IIGCC

Physical Climate Risk Appraisal Methodology (PCRAM) 2.0

Acknowledgements:

The Physical Climate Risk Appraisal Methodology (PCRAM) is a process methodology that was conceptualised and developed by the Asset Design & Structuring working group of the Coalition for Climate Resilient Investment (CCRI), with special contribution from Mott MacDonald. 35 different institutions, ranging from banks, investors, engineering firms, climate risk data providers, lenders, credit rating agencies and academic institutions, collaborated to produce PCRAM. It represents a cross-industry effort to advance a dynamic impact assessment of physical climate risks that can be incorporated into investment decision-making.

Its development passed to IIGCC in March 2023 when CCRI moved to a legacy programme.

This PCRAM 2.0 update and supporting case studies have been led by IIGCC's Anne Chataigné, with contributions from Alexandre Chavarot, Climate Finance 2050 Ltd. With special thanks to IIGCC's Mahesh Roy; Valentina Ramirez; Hugh Garnett, and Dr Adrian Fenton.

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Additionally, we are grateful to PCRAM 2.0 case study participants including Theia Investments, Stafford Capital Partners, Howden, Octopus Energy Generation, LSE Grantham Institute for Climate Change and Environment, Oxford University Environmental Change Institute, the Private Infrastructure Development Group (PIDG), AXA Investment Managers, Swiss Re, Mott MacDonald.

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Disclaimer:

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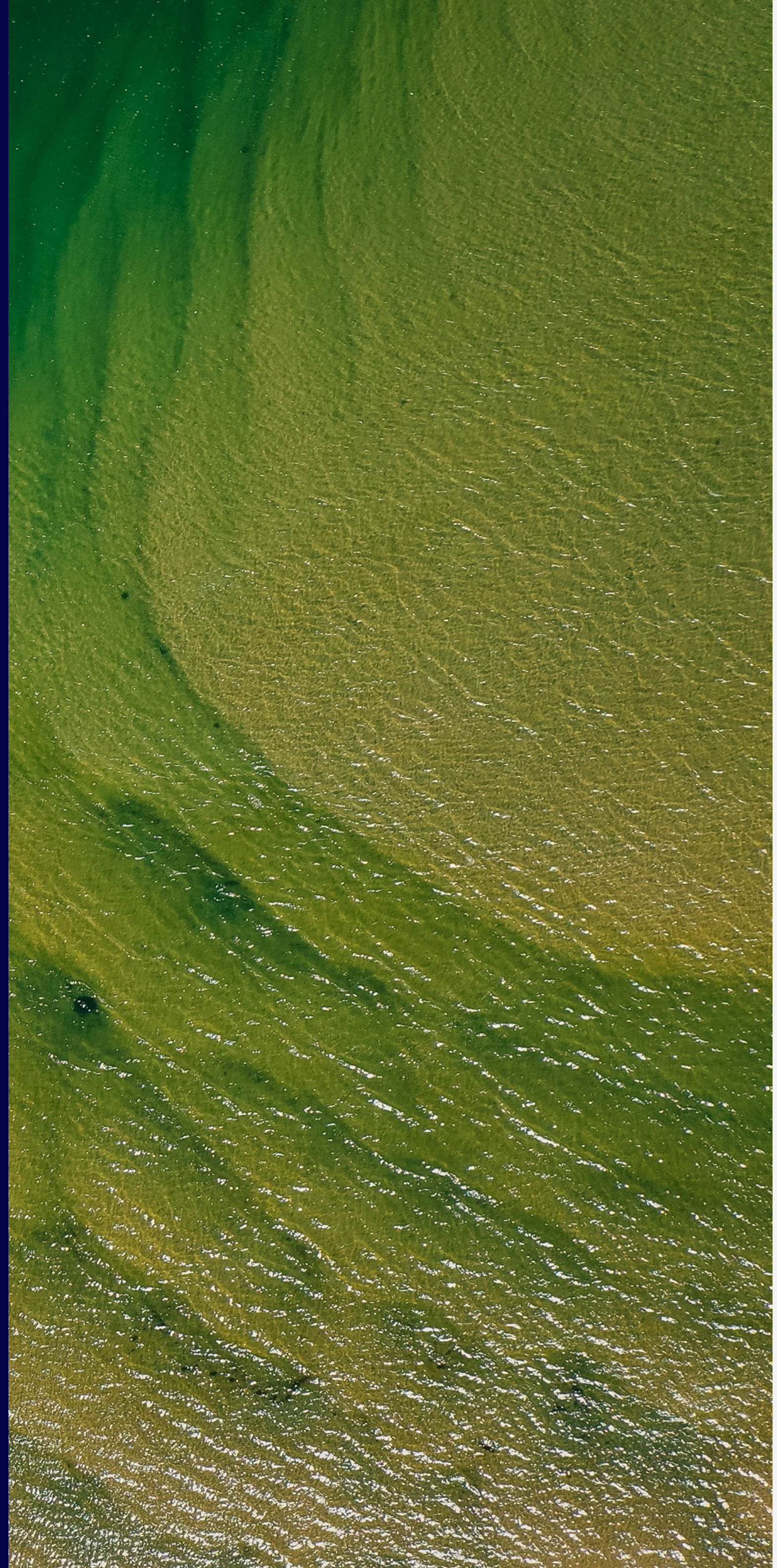


Introduction

Background:

The Physical Climate Risk Appraisal Methodology (PCRAM), formerly known as the Physical Climate Risk Assessment Methodology, provides systematic, objective, and replicable guidelines for integrating physical climate risks (PCRs) into investment decision-making. The methodology was initially developed by CCRI and successfully piloted through new case studies, embedding in investor practices with Physical Climate Risk Divergence PCRAM for investors and IIGCC's Climate Resilience Investment Framework. PCRAM 2.0, led by IIGCC, expands its application across various industries and has tested its applicability with mainstream institutional investors through new case studies and the IIGCC Climate Resilience Investment Framework.

PCRAM 2.0 changes:

PCRAM 2.0 outlines guidelines for integrating physical climate risks in real estate and infrastructure investment appraisal. It builds on the success of PCRAM 1.0, incorporating feedback from practitioners and new case studies to enhance its methodology. This version includes advancements such as:

1. **An investor portfolio and fund lens.**
2. **Systems analysis.**
3. **Value enhancement assessment and insurability considerations.**
4. **Nature-based solutions as resilience building.**
5. **Real estate applicability.**

Audience and Use Cases:

PCRAM is relevant to real-asset developers, managers, and capital providers. It is applicable to both public and private sector assets and is geography agnostic. The methodology combines insights from climate science, engineering, and finance to support a user to incorporate PCRs into asset appraisal. PCRAM 2.0 is relevant to investment decision-makers, offering practical applications for institutional investors, financial institutions and businesses to consider as they navigate uncertainty.

Note: *Per the original PCRAM document, we use the terms 'asset manager' and 'asset owner' in their engineering application, not as they are used in the investment sphere. Investors are simply referred to as 'investors' or 'institutional investors' to avoid confusion.*

Benefits for Investors:

1. **Standardisation:** Provides a consistent process for evaluating and managing investments in climate-resilient real estate and infrastructure.
2. **Risk and Opportunity:** Focuses on resilience benefits like predictable cash flows, enhanced credit quality, and efficient long-term cost management.
3. **Efficient Resource Management:** Encourages a holistic approach to risk management, ensuring effective resource allocation for building resilient assets.
4. **Building Investor Knowledge:** Helps institutional investors navigate uncertainty and inform their investment strategies.

Roles and Responsibilities:

- **Institutional investors, as stewards of long-term value:** Can use PCRAM as one methodology to assist them as they seek to fulfil their fiduciary duty by appraising and managing physical climate risks and enhancing asset resilience to protect the value of their investments over time. The findings can then be disclosed to relevant investment value chain stakeholders.
- **Real estate and infrastructure developers, managers, owners and operators, as responsible for delivering and maintaining climate-resilient real estate and infrastructure:** Can use PCRAM as one methodology to proactively assess and manage physical climate risks, ensuring long-term asset performance, regulatory alignment, and transparency to investors and stakeholders.
- **Consultants and advisors (financial, engineering and strategic), as responsible for guiding clients toward resilient investment strategies:** Can use PCRAM as one methodology to incorporate robust physical climate risk appraisals into their advice, helping clients manage long-term risks, meet regulatory expectations, and align with sustainability goals.

Collaborative and Case-Study Led:

- **PCRAM is an evidence-based open-source methodology**, making it accessible and a public good. It has been piloted, and this report highlights how it can be applied with mainstream investors.
- **Multi-Disciplinary Process:** PCRAM combines insights from climate science, engineering, and finance to incorporate PCRs into asset appraisal, ensuring a comprehensive and robust approach.
- **PCRAM 2.0 is informed by four real-world case studies** which have improved the methodology or broadened its application. These case studies are introduced here alongside separate implementation deep dives. As the methodology is further adopted, further implementation guidance will be shared.

PCRAM 2.0 diagram

Figure 1: The PCRAM Process

	1	2	3	4
Steps	**Scoping and data gathering**	**Materiality assessment**	**Resilience building**	**Value enhancement**
Objective	Determine data sufficiency	Assessing asset vulnerability	Identifying adaptation options	Optimised resilience with residual risk transfer
Sub-tasks	→ Project initiation → Project definition → Data gathering and sufficiency	→ Hazard scenarios → Impact pathways → Financial sensitivities (return & debt) → Distinguish acute damage vs. chronic performance efficiency	Adaptation options, costs and availability: → Hard (Structural/Capex) → Soft (Operational/ Systems)	→ Identify resilience metrics → IRR comparisons → Insurability and credit quality
Outputs	→ Initial climate study → Critical asset and system components → KPI selection, risk appetite → Base Case cashflow forecast	→ Detailed climate study → Quantified list of impacts and severity by component → Climate Case(s) cashflow forecast	→ Repeat materiality assessment → Cost/benefit for suitable measures → Adaptive pathways → Resilience Case(s) cashflow forecast	→ Investment case narrative → Value implications across investment value chain actors e.g. investors, lenders, insurers
Decision gates	**Gate A** What are the scope boundaries and data sufficiency according to the investment strategy?	**Gate B** Are PCRs material for the asset(s)? Reviewing asset KPIs, what factors influence the materiality?	**Gate C** What are the most effective adaptation options for this asset, the optimal timing for their implementation, and the responsible parties for funding and execution?	**Gate D** How can resilience investment be optimised and incentivised, while ensuring equitable risk-reward distribution across the value chain actors?

Main findings

The **rich diversity of case studies** illustrates broad applicability across a wide range of asset types and geographic regions. However, the level of detail required and the resources necessary for its effective implementation can vary significantly depending on several contextual factors.

- One such factor is the **nature of the investment mandate.** Projects driven purely by commercial objectives, such as those undertaken by private sector investors, may prioritise financial returns and efficiency. In contrast, investments led by development finance institutions (DFIs), multilateral development banks (MDBs), or public sector entities often pursue social or environmental impact alongside financial performance, which can influence the depth and scope of the methodology's application.
- Another important consideration is the **investment horizon and the structure of the fund.** Investors with long-term strategies may approach risk and return differently compared to those with shorter tenures. Similarly, the structure of the investment vehicle — whether it is an open-ended or closed-ended fund — can affect how the methodology is applied, particularly in terms of flexibility and liquidity management.
- The **type of asset** also plays a crucial role. For example, real estate investments may involve different analytical frameworks and stakeholder considerations compared to infrastructure projects, such as those in the energy or transport sectors. Each asset class brings its own set of challenges and requirements for due diligence and performance monitoring.
- **Stakeholder dynamics** further influence the application of the methodology. In real estate, the asset level control and relationship between landlord and tenants can shape operational decisions and risk assessments. In infrastructure systems, interactions between upstream and downstream stakeholders — such as energy producers and consumers — can introduce additional layers of complexity that must be accounted for.
- **The complexity of the asset itself** is a determining factor. Simpler assets, such as a single solar plant installation, may require a more straightforward application of the methodology. In contrast, complex systems involving multiple stakeholders and interconnected infrastructure networks demand a more nuanced and resource-intensive approach to ensure comprehensive analysis and effective implementation.
- **Mindset shift required:** recognising the value of resilience is not just a technical adjustment. It requires an evolution in how investors assess risk, value, and long-term performance under climate uncertainty.

