FTSAI Climate Risk Assessment Framework

Methodological Foundations, Analytical Architecture, and Implementation Logic

Technical Framework · Version 1.0
August 2026

Achilleas Zapranis

Publication Information

Document ID	FTSAI-2026-FW-001
Publication Type	Framework
Title	FTSAI Climate Risk Assessment Framework
Version	1.0
Authors	Achilleas Zapranis
Affiliation	FTSAI, University of Macedonia
Publication Date	August 2026
Status	Published
DOI	https://doi.org/10.5281/zenodo.22071917

Publication Note

This document presents Version 1.0 of the **FTSAI Climate Risk Assessment Framework**, including its conceptual foundations, **methodological architecture**, assessment logic, and implementation principles. The Framework is intended to evolve through scholarly scrutiny, empirical application, and methodological refinement. Subsequent editions may incorporate further theoretical developments, empirical evidence, sector-specific applications, and refinements arising from research and practical implementation.

Copyright

Published by

Financial Technology & Strategic Artificial Intelligence Laboratory (FTSAI)
Department of Accounting and Finance
University of Macedonia
Thessaloniki, Greece

The concepts, methodologies, and recommendations presented in this document are subject to further scientific development and may be revised in future editions.

Comments, constructive feedback, empirical evaluations, and proposals for academic collaboration are warmly welcomed.

First Edition – August 2026

Purpose and Methodological Positioning

Climate risk has progressively evolved from an environmental concern into one of the defining systemic risks of the twenty-first century. Its implications extend far beyond the physical consequences of climatic events, affecting financial stability, productive systems, territorial governance, infrastructure resilience, and ultimately the quality of strategic decision-making itself. Unlike traditional operational or financial risks, climate risk cannot be understood by looking at isolated events or simple cause-and-effect relationships. This arises from the continuous interaction of physical hazards, exposure structures, institutional arrangements, governance mechanisms and the choices that organisations make under conditions of persistent uncertainty.

This characteristic changes the very nature of climate risk assessment. The aim is not just to predict the likelihood of future events or to measure possible losses. It is to understand how risk is created, amplified, transferred, or mitigated through the structure and governance of the systems exposed to it. In this sense, climate risk is not simply observed; it is, to a significant extent, produced by the interaction between external conditions and internal organisational choices.

Most existing assessment methodologies remain rooted in fragmented perspectives. Some emphasize climatic hazards, others probabilistic modelling, and others historical loss experience. While each contributes valuable insights, none provides a sufficiently comprehensive explanation of how climate-related risks evolve within complex socio-economic systems. Consequently, organisations often possess increasing volumes of climate-related information while simultaneously exhibiting limited capacity to translate that information into coherent governance, strategic adaptation, and effective decision-making. This disconnect is one of the most significant methodological challenges in contemporary climate risk management.

The **FTSAI Climate Risk Assessment Framework** has been developed as a response to this challenge. Rather than introducing another scoring methodology or another predictive model, it proposes a governance-oriented **methodological architecture** for understanding climate risk as a systemic phenomenon. The Framework provides a coherent structure for identifying, assessing, classifying, and interpreting climate and weather-related risks while maintaining strict conceptual discipline regarding the role and limitations of each analytical component.

Accordingly, the Framework is neither a forecasting instrument nor a loss estimation model. It is not designed to predict future climatic events, nor does it constitute a certification, verification, or assurance scheme. Its purpose is considerably more fundamental. It establishes the **methodological architecture** within which climate risk can be analysed consistently across heterogeneous organisations, sectors, and decision contexts without confusing assessment with prediction, or methodology with regulatory compliance.

Central to the Framework is the proposition that climate risk should not be interpreted as an external environmental force acting upon otherwise passive systems. Risk emerges through the interaction between hazards, exposure pathways, vulnerability characteristics, resilience mechanisms, and adaptive governance capacity. Consequently, two organisations operating under identical climatic conditions may exhibit substantially different risk profiles because their governance structures, preparedness, decision-making discipline, and adaptive capabilities differ. The object of assessment is therefore not simply the hazard itself, but the entire system through which that hazard acquires economic and organisational significance.

This systemic perspective requires equally rigorous methodological discipline. Throughout the Framework, clear conceptual boundaries are maintained between climate risk and weather risk, between assessment and certification, between methodological authority and implementation guidance, and between analytical interpretation and managerial decision-making. Scoring mechanisms serve as instruments for structured interpretation rather than deterministic representations of reality. Likewise, uncertainty is not a defect to be removed, but an intrinsic property of complex systems that needs to be explicitly documented, interpreted with discipline and reasoned about with robustness in mind as opposed to artificial precision.

The Framework has been intentionally designed to remain sector-agnostic, scalable, and adaptable. Its methodological principles apply equally to agricultural systems, financial institutions, infrastructure operators, territorial authorities, industrial organisations, and other productive systems, while preserving a stable conceptual core governed through formal **version control** and methodological authority. This balance between adaptability and structural consistency is essential if assessment outcomes are to remain credible, comparable, and scientifically defensible over time.

The present document therefore defines the conceptual foundations, **methodological architecture**, governance principles, and **interpretive discipline** of the **FTSAI Climate Risk Assessment Framework**. It establishes the analytical boundaries within which climate risk assessments should be conducted and interpreted under this methodological reference system. Practical implementation guidance, illustrative workflows, and sector-specific applications are intentionally presented separately within the accompanying **Implementation Companion**, whose role is operational rather than methodological. The Companion facilitates implementation without modifying, extending, or reinterpreting the scientific foundations established in this Framework.

Achilleas Zapranis
FTSAI Lab
University of Macedonia

Table of Contents

List of Figures

List of Tables

Executive Overview

1. The Emerging Challenge: From Climate Disclosure to Climate Capability

Climate change is increasingly recognised not only as an environmental challenge but also as a **strategic**, **operational**, **financial**, and **governance issue**. Organisations are required to understand how **climate-related hazards** may affect their assets, activities, value chains, and long-term objectives under conditions of increasing uncertainty and changing climatic conditions. The central challenge is no longer limited to identifying whether climate change may create adverse impacts, but extends to understanding how those impacts may interact with **organisational structures**, dependencies, capabilities, and **decision processes**.

Over recent years, **climate-related disclosure frameworks** and sustainability reporting requirements have significantly improved transparency regarding how organisations identify, govern, and communicate climate-related risks and opportunities. Frameworks such as TCFD, IFRS S2, and emerging European sustainability reporting requirements have established important expectations regarding **governance arrangements**, **strategic integration**, **risk management processes**, **resilience considerations**, and **climate-related information**. These developments represent a major advancement in organisational accountability by requiring climate **considerations to become part of formal decision-making structures** rather than remaining separate from core business processes.

However, **disclosure alone does not demonstrate** **organisational capability**. The existence of climate policies, governance structures, reporting mechanisms, or adaptation plans provides important evidence, but does not necessarily establish that an organisation can effectively understand, manage, and adapt to evolving climate risks. A critical distinction therefore emerges between **communicating climate-related information and possessing the organisational capabilities required to act upon that information**. **Climate readiness** depends not only on what an organisation reports, but also on whether climate-risk knowledge reaches decision authority, influences resource allocation, supports implementation, informs monitoring processes, and contributes to **organisational learning**.

This distinction creates a methodological challenge. Organisations require **assessment approaches** that **move beyond the description of climate-related commitments** and examine the underlying configuration through which **climate risk** becomes consequential. Such assessment must consider not only the climatic hazards themselves, but also **the pathways through which those hazards may affect an organisation**, the characteristics that shape its response, and the **governance capabilities** that determine whether future risk trajectories can be modified.

The **FTSAI Climate Risk Assessment Framework** addresses this challenge by providing an **integrated assessment architecture** designed to connect climate-risk information with organisational capabilities and decision processes. The Framework **does not seek to predict future climatic outcomes**, prescribe specific adaptation strategies, or replace organisational judgement. Instead, it provides a structured methodological foundation for examining how climate hazards interact with exposure, vulnerability, resilience, readiness, and **adaptive capacity**, enabling organisations to develop a more complete understanding of their **climate-risk profile** and their ability to respond to future change.

The transition from climate disclosure to **climate capability** therefore represents a fundamental shift in how organisations approach climate risk. **Disclosure establishes transparency** regarding what organisations recognise and communicate. **Assessment** **examines whether that knowledge is sufficiently integrated into** **organisational systems** **to support effective action**. The purpose of the

FTSAI Framework is to support this transition by providing the analytical discipline required to transform climate-related information into organisational understanding and informed decision-making.

2. The Governance Gap

The increasing availability of climate-related information has created significant progress in organisational transparency. However, **the existence of information does not necessarily guarantee that such information is transformed into effective organisational action**. Between recognising climate-related risks and developing the capability to respond to them lies a critical **governance challenge**: the ability of organisations to **translate knowledge into decisions, decisions into actions, and actions into sustained adaptation**.

This challenge can be described as a **governance gap**. The **governance gap** **does not refer to the absence of governance structures, reporting mechanisms, or formal responsibilities**. Many organisations now possess climate policies, sustainability strategies, risk committees, disclosure processes, and adaptation plans. The challenge is **whether these structures function as effective mechanisms** through which **climate-risk knowledge** influences organisational behaviour.

A governance arrangement becomes meaningful only when it is connected to decision authority, **resource allocation**, **implementation capacity**, **monitoring processes**, and **organisational learning**. A committee that receives climate-related information but does not influence decisions, a strategy that identifies risks without affecting investment priorities, or a policy that is not reflected in operational practices **may satisfy formal expectations while failing to demonstrate substantive capability**.

This distinction is particularly important because **climate risk** differs from many conventional organisational risks. Climate-related impacts evolve over extended time horizons, interact with multiple systems, and may involve significant uncertainty regarding their timing, magnitude, and consequences. Organisations therefore require **not only information about possible risks, but also the capability to interpret changing conditions**, revise assumptions, modify strategies, and adapt existing configurations.

The **governance gap** consequently represents **the distance between formal recognition of climate risk and demonstrated organisational capacity to manage and adapt to that risk. It separates disclosure from capability, compliance from operational readiness, and stated commitment from evidence-based organisational action.**

The **FTSAI Climate Risk Assessment Framework** is designed around this distinction. It **does not assess readiness by examining only the existence of governance arrangements** or reported commitments. Instead, it evaluates whether climate-risk understanding **is embedded within the processes** through which organisations make decisions, allocate resources, implement responses, monitor outcomes, and learn from changing conditions.

By addressing this **governance gap**, the Framework seeks to complement existing disclosure and reporting architectures with an assessment perspective focused on **substantive organisational capability**. Its central proposition is that effective climate-risk management depends **not only on whether organisations know what risks they face, but also on whether they possess the governance capacity required to act upon that knowledge**.

Illustrative Example: **Identifying a Governance Gap**

An organisation may have established **formal climate governance arrangements**, including a **climate risk committee**, periodic climate assessments, and **climate-related disclosures** aligned with emerging reporting expectations. However, if the information generated through these processes **does not influence investment decisions, operational planning, resource allocation, or strategic priorities**, a **governance gap** remains between climate knowledge and organisational action.

The FTSAI Framework identifies such gaps by examining whether climate-risk information is connected with decision authority, implementation processes, monitoring mechanisms, and adaptive responses. The existence of governance structures therefore provides relevant evidence, but readiness depends on whether those structures enable the organisation to understand changing conditions, act upon identified risks, and adjust its decisions over time.

3. The FTSAI Climate Risk Assessment Framework

The **FTSAI Climate Risk Assessment Framework** provides an **integrated methodological architecture** for assessing how climate-related hazards interact with organisational systems, decision processes, and adaptive capabilities. Its purpose is to support organisations in developing a structured understanding of climate risk that **extends beyond disclosure requirements** and focuses on the **relationship between climatic conditions, organisational characteristics, and the ability to respond and adapt over time**.

The Framework is based on the principle that **climate risk does not arise from hazards alone**. **Climatic phenomena become organisationally significant through their interaction with** exposed assets, activities, operational dependencies, value chains, organisational structures, and governance arrangements. Consequently, meaningful assessment requires the **analytical separation** of the different conditions through which climate risk emerges and the disciplined integration of the **evidence generated across these dimensions**.

The Framework therefore adopts a **four-layer analytical architecture**:

- Hazard Characterisation examines the climatic and weather-related conditions that may create potential sources of disruption.
- Exposure Mapping identifies the assets, activities, dependencies, and value-chain relationships through which those hazards may become relevant to the assessed entity.
- Vulnerability and Resilience Analysis examines the characteristics that influence susceptibility to disruption and the ability of the system to absorb stress, maintain critical functions, and recover.
- Readiness and Adaptive Capacity Assessment evaluates whether organisational governance, decision processes, resources, and learning capabilities enable the organisation to modify its future risk trajectory.

This architecture is designed to preserve **analytical clarity** while recognising that climate risk is systemic, dynamic, and interconnected. **The Framework does not treat these dimensions as isolated categories**. Instead, it establishes **the relationships through which evidence moves from the identification of climatic conditions to the evaluation of organisational capability**.

A central feature of the Framework is the distinction between **current response capability and future capacity for change**. **Resilience** concerns the ability of an organisation to withstand and recover from disruption using existing capabilities. **Adaptive capacity** concerns whether the organisation can modify its structures, strategies, technologies, and practices as climatic conditions evolve. **Maintaining this distinction prevents organisations from interpreting present robustness as evidence of future adaptability**.

The Framework also places particular emphasis on **evidence-based readiness**. **Organisational capability is not inferred solely from the existence of policies, committees, strategies, or reporting structures**. Instead, **readiness is assessed through evidence demonstrating whether climate-risk information is connected with decision authority, resource allocation, implementation, monitoring, and organisational learning**.

Through this approach, the **FTSAI Climate Risk Assessment Framework** provides a bridge between climate-related information and **organisational capability**. It complements existing disclosure, reporting, and assurance architectures by addressing a different but essential question: **not only whether organisations identify and communicate climate risks, but whether they possess the governance and adaptive capabilities required to respond effectively as conditions change**.

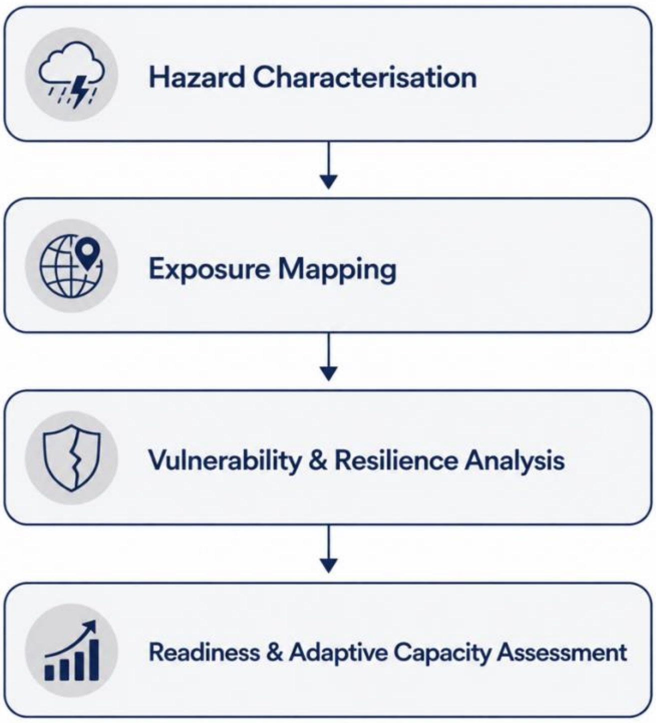

Figure 1. Analytical sequence of the FTSAI Climate Risk Assessment Framework.
The four-layer architecture establishes the directional relationship through which climate risk assessment progresses from the characterisation of external climatic conditions, through exposure and system response analysis, to the assessment of organisational readiness and adaptive capacity. The sequence represents analytical dependency rather than a deterministic causal chain.

4. What Makes the Framework Different

The **FTSAI Climate Risk Assessment Framework does not introduce new climate-risk concepts in isolation**. Hazard, exposure, vulnerability, resilience, adaptive capacity, governance, and **organisational readiness** have been extensively developed within existing scientific, regulatory, and professional traditions. The distinctive contribution of the Framework lies instead in **the way these established concepts are organised, connected, and assessed** within a **unified methodological architecture**.

The first distinguishing feature of the Framework is its emphasis on **analytical separation**. Climate risk is frequently discussed through aggregated representations that combine multiple dimensions into a single concept or indicator. While such approaches may support communication and comparison, they **may also obscure the mechanisms through which risk emerges**. The **FTSAI Framework** therefore preserves the analytical distinction between hazard, exposure, vulnerability, resilience, readiness, and adaptive capacity, **allowing each dimension to retain its specific explanatory function** while enabling their **structured integration**.

The second distinguishing feature concerns the transition from **climate information to organisational capability**. Existing disclosure and reporting frameworks provide essential information regarding governance structures, risk management processes, strategies, and climate-related actions. The **FTSAI Framework** examines an additional question: **whether available evidence demonstrates that these arrangements function as operational capabilities**. **Readiness** is therefore **not inferred from the existence of policies, committees, or reporting processes**, but assessed through evidence of their connection with decision authority, resource allocation, implementation, monitoring, and organisational learning.

The third distinguishing feature is the treatment of **resilience and adaptive capacity as distinct assessment functions**. An organisation may possess the ability to absorb disruption and maintain operations under current conditions while having limited capacity to modify its structures, strategies, or technologies as climate conditions evolve. By preserving this distinction, the Framework avoids interpreting **present resilience as evidence of future adaptability**.

The fourth distinguishing feature is the Framework's approach to **evidence and interpretation**. **Assessment findings are not treated as isolated numerical outputs**. They **remain connected to the evidence base, assumptions, uncertainty conditions, scope limitations, and analytical context** from which they are derived. The Framework therefore emphasises **evidence traceability** and **interpretive discipline**, ensuring that assessment conclusions remain proportionate to the information supporting them.

The fifth distinguishing feature concerns **non-compensatory interpretation**. Climate-risk assessment often requires synthesis across multiple dimensions, but **unrestricted aggregation may allow strong performance in one area to conceal critical weaknesses elsewhere**. The **FTSAI Framework** therefore permits **structured aggregation** while **preserving the visibility of material vulnerabilities, threshold conditions, dependencies, and dominant constraints** that may determine organisational outcomes under stress.

Taken together, these characteristics position the **FTSAI Climate Risk Assessment Framework** as a **complementary assessment architecture** between climate disclosure and **organisational action**. It **does not replace existing reporting standards, adaptation frameworks, or conformity assessment processes**. Instead, it addresses a different methodological question: **whether the available evidence demonstrates that an organisation possesses the capabilities required to understand, govern, and adapt to climate-related risks over time**.

5. Relationship with Existing Standards and Frameworks

The **FTSAI Climate Risk Assessment Framework** is designed to **complement, rather than replace**, established climate-related standards, disclosure frameworks, adaptation approaches, and **conformity assessment processes**. Existing frameworks address **important and distinct questions** within the broader climate-risk landscape, ranging from the communication of climate-related information to the structuring of adaptation processes and the evaluation of sustainable activities.

The purpose of the **FTSAI Framework** is not to duplicate these approaches. Instead, it addresses a **complementary methodological question**: **whether available evidence demonstrates that an organisation possesses the capabilities required to understand, govern, and adapt to climate-related risks**. In this sense, the Framework operates at the intersection between climate-risk information and **organisational capability**.

The relationship between the FTSAI Framework and selected established approaches is summarised in Table 1.

Table 1. Positioning of the FTSAI Climate Risk Assessment Framework in relation to established climate-related standards and frameworks. The table summarises the distinct analytical questions addressed by existing disclosure frameworks, adaptation standards, risk-management approaches, and sustainable finance requirements, highlighting the complementary role of the FTSAI Framework in assessing demonstrated organisational readiness.

Framework / Standard	Main Question Addressed	Complementary Relationship with FTSAI Framework
IFRS S2 Climate-related Disclosures	What climate-related information should organisations disclose to investors and other stakeholders?	IFRS S2 establishes **disclosure expectations** regarding governance, strategy, risk management, and metrics. The FTSAI Framework complements this by assessing whether disclosed arrangements demonstrate **substantive organisational capability**.
European Sustainability Reporting Standards (ESRS E1 – Climate Change)	How should organisations report climate-related impacts, risks, opportunities, strategies, and actions?	ESRS E1 strengthens **transparency regarding climate-related governance and resilience considerations**. The **FTSAI Framework** examines whether these reported elements correspond to **operational readiness supported by evidence**.
EU Taxonomy Climate Change Adaptation (DNSH criteria)	Has climate adaptation been adequately considered in determining alignment with sustainable activities?	The EU Taxonomy requires organisations to consider climate risk and vulnerability assessment processes when demonstrating alignment with sustainable activities. However, it **does not prescribe how the quality, organisational integration, or decision relevance of such assessments should be evaluated**. The **FTSAI Framework** addresses this **assessment gap** by examining whether climate-risk analysis **translates into demonstrated organisational capability and readiness**.
ISO 14090:2019 / ISO 14091:2021	How should organisations structure climate adaptation and climate-risk assessment processes?	These standards provide important principles and processes for adaptation and assessment. The **FTSAI Framework** builds upon these foundations by integrating **assessment layers**, **evidence traceability**, **governance capability**, and **readiness evaluation** within a unified architecture.
ISO 31000:2018 Risk Management	How should organisations manage risk under conditions of uncertainty?	ISO 31000 provides general risk-management principles. The **FTSAI Framework** applies these principles within a **climate-specific assessment architecture** focused on **organisational capability and adaptation**.
TCFD Recommendations	How should climate-related risks and opportunities be governed, managed, and disclosed?	TCFD established the **connection between climate risk and organisational governance**. The **FTSAI Framework** extends this perspective by assessing whether governance arrangements **translate into demonstrated readiness and action**.
FTSAI Climate Risk Assessment Framework	Does available evidence demonstrate **organisational readiness**	Provides an integrated **assessment architecture** for examining **whether climate-risk understanding is translated into demonstrated**

Framework / Standard	Main Question Addressed	Complementary Relationship with FTSAI Framework
	to understand, govern, and adapt to climate-related risks?	**organisational readiness** through **evidence-based interpretation**.

The increasing importance of climate-related disclosure and sustainable finance requirements reinforces the need for such complementary assessment approaches. **Disclosure frameworks establish what organisations communicate** regarding climate-related risks and actions. **Adaptation standards establish how climate adaptation processes may be structured**. Sustainable finance criteria establish conditions for evaluating alignment with environmental objectives. The **FTSAI Framework** addresses the complementary question of **whether these elements are supported by demonstrated organisational capability**.

By maintaining this distinction, the Framework **avoids competing with existing standards** and instead provides a **methodological bridge** **between climate-related information and effective organisational action**.

6. Assessment Outputs

The **FTSAI Climate Risk Assessment Framework** is designed to transform climate-related information into a structured representation of organisational climate-risk characteristics, capabilities, and areas requiring attention. The outputs generated through the Framework are **not intended to function as standalone scores or definitive statements regarding organisational performance**. Their purpose is to **support interpretation, decision-making, prioritisation, and continuous improvement** through an **evidence-based assessment process**.

The assessment produces an **integrated climate-risk profile** describing the relationship between external climatic conditions, organisational exposure, system characteristics, governance capabilities, and **adaptive potential**. Rather than reducing climate risk to a single numerical outcome, the Framework **preserves the analytical structure through which risk emerges** and enables organisations to understand the factors contributing to their **current and future risk trajectory**.

Key assessment outputs include:

Climate Hazard Profile

An assessment of the climate- and weather-related hazards relevant to the assessed organisation, including their characteristics, temporal considerations, and potential relevance within the defined assessment scope and horizon.

Exposure and Dependency Profile

An identification of the **assets**, **activities**, **operational dependencies**, and **value-chain relationships** through which climate-related hazards may affect the organisation. This output highlights **direct and indirect exposure pathways** that may influence organisational vulnerability.

Vulnerability and Resilience Profile

An evaluation of the characteristics that shape how the organisation may experience, absorb, and recover from climate-related disruption. This output distinguishes **susceptibility to adverse impacts** from existing **capabilities that support continuity and recovery**.

Readiness and Adaptive Capacity Assessment

An evaluation of whether organisational governance, decision processes, resources, learning mechanisms, and implementation capabilities **enable the organisation to respond to current climate risks and modify its future risk trajectory**.

Evidence and Uncertainty Profile

A structured representation of the evidence supporting assessment conclusions, including relevant **assumptions**, **limitations**, **uncertainty conditions**, and areas where additional information may improve confidence in the assessment.

Governance Gap Identification

An identification of potential **gaps between formal climate-related commitments, disclosed governance arrangements, and demonstrated** organisational capability. This output examines whether climate-risk information is sufficiently **connected with decision authority, resource allocation, implementation processes, monitoring mechanisms, and organisational learning**.

Assessment Priorities and Improvement Areas

A structured identification of **areas where strengthening exposure management, resilience capabilities, governance arrangements, adaptive capacity, or evidence quality may improve organisational preparedness**.

The assessment outputs are designed to support multiple organisational purposes, including strategic planning, investment analysis, risk management, adaptation planning, sustainability-related decision-making, and preparation for independent external examination where applicable.

Importantly, the Framework **does not prescribe specific adaptation strategies** or replace **organisational judgement**. Assessment outputs **provide structured evidence regarding the configuration of climate risk and** organisational capability, enabling decision-makers to determine appropriate responses according to their objectives, constraints, responsibilities, and operating context.

Through this approach, the **FTSAI Climate Risk Assessment Framework shifts the focus from identifying climate risks alone towards understanding whether organisations possess the capabilities required to govern, manage, and adapt** to those risks over time.

Table 2. Assessment pathways within the FTSAI Climate Risk Assessment Framework. The table summarises alternative levels of Framework application according to assessment purpose, analytical scope, and organisational needs.

Assessment Pathway	Purpose	Scope of Application
Screening Assessment	Provides an **initial understanding of major climate-risk drivers, exposure patterns, and potential organisational gaps**.	Used for preliminary evaluation, prioritisation, and identification of areas requiring further assessment.
Focused Assessment	Examines specific climate risks, assets, activities, sectors, or organisational capabilities in greater depth.	Used when particular risk areas or strategic decisions require **targeted analysis**.
Comprehensive Assessment	Applies the **full FTSAI Framework architecture** across **hazard characterisation**, **exposure mapping**, vulnerability, resilience, readiness, and adaptive capacity.	Used for **integrated climate-risk evaluation**, strategic planning, organisational assessment, assurance processes, **conformity assessment readiness**, or advanced decision-making.

7. Applications and Future Development

The **FTSAI Climate Risk Assessment Framework** is designed as a **sector-agnostic methodological architecture** capable of supporting applications across diverse organisational and economic contexts. Its **modular design** enables adaptation to different assessment purposes, organisational characteristics, sectoral conditions, and levels of analytical depth while **preserving the core methodological principles governing the Framework**.

Potential application areas include organisations operating in **climate-sensitive sectors**, including agricultural and agri-food systems, infrastructure-related activities, financial institutions with climate-exposed assets or portfolios, and other entities where climate-related conditions may influence **strategic, operational, or investment decisions**.

In financial and investment contexts, the Framework may support the assessment of how climate-related conditions influence assets, activities, portfolios, and organisational capabilities. By maintaining the distinction between **physical climate exposure**, **vulnerability**, **resilience**, and **adaptive capacity**, the Framework **provides a basis for understanding climate-related characteristics that may not be fully captured through conventional financial analysis alone**.

In operational and sectoral contexts, the Framework may support organisations seeking to **identify climate-related dependencies**, **evaluate resilience capabilities**, **strengthen governance arrangements**, and develop **evidence-based adaptation strategies**. **Sector-specific implementation** modules may subsequently extend the Framework by incorporating domain-relevant indicators, evidence structures, and assessment considerations while maintaining consistency with the underlying methodology.

The future development of the Framework will be guided by empirical application and methodological refinement. Consistent with Principle M8 — **Empirical Revisability** and Principle M9 — **Methodological Stability and Controlled Evolution**, **future versions will incorporate evidence derived from practical applications, validation activities, sector-specific experience, assessor feedback, and comparative assessment data**.

A central element of this development pathway is the gradual creation of **sector-specific modules** and **implementation guidance**. These modules **will not modify the core analytical architecture of the Framework** but will **provide contextual adaptation for different domains**, including sector-specific exposure patterns, vulnerability characteristics, resilience considerations, and governance requirements.

Future development may also include the establishment of **structured benchmarking capabilities** based on accumulated assessment experience. Such capabilities can support **comparative learning**, identify recurring patterns of climate-risk governance, and contribute to the **empirical refinement of assessment criteria** while preserving appropriate **confidentiality and governance safeguards**.

The long-term evolution of the **FTSAI Climate Risk Assessment Framework** is therefore based on a **controlled combination of methodological stability and empirical learning**. The Framework provides a **common analytical foundation**, while its future development is informed by evidence generated through responsible application across different organisational and sectoral contexts.

Through this approach, the **FTSAI Framework** aims to contribute to the **transition from climate-risk disclosure towards climate-risk capability** by supporting organisations in understanding **not only the risks they face, but also the governance and adaptive capacities required to respond to a changing climate**.

Foundations and Governance

1. Scope and Authority

The **FTSAI Climate Risk Assessment Framework v1.0** (hereafter **the Framework**) establishes a comprehensive **methodological architecture** for the identification, assessment, classification, and comparative interpretation of climate- and weather-related risks across organisations, productive systems, territorial entities, and economic activities. Rather than prescribing sector-specific assessment procedures, it provides a common scientific reference through which heterogeneous entities can be evaluated using a consistent conceptual language and methodological discipline.

The Framework is developed, maintained, and formally versioned by the Financial Technology and Strategic Artificial Intelligence Laboratory (FTSAI). FTSAI is responsible for maintaining the integrity of the **official Framework**, documenting methodological revisions, and designating successive official versions. This governance function does not restrict independent scholarly examination, empirical testing, criticism, or methodological development. It establishes instead the institutional process through which changes become incorporated into an official release of the **FTSAI Framework**.

The main aim of the Framework is to provide a transparent, robust and operationally credible reference model for the climate risk assessment. It provides a common methodological foundation for consistent interpretation of hazard, exposure, vulnerability, resilience and **organisational readiness** across sectors, jurisdictions and decision environments. The Framework aims to allow for **meaningful comparison without sacrificing contextual relevance** by providing conceptual consistency with operational flexibility.

Accordingly, the Framework has been intentionally designed as a sector-agnostic methodology capable of supporting applications across a broad spectrum of domains, including, but not limited to:

- agricultural production systems;
- cooperatives and producer organisations;
- financial institutions and insurance entities;
- local, regional, and national public authorities;
- infrastructure operators, utilities, and critical supply chains.

Although the Framework may serve as the methodological foundation for certification activities, **it is not itself a certification scheme**. Its role is to define the scientific architecture upon which independent certification, verification, conformity assessment, or assurance bodies may subsequently design their own assessment procedures, if these remain fully consistent with the methodological principles established herein and operate under appropriate licensing arrangements.

The **methodological integrity** of the **official Framework** constitutes one of its fundamental governance principles. Independent researchers and practitioners may examine, test, criticize, compare, or extend the methodology with appropriate attribution. Such work should be clearly distinguished from the official **FTSAI Framework**. **Modified, adapted, or derivative methodologies may not be presented as official FTSAI versions**, nor may FTSAI endorsement or authorisation be implied where none has been granted. Professional, certification, assurance, or commercial applications using the official FTSAI identity may be subject to separate authorisation or licensing arrangements.

Organisations applying the Framework for assessment, certification, auditing, advisory services, or any other downstream application **shall acknowledge FTSAI as the originating scientific authority** and shall comply with the governance, versioning, and licensing provisions governing its use.

To facilitate practical implementation without compromising methodological consistency, the Framework is accompanied by a separate **Implementation Companion**. The Companion translates the **methodological architecture** established by the Framework into operational guidance, implementation workflows, evidence collection procedures, reporting structures, and sector-specific application examples. Its purpose is to support organisations and practitioners in applying the Framework consistently within specific decision contexts while preserving the conceptual boundaries, methodological principles, and governance requirements established by the Framework itself.

The Companion **constitutes an implementation layer rather than a modification of the Framework methodology**. It may evolve through practical experience, sector-specific learning, and empirical application, provided that such developments remain consistent with the **official Framework** version to which it relates. It neither modifies nor extends the scientific methodology, conceptual definitions, governance principles, or normative content established by the Framework itself.

2. Conceptual Definitions

Every methodological framework ultimately rests on the precision of its conceptual language. Ambiguous terminology inevitably leads to inconsistent interpretation, while inconsistent interpretation undermines comparability, reproducibility, and methodological credibility. For this reason, the **FTSAI Climate Risk Assessment Framework** adopts a deliberately disciplined conceptual vocabulary in which each term carries a specific analytical meaning that remains consistent throughout the Framework.

The definitions presented below should therefore not be understood as generic dictionary descriptions or widely interchangeable expressions. They constitute an integrated conceptual system whose elements derive their full meaning from their relationship with one another. Collectively, they establish the common language upon which the Framework's assessment logic, governance principles, and **interpretive discipline** are built.

Climate Risk
The aggregate potential for adverse impacts arising from climate-related phenomena, emerging through the interaction between climate hazards, exposure, vulnerability, resilience, and adaptive capacity over a defined temporal horizon.

Weather Risk
The short- to medium-term manifestation of climate risk associated with stochastic weather variability, including extreme or anomalous events capable of producing immediate operational, financial, or productive consequences.

Climate Hazard
A climate- or weather-related physical event, process, or long-term trend, whether acute or chronic, with the potential to generate disruption, damage, or loss.

Exposure
The extent to which an entity's assets, operations, activities, or value chains are geographically, operationally, functionally, or economically positioned in relation to identified climate hazards.

Vulnerability
The degree to which an exposed entity is susceptible to adverse impacts following the materialization of a climate hazard, reflecting structural, operational, organisational, financial, and systemic characteristics.

Resilience
The ability of an entity to absorb and resist climate-related disruptions, maintain critical functions through the deployment or operational reconfiguration of existing capabilities, and recover within acceptable timeframes.

Adaptive Capacity

An entity's ability to adapt its governance, technologies, operations, or organisational practices to reduce adverse impacts or capitalize on opportunities arising from changing climatic conditions.

Climate Risk Readiness

The extent to which climate risk has been systematically identified and assessed, internalized, and embedded into governance structures, strategic planning, operational decision-making, and risk management processes.

Assessment Horizon

The temporal perspective within which climate and weather-related risks are assessed, taking into account short-, medium- and long-term perspectives appropriate to the characteristics of the assessed entity.

Risk Scoring

A structured, transparent, and reproducible methodology for translating qualitative and quantitative assessment evidence into comparative indicators supporting interpretation, classification, benchmarking, and longitudinal analysis.

The definitions presented in this chapter constitute an integral and inseparable component of the **FTSAI Climate Risk Assessment Framework**. They are not independent concepts that may be interpreted selectively or adapted according to specific applications. Their meaning derives from the conceptual architecture of the Framework as a whole. Consequently, any assessment, certification activity, derivative methodology, or downstream application explicitly based on the Framework shall apply these definitions consistently and without modification unless such changes have been formally authorized under the Framework's governance and versioning provisions.

3. Positioning within Existing Climate Risk and Resilience Frameworks

The **FTSAI Climate Risk Assessment Framework** does not emerge in isolation. Its conceptual foundations draw upon several established bodies of knowledge concerned with climate risk, vulnerability, resilience, adaptation, risk governance, and organisational decision-making. These traditions have developed different concepts and analytical approaches in response to different problems, ranging from understanding the interaction between climatic hazards and exposed systems to examining organisational adaptation, governance, and decision-making under uncertainty.

The purpose of this section is to locate the Framework within these existing traditions and to establish the boundaries of its methodological contribution. This requires distinguishing between concepts that are already well established and the way in which those concepts are organised and used within the FTSAI **assessment architecture**. **The Framework does not claim novelty for the individual concepts of hazard, exposure, vulnerability, resilience, adaptive capacity, governance, or readiness**. **Its contribution must instead be evaluated in terms of the analytical functions assigned to these concepts, the relationships established between them, and the methodological rules governing their assessment and interpretation.**

The discussion therefore proceeds from the intellectual development of climate risk and vulnerability through resilience and adaptive capacity, organisational adaptation, risk governance, and climate-related governance and disclosure, before examining representative operational assessment approaches. This progression provides the basis for comparing the **FTSAI Framework** with existing approaches and for identifying more precisely the methodological problem that its architecture is designed to address.

3.1 Evolution of Climate Risk and Vulnerability Thinking

The conceptualization of climate risk has evolved from approaches centred primarily on climatic hazards and their physical consequences towards a more systemic understanding of how climatic stress interacts with the characteristics of exposed human, ecological, and economic systems. An important step in this development was the recognition that similar climatic events may produce substantially different consequences depending upon the systems they affect. Vulnerability research contributed to this transition by shifting attention from the external stressor alone towards the conditions that shape susceptibility to harm and the capacity of systems to respond. (Turner et al., 2003), for example, conceptualized vulnerability within coupled human–environment systems as a property emerging from relationships among exposure, sensitivity, and resilience rather than as a direct consequence of an external hazard.

This broader understanding became increasingly explicit within the climate-risk literature. The IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation placed exposure and vulnerability alongside climatic events as fundamental determinants of disaster risk and emphasized that changes in any of these components may alter the resulting risk (Field et al., 2012). This represented an important methodological shift. **Climatic hazards could no longer be treated as sufficient explanations of adverse outcomes** because the consequences of those hazards depended upon what was exposed and upon the characteristics of the exposed system.

The Fifth Assessment Report developed this risk framing further by representing climate-related risk as arising from the interaction of hazard, exposure, and vulnerability. It also located these interactions within broader socioeconomic processes, recognising that adaptation, governance, development pathways, and other non-climatic factors can alter exposure and vulnerability over time (Field et al., 2014). Risk therefore became increasingly understood not as a fixed property attached to a climatic event, but as the outcome of relationships among changing climatic and socioeconomic conditions.

The Sixth Assessment Report extends this reasoning by placing greater emphasis on the dynamic character of these relationships. Climate risk results from dynamic interactions between climate-related hazards, exposure and vulnerability, and responses can themselves alter the determinants of risk (IPCC, 2022). Exposure is also defined more broadly than by geographic proximity. Systems may become exposed through connections and transmission mechanisms involving markets, infrastructure, movements of people, and other forms of interdependence. This development is particularly important for organisational assessment because it recognises that climatic stress may propagate across interconnected systems even when the organisation itself is not located at the point where the original hazard occurs.

Taken together, these developments establish several foundations upon which the **FTSAI Framework** builds. **Climate risk cannot be inferred from hazard characteristics alone**. Exposure and vulnerability must be examined as distinct determinants of how climatic stress reaches and affects a system, while each of these determinants may change through time. Their relationships may also extend beyond immediately observable physical interactions as disruption propagates through interconnected economic, operational, and social systems. The hazard–exposure–vulnerability structure used within the **FTSAI Framework** should therefore be understood as part of this established intellectual development rather than as a novel conceptualization of climate risk.

The methodological problem addressed by the Framework begins where this conceptual foundation ends. Identifying the determinants of climate risk does not by itself specify how they should be separated and examined within an organisational assessment, how evidence should move between analytical stages, or how the resulting conclusions should be interpreted without collapsing distinct system characteristics into a single undifferentiated representation of risk. The FTSAI architecture therefore adopts the established climate-risk foundations described above while assigning their constituent concepts specific analytical functions within a structured assessment process.

3.2 Resilience, Adaptive Capacity, and Organisational Adaptation

Resilience introduced a different way of thinking about how systems behave when disturbed. Rather than treating stability mainly as the tendency of a system to return to equilibrium, (Holling, 1973) directed attention to what happens when disturbance is absorbed without the system losing the relationships that allow it to continue functioning. Persistence under stress could therefore be examined independently of the speed or extent to which a system returned to a previous state.

This line of reasoning later developed into a broader distinction between persistence and the capacity for change. (Walker et al., 2004) separated three properties of social-ecological systems that address different aspects of this problem: resilience, adaptability, and transformability. Resilience describes the ability to withstand disturbance while retaining the characteristics that define the system, adaptability concerns the ability of actors to influence that resilience, and transformability concerns the possibility of creating a different system when the existing configuration can no longer be sustained. (Folke et al., 2010) subsequently developed this distinction by describing adaptability as the capacity to adjust responses to changing external drivers and internal processes while remaining within the existing development trajectory, and transformability as the capacity to cross thresholds into new development trajectories.

Climate adaptation research developed a related but not identical understanding of adaptive capacity. (Smit & Wandel, 2006) connected adaptive capacity to the conditions that enable systems, communities, and actors to respond to changing climatic circumstances, emphasizing that vulnerability and adaptive capacity are shaped by social, economic, institutional, technological, and other contextual conditions. Adaptive capacity therefore concerns more than the immediate ability to withstand a disturbance. It concerns the resources, processes, and capabilities through which responses to changing conditions become possible.

The extension of these ideas to organisations introduces an additional analytical requirement. Organisations do not merely absorb climatic disturbances; they observe changing conditions, interpret information, allocate resources, modify routines, invest in new capabilities, and revise strategic and operational arrangements. (Berkhout et al., 2006) therefore conceptualize organisational adaptation as a process of learning and adjustment to experienced or anticipated climate impacts. Similarly, organisational resilience concerns the processes and capabilities through which organisations sustain functioning and respond effectively in the face of disruption (Vogus & Sutcliffe, 2007).

These traditions provide a significant basis for the **FTSAI Framework** but also reveal a distinction that must be maintained for assessment purposes. **The capacity of an organisation to continue functioning under climatic stress is not the same as its capacity to change the conditions governing its future response**. An organisation may be sufficiently redundant, operationally flexible, financially buffered, or equipped with emergency procedures to be able to withstand disruption, but have limited capacity to change infrastructure, technologies, governance arrangements, or operating practices as climatic conditions evolve. Conversely, an organisation may possess substantial capacity for longer-term adaptation while remaining vulnerable to immediate disruption.

For this reason, the FTSAI Framework treats resilience and adaptive capacity as analytically distinct assessment functions. Resilience concerns the capacity of the assessed system to absorb disruption, maintain critical functions, and recover using capabilities available within its existing configuration. Adaptive capacity concerns the ability to modify that configuration when existing arrangements become inadequate under changing climatic conditions. The distinction does not imply that resilience and adaptive capacity are independent. It prevents their relationship from obscuring two different questions that an organisational climate-risk assessment must answer: how effectively can the system respond with what it currently has, and how effectively can the organisation change what it has when circumstances require it?

This operational distinction does not claim to introduce the broader theoretical separation between persistence, adaptation, and transformation, which is well established in the resilience literature. Its methodological purpose is narrower. It translates that intellectual distinction into separate organisational assessment functions so that **present response capability is not mistaken for future capacity to change**. This separation provides the conceptual basis for the different roles assigned to resilience and adaptive capacity within the FTSAI **assessment architecture**.

3.3 Risk Governance, Uncertainty, and Decision-Making

Understanding the characteristics of an exposed system does not by itself determine how decisions should be made when the future remains uncertain. Climate-related decisions are frequently taken before the magnitude, timing, or interaction of future changes can be known with confidence. The problem is therefore not simply to improve the accuracy of available information, but to determine how organisations can make defensible decisions when relevant knowledge remains incomplete and alternative interpretations of risk remain possible.

Risk governance provides an important foundation for addressing this problem. (Renn et al., 2011) distinguish among complexity, uncertainty, and ambiguity as different challenges to risk governance. Complexity arises when causal relationships are difficult to identify because many interacting factors contribute to an outcome. Uncertainty arises when the possible outcomes, their consequences, or their likelihood cannot be characterised with sufficient confidence. Ambiguity arises when the same evidence can be interpreted in varying ways in terms of the issue or the appropriate response. These conditions call for different kinds of analysis and governance, not one single answer based on more and more precise risk estimates.

These differences are especially relevant when considering climate risk assessment where more sophistication does not necessarily reduce uncertainty. Long time horizons, changing climatic conditions, interactions between physical and socio-economic systems, and incomplete knowledge of how systems may respond in the future all may make precise forecasts unreliable. Decision methods developed for such conditions therefore shift attention from identifying a single optimal response towards examining whether decisions remain defensible across a range of plausible futures. (Hall et al., 2012), for example, compare robust decision-making and info-gap approaches as methods for developing climate policies under conditions in which uncertainty cannot be represented adequately through conventional probabilistic analysis.

