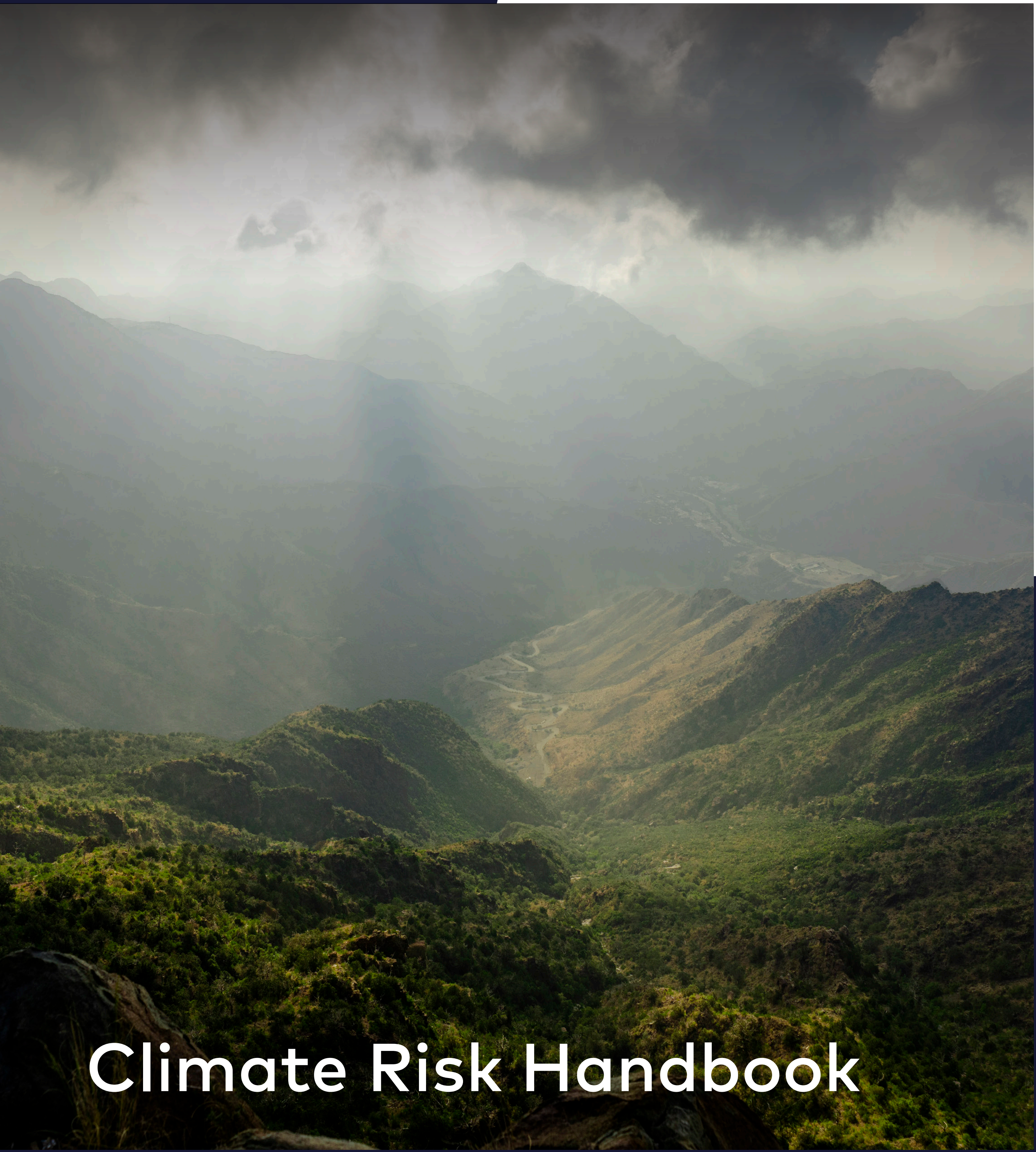

# Climate Risk Handbook

Taking the guess work out of climate risk and adapting cost effectively

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Soudah Development

# Introduction

Climate risk is no longer a distant concern – it's a material business risk. For executive teams, the challenge is not recognizing the issue but determining how to cut through the noise and identify where it truly affects operations, assets, and long-term growth. Too often, climate risk assessments feel abstract, lack a clear approach, and leave leadership guessing.

Extreme weather events are already disrupting operations, insurance markets are offering less coverage at higher cost, and regulatory pressure is moving faster than many businesses anticipated. At the same time, climate models are becoming far more precise, revealing exposures that were invisible even a few years ago. Companies that rely on broad, qualitative assessments increasingly find themselves surprised by asset degradation, operational disruption and escalating recovery costs. Boards and investors are now asking harder questions: not just whether climate risk is understood, but whether it has been quantified in a way that guides capital allocation and operational planning.

This handbook offers a practical, stepwise approach to do exactly that. It provides a defensible calculation of financial exposure across assets and operations, translating physical hazards into clear Value at Risk (VaR) framework (the maximum potential financial loss due to exposure to risk). It shows where climate-driven failures are most likely, how severe they could be, and which interventions reduce exposure at the lowest cost. Instead of treating climate adaptation as an open-ended problem, this approach narrows decisions to the actions that matter most and gives leadership a clear basis for prioritization, investment, and accountability.

> “
>
> **Climate change is a strategic risk that should be managed with the same rigor and economic discipline than any other corporate risk.**

The framework removes subjectivity and guesswork, giving you clarity and confidence to act., It consists of eleven steps: calculating VaR, prioritizing adaptation measures, and operationalizing chosen risk reduction actions. The phases and underlying steps are designed so that a decision can be made at each stage on whether it makes sense to progress to the next. Figure 1 summarizes the overall workflow.

