing Power Parity) and agricultural area to climate hazards. Sub-sovereign/city level data provides population weighted climate risk scores. 	
Level of analysis						
Inputs required	Asset location & activity type		ISIN		ISIN	
Output format	Single asset scorecard, aggregated portfolio reports and global exposures.		Aggregated portfolio and company level reports. Access to company facility level data for additional fee.		Country & city level hazard and climate risk scores and hazard impacts on key risk indicators.	
Physical climate risk key metric	Underlying hazard risk exposure data and normalised score for each hazard and asset.		Total portfolio and company level risk scores (operational risk vs. market and supply chain risk)		Hazard climate risk scores for sovereigns and sub sovereigns (at city level).	
Financial impact key metric	None		Climate-adjusted probability of default frequency metrics (available via Moody's Analytics)		Sovereign climate risk score (population, GDP & agricultural land)	
Asia coverage	Global coverage		LE: 61% (with significantly lower coverage for China) FI-C: 55% (with slightly stronger coverage for Singapore & Sth Korea & lower for China)		39 Asian countries	
Access						
Climate scenarios	RCP8.5					
Time horizon	2030-40 (10 year average)					
Hazard coverage & resolution	 90m ²	 90m ²	 25km ²	 Historical occurrence & frequency	 Watershed (5-50km ²)	 25km ²
Additional features offered/in development	<ul style="list-style-type: none"> Climate Adjusted EDF (Expected Default Frequency) product that assesses the credit impact of climate risk for corporates also available from Moody's Analytics. They also offer climate adjusted macroeconomic models, with plans for Climate Adjusted EDF's to expand to cover sovereigns. Offers transition risk analytic services. Additional features to be added include the expansion of hazards, time horizons and scenarios (2020-2100 & RCP4.5). A new platform providing physical, transition and governance data and analysis will be available in late 2021. Moody's ESG have recently entered into an agreement to acquire RMS, who also offer physical risk modelling. 					

Asia – fixed income (sovereign)

Provider Moody's ESG Solutions

Asset class Fixed income – Sovereign

Process **Moody's ESG Solutions provide a forward-looking view on exposure to six physical climate hazards: floods, heat stress, hurricanes & typhoons, sea level rise, water stress and wildfires.** There are several indicators underlying each climate hazard, meant to capture different dimensions of how this risk will manifest, as shown in the chart below. Absolute and relative change compared to a location-specific historical baseline are captured, leveraging projections to the 2030-2040 time period.

Heat stress	Floods	Hurricanes & typhoons
<ul style="list-style-type: none"> Energy demand Extreme heat days Extreme temperature 	<ul style="list-style-type: none"> 1-in-100-year flood Rainfall intensity Wet days (<10mm) Very wet days (>95th%) 	<ul style="list-style-type: none"> Cumulative wind speed
Sea level rise	Water stress	Wildfires
<ul style="list-style-type: none"> 1-in-100-year flood 	<ul style="list-style-type: none"> Current baseline water stress Current interannual variability Future water demand Future water supply Water demand change Water supply change 	<ul style="list-style-type: none"> Change in days with high wildfire potential Change in maximum wildfire potential Days with high wildfire potential Maximum wildfire potential

The distribution of climate hazards varies across a country, especially those with large areas, so Moody's ESG Solutions overlays this climate data with data on the locations of projected population, GDP (Purchasing Power Parity) and current agricultural areas to provide a view on how much economic activity and population will be exposed to increasing climate extremes. **The result is an overall physical climate risk score for sovereigns, as well as granular underlying data unpacking the drivers of this risk.** Similar data and models are leveraged to provide population-weighted physical risk scores for global sub-sovereigns.

Key challenges

- Not all land use types are relevant from an economic standpoint
- Climatic zones vary widely from one region to another and not all are populated

Solutions

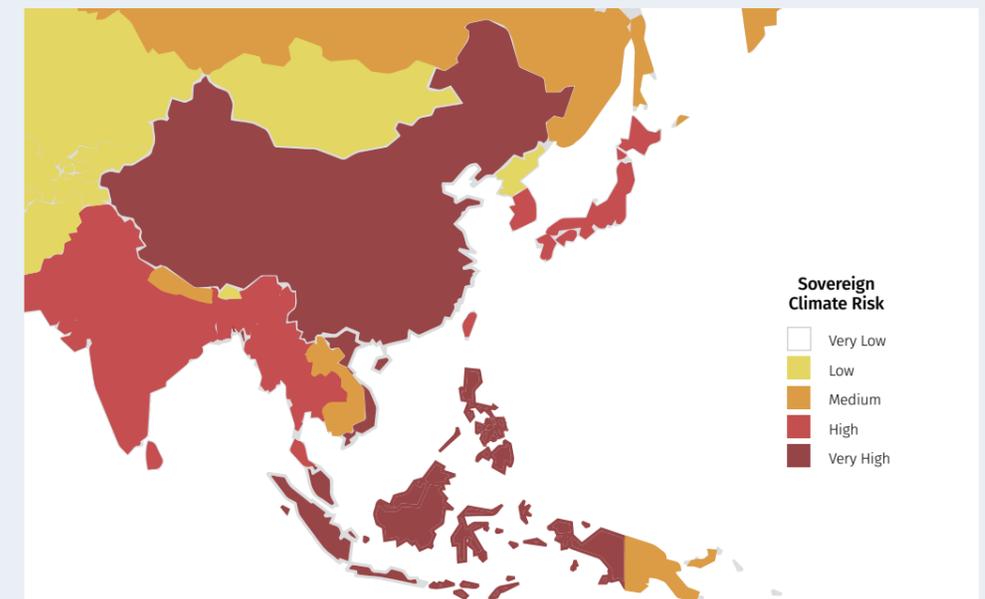
- Granular socioeconomic data mapped to granular climate risk data
- 42 metrics for each sovereign (percent and total GDP, population and agriculture exposed to each hazard N.B. Flooding data and extreme precipitation data together make up the Flood score, but we provide metrics for these dimensions separately).

Results The results of the sovereign analysis include one Sovereign Physical Climate Risk Score for each sovereign in the Moody's ESG Solutions' global dataset; as well as a hazard score for each of the six hazards and the 42 underlying metrics covering the percent and total of population, GDP (PPP) and agricultural area exposed to each hazard. The dataset includes 39 countries across Asia with hazard level exposure varying by country.

Key results include:

- The Philippines emerges with the highest risk score followed by China.
- Larger economies tend to have a larger total sum of people and capital exposed to hazards, while smaller nations tend to have a larger percent of their assets exposed. Both types of exposure have significant implications for nations, economies and supply chains.
- Approximately 60% of Singapore's GDP (PPP) and 39% of its population are projected to be at high risk of floods, which suggests the potential for significant impacts on commutes and supply chains, in addition to asset level damage.
- In the Philippines, 77% of the population and 80% of the GDP (PPP) is projected to be at risk of hurricanes which can exacerbate other challenges and require significant rebuilding expenses.
- Meanwhile 49% of China's GDP (PPP) will be at high risk of flooding by 2040, while 41% of its population will be at risk. This equates to about US\$21 trillion and 547 million people.