This perspective is consistent with a broader principle of risk management: uncertainty forms part of the conditions under which risk is understood and managed rather than a residual problem that must always be eliminated before action can occur. (ISO 31000, 2018) defines risk in relation to the effect of uncertainty on objectives and embeds risk assessment within an iterative process of communication, consultation, monitoring, review, and organisational decision-making. From this perspective, the quality of risk management depends not only on the information available at a particular moment but also on the processes through which assumptions are examined, evidence is reconsidered, and decisions are revised as conditions change.

These ideas have direct implications for climate risk assessment. An assessment that converts uncertain evidence into apparently precise conclusions may simplify communication while concealing the conditions under which those conclusions remain valid. Conversely, refusing to draw conclusions whenever uncertainty is present would make assessment ineffective precisely where decision support is most needed. **The methodological requirement is therefore to preserve uncertainty without allowing it to prevent interpretation**. This requires the assessment to distinguish what is supported by available evidence, what remains uncertain, and where uncertainty is sufficiently material to influence the interpretation of results or the decisions based upon them.

The FTSAI Framework incorporates this principle by treating uncertainty as a property that accompanies evidence and interpretation throughout the assessment (Walker et al., 2004) rather than as a separate adjustment applied after scoring has been completed. Uncertainty may arise from limitations in climatic information, incomplete exposure data, assumptions concerning system dependencies, evidence about organisational capabilities, or the interpretation of future conditions. Its presence does not automatically invalidate an assessment, but it must remain visible wherever it materially affects the confidence that can be placed in a conclusion.

This treatment also establishes an important boundary around the role of the Framework in organisational decision-making. The **FTSAI Framework** does not identify an optimal adaptation strategy or prescribe the decision that an organisation should make. It provides a structured basis for identifying relevant climatic stresses, understanding how they may reach the assessed system, examining the characteristics that shape system response, and determining whether organisational capabilities support adaptation as conditions evolve. **Decision authority remains with the organisation**, but the evidentiary basis, uncertainty, and structural constraints surrounding that decision are made more explicit.

Risk governance therefore contributes more than an additional conceptual component to the Framework. It establishes the principle that climate risk assessment must remain useful under conditions in which knowledge is incomplete, competing interpretations are possible, and decisions cannot always wait for uncertainty to disappear. The objective is not to manufacture certainty, but to make the conditions under which organisational judgement is exercised sufficiently explicit for that judgement to remain transparent, reviewable, and capable of revision.

3.4 Climate Governance, Disclosure, and Organisational Readiness

As climate risk became increasingly relevant to organisational strategy and financial decision-making, attention expanded beyond the identification of physical impacts towards the governance arrangements through which organisations recognise, evaluate, and respond to those impacts. Climate risk could no longer be treated solely as an environmental or technical issue. Its implications for strategy, investment, risk management, and organisational accountability created a need to understand how climate-related information enters formal decision processes.

Climate governance acquired a more explicit organisational form with the development of the TCFD recommendations. Rather than considering climate-related issues in isolation, the TCFD brought them together within four areas of organisational activity: governance, strategy, risk management, and metrics and targets (Task Force on Climate-related Financial Disclosures, 2017). This structure links responsibility for climate-related risks and opportunities with strategic planning and with the processes used to identify, assess, and manage those risks. It also places climate resilience within strategic analysis through the use of scenarios. The underlying implication is important: climate considerations need to become part of the structures through which organisations are governed and decisions are made, rather than remain confined to a separate reporting function.

Since then, this approach has been incorporated into the international architecture for sustainability disclosure. IFRS S2 builds on governance, strategy, risk management and metrics and targets as the core content areas and requires organisations to disclose information about the processes, controls and procedures they have in place to monitor and manage climate-related risks and opportunities (IFRS Foundation, 2023). It also requires consideration of climate resilience, including the use of climate-related scenario analysis, thereby connecting governance arrangements with the ability of organisational strategy and business models to respond to climate-related change.

Recent developments within the European sustainability reporting and sustainable finance architecture have further strengthened this distinction between disclosure and substantive **organisational capability**. The European Sustainability Reporting Standards (ESRS), particularly ESRS E1 concerning climate change, extend organisational reporting expectations beyond the communication of climate-related information towards the disclosure of how climate considerations are addressed through strategy, governance, risk management, and resilience-related processes. Similarly, the climate adaptation requirements under the EU Taxonomy's Do No Significant Harm (DNSH) framework require organisations to consider robust climate risk and vulnerability assessment processes and appropriate adaptation measures when demonstrating alignment with sustainable activities.

These developments reinforce an important methodological distinction addressed by the **FTSAI Framework**. **The existence of climate-related disclosures, policies, governance structures, or formal adaptation plans provides relevant evidence, but does not by itself demonstrate that an organisation possesses effective climate-risk readiness**. Substantive readiness requires evidence that climate-risk information influences decisions, resource allocation, implementation processes, monitoring mechanisms, and organisational learning. The Framework therefore complements emerging disclosure and sustainable finance requirements by providing an **assessment architecture** focused on whether reported governance arrangements correspond to operational organisational capabilities.

A related development has taken place within climate adaptation standards. ISO 14090:2019 treats adaptation as an organisational process that requires integration into policies, strategies, plans, and decision-making rather than as an isolated technical intervention (ISO 14090, 2019). This perspective is particularly relevant because it extends the governance problem beyond disclosure. Adaptation requires organisations to establish responsibilities, use relevant knowledge, evaluate changing conditions, implement responses, and review whether those responses remain appropriate over time.

Together, these approaches establish that organisational governance is already an integral part of contemporary climate-risk and adaptation practice. The **FTSAI Framework** therefore does not claim novelty for incorporating governance, strategy, risk management, monitoring, or adaptation into climate-risk analysis. Nor does it assume that the presence of formal governance arrangements alone demonstrates an organisation's ability to respond effectively to climate-related change.

The methodological distinction introduced by the **FTSAI Framework** concerns the role assigned to these arrangements within the assessment itself and their relationship with the broader analytical structure through which climate-related risks are characterised, interpreted, and translated into organisational action. Disclosure frameworks are principally concerned with whether organisations provide information that enables users to understand how climate-related risks and opportunities are governed and managed. The **FTSAI Framework** asks an additional assessment question: whether available evidence demonstrates that the organisational arrangements being described connect climate-risk information with decision authority, resource allocation, implementation, monitoring, review, and adaptation.

This distinction provides the basis for the Framework's treatment of **organisational readiness**. **Readiness is not inferred from the existence of policies, committees, reporting structures, or formal statements of responsibility**. Such arrangements may provide relevant evidence, but their presence does not establish that climate-related information influences decisions or that the organisation can act when conditions change. Assessment therefore extends from the existence of governance structures to their operational connection with organisational action.

Within the FTSAI Framework, readiness consequently represents the organisational capability through which analytical understanding is converted into decision and action. It concerns whether responsibilities are defined, information reaches those with authority to act, decisions can mobilize appropriate resources, implementation can be monitored, and experience can inform subsequent adjustment. Adaptive capacity extends this logic further by examining whether the organisation can modify existing arrangements when they become inadequate under changing climatic conditions.

The relationship between disclosure and assessment is therefore complementary rather than competitive. Disclosure can provide important evidence about organisational governance and climate-related processes, while assessment examines what that evidence supports about the functioning of the organisation. The methodological contribution of the **FTSAI Framework** lies not in introducing governance into climate-risk analysis, but in treating governance and readiness as evidence-based organisational capabilities whose substantive operation must be assessed rather than inferred from their formal existence or disclosure.

Accordingly, the **FTSAI Framework** is positioned as a complementary **assessment architecture** that supports organisations seeking to evaluate the substantive foundations underlying climate-related disclosures, adaptation assessments, assurance processes, and sustainability-related decision-making.

3.5 Operational Climate Risk Assessment Approaches

The development of climate-risk concepts has been accompanied by efforts to translate them into practical assessment methods. This transition from conceptual framing to operational assessment is important because identifying the components of climate risk does not determine how evidence should be collected, organised, evaluated, or combined. Different methodologies have addressed this problem according to their intended unit of analysis and decision context, producing approaches that range from organisational risk assessment to country-level indices and project screening tools.

When climate risk analysis is set in the specific context of the operations of a given entity, it becomes a question for the organisation. This transition is addressed by ISO 14091:2021 that provides a process for the assessment of climate-related vulnerabilities and risks in different organisational and sectoral contexts (ISO 14091, 2021). The assessment process connects information about climate impacts with the identification and evaluation of risk and, ultimately, with adaptation planning. For the purposes of positioning the **FTSAI Framework**, the important point is that applying climate-risk assessment to organisations, considering both current and future conditions, and using assessment to inform adaptation are established practices rather than methodological innovations introduced by FTSAI.

ND-GAIN addresses the operational problem from a different level of analysis. Its unit of assessment is the country rather than the individual organisation, and its architecture keeps vulnerability and readiness as separate components (Notre Dame Global Adaptation Initiative (ND-GAIN), 2026). Vulnerability captures how susceptible a country is to climate-related effects through measures of exposure, sensitivity, and adaptive capacity across multiple sectors. Readiness considers the economic, governance, and social conditions that affect the country's capacity to make effective use of adaptation investment. These elements are represented through indicators and subsequently combined, allowing differences between countries and changes through time to be examined within a common measurement structure.

ND-GAIN is particularly relevant to the methodological positioning of the **FTSAI Framework** because it demonstrates that both adaptive capacity and readiness have already been operationalized within climate assessment. At the same time, its purpose requires a different aggregation logic. Country-level comparison depends upon standardized indicators and composite measures capable of summarizing performance across multiple dimensions. The **FTSAI Framework** addresses a different assessment problem. Its purpose is not to rank entities through a common index, but to identify the configuration of conditions through which climate risk may become consequential for a particular organisation or system.

Project-level screening provides another operational perspective. The World Bank Climate and Disaster Risk Screening methodology structures assessment around exposure, potential impacts, and adaptive capacity, enabling climate and disaster risks to be considered within project and policy design (World Bank). This approach demonstrates that sequential assessment structures linking climatic exposure with system characteristics and response capacity are already present in applied climate-risk practice. It also illustrates how the architecture of an assessment is shaped by its intended purpose: screening seeks to identify whether climate and disaster risks warrant further consideration within a project or policy process rather than to provide a comprehensive assessment of organisational climate-risk architecture.

These approaches establish an important boundary around claims concerning the **FTSAI Framework**. **Structured climate-risk assessment is not new**. Neither are organisational applicability, vulnerability assessment, adaptive capacity, readiness, sequential analytical processes, or the use of indicators and aggregate measures. The relevant question is therefore not whether the **FTSAI Framework** contains elements that are absent from all existing methodologies, but whether their combination addresses an assessment problem that remains insufficiently resolved when these elements are considered separately.

The FTSAI Framework approaches operationalization by preserving the analytical identity of the different conditions that contribute to climate risk. **Hazard characterisation** establishes the relevant stress environment, exposure identifies the pathways through which that stress may reach the assessed system, **vulnerability and resilience** examine how the system is likely to respond, and **readiness and adaptive capacity** examine whether organisational capabilities can translate understanding into action and change. The sequence is directional for assessment purposes because each stage establishes evidence required by the stages that follow, without implying that the underlying system itself operates through a simple linear causal chain.

This architecture also affects how assessment results are combined and interpreted. Aggregate measures can facilitate communication, comparison, and prioritisation, but they may also conceal material weaknesses when strong performance in one dimension offsets poor performance in another. **The FTSAI Framework therefore constrains aggregation through non-compensatory interpretation and retains visibility of critical weaknesses, dominant constraints, evidentiary limitations, and uncertainty**. The resulting assessment is intended to preserve the structure of the underlying risk configuration rather than reduce that configuration to a single summary measure.

The comparison with existing operational approaches therefore narrows the methodological contribution claimed by the **FTSAI Framework**. Its contribution does not lie in introducing operational climate-risk assessment or any single constituent concept. It lies in organizing established concepts within an **assessment architecture** that preserves their **analytical separation** while governing how evidence moves between them, how results may be aggregated, and how those results may be interpreted. This positioning provides the basis for a more explicit comparison between the **FTSAI Framework** and the principal approaches from which its conceptual and methodological foundations have developed.

3.6 Comparative Positioning of the FTSAI Framework

The preceding discussion shows that the **FTSAI Framework** shares important conceptual foundations with established approaches to climate risk, adaptation, resilience, and governance. Hazard, exposure, vulnerability, resilience, adaptive capacity, **organisational readiness**, uncertainty, and governance all have substantial intellectual and methodological histories. The contribution of the Framework must therefore be located not in the introduction of these individual concepts, but in the way they are organised into an integrated **assessment architecture** and in the rules governing the relationships between them.

The differences among existing approaches become clearer when they are viewed in relation to the questions they were designed to answer. Work associated with the IPCC explains climate risk by examining how climatic hazards encounter exposed and vulnerable systems within wider and evolving conditions (Field et al., 2012; Field et al., 2014; IPCC, 2022). A different question lies behind the resilience and adaptation literature: what enables a system to endure disturbance, adjust to changing circumstances, or undergo more fundamental transformation (Folke et al., 2010; Holling, 1973; Smit & Wandel, 2006; Walker et al., 2004). Once the problem shifts from understanding system behaviour to making decisions, another body of work becomes relevant. (Renn et al., 2011) examine the governance implications of complexity, uncertainty, and ambiguity, while (Hall et al., 2012) consider decision approaches intended to remain useful when no single representation of an uncertain future can provide an adequate basis for choice.

Moving from these conceptual questions to organisational practice introduces another set of requirements. General risk management principles are provided by ISO 31000:2018, while ISO 14090:2019 and ISO 14091:2021 bring adaptation and climate-risk assessment into organisational settings (ISO 14090, 2019; ISO 14091, 2021; ISO 31000, 2018). Climate-related information also enters organisations through disclosure requirements. TCFD and IFRS S2 place such information within governance, strategy, risk management, and related reporting processes (IFRS Foundation, 2023; Task

Force on Climate-related Financial Disclosures, 2017). Other methodologies serve still different purposes. ND-GAIN provides a common framework for vulnerability and **readiness assessment** at the country level, and the screening methodology from the World Bank helps integrate climate and disaster risk in project and policy contexts (Notre Dame Global Adaptation Initiative (ND-GAIN), 2026; World Bank). What we have is not a single competing methodology, but a set of approaches at different analytical levels and aimed at different questions.

Seen together, these approaches reveal that the methodological problem is not an absence of relevant concepts. The difficulty lies in preserving their different analytical functions while connecting them within an assessment process capable of supporting organisational judgement. Combining concepts without maintaining these distinctions can obscure whether an assessment result reflects climatic stress, exposure to that stress, susceptibility of the system, capacity to withstand disruption, or organisational ability to respond and adapt. Conversely, separating these elements without specifying how evidence moves between them leaves the assessment fragmented.

The FTSAI Framework addresses this problem through a directional but non-causal assessment architecture. **Hazard characterisation** defines the relevant climatic stress environment. **Exposure mapping** establishes the pathways through which that stress can reach the assessed system. **Vulnerability and resilience** examine the characteristics that shape the system's response once exposure exists. **Readiness and adaptive capacity** then examine whether the organisation can translate this understanding into action and modify its arrangements as circumstances evolve. Directionality governs the construction of evidence across the assessment, while the underlying climatic, organisational, and socio-economic system remains capable of feedback, interaction, and non-linear change.

A second distinguishing feature concerns the treatment of aggregation. Many assessment contexts require summary measures because they facilitate comparison and communication. The **FTSAI Framework** permits aggregation where it serves an analytical purpose, but does not allow aggregation to erase material weaknesses in individual dimensions. Its **non-compensatory interpretation** principle therefore preserves the visibility of critical constraints even where performance elsewhere in the assessed system is comparatively strong. The purpose is not to reject quantitative synthesis, but to prevent a favourable aggregate result from becoming evidence that a material weakness has ceased to matter.

The **non-compensatory interpretation** adopted by the Framework is consistent with established approaches in multi-criteria assessment, where aggregation mechanisms may be designed to prevent strong performance in selected dimensions from fully offsetting critical weaknesses in others. Such approaches recognise that certain assessment contexts require the preservation of limiting conditions rather than unrestricted compensation across dimensions. (Munda, 2005; OECD/EC-JRC, 2008).

A third distinction concerns the relationship between governance and assessment. Governance is not treated solely as a reporting category or as contextual information surrounding the technical assessment. **Within the FTSAI architecture, governance arrangements become part of the evidence used to determine whether analytical understanding can influence decisions, mobilize resources, support implementation, and enable subsequent adaptation**. This is the basis upon which **organisational readiness** becomes an assessable capability rather than an inferred consequence of formal governance structures.

Finally, the Framework preserves uncertainty and scope limitations within the interpretation of assessment results. Uncertainty is not removed through aggregation, while incomplete evidence is not automatically treated as evidence of poor performance. Similarly, an assessment conducted within a deliberately restricted scope is distinguished from one whose intended coverage could not be completed. These rules are intended to preserve the meaning of the assessment as information passes from evidence collection through scoring, aggregation, and interpretation.

The resulting contribution is therefore architectural and methodological rather than conceptual in isolation. The **FTSAI Framework** brings established climate-risk, resilience, adaptation, and governance concepts into a common organisational assessment structure while imposing explicit rules on analytical sequence, evidence dependency, aggregation, uncertainty, scope, and interpretation. Its distinctive proposition is that the usefulness of climate-risk assessment depends not only on what dimensions are assessed, but also on whether their analytical identities are preserved as evidence is transformed into organisational judgement.

3.7 Methodological Contribution and Boundaries

The comparative positioning developed above allows the contribution of the **FTSAI Framework** to be stated more precisely. Its purpose is not to replace established climate-risk concepts, resilience theory, adaptation standards, disclosure frameworks, or existing approaches to risk governance. Each addresses questions that remain relevant within its own analytical domain. The **FTSAI Framework** instead addresses the problem of how these different forms of knowledge can be organised for the assessment of an organisation without losing the distinctions that give them analytical meaning.

This leads to a first methodological boundary. **The Framework is an assessment architecture rather than a predictive model**. It does not estimate the probability of specific climatic events, forecast organisational losses, or determine how an organisation will perform under a particular future state. Hazard information and scenarios provide conditions against which organisational characteristics can be examined, but the resulting assessment should not be interpreted as a prediction of future outcomes. This distinction allows changing climatic conditions to inform assessment without requiring confidence in a single forecast of the future.

A second boundary concerns prescription. The Framework can identify material exposure pathways, structural vulnerabilities, resilience constraints, weaknesses in readiness, and limitations in adaptive capacity, but it does not determine the strategy an organisation should adopt in response. Different organisations may reasonably choose different responses to similar assessment findings because their objectives, resources, obligations, risk tolerances, and decision contexts differ. Assessment provides structured evidence for judgement; it **does not replace organisational judgement**.

A third boundary concerns measurement. Numerical representation can support consistency, synthesis, and communication, but the meaning of an assessment cannot be reduced to the numerical value produced at the end of a scoring process. Scores within the Framework represent structured evaluations against defined assessment criteria. Their interpretation remains dependent upon scope, evidence, uncertainty, and the configuration of strengths and weaknesses from which they were derived. For this reason, numerical equivalence does not necessarily imply substantive equivalence between assessed systems.

These boundaries help clarify the nature of the methodological contribution. The Framework separates analytical functions that are often closely connected in practice and then reconnects them through explicit evidence dependencies. Hazard does not substitute for exposure, exposure does not establish vulnerability, resilience does not establish adaptive capacity, and formal governance does not establish readiness. Each conclusion must be supported by evidence appropriate to the question being assessed before it can inform the next stage of analysis.

The same principle governs interpretation. Strong performance in one part of the assessment cannot automatically eliminate a material weakness elsewhere, uncertainty cannot be converted into certainty through scoring, and absence of evidence cannot be treated without qualification as evidence of absence. Scope restrictions must remain visible, as must limitations in the evidence supporting individual conclusions. These constraints are not secondary qualifications added after the assessment has been completed. They form part of the methodology through which assessment meaning is preserved.

The contribution claimed by the FTSAI Framework can therefore be stated in deliberately limited terms. It is an integrated organisational climate-risk **assessment architecture** that combines established concepts within a directional analytical sequence and applies explicit rules to evidence dependency, aggregation, uncertainty, scope, and interpretation. Its methodological proposition is that these rules are necessary if multidimensional climate-risk information is to be transformed into organisationally useful conclusions without concealing the structural conditions from which those conclusions arise.

This proposition is necessarily open to empirical examination. A coherent architecture does not establish that an assessment methodology performs as intended in practice. The validity, reliability, discriminatory capacity, and decision relevance of the Framework must therefore be evaluated through application across different organisational and sectoral contexts. **The contribution described in this section should consequently be understood as a methodological proposition to be tested, refined, and, where necessary, revised through empirical evidence rather than as a claim established by conceptual coherence alone.** The comparative positioning of the **FTSAI Framework** in relation to these established approaches is summarized in Table 3.

Table 3. Comparative positioning of the FTSAI Climate Risk Assessment Framework within established climate-risk, adaptation, resilience, and governance approaches

Approach	Primary analytical purpose	Unit / level of analysis	Core climate-risk structure	Resilience / adaptive capacity	Governance / readiness	Treatment of uncertainty	Aggregation / interpretation	Relationship to FTSAI
IPCC SREX / AR5 / AR6	Conceptualization of climate risk, impacts, vulnerability, and adaptation	Global to local systems	Hazard, exposure, vulnerability and their interactions	Adaptive capacity and resilience embedded within broader vulnerability and adaptation thinking	Governance recognised as a determinant of risk and adaptation	Explicit recognition of uncertainty and changing conditions	Primarily conceptual and assessment-oriented rather than an organisational scoring architecture	Provides the established conceptual foundations for hazard, exposure, vulnerability, and systemic climate risk
Resilience and adaptation literature	Understanding persistence, adjustment, and transformation under disturbance and change	Ecological, social-ecological, community, and organisational systems	Focus on system response rather than a fixed climate-risk sequence	Central distinction among resilience, adaptability / adaptive capacity, and transformation	Institutional and organisational conditions influence adaptation	Recognises changing conditions and limits to knowledge	No single standardized aggregation structure	Provides the conceptual basis for separating resilience from adaptive capacity within FTSAI
Risk governance / robust decision approaches	Supporting decisions under complexity, uncertainty, and ambiguity	Policy and organisational decision systems	Risk interpreted within uncertain and complex decision environments	Not generally structured as separate assessment layers	Governance and decision processes are central	Core methodological concern	Emphasis on robustness and defensibility rather than single optimal solutions	Supports FTSAI treatment of uncertainty as persistent and decision-relevant rather than something eliminated through scoring
ISO 31000:2018	General organisational	Organisations	Risk linked to uncertainty and	Not climate-specific	Risk management embedded	Integral to risk management	Does not prescribe a climate-	Provides general risk-management principles

Approach	Primary analytical purpose	Unit / level of analysis	Core climate-risk structure	Resilience / adaptive capacity	Governance / readiness	Treatment of uncertainty	Aggregation / interpretation	Relationship to FTSAI
	risk management		organisational objectives		in organisational processes		specific scoring architecture	underlying iterative assessment and review
ISO 14090:2019 / ISO 14091:2021	Climate adaptation and climate-risk assessment	Organisations	Structured assessment of climate-related impacts, risks, and vulnerabilities	Adaptive capacity relevant to adaptation assessment	Adaptation integrated with organisational planning and decision-making	Considered throughout assessment and adaptation processes	Flexible implementation rather than a universal organisational index	Establishes organisational climate-risk assessment and adaptation as existing practice upon which FTSAI builds
TCFD / IFRS S2	Climate-related financial governance and disclosure	Organisations and reporting entities	Climate-related risks and opportunities considered through governance, strategy, risk management, metrics and targets	Climate resilience considered, including through scenario analysis	Central focus on governance and organisational processes	Addressed through scenario analysis and disclosure of assumptions and information	Disclosure-oriented rather than an integrated climate-risk scoring architecture	Provides governance and disclosure foundations; FTSAI additionally assesses evidence of substantive **organisational readiness**
ND-GAIN Country Index	Comparative assessment of vulnerability and readiness	Countries	Vulnerability incorporates exposure, sensitivity, and adaptive capacity	Adaptive capacity is a component of vulnerability	Readiness assessed separately through economic, governance, and social dimensions	Reflected through underlying data and methodological limitations	Indicator-based aggregation supporting cross-country comparison	Demonstrates operational separation of vulnerability and readiness; FTSAI applies a different, organisation-specific and **non-compensatory**

Approach	Primary analytical purpose	Unit / level of analysis	Core climate-risk structure	Resilience / adaptive capacity	Governance / readiness	Treatment of uncertainty	Aggregation / interpretation	Relationship to FTSAI
								interpretation logic
World Bank Climate and Disaster Risk Screening	Screening climate and disaster risk in projects and policies	Projects and policy contexts	Exposure, potential impacts, and adaptive capacity	Adaptive capacity explicitly considered	Relevant to project and institutional response	Incorporated into screening and interpretation	Screening-oriented rather than comprehensive organisational assessment	Demonstrates sequential applied climate-risk screening; FTSAI extends assessment across organisational resilience, readiness, governance, and adaptation
FTSAI Climate Risk Assessment Framework	**Integrated assessment of organisational climate-risk architecture**	Organisations and defined organisational systems	Directional sequence from hazard → exposure → vulnerability / resilience → readiness / adaptive capacity	**Resilience and adaptive capacity retained as distinct assessment functions**	**Governance evaluated through evidence of readiness**, decision authority, implementation, monitoring, and adaptation	**Preserved throughout evidence, scoring, and interpretation**	**Constrained aggregation with non-compensatory interpretation** and preservation of critical weaknesses	Integrates established concepts through **explicit rules governing evidence dependency, analytical sequence, scope, uncertainty, aggregation, and interpretation**

Source: Author's synthesis based on the literature and methodological sources discussed in Section 3.

4. Core Methodological Principles

The **FTSAI Climate Risk Assessment Framework** is governed by a set of **core methodological principles** that apply across analytical layers, assessment modules, sectoral applications, scoring procedures, interpretation, and reporting. These principles translate the conceptual foundations of the Framework into **explicit methodological commitments** and establish the conditions that must remain **invariant across different implementations**.

Their purpose is not to prescribe identical indicators, data requirements, or analytical procedures in every application. Such requirements may vary according to sector, assessment purpose, organisational characteristics, and evidentiary conditions. The principles instead **define the methodological boundaries** within which such variation may occur. An implementation may therefore be adapted operationally without altering the **scientific logic of the Framework**, provided that the following principles remain satisfied. Figure 2 illustrates their relationship to the **assessment architecture** and their collective role as methodological invariants across Framework applications.

M1 — Analytical Separation

Climate risk shall be assessed through **analytically distinct constructs** whose individual explanatory functions are preserved throughout the assessment process. Hazard, exposure, vulnerability, resilience, readiness, and adaptive capacity shall not be treated as **interchangeable dimensions** or collapsed prematurely into composite representations. Relationships between these constructs may be examined and their outputs subsequently integrated, but integration shall not eliminate the analytical distinctions required to understand how climate risk emerges, propagates, and changes over time.

M2 — Evidence Traceability

Every material assessment conclusion shall remain **traceable to the evidence, assumptions, criteria, and analytical reasoning** from which it was derived. Quantitative data, qualitative evidence, proxy indicators, expert judgement, and contextual interpretation shall therefore be documented sufficiently to permit review of the evidentiary basis of an assessment. Where professional judgement materially influences an outcome, the reasoning supporting that judgement shall remain explicit and capable of independent examination. Traceability is required not only for reproducibility and auditability but also for identifying why assessment findings change across successive applications.

M3 — Non-Compensatory Interpretation

Material weakness in a critical dimension **shall not be obscured by favourable performance elsewhere through unrestricted compensatory aggregation**. Aggregated scores may support synthesis, comparison, and communication, but they shall preserve the visibility of **dominant vulnerabilities, critical dependencies, threshold conditions, interaction effects**, and other constraints capable of determining system behaviour under stress. Where aggregation cannot preserve such information adequately, interpretation shall return to the underlying analytical dimensions, and the relevant constraint shall remain explicit in the assessment conclusion.

M4 — Uncertainty Preservation

Uncertainty shall remain visible throughout evidence collection, analysis, scoring, aggregation, classification, interpretation, and reporting. It shall not be removed through unsupported assumptions, artificial precision, or aggregation procedures that conceal the limitations of the underlying evidence. Different forms of uncertainty may require different analytical treatment, but their existence and implications shall remain connected to the conclusions they qualify. Reducing uncertainty where evidence permits is desirable; **suppressing uncertainty where evidence does not permit its reduction is methodologically unacceptable**.

M5 — Interpretive Boundedness

No assessment conclusion shall extend beyond the evidentiary, methodological, temporal, and scope conditions under which it was established. Scores, classifications, comparisons, and other assessment outputs acquire meaning only within the analytical context that produced them and shall not be interpreted as universal measures of organisational safety, quality, resilience, or future performance. Partial assessment shall not be represented as comprehensive assessment, conclusions shall not be generalized beyond their declared scope, and changes in organisational or environmental conditions may invalidate the continued use of earlier findings where their underlying assumptions no longer hold.

M6 — Proportionality

The depth, evidentiary requirements, analytical resolution, and implementation burden of an assessment **shall remain proportionate to its purpose, materiality, complexity, and decision consequences**. Proportionality permits differences in assessment intensity **without permitting differences in methodological integrity**. Screening applications may legitimately employ lighter evidence structures than high-consequence regulatory, financial, assurance, or certification-related applications, but conclusions shall remain correspondingly limited by the depth and quality of the assessment supporting them.

M7 — Decision Independence

Assessment outputs **shall support judgement without substituting for the authority, accountability, or professional responsibility of decision-makers**. Scores, classifications, benchmarks, and readiness indicators are **structured analytical signals rather than autonomous decision rules**. Their use in investment, financing, insurance, certification, regulatory, strategic, or governance decisions requires consideration of objectives, constraints, legal responsibilities, and forms of expertise extending beyond climate risk assessment itself. The Framework therefore informs decisions while preserving the institutional separation between scientific assessment and the decisions subsequently made on its basis.

M8 — Empirical Revisability

The constructs, relationships, scoring procedures, classifications, and interpretive rules of the Framework **shall remain open to systematic empirical examination** (Messick, 1989). **Internal coherence alone does not establish methodological validity**. Evidence concerning construct validity, discriminant validity, inter-assessor reliability, empirical correspondence, or other relevant methodological properties may therefore require recalibration, refinement, or revision. Systematic evidence inconsistent with the behaviour or characteristics that an assessment construct is intended to represent **shall not be dismissed solely by reference to uncertainty, contextual variation, or professional judgement**.

M9 — Methodological Stability and Controlled Evolution

The Framework **shall evolve without sacrificing the methodological continuity** required for comparability, reproducibility, and cumulative learning. Core concepts, analytical relationships, scoring principles, and interpretive rules **shall remain stable within an official Framework version**, while modules, indicators, implementation parameters, and sector-specific applications may be refined under controlled methodological governance. Where changes affect the interpretation or comparability of assessment outcomes, they shall be explicitly documented through **version control** and, where necessary, re-baselining. Methodological evolution shall therefore occur transparently and deliberately rather than through unrecorded variation between applications.

Collectively, Principles M1–M9 define the **methodological invariants** of the **FTSAI Climate Risk Assessment Framework**. They distinguish **legitimate operational adaptation from methodological modification** and provide the reference against which modules, scoring procedures, sectoral applications, assessment outputs, and future revisions are to be evaluated. The analytical architecture derived in the following section represents the structural implementation of these principles within the Framework.

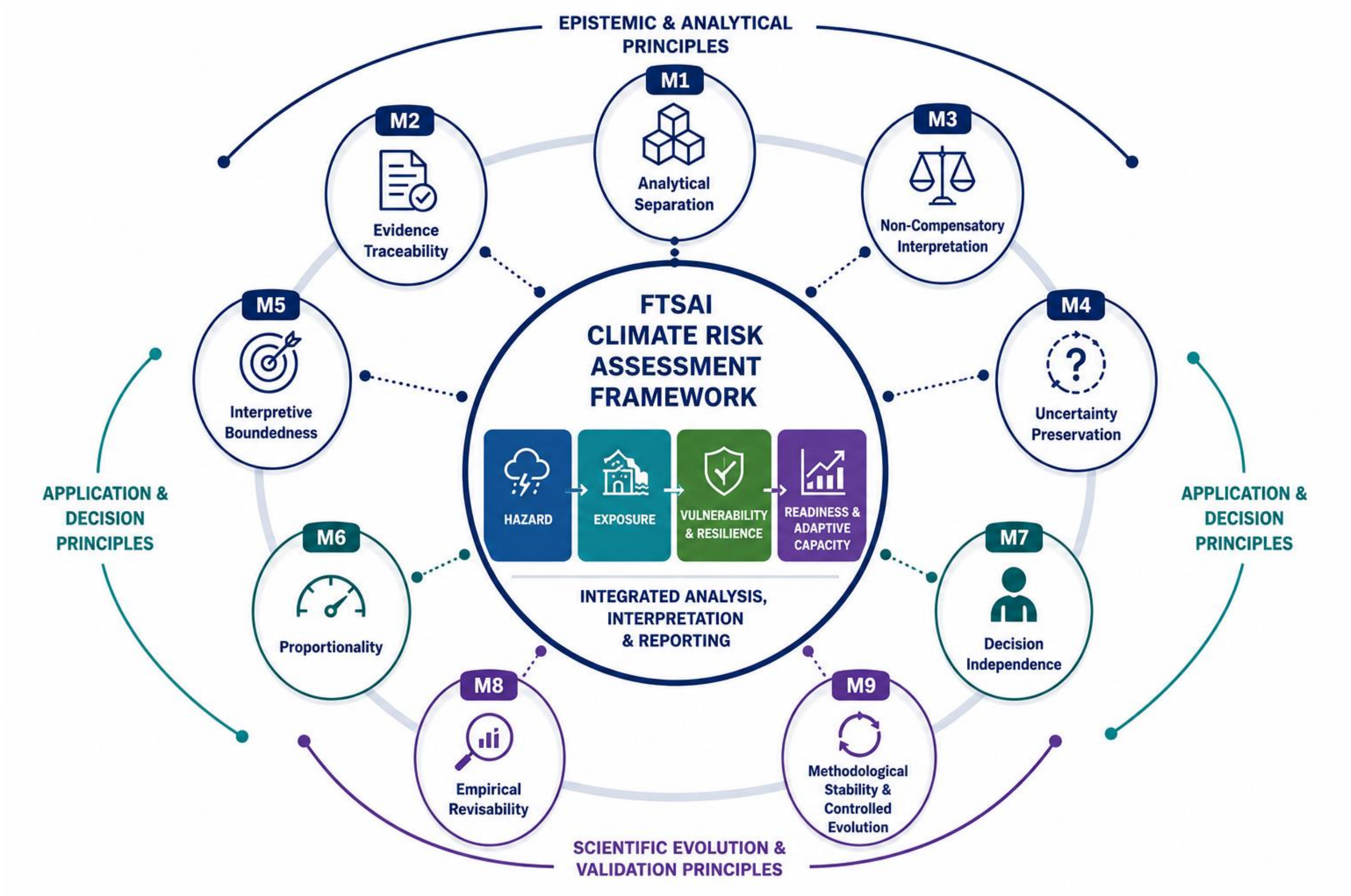

Figure 2. Core methodological principles of the FTSAI Climate Risk Assessment Framework. Principles M1–M9 operate as methodological invariants governing analytical design, implementation, interpretation, validation, and controlled evolution across all Framework applications.

5. Logical Derivation of the Assessment Architecture

The architecture of the **FTSAI Climate Risk Assessment Framework** follows from its systemic and dynamic conception of climate risk and operationalizes the principle of **Analytical Separation** (M1). Climate hazards constitute physical phenomena, but climate risk does not exist independently of the systems upon which those hazards may act. Risk emerges only when climatic disturbances interact with exposed assets, activities, organisational structures, institutional arrangements, governance mechanisms, and decision processes. The analytical architecture of the Framework must therefore reconstruct the conditions through which an external climatic phenomenon acquires organisational and economic significance.

The first analytical requirement concerns the external source of potential disruption. A climate hazard is defined as a climate- or weather-related physical event, process, or long-term trend, whether acute or chronic, with the potential to generate disruption, damage, or loss. **Hazard characterisation** is therefore necessary because assessment must first establish the climatic conditions under which risk may emerge. At this stage, however, no conclusion can yet be drawn regarding the risk faced by the assessed entity. A hazard may exist without materially affecting a particular organisation, asset, activity, or value chain. **Hazard characterisation** consequently establishes the external environmental conditions relevant to the assessment but cannot by itself establish climate risk.

A second analytical requirement therefore arises. For an identified hazard to acquire significance for a particular entity, a relationship must exist between that hazard and the assets, operations, activities, or value chains of the assessed system. The Framework defines exposure as the extent to which these elements are geographically, operationally, functionally, or economically positioned in relation to identified climate hazards. Exposure is therefore relational rather than consequential. It does not describe damage, susceptibility, or organisational performance. Its analytical function is to establish the direct and indirect pathways through which climatic disturbance may become relevant to the assessed system.

This distinction establishes the necessity of **Exposure Mapping** as a separate analytical layer. **Hazard characterisation** identifies what climatic phenomena may generate disruption. **Exposure mapping** identifies where and through which pathways those phenomena may encounter the assessed system. Neither can substitute for the other. A hazard may be severe while organisational exposure remains limited, just as material exposure may exist to hazards whose physical intensity is comparatively moderate. Assessment must therefore distinguish the external source of potential disruption from the relationship through which that disruption becomes relevant to the entity.

Establishing hazard and exposure nevertheless remains insufficient to explain climate risk. Organisations exposed to comparable climatic conditions may exhibit substantially different outcomes. Similar exposure does not imply similar disruption, because the consequences of exposure depend upon the characteristics of the systems through which climatic stress is transmitted. A third analytical requirement therefore arises: assessment must explain how the exposed system is likely to respond once climatic stress becomes operationally relevant.

The Framework separates this question into **vulnerability and resilience** because the two concepts describe different properties of system behaviour. Vulnerability concerns susceptibility to adverse impacts. It reflects the structural, operational, organisational, financial, and systemic characteristics that determine how readily an exposed entity may experience degradation, disruption, or loss. Resilience concerns response capability. It reflects the ability of the system, under its existing configuration, to absorb stress, maintain essential functions, reconfigure operational activity where possible, and recover following disruption.

Vulnerability and resilience therefore cannot be treated as opposite ends of a single continuum. A system may exhibit substantial structural vulnerability while retaining strong response mechanisms, just as relatively limited vulnerability may coexist with weak resilience. Together, the two concepts explain how the system behaves under climatic stress given the capabilities, structures, resources, and constraints that currently characterise it. The third analytical layer is consequently required to move assessment from the existence of exposure to the behaviour of the exposed system.

Even this analysis, however, remains incomplete if climate risk is understood as a dynamic phenomenon. Climate risk does not merely reflect the present interaction of hazard, exposure, vulnerability, and resilience. Its trajectory is progressively shaped by organisational choices. Exposure, **vulnerability and resilience** can be altered over time through investment decisions, technological change, governance arrangements, operational practices, resource allocation, institutional coordination and organisational learning. An assessment confined to the current configuration of the system would therefore provide only a static representation of a process that is inherently evolutionary.

This introduces the fourth analytical requirement. Climate risk assessment must examine whether the organisation possesses the governance and **organisational capability** to modify the conditions that determine its future risk trajectory. This is the analytical role of **readiness and adaptive capacity**.

The distinction between resilience and adaptive capacity is particularly important. Resilience concerns the ability of the system to respond to climatic stress using the capabilities available within its existing configuration. Adaptive capacity concerns the ability of the organisation to change that configuration. It reflects whether governance, decision-making, organisational learning, technological adjustment, operational change, investment, and institutional coordination can modify future exposure, vulnerability, or resilience as climatic conditions evolve.

In this sense, resilience concerns response, whereas adaptive capacity concerns transformation. A resilient organisation may perform effectively during disruption without necessarily possessing the governance capability required to alter its longer-term risk trajectory. Conversely, an organisation may currently exhibit limited resilience while nevertheless possessing strong adaptive capacity through effective governance, learning, investment capability, and institutional flexibility. Treating adaptive capacity merely as a resilience mechanism would therefore collapse two analytically distinct questions: how the system performs under its present configuration and whether that configuration itself can change.

Climate risk readiness represents the governance condition through which such change becomes possible. Readiness concerns the extent to which climate risk has been systematically identified, assessed, internalized, and embedded within governance structures, strategic planning, operational decision-making, and risk management processes. Its importance lies not in the formal existence of policies, committees, plans, or monitoring systems, but in the ability of governance to transform climate-risk knowledge into organisational action. Readiness therefore establishes the decision architecture through which adaptive capacity can become operational.

The four analytical layers can consequently be understood as addressing four logically distinct conditions of climate risk formation, as summarized in Table 4.

The architecture should therefore not be interpreted as an arbitrary decomposition of climate risk into four convenient categories. It represents the necessary analytical decomposition for the purposes of this Framework required by the Framework's systemic and dynamic conception of risk. Each layer captures a different analytical condition that cannot be inferred reliably from the others. Removing **Hazard Characterisation** would leave the external source of potential disruption unspecified. Removing **Exposure Mapping** would leave the relationship between climatic phenomena and the assessed entity undefined. Removing **Vulnerability and Resilience Analysis** would prevent explanation of why comparable exposure may produce different organisational outcomes. Removing **Readiness and Adaptive Capacity Assessment** would reduce climate risk to a static condition and ignore the capacity of organisational decisions to alter its future trajectory.

Table 4. Analytical questions and corresponding layers of the FTSAI Climate Risk Assessment Framework.

Analytical question	Required analytical layer
What climatic conditions have the potential to affect the system?	**Hazard Characterisation**
Through what direct or indirect relationships can those conditions become relevant to the assessed entity?	**Exposure Mapping**
Given the current configuration of the system, how susceptible is it to disruption and how capable is it of maintaining and restoring function under stress?	**Vulnerability and Resilience Analysis**
Can the organisation deliberately alter that configuration and thereby modify its future climate-risk trajectory?	**Readiness and Adaptive Capacity Assessment**

The resulting analytical sequence can therefore be expressed as:

External Environment → Exposure Relationship → System Response → System Change

or, in the operational terminology of the Framework:

Hazard → Exposure → Vulnerability and Resilience → Readiness and Adaptive Capacity

Consistent with **Analytical Separation** (M1), this sequence is analytical rather than deterministic. It does not imply that climate risk evolves through a simple linear causal chain; interactions, feedback effects, temporal dependencies, and non-linear behaviour (Folke et al., 2010) remain integral to the Framework, as illustrated in Figure 3.

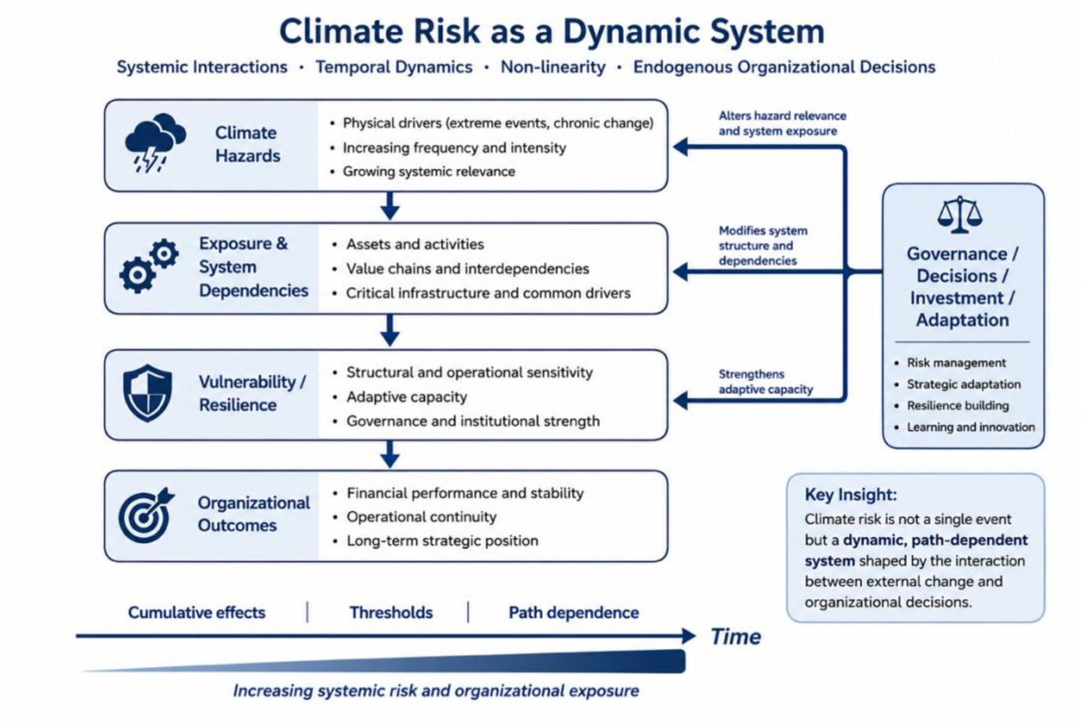

Figure 3. Climate risk as a dynamic system, illustrating the interactions among climate hazards, exposure and system dependencies, vulnerability and resilience, organisational outcomes, and endogenous organisational decisions over time.