Making the case for resilience investment: PCRAM 2.0 case study, solar and mini hydro

Investment characteristics

Asset type: Three solar assets and one mini hydro

Sector: Infrastructure

Geography: Italy

Finance type: Private sector funding Asset ownership in holding and life cycle operational

Asset objectives:

- Lifetime of +25 years
- Aggregated average annual energy generation of 24 GWh/year

PCRAM 2.0

Methodology and improvement focus: Portfolio level anlysis & insurability

Hazard:

- Acute - Hail (SCS)
- Chronic - Heat stress

Key takeaways

- The analysis showed that resilience measures would add value to the projects by enhancing the cash flow profile, within a five year exit timeline.
- The link between resilience-adjusted returns and insurability considerations were explored to unlock the value of resilience investment.
- Making the case for resilience investment: PCRAM 2.0 case study, solar and mini hydro

Making the case for resilience investment: PCRAM 2.0 case study, solar fund analysis

Investment characteristics

Asset type: 14 solar assets

Sector: Infrastructure

Geography: Europe

Finance type:

- Private sector funding
- Asset ownership in holding and life cycle operational

Asset objectives:

- 27 years average lifetime remaining
- 167 GWh/year potential annual energy generation

PCRAM 2.0

Methodology and improvement focus: Portfolio-level analysis and insurability

Hazard:

- Acute: Hail and wind stress (SCS)
- Chronic: Heat stress and solar irradiance

Key takeaways

- The team analysed hail and heat stress risks to solar panels and identified resilience strategies, including operational and structural interventions to maintain performance
- The analysis led to conversations on how resilience investment can be optimised and incentivised, while ensuring equitable risk-reward distribution across the value chain actors including investors, lenders and insurers.
- Making the case for resilience investment: PCRAM 2.0 case study, solar plant analysis (Octopus Energy Generation)

Making the case for resilience investment: PCRAM 2.0 case study, ferry and port (PIDG)

Investment characteristics

Asset type: Maritime transport and port infrastructure

Sector: Infrastructure

Geography: Lake Victoria, with ports in Tanzania and Uganda

Finance type: Patient capital, equity investment

Asset objectives:

- Lifetime of 30 years
- Trade flows and time saved

PCRAM 2.0

Methodology and improvement focus: Systems analysis & adaptation pathways

Hazard: Changing lake level - precipitation, evaporation, inflows and outflows impact on water level

eci | University of Oxford | PIDG Private Infrastructure Development Group | Resilient Planet Finance Lab

Key takeaways

- PIDG identified benefits in dealing with uncertainty, using adaptation pathways to allow flexible, iterative decision-making.
- System interdependencies were highlighted as an important point of consideration.
- Making the case for resilience investment: PCRAM 2.0 case study, ferry and port (PIDG)

Making the case for resilience investment: PCRAM 2.0 case study, real estate, AXA Investment Managers

Investment characteristics

Asset type: Warehouse

Sector: Real estate

Geography: Spain

Finance type:

- Private sector funding
- Asset ownership in holding and life-cycle operational

Asset objectives: Land is driving the asset value

PCRAM 2.0

Methodology and improvement focus: Real estate asset, systems resilience

Hazard: Pluvial flooding. fluvial flooding, heat stress

AXA Investment Managers | Swiss Re | Mott MacDonald

Key takeaways

- Coming January 2026

Step 1: Scoping and Data Gathering

Objective

Define the scope and determine data sufficiency and quality within the investment mandate and strategy.

It is recommended to use the annex open-source PCRAM Data Tracker to help navigate this section.

Purpose

To initiate a PCRAM appraisal, organisations should clarify their motivation and desired outcomes — whether driven by regulation, financial milestones, ownership changes, or strategic mandates. Objectives may include protecting long-term investment value, maintaining creditworthiness and insurability, meeting compliance obligations, enhancing portfolio performance, and/or achieving environmental or social goals. The scope should identify the relevant climate hazards for the assets being considered, outline the main financial variables to consider and, where possible, map the key asks across the asset's system.

A decision checkpoint (Gate A) then ensures alignment with investment strategy and confirms whether sufficient information is available to proceed.

Step 1a) Project Initiation

The organisation(s) collaborating on the assessment should define the objectives and expected outcomes that should fundamentally seek to address one simple question: ***'Is the asset at risk due to changes in the climate?'***.

It is also important for the organisations leading the assessment to assemble a data room of relevant information for the exercise, including climatic, engineering, commercial and financial information related to the asset. Additional data will also be required after completion of Step 1b).

Output step 1a

The outputs of Step 1a) Project Initiation should include the following:

- A clear formulation of the objective and motivation for appraisal.
- A list of expected outcomes.
- Mobilisation of a project team

Figure 2: Mobilising PCRAM project team key specialists

Key specialist	Responsibility and PCRAM role
Asset operation	**Asset developers, managers, owners and operators:** They bring detailed operational knowledge of the asset to inform operational KPIs, risk tolerance, and materiality assessments.
Finance	**Institutional investors:** As stewards of long-term value, they can allocate resources to assess and manage physical climate risks and enhance asset resilience to protect the value of their investments over time. **Investment consultants and financial advisors (internal and/or externally sourced):** They draw on project finance and financial modelling expertise to assess how asset performance impacts economic and financial KPIs. They evaluate adaptation options and translate these insights into asset valuation implications, informing investment decisions.
Engineering	**Engineering team:** Understands how the design of an asset is affected by the relevant climate thresholds (damage or performance efficiency thresholds); this could be the lender technical adviser appointed in the context of a project financing.
Climate science	**Climate risk data specialists:** Can use historical climate data and spatial and temporal scales, select appropriate forward-looking climate models (global and downscaling, regional or at local scale); and that are experienced at processing data, bias adjustment, downscaling, computation of climate indices and estimation of uncertainty. Specific climate hazard models might be required depending on the asset (e.g. hydrological model, coastal dynamics).
Key investment value chain stakeholders	Other key stakeholders of the investment value chain as relevant, such as financial experts that can identify economic and financial materiality thresholds linked to a climate impact e.g. credit rating agencies, lenders, regulatory bodies, insurance providers.

Step 1b) Project Definition Operations & Engineering System

Climate Science	Operations & Engineering	Financial & Commercial
The climate scope of the assessment should be defined with respect to the following:	• Mapping critical asset system dependencies and identifying key risk owners and beneficiaries of the asset functioning, understanding the scope of the wider 'asset system'. • Not every PCRAM exercise will require the same amount of detail. • Scoping critical system components helps manage the complexity in order not to overwhelm the appraisal process.	The financial and commercial scope of the assessment should be defined with respect to the following:
Climate hazards – Global warming will result in changes to a range of climate variables and hazards that result from these changes. The team should identify a list of potential climate hazards to consider in the assessment, based on known sensitivities of the asset type, coupled with climate projections of those hazards.	**Selection of the asset elements to be assessed –** Assets can contain many systems and sub-assets of varying function and relative importance. It is important for the project team to identify both a list of what aspects of the asset are in scope, as well as the level of detail with which these aspects are to be assessed. Will the assessment examine down to the individual component level or will it remain at a system level? At this stage, a long list of asset systems and components will be identified to scope into the assessment.	**Definition of the financial and commercial assessment –** Infrastructure and real estate assets have a variety of potential financial and commercial drivers, and at this stage the project team should define what financial and commercial factors will be analysed as part of the assessment. This could include impacts related to contractual obligations, debt service obligation, insurance coverage, credit ratings, financial return targets, broader socio-economic goals, and other potential factors.
Time period for analysis – Climate projections are available for a range of time periods up to the end of the 21st century and PCRs should be considered for multiple time periods. The choice of time periods should be relevant to the asset and/or investment being assessed (e.g. linked to maintenance or replacement cycles or refinancing or concession terms).	**Identification of the relevant asset management key performance indicators (KPIs) –** Or thresholds to be used to measure impact (e.g. targets related to downtime or availability requirements, production, safety, environmental, CAPEX, OPEX, etc.). Depending on the type of asset, for example occupancy and lease agreement lengths need to be considered.	**Selection of financial/commercial/sustainability/social KPIs –** In line with the financial and commercial scope of the assessment, the KPIs that will be used to measure impact of PCRs from a financial and commercial perspective should be selected. This could include: • Financial metrics such as DSCR, IRR, NPV, ROI and related debt covenants (stemming from changes to CAPEX and OPEX and revenues). • Commercial penalties or liquidated damages. • Socio-environmental metrics such as CO_2 emissions and other greenhouse gases. • Socio-economic metrics such as job creation/loss.

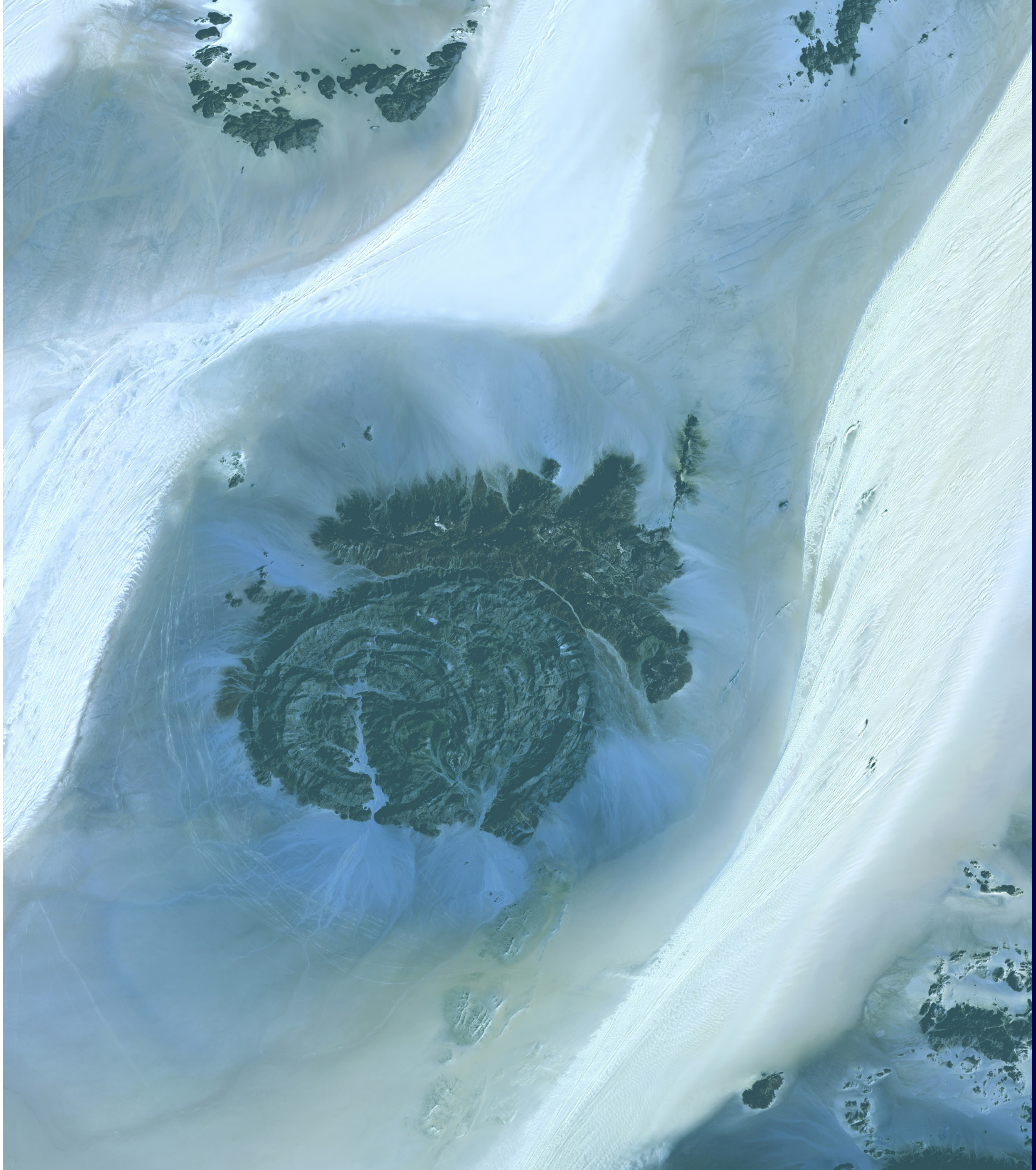
<table>
<tr><th>Climate Science</th><th>Operations & Engineering</th><th>Financial & Commercial</th></tr>
<tr>
<td>Type of projection – Climate projections can be probabilistic or deterministic. Probabilistic projections are based on multiple simulations from an ensemble of climate models and are commonly used to explore a set of plausible future climates. It is advisable to avoid deterministic values and instead use a range of probabilistic values (e.g., 10th, 50th, and 90th percentiles) in climate threshold analysis. Where full probabilistic assessment is not possible for certain hazards, qualitative scenario planning and stress tests can still provide valuable insights.</td>
<td>Identification of key technical documents and information sources – Need to be identified at this stage and requested by the project team. This information could include (depending on where the asset is within its asset life cycle):
Physical location and surroundings.
Engineering Drawings.
Specifications (including operational thresholds).
CAPEX.
Operations and Maintenance plans, manuals, records and warranties.
Condition Assessments.
OPEX.
Historic climatic information (e.g. past events).
Insurance policy coverage.
Previous weather related insurance claims.</td>
<td>Identification of key documents and information sources – See data tracker for a detailed list. At this stage, financial and commercial documentation will need to be identified and requested by the project team. This information could include:
Concession, transportation and/or off-take agreements.
Regulatory requirements.
Policies and guidelines.
Construction and O&M contracts with relevant warrantees / guarantees.
Insurance considerations.
Tax regimes.
Financial information (e.g. finance plan).
Loan agreements.
Financial models including historic and forecasted cash flows.</td>
</tr>
<tr>
<td>Shared Socio-Economic Pathways & Representative Concentration Pathways scenarios