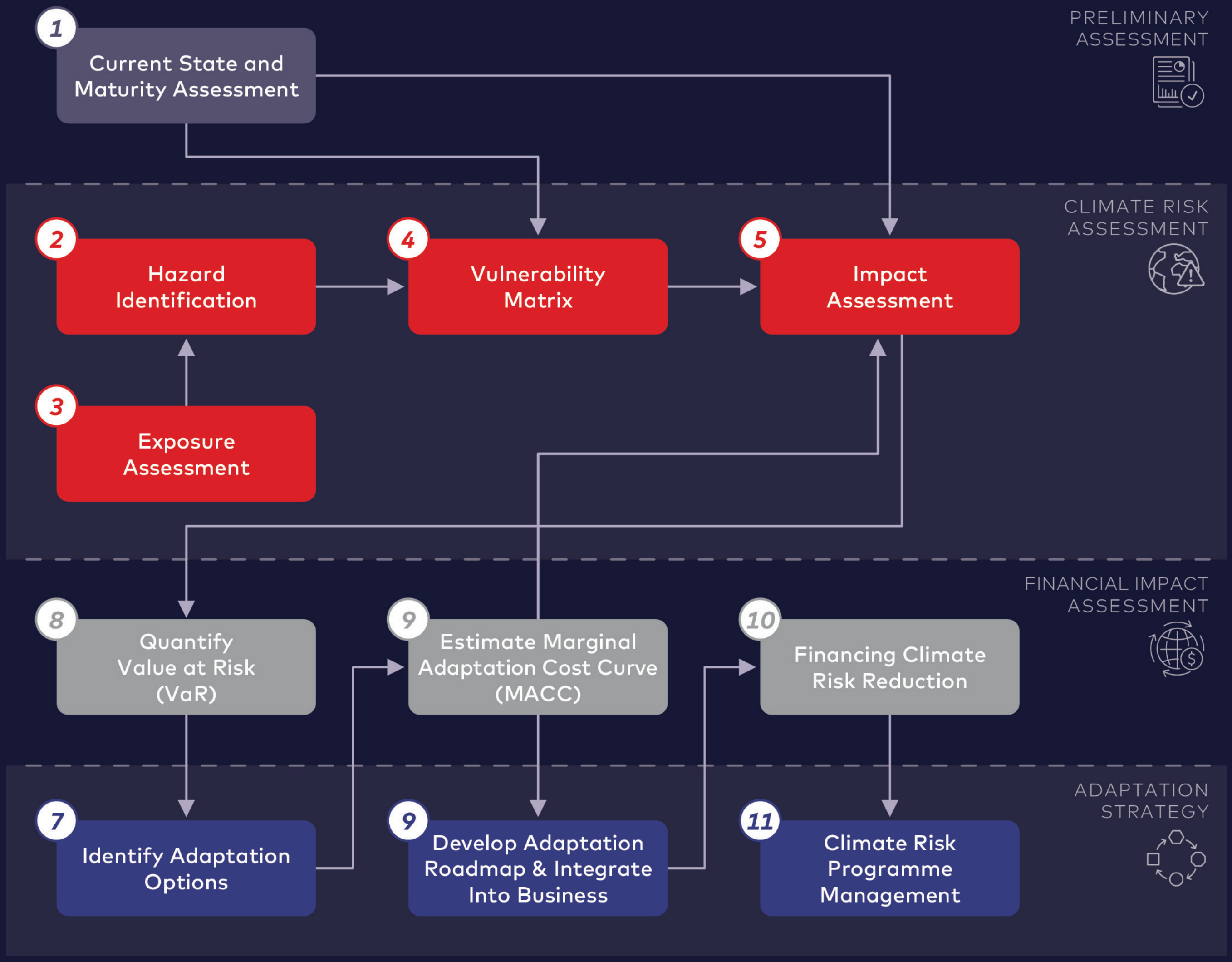


*Figure 1: Climate Risk Workflow*

This workflow lays out a clear progression: begin with foundational requirements, build a defensible view of risk, then prioritize and operationalize the most cost-effective actions.

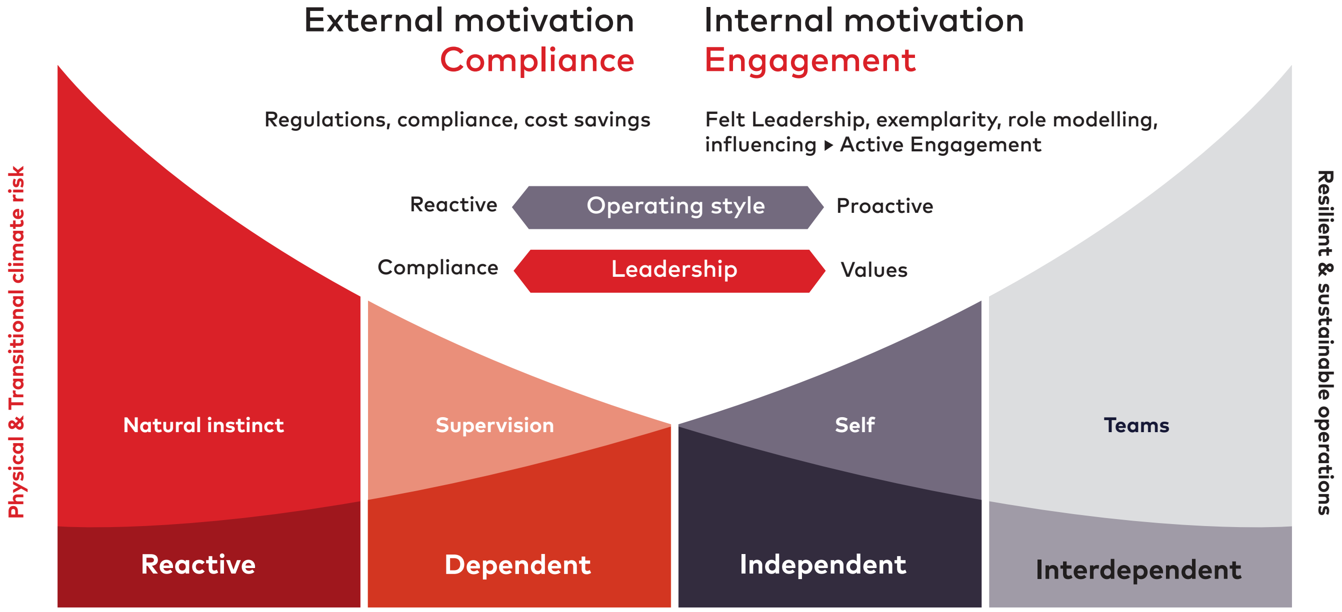
## STEP 1

# Current state and maturity assessment

Before taking action, it is critical to understand your organization's current maturity in managing physical climate risks and opportunities.