Flood risk ratings across Asia – with the darkest colours showing the areas most prone to flooding risk

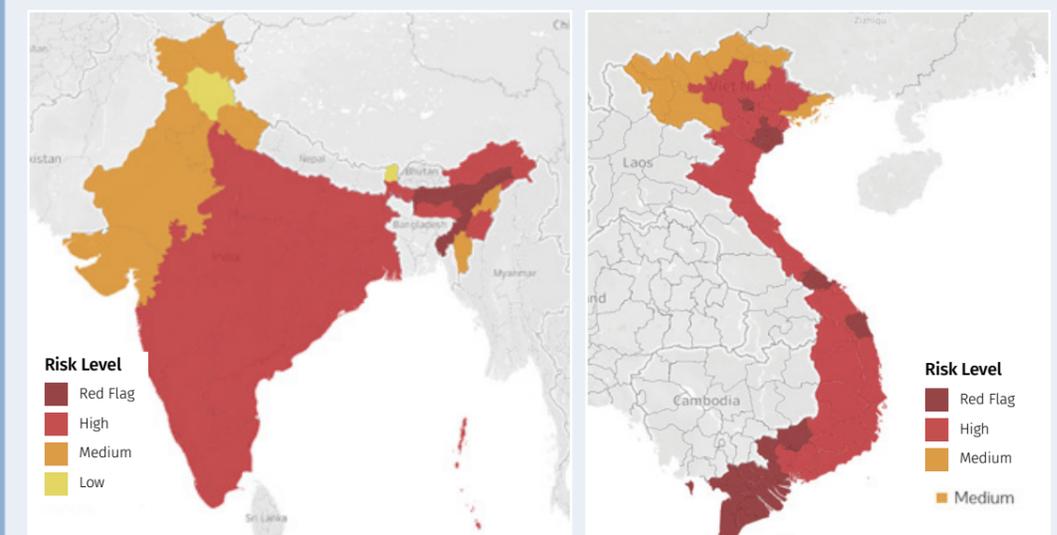


Sub sovereign flood risk

Floods	% Population exposed	% GDP exposed	% Agricultural land exposed
India	52	75	33
Vietnam	67	85	46
Philippines	50	79	33
Indonesia	56	84	43

This data can also be broken down to sub-sovereign boundaries to provide a more detailed view on the distribution of risk across a nation, weighted based on the concentrations of populations. The maps below show that flood risk is not distributed evenly across India or Vietnam and this understanding can inform more targeted resilience investment in the most exposed regions.

Distribution of flood risk in India and Vietnam, based on population-weighted sub-sovereign scores



MSCI ESG Research	
Tools offered	Climate Value at Risk (Climate-VaR)
Asset class coverage	LE FI-C RE
Summary	<ul style="list-style-type: none"> • Company level analysis that utilises business activity (covering NACE Rev. 2/88 sectors) and facility type to assess asset vulnerability against climate-related hazards. • Incorporates the potential business interruption and asset damage caused by hazards across an average and worse-case scenario, with the expected costs calculated as a result of these vulnerabilities x hazard x exposure of asset. • Differentiates between acute and chronic modelling, with acute risks more localised (and less sector-based vulnerabilities due to the vast difference across regions). • Includes all company assets, regardless of ownership. • Does not incorporate company level resilience however aspects of national and state resilience factors are refactored into the model.
Level of analysis	
Inputs required	<ul style="list-style-type: none"> • LE: ISIN & market value of investment • RE: Asset location, value, characteristics
Output format	Climate VaR report for portfolio and individual companies that includes a map of company facilities, a summary of the top exposed locations (by hazard) and underlying calculations for key hazards.
Physical climate risk key metric	
Financial impact key metric	<p>Climate Value at Risk (CVaR) derived from the potential loss and frequency of loss to create average risk contribution in US\$, projected over 15 years. CVaR is calculated by discounting a future time series of costs or profits and the change in asset valuation under scenarios to the present value and dividing this value by the current company value of the company.</p> <p>N.B. CVaR is both a risk and opportunity indicator, as physical climate change can create costs and/or generate revenues for a company's facilities, depending on its exposure and vulnerability to extreme weather events.</p>
Asia coverage	<ul style="list-style-type: none"> • LE: 70% (with stronger coverage for Japan and lower for China) • FI-C: 77% (with country coverage mirroring the benchmark) • RE: Global
Access	
Climate scenarios	RCP 8.5 (upper & lower certainty bands)
Time horizon	Detailed modelling until 2035, then extrapolated out to 2080/2100.
Hazard coverage & resolution	 11km ² 90m ² 56km ² 460m ²
Additional features offered/ in development	<ul style="list-style-type: none"> • MSCI offers an aggregated Climate VaR score that also covers transition risk that factors in MSCI direct emissions, electricity use, value chain and technology opportunities. The Climate VaR analysis also includes a warming potential metric to indicate the company's contribution to global warming. • The Climate VaR company summary also includes a summary of a company's contribution to rising temperatures. • MSCI are updating their damage functions, with additional physical risk models being introduced to cover more scenarios and wildfires being added to the hazards covered.

MSCI All Countries Asia incl. Japan index - Listed equities																																																																																																																																																																													
Provider	MSCI ESG Research (MSCI)																																																																																																																																																																												
Asset class	Listed equities																																																																																																																																																																												
Process	<p>MSCI established the current level of climate related physical risk from nine hazards on companies' facilities and modelled how that may change in the future under an aggressive physical scenario (in line with RCP 8.5). This 'aggressive scenario' represents a severe future physical climate and is derived from the 95th percentile of the cost distribution and explores the most serious downsides risk within the distribution tail. MSCI has also translated the physical risk from these hazards into detailed costs or opportunities for each company facility.</p>																																																																																																																																																																												
Results	<p>Climate VAR portfolio analysis</p> <p>A review of the results of MSCI's scenario analysis for the MSCI AC Asia incl. 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Top asset locations at risk

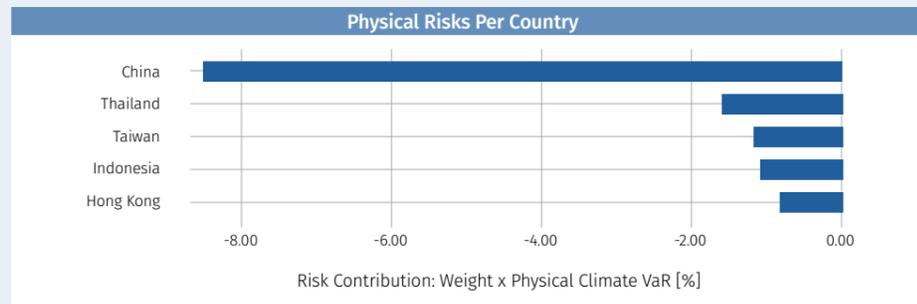
The map below illustrates the most exposed company facilities from the portfolio that are at risk from extreme weather hazards under the chosen physical risk scenario.



#	Location	Company Name	Risk Type	Total Discounted Costs (mUSD)
1	Suzhou Shi, China	SAMSUNG ELECTRONICS CO.,LTD	Coastal Flooding	-44,562.56
2	Austin, United States	SAMSUNG ELECTRONICS CO.,LTD	Extreme Heat	-27,977.94
3	China	HUANENG POWER INTERNATIONAL, INC.	Tropical Cyclones	-24,007.43
4	Xuhui, China	SUN HUNG KAI PROPERTIES LIMITED	Coastal Flooding	-19,719.99
5	Tanggu, China	SAMSUNG ELECTRONICS CO.,LTD	Coastal Flooding	-19,062.15

Key physical risk countries

The content below shows country level physical climate risk, with aggregated values illustrating the most exposed countries of the portfolio to physical climate risk and the most exposed facilities within these countries.



#1 PHYSICAL RISK COUNTRY: CHINA

This section displays detailed information on physical climate risk for a country with holdings from the portfolio. Displayed on the right hand side is the predicted cost from this country's physical climate risk contributions to the portfolio as well as the physical Climate Value-at-Risk contribution.