Climate projections are available for a range of Shared Socio-Economic Pathways (SSPs) & Representative Concentration Pathways (RCPs). A range of climate scenarios should be considered and the choice of scenarios guided by the sensitivity of the asset to climate change, taking account of the degree of flexibility to add adaptation options over the life of the asset. In most cases, the assessment should consider projected change in climate variables under medium and high/very high emissions scenarios. This allows for exploration and understanding of risk under a worst-case scenario, based on the precautionary principle.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYSTEM
Mapping the asset's system – Identifying qualitatively what is included within the system
identify boundaries and scale
physical assets usually infrastructure like water supply, telecoms
climate hazards
Environmental dependencies governance structures
Mapping interdependencies and nodes
Identifying points of connections and their dynamic relationships
positive
negative
complex</td>
<td>SYSTEM
Mapping system risk governance structures and risk allocation based on institutional responsibility –
Depending on the asset and its ownership and financing model, beneficiaries could include businesses (as tenants or other businesses), local governments, national governments, asset regulators, households and communities.</td>
<td>SYSTEM
Mapping beneficiaries of the functioning asset –
Depending on the asset and ownership and financing model, beneficiaries could include businesses, local governments, national governments, households and communities. The system perspective aims to devise an approach to identifying beneficiaries and monetise resilience benefits such as through levies or tax credits.</td>
</tr>
</table>

Output step 1b

The outputs for Step 1b) Project Definition should include the following:

- Climate hazards to be considered, time period for analysis, type of climate projections and Shared Socioeconomic Pathways (SSPs) and / Representative Concentration Pathways (RPCs).
- Asset components/systems to be mapped and analysed.
- KPIs which will be used to measure impact.
- Documentation needed to complete the assessment.
- Classification of hazards across probability, impact and confidence levels in uncertainty.[1]



Step 1c) Data Gathering and Sufficiency

Climate Science	Operations & Engineering	Financial & Commercial
Collecting data on historic climate and projected climate change, relevant to the climate hazards scoped in during Step 1 b):	Analysis of the data collected and provided:	Financial and commercial practitioners should analyse the data collected and provided:
Identify thresholds – Understand any climatic thresholds critical to successful delivery of the asset operational objectives and/or financial objectives. Any climatic factors or thresholds included in the basis of design, asset management objectives or standards used in asset design should also be identified. Given that a few hazards (e.g., heat stress, wildfire, storm, and flood) account for the majority of climate-related losses globally, and that for some hazards data remains patchy, it is recommended to adopt a flexible approach to materiality assessment that acknowledges limitations in climate data.	• Review the key functions and components of the asset and how they relate to the asset management KPIs. • Highlight key asset & system interdependencies that could lead to cascading failures. • Review of the asset life cycle and design life and provide this data to climate science workstream. • Review in detail the CAPEX and OPEX and their relationship to the asset management KPIs and broader financial model.	• Confirm the boundary of the assessment, including what commercial and financial elements will be included in the assessment. • Review the investment type and structuring e.g. equity and leverage (direct leverage on the asset or fund level). • Review the investment ownership structure to understand institutional responsibilities e.g. real estate asset controls (tenant vs landlord). • Review regulatory compliance and contractual requirements impacted by climate change. • Review how asset management information is reflected into the financial models. • Review detailed CAPEX and OPEX assumptions. • Review duration of the concession agreement or investment. • Confirm financial/commercial KPIs, asset value drivers (DSCR, IRR, NPV, penalties/LDs, ROI, etc.) in anticipation of step 2 performing sensitivity analysis or by other means on key inputs into the financial model. • Other KPIs such as sustainability indicators can also be considered.
Differentiate between chronic and acute hazards and map them to EU Taxonomy classification for reporting needs or any other relevant taxonomy.	Engineering, asset management and climate practitioners must collaborate with the commercial and financial teams in order to: • Confirm the boundary of the assessment, including what systems and asset components can and should be analysed. • Identify and confirm relevant asset management KPIs (e.g. downtime or availability requirements production targets, safety, environmental, CAPEX, OPEX, etc.) and ensure that the necessary linkages between asset performance and design are quantifiable. • Identify critical asset components and screen asset components based on exposure to hazards, in order to define vulnerability. • Identify climate thresholds used in design of critical components and in the operations and maintenance plan (e.g. schedule/unscheduled downtime, response to extreme events).	Map the threshold exceedance analysis to the investment stage and horizon. For example, if an investment exit is planned for five years from the Base Case of the PCRAM case study, this will inform the materiality assessment and resilience building to extract value according to shareholder terms.

Climate Science	Operations & Engineering	Financial & Commercial
• Understand performance of the asset – Or similar assets under historic climate. Data to analyse include: • Historic records of temperature, rainfall and wind patterns as well as sea level (if relevant) in the vicinity of the asset. Records should cover a minimum of 30 years (where possible). • Records of extreme events, such as floods, droughts, or heatwaves, and how the asset was impacted (e.g. loss of service, down time, repair or early replacement).	It is also important to identify limitations to the assessment.	It is also important to identify limitations to the assessment in terms of the asset, climate and financial data and any assumptions made. The limitations should be expressed at a minimum as a function of uncertainty (range) in the results.
Understand how climate is projected to change – Data to collect includes climate projection data relevant to the hazards, time periods and climate scenarios scoped in Step 1b). See Annex for EU Taxonomy Climate Hazards, or any other relevant taxonomy.		
• Threshold exceedance analysis – Once the projected climate data has been collected, it should be analysed to understand the frequency and timing of threshold exceedance. It should seek to answer the following questions (these can be tailored depending on the nature of the asset and/or threshold): • How frequently is the threshold exceeded in the future? The metric for this will depend on the nature of the asset (e.g. number of days per year, or number of occurrences over a defined period). What is the duration of threshold exceedance? When does threshold exceedance occur – near, medium or long term? If an asset is typically designed to a specific return period, what is the expected change in that return period?		

Output step 1c

The output of Step 1c) Data Sufficiency and Gathering should include the following:

- A climate study with probability of exceedance of specific thresholds mapped to the investment time horizon and asset life cycle as identified by the asset management, engineering and fund management team.
- A clear understanding of the availability of information and limitations that this may have on the appraisal.
- A short list of critical asset and system components that are expected to be carried forward into the detailed materiality assessment and resilience building.
- Confirmation of the scope of work.

Note: *The climate study should set out the following*:

- Climatic thresholds or factors critical to the successful delivery of the asset management objectives and/or financial objectives of the project.
- The historic climate context used to determine the asset management objectives, asset design or financial objectives of the project.
- The projected change in climate and associated hazards over the defined timescale of the assessment, which has been mapped to the investment horizon to keep in line with investment objectives.
- Results of the threshold exceedance analysis, including frequency, duration and timing of threshold exceedance.
- Discussion on the adequacy of the climate context used to determine the asset management objectives, asset design or financial objectives of the project with respect to projected climate and threshold exceedance.
- It is also important to identify limitations to the assessment.

Lessons learned

1. **Data Collection Efficiency**: Use a data tracker (see annex) to identify key data points, their owners, and sources — prioritising critical information and ensuring transparency.
2. **Team Structure & Roles**: Clearly define roles across climate, engineering, and finance teams to align workstreams and streamline communication.
3. **Sensitive Data Handling**: Mobilising internal and external teams may require NDAs and secure, accessible storage due to the sensitivity of some data.
4. **Evolving Scope**: Be prepared for changes in objectives and scope as the appraisal progresses.
5. **Time Horizon Limitation**: It is recommended to limit climate projections to 2100, even for assets with longer design lives, due to data availability and uncertainty.
6. **Scoping Uncertainty**: Early decisions may be made with limited asset knowledge, potentially affecting result quality.
7. **Climate Data Challenges**: Local historic data may be incomplete. Use global open data sources (such as the World Bank Climate Change Knowledge Portal or the GRI Risk viewer) and consider gridded projections for linear assets.
8. **Early Engagement for Data Providers**: Climate data providers vary in the variables they offer, the metrics they use, and how (or whether) they address uncertainty. Discuss available variables, metrics, and uncertainty treatment early to ensure relevant data is accessible.
9. **Defining Climate Thresholds**: Where thresholds are unclear, collaborate with engineers and asset managers to define them based on expertise.

Decision Gate A

What are the scope boundaries and data sufficiency according to the investment strategy?

The project team will determine the boundaries of the appraisal considering the investment aims and strategy. Is data robust, complete and sufficient, does the scope align with investment value drivers?

If not: return to the start of Step 1. Does the scope or objectives need to be revised? Can additional information be obtained through engagement with asset manager / corporate.

	1	2	3	4
Steps	**Scoping and data gathering**	**Materiality assessment**	**Resilience building**	**Value enhancement**
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Step 2: Materiality Assessment

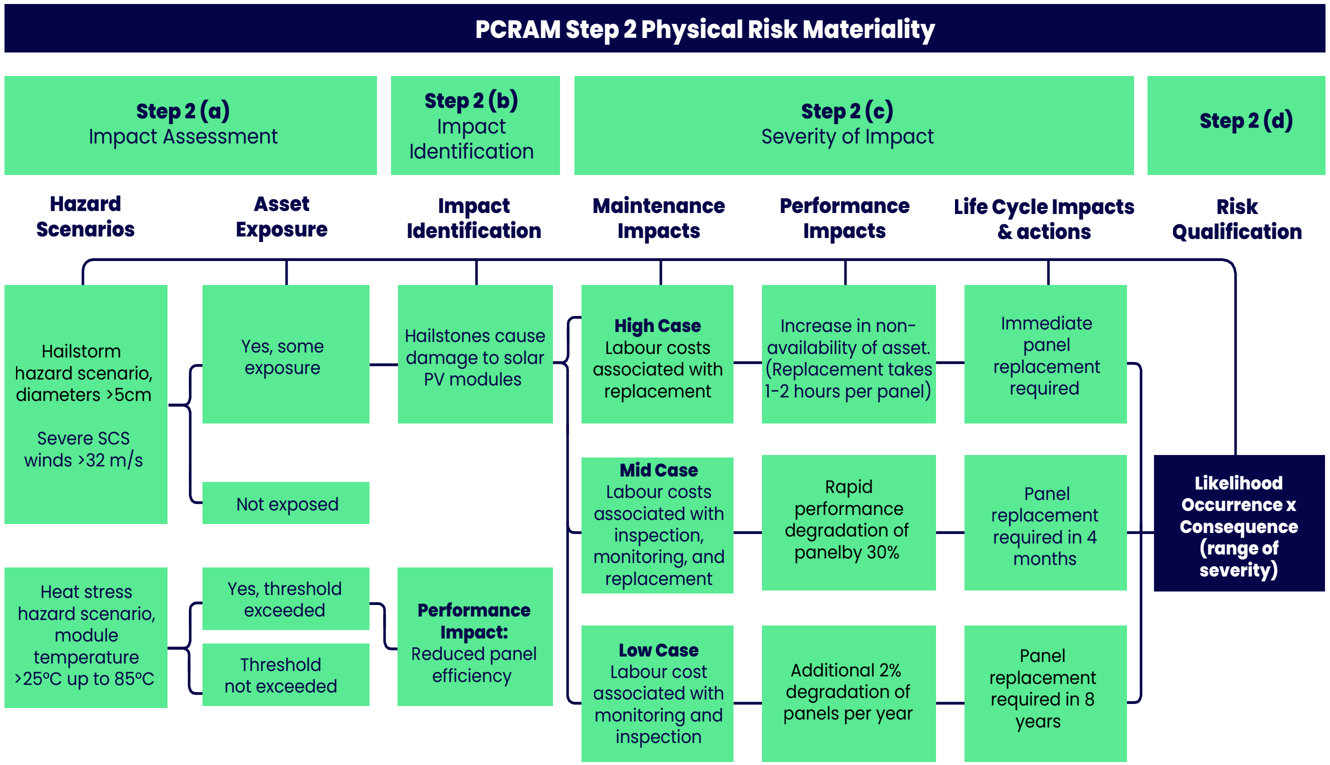
Objective

Assessing relevant physical and financial materiality thresholds to quantify vulnerability to climate change

Purpose

To evaluate the materiality of physical climate risks (PCRs) to the asset by linking climate hazards to potential impacts on key performance indicators (KPIs), and to develop 'Climate Cases' for financial modelling. This involves impact pathways that distinguish between chronic risks, which affect performance over time, and acute risks, which cause sudden damage and potential business interruption.