A literature review is conducted to identify location and sector specific hazards, as well as receptors relevant to the organization. Receptors refer to any asset, system, population, or ecological element that are exposed and impacted by climate hazards. This evolves into a targeted site assessment, which maps the value chain to calibrate the assessment's granularity from organizational strategy down to specific asset components. By synthesizing existing intelligence – including Environment and Social Impact Assessment (ESIAs) and Hazard Identification (HAZID) studies - we isolate hazard sources and finalize critical receptor nodes. The process concludes by reviewing current policies and procedures to map existing controls directly to these finalized receptors. This ensures the risk framework is not only technically precise but fully integrated into the organization's operational safeguards.

dss⁺ uses the **Bradley Curve** to evaluate this maturity, which typically ranges from Reactive – where responses are driven by compliance and past events – to Interdependent, where climate resilience is embedded across all functions and supported by a proactive culture of collaboration and innovation.



| | Reactive | Dependent | Independent | Interdependent |
|---|---|---|---|---|
| Physical | • Unmitigated exposure to climate events across value chain<br>• Compliance with legislation<br>• Decisions based on history | • Situational and risk awareness by management<br>• Climate hotspots identified and integrated into ERM | • Climate response strategy derived from TCFD aligned assessment<br>• Detailed asset vulnerability assessment based on flood and climate models | • Risk mitigation is operationalised across business functions<br>• Continues investment in R&D and climate resilient products & services |

*Figure 2: dss+ Bradley Curve*

STEP 2

# Hazard identification

The next step is to identify climate hazards that could impact your operations or supply chain. The EU Taxonomy provides a useful reference list for consideration.

> Hazards should be shortlisted based on regional topography and geography, historical incidence, academic research, industry-specific trends, and projected exposure under future climate scenarios, focusing only on those expected to change significantly over time.

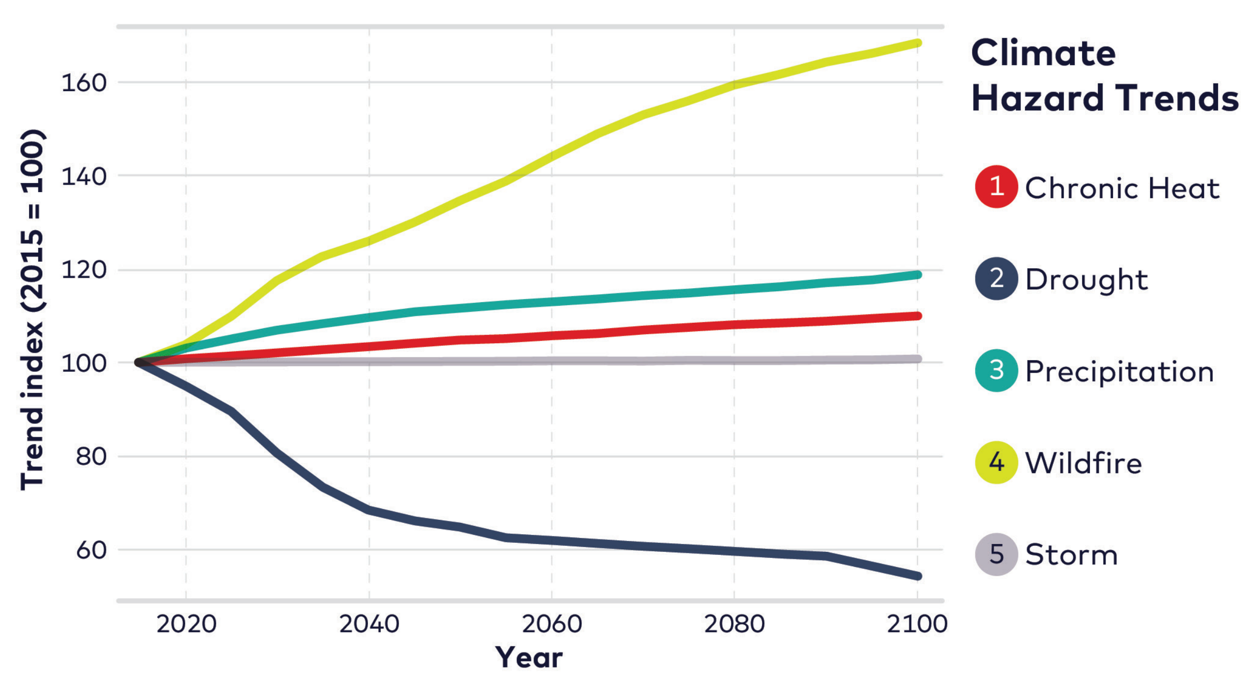


*Figure 3: Climate hazard trends for Saudi Arabia (Projected to 2100)*

*The Aseer region exemplifies the critical role of local topography in hazard shortlisting. While Saudi Arabia is predominantly arid, Soudah peaks create a distinct microclimate that intensifies rainfall and temperature variability. Notably, the region exhibits sharp gradients in precipitation and temperature within only a few kilometers, driven by rapid changes in elevation. This case underscores why Soudah Development must prioritize site-specific anomalies over broad national trends, ensuring the assessment captures the hazards most material to the local environment.*

# Exposure Assessment

Once the hazards and receptors have been identified, the receptors are assessed to understand the extent to which they are exposed to each hazard. Exposure refers to whether, and to what degree, a receptor located in an area is subject to a specific climate hazard, independent of its vulnerability or resilience.

Hazard exposure is assessed by using global open-source datasets for initial screening with high-resolution and proprietary models to achieve the granularity necessary for location-specific projections. To support forward-looking decision-making, exposure is evaluated across a spectrum of Shared Socioeconomic Pathways - standardized climate scenarios developed by the Intergovernmental Panel on Climate Change that reflect alternative global development and emissions trajectories. These span from low-emissions pathways aligned with the Paris Agreement's 1.5°C ambition (e.g., SSP1-1.9) to high-emissions, fossil-fuel intensive futures (e.g., SSP5-8.5). Exposure is assessed across multiple time horizons (e.g., 2030, 2050, 2080/2100) to understand how physical climate risks may evolve under different warming scenarios

This is supported by a targeted analysis of scientific literature and industry intelligence to establish evidence-based likelihood ratings. By synthesizing climate projections with empirical research, the methodology ensures that risk ratings are both technically rigorous and contextually grounded across all potential warming pathways.