The four-layer architecture consequently provides the minimum structure required to preserve conceptual clarity while remaining consistent with the central proposition of the Framework: climate hazards are physical, but climate risk is systemic, dynamic, and partly endogenous to organisational decision-making. The conceptual derivation of this architecture is summarized in Figure 4.

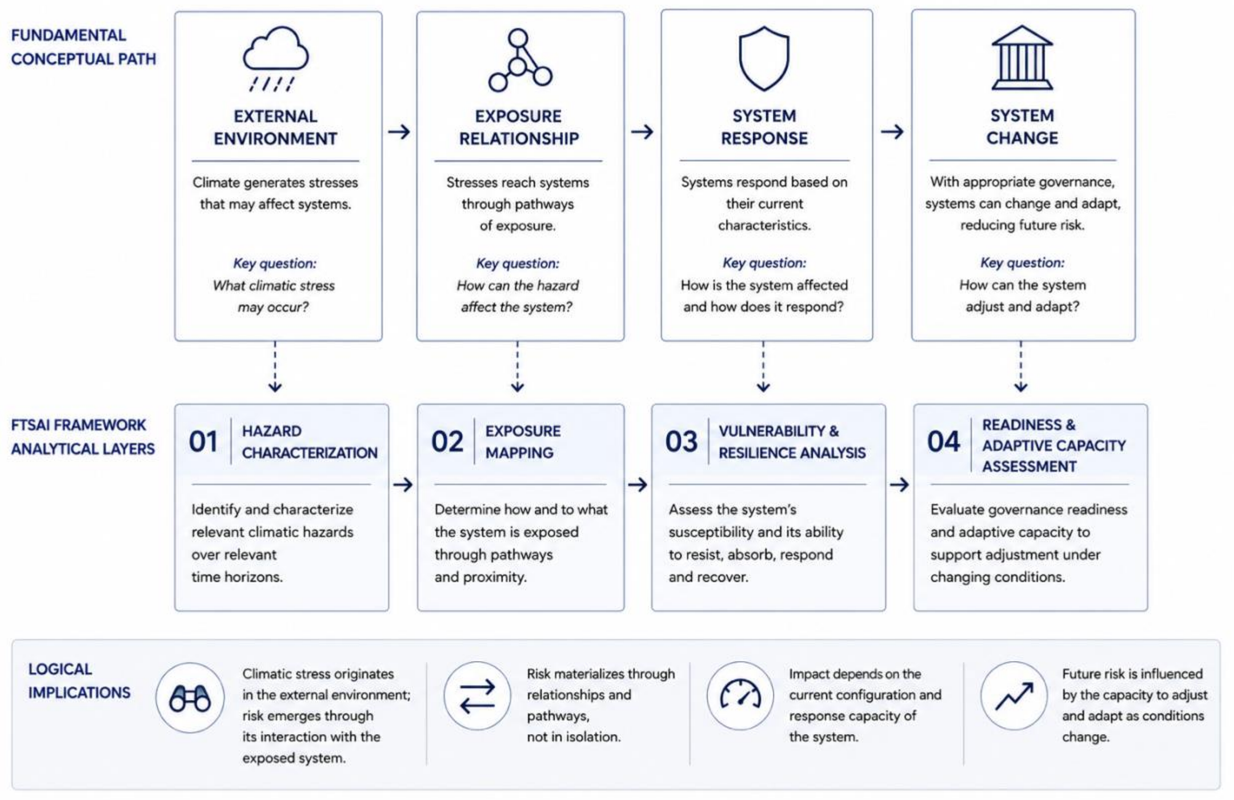

Figure 4. Conceptual derivation of the four-layer analytical architecture of the FTSAI Climate Risk Assessment Framework.

6. Assessment Architecture

Building on the methodological principles established in Section 4 and the logical derivation developed in Section 5, the **FTSAI Climate Risk Assessment Framework** operationalizes climate risk assessment through a modular and hierarchical four-layer architecture. Each layer addresses a distinct analytical question while remaining connected to the evidence and outputs generated by the preceding layers. The resulting architecture and the cross-cutting considerations that apply throughout the assessment process are summarized in Figure 5.

Layer 1 – Hazard Characterisation

Identifies and characterises the **climate- and weather-related hazards** relevant to the assessment, establishing the external environmental conditions under which climate risk may emerge.

Layer 2 – Exposure Mapping

Identifies the assets, activities, production systems, operational dependencies, and value-chain relationships through which identified hazards may become relevant to the assessed entity.

Layer 3 – Vulnerability and Resilience Analysis

Examines the characteristics that determine susceptibility to disruption and the existing capacity of the system to absorb stress, maintain critical functions, and recover.

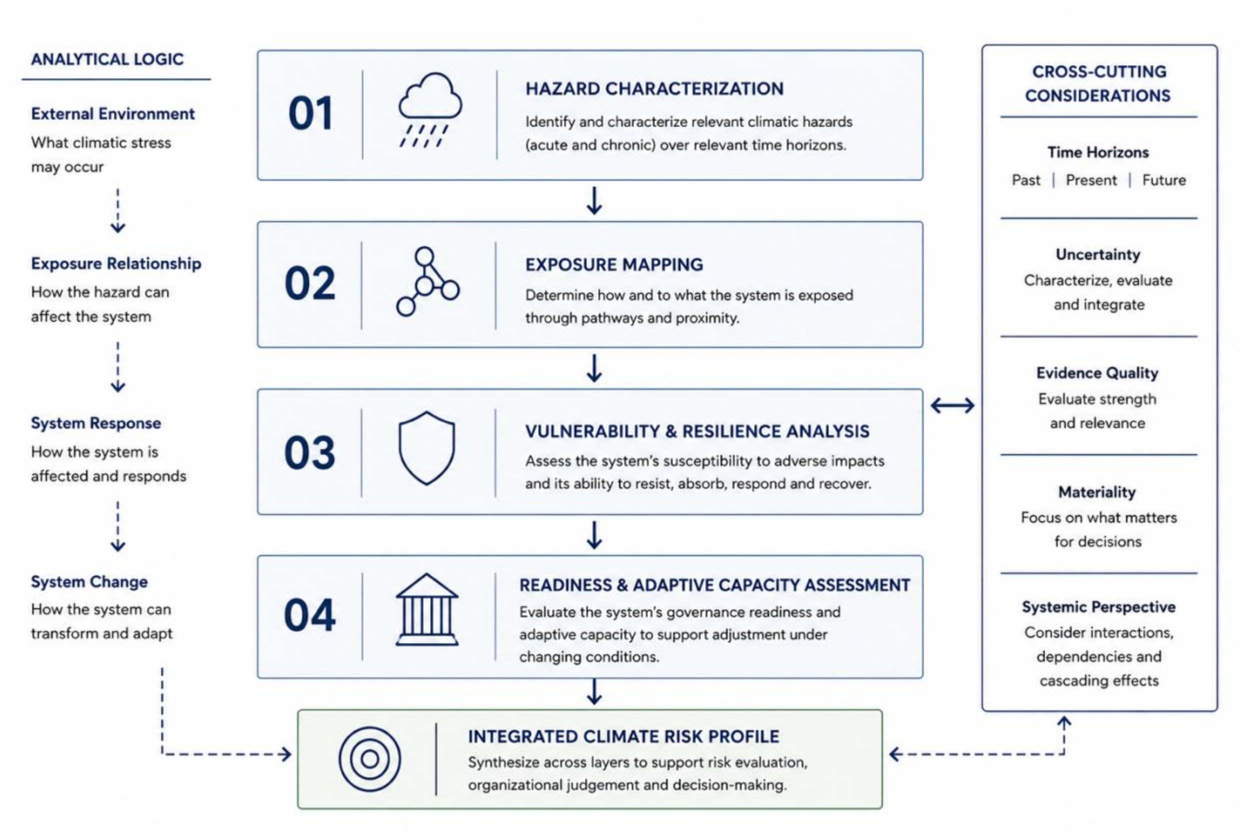

Figure 5. Analytical architecture of the FTSAI Climate Risk Assessment Framework, showing the directional relationship between the four assessment layers, the cross-cutting considerations applied throughout the assessment process, and their integration into the climate risk profile.

Layer 4 – Readiness and Adaptive Capacity Assessment

Examines the governance and organisational capabilities through which climate-risk knowledge is translated into action and through which future exposure, vulnerability, or resilience may be deliberately modified.

Consistent with **Analytical Separation** (M1), the four layers remain analytically distinct without constituting independent assessments. Their directional relationship preserves the evidentiary dependencies through which the climate risk profile is progressively constructed.

Consistent with **Methodological Stability and Controlled Evolution** (M9), each analytical layer is implemented through predefined assessment modules that may be configured according to sectoral relevance, organisational scale, and assessment purpose without altering the core **methodological architecture**. Flexibility is therefore achieved through controlled modular implementation rather than conceptual modification.

The Framework is accompanied by a controlled scoring methodology designed to support consistency across applications while preserving the analytical distinctions established by the **assessment architecture**. The scoring methodology defines the principles governing evidence evaluation, indicator interpretation, aggregation constraints, classification logic, and longitudinal comparison.

The specific calibration parameters, weighting structures, threshold values, and implementation specifications are maintained under controlled methodological governance because their validity depends upon empirical testing, sectoral calibration, and version-controlled revision. Controlled status does not imply absence of methodological transparency. **The governing principles, analytical relationships, interpretation rules, and conditions of application remain part of the official Framework methodology**, while **detailed calibration elements may be disclosed to authorised**

parties where required for implementation, independent verification, conformity assessment, validation, or audit.

This architecture is designed to support a wide range of downstream applications including risk reporting, investment analysis, insurance underwriting, public policy and certification readiness, while maintaining a single methodological logic across all implementation contexts.

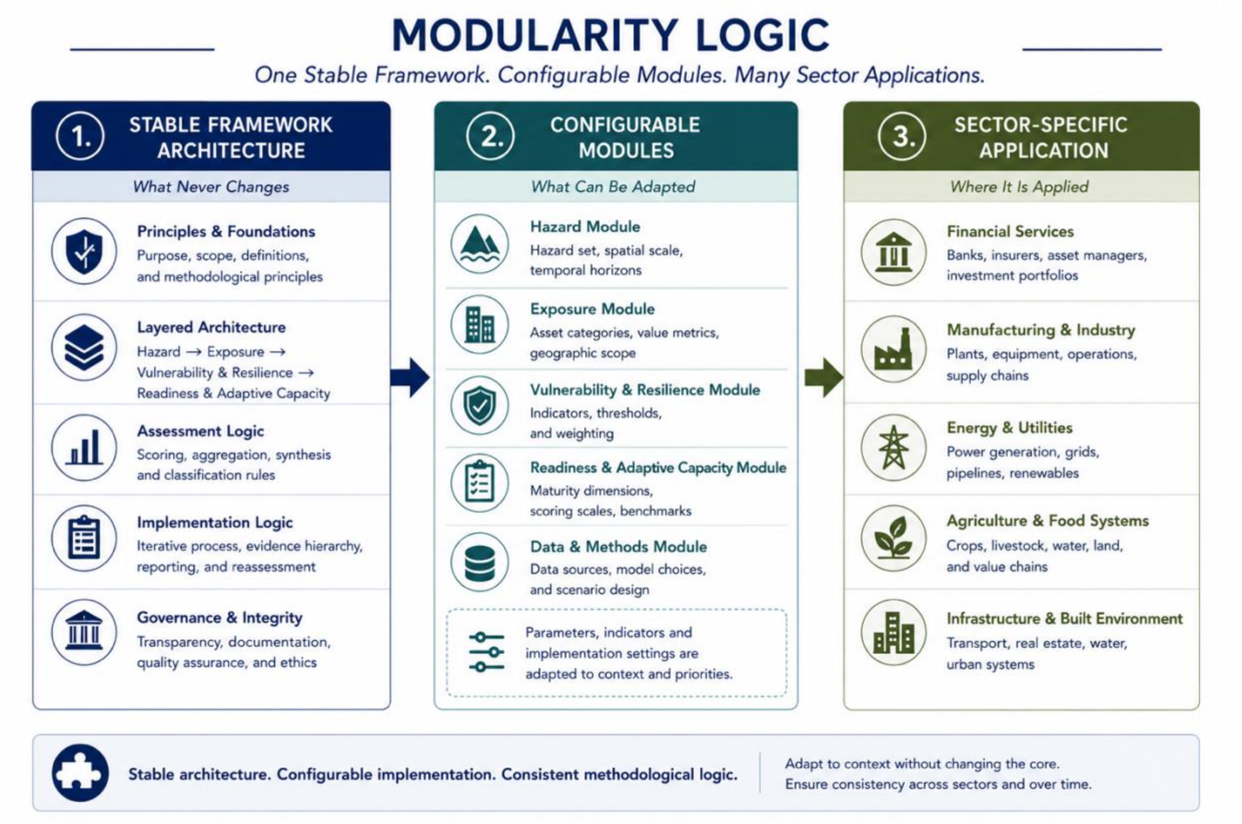

Figure 6. Modularity logic of the FTSAI Climate Risk Assessment Framework, distinguishing the stable methodological architecture from configurable assessment modules and sector-specific implementation.

7. Certification Readiness Logic

The **FTSAI Climate Risk Assessment Framework** maintains a strict institutional separation between assessment, certification readiness, and certification. Certification readiness within the Framework refers to readiness for independent external examination, assurance, conformity assessment, or other formal evaluation processes where climate-risk evidence, organisational capabilities, and methodological consistency must be demonstrated. Its purpose is to establish the conditions under which an organisation has developed the methodological, substantive, and evidentiary foundations necessary for such independent examination. It does not certify organisations, approve governance systems, or issue statements of conformity.

This separation preserves both scientific integrity and institutional independence. Assessment determines whether climate-related risks have been identified, interpreted, and integrated into organisational decision-making through a methodologically credible process. Certification is a separate conformity assessment function performed by an independent competent body under the requirements of the applicable certification scheme and conformity assessment standards (ISO 17065, 2012). Certification readiness therefore represents neither certification nor a favourable climate-risk assessment; it identifies whether the methodological, substantive, and evidentiary conditions required for subsequent independent examination have been established.

Within the Framework, certification readiness does not follow automatically from the completion of the assessment process. A methodologically complete assessment may reveal substantial weaknesses in governance, resilience, or adaptive capacity, just as an organisation may possess relevant capabilities that have not been demonstrated through sufficiently robust and traceable evidence. Certification readiness must therefore be distinguished both from the quality of the assessment itself and from the climate risk profile revealed by that assessment.

The Framework treats certification readiness as the result of three distinct but interdependent conditions: methodological sufficiency, substantive readiness, and evidentiary sufficiency.

Methodological sufficiency concerns the integrity of the assessment process. It requires the relevant components of the Framework to have been applied consistently, using appropriate data, transparent assumptions, coherent analytical procedures, and the prescribed relationships between assessment modules. Methodological sufficiency establishes that the resulting risk profile is a credible representation of the entity under the defined assessment scope and horizon. It does not, however, imply that the organisation is adequately prepared to manage the risks identified.

Substantive readiness concerns what the assessment reveals about the organisation itself. In contemporary sustainability and climate-governance contexts, such readiness may support multiple forms of external evaluation, including assurance of climate-related disclosures, evaluation of adaptation-related alignment, and independent examination of organisational climate-risk management capabilities. An organisation may be assessed rigorously while demonstrating significant vulnerabilities, limited resilience, weak governance arrangements, or insufficient capacity to adapt. Certification readiness therefore requires more than the methodological validity of the assessment. The assessment must also demonstrate that climate risk has been sufficiently internalized within governance, strategic planning, operational decision-making, risk management, and adaptive processes to satisfy the applicable readiness criteria established through the **Framework governance** process.

Consistent with **Evidence Traceability** (M2), evidentiary sufficiency concerns the basis upon which those conclusions can be independently examined. Capabilities of organisations cannot be inferred from stated intentions, formal policies, or undocumented practices. Evidence must be sufficiently relevant, consistent, traceable, and auditable to establish credible links between identified climate risks, organisational decisions, implemented actions, and observed or reasonably demonstrable capabilities. Evidentiary sufficiency therefore provides the bridge between internal assessment findings and subsequent independent conformity assessment.

These three conditions perform different analytical functions and should not be collapsed into a single assessment score. Methodological sufficiency establishes whether the assessment can be relied upon.

Substantive readiness establishes whether the organisation demonstrates the capabilities required by the Framework. Evidentiary sufficiency establishes whether those conclusions can withstand independent examination. Certification readiness arises only when these conditions are considered jointly, as illustrated in Figure 7.

This distinction also prevents certification readiness from being interpreted as a measure of climate risk itself. An organisation operating under conditions of substantial climate exposure may nevertheless demonstrate strong governance, resilience, adaptive capacity, and evidentiary discipline. Conversely, an organisation currently facing relatively limited climate exposure may demonstrate weak governance, insufficient adaptive capability, or inadequate evidence. Certification readiness therefore does not indicate that climate risk is low, nor does a high level of climate risk necessarily preclude readiness. It indicates that the organisation has assessed its climate risk through a methodologically credible process, has demonstrated the substantive organisational capabilities required by the Framework, and can support those conclusions through evidence suitable for independent examination.

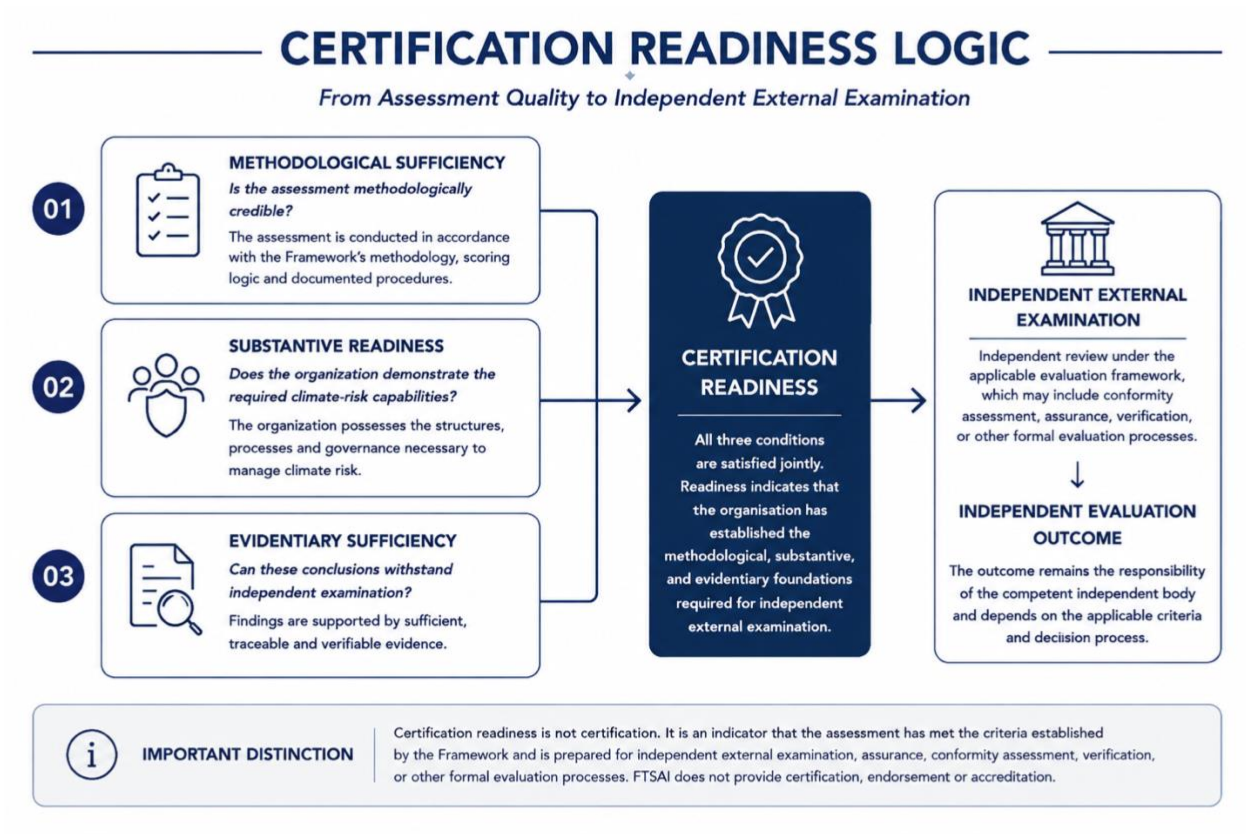

Figure 7. Certification readiness logic based on methodological sufficiency, substantive readiness, and evidentiary sufficiency.

Certification readiness can therefore be understood as an intermediate methodological state between assessment and certification:

Climate Risk Assessment → Methodological Sufficiency + Substantive Readiness + Evidentiary Sufficiency → Certification Readiness → Independent Conformity Assessment → Certification Decision

The sequence does not imply that certification or any other favourable external conclusion is the inevitable outcome of certification readiness. Certification readiness establishes that the organisation has reached the methodological, substantive, and evidentiary condition necessary to undergo independent external examination. The nature and outcome of such examination remain the responsibility of the competent independent body and depend upon the applicable evaluation framework, criteria, and decision process. Any subsequent certification process remains institutionally distinct and shall be conducted under the requirements of the applicable certification scheme and relevant conformity assessment standards. Where certification is undertaken by a body operating under ISO/IEC 17065, the applicable requirements of that standard and the corresponding certification scheme shall govern the conformity assessment process.

Independent conformity assessment therefore remains subject to the applicable requirements concerning competence, impartiality, verification, professional judgement, and governance of the responsible certification body.

Where certification or conformity assessment relies upon controlled FTSAI scoring specifications, weighting structures, thresholds, or aggregation rules, the applicable contractual or scheme arrangements shall provide the responsible independent body with access to all methodological information necessary for verification, audit, validation, and conformity assessment. Such access shall constitute a condition of the certification arrangement rather than a discretionary disclosure determined on a case-by-case basis.

Accordingly, the determination of certification readiness under the Framework shall never be interpreted as endorsement, approval, accreditation, or certification by FTSAI. Responsibility for audit execution, conformity assessment, certification decisions, and certificate issuance remains exclusively with the independent bodies authorized to perform those functions. The Framework provides the methodology; it does not exercise the authority of certification.

The purpose of certification readiness is therefore not to predict or guarantee the outcome of any subsequent certification, assurance, or conformity assessment process. Its purpose is to establish whether the organisation has developed the methodological discipline, organisational capabilities, and evidentiary foundation necessary to undergo such independent examination.

8. Governance and Versioning

Consistent with **Methodological Stability and Controlled Evolution** (M9), governance of the **FTSAI Climate Risk Assessment Framework** is intended to preserve methodological continuity while enabling systematic scientific development. Governance concerns the formal identity, content, and versioning of the **official Framework**; it does not restrict independent scientific criticism, reinterpretation, empirical testing, or methodological extension.

Accordingly, FTSAI retains responsibility for the formal methodological identity of the **official Framework**. This responsibility includes:

- the specification of core concepts and assessment principles in official releases;
- the introduction, modification, or retirement of official assessment modules;
- the development and revision of official scoring methodologies, thresholds, and aggregation logic;
- the release, identification, classification, and formal designation of Framework versions.

To ensure traceability and methodological consistency, the Framework operates under a formal versioning system. Each official release is uniquely identified, dated and documented, and supersedes all previous versions unless explicit transitional provisions are provided. Consequently, new assessments and certification readiness evaluations shall use the latest officially released version unless formally documented transitional provisions specify otherwise.

Scientific criticism, reinterpretation, empirical testing, methodological extension, and the development of alternative approaches remain unrestricted. Such work may inform future official releases but does not become part of the **FTSAI Framework** unless incorporated through its formal governance and versioning process. No modified, extended, or independently developed methodology may therefore be represented as an official version of the **FTSAI Climate Risk Assessment Framework**.

Where appropriate, FTSAI may establish formally documented transitional arrangements between successive versions to preserve continuity in ongoing assessments, certification readiness evaluations, or related implementation activities while maintaining transparency and comparability across versions.

For reasons of methodological traceability, every application of or reference to the official **FTSAI Framework** shall explicitly identify the applicable version. Modified, extended, obsolete, or partially adapted methodologies may refer to the **FTSAI Framework** where appropriate, but shall not be represented as applications of the current official methodology unless they satisfy the requirements of the applicable official version.

9. Use, Attribution and Licensing Principles

The **FTSAI Climate Risk Assessment Framework** is intended to support scholarly inquiry, empirical application, and responsible professional use. Different forms of use, however, create different requirements for attribution, methodological traceability, and authorisation. Scholarly examination, citation, criticism, comparison, independent empirical testing, and the development of modified or extended methodologies do not require authorisation, provided that the **FTSAI Framework** is appropriately attributed and that modifications, extensions, or departures from the published methodology are clearly identified.

Independent methodologies may build upon or refer to the **FTSAI Framework** without being regarded as implementations of the **official Framework**. Such work should distinguish clearly between elements derived from FTSAI and methodological choices introduced by the researcher, organisation, or practitioner responsible for the subsequent work. This distinction enables scientific development of the methodology while preserving clarity about what constitutes the published **FTSAI Framework**.

Authorisation or licensing may apply where the FTSAI name, identity, official documentation, controlled methodological specifications, or associated implementation materials are used in commercial assessment services, certification or assurance schemes, formal professional offerings, training programmes, analytical platforms, or other applications explicitly represented as implementations of the official **FTSAI Climate Risk Assessment Framework**. Such arrangements govern the use and representation of official FTSAI materials and identity; they do not restrict independent use of the underlying scientific concepts, analytical principles, or methodological ideas. Their purpose is to preserve methodological traceability, consistency of official implementations, and appropriate use of the FTSAI identity rather than to restrict independent scientific or professional inquiry.

Where authorisation is granted for an official implementation, the applicable terms may specify the version of the Framework being implemented, the scope and purpose of its use, relevant documentation requirements, and conditions governing representation of the implementation as FTSAI-based or FTSAI-authorized. Authorisation to implement the **official Framework** does not imply endorsement of conclusions reached by an implementing organisation unless such endorsement is expressly provided.

Any application that modifies, extends, adapts, or selectively uses elements of the Framework remains free to describe its intellectual relationship to FTSAI with appropriate attribution, but should not represent the resulting methodology as the official **FTSAI Climate Risk Assessment Framework** or imply FTSAI authorisation or endorsement where none has been granted.

Where an **Implementation Companion** accompanies the Framework, it serves as operational guidance for applying the published methodology. The Companion does not alter the conceptual or methodological propositions established in the Framework and should be interpreted in conjunction with the version of the Framework to which it relates.

The practical value of the Framework lies in transforming fragmented climate-related information into a structured organisational understanding of climate risk. Through the systematic examination of hazards, exposure pathways, vulnerability, resilience, readiness, and adaptive capacity, the Framework enables organisations to identify where climate-related pressures may become consequential, understand the structural characteristics influencing their response, and evaluate whether existing governance arrangements support effective adaptation. The resulting assessment does not provide an automated decision outcome or replace organisational judgement. Instead, it provides a traceable analytical basis through which strategic decisions, investment priorities, risk management processes, and adaptation actions can be examined and improved.

Part I

Methodological Foundations of Climate Risk Assessment

1. Climate Risk as a Systemic Risk Construct

A fundamental proposition underpins the **FTSAI Climate Risk Assessment Framework**: **climate hazards are physical, but climate risk is systemic**. Although these concepts are frequently treated as interchangeable, they describe fundamentally different phenomena. Hazards originate in climatic processes. Risk emerges only when those processes interact with economic systems, organisational structures, institutional arrangements, and human decision-making. The distinction is not semantic. It defines the conceptual foundation upon which the entire Framework is built.

Traditional approaches to climate risk assessment often begin with the hazard itself. They detect climate events, estimate the likelihood of them occurring, and attempt to measure their possible impacts. Such approaches provide valuable information about the physical environment, but they explain only part of the phenomenon. Climatic hazards exist independently of the organisations, communities, or economies they affect. Climate risk does not. It exists only where hazards encounter systems capable of transmitting, absorbing, amplifying, or mitigating their consequences.

The **FTSAI Climate Risk Assessment Framework** therefore does not redefine climate risk. It begins from the proposition that **climate risk is inherently systemic**. **The methodological architecture of the Framework is not an arbitrary analytical choice but the logical consequence of this proposition**. If risk emerges from the interaction between climatic processes and complex socio-economic systems, then its assessment must necessarily extend beyond the characterisation of hazards themselves.

From this perspective, climate risk is understood as an **emergent property** arising from the continuous interaction between climatic dynamics, economic structures, institutional arrangements, organisational characteristics, governance mechanisms, and the decisions taken by individuals and institutions over time. None of these elements possesses independent explanatory power. **Risk emerges only through their interaction**.

This distinction has important methodological consequences. Two organisations may experience identical climatic conditions yet exhibit fundamentally different levels of climate risk. Likewise, two regions exposed to similar hazards may experience entirely different economic and operational consequences. These differences cannot be explained by the hazard alone. They arise from differences in exposure, vulnerability, resilience, governance quality, and adaptive capacity. Understanding climate risk therefore requires understanding the systems through which climatic disturbances propagate.

Accordingly, the Framework adopts a systems-based analytical perspective. Rather than examining climate hazards as isolated events, it investigates the mechanisms through which disturbances travel across production systems, value chains, financial arrangements, institutional structures, governance mechanisms, and territorial networks. Climate risk is therefore interpreted not as a linear sequence of causes and effects but as the behaviour of an interconnected system whose properties cannot be understood by analysing its individual components in isolation.

Consistent with **Analytical Separation** (M1), systemic climate risk cannot be inferred from any single component of the risk system. Severe climatic hazards do not necessarily generate severe organisational risk where exposure is limited or response capabilities are strong, while comparatively moderate hazards may produce disproportionate consequences where structural vulnerability, critical dependencies, or governance weaknesses amplify their effects. Assessment must therefore preserve the distinct explanatory roles of the conditions through which climate risk emerges before integrating them into an overall interpretation.

Systemic climate risk is also temporally dynamic. Delayed effects, cumulative impacts, non-linear escalation, path dependency, and long-lived organisational decisions mean that risk profiles evolve rather than remain fixed. The temporal implications of this proposition are developed in the Foundations, particularly in the discussion of temporal horizons and non-linearity.

Climate risk is additionally partly endogenous to organisational decision-making. Exposure, vulnerability, resilience, and adaptive capacity evolve through managerial choices, governance arrangements, investment, technological change, institutional learning, and public policy. The implications of endogenous risk formation are developed in the Foundations, particularly in the discussion of decision-making, governance, and endogenous risk formation.

This systemic perspective changes the purpose of climate risk assessment. Assessment cannot be confined to estimating the probability of adverse climatic events or projecting future losses; it must also explain how organisational and socio-economic systems generate resilience or fragility and how decisions alter those conditions through time. The **FTSAI Climate Risk Assessment Framework** therefore integrates physical hazards with exposure, system characteristics, governance, and adaptive decision-making to provide a coherent basis for interpreting climate risk across heterogeneous organisational, sectoral, and territorial contexts.

2. Distinction between Climate Risk and Weather Risk in Assessment Practice

One of the most persistent sources of methodological confusion in contemporary risk assessment is the tendency to treat **weather risk** and **climate risk** as interchangeable concepts. Although closely related, they describe fundamentally different phenomena and operate over different temporal, analytical, and decision-making horizons. Failing to distinguish between them does not merely introduce conceptual ambiguity; it alters the entire logic of risk assessment and frequently leads to inappropriate governance, investment, and policy responses.

The distinction begins with the nature of the phenomena themselves. **Weather** describes the short-term state of the atmosphere and the variability associated with meteorological conditions. **Climate**, by contrast, describes the long-term evolution of those conditions and the structural patterns through which they influence natural and socio-economic systems. Consequently, weather events may trigger losses, but climate change progressively reshapes the conditions under which those losses become more, or less, likely.

This distinction has direct implications for the concept of risk. Weather risk refers to the operational consequences arising from short-term meteorological variability. The phenomenon is usually characterised by events, such as heatwaves, droughts, floods or extreme precipitation, that have direct and visible consequences. But climate risk is more than simply a function of weather event accumulation. It indicates the gradual development of risk profiles through the interaction of climate trends, economic structures, organisational characteristics, institutional contexts and governance decisions over extended periods.

The FTSAI Climate Risk Assessment Framework therefore treats weather risk not as an independent analytical construct but as one observable manifestation within a broader climate risk trajectory. Individual weather events are important because they reveal how systems respond to stress. They do not, by themselves, explain why some organisations remain resilient while others experience systemic disruption under similar physical conditions. That explanation lies in the interaction between exposure, vulnerability, resilience, governance, and adaptive capacity.

Confusing weather risk with climate risk has important methodological consequences. Assessment becomes dominated by the measurement of discrete events, historical losses, and short-term operational disruptions. While such information remains valuable, it encourages reactive approaches centred on compensation, emergency response, or immediate recovery. It provides only limited insight into the structural processes through which risk accumulates, evolves, and ultimately threatens the long-term sustainability of organisations and economic systems.

For this reason, the Framework adopts a dual analytical perspective. **Weather risk provides information about the immediate manifestation of climatic disturbances**. **Climate risk explains how those disturbances acquire strategic significance through time**. **The two concepts are therefore neither substitutes nor competing perspectives. They represent different levels of analysis within the same systemic process.**

In assessment practice, this distinction separates immediate operational sensitivity from longer-term systemic sustainability. Weather-risk analysis primarily informs business continuity, emergency preparedness, and short-term response, whereas climate-risk assessment examines how exposure, resilience, governance, investment choices, and adaptive capacity shape the evolving risk trajectory of the assessed system.

Consistent with **Analytical Separation** (M1), weather-related indicators enter the assessment primarily through **Hazard Characterisation**, where they provide empirical evidence concerning current and historical climatic disturbances. Climate risk, however, cannot be inferred from those observations alone; it emerges only when hazard information is interpreted in relation to exposure, vulnerability, resilience, governance, and adaptive capacity. Weather information therefore constitutes an input to climate-risk assessment rather than its final object.

By preserving the distinction between weather risk and climate risk without separating them analytically, the Framework avoids two methodological errors: reducing climate risk to a sequence of isolated weather events and treating it as an abstract construct disconnected from observable climatic disturbances. Weather provides observable manifestations of climatic stress; climate-risk assessment explains their significance within the evolving system.

3. Temporal Horizons and Non-Linearity in Climate Risk Assessment

Time does not simply extend climate risk; it changes the mechanisms through which climate risk evolves. The factors that explain short-term disruption are not necessarily those that determine long-term vulnerability, just as the decisions that appear inconsequential today may fundamentally shape future resilience. Climate risk is therefore not merely a phenomenon observed over time. Its very nature changes as the assessment horizon expands.

This proposition has important methodological implications. If the dominant drivers of climate risk evolve through time, then risk assessment cannot rely on static assumptions or single-period analysis. A methodology that accurately describes present conditions may nevertheless provide a misleading representation of future risk because the mechanisms governing that risk may themselves change. The **FTSAI Climate Risk Assessment Framework** therefore treats **time not as an external parameter added to the analysis but as an intrinsic dimension of the assessment process itself**.

The distinction between **short-**, **medium-**, and **long-term horizons** is introduced for this reason. It does not represent a convenient subdivision of time, nor does it imply that the same risk is simply observed at different moments. Instead, it reflects the proposition that different mechanisms progressively dominate the evolution of climate risk. Short-term assessment primarily reflects immediate system sensitivity to weather variability and acute disturbances. As the assessment horizon expands, cumulative processes, changing exposure, adaptation decisions, and structural constraints become progressively more important relative to isolated events. Over longer horizons, assessment therefore shifts from evaluating disruption towards evaluating structural change itself.

This change redefines the role of assessment. Short-term analysis focuses on how systems respond to sudden shocks. Medium-term analysis evaluates how repeated disturbances, adaptation decisions, and changing exposure gradually reshape system behaviour. Long-term analysis asks a different question altogether: whether the underlying structure of the system remains viable under evolving climatic conditions. **The assessment therefore evolves from measuring operational performance to evaluating strategic sustainability**.

Time also introduces a second defining characteristic of climate risk: non-linearity. Climatic change does not translate into organisational risk through necessarily smooth or proportional relationships. Complex systems may retain function across repeated disturbances while underlying resilience is progressively eroded, and relatively small additional stresses may produce disproportionately large consequences once critical thresholds are crossed. Such behaviour is consistent with established resilience theory, in which persistence, thresholds, and shifts between alternative system states are central to understanding system response under disturbance (Holling, 1973; IPCC, 2022). Apparent stability may therefore conceal accumulating structural fragility long before failure becomes observable.

Closely associated with non-linearity is the concept of **path dependency**. Climate risk is determined not only by future climatic conditions but also by the sequence of decisions that shapes the future range of available choices. Every significant decision concerning infrastructure, production technologies, financing structures, governance arrangements, or land use modifies the system's future capacity to adapt. Some decisions expand future flexibility; others progressively constrain it. Climate risk therefore reflects not only the evolution of climatic conditions but also the evolution of strategic options. This interpretation is consistent with established accounts of path dependence and technological or institutional lock-in, in which earlier choices alter the feasible set of subsequent choices and may generate persistent trajectories that become increasingly costly to reverse (Arthur, 1989; Unruh, 2000).

For this reason, the Framework does not attempt simply to extrapolate today's risk profile into the future. Its objective is to identify the mechanisms capable of changing the behaviour of the system itself. Structural sensitivities, tipping points, reinforcing feedback loops, and amplification mechanisms are examined not because they increase risk incrementally, but because they may fundamentally alter the trajectory through which risk develops. **The central analytical question is therefore not whether climate risk increases, but whether the system begins to behave differently**.

This perspective also changes the way assets and organisational structures are evaluated. Long-lived infrastructure, irreversible environmental interventions, highly specialized production systems, and rigid institutional arrangements are not assessed solely according to their present performance. They are evaluated according to their capacity to remain functional under uncertain future conditions and their ability to preserve strategic flexibility as climate risk evolves.

Temporal analysis within the Framework is implemented through horizon-specific indicators combined with scenario-informed evaluation. The objective is not to predict precise future outcomes or estimate losses with artificial precision. Rather, it is to understand how alternative but plausible future conditions influence the evolution of exposure, vulnerability, resilience, governance capacity, and ultimately climate risk itself.

The temporal perspective also changes the interpretation of assessment results. A favourable short-term risk profile cannot be interpreted as evidence of long-term resilience, just as present stability does not necessarily imply future robustness. In many cases, the most significant climate risks remain invisible when viewed over short observational periods because structural fragility accumulates gradually before becoming suddenly apparent.

By incorporating temporal horizons, non-linearity, and path dependency into its methodological core, the Framework treats climate risk as an evolving systemic phenomenon rather than a static extension of present conditions. Temporal assessment therefore seeks to identify not only how risk may change, but when the mechanisms governing system behaviour may themselves change.

4. Decision-Making, Governance, and Endogenous Risk Formation

Climate risk is often presented as an external force acting upon organisations, productive systems, and economies. This perspective, although widespread, captures only part of the phenomenon. **Climatic hazards originate outside the organisation, but a substantial part of climate risk is generated within it**. The decisions organisations make regarding investment, governance, production, financing, technology, and adaptation continuously shape their future exposure, vulnerability, and resilience. **Climate risk is therefore not merely experienced; it is progressively created, transformed, and, in many cases, amplified by the organisations themselves**.

This proposition fundamentally changes the purpose of climate risk assessment. If organisations actively participate in the formation of their own risk profiles, then assessment cannot be limited to measuring external hazards. It also must examine the internal processes through which strategic decisions affect the development of risk over time. The **FTSAI Climate Risk Assessment Framework** therefore treats **governance and decision-making not as contextual variables but as intrinsic components of climate risk itself**.

The distinction is important. Two organisations operating under identical climatic conditions may ultimately face very different levels of climate risk. The difference often lies not in the external environment but in the quality of the decisions that preceded the climatic event. Choices concerning infrastructure, production methods, financing structures, insurance coverage, technological investment, land use, and organisational design progressively determine how future hazards will be experienced when they eventually materialize.

Governance provides the institutional mechanism through which these decisions are made. It determines how information is collected, how responsibilities are allocated, how uncertainty is interpreted, and how corrective actions are implemented. Climate governance therefore cannot be evaluated simply by the existence of committees, policies, or reporting structures. Its value lies in its power to affect decisions before the danger is apparent.

Climate uncertainty makes decision making even more challenging. Organisations rarely have complete information on future climatic conditions. Strategic decisions have long investment horizons, uncertain technological developments and competing organisational priorities. Short planning horizons, fragmented accountability, institutional inertia, and incentives favouring immediate performance may gradually increase future vulnerability without producing visible short-term warning signals. Organisational adaptation research similarly emphasizes that adaptation emerges through organisational learning, institutional routines, and decision processes rather than through exposure to environmental change alone (Berkhout et al., 2006). **One of the defining characteristics of endogenous climate risk is precisely this delayed relationship between present decisions and future consequences**.

For this reason, the Framework evaluates governance as an active process rather than as a formal organisational attribute. Indicators related to strategic oversight, risk ownership, monitoring practices, organisational learning, adaptive capacity, and response effectiveness are integrated directly into the **assessment architecture** because they influence the future trajectory of climate risk rather than merely describing the present state of governance.

This perspective also explains why the Framework distinguishes between formal compliance and effective governance. Organisations may comply with reporting requirements, create governance structures, and generate climate-related documentation without materially diminishing their future climate risk. **The decisive question is not whether governance mechanisms exist, but whether they**

consistently translate climate risk awareness into timely, proportionate, and strategically coherent decisions.

Viewing climate risk as an endogenous phenomenon also changes the interpretation of assessment outcomes. Risk profiles should never be regarded as fixed organisational characteristics. They evolve continuously because organisations themselves evolve. Governance reforms, technological innovation, investment decisions, organisational learning, and institutional adaptation may all alter future exposure, vulnerability, resilience, and ultimately climate risk. **Assessment must therefore examine not only the organisation's current risk configuration, but also the decision processes through which that configuration may be reproduced, amplified, or transformed over time.**

Analytical Structure and Assessment Modules

1. Modular Design Principles

Every assessment methodology eventually encounters the same methodological dilemma. If it is designed to be universally applicable, it gradually loses sensitivity to the diversity of sectors, organisations, and operating environments in which it is expected to function. If, on the other hand, it is extensively customized for each application, it progressively loses comparability, methodological consistency, and scientific credibility. A robust assessment methodology must therefore achieve two objectives that appear, at first sight, to be mutually incompatible: **it must remain conceptually stable while being operationally adaptable**.

The **FTSAI Climate Risk Assessment Framework** addresses this dilemma through a **modular analytical architecture**. Modularity is not adopted as a matter of technical convenience or software design. It represents the methodological mechanism through which a single conceptual framework can be applied across heterogeneous contexts without sacrificing analytical consistency. **The Framework itself remains unchanged; only its implementation varies according to the characteristics of the entity being assessed**.

Consistent with **Analytical Separation** (M1), each module performs a distinct analytical function within the **assessment architecture**. The objective is not simply to divide the assessment into smaller components, but to preserve conceptual clarity throughout the methodology. Analytical modules derive their value not from the number of issues they address but from the precision with which they address one specific dimension of climate risk. Once a module attempts to explain several dimensions simultaneously, its analytical boundaries become uncertain and its contribution to the overall assessment becomes progressively more difficult to interpret.

To preserve this methodological discipline, module design follows five operational requirements.