Figure 3: See solar case studies on page 8 for more details



Step 2a)
Exposure to Climate Hazards

Identify which critical asset components are exposed to climate hazards under selected climate scenarios (e.g. SSPs or RCPs). For each hazard and component, identify:

- Is the component exposed to the hazard?
- Is it critical to asset function and linked to KPIs?

Output: A list of exposed components and systems, noting that one component may face multiple hazards.

Step 2b)
Identify Impacts on Assets

For exposed components, assess whether design thresholds will be exceeded. If so, classify impacts as:

- **Maintenance:** Increased cleaning or repairs.
- **Performance:** Reduced efficiency or availability.
- **Life Cycle:** Early replacement or total loss.

Where needed, consult with experts and use tools such as fault-tree analysis. Consider cascading failures and define system boundaries early.

Output: A range of potential impacts per component, from minor service changes to catastrophic failure.

Step 2c)
Assess Severity of Impact(s) on Assets

Quantify the severity of each impact using best-case, most-likely, and worst-case scenarios. Use damage functions where applicable, and sensitivity testing where data is limited.

Impact Categories:

Type	Acute Hazards	Chronic Hazards
Maintenance	Immediate repair costs, downtime	Increased or new maintenance needs
Performance	Sudden efficiency loss, downtime	Gradual performance decline
Life Cycle	Immediate replacement	Increased replacement frequency

Output: Severity ranges for each impact, ready for financial modelling.

Step 2d)
Quantify Impacts on KPIs

Translate impact severity into cost estimates for:

- **Maintenance costs** – Downtime and repair costs, typically represented as a function of downtime of the asset and cost to perform maintenance activities.
- **Performance costs** – Revenue loss or penalties, typically represented as a function of availability and efficiency, both of which can be negatively impacted.
- **Life cycle costs** – Increased replacement costs, typically the function of an increase in replacement frequency, which would increase costs.
- **Return sensitivities** - Quantified comparison of IRR under Base Case vs. Climate Case scenarios.
- **Debt sensitivities** - Analysis of revenue loss (or other) thresholds that could breach loan covenants.

Use stochastic methods (e.g. Monte Carlo analysis) to adjust for risk probability.

Financial Stakeholder Considerations in Materiality Assessment

In practice, when a climate-induced physical risk materialises, causing damage or performance disruption to the physical assets, the course of action is determined based on multiple factors and stakeholders-with which information risks and/or costs may be shared:

- **Insurers:** Can typically cover acute events causing damage and business interruption.
- **Manufacturers:** Cost recovery, particularly for chronic impacts, may be managed based on warranties and production impact can be coordinated with O&M contractors during routine maintenance.
- **Lenders:** Informed via maintenance reports; may require consent or pre-approval for addressing material issues with secured assets.

By understanding how climate risks translate into financial exposure across insurers, operators, and lenders, investors can ensure these risks are priced, managed, and integrated into investment decisions.

Output Step 2: Materiality Assessment

1. **Exposure Mapping**
   - Identified asset systems or components exposed to specific climate hazards.
2. **Impact Identification**
   - List of potential impacts on exposed systems or components.
3. **Impact Severity Estimates**
   - Severity ranges for each impact, expressed in cost terms (or other project-relevant metrics).
4. **Risk-Adjusted Cost Analysis**
   - Stochastic modelling of each hazard to estimate risk-adjusted impact costs per asset component.
5. **Return Sensitivities**
   - Quantified comparison of IRR under Base Case vs. Climate Case scenarios.
6. **Debt Sensitivities**
   - Analysis of revenue loss (or other) thresholds that could breach loan covenants.

Climate Cases Definition

The outputs above collectively define the **Climate Case(s)** — quantified, (un)insured views of physical climate risk impacts. Multiple Climate Cases may be developed to reflect different time horizons or distinct climate risk scenarios.

Lessons learned

1. It is important to **distinguish between chronic and acute risk impacts.** Chronic risks primarily affect performance over time. Meanwhile acute risks are associated with sudden damage and business interruption, and may occur on multiple occasions throughout and asset's lifecycle. Although both types of risks influence asset value, they do so in different ways. Acute risks are typically represented in climate and resilience analyses through one-off downside sensitivity scenarios, rather than as part of a continuous cash flow forecast. As such, portraying both chronic and acute risks as part of a forecast continuum may be misleading, when not accurately accounting for correlation.

   A more practical approach is to compare multiple distinct Climate Case scenarios to capture the full range of potential acute and chronic impacts. These may then be aggregated when considering the most appropriate correlations, e.g. cascading vs. compounding fluvial and pluvial flooding, or hail and heat risk.
2. In some instances, the range of potential impacts will be difficult to quantify, and it may not be possible to determine the severity of the impact. If this is not possible, **the best efforts should be made to conduct sensitivity testing** and monitor these risks qualitatively to evaluate the potential range of risks.
3. **Combining multiple climate risks can cause difficulties** for over- or under-estimating specific risks. This is also an issue when addressing risks that may or may not be independent, e.g. high winds and flooding can be both dependent and independent.
4. Acute climate risks cannot always be offloaded to insurance; growing vulnerability and withdrawal of coverage can render assets non-bankable, erode equity value, and create stranded investment risk.

Decision Gate B

Are PCRs material to the asset? If they are physically material, what are the financial materiality drivers and associated loss (direct and indirect)?

These drivers will help inform the resilience building in step 3 and value implications in step 4. If a portfolio/fund screening approach has been undertaken at steps 1 & 2, choose one asset to focus on in steps 3 and 4.

If PCRs are managed and therefore not material, factor this into the portfolio exposure, identify when a next PCRAM could be triggered and continue to monitor in risk register.

	1	2	3	4
Steps	**Scoping and data gathering**	**Materiality assessment**	**Resilience building**	**Value enhancement**
Objective	Determine data sufficiency	Assessing asset vulnerability	Identifying adaptation options	Optimised resilience with residual risk transfer
Sub-tasks	→ Project initiation → Project definition → Data gathering and sufficiency	→ Hazard scenarios → Impact pathways → Financial sensitivities (return & debt) → Distinguish acute damage vs. chronic performance efficiency	Adaptation options, costs and availability: → Hard (Structural/Capex) → Soft (Operational/ Systems)	→ Identify resilience metrics → IRR comparisons → Insurability and credit quality
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Step 3: Resilience Building

Objective

Identify adaptation options per hazard, estimated costs and benefits, the best location for intervention (asset, site boundaries or beyond site boundaries) and the resource and expertise availability for solutions (e.g. resource supply/ manufacturing availability, local installation capacity).

Purpose

To identify and evaluate adaptation options' cost effectiveness for material climate risks affecting assets, quantifying their impact on KPIs. These measures revise the step 2 materiality assessment to form the **Resilience Case(s) cashflow forecasts.** The resource and expertise availability for adaptation options is key to PCRAM implementation and investment decisions, this particularly prevalent in 'climate adaptation solutions', many of which are nascent and yet to be scaled. The optimal intervention point — whether at the asset, site, or beyond — should also be considered.

Description

Engineering-led specialist teams collaborate to identify viable adaptation options — both structural and non-structural — to address the material climate risks identified in Step 2. Only risks deemed material by the project team are considered at this stage.

Adaptation options should be screened based on:

- **Cost and schedule.**
- **Optimal intervention location** (asset, site boundary, or beyond).
- **Market maturity** (e.g. supply availability, local installation capacity).
- **Environmental and other impacts,** including potential maladaptation risks e.g., the EU Taxonomy's Do No Significant Harm (DNSH) criteria or similar taxonomy as relevant.

Measures may target structure, operations, management, or maintenance, and can include both grey (engineered) and nature-based solutions. Different climate hazard scenarios may require tailored interventions.

Step 3a)
Identify Adaptation Options

1. Structural Measures

Adaptation options should include both **engineering** and **nature-based** solutions:

- **Engineering Solutions**
  Traditionally built solutions that enhance resilience in water, drainage, or transport systems.
  Examples: storm drains, levees, sea walls, tidal gates, water treatment upgrades.
- **Nature-Based Solutions**
  Interventions that mimic or enhance natural systems to manage climate risks.
  Examples: living shorelines, green roofs, rainwater harvesting, wetland or reef restoration, tree planting.

2. Non-Structural Measures

Operational and management-focused interventions:

- **Maintenance Interventions**
  Reduce downtime and extend asset functionality.
- **Performance Interventions**
  Maintain availability and service levels.
- **Life Cycle Interventions**
  Improve repair and replacement strategies.
- **Other Measures**
  Identified through project-specific assessments.

3. Screening Criteria

All adaptation options should be evaluated based on:

- Cost and schedule.
- Intervention location (asset, site boundary, beyond site).
- Market maturity (supply chain, installation capacity).
- Environmental and social impacts.
- Risk of maladaptation (e.g., EU Taxonomy's DNSH criteria, or any other relevant taxonomies).

Figure 4: Step 3 Adaptation Options Identification

Adaptation options	Hazard	Asset level	Site level	System (beyond site boundaries)	Resource and expertise availability for adaptation options (supply /manufacturing availability, local installation capacity)	Resilience categorisation (preparedness, resistance, recoverability)	Who pays (investor, insurer, lender, public sector)
Early warning system	Surface water flooding	Y	Y	Y	Mature in X geography although limitations to 3 hours projections for surface water flooding	Preparedness	Ex-ante investor, ex-post insurer (check if covered)
Flood door	Surface water flooding	Y	N	N	Manufacturing maturity but expensive	Resistance	Ex-ante investor, ex-post insurer (check if covered)
Raising electrics	Surface water flooding	Y	N	N	Low cost, easy to implement	Recoverability	Ex-ante investor, ex-post insurer (check if covered)
Sustainable drainage systems	Surface water flooding	N	Y	Y	It depends on the technical capacity of local authority	Recoverability nature-based	Public sector outside of site boundaries, private sector inside site boundaries

Illustrative including flood hazard related adaptation options

4. Supporting Activities

- **Collaboration** across specialist teams is essential to ensure comprehensive option identification.
- **Literature Review** of global best practices and climate proxies can inform option selection.
- **Taxonomies** (national/global) can guide classification and evaluation.

5. Shortlisting

From the long list of options, develop a **realistic shortlist** by applying the screening criteria. Engage relevant specialists in this process.

Step 3b)
Reassess Materiality with Adaptation Options

Once preferred interventions are selected, repeat the materiality assessment (Step 2) to reflect the improved asset condition:

- Reassess exposure to climate hazards.
- Redefine potential impacts.
- Recalculate severity of impacts.
- Integrate intervention costs into financial models (CAPEX/OPEX).
- Re-quantify KPI impacts for each intervention.

Step 3c)
Cost Benefit Analysis

Climate and Resilience Case Comparison

The impact of physical climate risks (PCRs) is quantified by comparing KPIs from the **Base Case** (pre-PCR) with those from **Step 2,** resulting in one or more **Climate Cases.** These reflect different time horizons, risk types (chronic vs. acute), and SSP/RCP scenarios, capturing the financial effects of "doing nothing," such as performance loss or penalties.

Each Climate Case is then compared to one or more **Resilience Cases** developed in Step 3. These include the costs and benefits of adaptation options — such as CAPEX, OPEX and improved revenue stability.

The comparison focuses on **changes in Internal Rate of Return (IRR), life cycle costs,** and other KPIs. Sensitivity analysis supports decision-making.

For example:

- **Resilience Case 1:** Early, moderate investment lower long-term costs and improved IRR.
- **Resilience Case 2:** Delayed, larger investment higher life cycle costs, variable IRR outcomes.

Once complete, results are presented to relevant stakeholders. Step 1 and 3 standardises risk appraisal but does not define acceptable risk thresholds, this is covered in Step 4 Value enhancement assessment.