*The Aseer Province has warmed by 0.69°C between 1995 and 2014, with an average historical temperature of 24.34°C. Even under the low-emission pathway (SSP1-1.9), temperatures are expected to keep rising, reaching about 25.40°C in the mid-term (2041–2060) before slightly easing to 25.23°C by the end of the century.*

*Near-term warming (2020–2040) is similar across all scenarios, but differences widen by mid-century. Under SSP2-4.5, mid-term warming (1.57°C) is around 1.5 times higher than under SSP1-1.9, increasing to 2.29°C in the long term (26.63°C). The high-emission scenario (SSP5-8.5) shows the strongest warming—2.20°C by mid-century (26.53°C) and 4.24°C by the end of the century (28.58°C).*

*Overall, all scenarios point to continued warming in Aseer, with the scale of increase closely tied to future global emissions that would directly impact Soudah Peaks.*

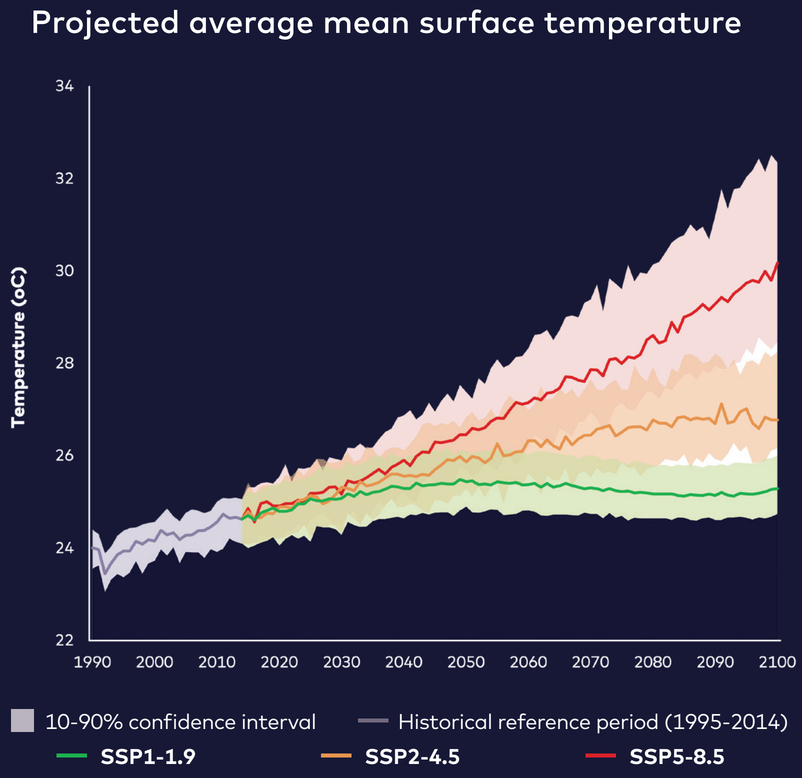


*Figure 4: Historical and projected changes in average mean temperature in Aseer Province under SSP1-1.9, SSP2-4.5, and SSP5-8.5 scenarios*

STEP 4

# Vulnerability Matrix

The identified climate hazard and receptors are combined to create a vulnerability matrix. This matrix assesses how each climate hazard could impact critical systems, operations, value chain components or any known receptors.

A literature review is conducted to identify known or anticipated vulnerabilities – such as increased temperature driving higher cooling and ventilation energy demand or extreme rainfall requiring upgraded stormwater infrastructure. This desktop analysis is then validated through site visits with subject matter experts to stress-test the resilience of assets, systems, and processes against projected climate changes.

Engagement with facility management teams, building engineers, asset managers, OEMs, and procurement teams, provides practical insights into building operations, maintenance constraints, and potential system failure modes. Preliminary hotspots are flagged based on potential infrastructure damage, increased building maintenance, operational disruption and risks to resident/tenant safety.

These findings form the foundation for quantifying value at risk and prioritizing adaptation measures in subsequent steps.

| **Receptors** | **Climate Hazards** | | | |
|---|---|---|---|---|
| | **Chronic Heat and Heatwaves** | **Precipitation and Flooding** | **Wildfire** | **Sandstorm** |
| **Buildings** (residential, hospitality, commercial, etc.) | 🟨 Thermal stress on roofs, façades, glazing, and insulation; accelerated deterioration of HVAC and electrical systems | 🟥 Water ingress and flooding of basements, ground floors, and utility areas, causing material loss, dampness, mould, and deterioration of finishing | 🟧 Structural damage, interior destruction, smoke damage, and fire risk to occupants. | 🟩 Roof uplift; façade and glazing damage; damage to fixed external elements |
| **Attractions** (adventure park, skybridge, etc.) | 🟧 Thermal expansion and fatigue of structural elements; stress on mechanical and safety systems | 🟥 Erosion and water damage to foundations, supports, access routes, fixed equipment, and structural or safety components | 🟧 Damage to structures and equipment, temporary closure, safety hazards | 🟧 High structural stress on exposed and elevated elements; damage to rides, decks, and safety infrastructure |
| **Open Spaces** (nature reserves, farms, etc.) | 🟧 Heat stress leading to soil moisture loss; additional stress on irrigation and surface materials | 🟥 Soil erosion and runoff damaging landscaping, paths, irrigation, and unpaved surfaces | 🟥 Vegetation loss, soil degradation, air pollution, habitat destruction | 🟩 Damage to vegetation; erosion and damage to fencing and lightweight structures |
| **Other infrastructure** (parking, roads, etc.) | 🟨 Surface degradation and material fatigue of pavements; thermal stress on shading and lighting | 🟥 Ponding and inundation causing damage to pavements, drainage, lighting, and EV charging points | 🟧 Surface damage, accessibility issues, debris blocking access, risk to vehicles | 🟧 Damage to lighting poles, shading structures, and surface fixtures |

🟩 *Low* 🟧 *High*
🟨 *Moderate* 🟥 *Critical*

*Table 1: Vulnerability matrix*

*The extent and nature of vulnerabilities to climate hazards are influenced by topographical features. For instance, for Soudah Development, valleys are likely to experience more intense flooding and water accumulation during heavy precipitation, whereas ridges may face different impacts such as runoff and erosion.*

## STEP 5

# Impact Assessment

A detailed impact assessment is done for each receptor-hazard combination by combining the inherent and residual impact ratings with the likelihood ratings established during the exposure assessment stage, providing an integrated measure of overall physical climate risk.