Purpose Specificity

Each module is designed to answer one clearly defined analytical question. A single analytical objective per module avoids conceptual overlap, limits ambiguity in interpretation, and keeps the contribution of each module to the overall assessment explicit.

Input Transparency

Consistent with **Evidence Traceability** (M2), every module relies on explicitly identified qualitative and quantitative inputs. Data sources, expert judgement, proxy indicators, observational evidence, assumptions, and material interpretive choices shall be documented sufficiently to preserve traceability, reproducibility, auditability, and independent examination of assessment outcomes.

Scoring Coherence

Individual modules may employ different indicators, measurement scales, or decision thresholds according to their analytical purpose. Such variation shall remain consistent with the Framework's common scoring logic and with the requirements of **Non-Compensatory Interpretation** (M3) and Uncertainty Preservation (M4). Consistency therefore does not require identical scoring structures across modules; it requires that different structures remain methodologically compatible with the principles governing interpretation and aggregation.

Inter-Module Compatibility

Modules shall complement rather than duplicate or compete with one another. Information generated within one module may provide essential inputs for another, yet each retains an independent analytical purpose within the overall **assessment architecture**. The analytical integrity of the Framework therefore emerges from the interaction of specialized modules rather than from duplication of analytical functions.

Version Control and Extensibility

Consistent with **Methodological Stability and Controlled Evolution** (M9), the modular architecture permits individual modules to be refined, expanded, or replaced without requiring reconstruction of the Framework itself, provided that such changes preserve the methodological invariants of the applicable Framework version. Methodological evolution can therefore occur incrementally while maintaining traceability, conceptual continuity, and, where appropriate, comparability across applications and versions.

This modular philosophy also changes the meaning of adaptability. **Sectoral diversity does not require multiple climate risk methodologies. It requires multiple implementations of the same methodology**. The distinction is fundamental. The conceptual architecture of the Framework remains identical regardless of the sector under assessment. Adaptation occurs through the selection, configuration, and parameterization of modules rather than through modification of the methodology itself.

Methodological consistency and operational flexibility can therefore coexist because they operate at different levels. Consistency is preserved through the Framework's methodological invariants and analytical architecture, while flexibility is achieved through controlled module configuration and implementation. Modularity consequently provides the mechanism through which the Framework can accommodate heterogeneous sectors, organisations, and assessment contexts without requiring methodological fragmentation.

2. Hazard Characterisation Modules

Hazard Characterisation Modules constitute the entry point of the analytical process within the **FTSAI Climate Risk Assessment Framework**. Their purpose is to establish a structured understanding of the climatic environment within which the assessed entity operates. **They do not determine climate risk, nor do they estimate the consequences of climatic events. Instead, they define the external conditions under which climate risk may subsequently emerge during the assessment process**.

The modules identify and characterise the climate and weather hazards relevant to the assessed entity by considering its geographical location, climatic regime, operational characteristics, and assessment horizon. Both acute and chronic hazards are considered, including, where appropriate, temperature extremes, precipitation variability, drought conditions, flooding, coastal hazards, wildfires, and compound climatic events.

The outputs produced by the **Hazard Characterisation** Modules provide the contextual basis for all subsequent stages of the Framework. They establish the **hazard landscape within which exposure**, **vulnerability**, **resilience**, **readiness**, and **adaptive capacity** are subsequently evaluated, without predetermining either the level or significance of climate risk.

Accordingly, the **Hazard Characterisation** Modules produce:

- a structured inventory of climate and weather hazards relevant to the assessed entity;
- a qualitative characterisation of hazard dynamics;
- horizon-specific indicators describing the relevance of identified hazards.

These outputs are subsequently integrated into the downstream assessment modules, where their interaction with organisational and systemic characteristics contributes to the overall climate risk assessment.

2.1 Analytical Purpose and Role within the Framework

Consistent with **Analytical Separation** (M1), **hazard characterisation** establishes the external environmental conditions relevant to the assessment without assigning climate-risk levels or organisational consequences. Climatic hazards originate largely outside the assessed entity, whereas climate risk emerges through their interaction with exposure, vulnerability, resilience, readiness, and adaptive capacity. **Hazard characterisation** therefore defines the external stress environment within which subsequent analytical modules operate rather than predetermining their conclusions.

For this reason, the objective of **hazard characterisation** is not the prediction of individual climatic events. The Framework does not attempt to forecast precisely when a drought, flood, heatwave, or severe storm will occur. Instead, it seeks to establish a structured understanding of the hazard environment within which the assessed entity operates. Emphasis is therefore placed on **relevance rather than prediction** and on **contextual understanding rather than probabilistic estimation**.

This methodological perspective distinguishes the Framework from approaches centred primarily on probabilistic hazard modelling. Such approaches play an important role in **catastrophe modelling, actuarial analysis, and probabilistic hazard assessment** because they estimate the likelihood and magnitude of specific events. **Hazard characterisation** within the Framework serves a different purpose. It establishes the boundary conditions under which climate risk may develop rather than estimating the probability that individual hazards will occur.

The significance of a hazard is inherently relational. A relatively infrequent climatic event may become strategically significant where exposure is concentrated, vulnerability is structurally embedded, or adaptive capacity is limited, while frequently occurring hazards may have limited systemic consequences where exposure is controlled and response capabilities are strong. Hazards are therefore interpreted as potential sources of stress rather than direct measures of climate risk.

The **Hazard Characterisation** Modules consequently establish the stress landscape within which subsequent modules determine what is exposed, how susceptible the system is to disruption, what response capabilities exist, and whether organisational decisions can alter the resulting risk trajectory. Hazard characterisation initiates the analytical sequence, but climate risk emerges only through integration across the Framework.

Hazard characterisation does not end with the identification of relevant climate and weather hazards. Once hazards have been identified, a second methodological question immediately arises: how should they be organised so that they can be interpreted consistently throughout the assessment process? A simple inventory of hazards provides information about the external environment, but it does not explain how different hazards contribute to the formation of climate risk. An analytical structure is therefore required before hazards can be compared, interpreted, or integrated into subsequent stages of the Framework.

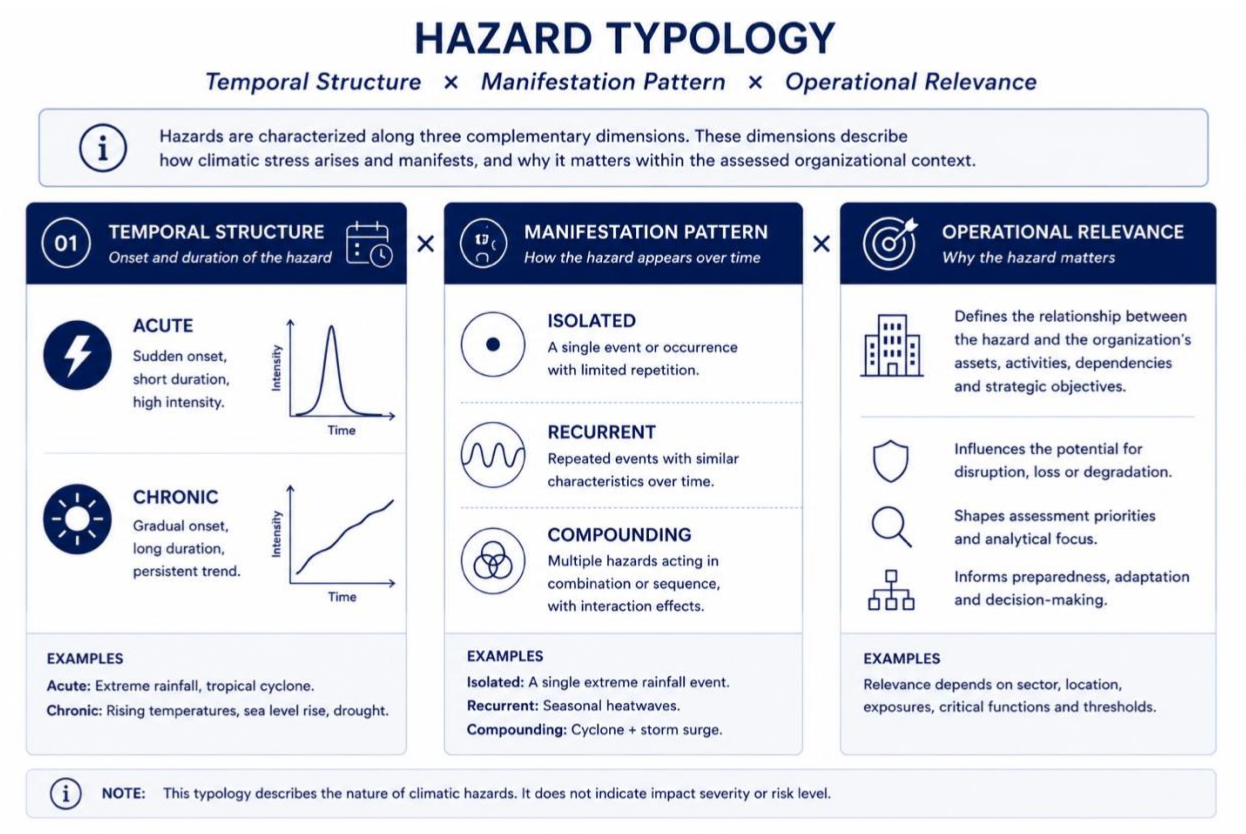

Figure 8. Hazard typology across temporal structure, manifestation pattern, and operational relevance.

That structure cannot rely on a single classification criterion. Climate hazards differ not only in their physical characteristics but also in the mechanisms through which they influence organisations and socio-economic systems. A typology based exclusively on meteorological characteristics would overlook the temporal behaviour of hazards. A classification based solely on temporal behaviour would ignore the ways in which hazards interact. Equally, a typology centred only on physical intensity would provide little insight into the operational significance of climatic disturbances. No single analytical dimension is therefore sufficient to characterise the role of hazards within systemic climate risk.

For this reason, the **FTSAI Climate Risk Assessment Framework** adopts a **multidimensional hazard typology**. The objective is not to produce a more detailed catalogue of climatic phenomena but to establish a consistent analytical structure through which hazards can be interpreted across different sectors, organisations, and assessment contexts. The typology reflects the different mechanisms through which hazards contribute to climate risk rather than differences in their physical description alone, as summarized in Figure 8.

Temporal Structure

The first analytical distinction arises from time. Climate hazards do not influence organisations through identical temporal mechanisms. Some challenge systems through discrete events whose consequences become apparent over relatively short periods. **Others progressively alter the environmental conditions under which organisations operate, changing exposure, vulnerability, and adaptive needs over extended periods.**

The Framework therefore distinguishes between **acute** and **chronic hazards**. Acute hazards include events such as heatwaves, frost episodes, storms, floods, and extreme precipitation. Chronic hazards describe gradual processes, including sustained temperature increases, changing precipitation regimes, progressive aridity, sea-level rise, and long-term environmental degradation. **The distinction is not**

introduced to separate short-term from long-term phenomena as such. It reflects the recognition that different temporal processes generate different pathways through which climate risk develops.

Manifestation Pattern

Temporal behaviour alone does not explain how hazards influence complex systems. Hazards may produce very different consequences depending on the way they occur and interact. Some appear as isolated events with limited interaction effects. Others expose systems repeatedly to similar stresses, allowing vulnerability to accumulate over time. Still others interact with additional climatic disturbances, creating combined effects that cannot be understood by analysing each hazard independently.

The Framework therefore distinguishes between **isolated**, **recurrent**, and **compounding hazards**. This distinction is not intended to describe frequency alone but to capture different mechanisms of systemic stress accumulation. Compounding hazards receive explicit methodological attention because interacting climatic drivers and hazards may generate consequences that differ materially from those inferred by examining each component independently, making compound events an important potential source of underestimated systemic risk (IPCC, 2022; Zscheischler et al., 2018).

Operational Relevance

Neither temporal behaviour nor manifestation dynamics fully determine the analytical importance of a hazard. Ultimately, a climatic disturbance becomes significant only when it interferes with the functioning of the assessed system. **Hazard characterisation** must therefore extend beyond physical description to consider operational context.

For this reason, the Framework evaluates hazards according to their **operational relevance**. The same climatic event may be largely inconsequential for one organisation while critically disrupting another because of differences in production processes, seasonal timing, technological dependence, supply-chain configuration, or organisational structure. **Operational relevance does not itself constitute exposure assessment**. It identifies whether a hazard warrants consideration within the defined assessment context; the pathways through which that hazard encounters assets, activities, dependencies, or value chains are examined separately within **Exposure Mapping**.

Taken together, these three analytical dimensions provide a coherent methodological structure for **hazard characterisation**. They enable hazards to be interpreted consistently without reducing them to a single classification criterion and without sacrificing sensitivity to sectoral or organisational context.

Hazard typology within the Framework is analytical rather than evaluative. Classification does not rank hazard importance or severity; it establishes a common structure through which temporal behaviour, manifestation patterns, and operational relevance can inform subsequent assessment modules without being mistaken for climate-risk conclusions.

2.2 Evidence Typology and Evidentiary Coherence

Hazard characterisation is ultimately constrained by the quality and interpretation of the evidence upon which it is based. Climate and weather hazards are observed through multiple sources of information, each capturing different aspects of the physical environment and the systems affected by it. No single source, however, provides a complete representation of the hazard environment. A methodological question therefore arises before any assessment can begin: how should heterogeneous evidence be combined without compromising analytical consistency or creating a false impression of certainty?

The FTSAI Climate Risk Assessment Framework addresses this question by distinguishing between the analytical role of evidence and its perceived authority. The objective is not to establish a hierarchy in which one source systematically overrides another. Rather, it is to organize evidence according to the different forms of knowledge it contributes to **hazard characterisation**. **The robustness of an assessment therefore depends less on the authority of individual evidence than on the coherence achieved through the integration of complementary sources**.

For this reason, the Framework distinguishes between **primary**, **secondary**, and **contextual evidence**.

Primary Evidence

Primary evidence establishes the physical context within which climate hazards may emerge. It includes climatological observations, long-term environmental datasets, remotely sensed information, and regionally relevant climate analyses derived from recognised scientific sources. Such evidence provides the baseline description of climatic conditions, long-term trends, and environmental variability. Although generally quantitative, longitudinal, and spatially referenced, **its analytical value depends on its relevance to the assessed entity rather than on its spatial resolution or statistical sophistication alone**.

Secondary Evidence

Primary climatic information rarely explains how hazards influence specific sectors or operational environments. That interpretation requires additional knowledge linking climatic conditions to organisational processes and sectoral characteristics. Secondary evidence fulfils this role.

Secondary evidence includes sectoral studies, expert assessments, technical reports, modelling outputs, and proxy indicators developed for operational contexts. **Such evidence provides interpretative understanding rather than direct observation.** The evidence necessarily includes assumptions, modelling choices and domain-specific judgment; therefore, its relevance cannot be assumed to be universal or transferable across contexts.

Contextual Evidence

Even detailed scientific datasets and sectoral analyses may not capture local characteristics that affect hazard behaviour. Operational experience, historical records, observational knowledge, and practical insights available to organisations often expose system sensitivities beyond those captured in formal data sets.

The Framework therefore acknowledges **contextual evidence as a necessary part of analysis**. Local operational records, stakeholder knowledge, field observations and historical organisational experience are the basis of understanding how hazards interact with specific systems. **Such evidence is evaluated according to its internal consistency and plausibility rather than treated as independent proof of hazard conditions**.

The distinction between these three categories should not be interpreted as a ranking of evidential importance. **Hazard characterisation** does not assume that primary evidence is inherently superior to secondary evidence or that contextual evidence merely supplements scientific observations. Each category contributes different knowledge to the assessment process. Their analytical value emerges through complementarity rather than substitution.

For this reason, the Framework evaluates evidence according to its coherence rather than according to the authority of individual sources. When independent evidence categories converge toward the same interpretation, confidence in **hazard characterisation** increases. When evidence diverges, the Framework does not resolve inconsistencies by automatically privileging one source over another. Disagreement is recorded explicitly. Conflicting evidence often indicates uncertainty, structural complexity or the current limits of knowledge.

This perspective also explains why the Framework discourages reliance on single datasets, point estimates, isolated model outputs, or narrowly parameterized indicators as definitive representations of hazard conditions. Such information often reflects assumptions, boundary conditions, or modelling choices that remain invisible to downstream users. **Hazard characterisation** therefore seeks to identify plausible stress environments rather than produce deterministic descriptions of future climatic behaviour.

Evidence selection is consequently guided by relevance rather than abundance. Highly detailed datasets lacking decision relevance may contribute less to **hazard characterisation** than simpler information directly connected to the assessment context. Conversely, highly aggregated indicators may obscure local characteristics essential for understanding hazard behaviour. Every assessment therefore documents data limitations, spatial and temporal constraints, interpretative assumptions, and remaining sources of uncertainty as integral components of the analytical process.

By organizing evidence according to complementarity rather than hierarchy, the **FTSAI Climate Risk Assessment Framework** preserves methodological transparency while avoiding both false precision and arbitrary subjectivity. **Hazard characterisation** becomes more robust not because uncertainty has been eliminated, but because uncertainty itself has been explicitly incorporated into the analytical process. This disciplined treatment of evidence establishes a reliable foundation for the subsequent assessment of exposure, vulnerability, resilience, readiness, and adaptive capacity.

2.3 Spatial and Contextual Resolution

Hazard characterisation inevitably requires a decision regarding spatial scale. This decision cannot be treated as a technical detail because the way space is represented directly influences the way climate risk is interpreted. **The central methodological question is therefore not how detailed a spatial representation can become, but at what spatial scale hazards should be analysed to support meaningful decisions**.

The answer cannot be derived from the resolution of available datasets alone. Highly detailed climatic information does not necessarily produce a better assessment, just as broad regional averages do not necessarily provide an adequate representation of hazard conditions. The analytical value of spatial information depends on whether it reflects the scale at which hazards influence organisational systems and the scale at which management, investment, adaptation, and governance decisions are made.

For this reason, the **FTSAI Climate Risk Assessment Framework** adopts the principle of **contextual spatial resolution**. **Spatial resolution is determined by decision context rather than by data resolution**. The objective is not to maximize geographical detail but to represent climatic conditions at the level where they become operationally meaningful.

This distinction also explains why administrative boundaries are not automatically adopted as analytical units. Administrative regions exist primarily for legal, statistical, or governance purposes. Climate hazards, however, rarely evolve according to administrative divisions. Whenever operational systems extend beyond those boundaries, or whenever meaningful climatic variation exists within them, **hazard characterisation follows the structure of the operational system rather than the structure of administrative geography**.

Agricultural production illustrates this principle particularly well. Crop performance is frequently influenced by microclimatic variation, soil characteristics, irrigation availability, topography, and logistical accessibility that vary considerably within the same administrative region. Under such conditions, administrative boundaries remain useful for reporting purposes but do not necessarily represent the appropriate analytical units for **hazard characterisation**. The Framework therefore aligns spatial analysis with production systems rather than political or statistical divisions whenever these differ materially.

Selecting an inappropriate spatial scale introduces two different forms of analytical distortion. When spatial resolution is excessively coarse, meaningful local variation disappears, localized hazard concentrations remain undetected, and operationally important differences become obscured within regional averages. When spatial resolution becomes unnecessarily fine, the opposite problem emerges. Apparent geographical precision may exceed the reliability of the underlying evidence, creating distinctions that appear analytically meaningful but have little or no relevance for decision-making. Both forms of distortion reduce the quality of **hazard characterisation**, although they do so through different mechanisms.

Spatial variability is therefore interpreted as an analytical feature rather than as statistical noise. Differences observed across the assessed system may identify localized climatic conditions or spatial concentrations of potential stress that are relevant to subsequent exposure, vulnerability, resilience, readiness, and **adaptive capacity assessment**. Wherever such variation may materially affect downstream interpretation, it is preserved rather than removed through spatial averaging.

Consistent with Uncertainty Preservation (M4), spatial uncertainty cannot be eliminated through increasingly detailed datasets, nor can it be resolved simply by selecting a different mapping scale. It originates from data coverage, measurement density, interpolation methods, temporal inconsistency, and unavoidable mismatches between physical processes and analytical units. The methodological objective is therefore not to conceal these limitations but to make them explicit. Once spatial assumptions and their associated limitations are documented, the scope, validity, and appropriate interpretation of assessment results become transparent to subsequent users.

Once spatial resolution is linked to the scale of decision-making rather than to the scale of available data, spatial analysis assumes a different methodological role. **It ceases to be an exercise in maximizing geographical precision and becomes a disciplined representation of the spatial conditions that are genuinely relevant to climate risk formation**. Analytical rigor and practical relevance no longer compete with one another because both emerge from the same methodological principle. This approach provides a robust spatial foundation for subsequent **exposure mapping**, **vulnerability** and **resilience analysis**, and **readiness** and **adaptive capacity assessment**, while preserving full transparency regarding the assumptions upon which spatial interpretation depends.

2.4 Temporal Horizons and Horizon Interaction

Hazard characterisation requires more than identifying the climatic conditions relevant to the assessed entity. It also requires determining the temporal horizon within which those hazards are interpreted. The same climatic phenomenon may represent a transient operational disturbance over one time horizon while constituting evidence of structural environmental change over another. **Hazard characterisation must therefore specify not only what hazards are relevant but also when their significance is evaluated**.

This distinction explains why the Framework does not treat temporal horizons as independent analytical windows. **A hazard does not acquire a different identity because time passes. Rather, its analytical significance changes as the temporal perspective expands**. **Hazard characterisation** therefore examines the same hazard through multiple but interconnected temporal horizons, each revealing different mechanisms through which climatic stress influences organisational systems.

Short-Term Horizon

The short-term horizon views hazards as immediate sources of climatic stress. Weather variability, acute climatic events, and short-duration disturbances are prominent at this horizon because their operational relevance may emerge over comparatively short periods. The principal analytical objective is therefore to characterise the immediate climatic stress conditions relevant to the assessed system.

Medium-Term Horizon

Extending the temporal horizon changes the analytical perspective. The analytical significance of individual climatic events is reduced relative to that of recurring or cumulative climatic stress. Medium-term **hazard characterisation** therefore focuses on recurring climatic stresses, changing hazard patterns, and cumulative environmental conditions that may become visible only when climatic disturbances are interpreted as repeated processes rather than isolated events. These patterns provide temporal context for subsequent assessment of how repeated climatic stress may affect exposure, vulnerability, resilience, readiness, and adaptive capacity.

Long-Term Horizon

At longer temporal horizons, **hazard characterisation** undergoes a further conceptual shift. Climatic hazards are no longer interpreted primarily as individual disturbances but as indicators of **structural environmental transformation**. **Persistent changes in climatic regimes, resource conditions, and relevant ecosystem processes become the dominant analytical concern.** The objective is no longer to understand immediate disruption but to examine how changing environmental conditions may progressively redefine the operating environment itself.

Considering these horizons separately, however, remains insufficient. Climatic processes frequently interact across time, allowing conditions observed within one horizon to influence hazard behaviour in another. Long-term climate trends may change the frequency, intensity, duration or operational significance of acute weather events. Conversely, recurrent short-term climatic disturbances may accumulate over time, creating patterns of stress whose significance cannot be understood from individual events alone. **Hazard characterisation** must therefore consider not only individual temporal horizons but also the interactions linking them.

These interactions are important because processes operating at different temporal scales may reinforce or modify one another. Ignoring them may produce **hazard characterisations** that accurately describe individual climatic phenomena while failing to represent the evolving stress environment relevant to downstream climate-risk assessment.

The Framework therefore treats horizon interaction as an integral component of **hazard characterisation**. The objective is not to analyse each temporal horizon independently but to understand how climatic hazards and stress conditions evolve across time and how processes operating over different horizons establish the temporal context for subsequent assessment modules.

Selecting appropriate temporal horizons also requires methodological discipline. Horizons are determined according to the purpose of the assessment, the characteristics of the assessed entity, the expected lifetime of relevant assets, and the decision context within which assessment results will be used. Horizons that are too narrow may overlook gradual structural change, whereas excessively distant horizons may introduce assumptions that cannot be meaningfully supported by available evidence. Appropriate temporal framing therefore depends on analytical relevance rather than on maximizing temporal coverage.

Consistent with Uncertainty Preservation (M4), long-term uncertainty forms an inherent component of **hazard characterisation**. The Framework does not attempt to predict specific future climatic conditions or deterministic hazard trajectories. Instead, it examines plausible patterns of climatic stress and considers how hazard behaviour may evolve under alternative future conditions. These insights establish the temporal foundation upon which subsequent **exposure mapping**, **vulnerability and resilience analysis**, and **readiness and adaptive capacity assessment** build.

2.5 Typical Failure Modes in Hazard Characterisation

Every analytical methodology is defined not only by the procedures it prescribes but also by the errors it seeks to prevent. **Hazard characterisation** is no exception. Because it represents the first analytical stage of the **FTSAI Climate Risk Assessment Framework**, methodological mistakes introduced at this point inevitably propagate throughout all subsequent stages of the assessment. **Understanding these failure modes is therefore not a matter of good practice but a prerequisite for preserving the internal logic of the Framework**.

Consistent with **Analytical Separation** (M1), a common feature of most methodological failures is that **hazard characterisation** is asked to answer questions that belong elsewhere in the assessment process. Hazards are expected to explain risk before exposure has been analysed, **vulnerability and resilience** have been examined, or **readiness and adaptive capacity** have been assessed. Once this analytical sequence is disrupted, **hazard characterisation** gradually ceases to describe the external stress environment and begins to embed conclusions that have not yet been justified.

One manifestation of this problem is **hazard absolutism**. Climatic hazards are interpreted as inherently risky because they appear physically severe, occur frequently, or are associated with extreme meteorological conditions. This interpretation assumes that hazards possess intrinsic levels of risk independently of the systems they affect. The Framework rejects this assumption. **Hazards describe potential sources of climatic stress. Climate risk emerges only through the interaction of hazards with exposure, vulnerability, resilience, readiness, and adaptive capacity.** Treating hazards as direct measures of risk therefore confuses two analytically distinct concepts.

A different form of methodological distortion arises through **historical anchoring**. Historical observations provide valuable evidence regarding climatic conditions and past hazard behaviour. They cannot, however, be assumed to define future hazard environments automatically. Climatic baselines, hazard frequencies, intensities, durations, and interaction patterns may change over time. Historical evidence therefore contributes important context, but it cannot serve as the sole reference point for forward-looking **hazard characterisation**.

Another failure occurs when **indicators replace analysis**. Composite indices, proxy variables, and simplified indicators often provide useful summaries of complex climatic information. Their convenience, however, may encourage their use as substitutes for structured **hazard characterisation** itself. The Framework distinguishes clearly between indicators and analysis. **Indicators support interpretation; they do not replace the analytical reasoning through which hazard conditions are identified and understood**.

Methodological problems also arise when apparent analytical precision exceeds the reliability of available evidence. Increasing numerical detail, finer spatial resolution, or highly specific temporal estimates may create an impression of scientific without improving analytical validity. Consistent with Uncertainty Preservation (M4), the Framework treats false precision as a methodological risk in its own right. The objective of **hazard characterisation** is not to maximize numerical refinement but to represent climatic stress conditions at a level of detail justified by the available evidence and relevant to the decisions the assessment is intended to support.

A further source of distortion appears when hazards are interpreted within a single temporal perspective. Focusing exclusively on short-term weather events obscures the structural influence of long-term climatic change. Concentrating only on long-term trends may equally overlook the operational significance of immediate climatic disturbances. **Hazard characterisation** therefore examines interactions across temporal horizons rather than treating each horizon as an independent analytical window.

Perhaps the most significant methodological failure arises when **hazard characterisation** attempts to produce risk scores or establish priorities before the remaining analytical stages have been completed. At that point, the distinction between **hazard characterisation** and climate risk assessment effectively disappears. Exposure, vulnerability, resilience, readiness, and adaptive capacity are no longer allowed to influence the assessment because conclusions have already been embedded at its earliest stage. The Framework explicitly prevents this form of **premature synthesis** by maintaining strict **analytical separation** between **hazard characterisation** and subsequent stages of climate risk evaluation.

Taken together, these failure modes illustrate a common methodological principle. **Hazard characterisation** should establish the conditions under which climate risk may emerge, but it should never anticipate the conclusions of the assessment itself. Every safeguard incorporated into the Framework serves this single objective: preserving the analytical sequence through which climate risk is progressively constructed rather than prematurely assumed. Only by maintaining this discipline can **hazard characterisation** provide a reliable foundation for subsequent **exposure mapping**, **vulnerability**

and resilience analysis, **readiness and adaptive capacity assessment**, and ultimately the integrated interpretation of climate risk.

2.6 Interpretation Boundaries and Interface with Downstream Modules

Consistent with **Analytical Separation** (M1), every analytical stage within the **FTSAI Climate Risk Assessment Framework** is designed to answer a specific methodological question. The reliability of the overall assessment depends not only on the quality of the analysis performed within each module but also on the discipline with which the analytical boundaries between modules are maintained. Once a module begins to answer questions assigned to subsequent stages of the Framework, methodological consistency is progressively lost, and the interpretation of assessment results becomes increasingly ambiguous.

The interpretation boundary of **hazard characterisation** follows directly from its analytical purpose. Hazard outputs describe the climatic stress environment relevant to the assessed entity by identifying relevant hazards, characterising their temporal and spatial behaviour, and documenting the environmental conditions under which they may become operationally significant. They do not determine climate risk, evaluate organisational consequences, estimate losses, assign overall risk classifications, or substitute for the downstream assessment modules through which the significance of climatic stress is subsequently established.

The same reasoning determines the role of quantification within **hazard characterisation**. Numerical representation is not excluded from the Framework; it is introduced only when it becomes analytically meaningful. During **hazard characterisation**, quantitative information serves to describe climatic conditions and support structured classification. Consistent with Interpretive Boundedness (M5), aggregation, scoring, prioritisation, and comparative evaluation shall not extend hazard outputs beyond the analytical meaning supported by the evidence and scope of **hazard characterisation**. **Quantification therefore follows analytical understanding rather than preceding it.**

Maintaining these boundaries defines the interface between **hazard characterisation** and downstream assessment modules. Hazard outputs provide the environmental context against which exposure is mapped and establish the climatic stress conditions relevant to subsequent **vulnerability and resilience analysis** and **readiness and adaptive capacity assessment**. Each downstream module therefore builds upon **hazard characterisation** while introducing analytical information that hazard outputs themselves do not contain.

The dependency between assessment modules is directional at the analytical level. **Hazard characterisation** establishes evidence concerning the external stress environment; downstream modules progressively add evidence concerning exposure, system response, and organisational capacity for change. The analytical sequence is therefore directional, but the system being assessed is not. The ordering of modules reflects epistemic dependency rather than a claim of linear causality. Climate-risk systems remain recursive and adaptive: organisational decisions may alter exposure, adaptive actions may modify **vulnerability and resilience**, and experience of disruption may reshape subsequent governance and organisational behaviour. Directionality governs how evidence is constructed during assessment; it does not constrain the causal relationships operating within the assessed system.

Interpretation boundaries therefore preserve the epistemic structure of the Framework. Each module answers a distinct analytical question, contributes evidence required by subsequent stages, and remains bounded by the meaning that its outputs can legitimately support. **Hazard characterisation** consequently provides the environmental foundation of the assessment without assuming the analytical functions assigned to downstream modules.

2.7 Implications for Certification and Downstream Use

Once **Hazard Characterisation** has been completed, a further methodological question arises. How should its outputs be used? The answer is not self-evident. Information describing climatic hazards may support a wide range of downstream decisions, yet the existence of analytical value does not imply decision authority. **The Framework therefore distinguishes carefully between information that informs decisions and information that determines them**.

In certification-readiness contexts, **Hazard Characterisation** provides the environmental reference context against which subsequent assessment findings are interpreted. It does not establish certification readiness, determine the adequacy of organisational capabilities, or support a certification decision independently of the remaining analytical layers. Its role is to define the climatic stress environment to which the organisation must demonstrate an appropriate and sufficiently evidenced response. Certification readiness and any subsequent conformity assessment remain governed by the distinct methodological and institutional conditions established in the Framework's Certification Readiness Logic.

The same principle applies to other downstream applications. Financial institutions, insurers, policymakers, infrastructure operators, and strategic planners may derive important information from **Hazard Characterisation**, but hazard outputs remain contextual inputs rather than autonomous decision criteria. Their decision relevance depends upon their integration with the downstream analytical dimensions required by the specific application.

Accordingly, **Hazard Characterisation** shall not be used as a stand-alone proxy for climate risk or as an autonomous basis for exclusion, prioritisation, certification, or other consequential decisions. Such uses assign decision authority to outputs that were designed to describe climatic stress conditions rather than determine their organisational significance. Where hazard information is used for preliminary screening, the resulting conclusions shall remain explicitly bounded by that limited purpose and shall not be represented as climate-risk assessment conclusions.

The distinction between analytical support and decision authority also enables the responsible reuse of **Hazard Characterisation** outputs across multiple applications without altering their methodological meaning. Because these outputs remain bounded by their defined analytical purpose, they may inform different decision processes provided that their provenance, assessment scope, temporal horizon, evidentiary limitations, and applicable Framework version remain traceable.

Hazard Characterisation therefore informs downstream decisions without determining them. Its outputs acquire decision relevance through integration with subsequent analytical layers and remain subject to the **interpretation boundaries** established by the Framework. This preserves their methodological meaning while allowing them to support certification readiness, financial analysis, insurance, public policy, infrastructure planning, and strategic decision-making.

2.8 Summary of Methodological Position

The purpose of **Hazard Characterisation** within the **FTSAI Climate Risk Assessment Framework** is not to determine climate risk but to establish the analytical conditions under which climate risk can subsequently be understood. It provides a disciplined description of the climatic stress environment while remaining bounded by the analytical question assigned to the first layer of the Framework.

This methodological position follows directly from the systemic conception of climate risk adopted by the Framework. Because climate risk emerges through the interaction between hazards, exposure, vulnerability, resilience, readiness, and adaptive capacity, **Hazard Characterisation** contributes one essential component to the assessment without anticipating conclusions that depend upon downstream analytical stages.

The methodological discipline established throughout this Part is reflected in four requirements: hazards are interpreted within appropriate temporal and spatial contexts; evidence is integrated through coherence rather than hierarchical substitution; classification serves analytical understanding rather than prioritisation; and **interpretation boundaries** prevent premature synthesis or the assignment of decision authority to hazard outputs.

Hazard Characterisation is therefore contextual rather than evaluative. Its value lies in ensuring that subsequent **exposure mapping**, **vulnerability** and **resilience analysis**, and **readiness and adaptive capacity assessment** are grounded in a transparent, coherent, and methodologically consistent understanding of the climatic environment.

This position also explains the broad applicability of the Framework. Because **Hazard Characterisation** remains independent of sector-specific performance measures, certification criteria, financial objectives, or policy priorities, it can be applied consistently across heterogeneous organisational and geographical contexts without altering the methodological principles governing the first analytical layer.

Hazard Characterisation consequently provides the structured environmental context within which climate risk assessment becomes possible, but it does not constitute climate risk assessment itself. Preserving this distinction supports analytical traceability, methodological consistency, and responsible downstream use.

3. Exposure Mapping Modules

Overview

The identification of climate hazards does not, by itself, explain how those hazards may affect an assessed entity. **A climatic stressor can exist without producing material consequences if no meaningful pathway connects it to the activities, assets, or processes of the system under consideration**. Once the hazard environment has been established, the next methodological question therefore becomes unavoidable: **through which pathways can identified hazards reach the assessed system?**

Consistent with **Analytical Separation** (M1), the **Exposure Mapping Modules** identify and structure the relationships through which identified climatic hazards may become relevant to the assessed system without evaluating the consequences of those relationships. Exposure is therefore relational rather than consequential: it describes how assets, activities, processes, resources, dependencies, or value chains are positioned in relation to climatic hazards, but does not itself imply damage, susceptibility, vulnerability, or organisational loss.

Exposure is examined across multiple but complementary dimensions. Physical exposure reflects the geographical relationship between hazards and fixed or mobile assets. Operational exposure considers the timing and organisation of activities that may coincide with hazardous conditions. Economic and systemic exposure extend the analysis beyond direct physical assets to include supply chains, resource dependencies, critical services, and interconnected operational processes through which climatic disturbances may become relevant indirectly.

Because these dimensions describe different pathways through which hazards may influence the assessed entity, no single representation of exposure is sufficient. **Exposure mapping** therefore seeks to construct a structured representation of the multiple channels through which climatic stress may enter the system rather than reducing exposure to a single numerical indicator or geographical description.

The outputs of the **Exposure Mapping** Modules remain descriptive at this analytical stage. They identify exposure profiles across relevant assets, activities, dependencies, and value-chain relationships; reveal concentrations of exposure and potential single points of dependency; and distinguish between concentrated, diversified, and redundant exposure structures. These outputs characterise how identified hazards intersect with the assessed system without determining the consequences of that interaction.

Exposure Mapping therefore performs a distinct methodological function within the Framework. **Hazard Characterisation** defines the external stress environment; **Exposure Mapping** establishes the relationships through which that environment becomes relevant to the assessed entity. Only after those relationships have been identified can subsequent modules examine susceptibility to disruption, response capability, and organisational capacity for change. **Exposure Mapping** consequently constitutes the analytical bridge between the external climatic environment and the internal characteristics through which climate risk ultimately emerges.

Exposure Mapping Modules - Extended Methodological Specification

3.1 Conceptual Positioning of Exposure within Climate Risk Assessment

Consistent with **Analytical Separation** (M1), exposure occupies a distinct conceptual position between the identification of climatic hazards and the assessment of system response. **Hazard Characterisation** establishes the external stress environment, but an additional analytical condition is required before that environment becomes relevant to a particular entity: a relationship must exist through which climatic stress can encounter the assessed system.

This requirement explains the conceptual role of exposure within the **FTSAI Climate Risk Assessment Framework**. Exposure is therefore not interpreted as an inherent property of an asset, activity, or geographical location, nor can it be inferred directly from the existence of a climatic hazard. It arises when a relevant relationship exists between an identified hazard and the configuration or operation of the assessed system. Exposure is consequently relational: it describes how climatic stress may encounter assets, activities, processes, resources, dependencies, or value chains rather than a characteristic possessed independently by any of those elements.

Viewing exposure as a relationship rather than as an attribute prevents two important methodological errors. The first is **hazard determinism**, whereby the mere presence of climatic hazards is assumed to imply exposure without examining how organisational systems interact with those hazards. Such reasoning overlooks the fact that identical climatic conditions may generate fundamentally different exposure profiles because assets, operations, and decision processes are organised differently. The second is **asset reductionism**, whereby exposure is interpreted solely in terms of the physical location of assets while ignoring operational dependencies, organisational processes, and indirect pathways through which climatic stress may become relevant.

Once these limitations are recognised, the analytical objective of **exposure mapping** becomes clear. The purpose is not to catalogue assets or to describe organisational structures independently of climate hazards. It is to identify the interfaces through which hazards and system components may interact. These interfaces represent the relationships through which climatic stress becomes relevant to the assessed system and may be physical, spatial, temporal, operational, functional, economic, or dependency-based in nature.

Understanding exposure in terms of interfaces also explains why exposure cannot be regarded as a static condition. Organisational systems evolve continuously through changes in operating practices, production schedules, technologies, infrastructure configurations, sourcing arrangements, and external dependencies. As these changes occur, the interfaces connecting hazards with the system may also change, even where neither the hazards themselves nor the underlying assets have materially altered. Exposure is therefore inherently dynamic because it reflects changing relationships rather than fixed characteristics.

The same reasoning extends beyond direct physical interaction. Climatic hazards may become relevant to organisations through indirect pathways that are not visible when geographical proximity is treated as the sole indicator of exposure. Supply chains, logistics networks, energy systems, labour dependencies, critical suppliers, communication infrastructure, and market connectivity may create exposure relationships even where the assessed organisation has no direct physical contact with the hazard. **Exposure Mapping** therefore incorporates both direct and indirect pathways while leaving the consequences associated with those pathways to subsequent analytical stages.

Maintaining this relational interpretation also preserves the analytical distinction between exposure and vulnerability. **Exposure describes the existence of relevant relationships or pathways; vulnerability and resilience examine how the system is likely to behave when climatic stress operates through**

those relationships. High exposure does not inevitably imply severe organisational consequences, just as limited exposure does not by itself imply low climate risk. Confusing these concepts would collapse two analytically distinct stages of the Framework and obscure the mechanisms through which climate risk is progressively formed.

The conceptual position of **Exposure Mapping** therefore follows directly from the systemic architecture of the Framework. **Hazard Characterisation** establishes the external stress environment; **Exposure Mapping** identifies the relationships through which that environment becomes relevant to the assessed entity; **Vulnerability and Resilience Analysis** examines system behaviour under the resulting climatic stress; and **Readiness and Adaptive Capacity Assessment** examines whether the organisation can deliberately alter its future risk configuration. **Exposure Mapping** thus provides the analytical bridge between external climatic conditions and system-specific response while preserving the distinct explanatory function of each assessment layer.

3.2 Dimensions of Exposure Analysis

The **FTSAI Climate Risk Assessment Framework** therefore analyses exposure through three complementary dimensions: **spatial**, **temporal**, and **functional exposure**. These dimensions do not represent alternative classifications of the same phenomenon. Rather, they describe different pathways through which climatic stress may become connected to assets, activities, processes, and value chains. None is sufficient on its own because each captures only one aspect of the relationship between hazards and organisational systems. **Exposure emerges from their combined interpretation rather than from any individual dimension considered in isolation**.

Spatial Exposure

Spatial exposure concerns the geographical relationships through which climatic hazards may become relevant to the assessed system. It examines how the location and spatial configuration of assets, infrastructure, resources, and supporting facilities create interfaces between climatic conditions and organisational activity.

This analysis extends well beyond geographical coordinates. Spatial configuration determines whether critical assets are concentrated or dispersed, whether essential infrastructure is connected through vulnerable corridors, and whether environmental thresholds coincide with operationally significant locations. In agricultural systems, for example, spatial exposure includes not only cultivated land but also irrigation networks, water resources, storage facilities, processing infrastructure, transport routes, and supporting services whose geographical organisation shapes the spatial structure of exposure.

Spatial exposure therefore identifies where hazard–system interfaces exist. It does not determine whether those interfaces will ultimately generate significant disruption. **Geographical proximity alone cannot establish climate risk unless the remaining dimensions of exposure and the downstream characteristics of the system are also considered**.

Temporal Exposure

Geographical coincidence alone is insufficient to describe exposure. The relevance of climatic stress may also depend on its temporal relationship with organisational activities, production cycles, asset use, maintenance schedules, service delivery, and other time-dependent processes. Exposure therefore possesses an essential temporal dimension.

Temporal exposure examines the relationship between hazard occurrence and the timing of operational activities, production cycles, maintenance schedules, service delivery, and other time-dependent organisational processes. **What matters is not simply how often hazards occur but whether they coincide with periods during which relevant organisational activities, assets, or processes are active or operationally significant.**

Agricultural production illustrates this principle clearly. The exposure relevance of a frost event depends strongly on its timing relative to crop development, with the same physical event representing a different exposure condition during flowering, fruit formation, or harvest than during less time-critical stages. Similarly, prolonged climatic stress may create cumulative temporal exposure across successive stages of a production cycle even where no individual event is exceptional. Temporal exposure therefore evaluates alignment, duration, sequence, and operational timing rather than frequency alone.

Functional Exposure

Even when hazards neither coincide geographically nor temporally with critical assets, climatic stress may still reach the organisation through functional relationships. Modern production systems depend upon complex networks of suppliers, infrastructure, logistics, labour, information systems, financial services, utilities, and market connections. These dependencies may create exposure relationships that extend beyond the organisation's own physical locations and assets.

Functional exposure therefore examines the dependency relationships through which climatic hazards may become relevant to organisational activity even without direct geographical contact. The analytical objective is to identify dependencies on suppliers, infrastructure, utilities, logistics, labour, information systems, financial services, and other external or internal functions whose operation connects the assessed entity to hazard-affected systems. At this stage, the existence and structure of those dependencies are mapped without determining the severity of the consequences that may arise if they are disrupted.

Functional exposure is important because it can reveal **indirect pathways of climate risk formation** that are not visible if exposure is understood in geographical terms only.

Taken together, the three dimensions describe complementary relationships rather than competing explanations of exposure. Spatial exposure identifies where relevant hazard–system relationships exist. Temporal exposure identifies when those relationships become relevant within organisational or production processes. Functional exposure identifies the dependencies through which exposure may extend beyond direct physical relationships. Their combined interpretation provides a multidimensional representation of exposure consistent with the systemic conception of climate risk adopted by the Framework.