Figure 5: Comparison between the Base Climate Case and the Resilience Case (see step 3c)

Base IRR	Climate Case IRR	Resilience Case 1 IRR	Resilience Case 2 IRR	Life Cycle Cost Change (vs. Climate Case)
9%	7% (SSP2-4.5)	8%	10%	-2% / +15%
	4% (SSP5-8.5)	9%	6%	+3% / +20%

Figures are nominal for illustrative purposes

Step 3d)
Adaptation Pathways

Managing Uncertainty with Adaptation Pathways

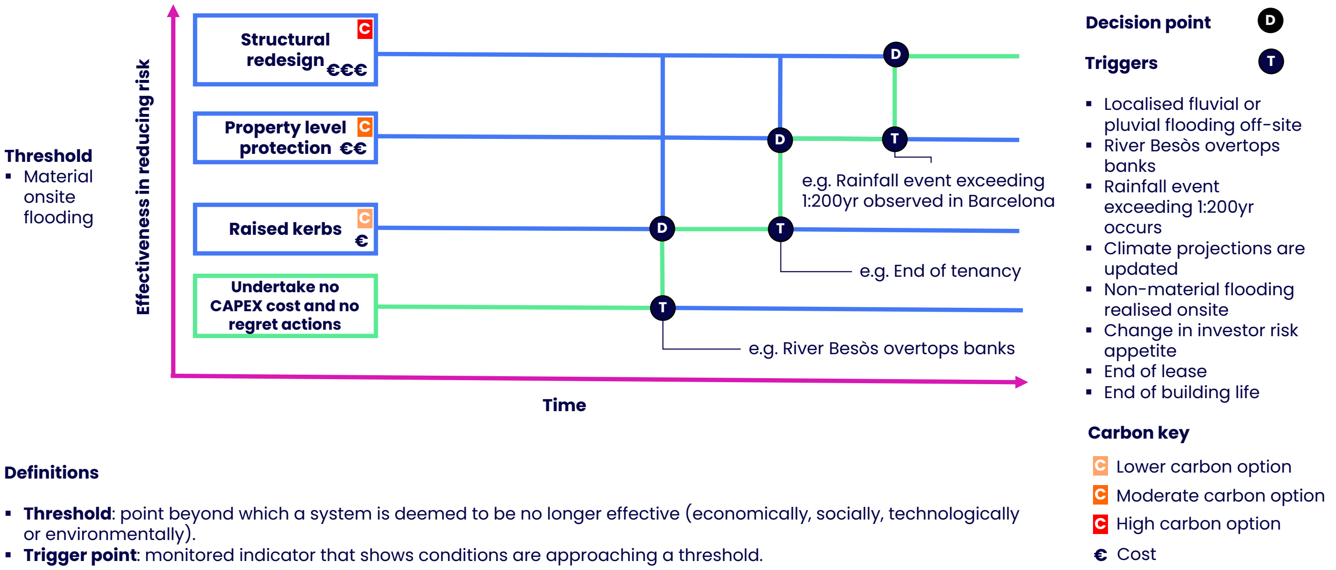
Projections of future physical hazards often lack coherence due to differences in climate model granularity and methodology. To address this uncertainty, an **Adaptation Pathways** approach is recommended , in line with the BS8631:2021[2] standard. This method enables flexible, staged decision-making by sequencing adaptation options based on predefined physical, operational, and policy-based triggers.

Adaptation options are assessed not only for their effectiveness but also for optimal timing and responsibility for implementation. Triggers, such as severe weather events, lease changes, or shifts in organisational policy activate monitoring protocols and guide responsive action.

This approach moves beyond static cost-benefit analysis, supporting dynamic planning that can evolve with changing climate projections and operational contexts. It provides a robust framework for managing uncertainty and enhancing long-term resilience in asset management and infrastructure planning.

Figure 6: Developed by Mott MacDonald from AXA IM Alts PCRAM case study (see page 11)

According to the level of risk we suggest undertaking no CAPEX cost and no regret actions



Definitions

- **Threshold**: point beyond which a system is deemed to be no longer effective (economically, socially, technologically or environmentally).
- **Trigger point**: monitored indicator that shows conditions are approaching a threshold.

Output of Step 3: Resilience Building

- A set of **Resilience Cases** which can be expressed as cashflow forecasts for investment that materially reduce the exposure and vulnerability of the asset(s).
- A ranking of adaptation options as a possible combination with structural and non-structural interventions.
- There could also be combinations of adaptation options that may achieve a better outcome than single options, depending on investment KPIs.
- The ability to create adaptation pathways can help prioritise adaptation options and map plausible futures to explore, as the investment stage and asset life-cycle change.
- The extent to which risk transfer is an alternative to adaptation options should be kept in mind ahead of Step 4.

Lessons Learned

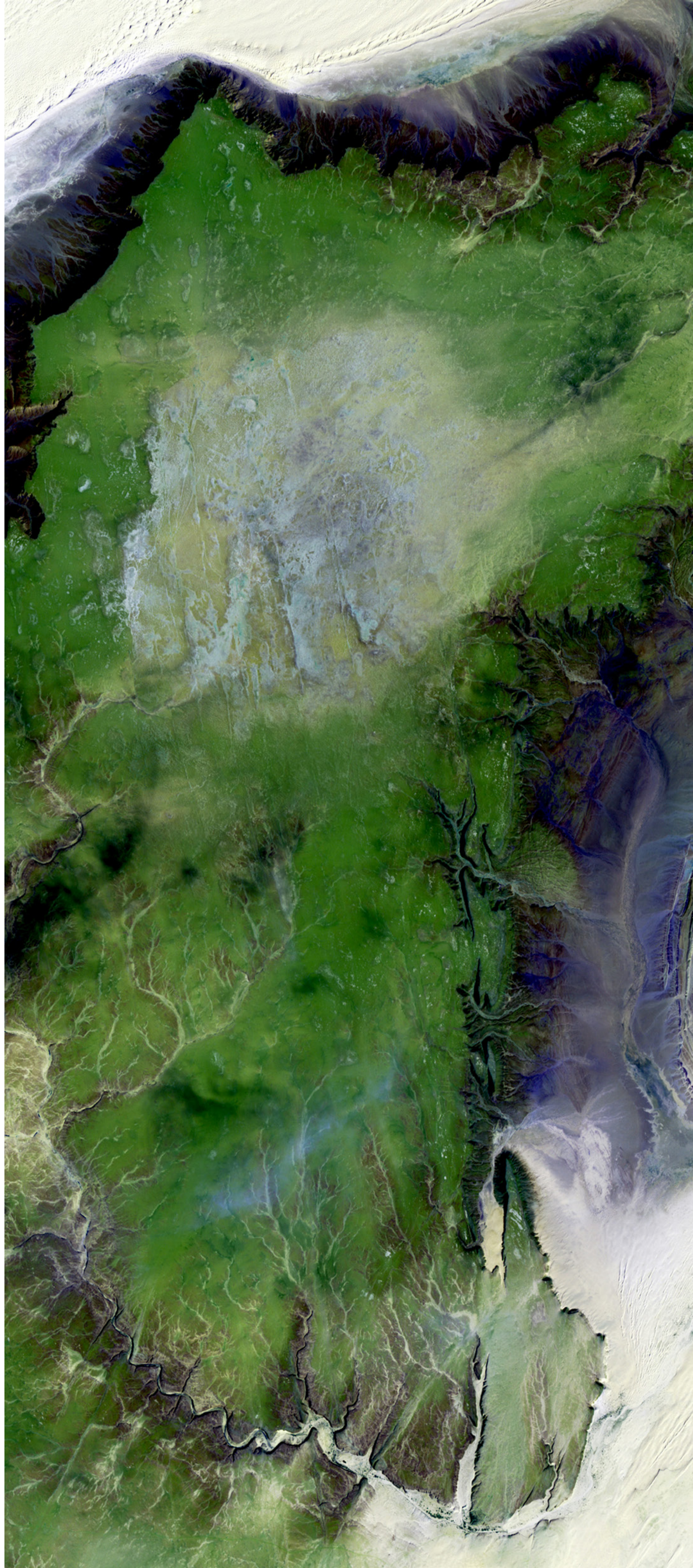
1. There is an industry need for a scoring methodology of the effectiveness of adaptation options.

Quantifying the impact of modified asset components can be complex, often requiring focus on a range of outcomes rather than a single value. The cost of these adaptation options are often estimates and not always ready for market. Their implementation will be dependent on the investors' risk appetite and asset management responsibilities.

Interventions may reduce impacts across multiple hazards and combinations of measures can produce non-linear effects. Simulating these scenarios may involve numerous iterations, adding to time and cost. To manage this, teams should use structured approaches to prioritise which adaptation paths to model.

2. Navigate uncertainties using dynamic adaptation pathways[3]

- Adaptive pathways are understood here as the actions to be undertaken and the dynamic choices to be made over time to manage physical climate risks. Physical climate risks are dynamic and probabilistic; and understanding them is inhibited by practical issues causing uncertainty.
- The adaptation pathways are plausible futures introducing adaptation options identified over the lifespan of the asset.



Decision Gate C

What are the most effective adaptation options for this asset, the optimal timing for their implementation, and the responsible parties for funding and execution?

With the help of adaptation pathways, the project team will determine what suitable resilience interventions exist, their costs, availability and whether and when these interventions can materially reduce PCRs to the asset.

The project team will also identify which stakeholder in the investment value chain could financially cover the risk ex-ante and ex-post.

	1	2	3	4
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Step 4: Value enhancement assessment

Objective

Determine whether there is a case for investment in resilience, how it can be optimised with insurability, and how risks and rewards can be shared across the value chain.

Purpose

This step draws out value implications from the appraisal, revisiting resilience incentives and rewards structure for this asset.

Step 4a) Risk Transfer: Enhancing Resilience and Insurability

At this stage, investors should explore risk transfer mechanisms — such as insurance — that can enhance the value of resilience investments. For instance, insurance pricing that reflects reduced risk could reward proactive adaptation options. In many cases, a combination of engineering solutions and insurance may offer the most effective approach to managing climate-related risks.

It is important to recognise potential mismatches between the duration of insurance cover and the investment holding period, as well as the fact that certain climate hazards may not be insurable. Shifts in insurance premia can serve as indicators of changing risk perceptions and should be monitored accordingly.

Adaptation options are designed to reduce an asset's vulnerability, thereby lowering its overall risk profile. This can improve both the affordability and availability of insurance. Insurance remains a vital tool for managing residual risks from extreme events, particularly when determining the optimal level of risk to transfer.

Parametric insurance products can also play a significant role. These rely on predefined triggers — such as specific weather events — to automatically initiate claims, enabling faster and more transparent payouts. For assets like solar farms, this can provide immediate financial support following extreme events, further strengthening resilience and financial stability.

Monitoring how insurance pricing evolves over time in response to physical climate risks can inform decisions on resilience investments and risk transfer strategies, helping to optimise climate risk management.

Risk can be pooled by different investment structures. Insurance is often negotiated at the fund level and can help mitigate the financial impact of individual asset-level risks across diversified portfolios.

As well as diversification, understanding the system level risk pooling is key. Flood risk, for example, is increasingly monitored in certain regions, with insurance coverage varying by jurisdiction. In some cases it is supplemented by public-private protection gap entity reinsurance schemes.

Step 4b)
Making the Investment Case for Resilience: Key Considerations

1. Identify Resilience Metrics

What are the resilience metrics, credit quality and insurability terms that can complement financial metrics to make the investment case?

Example: PCRAM case studies developed and quantified a set of resilience metrics that reflect improvements in downside scenarios.

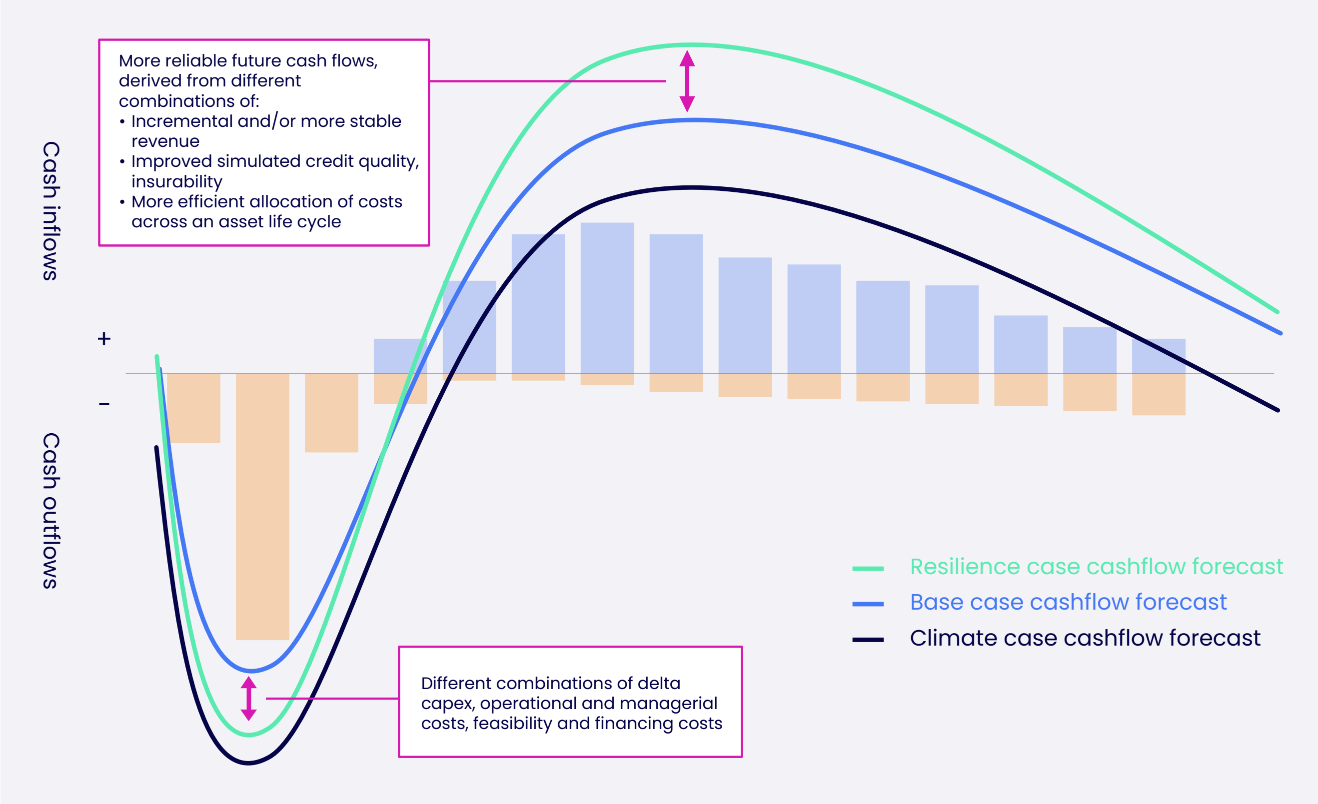
1. There may be different resilience metrics for different sectors, or even different projects.
2. Various initiatives aim to streamline this by developing a generic way of quantifying resilience benefits (e.g. UNDRR Global Risk Metrics for Resilience).
3. A measure of "insurability" could be the on-going availability of insurance cover and/or an increase in coverage for a specific risk exposure after a climate event has taken place.