A structured rating scale is then developed in alignment with the organization's existing Enterprise Risk Management (ERM) framework to enable seamless integration. This also includes defining the key vulnerability categories that influence risk outcomes, such as personnel health and safety, physical assets, and operational continuity.

Receptor-specific characteristics are reviewed, and each vulnerability category is assessed and rated for every hazard–receptor combination to establish the inherent risk profile. Residual risk ratings are subsequently assigned by reassessing each vulnerability category after considering the effectiveness of existing controls and mitigation measures identified in the preceding steps.The risks ratings are also validated through engagement with the corporate risk team and other relevant stakeholders.

*Impact ratings are established using the Soudah Development's scale ranging from 1 to 5, for each vulnerability category. Scores range from low (1) to critical (5); for example, in Personnel Health, a rating of 1 represents minor discomfort, while 5 indicates fatality or permanent disability. Likelihood is also rated from 1 (Rare) to 5 (Almost Certain), based on observed or expected frequency of events in the region.*

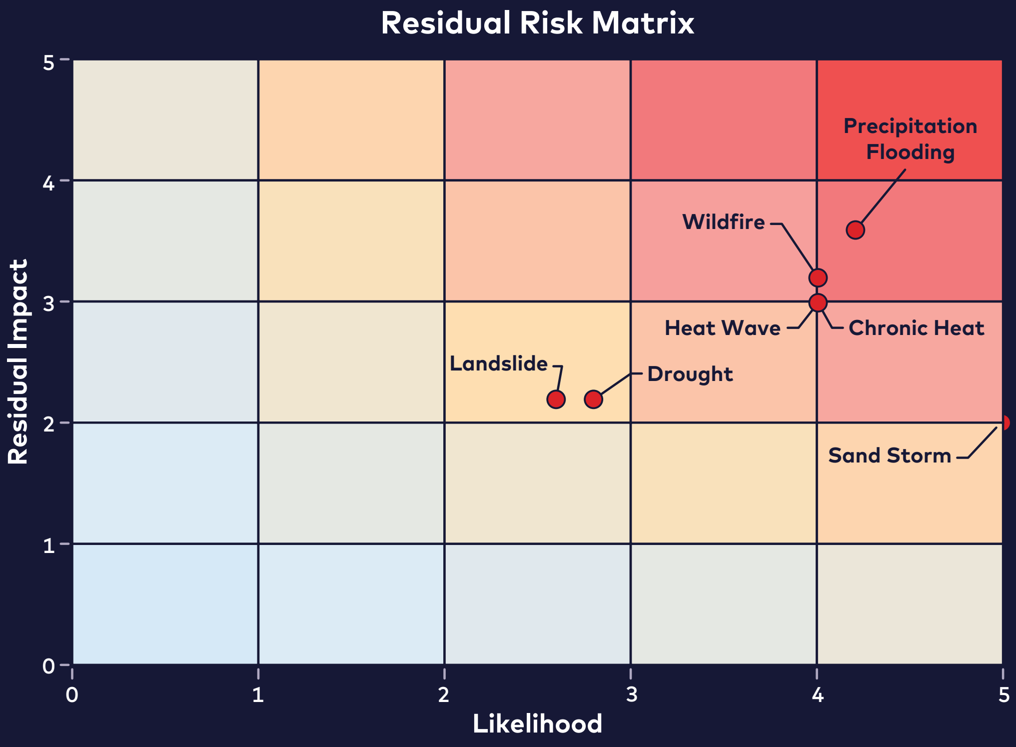


*Figure 5: Illustrative risk rating matrix*

## STEP 6

# Quantify Value at Risk (VaR)

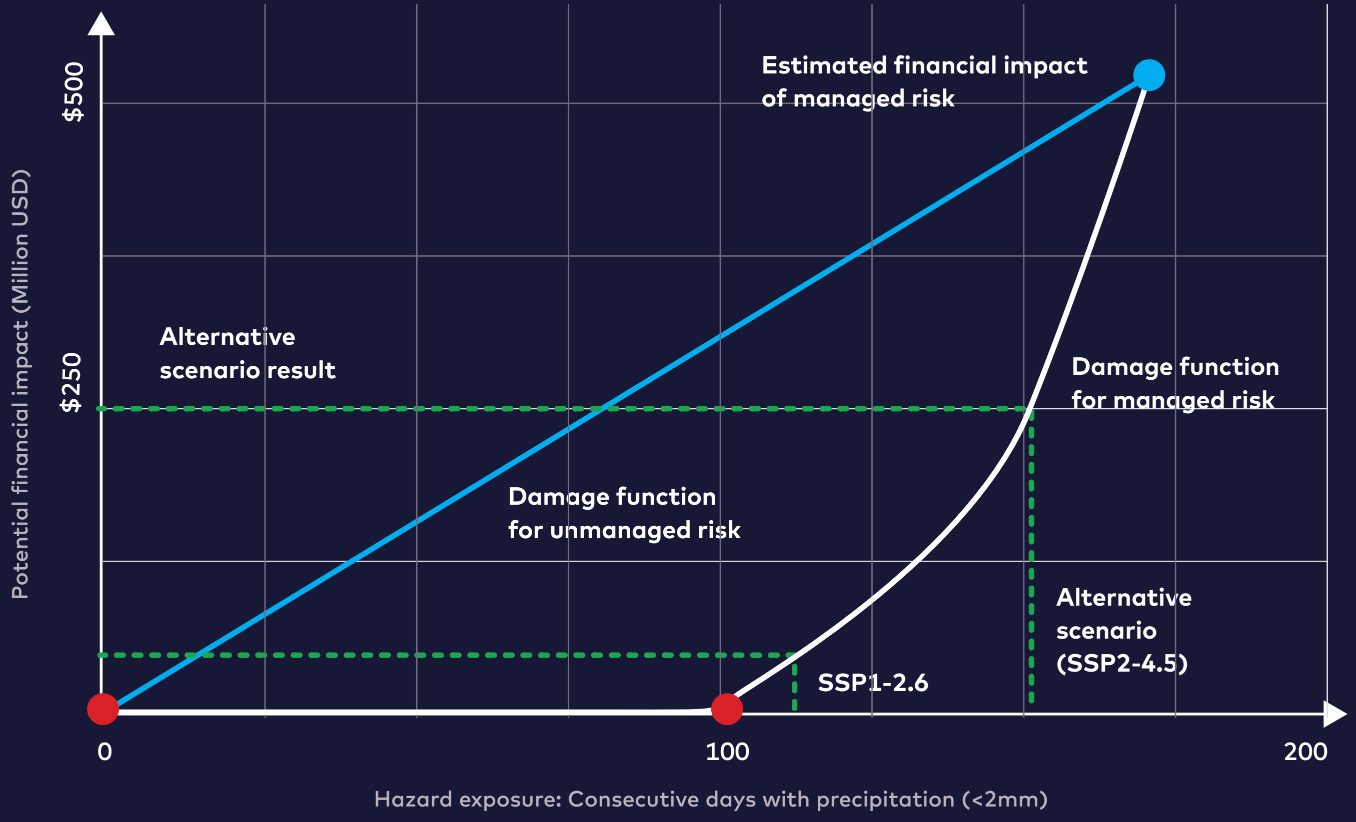


*Figure 6: Developing a damage function to assess multiple scenarios*

**The identified vulnerabilities are translated into financial terms by developing damage functions – mathematical models that estimate potential losses for each receptor-hazard combination.**

For example, if extreme precipitation of 35 mm in a single day is projected under SSP2-4.5 by 2040, and a residential or mixed-use development is designed for a lower drainage capacity, surface water accumulation and water ingress into basements, parking areas, or ground-floor units may occur, resulting in physical damage to building fabric and services. Conversely, where site drainage, waterproofing, and stormwater systems are designed to accommodate or exceed the projected precipitation intensity, the resulting VaR is effectively negligible and further interventions are not required.

Damage functions also capture less severe impacts but which result in secondary effects, such as increased energy costs for ventilation systems due to rising temperatures. These functions are informed by asset values from insurance schedules, revenue impacts, and productivity losses, while accounting for existing controls and response plans that mitigate risk.

The outcome is a clear visualization of VaR across the value chain, enabling identification of financial hotspots and guiding cost-effective adaptation strategies.

## STEP 7

# Identification of adaptation options

The purpose of developing an adaptation strategy is to identify and target the highest value-at-risk elements through structural, nature-based, policy, or behavioral interventions. This process should be co-designed with clients and stakeholders to ensure practicality and buy-in.

Start with quick wins such as early warning systems, emergency response plans, and insurance coverage, then progress to capital-intensive solutions like infrastructure upgrades, flood defenses, and retrofitting to improve thermal resistance. All options should align with national adaptation plans and sectoral strategies.

Importantly, this step is about creating a full “wish list” of potential actions, regardless of cost or complexity, to ensure no viable measure is overlooked. This comprehensive view enables informed prioritization in the next phase, balancing risk reduction with cost-effectiveness.

STEP 8

# Estimate Marginal Adaptation Cost Curve (MACC)

A Marginal Adaptation Cost Curve (MACC) ranks adaptation measures according to their cost-effectiveness in reducing VaR, helping decision-makers prioritise the most efficient actions for managing climate-related risks. Each option is plotted according to its implementation cost and the degree to which it lowers financial exposure, providing a clear visual for prioritization.

The Adaptation MACC considers the entire value chain, not just individual sites, and accounts for multiple options addressing the same vulnerability. Each measure modifies the damage function for that vulnerability, and this reduction in VaR - combined with cost – is what the curve captures. The result is a practical tool for decision-makers to identify the most cost-effective interventions that deliver the greatest risk reduction.