For this reason, exposure analysis remains descriptive throughout this stage of the assessment. The objective is to identify interaction pathways rather than evaluate their consequences. Judgements regarding vulnerability, resilience, readiness, adaptive capacity, and ultimately climate risk remain the responsibility of subsequent analytical modules. **Exposure Mapping therefore establishes the relational architecture upon which those later assessments will build without anticipating their conclusions**.

3.3 Direct and Indirect Exposure Pathways

Exposure mapping seeks to identify the pathways through which identified climatic hazards become capable of influencing an assessed system. Once these pathways are examined, an important methodological limitation immediately becomes apparent. **Not all pathways are directly observable**. Some connect hazards with organisational systems through immediate physical interaction, whereas others operate through dependencies distributed across processes, infrastructures, institutions, or value chains. Restricting exposure analysis to immediately visible interactions would therefore provide only a partial representation of how climatic stress reaches the assessed entity.

This observation explains why the **FTSAI Climate Risk Assessment Framework** distinguishes between **direct and indirect exposure pathways**. The distinction does not separate primary from secondary forms of exposure, nor does it imply different levels of analytical importance. It recognises that climatic stress propagates through fundamentally different mechanisms, each of which must be represented if exposure is to be understood as a systemic relationship rather than as a purely physical condition.

Direct Exposure Pathways

The most immediately recognizable exposure pathways arise through direct interaction between identified hazards and the components of the assessed system. Climatic stress affects assets, activities, or operational processes without requiring intermediate transmission mechanisms. This kind of exposure includes crops that are susceptible to extreme temperatures, facilities in floodplain zones or infrastructure directly impacted by extreme weather events. Such pathways are generally identifiable through their geographical and temporal correspondence with the hazards previously characterised.

Direct exposure, however, should not be confused with complete exposure. The visibility of these pathways makes them comparatively easy to identify, but visibility alone does not determine their overall contribution to climate risk.

Indirect Exposure Pathways

Once direct interactions have been identified, an additional question remains. **Can climatic stress influence organisational systems without direct physical contact?** In an increasingly interconnected economic and organisational world, the answer is often yes.

Hazards may interfere with energy supplies, disrupt transportation networks, reduce labour availability, constrain access to critical inputs, interrupt digital infrastructure, or affect suppliers and markets far beyond the geographical boundaries of the assessed entity. Climatic disturbances therefore travel along functional connections that tie organisational systems together across space, time, and institutional form. Often such indirect pathways are responsible for disruptions which cannot be explained by direct physical exposure alone.

Because indirect exposure comes about through interdependent dependencies, its behaviour is generally very different to that of direct exposure. Transmission may be delayed, spatially displaced, cumulative, or amplified as disruption propagates across successive organisational interfaces. A single climatic event may therefore generate consequences far removed from the original point of hazard occurrence, producing cascading effects that remain invisible when exposure is interpreted exclusively in geographical terms.

Recognizing these mechanisms fundamentally changes the purpose of **exposure mapping**. **The objective is no longer limited to identifying where hazards physically intersect with assets. It becomes the identification of all meaningful pathways through which climatic stress may enter and propagate throughout the assessed system**. Direct and indirect pathways are therefore examined within a unified analytical structure because both describe complementary mechanisms through which the same hazards influence organisational performance.

For this reason, the Framework does not assign analytical priority to either category. In some organisations, direct exposure represents the dominant pathway through which climatic stress materializes. In others, indirect dependencies embedded within supply chains, infrastructure networks, institutional arrangements, or market relationships become the principal sources of disruption despite relatively limited direct physical exposure. Their relative significance can only be understood within the broader context of the assessed system.

The distinction between direct and indirect exposure therefore serves a methodological rather than a classificatory purpose. It ensures that **exposure mapping** captures the complete architecture of hazard–system interaction rather than only its most visible components. By preserving both categories within a single conceptual framework, the **FTSAI Climate Risk Assessment Framework** provides a more comprehensive representation of exposure and establishes a robust foundation for the vulnerability, resilience, and governance analyses that follow.

3.4 Exposure Concentration, Diversification, and Redundancy

Exposure mapping establishes the pathways through which climatic hazards may reach an assessed system. While previous analysis identifies the existence and nature of direct and indirect exposure pathways, the present section examines how those pathways are structurally configured within the assessed system. Identifying those pathways, however, does not by itself reveal how exposure is distributed across the system. Two organisations may be exposed to the same hazards through comparable direct and indirect pathways while remaining structurally different in an important respect: one may depend heavily on a small number of exposed assets, locations, suppliers, or infrastructure networks, whereas the other may distribute comparable functions across multiple alternatives. **The architecture of exposure therefore depends not only on the existence of exposure pathways but also on the degree to which those pathways are concentrated, diversified, or supported by redundancy**.

Exposure concentration arises when multiple organisational functions depend upon a limited number of assets, locations, resources, suppliers, infrastructures, or other critical nodes that are exposed to the same climatic disturbance. Concentration matters because disruption at a single point may affect a disproportionately large part of the assessed system. A production system dependent upon a single water source, an organisation whose critical facilities are located within the same hazard-prone area, or a supply chain relying upon one transport corridor may exhibit substantial exposure concentration even when the number of individual assets or activities appears large.

Concentration should not therefore be interpreted solely in geographical terms. Exposure may also be concentrated functionally through dependence on common infrastructure, operationally through reliance on a limited number of critical processes, or economically through dependence on particular suppliers, markets, or resources. Assets that are geographically dispersed may still share the same underlying exposure if they depend upon a common electricity network, logistics hub, digital infrastructure, water system, or upstream supplier. **The relevant question is not simply how many components are exposed, but whether disruption affecting one exposure pathway can simultaneously compromise multiple organisational functions.**

Diversification describes a different structural property. **Exposure is diversified where critical organisational functions are distributed across assets, locations, suppliers, resources, or pathways whose susceptibility to climatic disruption is not strongly correlated**. Diversification can therefore limit the extent to which a single climatic disturbance affects the system as a whole. Geographic dispersion, multiple sourcing arrangements, alternative transport routes, or differentiated production locations may all contribute to diversification where they reduce dependence upon common exposure pathways.

Diversification, however, cannot be inferred from the number of available alternatives alone. Multiple suppliers located within the same hazard-prone region, several facilities dependent upon the same electricity grid, or alternative transport routes passing through the same vulnerable infrastructure may create the appearance of diversification while preserving substantial common exposure. Effective diversification therefore depends upon the independence of exposure pathways rather than merely upon their numerical multiplicity.

Redundancy introduces a further distinction. **Whereas diversification concerns the distribution of exposure, redundancy concerns the existence of alternative capacity capable of maintaining critical functions when an exposed component or pathway becomes unavailable**. Backup energy systems, alternative water sources, substitutable suppliers, reserve production capacity, or alternative logistics arrangements may provide redundancy where they can be activated without unacceptable disruption. **An alternative constitutes meaningful redundancy only where it remains operationally available under the conditions that disable the primary pathway.**

This distinction is methodologically important because concentration, diversification, and redundancy describe related but different properties of exposure architecture. Diversification may reduce dependence upon individual exposure pathways without guaranteeing continuity of critical functions. Redundancy may preserve continuity even where exposure remains concentrated, provided that an effective alternative can be activated when disruption occurs. Conversely, apparent diversification or redundancy may provide little protection where alternative components remain exposed to the same underlying climatic or infrastructural dependency.

The Framework therefore examines these characteristics not as independent indicators of climate risk but as structural properties of the exposure network. Their purpose is to identify whether climatic disturbances are likely to remain localized or whether common dependencies may allow disruption to propagate across multiple parts of the assessed system. **Exposure concentration identifies where dependence accumulates, diversification indicates whether that dependence is distributed across sufficiently independent pathways, and redundancy establishes whether critical functions can continue when particular pathways fail.**

Assessing these properties completes the transition from identifying exposure pathways to understanding the architecture through which exposure is distributed across the assessed system. It does not yet determine vulnerability, resilience, or the eventual consequences of climatic disruption. Those questions belong to subsequent analytical layers. Instead, concentration, diversification, and redundancy clarify the structural configuration of exposure upon which those later assessments must operate.

3.5 Data Typology and Evidence Structuring

Exposure mapping seeks to explain how climatic hazards become connected to organisational systems through multiple spatial, temporal, and functional pathways. Once these pathways have been identified, a further methodological question arises. Can relationships of such different nature be understood through a single type of evidence? The answer is necessarily negative. Because exposure itself is multidimensional, the evidence required to characterise it must also be diverse. A single dataset may describe one aspect of exposure while leaving equally important interaction pathways entirely unobserved.

This observation explains the approach adopted by the **FTSAI Climate Risk Assessment Framework**. **Evidence is not organised according to its format or technical origin but according to the analytical contribution it makes to understanding exposure**. **The objective is not to assemble the largest possible volume of information but to combine complementary forms of evidence capable of explaining how climatic stress may reach the assessed system**.

Spatial information contributes to the identification of geographical interfaces, concentration patterns, and the physical configuration of assets and infrastructure. Operational documentation describes production processes, organisational activities, and the sequence through which exposure develops over time. Dependency maps show the functional relationships between key processes, services and value chains. Expert knowledge and qualitative observations contribute contextual understanding of organisational practices, informal procedures, and adaptive behaviours that frequently remain invisible within structured datasets. Each evidence category therefore illuminates a different aspect of the exposure architecture.

Because these evidence sources describe complementary rather than competing aspects of exposure, the Framework does not establish a hierarchy in which one category systematically overrides another. **Their analytical value depends upon the coherence achieved through their combined interpretation**. **Exposure mapping** therefore seeks consistency across multiple forms of evidence rather than exclusive reliance upon any single dataset or measurement technique.

This perspective also explains why qualitative evidence occupies a central methodological position within the Framework. Exposure pathways frequently depend upon organisational behaviour, operational practice, institutional arrangements, or informal adaptation mechanisms that cannot be represented adequately through quantitative information alone. Where quantitative data are unavailable, incomplete, or inconsistent with the scale of the assessment, **structured qualitative evidence provides an essential analytical contribution rather than a secondary substitute**.

The objective of exposure mapping is consequently not exhaustive quantification but disciplined explanation. The Framework does not attempt to assign numerical values to every interface or dependency. Instead, it seeks to document how exposure arises, where significant interaction pathways exist, and under which conditions climatic stress may propagate throughout the assessed system. Every interpretative judgement is accompanied by explicit documentation of the evidence upon which it is based, together with the assumptions required for its interpretation.

This methodological discipline extends naturally to the treatment of uncertainty. Data gaps, proxy variables, differences in spatial or temporal resolution, and incomplete documentation are not concealed through implicit assumptions or artificial harmonization. They remain visible components of the assessment because they influence the confidence with which exposure pathways can subsequently be interpreted. Uncertainty therefore accompanies **exposure mapping** into downstream analyses rather than disappearing through unsupported analytical simplification.

For the same reason, the Framework discourages adapting available data to predetermined exposure templates simply because standardized indicators are easier to populate. **Evidence selection is guided by its relevance to identified exposure pathways, not by convenience or availability. The analytical structure follows the system being assessed rather than the structure of the available datasets**.

The methodological position established throughout this section follows directly from the systemic conception of exposure adopted by the Framework. If exposure is understood as a network of relationships linking climatic hazards with organisational systems, then evidence must likewise be organised as complementary sources illuminating different parts of that network. Data typology therefore serves not as an exercise in information management but as the methodological foundation upon which coherent, transparent, and auditable **exposure mapping** becomes possible.

3.6 Interaction with Vulnerability and Readiness Modules

The identification of exposure pathways does not complete climate risk assessment. Once the relationships through which climatic hazards reach the assessed system have been established, a further methodological question immediately arises. Does knowing where climatic stress can enter a system also explain what will happen once it arrives? The answer is necessarily negative. **Exposure identifies the existence of interaction pathways but says nothing about how the system will respond when those pathways become active**.

This distinction explains why the **FTSAI Climate Risk Assessment Framework** treats **exposure, vulnerability, and readiness as separate analytical stages**. Each module addresses a different methodological question, and each contributes a different element to the progressive construction of climate risk. **Preserving these distinctions is essential because climate risk emerges only after the answers provided by all three modules are interpreted together**.

Exposure mapping provides the starting point. It identifies where climatic hazards become connected to assets, activities, organisational processes, and critical dependencies. Its analytical responsibility ends once these interaction pathways have been described. **Exposure mapping neither predicts consequences nor evaluates the capacity of the system to withstand climatic stress**. It simply establishes the conditions under which such interactions become possible.

Once these interaction pathways have been identified, attention shifts naturally to vulnerability. The relevant question is no longer where climatic stress may occur but how the exposed components are likely to respond. Vulnerability assessment therefore examines the characteristics of the system itself, including structural fragility, process sensitivity, response thresholds, and adaptive limitations that influence the consequences of exposure. **Exposure defines the interface. Vulnerability explains the behaviour of the system at that interface**.

Understanding vulnerability, however, still leaves an important question unresolved. Even systems exhibiting substantial vulnerability may experience markedly different outcomes depending upon their capacity to anticipate, manage, and adapt to climatic stress. This consideration introduces the role of readiness.

Readiness assessment therefore examines the organisational capacity to respond once exposure and vulnerability have been established. Governance arrangements, decision-making processes, resource availability, institutional coordination, and adaptive mechanisms determine how effectively the organisation manages the conditions identified by the preceding analytical stages. **Readiness does not modify exposure pathways or eliminate vulnerability. Instead, it influences how those conditions ultimately translate into realized consequences**.

The analytical relationship between the three modules is therefore sequential rather than interchangeable. **Exposure identifies where climatic stress may reach the system. Vulnerability explains the consequences of that interaction. Readiness evaluates the organisational capacity to influence those consequences through planning, governance, and adaptation**. **None of these analytical questions can be answered by the others, and no module can legitimately substitute for another without compromising the internal logic of the Framework**.

This sequence also preserves methodological traceability. Information generated by **exposure mapping** guides vulnerability assessment by identifying the relevant interaction interfaces. **Vulnerability analysis** subsequently informs readiness evaluation by revealing where adaptive capacity becomes most consequential. The results of the downstream analyses do not alter the exposure pathways initially identified, but each stage is built upon the findings of the previous stage. **Maintaining this one-directional analytical progression prevents circular reasoning and preserves the transparency of the assessment process**.

For this reason, the Framework explicitly discourages interpreting exposure as a proxy for vulnerability, vulnerability as a proxy for readiness, or any individual module as a substitute for integrated climate risk assessment. High exposure does not necessarily imply severe consequences, just as substantial vulnerability does not inevitably produce adverse outcomes where **organisational readiness** is strong. **Climate risk emerges only after the interaction between all three analytical dimensions has been systematically examined**.

The interaction between exposure, vulnerability, and readiness therefore illustrates a broader methodological principle that underpins the entire Framework. Analytical modules derive their value not from operating independently but from answering different questions within a coherent sequence of reasoning. Preserving that sequence ensures that climate risk is progressively explained rather than prematurely assumed, thereby maintaining the methodological discipline, interpretive clarity, and analytical integrity upon which the Framework is constructed.

3.7 Common Failure Modes in Exposure Analysis

The Framework directly addresses recurring methodological failure modes that often undermine the validity and interpretive usefulness of exposure analysis application in applied climate risk assessments. Such failures are often caused by oversimplified assumptions, incomplete representation of the system, or premature evaluative judgments.

One common failure mode is to **over-rely on geographic exposure metrics**. Exposure is usually inferred directly from spatial proximity to hazards, with location assumed to be a sufficient proxy for exposure. This approach ignores the operational timing, functional dependencies and adaptive arrangements that may significantly change the way hazards interact with the components of the system. **The Framework rejects purely spatial interpretations of exposure detached from functional and temporal context**.

Another frequent failure mode is **neglect of indirect and functional dependencies**. Assessments may be narrowly focused on directly exposed assets, and miss exposure pathways embedded in supply chains, logistics, service provision, labour availability or institutional dependencies. Such omissions can lead to substantial underestimation of exposure in interconnected systems where indirect pathways dominate stress transmission.

Another failure mode is the **assumption of static exposure over time**. Exposure configurations may change because of changes in operational practices, use of assets, production cycles, governance arrangements or external conditions. **Treating exposure as fixed may mask dynamic interaction effects and misrepresent sensitivity under changing hazard regimes. The Framework therefore accounts explicitly for exposure dynamics and temporal variability.**

Conflation of exposure with vulnerability represents a particularly critical failure mode. **Exposure identifies where hazards may interface with system components. Vulnerability assesses how those components respond to stress**. Prematurely collapsing these concepts embeds judgments of sensitivity and subverts sequencing of analysis. The Framework maintains a strict conceptual separation of **exposure mapping** and vulnerability assessment.

Other modes of failure include **implicit prioritisation of exposure pathways without documented rationale**, **use of single indicators to infer exposure**, and the **suppression of uncertainty through forced aggregation**. Such practice reduces transparency and damages auditability.

The Framework's **exposure mapping** modules are specifically designed to overcome those failures. Methodological discipline is ensured by structured dimensional analysis, explicit documentation of assumptions and dependencies, and clear boundary definition between exposure, vulnerability and readiness. The Framework is intended to help identify and guard against common failure modes such that exposure analysis provides a reliable and interpretable foundation for subsequent vulnerability assessment, rather than a source of hidden bias or premature conclusions.

3.8 Implications for Certification and Downstream Applications

Once exposure pathways have been identified, a further methodological question naturally follows. What role should **exposure mapping** play in subsequent decision-making? The answer is not self-evident. Information describing how climatic hazards become connected to an organisational system is indispensable for understanding climate risk, yet its analytical importance should not be confused with decision-making authority. **The Framework therefore distinguishes carefully between information that supports downstream decisions and information that determines them**.

This distinction is particularly significant in certification **readiness assessments**. **Exposure mapping** provides a transparent, structured, and auditable representation of the pathways through which identified climatic hazards may interact with assets, activities, operational processes, and organisational dependencies. In doing so, it establishes the contextual foundation upon which subsequent analytical stages are performed. It does not, however, indicate whether these exposure pathways are adequately managed, whether organisational controls are sufficient, or whether certification requirements have been satisfied. Those conclusions belong to downstream assessment modules rather than to **exposure mapping** itself.

The reason for maintaining this distinction is methodological. **Exposure describes the existence of potential interaction pathways, not the consequences arising from them**. Certification decisions depend upon how these pathways interact with vulnerability, governance arrangements, resilience mechanisms, and **organisational readiness**. **Treating exposure mapping as a certification criterion would therefore bypass essential stages of the Framework and attribute evaluative meaning to information that was designed to remain descriptive**.

Exposure mapping nevertheless performs an essential role within certification readiness evaluation. By identifying where and how climatic stress may enter the assessed system, it provides certification bodies with the analytical context required to evaluate governance arrangements, operational controls, and adaptive measures in relation to the exposure conditions faced by the organisation. **Exposure mapping**

therefore informs certification without replacing independent verification, **assurance procedures, or professional judgement**.

The same methodological principle extends beyond certification. Financial institutions, insurers, investors, policymakers, infrastructure operators, and strategic planners may all benefit from **exposure mapping** because it clarifies the pathways through which climatic stress may influence organisational performance. In every application, however, **exposure outputs function as contextual inputs rather than autonomous decision criteria**. Their practical value emerges only when they are interpreted together with vulnerability, resilience, and **readiness assessments** appropriate to the decision under consideration.

For this reason, the Framework discourages the use of **exposure mapping** as a stand-alone screening mechanism, exclusion criterion, prioritisation tool, or proxy for climate risk. Exposure pathways describe opportunities for interaction between climatic hazards and organisational systems, but they do not explain the consequences of those interactions. Detached from the downstream analytical stages of the Framework, exposure findings provide an incomplete basis for evaluating climate risk and may therefore support conclusions that are methodologically unjustified.

The distinction between analytical support and decision authority also ensures that **exposure mapping** remains reusable across multiple institutional contexts without altering its methodological meaning. Because exposure outputs remain descriptive rather than evaluative, they can inform certification, financial analysis, insurance applications, investment decisions, public policy, and strategic planning while preserving consistency of interpretation and complete analytical traceability.

The Framework therefore maintains a clear boundary between **exposure mapping** and downstream decision-making. **Exposure mapping identifies how climatic hazards become connected to organisational systems. Subsequent analytical modules explain the consequences of those connections and evaluate the capacity of the organisation to manage them. Only after these stages** have been completed can climate risk be interpreted and decisions responsibly supported. Preserving this analytical sequence ensures that **exposure mapping** contributes to diverse downstream applications without assuming responsibilities that belong to later stages of the Framework.

3.9 Summary of Methodological Position

The purpose of exposure mapping within the FTSAI Climate Risk Assessment Framework is not to determine climate risk but to establish the structural relationships through which climate and weather-related hazards become capable of influencing an assessed system. Throughout this Part, **exposure mapping** has been developed as a disciplined analytical process for identifying these relationships without extending its interpretation beyond the methodological question it is intended to answer.

This position follows directly from the systemic conception of climate risk adopted by the Framework. Climatic hazards do not affect organisational systems simply because they exist. Their influence depends upon the existence of identifiable pathways linking environmental stress with assets, operational processes, critical dependencies, and organisational activities. **Exposure mapping** therefore explains how those connections are formed while deliberately avoiding conclusions concerning their eventual consequences.

The methodological discipline established throughout this Part is reflected in several complementary principles. **Exposure is interpreted as a relational rather than an intrinsic property**. Spatial, temporal, and functional dimensions are treated as complementary expressions of the same underlying phenomenon. Direct and indirect pathways are examined within a unified analytical structure, while evidence is organised according to its analytical contribution rather than its technical format. Throughout the assessment, uncertainty remains explicitly documented, and descriptive analysis is kept separate from evaluative judgement.

These principles define exposure mapping as a structural rather than diagnostic activity. Its objective is not to estimate impacts or infer climate risk, but to describe the architecture through which climatic stress may reach the assessed system. **The analytical value of exposure mapping therefore lies in providing a transparent and methodologically consistent representation of these interaction pathways before vulnerability, resilience, governance, and readiness are examined**.

This methodological position also explains the broad applicability of the Framework. Because **exposure mapping** remains independent of sector-specific performance measures, certification decisions, financial objectives, and policy priorities, it can be applied consistently across heterogeneous organisational and geographical contexts. Adaptation occurs through the interpretation of exposure within downstream analytical modules rather than through modification of the principles governing **exposure mapping** itself.

The Part therefore concludes with a clear methodological proposition. **Exposure mapping** establishes the relational architecture through which climatic hazards become connected to organisational systems, but it does not constitute climate risk assessment. Preserving this distinction is essential for maintaining the analytical coherence of the Framework, ensuring complete interpretive traceability, and supporting the responsible integration of exposure analysis with vulnerability, readiness, and downstream decision-making processes.

4. Vulnerability and Resilience Modules

Overview

If vulnerability alone were sufficient to explain how exposed systems behave, organisations exhibiting comparable vulnerability profiles would be expected to experience broadly similar consequences under equivalent climatic stress. In practice, this expectation is rarely confirmed. Systems facing comparable levels of vulnerability often differ substantially in their ability to maintain essential functions, limit disruption, adapt while stress persists, and recover once the disturbance has subsided. **Vulnerability therefore explains only part of system behaviour. A second analytical concept is required to account for differences in response capacity. The Framework identifies this complementary property as resilience**.

Resilience characterises the capacity of an exposed system to absorb climatic stress, preserve operational continuity, adapt to changing conditions, and restore functionality following disruption. Rather than representing the opposite of vulnerability, resilience explains a different aspect of system behaviour. **Vulnerability describes the conditions under which disruption becomes likely. Resilience describes the capacity of the system to withstand, manage, and recover once disruption occurs**. Together, the two concepts provide a more complete explanation of organisational response than either could provide independently.

Recognizing **vulnerability and resilience** as distinct properties also raises another methodological question. Are all determinants of **vulnerability and resilience** equally amenable to intervention? Again, the Framework concludes that they are not. Some characteristics arise from structural, environmental, technological, or geographical conditions that cannot readily be modified by the assessed entity. Others reflect governance arrangements, investment choices, operational practices, organisational learning, and resource allocation that remain subject to managerial influence. The Framework therefore distinguishes between **inherent and managed vulnerability**, while applying the same analytical reasoning to resilience. **Structural endowments establish the baseline capacity of the system, whereas governance and organisational choices determine how effectively that capacity is translated into operational performance**.

Once **vulnerability and resilience** have been distinguished in this way, the methodological role of the modules becomes clear. **Their purpose is not to prescribe corrective actions or predict inevitable outcomes, but to characterise how exposed systems are likely to behave under climatic stress**. The outputs therefore remain analytical and diagnostic. They are intended to characterise vulnerability profiles over relevant system dimensions, pinpoint structural fragilities, characterise resilience capacity and expose potential leverage points for adaptation, without implying predetermined losses or ensuring successful recovery.

Vulnerability and Resilience Modules - Extended Methodological Specification

4.1 Conceptual Distinction between Vulnerability and Resilience

Once exposure pathways have been established, climate risk assessment shifts from understanding how climatic stress reaches an organisational system to understanding how that system behaves when stress occurs. This transition immediately raises a fundamental methodological question. Can system response be explained through a single analytical property? If the answer were affirmative, one concept would be sufficient to characterise how exposed systems behave under climatic stress. The Framework concludes, however, that such a representation would be incomplete.

Systems exposed to comparable climatic conditions often exhibit remarkably different patterns of behaviour. Some experience substantial disruption despite relatively limited structural sensitivity, whereas others continue to operate effectively even under adverse conditions. These differences cannot be explained through a single concept because two fundamentally different properties are involved. One concerns the **susceptibility of the system to disruption**. The other concerns its **capacity to continue functioning, adapt**, **and recover once disruption occurs**. Although closely related, these properties describe different aspects of system behaviour and therefore require separate analytical treatment.

The **FTSAI Climate Risk Assessment Framework** identifies the first of these properties as vulnerability. Vulnerability describes the propensity of an exposed system to experience degradation, disruption, or loss when climatic stress reaches the interaction pathways identified during **exposure mapping**. It reflects the influence of structural characteristics, operational dependencies, technological constraints, financial conditions, organisational arrangements, and other factors that determine how readily the system is affected once exposure becomes operationally relevant. **Vulnerability therefore describes system sensitivity rather than the hazards themselves**.

The second property is resilience. **Whereas vulnerability explains why disruption may occur, resilience explains how the system responds once disruption has begun**. It reflects the capacity to absorb climatic stress, maintain essential functions, reconfigure operational behaviour using existing capabilities, mobilize available resources, and restore functionality within acceptable timeframes. **Resilience therefore characterises response capability rather than susceptibility**. It captures the mechanisms through which systems continue to function despite the presence of conditions that make disruption possible.

Recognizing these concepts as analytically distinct has an important methodological consequence. **Vulnerability and resilience cannot be interpreted as opposite ends of a single continuum**. High vulnerability does not necessarily imply limited resilience, just as low vulnerability does not necessarily imply effective resilience. Systems can operate under structural disadvantage while retaining strong response capabilities, effective resource mobilization, and robust mechanisms for maintaining and restoring critical functions. Conversely, organisations benefiting from favourable structural conditions may nevertheless exhibit limited resilience because flexibility, coordination, redundancy, or decision-making capacity remain inadequate.

This observation introduces a further distinction. Are all determinants of **vulnerability and resilience** equally subject to organisational influence? Again, the Framework concludes that they are not. Some arise from structural, geographical, environmental, or technological conditions that cannot readily be modified by the assessed entity. Others reflect governance arrangements, investment decisions, organisational learning, operational practices, resource allocation, and adaptive management. The Framework therefore distinguishes between **inherent and managed vulnerability**, while applying the same analytical reasoning to resilience. Structural endowments establish the baseline characteristics of the system, whereas governance and organisational choices determine how those characteristics ultimately influence system behaviour under climatic stress.

Maintaining these distinctions prevents several common interpretive errors. Apparent robustness should not be inferred solely from limited observed damage, since favourable outcomes may reflect strong resilience despite substantial vulnerability. Equally, significant baseline sensitivity should not be interpreted as evidence of inevitable failure where adaptive capacity remains high. **By evaluating vulnerability and resilience independently before considering their interaction, the Framework preserves the analytical discipline required to explain why organisations operating under similar climatic conditions frequently experience markedly different outcomes**.

For this reason, **vulnerability and resilience** are always interpreted relative to identified exposure pathways and the specific hazard conditions established during previous stages of the assessment. Neither concept is treated as an abstract organisational characteristic or as a normative measure of performance. Their analytical meaning derives entirely from how systems behave when exposed to climatic stress. Preserving this conceptual distinction provides the methodological foundation upon which the subsequent design of vulnerability, resilience, and integrated climate risk assessment modules is constructed.

4.2 Structural Sources of Vulnerability

Once structural vulnerability has been distinguished from managed vulnerability, the next methodological task is to identify its principal sources. **Structural vulnerability does not arise from a single cause but from a range of relatively persistent system characteristics that shape how climatic stress is experienced**. Although these characteristics differ across sectors and organisational contexts, they share an important common feature: **they cannot normally be modified rapidly through managerial action, operational adjustment, or short-term investment**. **Their analytical significance lies in defining the baseline conditions within which exposure, adaptation, and resilience subsequently operate**.

One important source of structural vulnerability arises from the natural environment itself. **Climatic baselines**, **geomorphological characteristics**, **soil composition**, **hydrological conditions**, and other **environmental constraints** may substantially restrict the range of feasible adaptation options available to an organisation. These conditions do not determine future outcomes, but they establish the physical context within which organisational decisions must be taken and therefore influence the degree of sensitivity that can realistically be reduced.

Structural vulnerability is not confined to environmental conditions. It may also originate from the **physical configuration of the system itself**. Critical infrastructure is often geographically fixed, and this immobility, along with the location, often limits the ability to relocate assets or change operating configurations in response to climate change. Infrastructure constructed under historical climatic assumptions may therefore remain exposed to forms of climatic stress that cannot be eliminated without substantial economic cost, operational disruption, or long-term investment.

A further source of structural vulnerability emerges from the **technological architecture of the system**. Production systems built around highly specialized technologies, fixed manufacturing processes, or climate-sensitive production inputs often possess limited flexibility when environmental conditions depart from those for which they were originally designed. Dependence upon resources such as water, energy, biological inputs, or other climate-dependent factors may further restrict the capacity of the system to adjust under changing climatic conditions, even where managerial willingness to adapt is strong.

Within agricultural systems, structural vulnerability frequently reflects the combined influence of natural and production-related characteristics. Soil properties, long-term water availability, crop selection, perennial cultivation systems, land-use constraints, investment horizons, and tenure arrangements collectively define the structural conditions within which adaptation becomes possible. Because these characteristics usually evolve only gradually, they represent enduring components of the vulnerability profile rather than temporary operational conditions.

Recognizing these structural sources has an important methodological consequence. **Structural vulnerability should not be interpreted as evidence of inadequate management or deficient governance**. Instead, it defines the context within which managerial decisions are made and adaptive strategies are implemented. Distinguishing structural constraints from organisational choices allows vulnerability assessments to evaluate system performance more fairly and to avoid attributing responsibility for conditions that cannot reasonably be altered within the relevant planning horizon.

This distinction also prevents a second interpretive error. **Structural vulnerability does not predetermine future outcomes**. Systems operating under substantial structural constraints may nevertheless demonstrate high levels of resilience through effective governance, diversification, innovation, redundancy, and adaptive management. Conversely, organisations benefiting from favourable structural conditions may remain highly vulnerable where governance quality, operational flexibility, or response capacity are inadequate. **Structural vulnerability therefore defines the boundaries within which adaptation operates rather than the outcomes that adaptation inevitably produces**.

The methodological role of structural vulnerability is consequently descriptive rather than deterministic. By explicitly identifying its principal sources, the Framework establishes the baseline conditions against which managed vulnerability, resilience, and governance capacity can subsequently be evaluated. This approach maintains analytical fairness, does not assign undue blame, and offers a more balanced and scientifically defendable interpretation of organisational vulnerability in various environmental, technological and institutional settings.

4.3 Operational and Organisational Vulnerability

Following the identification of structural sources of vulnerability, climate risk assessment must explain how vulnerability is generated within the normal functioning of the system itself. Structural conditions establish the boundaries within which organisations operate, but they do not fully explain why systems subject to comparable structural constraints frequently exhibit markedly different levels of disruption under similar climatic stress. **The explanation lies in the mechanisms through which operational and organisational processes transform external stress into degraded system performance**.

Operational vulnerability arises whenever climatic stress cannot be accommodated without disrupting the continuity of essential processes. Its defining characteristic is therefore not the existence of operational activities themselves, but the limited capacity of those activities to absorb disturbance while maintaining acceptable levels of performance. Operational vulnerability reflects the degree to which normal system functioning depends upon conditions that become difficult or impossible to preserve once climatic stress begins to interfere with routine operations.

The principal mechanism through which operational vulnerability develops is the loss of operational flexibility. Whenever critical processes cannot be modified, reordered, substituted, or temporarily reconfigured without degrading overall system performance, relatively modest disturbances may propagate well beyond their original point of occurrence. Tightly coupled production systems, inflexible process sequences, narrowly specified operational capacities, and dependence upon unique production inputs are different manifestations of the same underlying mechanism: the absence of sufficient operational flexibility to accommodate changing conditions while preserving functional continuity.

A second mechanism arises from the **concentration of operational capability**. Essential functions often depend disproportionately upon specific resources whose temporary loss cannot readily be compensated. Specialized expertise concentrated within a limited number of individuals, restricted workforce availability, dependence upon seasonal labour, outsourced activities, or critical operational services may all create single points of operational sensitivity. Climatic disturbances affecting workforce mobility, health, or availability therefore have the potential to disrupt organisational performance through mechanisms that remain largely invisible within conventional asset-based assessments.

Operational processes, however, do not function independently of the organisations responsible for directing them. Even where operational flexibility remains adequate, effective response depends upon the organisation's ability to transform available resources into coordinated action. This requirement introduces the distinct concept of organisational vulnerability.

Organisational vulnerability arises whenever available organisational capacity cannot be converted into timely, coherent, and coordinated decisions under conditions of climatic stress. Its defining mechanism is not resource scarcity but coordination failure. Delayed decision-making, fragmented authority, unclear allocation of responsibilities, ineffective escalation procedures, and weak horizontal or vertical coordination may significantly increase organisational sensitivity despite the availability of adequate physical, financial, and operational resources.

The effectiveness of organisational coordination depends fundamentally upon the quality of information circulating throughout the system. Organisational vulnerability therefore becomes particularly evident when decision-makers lack timely situational awareness or when reliable information cannot be communicated efficiently between organisational units. Delayed reporting, fragmented communication structures, inconsistent information flows, or excessive reliance upon informal communication channels may substantially impair adaptive response, not because the organisation lacks capability, but because existing capability cannot be mobilized when required.

Unlike structural vulnerability, operational and organisational vulnerability remain substantially influenced by managerial decisions. **Their defining characteristics are therefore not permanence but modifiability**. Improvements in process flexibility, operational redundancy, workforce planning, governance arrangements, decision structures, communication systems, and organisational learning may progressively reduce these forms of vulnerability, although such improvements generally require sustained institutional commitment rather than isolated interventions.

Recognizing operational and organisational vulnerability as distinct mechanisms of sensitivity has important methodological implications. These dimensions explain how organisations operating under comparable structural conditions may nevertheless experience substantially different outcomes because climatic stress is translated into operational disruption through different organisational mechanisms. **They therefore occupy an essential intermediate position between structural vulnerability and resilience, explaining not why systems are exposed, but how that exposure becomes operationally significant**.

The analytical role of operational and organisational vulnerability is consequently explanatory rather than prescriptive. By identifying the mechanisms through which climatic stress is transformed into operational disruption, the Framework provides a coherent bridge between structural constraints and resilience capacity while preserving the analytical distinction between system sensitivity, organisational behaviour, and adaptive response.

4.4 Financial Vulnerability and Buffer Capacity

Financial resources influence climate risk not because they eliminate exposure or reduce system sensitivity, but because they determine the extent to which an organisation can continue operating once climatic disruption occurs. This observation immediately raises a methodological question. Does the mere existence of financial resources necessarily reduce vulnerability? If financial capacity always translated directly into effective response capability, climate risk assessment would require little more than measuring available financial resources. The Framework concludes, however, that this assumption is fundamentally misleading.

Financial vulnerability arises whenever the financial structure of an organisation is unable to absorb climatic disruption without impairing operational continuity, delaying recovery, or constraining

adaptive action. Its defining characteristic is therefore not the absolute quantity of available financial resources, but the effectiveness with which those resources can be mobilized under conditions of stress. Financial vulnerability describes the mechanisms through which financial arrangements either amplify or attenuate the operational consequences of climatic disruption.

The first of these mechanisms concerns **financial buffering capacity**. Businesses with sufficient liquidity, multiple sources of revenue and access to financing or other financial resources that are readily available are better positioned to remain in business when faced with climate disruptions. Financial buffers reduce vulnerability because they provide time for adaptation and recovery before operational disruption evolves into financial instability. Their effectiveness, however, depends upon whether they remain available when they are needed rather than upon their nominal existence under normal operating conditions.

This distinction makes clear the difference between nominal financial capacity and effective financial capacity as distinguished in the Framework. Financial instruments such as credit facilities, insurance policies, emergency funding arrangements, or public support mechanisms may appear adequate when assessed in isolation. **Their practical contribution to vulnerability reduction depends instead upon whether they can be activated rapidly, predictably, and in sufficient magnitude during periods of climatic stress**. Administrative delays, contractual exclusions, counterparty risk, conditional eligibility, or implementation constraints may substantially reduce effective financial protection despite apparently strong financial resources.

Financial capacity must also be interpreted relative to the scale and duration of anticipated disruption. The same liquidity reserve, insurance arrangement, or financing structure may prove entirely adequate under short-lived disturbances while becoming insufficient during prolonged disruption or repeated climatic shocks. Financial vulnerability therefore cannot be evaluated independently of exposure conditions and expected recovery requirements. **The analytical question is not how much financial capacity exists, but whether that capacity remains proportionate to the demands imposed by the identified climate risk scenario**.

A further mechanism through which financial vulnerability develops is the structure of financial obligations themselves. High leverage, short debt maturities, rigid repayment schedules, or restrictive financial covenants may substantially reduce organisational flexibility once climatic disruption begins. Conversely, financing arrangements that are designed to absorb variability, with an appropriate maturity structure and contractual flexibility may reduce vulnerability even if absolute debt levels are relatively high. The vulnerability mechanism therefore lies not in indebtedness alone but in the extent to which financial commitments restrict adaptive decision-making under stress.

The same reasoning applies to insurance. Insurance contributes to vulnerability reduction only when it functions as an effective financial buffer rather than as a nominal contractual arrangement. Coverage scope, trigger mechanisms, exclusions, payout timing, basis risk, and claims reliability determine whether insurance can support recovery once disruption occurs. Insurance is therefore evaluated according to its operational effectiveness under identified hazard conditions rather than according to its mere existence.

Recognizing these mechanisms has an important methodological consequence. **Financial vulnerability should not be interpreted as a measure of financial performance or organisational solvency**. Strong financial indicators under normal operating conditions do not necessarily imply effective protection against climatic disruption, just as relatively modest financial resources do not inevitably produce high vulnerability where exposure remains limited, and recovery requirements are manageable. **Financial vulnerability therefore reflects the relationship between financial capacity and operational demands rather than financial strength in isolation**.

The analytical role of financial vulnerability is consequently explanatory rather than evaluative. By identifying the mechanisms through which financial arrangements influence the ability of organisations to absorb climatic disruption, the Framework provides the financial dimension of vulnerability without confusing financial capacity with organisational resilience or ultimate climate risk outcomes. This positioning preserves methodological consistency while establishing a robust analytical foundation for the resilience assessment that follows.

4.5 Resilience Mechanisms and Response Capacity

Following the assessment of vulnerability, the analytical focus shifts from system sensitivity to system response. Vulnerability explains the conditions under which climatic stress is likely to impair organisational performance. Resilience assessment examines a different question: **to what extent is the organisation capable of maintaining essential functions, operationally reconfiguring existing capabilities, and restoring performance once disruption has occurred?** **The objective is not to determine whether disruption can be avoided, but whether disruption can be managed without progressive loss of functionality**.

Within the Framework, resilience is assessed through the mechanisms that support continuity of operation under climatic stress. These mechanisms are not evaluated according to their nominal existence, but according to their capacity to function under the conditions created by the identified hazard, exposure, and vulnerability profile. **The analytical emphasis therefore shifts from the availability of resilience measures to their operational effectiveness**.

Operational flexibility represents one such mechanism. The existence of alternative production processes, substitute inputs, resource reallocation options, or reconfigurable operational pathways does not in itself demonstrate resilience. The relevant analytical question is whether these alternatives remain deployable while essential functions are under stress. Operational flexibility is therefore evaluated according to its ability to preserve functional continuity under realistic disruption conditions rather than according to the number of alternatives available under normal operating circumstances.

Functional redundancy is assessed according to the same principle. Redundancy in spare capacity, redundant assets, more people or alternative routes of operation add resilience only where those alternatives can adequately replace critical functions in the absence of the primary capabilities. **The Framework therefore evaluates redundancy in terms of functional substitutability rather than resource duplication**. Redundancy that cannot be activated when disruption occurs provides little practical contribution to organisational resilience.

Operational learning may strengthen resilience when experience improves the deployment or coordination of capabilities already available to the system. Where learning instead produces changes in operational practices, resource allocation, governance arrangements, technologies, or decision-making processes that alter the system's future configuration, it constitutes evidence of adaptive capacity and is assessed within the **Readiness and Adaptive Capacity Modules**.

Governance provides the organisational conditions under which resilience mechanisms become operational. Decision authority, coordination structures, communication processes, and access to timely information are evaluated according to their ability to activate resilience mechanisms during disruption rather than according to their formal organisational design. Governance contributes to resilience only when available organisational capabilities can be translated into coordinated operational action within the time constraints imposed by climatic stress.

The Framework therefore treats the effective deployment of resilience mechanisms as an operational property of the system rather than as evidence of adaptive capacity. Resilience is demonstrated when existing capabilities can be mobilized, coordinated, and, where necessary, operationally reconfigured under changing conditions of climatic stress. Adaptive capacity remains analytically distinct: it concerns the organisation's ability to modify the capabilities, structures, technologies, practices, or governance arrangements that will shape its future response to climatic conditions.

Because resilience mechanisms operate within the context established by hazards, exposure pathways, and vulnerability profiles, their effectiveness is necessarily context dependent. Mechanisms that preserve continuity under one set of climatic conditions may contribute little under another where operational dependencies, recovery requirements, or disruption dynamics differ substantially. The Framework therefore evaluates resilience mechanisms relative to the specific operational conditions under assessment rather than against predefined models of organisational best practice.

The analytical role of resilience assessment is consequently distinct from that of vulnerability assessment. **Vulnerability identifies the conditions that increase system sensitivity. Resilience evaluates the effectiveness of the mechanisms available to sustain continuity, support operational reconfiguration, and enable recovery once those conditions become operationally relevant**. By maintaining this distinction, the Framework preserves conceptual clarity while providing the final analytical component required for integrated climate risk assessment.

4.6 Interaction Effects and Non-Linear Behaviour

The separate assessment of **vulnerability and resilience** provides an essential analytical foundation for climate risk evaluation. A further methodological question nevertheless remains. Can the overall behaviour of a system be inferred simply by combining the results of these separate assessments? If **vulnerability and resilience** influenced system behaviour independently, climate risk could be estimated through straightforward aggregation of their respective indicators. The Framework concludes, however, that this assumption fails to capture the behaviour of complex systems exposed to climatic stress.

System behaviour emerges not from vulnerability or resilience considered in isolation, but from their interaction. The consequences of a given level of vulnerability depend upon the resilience mechanisms available when disruption occurs, just as the effectiveness of resilience depends upon the nature, intensity, and distribution of underlying vulnerabilities. **Climate risk therefore reflects the interaction between system sensitivity and response capability rather than the independent contribution of either dimension alone**.

This interaction is rarely proportional. Relatively modest changes in vulnerability or resilience may produce disproportionately large changes in overall system behaviour because their effects are mediated through the interaction between multiple operational, organisational, financial, and institutional processes. Moderate vulnerability may therefore result in severe disruption where resilience mechanisms are weak or cannot be deployed effectively. Conversely, systems characterised by substantial structural vulnerability may nevertheless maintain acceptable performance when operational resilience, resource mobilization, and response coordination remain sufficiently robust.