Adaptation options can be evaluated through both financial and technical metrics to strengthen the investment case. Bespoke indicators and metrics that capture resilience, such as reductions in Average Expected Loss (AEL), Average Annual Loss (AAL), or Probable Maximum Loss (PML), can be compared against changes in insurance premia or insurability terms.

These metrics may be expressed as ratios to Net Present Value (NPV), such as AAL/NPV or PML/NPV, and assessed under different stress scenarios such as P10, P50, and P90 percentiles, representing low, median, and high-risk outcomes respectively.

However, the insurance market may not always be in a position to quantify the changes in AAL/PML associated with incremental resilience measures. Engaging insurers to recognise asset-level resilience interventions could help monetise these benefits. For example, in real estate, tenants could quantify theoretical annual reductions in AEL associated with resilience upgrades and calculate a return on investment, taking into account the cost of the upgrades and any adjustment in insurance terms. Funding for such upgrades could be done via a sinking fund that would capture loss reductions and savings in insurance premium.

Figure 7: The resilient investment perception problem.
Illustrative example of cashflow integration showing the difference between the Base Case, Climate Case and Resilience Case cashflow forecasts. **See case studies** for more details on cashflow integration.



2. Translate Resilience into Financial Value

Pinpoint the transmission channels through which resilience adds value:

- Improved insurance terms.
- Better lending conditions (e.g. higher debt capacity, lower margins).
- Improved cashflows.

On asset exit, lower required IRR for new investors, due to reduced asset risk.

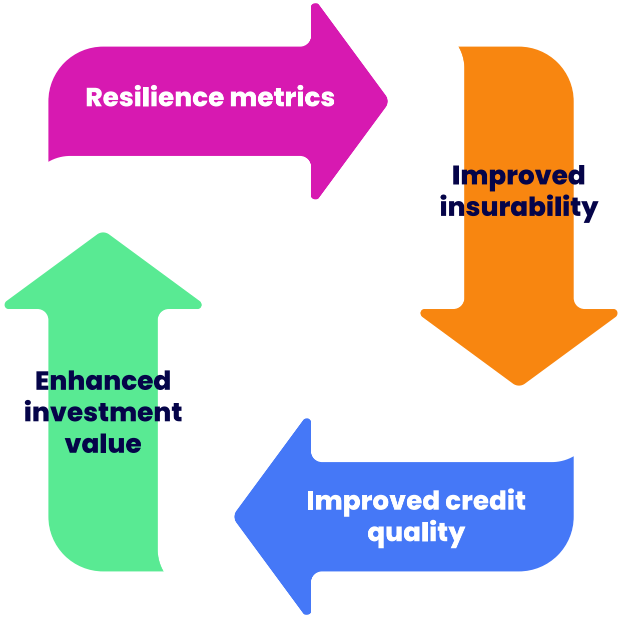
3. Key Strategic Considerations for Risk Sharing

- What acceptable level of resilience aligns with the investor's risk tolerance?
- When should residual risk be transferred to insurance? Use **dynamic adaptive pathways** (including quantification of changes to insurance metrics where possible) to help make that decision
- How should risk and reward be distributed across stakeholders — e.g. manufacturers (warranties), insurers, lenders, and investors?

4. The Value Enhancement Loop

A virtuous circle for creating incentives and rewards:

Figure 8.



Value Enhancement – Key Points

- **Resilience measures add value** under climate risk scenarios ("Climate Case") by improving cash flow profiles, but recognition depends on investor perspective.
- **Exit risk for short-term investors:** Value may not be realised if future buyers assess projects using a "business as usual" lens, which ignores climate risks.
- **Broader investor recognition is essential:** Value is more likely to be recognised if resilience measures offer additional benefits (e.g. better insurance or lending terms).
- **Resilience may reduce nominal returns:** Lower nominal returns may be acceptable to investors if they reflect reduced climate risk.
- **Valuation challenges remain:** Despite the availability of tools, there is still limited consensus on how to integrate resilience into valuation across hazards and asset types. This makes it difficult to assess its impact on cost of capital and risk-adjusted returns.
- **Nuance on how to account for climate risks:** Climate risk could be reflected either in cash flows or cost of equity to avoid overstating risk or resilience value.[4]
- **Mindset shift required:** Beyond a technical adjustment, recognising the value of resilience represents a mindset shift and an evolution in how investors assess risk, value, and long-term performance under climate uncertainty.

Outputs of Step 4: Value Enhancement Assessment

- Identified resilience metrics
- Investment case narrative

Lessons learned

1. **Insurance affordability and availability** are increasingly strained by climate risks. This underscores the need to align resilience investments with innovative insurance solutions that support risk-based pricing, that accounts for adaptation options, and frees up future cashflow for resilience investment through lower premiums. Others, like parametric products and "build back better" models — help reduce residual risk and support proactive, cost-effective adaptation, though further industry collaboration is needed.

2. **Resilience investments can enhance financial stability by improving project risk profiles** and cash flow reliability, but standardised methods to reflect these benefits in financial metrics like discount rates or cost of capital are still under development and require industry consensus.

   The time of the shock significantly affects results. The impact of changes to cash flow forecasts in the long-run are reduced by the time value of money, which makes changes to IRRs more sensitive to shorter-term events and adjustments. In other words, shocks that are modelled in the short-term (e.g. a delay in revenue or cost spike), would impact IRR much more significantly than shocks modelled in the medium-long-term.

3. **There is still a debate on adjustment to discount rates in relation to climate risks.** As an asset becomes more resilient through incremental investments and/or the implementation of non-structural measures, its cost of equity should theoretically be reduced. The methodology for adjusting a project discount rate is still under development and this is a first approach which should be validated by the industry further. In addition to the technical discussion on the adjustment to the discount rate, there is a wider discussion on pricing and how multiple actors in the investment value chain can apply the new valuation landscape proposed by PCRAM. See the further improvements section for more details.

Decision Gate D

How can resilience investment be optimised and incentivised, while ensuring equitable risk-reward distribution across the value chain actors?

The project team will determine the investment case by answering these questions:

- What acceptable level of resilience aligns with the investor's **risk appetite?**
- When should **residual risk** be transferred to insurance? Use the **dynamic adaptation pathways** to help make that decision.
- How should **risk and reward** be distributed across stakeholders — e.g. manufacturers (warranties), insurers, lenders, and investors?

	1	2	3	4
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PCRAM 2.0 Lessons Learned

PCRAM goes beyond current disclosure requirements. It is best practice and the methodology will continue to improve as the ecosystem integrates it. For PCRAM 2.0, IIGCC convened new case studies which provided valuable lessons learned.

1. Systems Thinking in PCRAM

Why Systems Thinking Matters

Incorporating systems thinking from the outset — particularly in Step 1 — lays a conceptual foundation for the entire PCRAM process. Mapping the wider asset system helps identify interdependencies, co-benefits, and indirect risks that may otherwise be overlooked in traditional asset-level assessments. Not every PCRAM exercise will require the same amount of detail. Scoping critical system components helps manage the complexity to not overwhelm the appraisal process.

Visualising Interdependencies

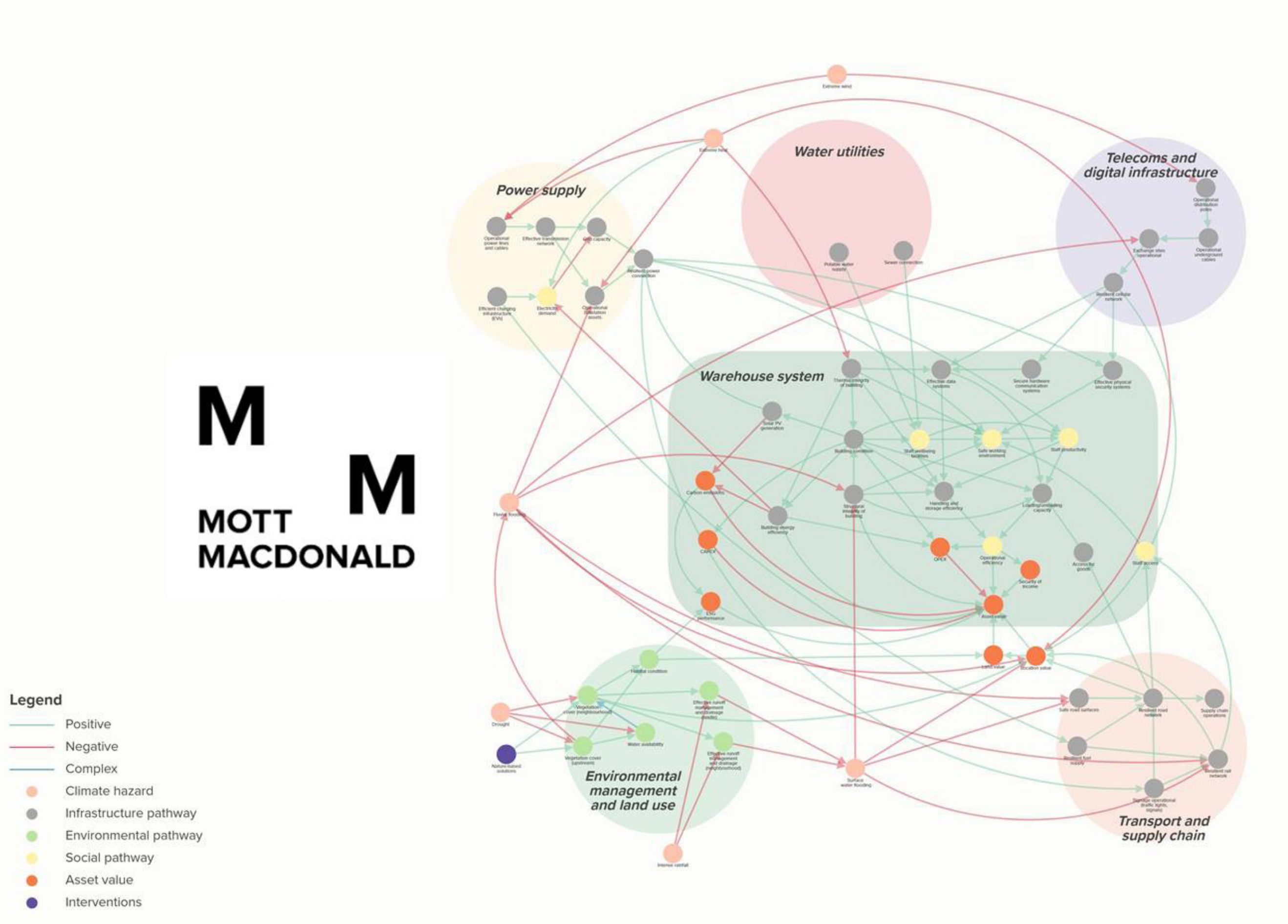
By mapping how an asset interacts with surrounding infrastructure and services, project teams can better communicate the true nature of climate risks to asset owners. For example, a widespread power outage might be seen as the responsibility of the utility provider, but its consequences — such as operational downtime or revenue loss — still affect the asset's value. Repeated shocks of this nature, which may become more frequent due to climate change, could justify investments in onsite backup systems or other adaptation options.

Insights from PCRAM 2.0 Case Studies

Case studies have demonstrated the value of systems mapping in improving the targeting of stakeholder engagement and financial modelling. Key learnings include:

- **Understanding system scale**
  System mapping raises important questions about the appropriate level of analysis. For some projects, it may be more valuable to assess risks at the portfolio level rather than the individual asset level. This is especially relevant for large infrastructure assets with multiple users (e.g. hydropower), where broader system dynamics come into play.
- **Clarifying asset value and boundaries**
  Defining asset value — including land and location value — early in the process helps consistently assess the materiality of system-level risks. Mapping should also clarify the boundaries of risk ownership and identify opportunities for collaboration on offsite adaptation options.
- **Quantifying system risks**
  While financial quantification of system-level interdependencies is still emerging, a qualitative approach aligned with the quantitative materiality assessment can provide consistency. This is particularly important when data is limited or when modelling complex, cascading impacts.
- **Stakeholder engagement and governance**
  Mapping potential beneficiaries and co-benefits during the scoping phase supports the development of a targeted stakeholder engagement plan. This can help identify co-funding opportunities for adaptation options — particularly nature-based solutions — and ensure that key actors are engaged early in the process.