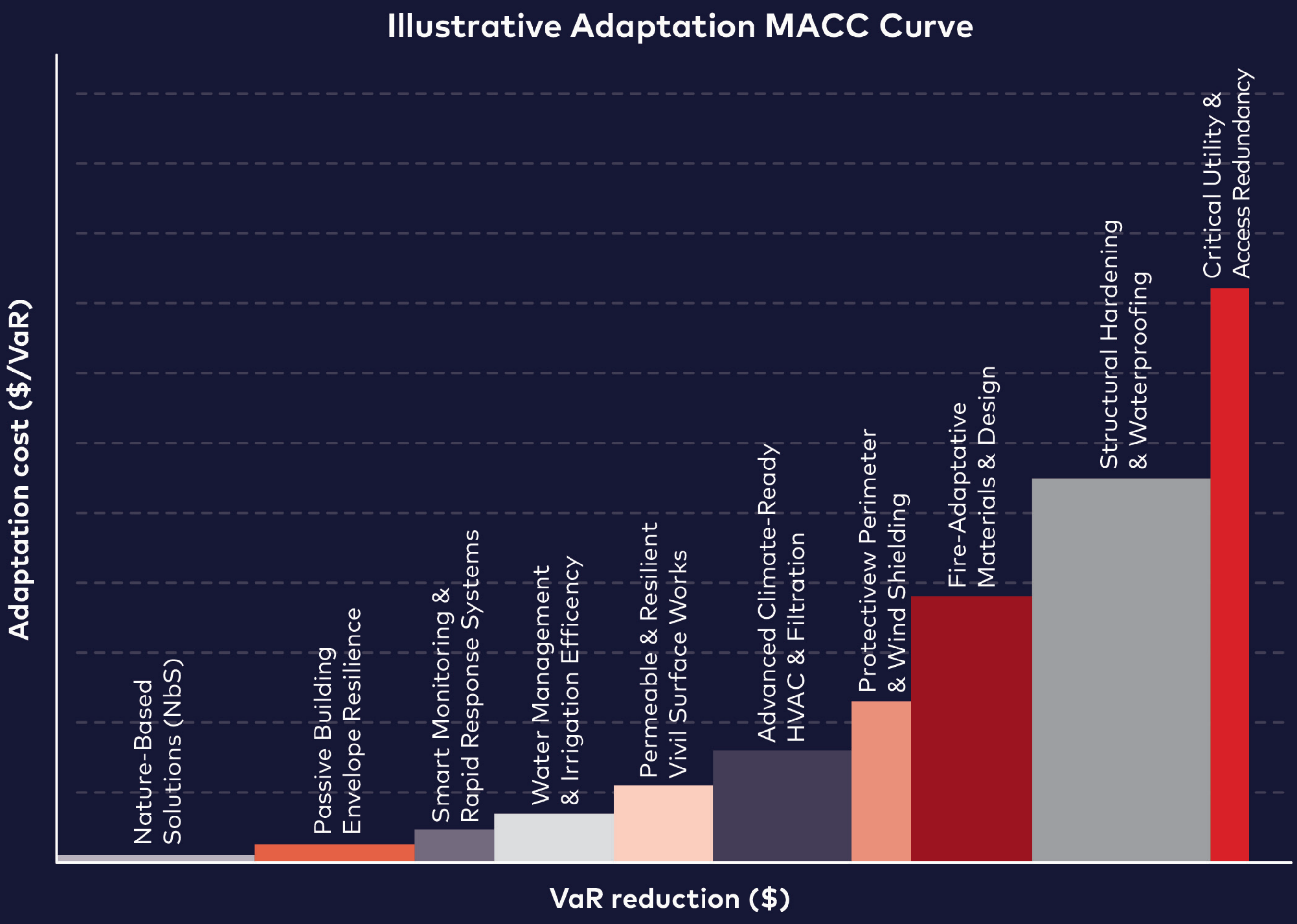


*Figure 7: Adaptation cost curve*

STEP 9

# Develop adaptation roadmap and integrate into business

To minimize VaR within operational and capital constraints, what follows is the translation of the the analysis into a practical, prioritized adaptation roadmap. This roadmap weighs technical feasibility, cost, social impacts, and institutional capacity, using multi-criteria decision analysis (MCDA) to balance trade-offs and set clear implementation milestones. However, technical choices alone do not ensure resilience.

Most adaptation efforts fail not because the risks or solutions are unclear, but because organizations lack the governance, capabilities, or processes to execute them. Using insights gathered through steps 1 to 8, we assess organizational readiness to implement the roadmap across four pillars: mindset and behaviors, governance and management processes, capabilities and competencies, and enabling technologies.

This allows us to define the organizational conditions required for success and design targeted interventions—from clarifying decision rights and accountabilities, to embedding climate considerations into budget cycles, maintenance strategies, asset integrity reviews, site performance dialogues, and internal health, safety, security and environmental (HSSE) audits.

The result is an adaptation roadmap that is both technically robust and organizationally executable: a plan that aligns with capital allocation processes, withstands scrutiny from investment committees, and can be integrated into day-to-day operations and long-term planning.

STEP 10

# Financing climate risk reduction

Financing determines the pace and scale at which climate risks can be reduced. The quantified VaR, the Adaptation MACC, and the roadmap developed in previous steps provide the analytical foundation for investment decisions, enabling companies to prioritize the highest-impact, lowest-cost interventions.

From here, **two financing pathways** are available.