An important consequence follows. **The Framework rejects the mechanical aggregation of vulnerability and resilience indicators**. Linear combinations or weighted summation assume that improvements in one dimension compensate proportionally for deterioration in another. Such assumptions overlook the interaction mechanisms through which sensitivity and response capacity jointly determine system behaviour. **Vulnerability and resilience** are therefore interpreted through integrated analytical evaluation rather than through arithmetic combination.

Non-linearity becomes particularly evident when systems approach critical thresholds. Organisational, operational, financial, or institutional systems may continue functioning despite gradually increasing stress until the limits of available resilience mechanisms are reached. Beyond these limits, relatively small additional disturbances may produce abrupt deterioration, widespread functional disruption, or rapid loss of response capability. **Threshold behaviour therefore reflects the changing relationship between vulnerability and resilience rather than changes in either dimension considered independently**.

The same reasoning applies over time. Repeated disturbances or prolonged periods of climatic stress may progressively weaken resilience mechanisms even where individual events remain manageable.

Sufficient resilience capacity for individual disruptions can be progressively eroded through resource depletion, organisational fatigue, shortened recovery time, or repeated triggering of resilience mechanisms. Tipping points therefore emerge not only from increasing hazard intensity but also from the cumulative interaction between **vulnerability and resilience** across successive episodes of climatic stress.

Interaction also occurs among resilience mechanisms themselves. Individual mechanisms that perform effectively in isolation may compete for resources, constrain one another, or become mutually reinforcing once activated simultaneously. The effectiveness of operational flexibility, redundancy, **adaptive learning**, and governance coordination therefore depends not only upon their individual quality but also upon the way they interact during disruption. **The Framework consequently evaluates resilience as an integrated system of mutually interacting mechanisms rather than as a collection of independent organisational attributes**.

The methodological implication is clear. **Climate risk assessment cannot rely upon proportional reasoning or linear indicator aggregation where system behaviour is governed by interaction effects**. Instead, **vulnerability and resilience** findings are interpreted jointly to identify the conditions under which their interaction may amplify disruption, preserve functionality, or trigger abrupt changes in system performance.

By explicitly incorporating interaction effects and non-linear behaviour into the assessment methodology, the Framework provides a more realistic representation of organisational behaviour under climatic stress. This interaction-oriented perspective preserves analytical consistency while establishing the conceptual bridge between individual assessment modules and the integrated climate risk synthesis developed in the following sections.

4.7 Evidence Typology and Assessment Discipline

The assessment of **vulnerability and resilience** depends fundamentally upon the quality of the reasoning process through which available evidence is interpreted. The existence of extensive operational, financial, technical, or organisational information does not, by itself, guarantee reliable conclusions regarding the behaviour of a system under climatic stress. **The central methodological challenge is therefore not the collection of evidence, but the disciplined interpretation of heterogeneous evidence within a coherent analytical framework**.

For this reason, the Framework does not evaluate evidence according to its format or its apparent objectivity. **Different forms of evidence contribute different forms of knowledge, each illuminating distinct aspects of system behaviour**. Operational information explains how systems function under normal and disrupted conditions. Financial information is a window into resource availability and recovery potential. Qualitative evidence captures governance practices, organisational behaviour, informal processes, and adaptive mechanisms that cannot be inferred from quantitative observations alone. **No individual category of evidence is sufficient because each represents only a partial perspective of the system under assessment**.

The analytical value of evidence therefore depends on its contribution to a coherent explanation rather than on its individual authority. The Framework evaluates the consistency of interpretations emerging from multiple evidence sources rather than privileging any single category of information. Confidence in assessment findings increases when independent forms of evidence converge towards compatible explanations of system behaviour. Conversely, **inconsistency between evidence sources is treated as an analytical finding requiring explicit examination rather than immediate reconciliation or exclusion**.

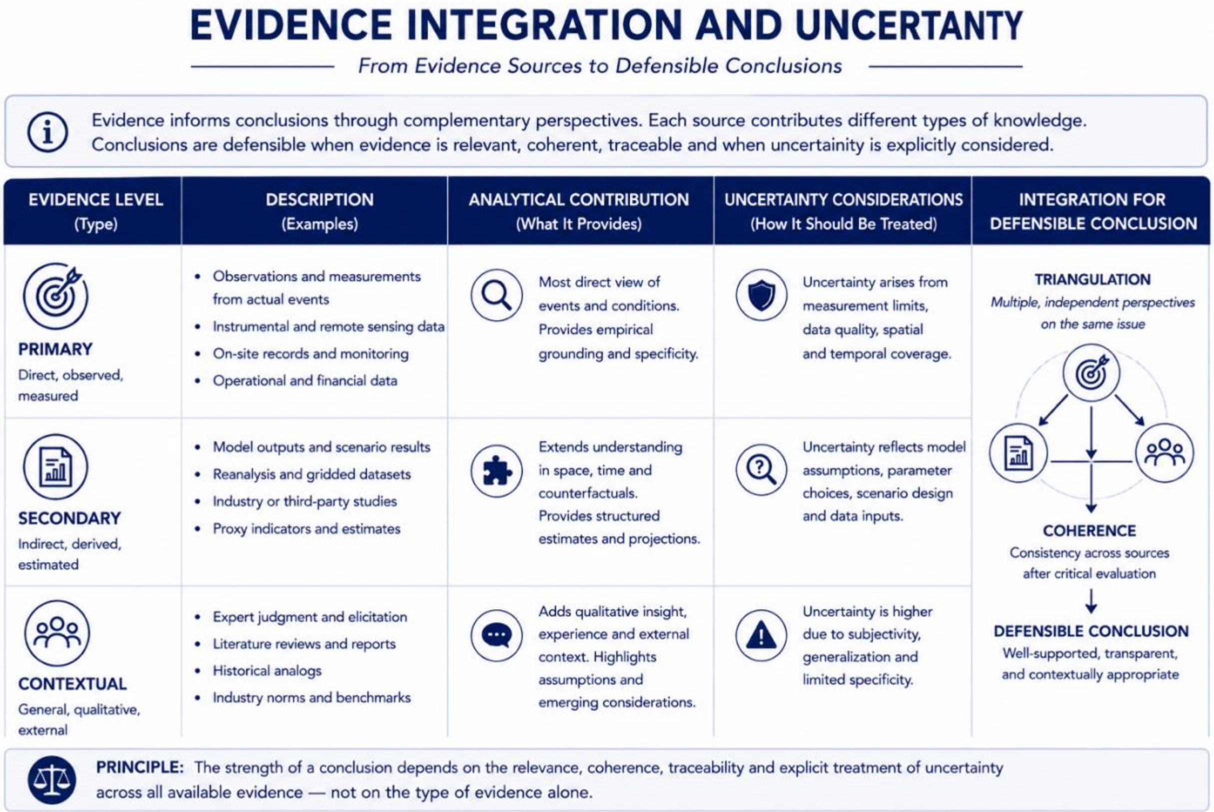

Figure 9. Evidence Integration and Uncertainty in the FTSAI Climate Risk Assessment Framework.

This approach places particular importance on methodological traceability. Every significant assessment conclusion must be linked explicitly to the evidence supporting it, the assumptions guiding its interpretation, and the analytical reasoning through which that conclusion has been derived. **The objective is not merely to document evidence, but to document the reasoning process itself**. Assessment results should therefore remain understandable, reproducible, and open to independent review even where professional judgment plays a substantial role.

Professional judgment is recognised as an essential component of **vulnerability and resilience** assessment rather than as a methodological weakness. The complexity of organisational behaviour, governance arrangements, and adaptive capacity frequently exceeds what can be represented through standardized indicators alone. **The Framework therefore does not seek to eliminate judgment through artificial quantification or excessive formalization. Instead, it disciplines judgment by requiring explicit justification, transparent reasoning, and continuous consistency between evidence, interpretation, and assessment conclusions**.

The same principle governs the treatment of uncertainty. Uncertainty is not interpreted as evidence failure, nor is it regarded as a deficiency that should be concealed through unsupported assumptions or numerical precision. Incomplete information, conflicting observations, limited data resolution, and ambiguity regarding future system behaviour constitute legitimate analytical conditions that must remain visible throughout the assessment process. The Framework therefore requires uncertainty to be documented explicitly and carried forward into subsequent stages of analysis rather than being suppressed through premature simplification

An important methodological consequence follows from this position. Assessment reliability is determined less by the quantity of available evidence than by the coherence with which diverse forms of evidence support a consistent interpretation of system behaviour. Additional information does not necessarily improve an assessment if it fails to strengthen or refine the explanatory framework through which **vulnerability and resilience** are understood.

The analytical role of evidence within the Framework is therefore supportive rather than determinative. Evidence informs interpretation, but interpretation remains governed by methodological discipline. By combining heterogeneous evidence with structured analytical reasoning, transparent documentation, and explicit treatment of uncertainty, the Framework ensures that **vulnerability and resilience** assessment remains robust under diverse data conditions, defensible in audit and certification contexts, and scientifically credible without creating an illusion of false certainty.

4.8 Common Misinterpretations and Methodological Pitfalls

Every assessment methodology operates within explicitly defined conceptual and methodological boundaries. Assessment findings remain scientifically valid only while these boundaries are respected. Whenever conclusions are interpreted beyond the conditions under which they were derived, methodological validity is progressively lost, regardless of whether the assessment itself has been performed correctly. The Framework therefore identifies common forms of misuse that arise from violations of these interpretive boundaries rather than from deficiencies in the assessment methodology itself.

The first boundary prohibits the transformation of analytical findings into normative judgments. Vulnerability assessment explains system sensitivity under specified conditions of climatic stress; it does not evaluate managerial competence, organisational quality, or institutional performance. Vulnerability reflects the interaction between hazards, exposure pathways, structural characteristics, and system configuration. Interpreting vulnerability as evidence of incompetence, poor management, or organisational failure therefore exceeds the analytical scope of the Framework and converts diagnostic assessment into evaluative judgment.

A second boundary separates resilience from invulnerability. Resilience mechanisms influence how systems respond once disruption occurs, but they do not eliminate the possibility of disruption itself. Systems possessing substantial resilience may nevertheless experience operational degradation whenever climatic stress exceeds the limits within which their response mechanisms remain effective. Interpreting resilience as immunity therefore extends the concept beyond its methodological definition and attributes capabilities that the assessment is not intended to evaluate.

A third boundary concerns the interpretation of resilience mechanisms. **The existence of contingency plans, technological solutions, financial resources, redundant capacity, or other response arrangements should not by itself be interpreted as evidence of effective resilience**. Within the Framework, resilience is evaluated according to the demonstrated deployability of existing capabilities under realistic operating conditions rather than their formal existence. Crossing this boundary confuses the possession of response mechanisms with the organisational ability to mobilize them effectively under climatic stress and may therefore substantially overestimate resilience.

A fourth boundary preserves the analytical distinction between vulnerability and resilience. These dimensions describe different characteristics of system behaviour and therefore cannot be collapsed into a single composite indicator without losing essential information regarding their interaction. Mechanical aggregation assumes proportional relationships that the Framework explicitly rejects. **Vulnerability and resilience** remain separate analytical constructs whose combined interpretation depends upon contextual analysis rather than arithmetic integration.

A fifth boundary limits the transferability of assessment findings. **Vulnerability and resilience** are evaluated relative to specific hazards, exposure pathways, operational conditions, and organisational configurations. Conclusions that remain valid within one assessment context cannot automatically be generalized to different climatic conditions, hazard environments, or organisational settings. Extending assessment findings beyond the conditions under which they were derived therefore represents a methodological misuse rather than a legitimate analytical inference.

A sixth boundary addresses the interpretation of evidence itself. If the organisation is fragile or robust, the rationale for the assessment should be open to evidence that refutes the original assumption. The selective use of information that supports preconceived conclusions introduces confirmation bias, which gradually destroys the integrity of analysis. **The Framework therefore requires explicit consideration of conflicting evidence, transparent documentation of interpretive decisions, and systematic treatment of uncertainty throughout the assessment process**.

A final boundary governs the downstream application of assessment outputs. **Vulnerability and resilience profiles are designed as diagnostic instruments that support understanding of system behaviour under climatic stress. They are not intended to function as performance rankings, reputational measures, certification outcomes, or** standalone decision criteria. Applying assessment results beyond these methodological limits transforms analytical outputs into normative instruments for which the Framework provides neither conceptual justification nor methodological support.

The methodological implication follows directly from these boundaries. Reliable assessment depends not only upon rigorous analytical procedures but also upon disciplined interpretation of assessment findings within the conceptual limits established by the Framework. By explicitly defining these limits and identifying the forms of misuse that arise when they are exceeded, the Framework preserves analytical integrity, supports responsible downstream application, and ensures that **vulnerability and resilience** assessment remains a scientifically credible tool for understanding organisational behaviour under climatic stress rather than a source of oversimplified judgment or inappropriate decision-making.

5. Readiness and Adaptive Capacity Modules

Overview

Climate risk assessment improves understanding of how climatic hazards may affect an assessed system, but understanding alone cannot influence future outcomes. Hazards remain unchanged, exposure pathways persist, and vulnerability does not diminish simply because it has been identified. **Climate risk can only be managed when assessment findings become an integral component of organisational decision-making**. **The central methodological question addressed by the Readiness and Adaptive Capacity Modules is therefore not whether climate risk has been correctly assessed, but whether that knowledge has been systematically incorporated into organisational governance before disruption occurs**.

Within the Framework, readiness describes the extent to which climate risk considerations have become embedded within the governance structures, planning processes, decision-making arrangements, and resource allocation mechanisms of the assessed entity. **Readiness is evaluated as an operational governance characteristic rather than as evidence of strategic intent**. **Climate risk influences organisational behaviour only when it becomes part of routine decision-making**. Risk that remains external to organisational decisions cannot shape operational priorities, investments, resource allocation, or governance behaviour regardless of the quality of the underlying assessment. **Organisational readiness therefore depends upon the extent to which climate risk considerations have become an ordinary component of managerial decision-making rather than an isolated analytical exercise**.

Readiness alone, however, cannot ensure effective climate risk governance. Governance arrangements that adequately support organisational decisions under present conditions may progressively lose effectiveness as hazard characteristics, exposure pathways, vulnerability profiles, technological capabilities, regulatory expectations, and organisational priorities evolve. **Organisational readiness**, therefore, cannot simply mean maintaining existing governance arrangements. Governance systems should be able to revise decisions, incorporate new knowledge, allocate assets differently and adapt organisational behaviour as climate-relevant conditions change over time.

This ongoing governance capability is referred to as adaptive capacity in the Framework. **Adaptive capacity reflects the ability of governance systems to evolve together with the climate risk environment within which they operate**. Adaptive capacity is analytically distinct from **organisational readiness** but depends upon it. Readiness establishes the governance architecture through which climate-risk information can influence decisions, while adaptive capacity reflects the organisation's demonstrated ability to use that architecture to modify structures, technologies, practices, resource allocation, or governance arrangements in ways that alter its future climate-risk trajectory. Its analytical purpose is therefore to determine whether the organisation can convert governance readiness into sustained structural and behavioural change as climate-relevant conditions evolve.

The relationship between readiness and resilience requires explicit clarification because both contribute to an organisation's ability to manage climate-related disruption. Adaptive governance, however, cannot eliminate every source of uncertainty or prevent every disruptive event. Even organisations characterised by high levels of readiness may eventually encounter climatic conditions that exceed the capacity of anticipatory governance alone. At that point, the analytical focus necessarily shifts from the quality of organisational preparation to the behaviour of the system under stress. This transition defines the conceptual boundary between readiness and resilience. Readiness governs the quality of organisational anticipation and decision-making before disruption occurs. Resilience governs the effectiveness of organisational response once climatic disruption has become operationally significant. Organisations may therefore exhibit substantial resilience despite limited readiness when response capabilities exist without systematic governance integration. Conversely, organisations demonstrating strong readiness may continue to exhibit residual vulnerability where structural constraints limit the range of feasible adaptation options.

Assessment of **readiness and adaptive capacity** consequently provides insight into the maturity of governance arrangements, the effectiveness of organisational decision-making, the ability of institutions to translate climate risk knowledge into operational action, and the governance constraints that may inhibit adaptation despite adequate technical understanding of climate risk. These outputs provide the governance perspective necessary to interpret **vulnerability and resilience** findings within the broader context of organisational adaptation and long-term climate risk management.

By introducing **readiness and adaptive capacity** as distinct but complementary analytical dimensions, the Framework extends climate risk assessment beyond the characterisation of system behaviour toward the evaluation of governance capability itself. Climate risk assessment thereby becomes not only a means of understanding how organisations may be affected by climatic stress, but also a disciplined methodology for evaluating whether governance systems possess the capacity to anticipate change, incorporate new knowledge, continuously adapt organisational decisions, and sustain effective climate risk management under evolving conditions.

Readiness and Adaptive Governance Modules - Extended Methodological Specification

5.1 Conceptualization of Readiness in Climate Risk Management

The preceding modules of the **FTSAI Climate Risk Assessment Framework** examine different dimensions of climate risk itself. **Hazard characterisation** defines the external sources of climatic stress. **Exposure mapping** identifies where those stresses may interact with organisational systems. Vulnerability assessment examines system sensitivity, while resilience assessment evaluates the capacity to maintain functionality and recover once disruption occurs. **Readiness assessment** introduces a fundamentally different analytical perspective. **Its object of assessment is no longer the risk environment or the behaviour of the assessed system under climatic stress, but the governance capability through which climate risk knowledge is translated into organisational action.**

This change in analytical focus is necessary because climate risk knowledge alone cannot influence future outcomes. Awareness of climate-related threats, strategic commitment, and formal governance arrangements do not by themselves modify organisational behaviour. Climate risk begins to influence organisational performance only when governance systems consistently incorporate assessment findings into planning, resource allocation, operational management, and organisational decision-making. The Framework conceptualizes this governance capability as **organisational readiness**.

Readiness therefore reflects the ability of governance systems to transform climate risk knowledge into coordinated organisational action. It does not describe what an organisation knows, what it intends to achieve, or which governance structures formally exist. Instead, it evaluates whether governance is capable of systematically incorporating climate risk into the decisions through which organisational behaviour is directed. Governance systems that routinely integrate climate risk considerations into operational planning, investment decisions, resource allocation, and managerial processes exhibit higher readiness than governance systems in which climate risk remains disconnected from routine organisational decision-making.

This conceptualization distinguishes readiness from climate risk awareness. **Awareness concerns recognition and understanding of climate-related threats. Readiness concerns the operational capability of governance to act upon that understanding**. Organisations may therefore demonstrate sophisticated climate risk awareness while remaining operationally unprepared if governance systems fail to convert knowledge into coordinated organisational decisions.

A similar distinction applies to strategic intent. Climate strategies, adaptation plans, governance policies, and organisational commitments provide evidence that climate risk has been acknowledged as an institutional priority. They do not, however, demonstrate that governance systems consistently influence organisational behaviour in accordance with those intentions. **Readiness therefore evaluates governance in operation rather than governance by declaration**, recognizing that effective climate risk management depends upon implementation rather than formal commitment.

Governance capability cannot be regarded as a static organisational property. The conditions under which governance systems operate continue to evolve as hazard characteristics, exposure pathways, vulnerability profiles, regulatory expectations, technological capabilities, and organisational priorities change over time. Governance arrangements that effectively support decision-making under one set of conditions may progressively lose effectiveness under another. **Readiness assessment** must therefore extend beyond the evaluation of current governance capability and examine whether governance itself remains capable of adapting to changing circumstances.

The Framework evaluates this continuing capability as adaptive capacity. **Adaptive capacity reflects the ability of governance systems to incorporate emerging knowledge, revise assumptions, modify decisions, reallocate resources, and adjust organisational behaviour as climate risk conditions evolve**. Rather than constituting a separate organisational characteristic, adaptive capacity represents the continuing effectiveness of governance in preserving **organisational readiness** under changing conditions.

The distinction between readiness and resilience follows directly from their different objects of assessment. Readiness evaluates governance before climatic disruption occurs by examining the capability of organisational decision systems to anticipate, integrate, and manage climate risk proactively. Resilience evaluates organisational behaviour after climatic stress has become operationally significant by examining the capacity of the assessed system to absorb disturbance, maintain essential functions, and recover operational capability. **Readiness therefore characterises governance under conditions of anticipation, whereas resilience characterises system behaviour under conditions of disruption**.

Readiness is likewise interpreted relative to the specific decision environment within which governance operates. Appropriate governance capability depends upon the hazard context, exposure configuration, vulnerability profile, institutional responsibilities, and operational complexity of the assessed entity. Readiness is therefore assessed against the demands imposed by the organisation's own climate risk environment rather than against universal models of organisational best practice.

By conceptualizing readiness as the capability of governance to transform climate risk knowledge into organisational action, the Framework establishes a clear distinction between the assessment of climate risk and the assessment of climate risk governance. This conceptual shift provides the methodological foundation for all subsequent evaluation of adaptive governance capacity and marks the point at which the Framework moves from analysing organisational exposure to evaluating the capability of organisations to govern that exposure effectively.

5.2 Governance Structures and Decision Authority

Governance structures do not influence organisational behaviour simply because they exist. Policies, committees, reporting lines, and organisational roles acquire practical significance only when they can influence the decisions through which organisations allocate resources, establish priorities, and direct operational activity. **Governance therefore becomes operational not through its formal architecture, but through its capacity to exercise effective decision authority**. The Framework begins **readiness assessment** by examining whether climate risk governance possesses this operational capability.

Decision authority represents the mechanism through which governance translates climate risk knowledge into organisational action. Governance systems lacking effective decision authority may improve organisational awareness, facilitate communication, or provide technical advice, yet remain unable to influence organisational behaviour. **The existence of governance structures is therefore not, by itself, evidence of organisational readiness**. Readiness depends upon whether governance possesses the authority necessary to shape organisational decisions under conditions of climate-related uncertainty.

The emergence of effective decision authority requires clearly defined responsibility. Governance cannot influence organisational behaviour where responsibility for climate risk decisions remains fragmented, ambiguous, or inconsistently assigned. Unless governance establishes who is expected to evaluate climate risk, coordinate organisational responses, and authorize action, climate risk knowledge remains disconnected from the decisions through which organisations operate. **Clear allocation of responsibility therefore constitutes the first operational condition through which governance acquires effective decision authority**.

Decision authority must also possess sufficient organisational legitimacy to influence behaviour. Governance arrangements operating solely as advisory committees, informal working groups, or consultative functions may contribute valuable expertise while remaining unable to alter organisational priorities, investment decisions, operational controls, or resource allocation. **The Framework therefore distinguishes between governance that provides recommendations and governance that possesses the authority to influence organisational outcomes. Readiness depends upon the latter**.

Authority that cannot operate under conditions of uncertainty remains operationally incomplete. Climate-related risks frequently emerge gradually, requiring governance systems capable of escalating concerns before operational disruption becomes evident. Effective escalation mechanisms therefore represent a further operational condition of decision authority. Where escalation pathways are absent or poorly defined, governance may retain formal authority while losing the practical ability to influence decisions when timely intervention is most needed.

Decision authority must also be embedded within the ordinary governance processes through which organisations operate. Governance mechanisms functioning outside strategic planning, financial management, investment approval, or executive oversight rarely influence organisational behaviour regardless of their technical quality. **Climate risk governance becomes operational only when it participates directly in the routine decision processes that shape organisational priorities**. The Framework therefore evaluates governance integration rather than governance isolation.

Finally, decision authority requires accountability if governance decisions are to produce sustained organisational learning and behavioural change. Authority that cannot be linked to identifiable responsibility, evaluation, and organisational learning gradually loses its practical effectiveness.

Accountability therefore reinforces decision authority by ensuring that governance decisions remain visible, reviewable, and capable of influencing future organisational behaviour.

Governance structures, responsibility, organisational legitimacy, escalation mechanisms, integration, and accountability should not be interpreted as independent governance characteristics. Together they represent the operational conditions through which governance acquires the capability to influence organisational decisions. By evaluating these conditions as components of a single operational mechanism, the Framework ensures that **readiness assessment** reflects the practical effectiveness of climate risk governance rather than its formal organisational appearance.

5.3 Integration of Climate Risk into Planning and Operations

Organisational readiness is ultimately expressed through decisions. Organisations do not adapt to climate risk because they possess governance structures, policies, or risk assessments; they adapt because climate-related information influences the decisions through which strategy is formulated, resources are committed, operations are executed, and organisational responses are activated. **Consequently, the assessment of readiness cannot be based solely on the existence of governance mechanisms. It must determine the extent to which climate risk has become an active determinant of organisational decision-making**.

This perspective requires a distinction between **procedural inclusion** and **substantive integration**. Procedural inclusion means formally recognizing climate risk in governance arrangements, planning processes or organisational documentation. Substantive integration exists only when climate-related information modifies organisational judgement and changes the decisions that shape organisational behaviour. **Since organisational readiness concerns the capacity to act rather than the intention to act, the Framework evaluates substantive integration rather than procedural compliance**.

Substantive integration, however, cannot occur simultaneously across the organisation. Organisational decisions are not homogeneous but form a hierarchy in which higher-level decisions define the context within which subsequent decisions are made. Climate risk therefore becomes progressively embedded within the organisation through successive layers of decision-making. Each layer represents a deeper level of organisational integration and provides stronger evidence that climate risk has become an intrinsic component of organisational behaviour.

The first layer of integration is strategic decision-making. Strategy establishes the long-term direction of the organisation and determines the priorities through which future resources will be committed. If climate risk does not influence strategic judgement, its subsequent appearance elsewhere in the organisation can only represent localized operational adaptation rather than genuine organisational integration. The Framework therefore examines whether climate-related opportunities, constraints, and uncertainties influence strategic objectives, investment priorities, asset portfolios, growth strategies, and business development decisions. Strategic integration is demonstrated only when climate considerations alter strategic judgement itself.

Strategic integration alone, however, does not establish **organisational readiness**. Organisational strategies acquire practical significance only through their implementation. **The second layer of integration therefore concerns operational decision-making**. At this level, the Framework looks at whether climate risk is integrated into decisions and activities related to production planning, maintenance scheduling, logistics, inventory management, procurement activities, operational sequencing and resource deployment. Climate risk is operationalized when it informs the routine organisational activity rather than being a conceptual strategic consideration.

Operational decisions primarily influence current organisational performance. Investment decisions, by contrast, determine future organisational capabilities. They therefore constitute a deeper level of substantive integration because they reveal whether climate risk influences commitments whose consequences extend over decades. The Framework accordingly examines whether climate considerations influence asset design, site selection, technology selection, infrastructure specifications, expected asset lifetimes, and capital investment approval processes. **Organisations that recognise climate risk while allowing investment decisions to remain unchanged demonstrate procedural awareness rather than substantive integration**.

The progressive embedding of climate risk extends beyond the organisation's internal boundaries. **Procurement and supply chain decisions determine the resilience of critical external dependencies and therefore represent the next layer of organisational integration**. The Framework assesses whether climate-related disruption is a specific decision criterion in supplier selection, contracting, supplier diversification, and contingency capacities. **Integration is shown by incorporating climate resilience into the supplier selection process, rather than looking at it after procurement decisions have been made.**

Substantive integration becomes most evident when organisations must make decisions under conditions of disruption. Contingency planning, business continuity arrangements, stress-testing exercises, emergency response procedures, and operational simulations reveal whether climate risk continues to influence decisions under conditions of uncertainty and operational pressure. The Framework therefore examines whether these activities are linked to clearly defined decision authorities, escalation mechanisms, and resource mobilization procedures, ensuring that preparedness represents an executable **organisational capability** rather than a procedural requirement.

The sequence from strategic direction to operational execution, long-term investment, external dependencies, and organisational response is not simply a classification of organisational functions. It represents the progressive hierarchy through which climate risk becomes embedded within organisational decision-making. **Readiness therefore increases not because additional procedures are introduced, but because climate risk exerts influence over progressively more consequential decisions**. **Integration, in this sense, constitutes the mechanism through which governance is translated into adaptive capacity**, transforming climate risk from an object of assessment into a determinant of organisational behaviour.

5.4 Monitoring, Feedback, and Adaptive Learning

Adaptive governance depends on the continuous ability to observe changing conditions, evaluate organisational responses, and incorporate experience into future decisions. Within the Framework, monitoring, feedback, and adaptive learning are therefore treated as essential components of **organisational readiness** rather than as supplementary governance activities. **Readiness assessment** consequently extends beyond the existence of monitoring systems to examine whether they generate information that is sufficiently relevant, timely, and operationally meaningful to support organisational judgement.

Monitoring encompasses more than the observation of climatic hazards. It also includes changes in organisational exposure, system performance under stress, and the effectiveness of implemented adaptation measures. **Technical sophistication alone does not constitute evidence of readiness**. **What matters is whether monitoring produces information that reaches decision-makers in time to influence organisational action**.

Review provides the connection between information and governance. Monitoring may generate large volumes of data, yet data alone have little organisational value. The Framework therefore examines whether monitoring outputs are systematically interpreted, discussed within appropriate governance structures, and translated into decisions. Where monitoring exists without review, or review produces no organisational response, readiness remains inherently limited.

Feedback mechanisms extend this process. Their function is to convert observed outcomes into revised assumptions, updated plans, modified priorities, and adjusted resource allocation. **The quality of feedback is therefore judged by its capacity to influence subsequent organisational behaviour rather than by the quantity of information collected**.

Adaptive learning represents the organisational consequence of effective feedback. The Framework evaluates learning as an observable capability reflected in documented changes to procedures, investments, governance arrangements, or planning assumptions following stress events, near misses, implementation experience, or emerging climate trends. Informal learning or learning that is not linked to organisational decision making is poor evidence of adaptive readiness.

Uncertainty does not block learning. By contrast, organisations tend to be adaptive where information is incomplete and future states are uncertain. **Iterative adjustment, experimentation and openness to revise prior assumptions are therefore interpreted as signs of stronger adaptive capability**, even when structural vulnerabilities remain constraining outcomes.

The reverse is true of the same. Adaptive learning is not guaranteed by formal monitoring or review procedures. Adaptive learning is weak where similar disruptions are repeated without changes to governance arrangements, operational practices or planning assumptions.

Ultimately, monitoring, review, feedback, and adaptive learning derive their value from their collective influence on organisational decisions. Their purpose is not simply to observe climate risk but to enable organisations to revise judgement before changing conditions undermine strategic or operational objectives. **For this reason, the Framework treats adaptive readiness as a continuing governance capability through which evidence is transformed into organisational action rather than merely accumulated within monitoring systems**.

5.5 Decision-Making under Uncertainty

Climate risk decisions cannot be separated from uncertainty. The evolution of hazards, the exposure of organisational systems, and the effectiveness of future responses can never be established with complete certainty before decisions are made. Consequently, organisations are required to act despite incomplete information and continuously changing conditions. Under these circumstances, **the quality of climate risk governance depends less on predicting the future correctly than on the discipline with which decisions are made**. For this reason, the Framework evaluates the structure and quality of decision-making processes rather than the outcomes that eventually emerge.

Once uncertainty is recognised as an inherent property of climate risk, it can no longer be regarded as a weakness of governance or analysis. The relevant question is therefore not whether uncertainty exists, but whether it is explicitly acknowledged and systematically incorporated into organisational judgement. Readiness is strengthened where uncertainty is documented, communicated transparently, and reflected in decision rationales instead of being ignored, minimized, or concealed behind unwarranted certainty. **The explicit treatment of uncertainty therefore becomes an indicator of decision maturity rather than evidence of analytical limitation**.

Recognizing uncertainty, however, is only the starting point. Decision processes must also remain robust despite it. The Framework therefore examines whether decisions are supported by conditional reasoning, consideration of alternative scenarios, appropriate safety margins, reversibility where feasible, and avoidance of irreversible commitments based upon narrow assumptions. **Robust decisions are not those that prove correct under one future. They are those capable of remaining defensible across a range of plausible future conditions**.

This distinction explains why the Framework deliberately avoids penalizing organisations simply because they operate in highly uncertain environments. Climate risk management inevitably involves incomplete knowledge, evolving evidence, and changing external conditions. **Readiness is therefore evaluated according to the adequacy of the decision process used to manage uncertainty rather than according to the amount of uncertainty surrounding the decision itself**.

The same principle extends to communication. Decision-makers cannot exercise informed judgement unless the assumptions, limitations, and remaining uncertainties underlying available information are communicated clearly throughout the governance structure. **Readiness is therefore weakened**

whenever uncertainty is obscured or replaced by deterministic narratives that create confidence unsupported by available evidence.

Decision quality also needs to be flexible over time. New evidence may undermine previous assumptions, change exposure patterns or reveal hitherto unknown vulnerabilities. Therefore, the Framework considers if governance arrangements provide for the revisiting of decisions, the periodic re-examination of assumptions and the adjustment of organisational responses without undue delay. **Governance systems that preserve obsolete assumptions despite changing conditions provide weaker evidence of readiness than those capable of continuous revision**.

The Framework therefore distinguishes disciplined decision-making from fortunate outcomes. **Organisational readiness** is not demonstrated because decisions eventually prove successful, nor weakened because uncertain events develop differently than anticipated. **Instead**, **readiness reflects the organisation's continuing ability to make transparent**, **well-reasoned**, **and adaptable decisions despite the unavoidable uncertainty that characterises climate risk itself**.

5.6 Institutional Coordination and External Interfaces

Internal governance alone cannot fully explain an organisation's readiness for climate risk. Many of the decisions that determine exposure, vulnerability, and adaptive response depend upon actors operating beyond organisational boundaries. Suppliers, financial institutions, regulators, infrastructure providers, insurers, and public authorities all influence conditions that individual organisations cannot control independently. If readiness were assessed exclusively through internal governance arrangements, an important part of adaptive capacity would remain outside the assessment itself.

Readiness must therefore include the organisation's capacity to operate within this wider institutional environment. Climate adaptation rarely results from isolated organisational decisions. It depends upon coordination among multiple actors whose actions become mutually dependent during both routine operations and disruptive events. **Institutional coordination is consequently not an additional governance activity but a necessary component of adaptive readiness**.

This explains why the Framework examines the mechanisms through which organisations coordinate beyond their own boundaries. Information sharing, communication protocols, data exchange arrangements, formal agreements, and established collaborative practices are evaluated because they enable coordinated action rather than because they exist as administrative arrangements. **Their contribution to readiness depends upon their ability to support organisational decisions before, during, and after disruptive events**.

Coordination, however, cannot be reduced to communication alone. Organisations may exchange information effectively while remaining unable to act collectively because institutional incentives pull decisions in different directions. While there is widespread knowledge of climate risk, adaptation may be constrained by contractual obligations, regulatory requirements, financial arrangements and competing organisational priorities. **The Framework thus assesses the extent to which institutional relationships enable or systematically constrain coordinated adaptation**.

The same relationships should also be robust outside normal operating conditions. Coordination mechanisms that seem to work in normal times may break down under strain when resources are scarce, priorities conflict, or institutional fragmentation increases. Readiness is therefore strengthened where external coordination arrangements have been clarified, exercised, or reinforced specifically for adverse conditions rather than assumed to function automatically during disruption.

This reasoning also explains why strong internal governance cannot, by itself, demonstrate **organisational readiness**. Adaptive action may ultimately depend upon institutions over which the organisation exercises little or no direct control. **The Framework therefore avoids overestimating readiness on the basis of internal capabilities alone by explicitly incorporating institutional dependencies into the assessment**.

Readiness is therefore determined not by the degree of control an organisation exercises over external actors but by its ability to recognise institutional dependencies, sustain effective coordination, and integrate those relationships into planning and decision-making. **Institutional coordination thus emerges as a necessary condition for credible climate risk readiness rather than as a supplementary element of organisational governance**.

5.7 Evidence Typology and Documentation Standards

Readiness cannot be assessed simply by collecting evidence. The same body of documentation may either reveal genuine **organisational capability** or create a misleading impression of preparedness, depending on how that evidence is interpreted. **Credible assessment therefore depends not only on the availability of evidence but also on the principles governing its evaluation**. For this reason, the Framework establishes an evidence typology together with documentation standards that ensure evidence contributes to understanding **organisational readiness** rather than merely demonstrating organisational activity.

This requirement explains why **no individual evidence source is regarded as sufficient in isolation**. Governance records, decision logs, planning documents, operational adjustments, investment rationales, monitoring outputs, and stakeholder engagement practices each illuminate different aspects of organisational behaviour. Only when these sources are interpreted collectively can they provide a reliable representation of how climate risk has influenced governance, operational decisions, and adaptive action.

The value of evidence therefore depends less upon its volume or formal presentation than upon its capacity to establish traceable links between climate risk considerations and organisational decisions. The Framework consequently emphasizes traceability, internal consistency, and demonstrable decision influence rather than compliance with predefined documentation formats. **Evidence is evaluated according to what it explains about organisational behaviour, not according to how extensively it has been documented**.

This principle guides the interpretation of individual evidence categories. Governance records are reviewed for decision authority, accountability, and escalation paths. We review the decision logs and meeting records to see if climate-related assumptions, uncertainty, and decision rationale are discussed explicitly. Operational evidence is interpreted through documented changes in practices, processes or resource allocation that show climate risk considerations have influenced organisational action.

The same reasoning extends beyond internal documentation. Stakeholder engagement becomes meaningful evidence only where information exchange, institutional coordination, or joint decision-making contributes directly to **organisational readiness**. Documentation of engagement is therefore evaluated according to its influence on decisions and adaptive action rather than the frequency of consultations or communications themselves.

This distinction also explains why **the Framework separates documentary presence from documentary function**. Limited evidence of readiness is provided by documents that do not affect decisions, do not initiate reviews, or do not support adaptation. In contrast, if short documentation clearly shows the influence on decisions and has the intent for adaptivity, it can be strong evidence.

Evidence must also remain internally coherent. **Apparent inconsistencies between documented policies, observed decisions, and operational behaviour are not reconciled through assumption but treated as assessment findings**. Such divergence may reveal important characteristics of **organisational readiness** that would otherwise remain hidden.

Finally, documentation itself must reflect the uncertainty inherent in climate risk management. Assumptions, limitations, and remaining uncertainties are therefore recorded explicitly rather than removed through selective documentation or retrospective justification. Transparent acknowledgement of incomplete knowledge strengthens assessment credibility because it allows evidence to be interpreted within its proper decision context.

Taken together, these principles transform evidence from a collection of organisational documents into a structured basis for scientific assessment. **Readiness is therefore supported not by the quantity of documentation available but by the extent to which evidence provides a consistent, traceable, and decision-relevant explanation of organisational capability**.

5.8 Common Failure Modes in Readiness Assessment

No assessment methodology can be considered scientifically reliable unless it explicitly recognises the conditions under which its conclusions may become misleading. Climate risk readiness is particularly susceptible to systematic assessment errors because preparedness is often inferred from indirect evidence, organisational intentions, or historical experience rather than from demonstrated adaptive capability. **Identifying these recurring failure modes is therefore not a supplementary analytical exercise but a necessary condition for maintaining methodological credibility**.

One such failure arises when organisational intent is confused with organisational capability. Policies, strategies, and formal commitments may indicate awareness of climate risk, yet they provide little evidence that an organisation can respond effectively when adaptation becomes necessary. **Readiness therefore cannot be inferred from policy existence alone**. The Framework recognises such instruments as meaningful evidence only where implementation, periodic review, and demonstrable influence on organisational decisions can also be established.

The same distinction applies to organisational planning. Contingency plans and adaptation strategies frequently exist as static documents whose assumptions have not been systematically revisited and whose implications have not been incorporated into subsequent organisational decisions. **Their existence may create an appearance of preparedness while contributing little to actual adaptive capability**. The Framework therefore evaluates the continuous revision of such plans and their demonstrable integration into governance, planning, resource allocation, and organisational decision-making rather than their formal existence.

A different source of error emerges when past success is interpreted as evidence of future readiness. Organisations often operate successfully under conditions that differ substantially from those they are likely to encounter in the future. Hazard regimes evolve, institutional relationships change, and patterns of exposure shift over time. Historical performance therefore provides only limited evidence unless current decision processes and adaptive capability are evaluated directly.

Readiness may also be systematically overestimated when institutional dependencies remain outside the assessment. Internal governance may be strong but successful adaptation also depends on external actors whose objectives, incentives or ability to operate cannot be assumed to remain aligned. Ignoring these interdependencies risks imputing to organisations an adaptive capability they cannot independently exercise. Thus, the Framework embeds institutional coordination as an essential component of a **readiness assessment** rather than as an external consideration.

A further source of distortion arises when assessments depend heavily on self-reported claims of preparedness, retrospective rationalizations of past decisions, or selective presentation of supporting evidence. Such practices are likely to reinforce optimistic readings while obscuring organisational weaknesses and remaining uncertainty. The Framework addresses this risk through requirements for traceable evidence, consistency across multiple sources, and explicit documentation of uncertainty throughout the assessment process.

These failure modes should not be interpreted as isolated methodological weaknesses. **Together they define the principal mechanisms through which readiness may be systematically overestimated**. Their explicit identification therefore strengthens the credibility of the assessment itself by ensuring that **adaptive capability is distinguished from intention, documentation, historical fortune, or**

institutional optimism. In this sense, recognizing failure modes becomes an integral component of scientific assessment rather than a concluding methodological precaution.

5.9 Implications for Certification and Downstream Applications

The value of **readiness assessment** extends beyond the production of assessment findings. Its practical significance depends upon how those findings are interpreted and applied within subsequent decision processes. Without clear methodological boundaries, readiness outputs may be misunderstood, overextended, or used for purposes they were never intended to support. **The Framework therefore defines explicitly the role that readiness assessment plays within certification activities and other downstream applications**.

Certification represents one of the principal contexts in which readiness findings acquire practical value. Assessment outputs provide essential context for understanding whether identified climate risks are recognised, governed, and incorporated into organisational decision-making through credible adaptive processes. **They assist certification bodies in interpreting governance capability relative to observed exposure, vulnerability, and resilience without serving as independent determinants of certification outcomes**.

This distinction is fundamental to the methodology. **Readiness assessment** informs certification; it does not determine certification. Its role is to illuminate the quality of governance arrangements, decision authority, escalation mechanisms, and adaptive discipline so that audit findings can be interpreted more accurately. **Independent verification of organisational performance, operational controls, and achieved outcomes remains outside the scope of readiness assessment itself**.

Maintaining this methodological separation also improves differentiation between organisations operating under similar climate conditions. Comparable exposure does not necessarily imply comparable readiness. Organisations demonstrating systematic integration of climate risk into governance and decision-making may therefore be interpreted differently from organisations relying primarily upon formal policies or aspirational commitments, even where external risk conditions remain broadly similar.

The usefulness of **readiness assessment** extends well beyond certification. Financial analysis, investment due diligence, insurance assessment, strategic planning, and public policy all require informed judgement regarding an organisation's capacity to adapt under uncertain conditions. **Within these contexts, readiness findings function as interpretive evidence supporting evaluations of governance reliability, adaptive behaviour, and decision credibility rather than as predictions of future performance**.

For the same reason, the Framework discourages treating readiness outputs as compliance checklists, organisational rankings, or proxy measures of future success. Such interpretations confuse governance capability with guaranteed performance and overlook the dynamic nature of adaptive readiness. **Assessment findings should therefore inform professional judgement rather than replace it**.

The methodological value of **readiness assessment** ultimately depends upon preserving these boundaries. By distinguishing clearly between readiness evaluation and the decisions that subsequently rely upon it, the Framework strengthens interpretive transparency while protecting **methodological integrity**. Readiness outputs therefore support responsible application across certification, financial, regulatory, and strategic contexts without reducing adaptive governance to a compliance exercise.

5.10 Summary of Methodological Position

The analytical chain of the **FTSAI Climate Risk Assessment Framework** remains incomplete until risk identification is connected to an entity's capacity to make decisions and implement adaptive action. Exposure, vulnerability, and resilience explain where climate risk exists and how systems may respond, but they do not establish whether organisations can act upon that knowledge. **The readiness and**

adaptive governance modules complete this analytical progression by evaluating whether climate risk information is translated into credible institutional decisions and adaptive behaviour.

This methodological role explains why the Framework emphasizes actionability rather than formalism. Organisational awareness, policy commitments, and strategic intentions provide only limited evidence unless climate risk considerations become embedded within governance structures, planning processes, and decision pathways capable of influencing operational behaviour. **Readiness therefore reflects the practical integration of climate risk into organisational decision-making rather than the existence of formal governance instruments alone**.