Climate VaR Contribution Physical Scenarios
-8.43%

ASSET LOCATIONS AT RISK

The country map below displays the locations with the greatest physical climate risk from impacts related to the eight extreme weather hazards modeled by MSCI ESG Research until 2100. The locations are numbered and colored; this corresponds to the table below and the hazard type. Please see the legend to understand the color coding.



TOP EXPOSED LOCATIONS

The table below displays the locations with the greatest physical climate risk from impacts related to the nine extreme weather hazards modelled by MSCI ESG Research over the next 15 years. The locations are numbered, and this corresponds to the map above. The monetary impact from the extreme weather hazard for the next 15 years on this location is also displayed.

#	Location	Company Name	Risk Type	Total Discounted Costs (mUSD)
1	Suzhou Shi, China	SAMSUNG ELECTRONICS CO.,LTD	Coastal Flooding	-44,562.56
2	China	HUANENG POWER INTERNATIONAL, INC.	Tropical Cyclones	-24,007.43
3	Xuhui, China	SUN HUNG KAI PROPERTIES LIMITED	Coastal Flooding	-19,719.99
4	Tanggu, China	SAMSUNG ELECTRONICS CO.,LTD	Coastal Flooding	-19,062.15
5	Shenzhen City, China	ANHUI CONCH CEMENT COMPANY LIMITED	Coastal Flooding	-18,154.21

MunichRe

Location Risk Intelligence Platform – Climate Change Edition																								
Tools offered	Location Risk Intelligence Platform – Climate Change Edition																							
Asset class coverage	RE LE																							
Summary	<ul style="list-style-type: none"> Insurance-based physical damage metrics for single sites and portfolios in which climate-related hazard scores are combined with average annual loss (AAL) data. The AAL information is a central piece of the proprietary Munich Re pricing schemes and is based on the world's largest natural catastrophe loss database. Risk scores are generated from their NATHAN catastrophe modelling system. The analysis does not consider any resilience measures made to an asset or the type of asset. 																							
Level of analysis																								
Inputs required	Asset location																							
Output format	The output generates peril specific evaluations across the hazards covered, with a visualisation tool showing clusters of risk, grid and heatmapping of assets as well as regions at risk.																							
Physical climate risk key metric	Under development																							
Financial impact key metric	Under development																							
Asia coverage	Global																							
Access																								
Climate scenarios	RCP 2.6, RCP 4.5 & RCP 8.5																							
Time horizon	Present, 2030, 2050, 2100																							
Hazard coverage & resolution	<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>5km²</td> <td colspan="2">30m²</td> <td colspan="4">25km²</td> </tr> <tr> <td colspan="8">RCP 4.5 & RCP 8.5 only</td> </tr> </table> <p>Note: Additional hazards are covered under natural catastrophe modelling however this does not include an overlay of climate scenarios.</p>									5km ²	30m ²		25km ²				RCP 4.5 & RCP 8.5 only							
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Additional features offered/ in development	<ul style="list-style-type: none"> Analysis also includes access to the climate expert mode (accessed via API) including the parameters used underneath for the climate stress indexes i.e. annual maximum temperature, fire season length etc. with detailed statistical attributes like mean, standard deviation etc. allowing highly skilled users to tweak parameters and attributes for different scenarios and exposures to enable customised analysis. Climate Change Edition can be supplemented with the functions of Munich Re's Natural Hazards Edition and additional risk modules to generate an assessment that covers risk assessments calculated on the basis of past events. Currently working on integrating financial risk scores for climate scenarios and working on an overall hazard score that sums up risk exposure across all hazards. They are planning to increase the projection year frequency covered and are working on the ability to filter the most at risk assets across various hazards when looking at multi asset portfolios. 																							

Ortec Finance		
Tools offered	Climate MAPS	Climate PREDICT
Asset class coverage	SAA	RE IN
Summary	<ul style="list-style-type: none"> • Top-down risk approach for assessing broad economic and multi-asset portfolio exposure to physical risks. • Identifies how risk and return profiles may be impacted across different climate scenarios and how this can be fed into strategic asset allocation processes. • Utilises Cambridge E3ME to model relationships between the economy, energy, emissions and climate to capture networked impacts, alongside a stochastic model in which economic scenarios translate climate adjusted GDP expectations. • Analysis looks at slow onset physical risk and models temperature rise impacts on labour, land and industrial productivity. It separately models extreme weather events and then calculates damages from perils and projected GDP impact. 	<ul style="list-style-type: none"> • Quantifies future physical risk exposures and potential losses for real assets. • Considers macroeconomic level impacts such as urbanisation, impacts on GDP and the contribution of climate change to physical risk exposures. • Utilises historical data on extreme weather, looking at country, region and city level trends, (covering 150 countries and 1800 cities) and their underlying risk to extreme weather (including climate drivers of these). • Identifies the number of extreme weather events, direct losses on a per country basis by peril classes and the translation of these direct losses into GDP impacts.
Level of analysis		
Inputs required	Sector & country breakdown by asset class	Asset location & value.
Output format	<ul style="list-style-type: none"> • Asset class and sector/region heat maps showing value at risk. • Access to dashboard with assumptions and inputs that are used to feed into key model decisions. 	<ul style="list-style-type: none"> • Interactive mapping tool that provides heat maps of relative risk intensity and reports that provide insights across key metrics and hazards. • Distils large amounts of data for the most at risk assets for further analysis and distinguishes between physical risks from climate change vs. urbanisation.
Physical climate risk key metric		<ul style="list-style-type: none"> • Projected future extreme weather data by hazard type, location and year.
Financial impact key metric	<ul style="list-style-type: none"> • Annual climate-adjusted risk-return metrics for GDP, inflation, interest rates, funding ratios, net contribution rates across asset classes, sectors and benchmarks. • Total climate risk broken down into the individual risk drivers e.g. extreme weather which allows user to prioritise climate risk mitigation action per region and sector. 	<ul style="list-style-type: none"> • Direct loss (insured and uninsured) (\$) categorised by type of extreme weather, location and year (annual up to 2100). • GDP impact (\$) and vulnerability ratio (direct loss/local GDP per capita) that shows the resilience of local communities to extreme weather events.
Asia coverage	China, India, Indonesia, Japan, Malaysia, Singapore, South Korea & Taiwan.	All countries in Asia.
Access		
Climate scenarios	RCP 2.6, RCP 4.5, RCP 6.0 & RCP 8.5, with customised scenarios also available.	RCP 2.6 & RCP 8.5, with customised scenarios also available.
Time horizon	Up to 2060, with up to 2100 available on request.	Annual to 2100
Hazard coverage & resolution		
	Climate MAPS: Country & sector level analysis Climate PREDICT: City, country & regional level analysis	
Additional features offered/ in development	<ul style="list-style-type: none"> • Also offers a transition risk assessment at the strategic asset allocation level, with additional climate and ESG solutions including Climate Align, Climate Signs and ESG Radar. • Planned developments for Climate MAPS include the addition of NGFS scenarios, integration of physical risk impacts on food supply (and other supply inflation metrics), debt dynamics and enhancing their approach to calculating the volatility of asset returns. 	