**The first is self-funding, where climate adaptation measures are integrated into capital allocation frameworks & compete for investment on the basis of risk reduction and economic return.** The Adaptation MACC strengthens the business case by showing precisely how each intervention lowers financial exposure, providing the level of evidence typically required by investment committees and CFOs to approve projects within existing operational and capital constraints.

**The second pathway is climate finance, which leverages external funding sources—including concessional loans (below-market-rate loans designed to make projects more affordable), grants (non-repayable funds used to support priority adaptation actions), blended finance mechanisms (structures that combine public and private capital to reduce investment risk and attract larger funding pools), and resilience bonds (insurance-linked financial instruments that channel capital into projects that lower climate-related risks).** These sources – including Green and Climate Resilience Bonds, multilateral funds such as the Green Climate Fund, disaster risk finance, and payment-for-ecosystem services schemes – can significantly reduce upfront capital requirements. Accessing them generally requires alignment with national adaptation plans, demonstration of measurable resilience outcomes, and collaboration with public agencies or private financiers through pooled or partnership models. When used effectively, climate finance not only lowers the cost of adaptation but also de-risks investments and enables more ambitious or capital-intensive resilience measures.

Together, these pathways allow organizations to match financing options to risk priorities, ensuring that high-value adaptation measures are both economically justified and financially feasible.

STEP 11

# Climate risk programme management

Climate risk management is not a one-time exercise, but a continuous improvement program designed to maintain momentum in reducing VaR – similar to pathways toward net-zero. Success requires embedding resilience into the organization through mindset and behaviors, governance structures, management processes, capabilities, and enabling technologies.

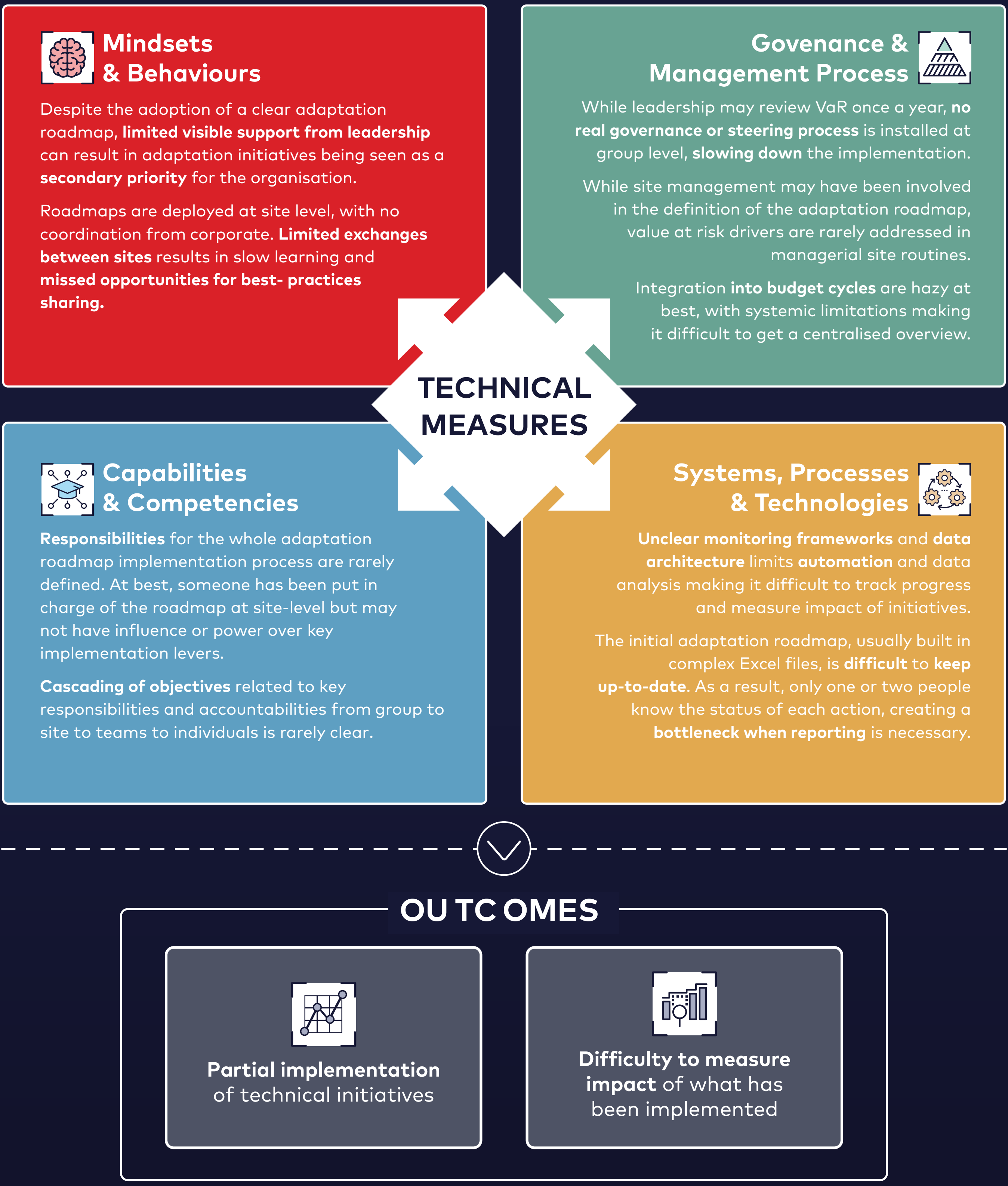
In our experience, organizations do not fail to adapt to climate change because they fail to recognize risks and technical solutions but rather because once understood and identified, gaps in the organizational readiness hinder the effective execution of the adaptation plan.