Figure 9: Mapping system interconnections of illustrative PCRAM case study on a warehouse real estate asset



Systemic Benefits

Insights from PCRAM 2.0 case studies contribute to a growing evidence base on the systemic nature of resilience and the broad range of beneficiaries that such investments can generate.

System Interdependencies and Risk Trade-offs

Real assets do not operate in isolation. Their performance and viability often depend on the functioning of interconnected systems, such as energy, water, transport, and ecosystems. For example, the effectiveness of a logistics corridor or a waterfront development may rely on upstream water management decisions, which in turn influence energy generation and environmental stability. These interdependencies highlight that resilience is most effectively addressed at the system or network level.

Strategic investments must account for potential trade-offs, such as balancing energy production with environmental preservation, and avoid maladaptation or breaches of Do No Significant Harm (DNSH) principles. At the same time they can unlock co-benefits, including improved environmental outcomes, enhanced service reliability, and reduced long-term costs.

Implications for Investment and Policy

For institutional investors, system-level resilience analysis could support more accurate risk pricing, better-informed portfolio strategies, and identification of investment opportunities. For policymakers, it reinforces the need for enabling environments that facilitate cross-sector collaboration, incentivise resilience, and ensure alignment with climate adaptation and development goals. The allocation of the costs and benefits of climate risks should also be taken into account by regulators of infrastructure assets, including in the calculation of any Regulated Asset Base.

Effective public–private partnerships are essential to identify, finance, and manage resilience measures that deliver shared value across interconnected systems. These partnerships should be supported by transparent governance, and an adaptive pathways approach.

2. Insurance and Resilience Metrics

Insurance and Risk Transfer

Insurance availability and affordability in the face of physical climate risks is a growing concern. There is an opportunity to align resilience investments with insurance incentives — such as parametric products or "build back better" models — to encourage proactive adaptation. PCRAM case studies explore how adaptation options can reduce residual risk to a level that may be insurable, though further testing with the insurance industry is needed.

Resilience Metrics and Financial Implications

While insurance focuses on risk transfer, resilience investments can also influence financial metrics like project risk profiles. As assets become more resilient, they may exhibit more stable cash flows, potentially improving credit quality or investor confidence. However, methodologies for adjusting financial parameters — such as discount rates or cost of capital — are still under development and require industry consensus.

3. Towards Standardisation and Market Integration

From Proof of Concept to Minimum Viable Product

PCRAM 1.0 provided the proof of concept. PCRAM 2.0 and new case studies now have improved standardisation, evidence and practice. As the market continues to adopt PCRAM, there needs to be continued standardisation of process, a standardisation of metrics, and transparency in its application.

Governance and Ownership

Clear understanding of ownership structures is essential for defining effective engagement strategies and mobilising the right expertise. Crucially, securing buy-in from C-suite leadership significantly enhances the legitimacy, resourcing, and integration of the methodology into decision-making processes. Without senior-level ownership, implementation risks being fragmented or deprioritised.

Policy and Market Engagement

Current investment frameworks lack incentives to value resilience. External actors — including **project developers, data providers, (re)insurers, banks, and the public sector** — must be engaged to support resilience integration.

For example, lenders may not yet fully assess PCR impacts on bankability or require resilience investments. The public sector also plays a vital role in enabling co-investment, setting standards, and addressing systemic risks. **PCRAM offers a convening approach to bring the investment value chain together to unlock the full value of resilience.**

Applying PCRAM for funds and portfolios

PCRAM 1.0 was initially tested at the asset level, with some understanding of system boundaries. However, there was limited consideration of its applicability within portfolio management, strategic asset allocation, and fund management. While comprehensive evaluations — like those demonstrated in the PCRAM case studies — are valuable, they are not feasible for all existing or prospective assets within investment portfolios. Feedback from the finance community has emphasised the need for a more resource-efficient version of the methodology, along with guidance on how it can be integrated into existing risk management and due diligence processes.

In response, the IIGCC Adaptation and Resilience Working Group, in collaboration with broader stakeholders, sought to refine the PCRAM process for use within financial institutions' internal practices. The publication Physical Climate Risk Divergence: PCRAM for Investors helps identify where a full, in-depth PCRAM appraisal is warranted.

In PCRAM 2.0, three case studies explored a portfolio/fund screening approach for scoping and materiality assessment (Steps 1 and 2). This method helps streamline the process and aligns it more closely with fund and portfolio management. In Step 2, the goal is to inform targeted resilience-building strategies by evaluating portfolio/fund relevant financial materiality — specifically, impacts on debt metrics (e.g. Cash Flow Available for Debt Service [CFADs], Debt Service Coverage Ratio [DSCR]) and returns (e.g. Internal Rate of Return [IRR]) for vulnerable assets within the portfolio/fund. Once the list of most exposed assets is identified, an asset level PCRAM for material assets should be carried out [see Asset level methodology section]. In Step 3, The improved vulnerability profile of assets — achieved through adaptation options — is then reintegrated into the portfolio exposure analysis. As described in Figure 5 below, this feedback loop allows for a more accurate understanding of risk.

By incorporating PCRAM results, such as avoided damages due to resilience investments and therefore reduced vulnerability, exposures initially classified as 'high' may prove to be more manageable. Integrating these insights into portfolio management enables investors to make more strategic capital allocation decisions, enhancing overall portfolio resilience.

Importantly, this approach suggests that not all material risks need to be transferred to insurance. Instead, investors can potentially create value by investing in resilience, unlocking opportunities in areas that might otherwise be subject to exclusion or uninsurable.

Figure 10: Applying PCRAM from a fund/portfolio level

	1	2		3
Steps	**Scoping and data gathering**	**Materiality assessment**	**Asset level PCRAM for material assets**	**Reassess portfolio/ fund exposure**
Objectives	Determine scope & data sufficiency	Portfolio/ fund exposure concentration		Refined exposure from PCRAM analysis
Sub-tasks	→ Project initiation → Project definition → Data gathering and sufficiency	→ Hazard scenarios → Financial sensitivities (return & debt) → Distinguish acute damage vs. chronic performance efficiency		→ Factor vulnerability reduction back into portfolio/ fund level exposure metrics → Identify resilience metrics → Insurability and credit quality
Outputs	→ Initial portfolio climate study → Critical asset & system components → KPI selection, risk appetite → Base case cashflow forecast	→ Detailed climate study → Quantified list of most exposed assets → Climate Case (exposure) cashflow forecast		→ Value implications across investment value chain actors e.g. investors, lenders, insurers → Resilient Strategic asset allocation
Decision gates	**Gate A** Scope boundaries and data sufficiency	**Gate B** Are PCRs material to this asset?		**Gate C** Ongoing PCRAM informed portfolio management

Implications for corporate and government entities

This demonstrated application of PCRAM to funds and portfolios may open the way for corporate and government entities to use PCRAM to screen and prioritise resilience investment in assets they own, operate or rely upon. Further investigation and application of these learnings are required and will form part of IIGCC's future work on adaptation and resilience for corporate, sovereign and sub-sovereign issuers.

Lessons learned

1. **Integrating investor debt and return sensitivity tests into the scoping** or materiality phase allows hazard screening processes to accurately account for necessary levels of loss that could materially impact an investment.
2. **Assets may be funded by complex structures at the senior debt level,** and the risk of default or triggering debt covenants depends on the exposure of the overall loan to the assessed investment.
3. **Further development is needed in the portfolio and fund lens.** However, investors using the IIGCC Climate Resilience Framework may find this approach particularly useful for demonstrating progress toward portfolio-level climate alignment.

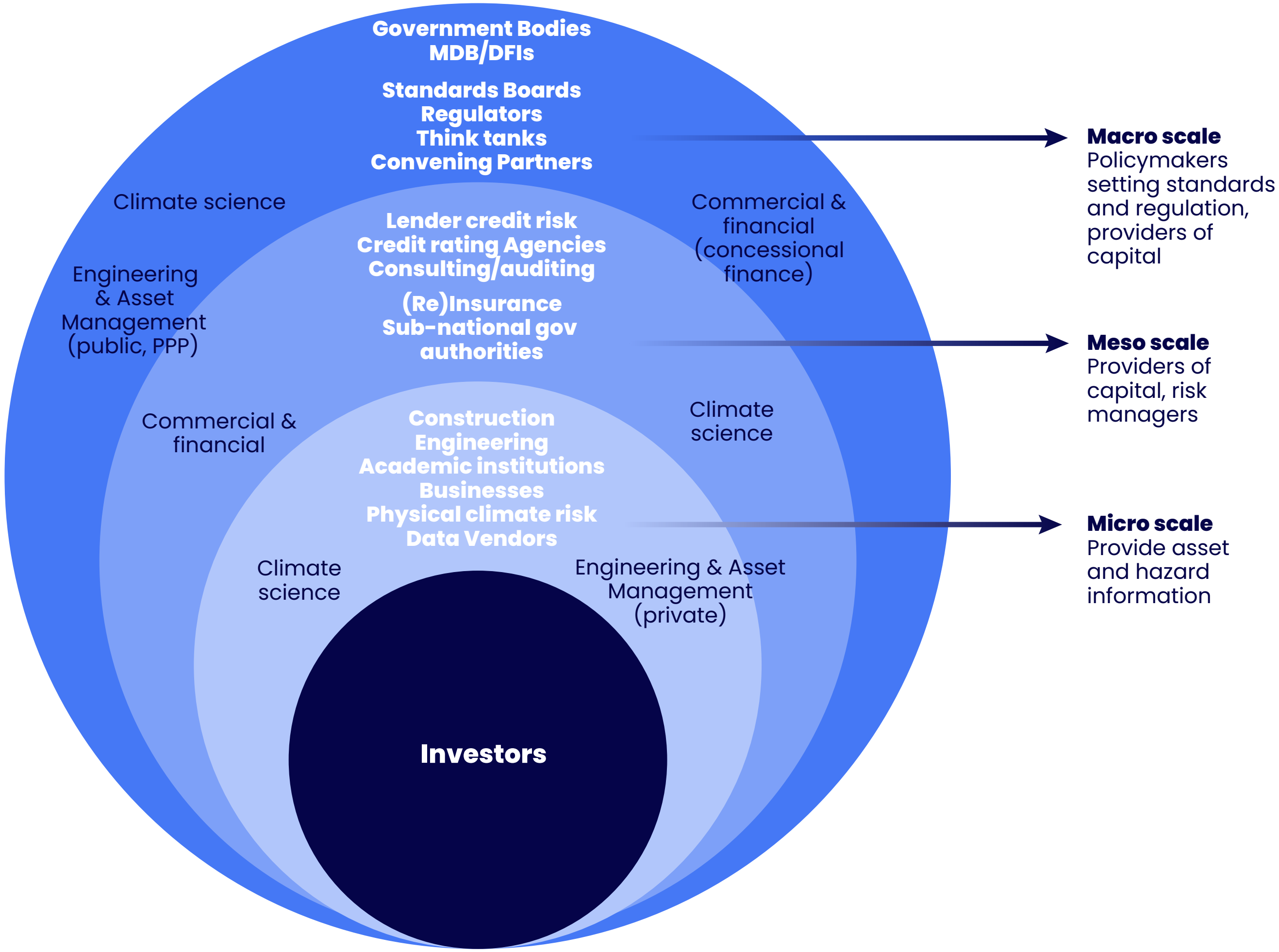
PCRAM's Wider Adoption

IIGCC continues the successful CCRI legacy and engages with investors, credit rating agencies, and government actors on integrating physical climate risk assessment across financial decision-making processes.

IIGCC raises PCRAM's profile through engaging the ecosystem:

- Regulators of assets.
- Financial regulators and forums.
- Government and NGO standard setters.
- Government foreign aid and development finance institutions.

Figure 11: PCRAM ecosystem mapping with scales and professional disciplines



PCRAM professional disciplines in navy text; organisations in the ecosystem in white text.