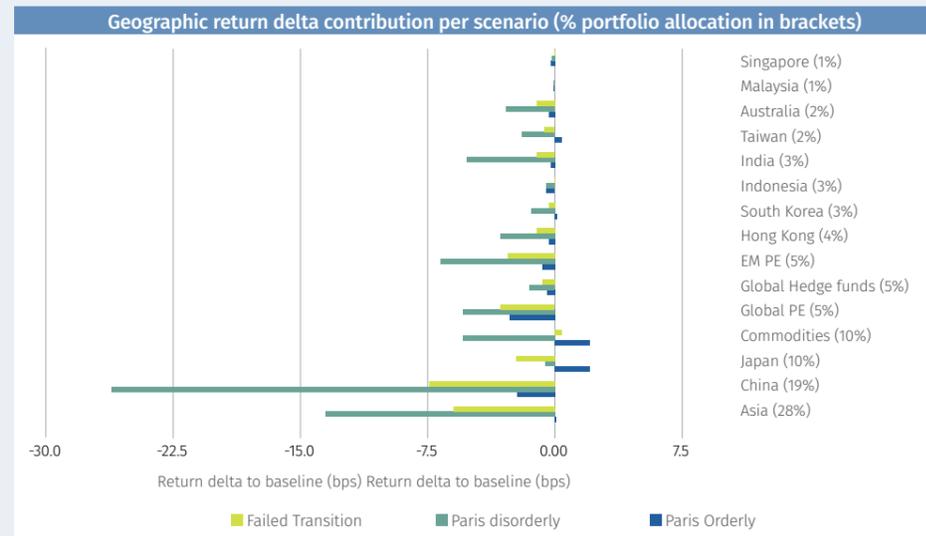
Multi-Asset Portfolio – Strategic asset allocation¹¹

Provider	Ortec Finance																																																																																						
Asset class	Strategic Asset Allocation																																																																																						
Process	<p>Asset class/country allocation of the multi-asset portfolio:</p> <p>For each climate scenario a full stochastic run was used to provide insights on both median outcomes and tail risks.</p>																																																																																						
Results	<p>Fund level results</p> <p>The modelling indicates that climate impacts across all scenarios lead to lower returns, and that the distribution of returns also materially shifts downward. This is mainly driven by physical risk impacts, either being priced-in by market expectations, or in direct impacts emerging later.</p> <p>The coloured lines in the graph above show the median cumulative returns relative to the baseline with shaded areas corresponding to the coloured lines.</p> <table border="1"> <thead> <tr> <th colspan="11">Quantified Risk Return Impact for Total Fund Value</th> </tr> <tr> <th rowspan="3">Benchmark portfolio</th> <th colspan="10">Annualised relative measures (compared to baseline)</th> </tr> <tr> <th colspan="2">2021-2025</th> <th colspan="2">2026-2030</th> <th colspan="2">2021-2030</th> <th colspan="2">2030-2040</th> <th colspan="2">2021-2060</th> </tr> <tr> <th>Median</th> <th>5% VaR</th> </tr> </thead> <tbody> <tr> <td>Baseline (absolute measure)</td> <td>6.2%</td> <td>-2.2%</td> <td>4.9%</td> <td>-3.4%</td> <td>5.6%</td> <td>0.4%</td> <td>6.2%</td> <td>0.7%</td> <td>6.2%</td> <td>3.3%</td> </tr> <tr> <td>RCP 2.6 (orderly transition)</td> <td>-0.2%</td> <td>-0.2%</td> <td>0.1%</td> <td>0.1%</td> <td>0.0%</td> <td>-0.1%</td> <td>-0.1%</td> <td>0.0%</td> <td>-0.2%</td> <td>-0.2%</td> </tr> <tr> <td>RCP 2.6 (disorderly transition)</td> <td>-2.3%</td> <td>-2.4%</td> <td>0.9%</td> <td>0.9%</td> <td>-0.7%</td> <td>-0.8%</td> <td>-0.1%</td> <td>-0.1%</td> <td>-0.3%</td> <td>-0.3%</td> </tr> <tr> <td>RCP 8.5 (BAU)</td> <td>0.0%</td> <td>0.0%</td> <td>-0.5%</td> <td>-0.5%</td> <td>-0.3%</td> <td>-0.3%</td> <td>-2.4%</td> <td>-2.3%</td> <td>-1.0%</td> <td>-1.0%</td> </tr> </tbody> </table> <p>The table above shows the non-cumulative, annualized median returns and lower 5% VaR (i.e. 5% of results from the stochastic runs with the worst outcomes) for a selection of 5 year, 10 year and 40 year periods. The baseline row shows absolute returns, whilst the climate scenario returns are expressed as deltas to the respective baseline. Notable impacts result in the next 5 years in a disorderly transition scenario from key transition-policy drivers causing significant market dislocations, this scenario does however allow for some recovery unwinding a proportion of market overreaction in the second half of the 2020s. The failed transition scenario assumes little drastic policy action and examines potential physical risk impacts resulting.</p>	Quantified Risk Return Impact for Total Fund Value											Benchmark portfolio	Annualised relative measures (compared to baseline)										2021-2025		2026-2030		2021-2030		2030-2040		2021-2060		Median	5% VaR	Baseline (absolute measure)	6.2%	-2.2%	4.9%	-3.4%	5.6%	0.4%	6.2%	0.7%	6.2%	3.3%	RCP 2.6 (orderly transition)	-0.2%	-0.2%	0.1%	0.1%	0.0%	-0.1%	-0.1%	0.0%	-0.2%	-0.2%	RCP 2.6 (disorderly transition)	-2.3%	-2.4%	0.9%	0.9%	-0.7%	-0.8%	-0.1%	-0.1%	-0.3%	-0.3%	RCP 8.5 (BAU)	0.0%	0.0%	-0.5%	-0.5%	-0.3%	-0.3%	-2.4%	-2.3%	-1.0%	-1.0%								
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11. Hypothetical global multi-asset portfolio with Asian tilt covering listed equities, fixed income, real assets and alternatives.

Deeper insights

When seeking to understand portfolio impacts, perhaps with a view to mitigating actions, it is helpful to consider the exposures to different countries and sectors. The chart below looks at the contribution different countries' portfolio exposures make over the next 10 years, with a view to understanding the major contributors and those that contribute more than their fair share.



Climate change will impact sectors differently, as illustrated by the sector/country impact matrix below. The matrix compares (mainly physical risk driven) impacts in the failed transition after 20 years for a selection of sectors in Asian countries, plus US, Europe and World for reference. Ortec Finance clients have access to the figures behind these types of tables, the numbers here have been redacted.

Return impact by geography/sector	China	Singapore	Indonesia	Malaysia	India	South Korea	Japan	Europe	US	World
Coal & manufactured fuels	Orange	Orange	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
Cons Disc	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
Cons Staples	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
Education	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
Financials	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
Forestry	Yellow	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange
Fossil-based utilities	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
Health	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange
Industrials	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
IT	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange
Materials	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
Nuclear	Yellow	Orange	Orange	Orange	Yellow	Orange	Red	Orange	Orange	Orange
Oil and Gas	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
Other Low-Carbon & Biobased Electricity	Orange	Red	Yellow	Orange	Orange	Orange	Orange	Orange	Orange	Orange
Public Administration and Defense	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange
Real Estate	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange
Telecom	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange
Water supply	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Green	Yellow
Wind and Solar	Orange	Yellow	Green	Green	Orange	Orange	Red	Yellow	Orange	Yellow