The same reasoning requires readiness to be interpreted as a dynamic organisational property rather than a static condition. Governance arrangements, decision authority, learning mechanisms, and institutional coordination continuously evolve as risk conditions change. Consequently, compliance, procedural conformity, or extensive documentation cannot by themselves demonstrate readiness unless they contribute to observable adaptive capability and decision influence.

This view further reinforces the institutional realism underlying the Framework. Organisations generally do not operate in ideal circumstances. Organisational structures, external dependencies, regulatory environments and resource constraints shape decisions about what adaptation is practically achievable. **Readiness assessment** thus looks at how organisations govern and navigate these realities as opposed to how closely they match abstract models of best practice.

This distinction is preserved to maintain the coherence of the analytical framework as a whole. **Exposure mapping identifies where hazards interact with organisational systems. Vulnerability and resilience assessment explain the sensitivity and response characteristics of those systems. Readiness assessment then determines whether these analytical in**sights are recognised, governed, and translated into credible organisational action through disciplined decision processes.

This distinction also clarifies the limits of **readiness assessment**. Readiness strengthens the credibility of adaptive action, but it does not eliminate uncertainty or guarantee favourable outcomes. Conversely, limited readiness may amplify climate risk even where exposure or vulnerability appear comparatively moderate because governance constraints reduce an organisation's capacity to respond effectively.

The methodological contribution of the readiness and adaptive governance modules therefore extends beyond the assessment itself. **By connecting analytical understanding with organisational decision capability, they transform climate risk assessment from a descriptive exercise into a decision-relevant governance framework**. This last step helps to ensure the internal consistency of the **FTSAI Framework** while also enabling its responsible use in certification, financial analysis, policy development and other downstream applications.

6. Module Integration and Assessment Flow

The sequence of the FTSAI Climate Risk Assessment Framework is not procedural convenience but methodological necessity. **Each analytical module depends upon information established by the preceding stage**, and altering this sequence would weaken the interpretability of subsequent findings. **The assessment flow therefore defines the logical dependencies through which climate risk is progressively transformed from environmental conditions into governance-relevant conclusions**.

The process necessarily begins with hazard characterisation because no assessment can evaluate organisational consequences before identifying the climatic and weather-related stressors that define the external risk environment. **Hazard characterisation** establishes this analytical reference point without assuming either probability or organisational impact. Only once relevant hazards have been identified does it become possible to examine where they intersect with organisational systems.

Exposure mapping provides this next analytical step. It identifies the assets, activities, processes, and dependencies through which previously identified hazards may influence organisational operations.

Without explicit exposure pathways, subsequent assessment of vulnerability or resilience would lack a defined analytical object, making system response impossible to interpret consistently.

Vulnerability and resilience assessment therefore depend directly upon the outputs of exposure mapping. Vulnerability is the assessment of the likelihood that exposed systems will respond to identified stressors; resilience is the assessment of the ability of those systems to absorb disruption, adapt, and recover. These modules explain the behaviour of exposed systems, but they do not determine whether organisations possess the capability to respond appropriately.

That remaining question is addressed through the readiness and adaptive governance modules. **Readiness assessment** evaluates whether analytical understanding generated during earlier stages is translated into governance arrangements, decision processes, and adaptive action. **Without this final step, the Framework would describe climate risk without establishing whether the organisation possesses the capacity to respond to it. This dependency between modules also explains why the Framework supports iterative reassessment without sacrificing methodological consistency.** A distinction must nevertheless be maintained between the directional sequence of primary assessment and the pathways through which reassessment may subsequently occur. Primary assessment follows the established analytical sequence because each stage depends upon information generated by the preceding stage. Reassessment, however, is triggered by material changes in the assessed system, its external environment, or the evidence upon which previous conclusions were based.

Such changes do not necessarily propagate only downstream through the analytical architecture. Updated hazard information may change exposure pathways, undermine the assumptions behind **vulnerability and resilience** assessments, or expose the limitations of existing arrangements for governance and adaptation. Similarly, governance decisions may modify exposure through relocation, supplier diversification, infrastructure investment, or changes in operating practices, while adaptation measures may alter **vulnerability and resilience** characteristics. **The point at which change originates therefore does not determine the direction in which its analytical consequences must be examined**.

Reassessment consequently follows material causal dependencies rather than the formal ordering of modules. When new information or organisational change affects a previous assessment finding, the Framework requires identification of all analytically dependent conclusions that may also have been affected. **Only those components for which a material dependency can be established require reassessment**. Once affected components have been identified, however, their re-evaluation continues to respect the conceptual boundaries, evidentiary requirements, and logical dependencies governing the primary assessment.

This distinction allows the Framework to represent climate risk as a dynamic and adaptive system without sacrificing analytical traceability. **Primary assessment is sequential because knowledge must be constructed in a disciplined order; reassessment is potentially recursive because the system itself evolves through feedback, organisational action, and changing environmental conditions**. Iteration may therefore move across the analytical architecture, but the methodological logic governing each assessment relationship remains unchanged.

This flexibility must be maintained through disciplined integration across the assessment chain. Within the primary assessment sequence, outputs of one module provide analytical inputs to subsequent modules, preserving traceability and preventing conclusions based on implicit assumptions or circular reasoning. **Every transition is therefore documented rather than inferred**, ensuring that analytical conclusions remain transparent throughout the assessment process.

The assessment flow consequently represents more than the order in which modules are applied. It defines the logical architecture through which evidence is progressively transformed into organisational judgement. By preserving these analytical dependencies while allowing proportionate iteration, the Framework combines methodological rigor with practical flexibility and provides a coherent foundation for certification, periodic reassessment, and ongoing climate risk management. The resulting workflow, including the feedback pathways supporting iterative reassessment, is summarized in Figure 10.

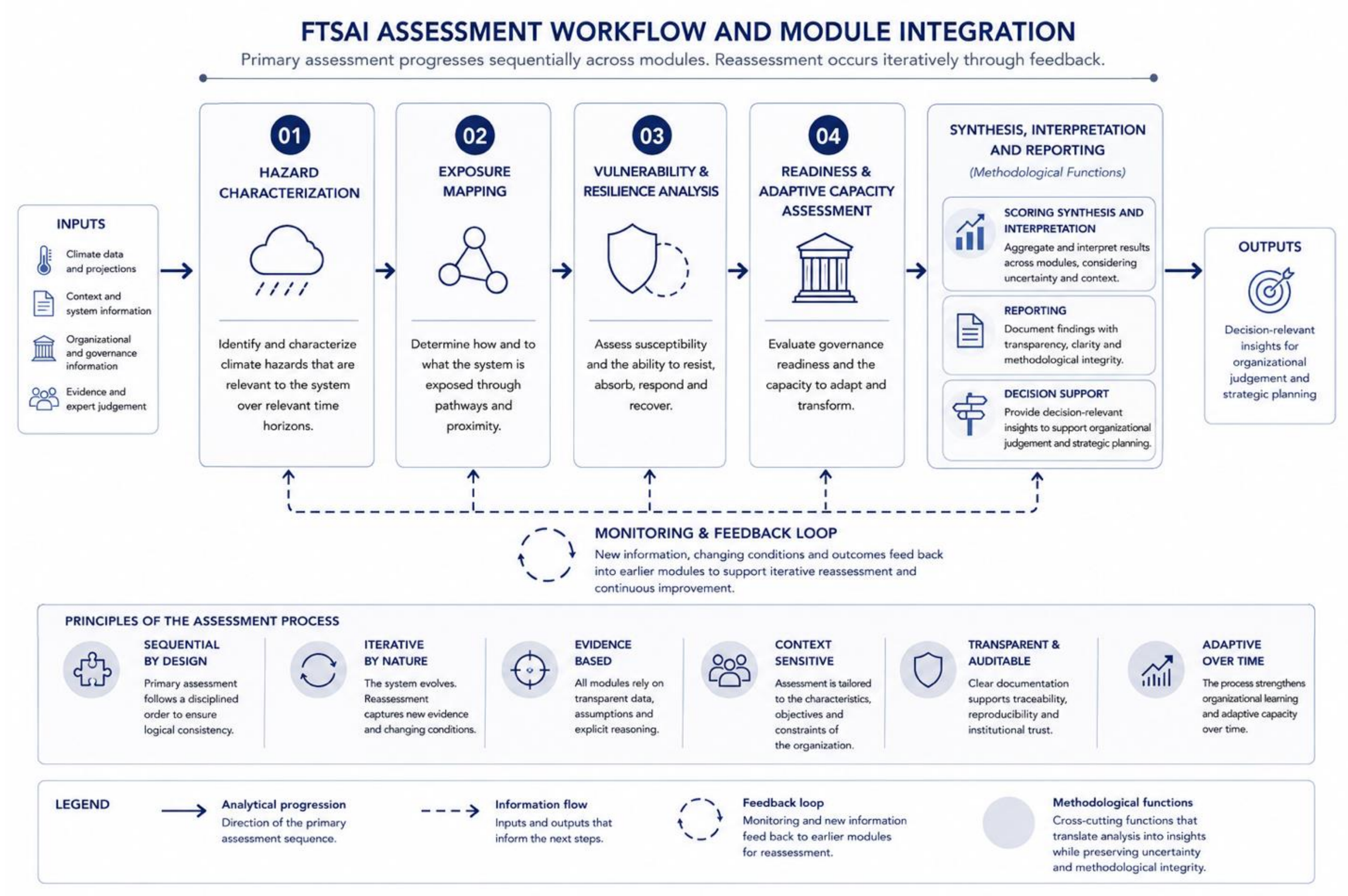

Figure 10. Assessment workflow and module integration within the FTSAI Climate Risk Assessment Framework, showing the directional progression of primary assessment and the feedback pathways supporting iterative reassessment.

Part III

Extended Scoring Logic, Uncertainty Treatment, and Interpretation Discipline

1. Treatment of Uncertainty and Incomplete Information

Every climate risk assessment ultimately requires judgments to be made before complete knowledge is available. Waiting until uncertainty disappears would make assessment impossible, while ignoring uncertainty would make its conclusions unreliable. The methodological challenge is therefore neither to eliminate uncertainty nor to postpone decisions indefinitely, but to ensure that decisions remain scientifically defensible despite incomplete information and evolving system behaviour. Within the **FTSAI Climate Risk Assessment Framework**, **uncertainty is consequently treated as a defining characteristic of assessment rather than as an analytical weakness to be minimized**.

This position reflects the nature of climate risk itself. **Uncertainty does not originate from a single source that can be corrected through additional analysis or improved data collection**. Instead, it emerges from several independent mechanisms operating simultaneously throughout the assessment process. Climatic variability, imperfect information, limitations of analytical models, and adaptive institutional behaviour each introduce uncertainty for fundamentally different reasons. Their combined effect defines the conditions under which climate risk assessment must operate.

Attempts to overcome this challenge through forced precision, excessive quantification, or deterministic scoring ultimately weaken rather than strengthen the assessment. Such approaches replace explicit uncertainty with implicit assumptions, creating an appearance of certainty that the available evidence cannot justify. The Framework therefore adopts a disciplined approach based on transparency, robustness, and interpretive restraint, ensuring that uncertainty remains visible instead of being concealed by apparently precise outputs.

The first source of uncertainty arises from the information on which assessment depends. Historical records may be incomplete, measurements may contain error, datasets may differ in quality or resolution, and direct observations are often replaced by proxy indicators. These limitations constrain the representation of hazards, exposure, vulnerability, and readiness even before analytical interpretation begins. Because they cannot always be eliminated, their implications are documented explicitly and carried forward throughout the assessment.

Even if these **information limitations** were fully resolved, uncertainty would remain because the systems being assessed are inherently complex. Climate risk develops through non-linear interactions, threshold effects, feedback mechanisms, and evolving relationships between hazards, exposure, vulnerability, and adaptive capacity that cannot be represented exhaustively within any analytical model. **Structural uncertainty** therefore reflects the limits of current knowledge rather than deficiencies in assessment practice and remains irreducible within practical decision horizons.

A further source of uncertainty persists even where both evidence and analytical understanding are strong. Organisations, regulators, markets, and other institutional actors continuously adapt their behaviour in response to changing conditions. These decisions alter exposure pathways, vulnerability profiles, and resilience characteristics while the assessment itself is being conducted. **Decision uncertainty** therefore becomes an endogenous feature of the assessment process rather than an external source of analytical noise.

Because these forms of uncertainty arise from different mechanisms, they cannot be represented meaningfully through a single confidence score or probabilistic adjustment. The Framework instead documents uncertainty explicitly within each module and preserves it throughout aggregation and synthesis so that decision-makers remain aware of both the assessment findings and the limits within which those findings should be interpreted.

This methodological position also shapes the interpretation of assessment outputs. **High uncertainty does not automatically diminish the value of an assessment, nor does it justify mechanical reductions in scores or readiness evaluations**. Instead, it requires greater **interpretive discipline**. Conclusions are expressed through conditional reasoning, sensitivity to assumptions, and plausible alternative outcomes rather than deterministic rankings or artificial precision.

The unavoidable consequence is that credible climate risk assessment depends not on eliminating uncertainty but on governing it transparently throughout the analytical process. By preserving uncertainty instead of concealing it, the **FTSAI Climate Risk Assessment Framework** supports scientifically defensible judgement while remaining aligned with the realities of complex socio-environmental systems and the practical demands of certification, regulation, and strategic decision-making.

2. Robustness and Consistency Checks

The value of a climate risk assessment depends not only on the conclusions it reaches but also on the confidence that those conclusions legitimately deserve. Decision-makers must therefore understand whether assessment findings remain reliable beyond the specific assumptions under which they were produced. Without such scrutiny, conclusions that appear persuasive may derive their apparent strength from fragile evidence, narrow assumptions, or accidental agreement across analytical stages rather than from genuine analytical robustness. For this reason, **the FTSAI Climate Risk Assessment Framework incorporates robustness, and consistency checks as integral elements of the assessment itself rather than as post hoc validation procedures**.

Robustness assessment begins from a simple methodological question: **would the principal interpretation remain essentially unchanged if the assessment were repeated under other equally plausible assumptions?** If relatively modest changes in contextual conditions, analytical inputs, or interpretive assumptions lead to fundamentally different conclusions, confidence necessarily shifts away from the conclusion itself and toward understanding why those assumptions exercise such influence. **Only findings that remain broadly stable across plausible alternatives justify greater interpretive confidence**.

This principle also determines how robustness findings are reported. The objective is not to identify a single “correct” interpretation by eliminating alternatives, but to distinguish conclusions that remain dependable across different analytical conditions from those that depend upon specific assumptions. Where such dependence exists, the Framework records it explicitly so that subsequent decisions remain proportionate to the actual strength of the supporting evidence rather than to the apparent certainty of the reported conclusion.

Confidence in individual conclusions alone, however, cannot establish confidence in the assessment. Once findings from different modules are combined, an additional methodological question arises: do the analytical relationships established throughout the Framework remain logically coherent when considered together? **Robustness must therefore be complemented by consistency assessment, which examines whether evidence retains its interpretive integrity as it progresses from one analytical layer to the next**.

Consistency, however, should never be interpreted as complete agreement. Complex climate systems rarely produce perfectly aligned signals and expecting them to do so would itself represent an unrealistic analytical assumption. **Apparent inconsistencies therefore require explanation before they justify correction**. High vulnerability accompanied by strong readiness, or substantial exposure associated with limited observed impacts, may reveal adaptive capacity, threshold behaviour, compensating mechanisms, or contextual influences that provide valuable insight into system behaviour rather than evidence of methodological failure.

The same reasoning explains why the Framework avoids artificially harmonizing assessment findings. The easiest way to create consistency is simply to adjust results until disagreement disappears. Such agreement, however, may be achieved only by removing analytically significant differences. Those differences often provide the first indication that important interactions, adaptive mechanisms, or emerging system dynamics are influencing the assessment. Eliminating them to improve apparent coherence may therefore conceal precisely the evidence needed to understand how the system behaves.

The purpose of robustness and consistency checks is consequently not to maximize agreement but to strengthen interpretive confidence. This requires documenting the reasoning that connects evidence, assumptions, and conclusions rather than relying primarily on numerical sensitivity measures or formal validation statistics. Such documentation allows both the strengths and the limitations of the assessment to remain visible throughout subsequent interpretation.

For the same reason, the outcomes of robustness and consistency assessment accompany the findings rather than remaining separate methodological observations. Conclusions that remain stable across alternative assumptions strengthen confidence in downstream decisions. Conclusions whose interpretation depends upon conditions retain those qualifications throughout aggregation and synthesis, ensuring that important limitations are preserved instead of disappearing as analysis progresses.

Robustness and consistency therefore strengthen the Framework not by reducing uncertainty or forcing analytical agreement, but by revealing how much confidence the available evidence can genuinely support. In doing so, they protect against overinterpretation, preserve methodological transparency, and enable climate risk assessment to support disciplined decisions without claiming greater certainty than the evidence can justify.

3. Non-Compensatory Interpretation under Stress Conditions

Decision-makers naturally seek simple indicators when systems become increasingly complex. Aggregate scores appear to satisfy this need by reducing multiple dimensions into a single interpretable result. Under conditions of elevated climate stress, however, this apparent simplicity may become misleading. **Critical system failures are rarely determined by average performance. They are typically governed by the weakest constraint, the dominant vulnerability, or the failure of a single essential capability. The FTSAI Climate Risk Assessment Framework therefore extends its non-compensatory logic beyond score construction to the interpretation of assessment results**.

This methodological position follows directly from the behaviour of complex systems under stress. As pressure increases, individual strengths do not necessarily compensate for critical weaknesses elsewhere. A system may demonstrate strong resilience in several dimensions while remaining vulnerable because one limiting factor determines its capacity to function. **Interpretation must therefore identify those dominant constraints rather than relying primarily on balanced aggregate performance**.

This principle changes the way assessment findings are interpreted. Instead of asking whether overall performance appears satisfactory, the assessment asks whether any individual dimension has reached a condition capable of compromising the functioning of the entire system. Hazard relevance, exposure, vulnerability, resilience, and readiness are therefore examined not only collectively but also individually whenever there is reason to believe that one of them may become decisive.

The same logic applies to governance. Strong technical controls, financial resources, or operational capabilities cannot compensate for an inability to recognise emerging threats, escalate critical information, or make timely adaptive decisions. Conversely, effective governance cannot eliminate structural vulnerabilities for which no realistic adaptive options exist. **Once a limiting condition dominates system behaviour, strengths elsewhere cease to provide equivalent protection**.

This explains why **the Framework cautions against interpreting aggregated scores as direct indicators of safety, robustness, or acceptability**. Composite indicators are valuable for communication, but they inevitably compress information. Under normal conditions this simplification may remain acceptable. Under elevated stress, however, it can conceal asymmetric risk profiles, threshold effects, or critical dependencies that fundamentally alter the meaning of the assessment.

For this reason, stress conditions require a different **interpretive discipline**. Compounding hazards, repeated disruptions, tightly coupled processes, dependence on single suppliers or critical actors, and limited recovery margins all increase the likelihood that weakest-link dynamics will dominate overall system behaviour. **Whenever these conditions are present, interpretation shifts from average performance to the identification of the factors most likely to determine system failure**.

The same principle also governs the communication of assessment results. Aggregate outputs may support comparison or high-level reporting, but they cannot be interpreted responsibly in isolation where critical vulnerabilities remain hidden within the underlying assessment. Narrative interpretation therefore accompanies aggregated findings whenever non-compensable weaknesses may influence decision-making.

The methodological consequence is unavoidable. **Aggregation remains useful only while it preserves the meaning of the underlying evidence. Once aggregation begins to obscure the factors that actually govern system behaviour under stress, interpretation must return to the individual analytical dimension**s from which the assessment was constructed. By enforcing this non-compensatory logic, the **FTSAI Climate Risk Assessment Framework** protects decision-makers against false reassurance, preserves analytical transparency, and ensures that critical vulnerabilities remain visible precisely when they matter most.

4. Interpretation under Partial Assessment Coverage

In real-world applications, climate risk assessments may be undertaken with incomplete module coverage owing to data limitations, scope limitations, phased implementation or proportionality considerations. The **FTSAI Climate Risk Assessment Framework** permits partial assessments under controlled and explicitly documented conditions, while imposing strict discipline on interpretation and use of resulting outputs.

A distinction is maintained between scoped assessment and incomplete assessment coverage. A scoped assessment deliberately limits the organisational, geographic, functional, asset-level, or decision context to which the assessment applies, while applying all methodologically required components within that defined scope. Incomplete assessment coverage arises when one or more components required for the stated assessment scope cannot be applied fully because of data, evidence, resource, or implementation constraints. **The former represents a complete assessment of a deliberately bounded system; the latter represents a partial assessment of the intended system**.

This distinction has direct implications for interpretation. A scoped assessment may support complete findings and classification within its explicitly defined boundaries where all required analytical components have been applied. An assessment with incomplete coverage cannot support equivalent conclusions, because unassessed dimensions remain analytically unknown. Neither form of assessment may be generalized beyond its declared scope.

Partial coverage is never treated as equivalent to full assessment. The scope and limitations of module coverage are clearly documented. Modules, dimensions or layers that are excluded or only applied partially are clearly documented. This documentation is provided with all assessment outputs and is an integral part of interpretation.

Partial assessment results are to be understood to give a provisional insight and not an ultimate classification. Partial coverage findings are reported as representing the observed patterns, sensitivities, or governance characteristics within the assessed scope, and are not extrapolated beyond the assessed scope. **The Framework explicitly forbids inference from assessed dimensions to unassessed dimensions**.

Interpretation is conservative in the case of missing or substantially incomplete critical modules. **Perceived strengths in the modules assessed do not compensate for unknowns in other areas**. In such cases interpretation is about the uncertainty introduced by incomplete coverage and avoids aggregate judgments about overall risk posture, resilience or readiness.

Comparability between entities is limited where assessment coverage differs materially. Where module coverage, depth or evidence quality do not align, benchmarking, ranking or comparative interpretation is considered indicative rather than conclusive. The Framework does not encourage comparisons across entities based on partial assessments without an explicit normalization of scope and coverage.

Partial assessments are explicitly presented as transitional or scoped analytical tools. They can help with prioritisation, learning or phased implementation, but they are not a substitute for a thorough assessment where full coverage is required for certification, regulatory, or other high-stakes decision contexts. The Framework also states that partial assessment outputs shall not be reused outside their intended interpretive boundaries. Partial results should not be used to make definitive claims of certification, compliance, or to exclude risk, unless additional layers of assessment are added.

Disciplined interpretation under partial assessment coverage enables the Framework to balance practical applicability with **methodological integrity**, supporting incremental implementation under real-world constraints without sacrificing transparency, analytical restraint, or the credibility of assessment outcomes.

5. Governance Gap Identification

Within the **FTSAI Framework**, **governance gaps** refer to situations where climate-risk knowledge, organisational responsibilities, decision processes, and adaptive actions are insufficiently connected to enable effective response under changing conditions.

Governance gaps are not inferred from the absence of formal governance structures, policies, committees, or reporting arrangements. Such elements may provide relevant evidence of organisational commitment and institutional development. However, effective climate-risk governance requires that these arrangements are operationally connected with decision authority, resource allocation, implementation processes, monitoring mechanisms, and organisational learning.

The Framework identifies **governance gaps** by examining the relationship between five interrelated dimensions:

Risk information integration concerns whether climate-risk information is incorporated into strategic planning, investment decisions, operational processes, and risk management activities.

Decision authority and accountability concerns whether responsibilities for interpreting climate-risk information and initiating responses are clearly defined and connected with appropriate levels of organisational authority.

Resource mobilisation concerns whether identified climate risks can influence prioritisation, allocation of financial and operational resources, and implementation of adaptation measures.

Monitoring and feedback mechanisms concern whether organisations track changing climate conditions, evaluate response effectiveness, and incorporate new information into subsequent decisions.

Organisational learning and adaptation concerns whether experience, observed outcomes, and changing conditions contribute to adjustment of strategies, processes, and governance arrangements.

The identification of a **governance gap** therefore does not indicate the absence of governance. Rather, it indicates a misalignment between the existence of governance arrangements and their ability to translate climate-risk understanding into organisational action.

6. Temporal Interpretation and Trajectory Analysis

Climate risk assessments are often interpreted as descriptions of current conditions. In practice, however, the conditions being assessed continue to evolve while the assessment itself is being interpreted and used. Hazards change, organisations adapt, governance arrangements mature, and external constraints continuously reshape the operating environment. An assessment that accurately describes a system today may therefore become progressively less informative if it is interpreted as though the system itself had remained unchanged. **The FTSAI Climate Risk Assessment Framework addresses this problem by interpreting assessment results within the context of temporal trajectories rather than as isolated observations**.

This distinction becomes evident whenever identical assessment scores arise from different underlying circumstances. The same numerical result may describe an organisation that has reached its current position through sustained adaptation and continuous strengthening of governance, or one that appears equally stable only because emerging weaknesses have not yet become visible. Although the reported assessment is identical, the decisions supported by that assessment may be fundamentally different. **A score therefore acquires meaning only when interpreted together with the trajectory that produced it**.

The same reasoning applies when assessment results change over time. A numerical change does not, by itself, explain what has changed within the system. Similar score movements may result from genuine adaptation, increasing exposure, improved governance, methodological refinement, better data quality, or reduced uncertainty. **Before any interpretation can be justified, the mechanisms responsible for the observed change must first be identified**. Only then can apparent improvement or deterioration be interpreted with confidence.

This perspective is particularly important for readiness and adaptive governance. Institutional learning, stronger governance arrangements, improved decision integration, and more effective adaptive processes frequently become visible before measurable reductions in exposure or vulnerability occur. **Early improvements in readiness should therefore be interpreted as evidence that adaptive capacity is developing rather than as proof that climate risk has already declined**.

The opposite pattern may be equally important. Favourable assessment results often persist after the conditions that originally supported them have begun to change. Existing buffers may continue to absorb increasing stress, structural weaknesses may accumulate gradually, and important exposure shifts may remain hidden until critical thresholds are reached. **Apparent stability should therefore not be interpreted automatically as evidence that the system itself remains resilient**. What appears stable at one point in time may already be following a deteriorating trajectory.

This explains why the Framework discourages mechanical interpretation of score movements. Small numerical changes may reflect substantial structural developments, while apparently large changes may result primarily from improved evidence, reduced uncertainty, or methodological refinement. **The significance of any observed change therefore depends less on its numerical magnitude than on the processes that produced it**.

Trajectory interpretation consequently incorporates uncertainty as an integral component of analysis. As information becomes more complete and uncertainty declines, assessment results may appear less favourable simply because important aspects of the system have become more visible. Apparent deterioration may therefore represent improved understanding rather than worsening system performance. Distinguishing between these possibilities is essential if assessment findings are to support proportionate and scientifically defensible decisions.

The objective of trajectory analysis is therefore not simply to record change but to understand its direction, causes, persistence, and likely implications. These characteristics frequently provide earlier and more decision-relevant insight than isolated assessment results because they reveal emerging vulnerabilities, adaptive opportunities, and developing governance challenges before these become fully reflected in aggregate assessment outputs.

The methodological implication follows directly from the behaviour of climate risk itself. **Climate risk evolves continuously, and assessment interpretation must evolve with it**. By emphasizing trajectories rather than static positions, the **FTSAI Climate Risk Assessment Framework** aligns interpretation with the dynamics of complex adaptive systems, strengthens long-term decision-making, and reduces the risk of drawing static conclusions from continuously changing realities.

7. Interpretation Pitfalls and Misuse Prevention

A rigorous assessment does not guarantee sound decisions. Once assessment results leave the analytical process and begin to inform certification, regulation, investment, or organisational decision-making, they become vulnerable to misinterpretation and inappropriate use. **Many of the most significant failures associated with risk assessment do not arise because the underlying analysis is flawed, but because its conclusions are applied beyond the limits for which they were designed**. The **FTSAI Climate Risk Assessment Framework** therefore treats misuse prevention as an integral component of the methodology rather than as supplementary guidance.

One of the most common forms of misuse occurs when assessment outputs are interpreted as predictions of future events. Framework results characterise current conditions, system sensitivities, adaptive capacity, and governance maturity under uncertainty. **They do not forecast specific losses, future disruptions, or the probability of outcomes**. Confusing assessment with prediction changes the meaning of the Framework itself and encourages decisions that extend beyond what the available evidence can legitimately support.

A similar problem arises when assessment classifications or aggregate scores are used as automatic decision rules. Numerical thresholds may appear attractive because they simplify complex decisions into apparently objective criteria. That simplicity, however, comes at the cost of analytical understanding. Once classifications replace interpretation, dominant risk drivers, uncertainty, module coverage, and non-compensable weaknesses may disappear from the decision process. **The Framework therefore requires assessment findings to be interpreted within their analytical context rather than through isolated thresholds**.

The same principle explains why uncertainty cannot be separated from assessment outputs. Uncertainty annotations are not supplementary qualifications added after the analysis has been completed; they define the conditions under which the findings should be interpreted. Removing those qualifications from reports, presentations, or decision-support material creates an appearance of precision that the assessment itself never claimed. **Preserving uncertainty is therefore essential to preserving the meaning of the assessment**.

Misinterpretation may also arise from the way assessment results change over time. Short-term movements often attract disproportionate attention because they appear to signal immediate improvement or deterioration. Modest score changes may result from improved evidence, methodological refinement, or temporary conditions rather than substantive changes in climate risk.

Conversely, important structural developments may occur long before they become visible in aggregated outputs. For this reason, **the Framework requires trajectory-based interpretation instead of mechanical comparison between successive assessment cycles**.

The same reasoning extends to the treatment of assessment outputs themselves. **Aggregate indicators should not be recombined into new composite indices, partial assessments should not be presented as comprehensive evaluations, and favourable findings should not be reported while identified vulnerabilities are omitted**. Each of these practices changes the analytical meaning of the assessment by separating conclusions from the methodological assumptions that made those conclusions valid.

Preventing misuse therefore requires more than accurate assessment. It requires disciplined interpretation. Users of the Framework are expected to respect module boundaries, uncertainty treatment, non-compensatory principles, and documented scope limitations whenever assessment results are communicated or applied. Narrative interpretation accompanies quantitative outputs because responsible judgement depends on understanding the reasoning behind the assessment rather than the numerical results alone.

The Framework consequently treats misuse prevention as a methodological safeguard rather than an administrative recommendation. Documentation requirements, interpretive guidance, and explicit constraints on downstream application exist to preserve the scientific validity of assessment outputs after the analytical process has been completed. Without such safeguards, technically sound assessments may still produce inappropriate decisions.

The methodological conclusion follows naturally. **The reliability of a climate risk assessment depends not only on how rigorously it is performed but also on how responsibly its results are interpreted and applied**. By identifying common misuse patterns before they influence decision-making, the **FTSAI Climate Risk Assessment Framework** protects against false certainty, inappropriate application, and loss of analytical integrity while ensuring that assessment outputs continue to support informed judgement within the limits for which they were originally developed.

8. Summary of Interpretive Discipline

A climate risk assessment is completed only when its findings can support responsible decisions without being separated from the analytical reasoning that produced them. The value of an assessment therefore depends not only on the quality of its analysis but also on the discipline with which its results are interpreted. Without that discipline, technically sound assessments may generate inappropriate conclusions simply because their outputs are applied beyond the limits within which they remain valid. **The FTSAI Climate Risk Assessment Framework treats interpretation as an integral component of assessment rather than as a final reporting exercise**.

This position follows directly from the role of assessment within decision-making. Once complex analytical evidence has been condensed into scores, classifications, or aggregated findings, something is inevitably gained and something is inevitably lost. Complexity becomes easier to communicate, but part of the analytical context disappears. **Assessment outputs should therefore be interpreted as structured summaries of evidence rather than as predictions, guarantees, or deterministic statements about future outcomes**. Their value depends as much on recognizing the limits of what they can establish as on understanding the information they successfully convey.

If this balance is to be maintained, it is necessary to make a clear acknowledgment of uncertainty. Assessment results are only meaningful when interpreted within the framework of the assumptions, evidence limitations, methodological constraints, and dynamic conditions of the system from which they were derived. Rather than weakening confidence, **transparent recognition of these limitations protects analytical credibility by ensuring that confidence remains proportional to the available evidence**.

The same discipline governs interpretation of aggregated results. Composite outputs remain useful only while they continue to represent the analytical relationships from which they were constructed. Where dominant vulnerabilities, governance constraints, threshold effects, or other non-compensable conditions become decisive, interpretation must return to the individual assessment dimensions that determine system behaviour. **Average performance alone cannot resolve questions that are governed by limiting factors**.

Confidence in assessment findings also depends on understanding how those findings have been established. Robustness analysis, consistency checks, and trajectory interpretation do not exist as independent methodological additions. Together they determine the extent to which assessment conclusions remain reliable as assumptions evolve, evidence improves, and system conditions change. Interpretation therefore encompasses not only the reported findings but also the reasoning that justifies confidence in those findings.

The same logic explains the distinction between comprehensive and partial assessments. Every partial assessment leaves part of the system outside the scope of analysis. Any conclusion derived from such an assessment is therefore constrained by what has, and has not, been examined. Provisional findings may provide valuable insight, but only while they remain within the analytical boundaries established by their coverage and scope. Extending them beyond those boundaries changes the meaning of the assessment rather than increasing its value.

Responsible downstream application depends upon preserving these methodological relationships. **Scores should not become predictions, classifications should not become automatic decision rules, uncertainty should not disappear during communication, and assessment findings should not be transferred to contexts for which they were never designed**. Respecting these constraints preserves the integrity of the assessment long after the analytical work itself has been completed.

The methodological implication follows naturally. **Assessment quality cannot be separated from interpretation quality because evidence influences decisions only through the meaning assigned to it**. **Interpretive discipline** therefore preserves the connection between analytical evidence, methodological reasoning, and informed judgement throughout the entire assessment process.

The interpretive cycle is completed not when scores are calculated but when those scores are used in ways that remain faithful to the analytical reasoning from which they originated. By integrating uncertainty treatment, **non-compensatory interpretation**, robustness assessment, trajectory analysis, and misuse prevention into a coherent **interpretive discipline**, the **FTSAI Climate Risk Assessment Framework** supports transparent, proportionate, and scientifically defensible decision-making across certification, regulatory, financial, strategic, and organisational applications. In doing so, it establishes climate risk assessment not as a mechanistic scoring exercise but as a structured process of informed judgement capable of supporting adaptive governance under conditions of persistent uncertainty.

Classification, Comparative Use, and Responsible Interpretation

1. Principles of Scoring and Aggregation

Decision-makers frequently ask for numerical indicators because they simplify complex information and facilitate comparison across organisations, sectors, and assessment cycles. This demand, however, creates an immediate methodological challenge. The greater the degree of simplification, the greater the risk that important characteristics of the underlying assessment will be lost. **A scoring system must therefore achieve two objectives simultaneously: it must make complex analytical findings easier to interpret without allowing numerical outputs to replace the reasoning from which those findings were derived**. The **FTSAI Climate Risk Assessment Framework** addresses this challenge through a structured scoring and aggregation methodology designed to support judgement rather than substitute for it.

Achieving this balance requires a scoring system that reflects differences in risk without implying a level of precision that the assessment cannot legitimately support. **Scores are therefore viewed as structured representations of relative conditions within the scope of an assessment, not as universal measures of safety or danger**. Their purpose is not to determine whether an entity is objectively "safe" or "unsafe," but to describe its position relative to the analytical context in which the assessment has been conducted. This principle of proportionality allows results to remain comparable while preserving sensitivity to differences in governance arrangements, sectoral characteristics, and operating environments.

The same reasoning explains why aggregation cannot rely solely on average performance. Complex systems rarely fail because every component performs poorly at the same time. More commonly, failure is determined by a small number of dominant vulnerabilities, governance weaknesses, or threshold conditions that cannot be offset by strengths elsewhere. **Aggregation must therefore preserve the visibility of critical constraints instead of allowing them to disappear within favourable overall scores**. This non-compensatory logic ensures that composite outputs remain faithful to the behaviour of the systems they represent rather than to the arithmetic properties of the scoring model.

Preserving analytical meaning also requires transparency regarding the interpretation of scores. Users cannot be expected to exercise sound judgement if numerical outputs appear more precise than they truly are. At the same time, protecting the **methodological integrity** of the Framework requires that detailed calibration procedures, weighting structures, threshold values, and scoring algorithms remain under controlled governance. **The Framework therefore distinguishes between public methodological transparency and controlled technical disclosure.** The principles governing score construction, their direction, meaning, interpretive limits, and appropriate use are documented sufficiently to permit scientific scrutiny of the methodology. **Detailed implementation parameters may remain non-public, but shall be accessible under controlled conditions to authorized assessors, independent reviewers, conformity assessment bodies, or other qualified parties where such access is necessary to reproduce, verify, validate, or audit assessment outcomes. Proprietary protection shall therefore never prevent the level of independent examination required by the purpose for which an assessment is used**.

Proprietary protection shall not prevent the level of independent examination required for validation, audit, assurance, or conformity assessment purposes. Where the Framework is applied within formal assurance or certification contexts, controlled access to relevant methodological specifications shall be established through appropriate governance arrangements.

These principles guide the generation of module-level scores. Qualitative and quantitative evidence is evaluated against predefined assessment criteria and translated into standardized ordinal or interval scales that reflect differences in significance, sensitivity, governance capability, or adaptive capacity. **The objective is not to reduce complex evidence to binary outcomes, but to preserve meaningful distinctions that remain analytically useful during subsequent interpretation**.

Aggregation across analytical layers follows the same methodological philosophy. Module scores are combined to produce integrated assessment outputs, but the process remains sensitive to dominant vulnerabilities, interaction effects, threshold behaviour, and amplification pathways. **Where important asymmetries, critical constraints, or threshold conditions cannot be represented adequately through aggregation, they remain analytically explicit and constrain the interpretation of composite outputs**. Interpretive annotations supplement this non-compensatory treatment rather than substitute for it.

The role of scoring therefore extends beyond numerical classification. Scores function as structured signals that guide diagnosis, prioritisation, communication, and governance dialogue rather than as independent decision rules. Their interpretation remains inseparable from uncertainty annotations, contextual evidence, and the analytical reasoning that generated them. **Final judgement consequently remains the responsibility of decision-makers rather than the scoring system itself**.

The methodological implication follows directly from these principles. Numerical structure contributes to climate risk assessment only while it strengthens analytical reasoning instead of replacing it. By grounding scoring and aggregation in proportionality, **non-compensatory interpretation**, and transparent communication, the **FTSAI Climate Risk Assessment Framework** preserves methodological credibility, reduces the risk of mechanistic application, and supports informed decision-making across regulatory, financial, certification, and strategic contexts.

2. Risk Classification Framework

The results of a climate risk assessment become significantly more useful once they can be communicated in a form that supports comparison, prioritisation, and decision-making. At the same time, this translation introduces a methodological risk. As complex analytical findings are condensed into a limited number of categories, part of the underlying information is inevitably lost. **A classification system must therefore simplify communication without simplifying the assessment itself**. **The FTSAI Climate Risk Assessment Framework addresses this challenge by treating risk classification as an interpretive layer rather than as a mechanical extension of numerical scoring**.

This distinction explains why classification cannot rely on a single analytical dimension. Similar external conditions do not necessarily produce similar risk profiles, and comparable assessment scores do not necessarily imply comparable governance capability. **A meaningful classification must therefore capture both the characteristics of the risk environment and the capacity of the assessed entity to respond to that environment**.

For this reason, the Framework organizes classification around three complementary dimensions. The first represents **structural risk conditions** as reflected through hazard relevance, exposure pathways, and vulnerability characteristics. The second represents **current response capacity**, reflected through the resilience of the assessed system under its existing configuration. The third represents **adaptive governance capacity**, reflected through **readiness and adaptive capacity**, including governance quality, decision capability, organisational learning, and the ability to modify future exposure, vulnerability, or resilience.

These dimensions capture analytically distinct characteristics of organisational climate risk. Structural risk conditions describe the environment and system characteristics through which disruption may arise. Current response capacity describes how effectively the organisation can maintain and restore function using capabilities already available to it. Adaptive governance capacity describes whether the organisation can modify those capabilities and thereby alter its future climate-risk trajectory.

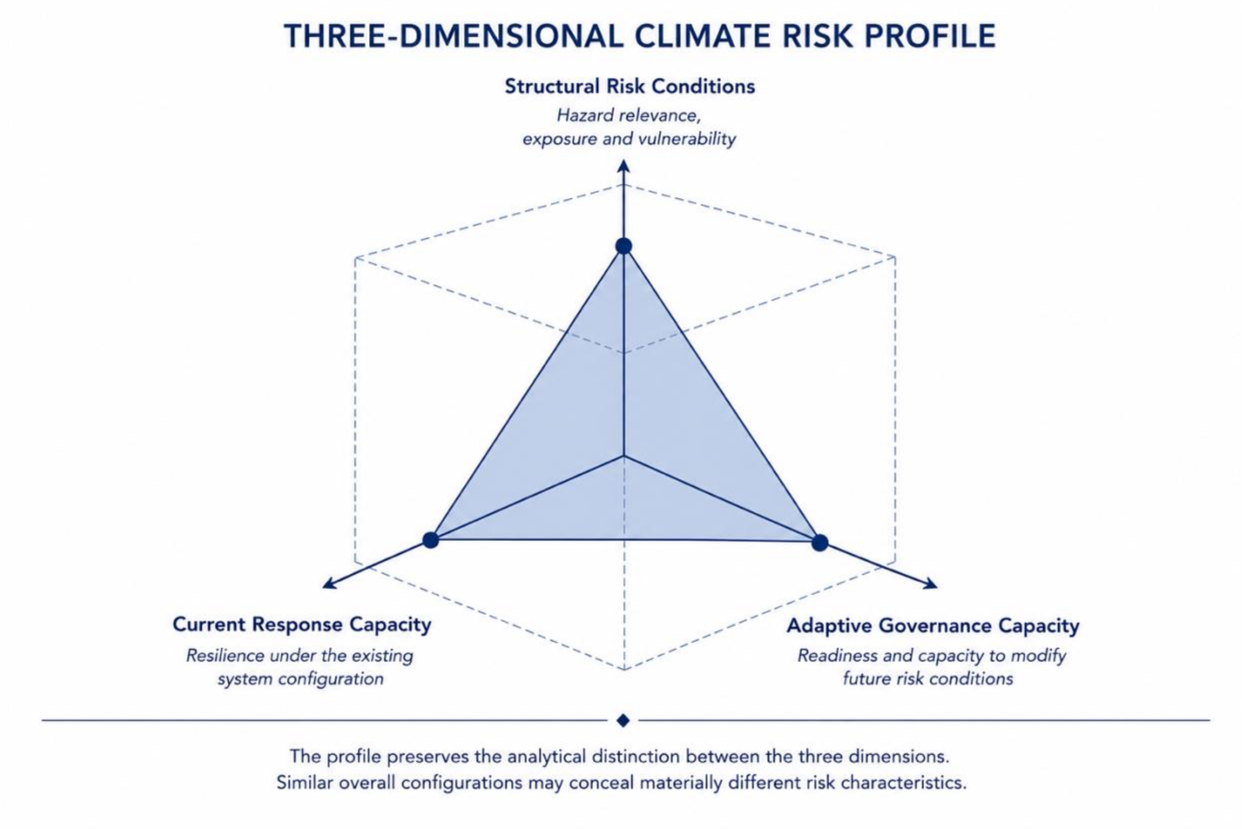

Figure 11. Three-dimensional climate risk profile integrating structural risk conditions, current response capacity, and adaptive governance capacity.

Strong performance in one dimension should therefore not be interpreted as evidence of strength in another. An organisation may face severe structural risk while remaining highly resilient, just as strong current resilience may coexist with limited capacity for longer-term adaptation. The resulting three-dimensional representation of organisational climate risk is illustrated in Figure 11.

The same reasoning determines how classification outcomes are expressed. Numerical labels might suggest a level of precision that the underlying assessment was never intended to provide. The Framework therefore employs standardized qualitative categories representing characteristic combinations of structural risk conditions, current response capacity, and adaptive governance capacity. These categories support communication while preserving the interpretive distinctions established across the analytical architecture.

Their role is consequently descriptive rather than normative. **Classification categories do not represent approval, compliance, acceptability, or predictions of future performance**. Instead, they summarize the dominant analytical characteristics revealed by the assessment and draw attention to the vulnerabilities, governance constraints, and adaptive opportunities that are most likely to influence subsequent decisions.