Those gaps include:

- Clear roles and responsibilities and allocation of accountability;
- Reporting lines, monitoring routines and processes;
- Decision process to include adaptation mechanisms in financial planning;
- Integration of climate risks into emergency plans;
- Monitoring regulatory developments and emerging climate-related obligations to stay aligned with evolving requirements.

Companies that succeed, establish a cross functional team to monitor progress and lift roadblocks that are bound to appear along the way, while ensuring their organizational key success factors are implemented in parallel to technical solutions, with a continuous improvement mindset to gradually increase their maturity and the level of integration into standard processes.

Automation is critical to ensure efficient reassessment, aligned with annual budget cycles and updates to global climate models (typically every five years). Systems and processes should be designed for scalability and integration, enabling rapid recalculation of VaR and adaptation priorities. By institutionalizing climate risk governance and building competencies across teams, organizations can mainstream adaptation into core business planning and sustain long-term resilience.



### Mindsets & Behaviours

Despite the adoption of a clear adaptation roadmap, **limited visible support from leadership** can result in adaptation initiatives being seen as a **secondary priority** for the organisation.

Roadmaps are deployed at site level, with no coordination from corporate. **Limited exchanges between sites** results in slow learning and **missed opportunities for best- practices sharing.**

### Governance & Management Process

While leadership may review VaR once a year, **no real governance or steering process** is installed at group level, **slowing down** the implementation.

While site management may have been involved in the definition of the adaptation roadmap, value at risk drivers are rarely addressed in managerial site routines.

Integration **into budget cycles** are hazy at best, with systemic limitations making it difficult to get a centralised overview.

### TECHNICAL MEASURES

### Capabilities & Competencies

**Responsibilities** for the whole adaptation roadmap implementation process are rarely defined. At best, someone has been put in charge of the roadmap at site-level but may not have influence or power over key implementation levers.

**Cascading of objectives** related to key responsibilities and accountabilities from group to site to teams to individuals is rarely clear.

### Systems, Processes & Technologies

**Unclear monitoring frameworks** and **data architecture** limits **automation** and data analysis making it difficult to track progress and measure impact of initiatives.

The initial adaptation roadmap, usually built in complex Excel files, is **difficult** to **keep up-to-date**. As a result, only one or two people know the status of each action, creating a **bottleneck when reporting** is necessary.

### OUTCOMES

**Partial implementation** of technical initiatives

**Difficulty to measure impact** of what has been implemented

*Figure 8: Critical organisational factors for successful adaptation*

# Conclusion

Climate risk is no longer an abstract sustainability issue – it is a material business risk that demands structured, data-driven action. The eleven-step framework outlined here transforms uncertainty into clarity by quantifying VaR, prioritizing adaptation measures, and embedding resilience into core business processes. From identifying climate signals and receptors to developing damage functions, estimating financial exposure and ranking interventions through a Marginal Adaptation Cost Curve, this approach ensures decisions are grounded in both science and economics.

The roadmap integrates adaptation into corporate strategy, governance, and financing mechanisms, enabling organizations to act within operational and capital constraints while leveraging external climate finance opportunities. By institutionalizing continuous improvement and automation, companies can maintain momentum, reassess risks efficiently, and align with evolving climate models and regulatory requirements.

**This is not just about compliance – it is about safeguarding assets, operations, and growth in a changing climate. Organizations that adopt this structured approach will not only reduce risk but also unlock competitive advantage through resilience, cost efficiency, and stakeholder confidence.**

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## About Soudah Development:

Soudah Development is a real estate development company wholly owned by the Public Investment Fund (PIF) of Saudi Arabia, established in 2021 to transform the Soudah and Rijal Almaa areas in the Aseer region into a premier luxury mountain tourism destination.

The company's mission is to create a year-round destination that blends immersive cultural experiences with the region's natural landscape, heritage, and unique environment. Central to its approach is preserving the environment, cultural heritage, and community empowerment while generating long-term economic benefits, attracting both domestic and international visitors.

Additional information is available at **www.soudah.sa/en**

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## About dss+

dss+ is the operational transformation partner for complex and high-hazard industries. Driven by our purpose, we help organizations achieve breakthroughs in safety, performance and sustainability that build business endurance and ensure long-term success.

We engage deeply within organizations to empower teams to shift mindsets, shape cultures, and establish the capabilities required at every level. We combine technical expertise and operational experience with a people-centered approach and data-driven insight.

Additional information is available at **www.consultdss.com**

*This handbook is general guidance only and not a substitute for professional advice tailored to a specific organisation. Its frameworks and recommendations should be adapted to each organisation's own circumstances, and implementation decisions remain its responsibility. While reasonable care has been taken to ensure accuracy, dss+ and Soudah Development Company accept no liability for any actions taken, or not taken, on the basis of this handbook.*

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