Planetrics

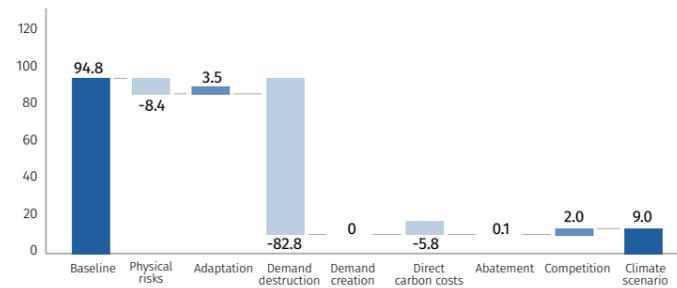
Planetrics									
Tools offered	Planetview								
Asset class coverage	LE FI-C FI-S RE PE								
Summary	<ul style="list-style-type: none"> A hybrid bottom up/top down approach that combines hazard impacts and adaptation analysis at country level with macroeconomic impacts from physical risks (labour and land productivity and supply/demand elasticities) at sector and country level, covering individual assets and portfolios. Methodology follows the hazard x exposure x vulnerability approach and covers climate scenarios, economic shocks (direct impacts incl. chronic and acute damages; and indirect impacts including changes to sectoral composition and GVA), asset value streams (exposure - location and market, adaptation, competition) and financial implications (financial impacts - change in earnings, default risk). Chronic physical risks are estimated using a Computational General Equilibrium (CGE) economic model that calculates the interactions between sectors (purchases of intermediate goods) and countries (trade), with outputs focused on quantifying the impact on future profitability and company/asset valuation. Models future cash flows across scenarios and interprets climate impacts as differences against a baseline scenario, offering slightly different approaches across different asset classes e.g. for corporate bonds, valuation is assessed by translating climate risk exposure into changes in credit risk. Covers property and private equity assets using sector as a proxy. Adaptation measures are integrated, however supply chain interruptions from physical risks are not covered in the standard modelling. 								
Level of analysis									
Inputs required	<ul style="list-style-type: none"> LE & FI: ISIN RE: Asset location (country), floor area, investment, property type PE: Asset location (country), sector 								
Output format	Insights at group, portfolio, sector, region and company level, with outputs showing sector risk drivers to allow focus areas, segment/sector deep dives to highlight variations in impacts across underlying companies, full book stress tests and data integration using Planetrics' primary data via API feed.								
Physical climate risk key metric									
Financial impact key metric	<ul style="list-style-type: none"> RE: Impact on property value LE: Impact on company value (DCF of future demand & cost impacts) FI-C: Impact on value, change in probability of default and associated change in corporate bond valuation FI-S: Impact on sovereign value PE: Impact on value 								
Asia coverage	<ul style="list-style-type: none"> LE: 99% (with country coverage mirroring the benchmark) FI: 60% (with country coverage mirroring the benchmark) RE: Proxy approach that is based on user input PE: Proxy approach that is based on user input 								
Access									
Climate scenarios	NGFS, IEA, Greenpeace, IIASA, BP, Shell, PRI IPR & CBES scenarios available, with an option to customise to enable integration of technology and policy uncertainties.								
Time horizon	2020-2050								
Hazard coverage & resolution	<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Country level loss using 1km² data</td> <td>Country level loss using 10km² data</td> <td colspan="2">Regional level impacts using 55km² data</td> </tr> </table>					Country level loss using 1km ² data	Country level loss using 10km ² data	Regional level impacts using 55km ² data	
Country level loss using 1km ² data	Country level loss using 10km ² data	Regional level impacts using 55km ² data							
Additional features offered/ in development	<ul style="list-style-type: none"> Also covers transition risks, and offer bespoke services on customisable scenarios, adjustments to modelling frameworks, internal education and capacity building, data gap filling and collection, and model deployment on internal systems. Planned developments include the integration of supply chain interruptions from physical hazards. 								

J.P. Morgan Asia Credit Index Core - Fixed income (corporate)

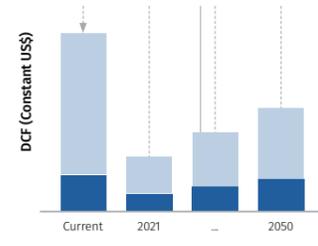
Provider	Planetrics
Asset class	Fixed income – corporate

Process
The Planetrics model determines the overall financial impacts for the various assets under each scenario. This is done by discounting the cash-flow estimates from the asset modelling component to net present value (NPV) terms, as illustrated in the graphs below. This fundamental approach forms the basis of valuation calculations for each asset class; however, there are some additional asset-class-specific modelling steps required for fixed income.

Change in company performance



Using current policies as baseline assumes that markets and risk analysis today does not capture climate risks, consistent with a stress test



The graphs above show the results of discounted cash-flow modelling that translate annual profit impacts into changes in valuation.

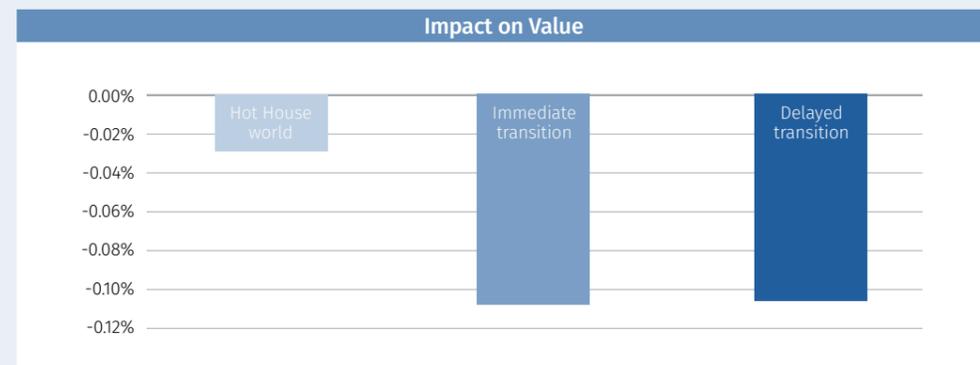
Modelling approach for fixed income - corporate

Corporate bond impacts are estimated by translating changes in equity valuations to changes in default risk and bond valuations. First, each issuer's Altman Z-score is calculated under climate scenarios and the baseline scenario based on changes in company income and balance sheet position changes calculated from the listed equities analysis. Next, changes in credit rating are estimated based on changes in the Z-scores, including potential changes within a given credit rating band. Then, changes in credit rating are translated into changes in probability of default based on empirical relationships between credit ratings and default risk. Finally, the expected payments associated with each corporate bond are discounted back to present value terms under each scenario to calculate changes in bond valuations.

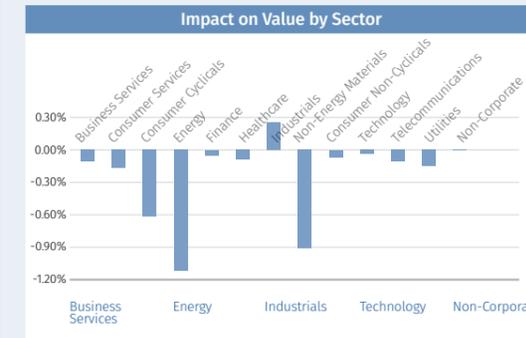
Results

Portfolio Level Impacts (fixed income portfolio, including credit and sovereigns)

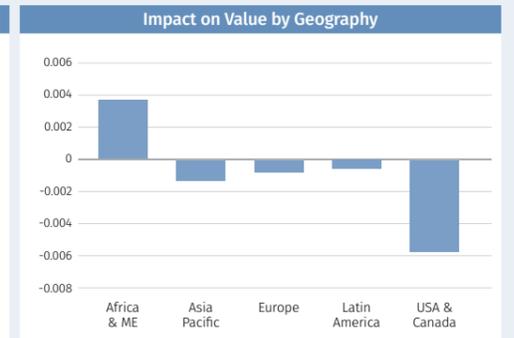
Residual net present valuations are accounting for the impact of physical impact, adaptation, demand destruction, demand creation, direct carbon costs, abatement, market impacts, sovereign asset class impacts, and real estate asset class impacts.