Embedding PCRAM into industry discussions

PCRAM has been successfully positioned on the agenda of adaptation and resilience industry initiatives. It is now referenced in numerous high-profile outputs, including:

- The Climate Bonds Initiative (CBI) Resilience Taxonomy.[5]
- UNPRI's Physical Climate Risk report.[6]
- OECD's Climate Adaptation Investment Framework.[7]
- The Atlantic Council's call for collaboration.[8]
- US FEMA newsletters.[9]
- World Bank adaptation report.[10]
- GFI's LNAS Framework to develop a UK Green Taxonomy for adaptation and resilience.[11]
- UNEP FI ARIC physical risk playbook for investors.[12]
- Outputs from the FCA and Bank of England's CFRF Adaptation Working Group.[13]
- Presented the PCRAM and CRIF at the European Commission Resilience Reflection Group which will feed into the upcoming European Adaptation Plan 2026.
- GRESB infrastructure Standards Committee reviewing their physical risk indicators.
- FAST Infra is signposting PCRAM and CRIF for the next update to their R5 indicator (June 2025 publication).
- WBCSD Adaptation Planning | Adaptation Planning Guidance, June 2025.[14]
- UNDRR and Howden Global Risk Metrics for Resilience.
- IISD NAP Global Network.
- UNDRR Prevention Web.[15]
- Oxford ECI – Oxford researchers help investors build climate resilience infrastructure.[16]
- World Bank IFC A&R report, January 2026.
- FCA and BoE Climate Financial Risk Forum Adaptation group report From Risk to Resilience: Integrating Adaptation into Finance.[17]
- IPFA, Physical Climate Risks in Investment Processes, Nov 2025.[18]
- ICSI, Resilience4Ports (R4P): Port Decision Makers' Guide to Climate Risk Assessment (CRA), Nov 2025.[19]

Integration of PCRAM into the Climate Resilience Investment Framework

PCRAM is central to the target setting methodology within the IIGCC Climate Resilience Investment Framework. This framework supports investors to develop targets and plans to improve the resilience of investments at both asset and portfolio level. Its target setting methodology stresses the importance of implementing PCRAM across an increasing proportion of investment holdings over time, with the intention of implementing suitable adaptation options to address material physical climate risks.

Connecting CRIF and PCRAM 2.0: Roles and functions

Focus	Climate Resilience Investment Framework (CRIF)	Physical Climate Risk Appraisal Methodology (PCRAM 2.0)
Type	Big-picture framework	Practical appraisal tool
Purpose	Guides adaptation and resilience plans	Identifies and analyses physical climate risks, opportunities, and their impact on current and future asset values
Approach	Strategic "what to do"	Technical "how to do it"
Components	Governance and Strategy, Objectives, Strategic Asset Allocation, Asset Level Assessment and Targets, Policy Advocacy, Stakeholder and Market Engagement	Determines the approach adopted within CRIF regarding target setting methodology
Process	Ongoing cyclical process	Case study-led, proportional approach, cyclical process to account for dynamic materiality
CRIF = strategy; PCRAM 2.0 = analysis		

Read more on how PCRAM and CRIF fit together.

Areas of further work

Several potential activities have been identified to expand and deepen the impact of PCRAM.

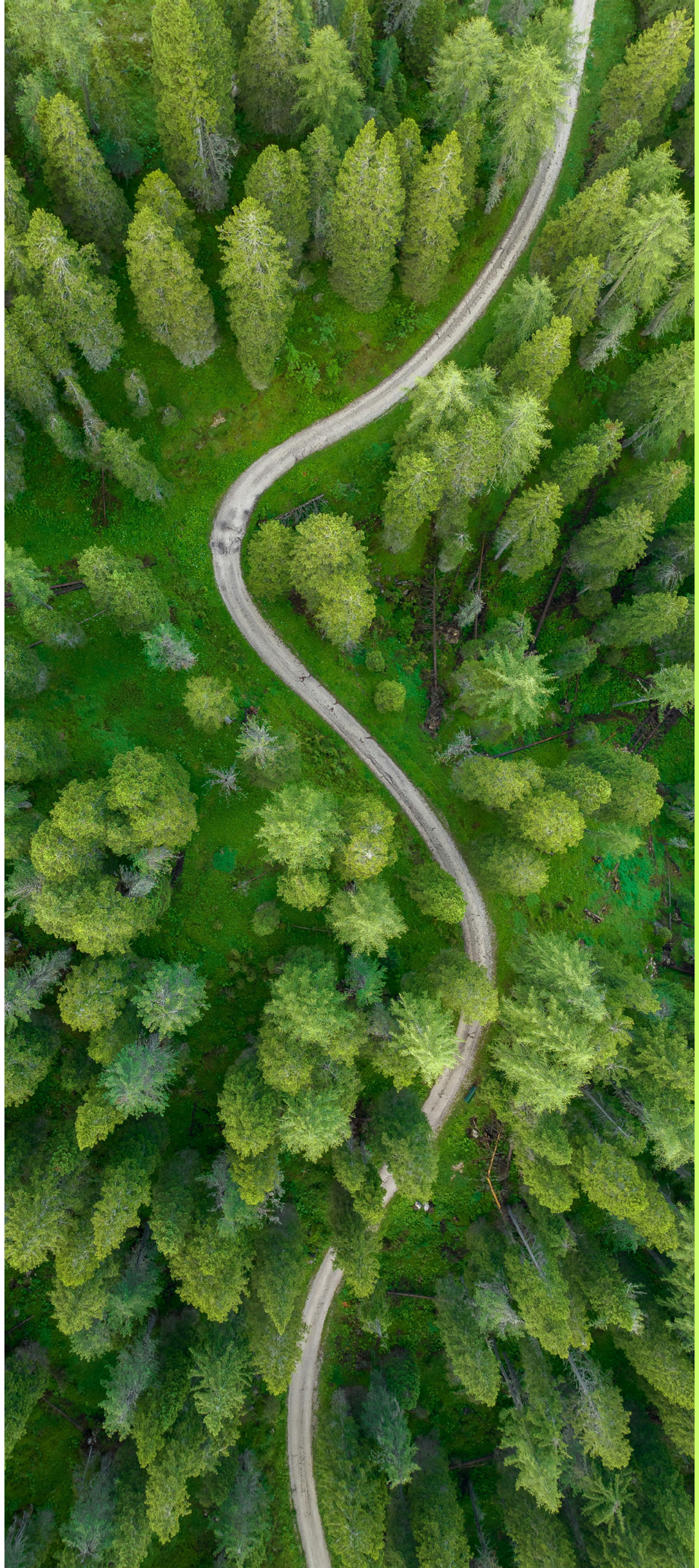
1. **Market and policy engagement**
   Strengthen collaboration with standard setters and labelling initiatives — such as the FAST-Infra Label, GRESB, and ISSB — to support standardisation and track user adoption of resilience-aligned practices.
2. **Aligning Resilience Metrics with Risk-Based Pricing**
   Collaborate with insurers and lenders in the finance industry to align resilience metrics with insurability and credit quality, providing incentives and rewards of resilience investments through risk-based pricing mechanisms.
3. **Enhancing Physical Climate Risk Data and Metrics**
   Engage the broader market ecosystem to enhance the availability, accuracy, and use of physical climate risk data, resilience metrics, and scenarios, with a focus on systemic resilience metrics and macro-stewardship. PCRAM can serve as a common methodology for data providers and investors to align on terminology and expectations.
4. **Advancing Climate Adaptation Solutions**
   Assess the market-readiness of resilience technologies, including supply chains, manufacturing capacity, and installation capabilities, to ensure scalability and accessibility of adaptation measures.
5. **Supporting PCRAM 2.0 Implementation in Emerging Markets**
   Compile and disseminate case studies from emerging markets and developing economies. Strengthen the narrative around capital mobilisation for adaptation and resilience aligned with the Sustainable Development Goals (SDGs).
6. **Enhance the role of MDBs and DFIs as enablers**
   Collaborate with Multilateral Development Banks (MDBs), Development Finance Institutions (DFIs), and initiatives such as UNEP FI's ARIC to explore blended finance models, shared risk frameworks, and public-private funding mechanisms. Encourage resilience assessments like PCRAM as a prerequisite for DFI lending and investment decisions.
7. **Exploring PCRAMs application for corporate and government entities**
   Iterating on the fund and portfolio assessments outlined in the case studies, applicability of this approach to these entities may help broader utilisation and collaboration on PCRAM amongst stakeholders.

These focus areas position PCRAM to deepen its global impact, support emerging market needs, foster public-private collaboration, and drive systemic change in climate-resilient investment practices.

Conclusion

The **Physical Climate Risk Appraisal Methodology 2.0 (PCRAM)** highlights the significant progress and impact of the PCRAM methodology since its successful inception, extensive stakeholder engagement, and advancements in case study development. These achievements demonstrate how well-positioned PCRAM is to support climate resilience investment.

While PCRAM is already a robust and comprehensive methodology, it is designed to evolve in response to industry feedback and emerging best practices. Future enhancements may include the integration of pricing signals, incentives, and reward mechanisms that better reflect the value of resilient investment. Tracking adoption and incorporating lessons learned from real-world implementation will be essential to ensuring its continued relevance and effectiveness.



Annex - Resources

PCRAM 2.0 Data Availability Tracker to streamline Step 1 data gathering

IIGCC PCRAM 2.0 Data Availability Tracker

Purpose

This document outlines the possible data points and sources needed to complete a PCRAM. Its use is intended to help assess the data availability and sufficiency under step 1 of PCRAM.

Assumptions and limitations

- The requests included in this document are based on what is expected to be required to complete a case study on a selection of assets. However, this is subject to change based on the scope of the assessment to be agreed with the investor.
- The data included under the financial category is not prescriptive, and is intended to support the investor identify the value drivers of the asset or fund.

Tabs in this document

Step 1 Scoping

Detailed Data Requests

Authors and Version control

Originator	Checker	Approver	Description	Date
XX	XX		XXX	01-Dec-25

See open-source PCRAM Data Tracker

Appendix A: Classification of climate-related hazards, EU Taxonomy

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

Or any relevant taxonomy to account for multiple geographies. The list of climate-related hazards in this table is non-exhaustive, and constitutes only an indicative list of the most widespread hazards that are to be taken into account as a minimum in the climate risk and vulnerability assessment.

Endnotes

1 Different approaches will be required for climate science and their respective hazards, according to investment and asset condition and characteristics. See case studies for more.
The Financial Conduct Authority and Bank of England convened Climate Financial Risk Forum Adaptation report 2025 builds on the ABC Framework and provides useful guidelines for climate science.

2 BS 8631:2021. Adaptation to climate change – Using adaptation pathways for decision making – Guide. British Standards Institution (BSI).https://knowledge.bsigroup.com/products/adaptation-to-climate-change-using-adaptation-pathways-for-decision-making-guide

3 Deltares, TU Delft, Dynamic Adaptive Policy Pathways

4 Musings on Markets: Catastrophic Risk: Investing and Business Implications

5 Climate Bonds Initiative. Resilience Taxonomy. Climate Bonds Initiative, 2021. https://www.climatebonds.net/resources/reports/resilience-taxonomy-white-paper

6 UN Principles for Responsible Investment (UNPRI). Investor Guidance on Managing Physical Climate Risks. UN PRI, 2021. https://www.unpri.org/climate-change-for-private-markets/assessing-physical-climate-risk-in-private-markets-a-technical-guide/13135.article

7 Organisation for Economic Co-operation and Development (OECD). A Framework to Quantify the Benefits of Climate Change Adaptation Investment. OECD Publishing, 2021. https://www.oecd.org/en/publications/climate-adaptation-investment-framework_8686fc27-en.html

8 Atlantic Council. Advancing Climate Adaptation: A Call for Collaboration. Atlantic Council, Adrienne Arsht-Rockefeller Foundation Resilience Center, 2022. https://onebillionresilient.org/cop28-call-for-collaboration/

9 Federal Emergency Management Agency (FEMA). FEMA Adaptation & Resilience Newsletters. U.S. Department of Homeland Security, various issues. https://www.fema.gov/emergency-managers/practitioners/recovery-resilience-resource-library

10 World Bank, Rising to the Challenge: Success Stories and Strategies for Achieving Climate Adaptation and Resilience. https://www.worldbank.org/en/publication/rising-to-the-challenge-climate-adaptation-resilience

11 Green Finance Institute (GFI). The LNAS Framework: Developing a UK Green Taxonomy for Adaptation and Resilience. Green Finance Institute, 2023. https://www.greenfinanceinstitute.com/wp-content/uploads/2024/12/LNAS-Framework-to-develop-a-UK-Green-Taxonomy-for-adaptation-and-resilience.pdf

12 United Nations Environment Programme Finance Initiative (UNEP FI). Physical Climate Risk: Investor Playbook. UNEP FI, 2023. https://www.unepfi.org/wordpress/wp-content/uploads/2024/10/ARIC-PCR-Playbook-2.pdf

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14 https://www.wbcsd.org/resources/adaptation-planning-for-business-navigating-uncertainty-to-build-long-term-resilience/

15 https://www.preventionweb.net/publication/documents-and-publications/physical-climate-risk-appraisal-methodology-pcram-20

16 https://www.eci.ox.ac.uk/news/oxford-researchers-help-investors-build-climate-resilience-infrastructure

17 https://www.fca.org.uk/publication/corporate/from-risk-resilience-integrating-adaptation-finance.pdf

18 https://www.ipfa.org/content-library/physical-climate-risks-in-investment-process/

19 https://sustainability-coalition.org/publication/resilience4ports-r4p-port-decision-makers-guide-to-climate-risk-assessment-cra/

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