Impact on Value by Sector

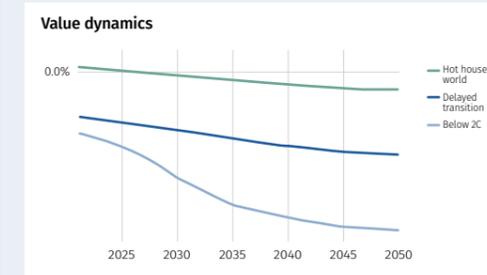


Impact on Value by Geography



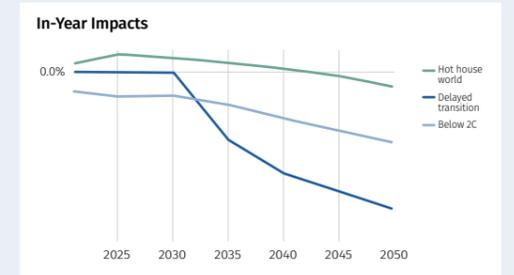
Value Dynamics

This assesses rollover risk, by estimating the impact of climate risk factors on a bond's valuation as if it had its present characteristics but was re-priced in the year in question.



In-Year Impacts

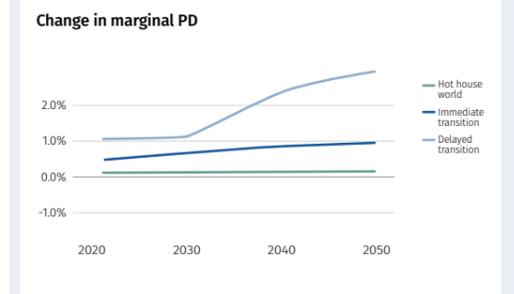
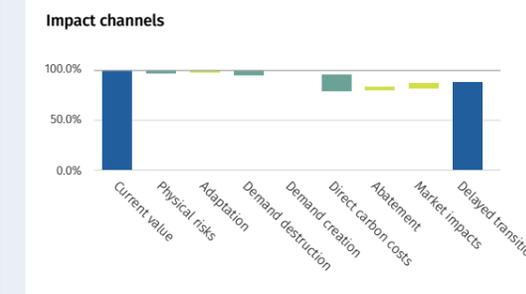
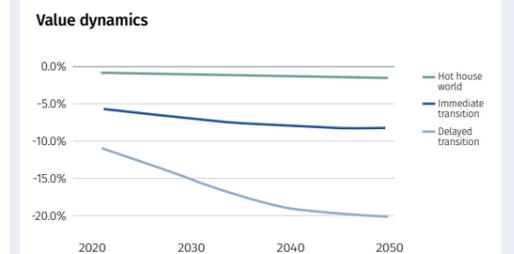
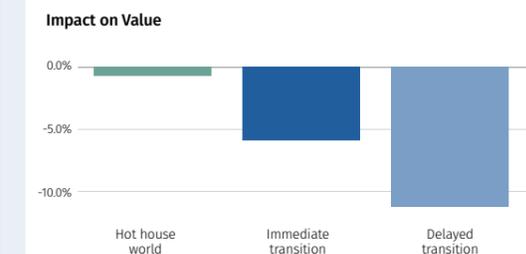
This assesses the impacts of climate risk factors on default probability (corporate debt) in the year in question. Model assumes this change applies in all years for the life of the bond in question, based on its present characteristics.



Corporate Credit Example - Reliance Industries Limited 4.875% 10-February-2045

This is including point in time default probability relative to baseline, using Planetrics' Altman ratings-based credit risk modelling approach.

Reliance Industries Limited 4.875% 10-FEB-2045 (USY72570AM99)



S&P Trucost							
Tools offered	Physical Risk Solution						
Asset class coverage	LE	FI-C	FI-S	RE	IN	PE	
Summary	<ul style="list-style-type: none"> Generates asset, company and portfolio level risk profiles and scores by mapping weather related hazards, quantifying asset exposures to these and adjusting for risk sensitivity/materiality of water, labour and capital intensity vulnerabilities depending on company activity on site. Access to asset level data for companies that captures local infrastructure dependencies. 						
Level of analysis							
Inputs required	<ul style="list-style-type: none"> LE: ISIN & value FI-C & FI-S: ISIN & value RE & IN: Location of asset, ownership, value, type of asset PE: Capital IQ identifier, ownership, value, type of asset 						
Output format	Asset, company and portfolio level dashboard covering key hazards & scores, with outputs including data downloads and asset level mapping tools. For certain assets, multiple layers of analysis are available including property profiles, location and claims, work histories, discoveries and milestones, capital costs, geology and subcontractors.						
Physical climate risk key metric	<ul style="list-style-type: none"> Raw Climate Risk Score (1-100) and Sensitivity Adjusted Risk Score (1-100) generated across each hazard and provided at asset level where available. For companies, S&P then generate a composite score across all of the hazards (using underlying asset level data and country level proxies derived from headquarters location and geo-revenue) to give an indication of overall exposure. 						
Financial impact key metric	Under development – metric will integrate macroeconomic impacts, productivity losses, revenue at risk and asset impairment.						
Asia coverage	<ul style="list-style-type: none"> LE: 63% (with lower coverage for China) FI: 63% (with country coverage mirroring the benchmark) PE: All assets can be modelled and aggregated to company risk scores. 						
Access							
Climate scenarios	RCP 2.6, RCP 4.5 & RCP 8.5						
Time horizon	2020, 2030 & 2050						
Hazard coverage & resolution	 10km ²	 1km ²	 30km ²	 100km ²	 River basin	 100km ²	 100km ²
Additional features offered/ in development	<ul style="list-style-type: none"> Physical risk analysis also covers loans, project finance and mortgage portfolios. Transition risk analysis also available for carbon earnings at risk and Paris alignment. Currently developing a methodology to quantify value at risk associated with physical risk exposures capturing balance sheet and cash flow impacts as well as a supply chain physical risk methodology to identify country exposure in company supply chains. 						

South Pole		
Tools offered	Climate Risk Assessment Service – Risk screening	Climate Risk Assessment Service – In-Depth Assessment
Asset class coverage	LE	FI-C RE PE
Summary	<ul style="list-style-type: none"> Top-down risk screening service that provides a country and sector-based risk assessment, using publicly available information on sector and geographic distribution of underlying assets/operations. In-depth assessment into areas of concentrated risk, offering a sub-regional assessment (at local level) of subcategories of physical risks. The model focuses on the vulnerability of countries including economic impacts and industry specific analysis, with damage functions downscaled from global to country level. Follows the hazard x vulnerability x exposure approach - using a damage function that measures the loss of revenue generating capabilities of economies due to climate change impacts to assess hazard impacts then integrating country and industry vulnerabilities and identifying geographic areas of operation (based on revenue and asset location by country). Analysis estimates the financial impacts of risks under a variety of scenarios and generates a final risk score for each position in the portfolio. The mapping of companies utilises the dominant sector as a proxy, with diversified companies allocated 2-3 activity types. 	
Level of analysis		
Inputs required	<ul style="list-style-type: none"> LE & FI-C: ISIN RE: sector & country PE: sector & geography 	<ul style="list-style-type: none"> LE & FI-C: ISIN RE: Asset location
Output format	Portfolio screening outputs include risk score, weight, sector or geography metric and benchmarking against other portfolios or indices.	The in-depth assessment provides a comprehensive spreadsheet to allow for internal mapping and an optional detailed risk report including additional analysis, tableau dashboard and workshop to discuss results.
Physical climate risk key metric		The In-depth assessment provides hazard and asset class specific metrics e.g. number of days above a temperature threshold or return period of extreme events.
Financial impact key metric	Potential Revenue at Risk (PRR) & company risk scores.	
Asia coverage	<ul style="list-style-type: none"> LE: 41% (with an additional 5% of issuers covered utilising the company's country of domicile as a proxy and 54% using the company's geographic breakdown of revenue). FI-C: 28% (with an additional 62% of issuers covered utilising the company's country of domicile as a proxy and 10% using the company's geographic breakdown of revenue). RE & PE: Global 	
Access		
Climate scenarios	RCP 2.6, RCP 4.5 & RCP 8.5	
Time horizon	2030-2100	
Hazard coverage & resolution	Top down risk screening uses temperature as a proxy for all climate related hazards.	    25km ²     5km ² 1km ²
Additional features offered/ in development	Currently developing analysis for additional hazards including landslides and snow. Also increasing quality of damage functions to make them explicit for the underlying asset.	

SwissRe	
Tools offered	Framework for assessing physical climate risk
Asset class coverage	RE IN
Summary	<ul style="list-style-type: none"> Offers portfolio screening, climate hot spot deep dives and development of mitigation strategies utilising the catastrophe modelling used in underwriting for clients. Approach looks to quantify the expected damage from an event to a building at risk, with analysis integrating climate projections, hazard/catastrophe models, exposure resilience, and risk mitigation/transfer opportunities, covering: <ul style="list-style-type: none"> Portfolio screening tool - uses climate risk scores and natural catastrophe modelling to identify areas more heavily impacted by climate risk. Climate hot spot deep dives - capture resilience and economic loss for assets by identifying individual perils and climate risk drivers and performing detailed catastrophe modelling to establish a loss cost view (which includes business interruptions). Risk mitigation strategy development - includes the identification of macro and micro (site) level risk mitigation strategies and exploring risk transfer options (including in relation to anticipated insurance capacity challenges). The SwissRe model can take into account building construction, occupancy and height, however it doesn't take into account the type of asset or activity on site.
Level of analysis	
Inputs required	Asset location & value, with building construction material, occupancy type, height enabling deeper analysis.
Output format	Portfolio screening outputs include a climate risk scores report, with access to interactive map & dashboard. Hot spot deep dives include highly customised analysis and explicit loss cost modelling for hazards.
Physical climate risk key metric	Climate risk scores (0-100) that capture both trends in mean and extremes of climate variables. All scores are calculated across the 3 scenarios covered, and then 3 sub scores across hazards are calculated based on weighted Total Asset Value (TAV) at each site.
Financial impact key metric	Economic loss costs are produced for assets through the hot spot deep dive analysis.
Asia coverage	Global
Access	  
Climate scenarios	RCP 2.6, RCP 4.5 & RCP 8.5 Bespoke scenarios also available on request.
Time horizon	Present to 2100
Hazard coverage & resolution	        30km ² Resolution depends on peril scenario (starts at a 5km ² resolution for some and higher for others).
Additional features offered/in development	Offer a critical assessment of analyses performed by other climate service providers.

The Climate Service													
Tools offered	Climanomics Risk & Analytics Platform												
Asset class coverage	RE IN												
Summary	<ul style="list-style-type: none"> A bottom-up approach offering asset, company and portfolio level insights using a hazard x vulnerability x financial risk framework. Classifies assets by types e.g. vineyard/office/road (covering approx. 200 different asset types), then analyses the impact of hazards to these different assets. Impact analysis includes operations (property damage and repair, energy and water costs, employee productivity, ownership of asset/occupation type); supply chain (including interruptions and costs); and indirect impacts (including rental market growth, municipal level adaptation and insurability). For agricultural crops the analysis includes crop type and water stress analysis. Financial risk exposures are quantified covering loss of revenue, clean up costs, operating expenses (cooling costs and water expenses) and potential capital expenditure required (physical damage, HVAC degradation). 												
Level of analysis													
Inputs required	Asset location, value & characteristics												
Output format	Risk metrics and financial impacts provided via interactive dashboard, summary report and data download.												
Physical climate risk key metric													
Financial impact key metric	Average Annual Loss (%/\$) based on the total asset value (either based on index or client input - replacement value of the asset)												
Asia coverage	Global												
Access	 												
Climate scenarios	RCP 4.5 & RCP 8.5												
Time horizon	Decadal from 2020-2100												
Hazard coverage & resolution	<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>25km²</td> <td>25km²</td> <td>100,000 coastal segments</td> <td>25km²</td> <td>River basin</td> <td>25km²</td> </tr> </table>							25km ²	25km ²	100,000 coastal segments	25km ²	River basin	25km ²
													
25km ²	25km ²	100,000 coastal segments	25km ²	River basin	25km ²								
Additional features offered/in development	<ul style="list-style-type: none"> Transition risk and opportunity analysis also available. Indirect impacts (including rental market growth, insurability, liquidity, building & municipality level adaptation) offered as a separate overlay for cities (currently covering major metro areas globally). Supply chain analysis expansion to cover more companies & supply chain tiers, includes the use of company supply chain data and location of suppliers (incl. value of crops and inputs from these locations). RCP 2.6 and RCP 6.0 will be added in 2021 and listed equity coverage will be expanded from the S&P500 to MSCI ACWI by Q1 2022. Also expanding coverage of fixed income and private equity in 2022. 												

Willis Towers Watson			
Tools offered	HeatMapR	Climate Diagnostic	Property Quantified
Asset class coverage	SAA	RE IN	RE IN
Summary	<ul style="list-style-type: none"> A high level screening tool that identifies risk hotspots for deeper analysis. Aims to capture the full range of value chain impacts across sectors including reliance on climate-sensitive suppliers, efficient operation of assets, potential for environmental and social impact. 	<ul style="list-style-type: none"> Provides insights on future physical hazard impacts at asset and portfolio level. Maps assets with hazard information, covering hazard probability & intensity. Online tool also includes live event tracking and alerts. 	<ul style="list-style-type: none"> Quantifies expected financial loss for assets, including asset damage and asset business interruption, with supply chain impacts indirectly incorporated at a high level.
Level of analysis			
Inputs required	Sector & country breakdown by asset class	Asset location	Asset location
Output format	Report and summary table of asset allocation that identifies most at risk sectors across most at risk geographies within asset classes.	Report and summary table of asset exposure to hazards, risks including breakdown by peril, region and asset location.	Report and summarised quantitative tables per property, post code and/or region.
Physical climate risk key metric	Vulnerability indicator score combined with exposure data and climate hazards.	Hazard scores	Identification of most at risk postcodes.
Financial impact key metric			Annual average and extreme loss amounts.
Asia coverage	Global coverage for climate data, with less detail available for some regional risk models across Asia.		
Access			
Climate scenarios	RCP 2.6, RCP 4.5 & RCP 8.5		
Time horizon	Present day, 2030, 2050, 2100		
Hazard coverage & resolution	 9km ²	 9km ² 0.25km ² 1km ² 30m ²	 9km ² 0.25km ² Sub-basin 0.25km ² 1km ² 10m ²
Additional features offered/in development	<ul style="list-style-type: none"> WillisTowersWatson also offer a scalable climate risk deep dive assessment across most financial asset types for all sectors. 		

VERISK-AIR		
Tools offered	AIR	Maplecroft
Asset class coverage	RE IN	
Summary	<ul style="list-style-type: none"> Catastrophe modelling analysis that assesses losses to buildings and contents from hazards, incorporates local building codes across different areas and years, and can integrate daily revenue projections to help capture financial impacts from building downtime. The analysis does not take into account adaptation however they can integrate these into the model where clients can provide this information. 	<ul style="list-style-type: none"> The Maplecroft service produces a percentage increase for key weather impacts at asset or portfolio level. The spatial analysis of hazards & associated impacts is undertaken using a high level of detail.
Level of analysis		
Inputs required	Asset location, replacement value, construction type, occupancy, height and year built.	Asset location
Output format	Industry level loss exposure also available (does not include uninsurable properties)	Heat map visualisation tool
Physical climate risk key metric		Quantification of risk across exposure bands (% increase of key weather impacts).
Financial impact key metric	Average Annual Loss (AAL) and change in loss projections for decades over 100 year periods.	
Asia coverage	Studies created for individual countries for different RCP scenarios, as requested by clients.	Global
Access		
Climate scenarios	RCP 4.5, RCP 8.5 & NGFS scenarios	
Time horizon	Any timeframe as requested by client.	Decadal coverage from 2010-2100.
Hazard coverage & resolution	 >1km ²	1km ²
Additional features offered/in development		

Conclusion

In reviewing the range of physical risk analytics available on the market, a number of key themes came to light:

- **Tools have strong Asian coverage** - making them relevant and useful to investors across the region. While some offer physical risk exposure analysis and quantification of the financial implications of these, others combine analysis with transition risk exposures. The range of metrics produced by the service providers reflect these varied approaches. Most tools had additional features currently in development, with complexity of analysis and coverage increasing. Some are utilising machine learning and most are looking to update their analysis through the integration of the downscaled impacts of the latest climate science.
- **Integration of adaptation measures should be considered** - Some assets may already have mitigation and adaptation strategies built into them, thereby significantly decreasing the risk exposure present. While some service providers are starting to integrate resilience and adaptation measures, they are generally at a national or regional level. There are significant opportunities to build on existing models to factor in company and/or asset level resilience measures into assessment methodologies. This makes qualitative overlay and company engagement important considerations.
- **International biodiversity loss is the next risk frontier for investors** - Integrating biodiversity risk appears to be a logical next step for physical risk mapping service providers. Investors need to understand the impacts and dependencies that portfolio companies have on biodiversity, and physical risk mapping tools provide the perfect platform to assess these. Separate from, although related to this - climate and biodiversity risks should be considered together in the same assessment framework, as climate change will have significant impacts on biodiversity, while biodiversity is a crucial factor in mitigating and adapting to climate change. Several of the service providers have indicated that they are working on integrating biodiversity mapping into their products, so expect to see further developments in this area over the next 12-24 months.
- **Nuances in the regional applicability of climate science models and scenarios need to be better understood** - Physical risk service providers should expect an increased level of focus and questioning from investors across Asia on the regional applicability of international scenarios as they do not provide sufficient granularity to accurately project physical impacts at a subnational level¹². The tools and analytics provided will need to be agile to ensure scenario modelling capabilities can be adapted to integrate regional nuances across macroeconomic conditions & resilience, demographics, geographies, building standards and the occurrence and impacts of weather-related hazards.
- **Physical risk analytics are one tool in the toolbox to assess climate-related risks** - These tools offer a spotlight to help highlight the most at risk assets and sectors. Development of datasets leveraging climate models to analyse exposure to hazards is a positive first step, however broader vulnerabilities and risks need to be comprehensively assessed to enable a clear understanding of asset and company resilience. Different tools will suit different investor needs. Some highlight physical risk exposures while others attempt to quantify these risks through various financial metrics. Value at Risk appears to be the most common metric used, however the methodology used to calculate this differs across providers. The outputs generated by these tools should be used as an initial signpost that leads to detailed asset engagement and resilience assessment and planning.
- **Systemic risks and supply chain exposures should not be neglected from physical risk analysis** - There is a need to think more broadly beyond the risk that is present to an individual asset. Assets do not operate in isolation and are dependent on inputs and outputs and highly reliant on local infrastructure and support systems. Investors need to think about how local and global supply chains may be impacted by physical risk – upstream and downstream, and the reliance on key inputs, infrastructure, logistics and access to markets. In particular, the access to, and reliance on, key infrastructure should not be negated when considering physical risk exposures. The linkages and interdependencies between companies and countries in our hyper globalised world is also a key factor to consider when looking at physical risk. The latest IPCC report and supporting research highlights the increasing occurrence of compound and concurrent events where multiple hazard events occur simultaneously across the world and the devastating knock on effects that these can have on the economic stability and resilience of society globally e.g. researchers found that a heatwave in Russia in 2010 led to the country restricting wheat exports, which may have contributed to instability and uprising in Egypt, and at the same time Pakistan suffered record-breaking floods.¹³

12. Energetics, 2021, [How the world's central banks are thinking about climate stress testing](#).

13. Zscheischler et al, 2018, [Future climate risk from compound events](#) and IPCC, 2021, [Chapter 11: Weather and climate extreme events in a changing climate](#).

- **Geopolitical tensions about national climate strategies & physical climate change impacts are increasing** - In addition to the current discussions on carbon pricing and border adjustment tariffs, there is also potential for increased hostility from governments and local communities in countries that are struggling in the face of increasingly severe climate change impacts. Protectionist policies may be pursued to protect national interests, enable local access to natural resources and address scarcity issues e.g. water that is currently used for textile manufacturing in an area under significant water stress could be diverted for human consumption. Ramifications for companies could range from customers boycotting products to the restriction of access to facilities, land and resources and the creation of stranded assets.
- **Holistic integration is needed to ensure climate-related risks are effectively managed** - To be effective, outputs from these physical risk tools need to be comprehensively integrated into existing investment and risk management analytics and tools, not dissimilar to mitigation efforts. There needs to be broad multi/cross disciplinary involvement across investment teams as similar risks are present across different asset classes and mitigation and adaptation strategies can be applied universally, reducing duplication and waste of resources. Liquidity should play a role in prioritising the assessment and management of risk exposure. Detailed physical risk analysis is pertinent for directly held real assets however this does not diminish the role of assessing physical risk exposures in more liquid assets classes, particularly given the universal and long-term ownership of listed equities that is generally held by institutional investors. It is useful to undertake risk analysis across listed equities to inform engagement programs, and to factor in credit worthiness across corporate and sovereign bonds. Risk analysis outputs enable meaningful engagement by investors with their underlying assets and provide an opportunity to hold them to account to ensure they are integrating climate risk into the operation and maintenance schedules, thereby preserving asset value.
- **Investor engagement is critical to understanding local context and enabling effective risk management and resilience building initiatives across the region, ensuring the future sustainability of the Asia economy.** In some instances, adaptation measures may be more attractive to local communities rather than mitigation efforts due to the direct tangible benefits and sense of security provided. Measuring and managing physical risk exposures will enable additional investment opportunities across the region on top of the projected US\$1.7 trillion that will be invested in infrastructure throughout Asia annually to 2030.¹⁴ This huge investment program provides a unique opportunity to enhance the integration of physical risk considerations into future expansion and construction of assets and build resilience into the operation and maintenance schedules for existing assets and company supply chains more broadly – both of which will be critical to ensuring future growth and consistent returns.

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14. McKinsey Global Institute, 2020, [Climate risk and response in Asia](#).