For the same reason, classification cannot function as an automatic decision rule. Once categories are separated from the module findings, uncertainty annotations, and analytical scope that produced them, they lose much of their intended meaning. Binary use of classifications for eligibility decisions, exclusion criteria, or automatic prioritisation therefore replaces informed judgement with mechanical interpretation. The Framework explicitly requires classification outcomes to remain connected to the analytical evidence from which they were derived.

Meaningful comparison between entities depends on the same discipline. Classification results can only be compared where assessment scope, evidence quality, methodological coverage, and uncertainty conditions remain sufficiently aligned. Where these conditions differ materially, apparent differences between classifications may reflect methodological variation rather than genuine differences in climate risk. The Framework therefore accompanies such comparisons with explicit interpretive qualifications.

The methodological consequence follows directly. **Risk classification succeeds only while it preserves the analytical meaning of the assessment it summarizes**. By organizing assessment findings within a structured but context-sensitive interpretive framework, the **FTSAI Climate Risk Assessment Framework** supports communication, prioritisation, benchmarking, and strategic decision-making without reducing complex climate risk assessment to simplistic rankings or categorical labels.

3. Interpretation of Assessment Results

Assessment results acquire value only when they are interpreted within the methodological context that produced them. Analytical findings do not carry an inherent or self-evident meaning simply because they have been expressed as scores, classifications, or other standardized outputs. Once detached from the assumptions, evidence, and reasoning on which they are based, even technically sound assessment results may support inappropriate conclusions. For this reason, the **FTSAI Climate Risk Assessment Framework** treats interpretation as an essential component of assessment rather than as a separate activity performed after the analytical work has been completed.

This principle becomes particularly important when assessment results are considered across different time horizons. A single assessment may accurately represent current conditions while conveying very different implications over the short, medium, and long term. Short-term stability may coexist with gradually deteriorating exposure or vulnerability, whereas elevated near-term sensitivity may simply reflect temporary transitional conditions. **The significance of an assessment therefore depends not only on its current findings but also on the temporal perspective from which those findings are interpreted**.

The same assessment result may also carry fundamentally different implications across sectors. **Similar scores do not necessarily describe comparable operating environments** because industries differ in regulatory constraints, capital intensity, operational flexibility, recovery dynamics, and available adaptive options. Interpreting identical classifications as though they represented equivalent risk conditions therefore removes the contextual information that gives those classifications their analytical meaning.

Context remains equally important at the organisational level. Two entities operating under similar external conditions may face very different practical constraints. Asset immobility, dependence on climate-sensitive resources, fragmented governance, or institutional limitations may significantly restrict the range of feasible adaptive responses. Conversely, organisations exposed to severe structural conditions may nevertheless demonstrate governance capability and adaptive maturity that substantially alter the practical implications of their assessed risk profile.

These observations explain why aggregate assessment results require careful interpretation. **A favourable overall score does not demonstrate the absence of climate risk; it merely summarizes the balance of evidence within a defined methodological framework**. Important vulnerabilities, dominant risk drivers, interaction effects, or threshold conditions may continue to determine system behaviour even when aggregate positioning appears favourable. Interpretation therefore returns to the underlying analytical evidence before drawing conclusions from the overall assessment outcome.

The same reasoning applies when higher risk classifications are observed. **Higher-risk classifications indicate conditions requiring additional analytical attention; they do not constitute predetermined judgements regarding organisational viability, regulatory compliance, or future performance**. Their purpose is to direct analytical attention toward the factors most likely to influence subsequent decisions rather than to predict how those decisions will ultimately unfold.

For this reason, assessment outputs cannot function as independent decision rules. Scores and classifications support expert judgement because they organize complex evidence into forms that facilitate analysis and comparison. **They cannot replace judgement because they do not contain the full contextual reasoning from which they were derived**. Decisions based solely on numerical outputs therefore represent an interpretation of the assessment that the Framework itself does not support.

The Framework consequently addresses not only how assessment results should be interpreted but also how they are commonly misunderstood. Short-term score movements may be mistaken for lasting trends, structural constraints may disappear behind aggregate indicators, readiness may be confused with guaranteed performance, and overall improvement may be assumed to reflect uniformly increasing resilience. Narrative interpretation accompanies substantive use of assessment findings precisely because these misinterpretations cannot be prevented through numerical outputs alone.

The methodological implication follows directly. **Assessment results become decision-relevant only when interpretation preserves the analytical relationships that produced them**. By requiring context-aware interpretation grounded in evidence, uncertainty, structural conditions, and methodological scope, the **FTSAI Climate Risk Assessment Framework** ensures that assessment outputs remain instruments of informed judgement rather than mechanistic verdicts. In doing so, it preserves analytical integrity while supporting governance decisions that reflect the complexity of climate risk rather than oversimplified representations of it.

4. Longitudinal Use and Comparative Benchmarking

A single climate risk assessment provides only a partial understanding of a system. It captures conditions at the time of assessment, but it cannot reveal whether those conditions are strengthening, weakening, or remaining unchanged. Likewise, comparing two organisations may expose important differences, yet comparison alone cannot explain why those differences exist. **Meaningful learning therefore emerges only when assessment results are interpreted as part of an evolving process rather than as isolated observations**. The **FTSAI Climate Risk Assessment Framework** supports this objective through structured longitudinal analysis and disciplined comparative benchmarking.

Repeated assessments become informative because they allow changes in system behaviour to be observed over time. The observation itself, however, is only the starting point. A numerical change does not reveal why the system has changed. Similar score movements may result from governance reform, altered exposure, increasing vulnerability, improved resilience, methodological refinement, enhanced evidence, or reduced uncertainty. Although the numerical outcome appears comparable, the processes that produced it may be fundamentally different. **Interpreting identical score movements as equivalent therefore replaces causal understanding with arithmetic comparison**.

The same principle explains why trajectories are more informative than isolated measurements. Two assessments may report the same current position while describing systems moving in opposite directions. One organisation may have reached its present condition through continuous adaptation and strengthening of governance, whereas another may appear equally stable only because structural weaknesses have not yet become visible. Their present assessments appear similar, yet their future risk profiles are already diverging. **Understanding relative performance therefore requires attention to the direction and persistence of change rather than to present position alone**.

Comparison across organisations presents a similar challenge. Organisations in different sectors, regulatory contexts or institutional frameworks rarely confront the same constraints or opportunities for adaptation. Similar classifications may therefore reflect fundamentally different climate risk realities. **Benchmarking serves not to determine which organisation performs better, but to reveal recurring patterns, structural similarities, contrasting governance responses, and differences in adaptive capacity that become visible only through disciplined comparison**.

Such comparisons remain meaningful only when they rest upon comparable analytical foundations. Differences in assessment scope, module coverage, evidence quality, or uncertainty treatment may influence classification outcomes as much as genuine differences in climate risk. **Before interpreting variation between organisations, it is therefore necessary to establish that the assessments themselves remain sufficiently comparable**. Otherwise, apparent differences may describe methodological variation rather than differences in the systems being evaluated.

A similar consideration applies to comparisons across time. Organisations rarely evolve at the same pace. Governance capability, institutional learning, adaptive investment, and exposure conditions develop over different time horizons. Two entities occupying similar positions today may therefore be following entirely different developmental paths. A static comparison captures where they currently stand but cannot reveal whether they are converging, diverging, or responding differently to changing climate conditions.

Once comparison becomes detached from the context that gives it meaning, numerical differences begin to function as decisions rather than as evidence. A benchmark intended to stimulate further analysis can easily become an implicit ranking, and a longitudinal trend intended to encourage investigation can be mistaken for proof of success or failure. At that point, comparison no longer supports judgement; it replaces it. **The Framework therefore does not permit longitudinal or comparative outputs to function as automatic decision triggers**.

When interpreted within their methodological boundaries, longitudinal analysis and comparative benchmarking become powerful instruments of organisational learning. They support evaluation of adaptation strategies, assessment of governance reforms, monitoring of policy effectiveness, identification of systemic risk patterns, and review of certification readiness. Their contribution lies not in producing rankings but in explaining why different systems evolve differently under changing climate conditions.

The methodological implication follows naturally. Repeated assessments and comparative analyses create value only while their interpretation remains faithful to the analytical reasoning that produced them. **By embedding strict methodological controls on longitudinal use and benchmarking, the FTSAI Climate Risk Assessment Framework transforms comparison from a numerical exercise into a disciplined process of scientific learning**, strengthening informed judgement while preventing misleading rankings, false conclusions, and inappropriate generalization.

5. Limitations and Responsible Use

No climate risk assessment can provide a complete representation of the system it examines. Climate risk evolves through interactions among climatic conditions, exposure pathways, structural vulnerabilities, organisational responses, governance decisions, and changing external conditions. Any assessment necessarily observes only part of this evolving system through the evidence, analytical boundaries, and time horizons available at the moment of assessment. **The FTSAI Climate Risk Assessment Framework therefore treats recognition of methodological limitation not as a qualification added to its results, but as a condition of their scientific validity**.

The first limitation concerns the relationship between assessment and prediction. The Framework evaluates the configuration of climate risk under specified conditions and examines how that configuration may behave under alternative plausible circumstances. **It does not predict the occurrence, timing, or magnitude of future climatic events, nor does it estimate with certainty the losses that an organisation will experience**. Scenario reasoning, trajectory analysis, and assessment of adaptive capacity extend understanding of possible future conditions without transforming the

Framework into a forecasting model. Assessment findings must therefore remain conditional upon the assumptions and analytical context from which they were derived.

A second limitation arises from the boundaries of the assessment itself. Every application defines an organisational, geographic, functional, temporal, and decision context within which evidence is collected and interpreted. **Conclusions remain valid only within those boundaries**. A finding concerning one asset, activity, region, sector, or assessment horizon cannot automatically be extended to another simply because the systems appear similar. Where assessment scope is deliberately restricted, interpretation must remain correspondingly restricted. Where required analytical components cannot be completed, the resulting limitation must remain visible in all subsequent reporting and downstream use.

Evidence introduces a further constraint. Climate risk assessment frequently combines observations, models, organisational records, expert judgement, proxy indicators, and contextual information of different quality and resolution. The existence of extensive information does not eliminate uncertainty, and numerical representation does not convert uncertain evidence into precise knowledge. **The strength of any conclusion must therefore remain proportionate to the evidence supporting it**. Where evidence is incomplete, conflicting, indirect, or sensitive to assumptions, this condition forms part of the assessment result rather than a deficiency to be removed through unsupported estimation or artificial precision.

The Framework is also limited by the dynamic nature of the systems it assesses. Exposure pathways change, vulnerabilities emerge or diminish, resilience mechanisms deteriorate or improve, governance arrangements evolve, and organisations alter their behaviour in response to new information and incentives. **An assessment should therefore not be interpreted as a permanent characterisation of an organisation**. It represents an analytically structured understanding of the system under the conditions and evidence applicable at a particular stage in its development. Material changes in those conditions may require reassessment before earlier conclusions can continue to support decisions.

These limitations become particularly important when assessment outputs are translated into scores and classifications. Numerical representation can facilitate communication, comparison, and decision support, but it necessarily compresses the analytical structure from which it is derived. Aggregate results may conceal dominant vulnerabilities, non-compensable weaknesses, uncertainty, or differences between systems that receive similar classifications for different reasons. **Scores and classifications therefore support interpretation; they do not constitute independent measures of safety, acceptability, organisational quality, or future performance**.

The same boundary applies to downstream decision-making. The Framework is designed to inform professional and organisational judgement, not to replace it. Assessment outputs may contribute to strategic planning, financial analysis, certification readiness, investment evaluation, policy development, and governance review, but they cannot determine those decisions autonomously. Each downstream application introduces objectives, constraints, legal responsibilities, and forms of expertise that extend beyond climate risk assessment itself. The existence of an assessment result therefore does not remove the responsibility of decision-makers to consider the broader context in which action is taken.

Responsible use consequently requires preservation of the relationship between evidence, analysis, uncertainty, interpretation, and decision. Results should not be detached from their assumptions, uncertainty should not disappear during communication, partial findings should not be presented as comprehensive conclusions, and classifications should not be transformed into automatic approval or exclusion criteria. Where assessment outputs are transferred between technical, governance, financial, regulatory, or certification contexts, their analytical meaning must remain unchanged even when the form in which they are communicated differs.

Professional judgement remains essential throughout this process. The Framework disciplines judgement through explicit definitions, modular analysis, evidence requirements, scoring principles, uncertainty treatment, and documented interpretation, but it does not attempt to eliminate judgement through mechanistic rules. Climate risk involves conditions in which evidence may remain incomplete and system behaviour may remain uncertain even after rigorous assessment. Responsible application therefore requires qualified interpretation capable of distinguishing what the evidence establishes, what it suggests, and what remains unresolved.

The methodological implication is fundamental. **The credibility of climate risk assessment does not depend upon claiming that uncertainty, contextual dependence, or analytical limitation can be eliminated. It depends upon ensuring that conclusions never extend beyond what the assessment can legitimatel**y support. By making these boundaries explicit, the **FTSAI Climate Risk Assessment Framework** preserves the connection between analytical evidence and informed judgement, allowing assessment results to support decisions without acquiring an authority that the methodology itself does not claim.

Sectoral Application: Agricultural Production Systems

1. Sectoral Rationale and Scope

The **FTSAI Climate Risk Assessment Framework** is designed to support climate risk assessment across diverse sectors. **A common methodological structure, however, does not imply that every sector can be assessed in the same way**. Climate risk emerges through the interaction between environmental hazards and the structural characteristics of the systems they affect. As those structures differ substantially across sectors, the pathways through which climate risk develops, propagates, and influences decision-making also differ. **Agriculture therefore requires a dedicated sectoral application that preserves the general methodological principles of the Framework while illustrating how those principles are translated within the distinctive characteristics of agricultural production systems.**

These distinctive characteristics originate from the nature of agricultural production itself. Unlike many economic activities, agricultural systems depend directly on biological processes that evolve within seasonal cycles and remain closely linked to local climatic conditions. Production cannot simply be accelerated, postponed, or relocated without biological consequences. At the same time, agricultural assets range from short-lived seasonal inputs to long-term investments in land, orchards, irrigation infrastructure, and production facilities, each responding differently to climatic stress. **Climate impacts therefore emerge not as external disturbances imposed upon production but as influences acting directly on the biological and operational processes through which production takes place**.

The consequences of these characteristics extend well beyond the farm. Agricultural performance depends upon a wider network of economic, financial, and institutional relationships that shape the ability of producers to anticipate, absorb, and respond to climate-related stress. Access to credit, insurance, agricultural inputs, cooperative structures, processing capacity, regulatory arrangements, and public support mechanisms all influence the way climatic pressures ultimately affect production, income stability, and long-term resilience. **Understanding agricultural climate risk therefore requires analysis of the system within which individual production units operate rather than of those units in isolation**.

The **FTSAI Framework** therefore approaches agriculture as a systemic production system rather than as a collection of isolated farms. Climatic disturbances may propagate through interconnected production networks, cooperatives, processors, storage facilities, transport systems, financial arrangements, labour markets, and institutional structures. Agricultural climate risk consequently depends not only on direct exposure to climatic hazards but also on the organisational, economic, and institutional conditions that determine whether disruption is absorbed, amplified, or transformed into wider consequences.This systemic perspective also explains the flexibility of the Framework’s assessment boundaries. Agricultural climate risk does not exist at a single organisational level. Decisions taken by individual farmers interact with producer organisations, cooperatives, supply chains, regional production systems, and national agricultural policies. The Framework therefore supports assessment at multiple spatial and organisational scales while maintaining a common methodological structure that allows findings to remain analytically consistent across different applications.

Viewing agriculture through this broader lens also prevents climate risk from being reduced to an environmental issue alone. Climatic hazards undoubtedly initiate many forms of agricultural disruption, but their eventual consequences depend equally on economic incentives, institutional arrangements, governance quality, financial capacity, and adaptive decision-making. **Agricultural climate risk**

therefore emerges from the interaction between environmental, organisational, economic, and governance factors rather than from climatic conditions in isolation.

The methodological implication follows directly. **Agriculture does not require a different climate risk framework because it is exposed to different hazards; it requires a dedicated application because the mechanisms through which hazards become risk differ fundamentally from those found in many other se**ctors. By explicitly incorporating these biological, economic, and institutional characteristics, the **FTSAI Climate Risk Assessment Framework** supports adaptation planning, investment prioritisation, policy development, insurance design, certification readiness, and governance improvement while preserving methodological consistency with the broader cross-sectoral architecture of the Framework.

The purpose of this Part is not to prescribe crop-specific thresholds, climatic datasets, agronomic coefficients, or standardized operational procedures. Such parameters necessarily vary across crops, production systems, geographical conditions, assessment purposes, and temporal horizons. The agricultural application therefore identifies the sector-specific analytical relationships through which the general architecture of the Framework is translated into agricultural production systems, while detailed data specifications, operational thresholds, worked assessment examples, and implementation procedures are addressed through the accompanying **Implementation Companion** and associated application materials.

2. Hazard Profiles in Agricultural Contexts

Hazard characterisation provides the starting point for every climate risk assessment. In agricultural systems, however, identifying a climatic event is only the beginning of the analysis. The same climatic condition may produce negligible consequences in one production system while threatening the viability of another. **The significance of agricultural hazards therefore cannot be determined by their physical characteristics alone**. It emerges only through their interaction with biological processes, production systems, and management decisions. **The FTSAI Climate Risk Assessment Framework consequently characterises hazards in agriculture as context-dependent stressors rather than as isolated environmental events**.

This dependence on production context explains why **hazard characterisation** cannot rely on generic hazard categories. Crop species, livestock systems, production methods, geographical conditions, and seasonal timing all influence the way climatic stress affects agricultural performance. Perennial and annual crops respond differently to prolonged drought, irrigated and rain-fed systems differ fundamentally in their sensitivity to precipitation deficits, while controlled production environments provide adaptive options that are unavailable in open-field agriculture. **Hazard relevance therefore changes with the characteristics of the production system itself rather than remaining an inherent property of the climatic event**.

The same reasoning requires consideration of both acute hazards and gradual climatic change. Some hazards produce immediate disruption through heatwaves, frost, floods, hailstorms, wind extremes, or intense precipitation events. Others influence agricultural systems progressively through rising temperatures, changing rainfall patterns, increasing aridity, declining soil moisture, or evolving pest and disease pressures. Although these hazards differ in the speed with which they develop, both alter the conditions under which agricultural production takes place and therefore contribute to climate risk.

Agricultural climate risk becomes even more complex when hazards interact. Production systems are rarely affected by a single climatic stress operating in isolation. Drought may intensify heat stress, repeated rainfall variability may accelerate soil degradation, and persistent temperature changes may alter crop phenology long before extreme events occur. The consequences observed within agricultural systems frequently arise from these interacting processes rather than from individual hazards considered separately. **Hazard characterisation therefore focuses on the combined behaviour of climatic stressors instead of analysing each hazard independently**.

The importance of a hazard also depends on when it occurs. Climatic events that are relatively benign during one stage of production may become critical during flowering, fruit development, harvest, or sensitive phases of livestock production. Similarly hazards that have been of little concern may become more prominent as climatic baselines change, production calendars shift or adaptive capacity erodes. **Hazard relevance is therefore determined by the interaction between climatic conditions and production timing rather than by historical frequency alone** (Hatfield et al., 2011).

The same contextual perspective applies across space. Agricultural production rarely experiences uniform climatic conditions even within the same administrative region. Variations in topography, soil characteristics, water availability, and local microclimates may produce substantially different hazard profiles over relatively short distances. These differences are not treated as statistical variation to be averaged away but as fundamental characteristics of agricultural systems that influence exposure, vulnerability, and adaptive capacity.

These observations explain why hazard profiles within the Framework remain descriptive rather than predictive. **They are not intended to predict specific weather conditions or estimate the probability of particular future outcomes.** Instead, they define the stress landscape within which exposure, vulnerability, resilience, and readiness are subsequently evaluated. By separating **hazard characterisation** from prediction, the Framework preserves analytical flexibility while avoiding false precision under changing climatic conditions.

The methodological implication follows directly. **In agriculture, hazards cannot be understood independently of the biological, operational, and institutional systems through which they influence production**. By anchoring **hazard characterisation** in production sensitivity, seasonal timing, spatial heterogeneity, and system interactions, the **FTSAI Climate Risk Assessment Framework** establishes a scientifically coherent foundation for agricultural climate risk assessment while supporting decision-making across farm management, cooperative governance, financial planning, and agricultural policy.

3. Exposure Mapping for Agricultural Systems

Exposure mapping identifies where and how climate hazards are able to interact with the agricultural production system. This distinction is important because **exposure cannot be inferred from location alone**. Agricultural production is shaped by biological processes, operational organisation, resource dependencies, and institutional relationships that determine how climatic stress reaches the production system. The same geographical setting may therefore generate different exposure conditions depending on how production is organised. **Within the FTSAI Climate Risk Assessment Framework, exposure is consequently treated as a dynamic configuration of relationships rather than as a static property of land, assets, or infrastructure**.

This perspective extends the meaning of spatial exposure. The geographical location of cultivated land or livestock facilities represents only one component of the exposure profile. Agricultural production also depends upon irrigation systems, water sources, storage facilities, transport access, supporting infrastructure, and environmentally sensitive areas that influence the pathways through which climatic hazards affect production. Spatial exposure therefore reflects the configuration of these interconnected elements rather than their individual locations considered separately.

The same reasoning applies to time. Agricultural systems do not remain equally exposed throughout the production cycle because biological processes create periods of markedly different sensitivity. Climatic events that produce limited consequences during one production stage may become highly disruptive during planting, flowering, maturation, harvesting, or storage. **Exposure is therefore determined not**

only by the occurrence of climatic hazards but also by their coincidence with operationally and biologically critical periods (Hatfield et al., 2011; Hatfield & Prueger, 2015).

Exposure also depends upon the functional organisation of agricultural production. The continuity of farming activities requires reliable access to water, energy, labour, agricultural inputs, transport, logistics, and markets. Climatic disruption affecting any of these supporting functions may influence production even where direct physical impacts remain limited. **Exposure therefore develops through functional dependencies as well as through direct interaction between hazards and agricultural assets**.

Once exposure is understood as a characteristic of the production system rather than of the production site alone, additional pathways become analytically relevant. Processing facilities, storage infrastructure, cooperative organisations, financial institutions, transport networks, and supply chains influence the ability of agricultural systems to maintain production under climatic stress. **These relationships create indirect exposure pathways through which disturbances may propagate beyond the point where the climatic event originally occurs** (IPCC, 2022).

The structure of the production system further shapes exposure. Concentration and diversification do not represent inherently favourable or unfavourable characteristics. Instead, they influence the way climatic stress is distributed throughout the system. Concentration in production may increase the sensitivity to localized disruption while diversification in production may reduce the dependence on individual activities but at the same time introduce additional coordination and management requirements. Their significance therefore depends on how they modify the interaction between climatic hazards and the production system.

A similar distinction applies to redundancy. **Diversification describes how exposure is distributed, whereas redundancy reflects the availability of alternative functional pathways when disruption occurs**. Alternative water supplies, multiple input providers, different transport routes, or access to additional processing facilities may substantially reduce exposure even where production remains geographically concentrated. Redundancy is therefore evaluated independently because it modifies the capacity of the production system to continue functioning under climatic stress.

These relationships define the purpose of **exposure mapping** within the Framework. **Exposure mapping** does not predict losses or determine risk severity. Instead, it identifies the spatial, temporal, functional, and institutional interfaces through which climatic hazards may influence agricultural production. These interfaces provide the analytical basis upon which vulnerability, resilience, and readiness are subsequently evaluated.

The methodological implication follows directly. **Agricultural exposure cannot be understood simply by identifying where climatic hazards occur. It requires understanding how the production system is organised, how its components interact, and how climatic stress propagates through those relationships**. By treating exposure as a dynamic and multidimensional system characteristic, the **FTSAI Climate Risk Assessment Framework** establishes a coherent analytical foundation for identifying sensitivity patterns and informing adaptation planning, investment decisions, and agricultural policy.

4. Vulnerability and Resilience Characteristics

Agricultural systems exposed to similar climatic hazards do not necessarily experience similar consequences. Even where exposure conditions appear comparable, production losses, operational disruption, financial impacts, and recovery patterns may differ substantially. **Exposure alone therefore cannot explain how climate-related disturbances ultimately affect agricultural systems**. Once climatic stress reaches the production system, its consequences depend on the characteristics that shape the system's response. Within the **FTSAI Climate Risk Assessment Framework**, these characteristics are examined through the complementary concepts of **vulnerability and resilience**.

This distinction reflects two different questions. **Vulnerability explains why a production system is sensitive once climatic stress occurs. Resilience explains how that same system continues to function, adapts, and recovers despite that stress**. Neither concept is meaningful in isolation because both describe different aspects of the same interaction between climatic hazards and agricultural production.

Understanding vulnerability therefore requires moving beyond individual characteristics. No single attribute determines how an agricultural system responds under climatic stress. **Sensitivity emerges from the combined influence of biological, environmental, operational, technological, and financial conditions that together shape the behaviour of the production system**. Only after vulnerability is understood as a systemic property do individual characteristics such as crop or livestock selection, soil condition, dependence on irrigation or rainfall, technological flexibility, capital intensity, financial capacity, and access to risk mitigation mechanisms become analytically meaningful (Adger, 2006; Smit & Wandel, 2006).

Not all sources of vulnerability arise from the same origins. Some are embedded within the physical and environmental characteristics of the production system itself and remain difficult to modify within operational decision horizons. Soil quality, water availability, land fragmentation, climatic location, and long-lived infrastructure investments define the conditions within which adaptation must occur rather than reflecting the quality of management decisions. **Structural vulnerability therefore establishes the practical boundaries within which adaptive responses can realistically be developed**.

Other sources of vulnerability emerge from the way agricultural production is organised. Production scheduling, dependence on critical inputs or suppliers, labour availability during sensitive production stages, and operational bottlenecks influence the ability of the system to continue functioning once climatic stress materializes. Although these characteristics may be modified through improved management, coordination, or investment, the degree to which they can be altered remains conditioned by organisational capacity and available resources.

Financial conditions introduce another dimension of system sensitivity. Climatic disruption affects not only production but also the resources required to sustain operations and restore continuity. The practical ability to recover depends on the financial structure supporting the production system rather than on nominal access to financial instruments alone. Liquidity reserves, credit availability, revenue diversification, debt structure, and insurance arrangements therefore become relevant because they influence whether adaptation measures can actually be implemented when climatic stress occurs.

Recognizing vulnerability alone, however, does not explain why many agricultural systems continue operating successfully despite substantial structural constraints. Production systems facing similar vulnerabilities frequently exhibit markedly different operational outcomes under comparable climatic conditions. **The difference lies in their capacity to absorb disturbance, reorganize operations, and restore production continuity. This capacity is captured through the concept of resilience**.

Resilience does not arise from any single adaptive measure. Agricultural systems maintain continuity because multiple adaptive capabilities operate simultaneously and reinforce one another under changing conditions. Operational flexibility in agronomic practices, redundancy of critical inputs, alternative water or feed sources, flexibility in production planning, and institutional support mechanisms become important not as isolated measures but as interacting components that collectively strengthen the system's capacity to respond to climatic stress (Folke et al., 2010; Meuwissen et al., 2019).

The same principle extends beyond individual production units. The resilience of agricultural systems is also shaped by collective organisational capacity. Cooperative arrangements, shared infrastructure, knowledge exchange, and institutional coordination may substantially strengthen collective response capacity even where individual farms remain structurally vulnerable. **Resilience therefore reflects characteristics of the wider agricultural system as well as those of individual producers** (Meuwissen et al., 2019).

These observations explain why **vulnerability and resilience** must be interpreted together. **Structural vulnerability does not preclude effective resilience, just as apparent resilience does not eliminate underlying structural fragility**. Their interaction determines how agricultural systems respond when climatic stress exceeds routine operating conditions. Examining either characteristic independently provides only a partial understanding of climate risk.

The methodological implication follows naturally. Agricultural climate risk cannot be understood solely by identifying hazards or mapping exposure. It also requires understanding how the characteristics of the production system influence its sensitivity to climatic stress and its capacity to respond effectively once that stress materializes. By examining **vulnerability and resilience** as complementary properties of agricultural systems, the **FTSAI Climate Risk Assessment Framework** provides a coherent analytical foundation for adaptation planning, investment prioritisation, governance improvement, and agricultural policy while avoiding simplistic assumptions of either inevitable failure or guaranteed resilience.

5. Readiness and Adaptive Capacity in Agricultural Governance

Climate adaptation in agriculture does not occur within individual farms alone. Producers undoubtedly make many of the operational decisions that influence agricultural performance, yet successful adaptation also depends upon water management, shared infrastructure, market organisation, financial systems, technical advisory services, regulatory arrangements, and collective resource management that extend beyond the boundaries of any single production unit. The object of adaptation is therefore not the individual producer but the agricultural production system as a whole. **Once climate adaptation is understood as a system property rather than an individual activity, the question shifts naturally from how producers adapt to how the agricultural system itself becomes capable of adaptation**. Within the **FTSAI Climate Risk Assessment Framework**, this capability is assessed through the concepts of **readiness and adaptive capacity** as properties of agricultural governance (Adger et al., 2009; Smit & Wandel, 2006).

This perspective changes the object of assessment. **Readiness is no longer interpreted as the preparedness of individual actors but as the capacity of the governance system to transform distributed knowledge, responsibilities, and resources into coordinated adaptive action**. The relevant question is therefore not whether climate-related information exists, but whether governance arrangements consistently convert that information into decisions capable of reducing future climate-related disruption.

Individual producers remain central because adaptation ultimately materializes through decisions taken within production systems. **Information about climate risk, however, contributes to readiness only when it changes the way production is planned, resources are allocated, contingencies are prepared, and operational decisions are made**. Practices such as the use of early warning information, production flexibility, systematic record-keeping, and timely operational adjustment therefore become meaningful not because they are desirable practices in themselves, but because they provide observable evidence that climate considerations have become embedded within routine decision-making.

Many adaptive decisions, however, cannot be produced or implemented effectively by individual producers acting independently. Shared irrigation systems, transport infrastructure, market coordination, financial arrangements, technical support, and emergency response all require decisions distributed across multiple organisations. **Adaptive capacity therefore depends not only on the quality of farm-level decisions but also on the ability of governance arrangements to integrate those decisions into coherent collective responses** (Adger, 2003; Meuwissen et al., 2019).

This distinction explains why the Framework evaluates organisational function rather than organisational existence. Cooperatives, producer organisations, and other collective institutions strengthen adaptive capacity only when they actively coordinate climate-related decisions, mobilize shared resources, and organize collective action before climatic stress develops into operational disruption. **Their contribution**

derives from the governance functions they perform rather than from their formal institutional presence.

The same reasoning extends beyond agricultural organisations themselves. Public authorities, regulatory frameworks, advisory services, insurance arrangements, and financial support mechanisms all influence agricultural adaptation because they shape the institutional environment within which collective decisions are produced and implemented. Their significance therefore depends less on their formal availability than on the extent to which they strengthen anticipatory governance before climatic disruption occurs.

This distinction becomes particularly important when considering compensation mechanisms. Recovering losses after climatic disruption is fundamentally different from strengthening the capacity to anticipate and manage future climatic risks. Financial support provided after an event may reduce immediate economic consequences, yet it does not necessarily improve the governance processes through which future adaptation is organised. **Readiness is therefore evaluated primarily through the quality of anticipatory decision-making rather than through the magnitude of post-event assistance**.

Adaptive capacity also depends upon the ability of governance systems to learn. Agricultural systems are continuously exposed to new climatic conditions, but experience contributes to readiness only when it changes future decisions. Future decision-making is improved not by the mere accumulation of experience but by governance arrangements that systematically integrate new information, revise existing practices and adapt institutional responses, thus improving readiness (Folke et al., 2010; Pahl-Wostl, 2009).

These observations explain why governance weaknesses frequently constrain adaptation even where individual producers demonstrate high levels of technical competence. Fragmented authority, ineffective coordination, conflicting incentives, or weak institutional relationships may prevent capable individual decisions from developing into coherent collective adaptation. The adaptive capacity of the agricultural system therefore depends upon the quality of governance relationships linking its participants rather than upon the competence of any participant considered independently.

The methodological implication follows directly. Agricultural readiness cannot be inferred from individual preparedness, organisational existence, or public support viewed separately because none of these represents the true object of adaptation. **Climate adaptation is ultimately a property of the agricultural governance system itself**. By evaluating how that governance system generates, coordinates, implements, and continuously revises climate-related decisions, the **FTSAI Climate Risk Assessment Framework** provides a coherent basis for strengthening institutional coordination, guiding adaptation planning, informing investment decisions, and supporting agricultural policy within the complex systems through which climate risk is managed.

6. Interpretation of Agricultural Risk Profiles

An agricultural risk profile does not determine what decision should be taken. The same assessment may support different courses of action depending on production objectives, financial constraints, governance arrangements, adaptive opportunities, and the strategic priorities of the entity being assessed. A risk profile therefore possesses little practical value when interpreted independently of the decision context for which it was produced. **Within the FTSAI Climate Risk Assessment Framework, agricultural risk profiles are consequently interpreted as decision-support instruments rather than as decision outcomes** (Hall et al., 2012; ISO 31000, 2018).

This distinction changes the purpose of interpretation. The objective is not to determine whether an agricultural system should be regarded as successful or unsuccessful, viable or non-viable. Instead, interpretation seeks to explain how climate-related stress interacts with production systems, financial conditions, governance arrangements, and adaptive capacity in ways that are relevant to subsequent decisions. **A risk profile therefore acquires meaning only when it is connected to the practical questions that decision-makers seek to answer**.

Viewed in this way, **elevated risk classifications do not constitute predictions of failure**. They identify conditions in which structural sensitivities, operational constraints, or governance limitations may significantly influence performance if climatic stress materializes. Their analytical value lies in directing attention toward the characteristics of the agricultural system that are most likely to benefit from adaptation, investment, organisational improvement, or changes in risk management rather than in assigning categorical judgements about future performance.

The same reasoning applies to favourable risk profiles. A comparatively favourable assessment does not demonstrate the absence of climate risk, nor does it imply that existing arrangements will remain effective as climatic conditions evolve. It indicates that, within the defined assessment scope and time horizon, exposure, vulnerability, resilience, and governance are aligned in a manner that currently supports adaptive performance. Interpretation therefore remains conditional upon the assumptions, evidence, and operating environment within which the assessment was conducted.

Once the meaning of the risk profile has been established, interpretation naturally extends to decision-making. Agricultural risk profiles support choices regarding production planning, crop or livestock selection, production timing, resource allocation, irrigation investment, soil management, technology adoption, storage capacity, and organisational development because they clarify where climate-related constraints are most likely to influence future performance. **Their purpose is not to prescribe these decisions but to improve the quality of the reasoning that precedes them**.

The same interpretive logic applies to financial decision-making. Climate risk profiles provide structured evidence regarding recovery requirements, financial buffering capacity, governance maturity, and adaptive capability. These characteristics support dialogue concerning financing conditions, insurance arrangements, credit allocation, and investment priorities. **They inform financial judgement by improving understanding of climate-related uncertainty rather than by functioning as automatic eligibility or exclusion criteria** (Berkhout et al., 2006; ISO 31000, 2018).

Interpretation also acquires a broader function when agricultural systems are considered collectively. Aggregated risk profiles reveal patterns that individual assessments cannot identify, including shared vulnerabilities, institutional constraints, infrastructure dependencies, and governance bottlenecks affecting wider production systems. At this level, interpretation shifts from evaluating individual producers to understanding the adaptive characteristics of the agricultural system itself, thereby supporting coordinated action and informed policy development.

The same principles apply when agricultural risk profiles contribute to certification or risk-transfer mechanisms. Their analytical value depends upon preserving the methodological discipline through which they were produced. Uncertainty annotations, **non-compensatory interpretation**, and contextual analysis remain essential because removing these elements transforms decision-support evidence into oversimplified classifications that the Framework itself does not support.

The methodological implication follows directly. **Agricultural risk profiles do not derive their value from the classifications they contain but from the disciplined interpretation that connects those classifications to the decisions they are intended to inform**. By grounding interpretation in production reality, governance capability, financial context, and adaptive objectives, the **FTSAI Climate Risk Assessment Framework** ensures that agricultural risk profiles remain instruments of informed judgement, supporting adaptation planning, investment decisions, certification, and public policy without becoming substitutes for the decisions they are designed to improve.

7. Integration with Certification Readiness and Financial Applications

A climate risk assessment often continues to create value long after the assessment itself has been completed. A report prepared to help a farming organisation understand its climate-related vulnerabilities may later be examined by certification bodies, financial institutions, insurers, or public authorities, each asking different questions while relying on the same underlying assessment.

These different users do not require different assessments. They require different interpretations of the same evidence. A certification body may ask whether governance arrangements are appropriate for the level of climate risk identified. A lender may focus on the organisation's ability to withstand future disruptions. An insurer may be interested in how different hazards interact and whether losses are likely to remain isolated or become systemic. Although their objectives differ, they all begin with the same understanding of how climate risk affects the assessed system.

For this reason, the Framework separates assessment from the decisions that may follow. The assessment explains the nature of climate risk, identifies its principal drivers, and evaluates the organisation's capacity to respond. **It does not determine whether certification should be granted, whether financing should be approved, or whether insurance coverage should be offered**. **Those decisions remain the responsibility of the institutions using the assessment rather than the assessment itself**.

Certification bodies can use the assessment to understand whether governance arrangements, adaptation measures, and risk management practices are proportionate to the climate conditions under which the organisation operates. **The assessment therefore supports consistent and transparent certification processes without becoming a compliance checklist or replacing professional judgement**.

Financial institutions can use the same assessment for a different purpose. Rather than relying solely on historical financial information, they gain a clearer picture of how climate risk may influence future performance, recovery capacity, and organisational resilience. This supports more informed discussions about financing conditions, insurance arrangements, and longer-term risk management without reducing assessment results to automatic approval or rejection criteria.

The same principle applies at broader levels of analysis. When assessments are conducted consistently across many organisations, they can help identify emerging patterns of climate risk within agricultural sectors or investment portfolios. Such information may support strategic planning, financial product development, and public policy while preserving the integrity of individual assessments.

Throughout these different applications, the Framework maintains the same methodological discipline. **Assessment findings remain subject to the declared scope of the assessment, the documented uncertainty surrounding the available evidence, and the non-compensatory interpretation principles that underpin the Framework**. These safeguards ensure that assessment results continue to support informed judgement rather than mechanical decision-making.

In this way, the Framework provides a common analytical foundation that can support certification readiness, financial decision-making, and wider climate risk governance without altering the purpose of the assessment itself or compromising its methodological integrity.

Part VI

Use Cases and Downstream Applications

1. General Principles of Use

A climate risk assessment rarely reaches the end of its usefulness when the final report is completed. In practice, this is often the point at which its wider value begins to emerge. The same assessment may later be examined by managers planning future investments, certification bodies evaluating governance arrangements, financial institutions considering lending decisions, insurers assessing risk exposure, or public authorities designing adaptation policies. Although these users pursue different objectives, they all begin with the same question: What does this assessment tell us about climate risk?

Answering that question does not require different assessment methods. **It requires a single analytical foundation capable of supporting different forms of decision-making without changing its methodological logic**. The **FTSAI Climate Risk Assessment Framework** was developed for precisely this purpose. It provides a common analytical basis that can be interpreted across operational, financial, policy, and institutional settings while preserving methodological consistency.

An assessment, however, does not make decisions. It improves the quality of the decisions that people make. Managers, auditors, lenders, insurers, regulators, and policymakers remain responsible for their own judgements. The Framework contributes structured evidence, disciplined analysis, and transparent interpretation, but it does not prescribe actions or determine outcomes.

Because different users ask different questions, the same assessment may support a wide variety of downstream applications without changing its analytical content. **What changes is not the assessment itself but the context in which its findings are interpreted**. Each application therefore relies on the same assessment while viewing it from a different decision-making perspective.

This distinction is fundamental. **Assessment findings do not constitute predictions, guarantees, or instructions for action**. They describe the conditions under which climate risk is understood at the time of assessment, identifying the principal sources of exposure, vulnerability, adaptive capacity, and governance readiness. Decisions informed by these findings remain conditional upon the objectives, responsibilities, and risk appetite of those using them.

The same principle applies to the level of detail required for different applications. Big strategic decisions can be made from broad assessments of dominant patterns and priorities. More detailed operational or financial decisions require correspondingly richer evidence and more granular assessment coverage. **Extending conclusions beyond the level of evidence available weakens the reliability of subsequent decisions and is therefore discouraged**.

Interpretation must also preserve the internal logic of the assessment. Strong performance in one area cannot compensate for critical weaknesses elsewhere simply because an overall score appears favourable. **The Framework therefore requires downstream applications to retain visibility of dominant vulnerabilities, structural constraints, and uncertainty rather than relying exclusively on aggregate indicators**.

Equally important is the preservation of uncertainty. Assessment findings cannot be separated from the assumptions, evidence, and limitations under which they were produced. Uncertainty annotations form part of the assessment itself and should remain visible whenever results are interpreted or communicated. Without this context, an impression of certainty is created, which was never the assessment's intention.

The Framework is designed to support informed discussion rather than mechanical decision-making. By providing a common analytical language, it enables managers, technical experts, financial institutions, certification bodies, and public authorities to examine climate risk from a shared evidential foundation while remaining free to reach different decisions according to their respective responsibilities.

For this reason, the Framework maintains a clear distinction between assessment and decision authority. **It explains climate risk; it does not decide how organisations should respond to it. Responsibility for subsequent decisions always remains with the individuals and institutions using the assessment**.

The principles presented in this Part establish the methodological discipline governing every downstream application of the Framework. Each use case illustrates how the same assessment can support different forms of decision-making without altering its analytical foundations, extending its evidential limits, or compromising its interpretive integrity.

2. Financial and Credit Applications

There were two loan applications before the bank, both from agricultural firms in the same area. Both farms grow similar crops, face similar climatic conditions and seek finance for future investment. Based on conventional financial information alone, the two borrowers are very similar. But a closer look at the facts shows some key differences. A single business has diversified its production, invested in water management, strengthened its governance arrangements and developed clear adaptation plans. The latter continues to depend heavily on one production system and has limited ability to respond to changing climatic conditions.

These differences may not be fully captured by conventional financial analysis. Historical financial performance provides valuable information about the past, but it cannot always explain how an organisation is likely to cope with future climate-related disruption. As climate risk becomes an increasingly important driver of operational continuity, asset value, cash-flow stability, and long-term resilience, financial institutions require a broader understanding of the factors shaping future performance.

The **FTSAI Climate Risk Assessment Framework** provides this additional perspective. Rather than functioning as a credit scoring system or replacing financial judgement, it contributes structured evidence describing how climate risk is created, how it is managed, and how governance influences an organisation's capacity to adapt. **Assessment outputs therefore complement traditional financial analysis instead of substituting for it**.

Within credit evaluation, assessment findings help distinguish between organisations operating under similar external climatic conditions but exhibiting very different internal capacities to manage those conditions. **Exposure to the same hazards does not necessarily imply the same level of financial risk**. Differences in production structure, diversification, financial buffers, insurance arrangements, governance quality, and adaptive capacity may lead to substantially different resilience profiles despite comparable environmental exposure.

This distinction is particularly important because climate risk is not simply a function of external hazards. Financial resilience depends equally on the ability of organisations to anticipate disruption, absorb losses, recover from adverse events, and adapt as climatic conditions evolve. Assessment outputs therefore provide insight not only into exposure but also into the organisational characteristics that influence future financial performance.

For this reason, the Framework supports risk-informed financial dialogue rather than automated financial decisions. Assessment findings may assist institutions when considering lending conditions, financing structures, insurance arrangements, covenant design, or broader risk management strategies. They provide additional analytical evidence that enriches financial judgement without replacing the professional responsibilities of lenders, insurers, or investment committees.

The Framework also encourages a forward-looking perspective. Financial decisions benefit not only from understanding current climate risk but also from recognising whether an organisation's resilience is improving, deteriorating, or remaining structurally constrained over time. **Longitudinal assessments help distinguish temporary operational difficulties from persistent structural vulnerabilities and identify where governance improvements are strengthening adaptive capacity**.

The same analytical logic can be applied beyond individual borrowers. When assessments are conducted consistently across multiple organisations, they provide valuable insight into concentrations of climate risk within lending portfolios, agricultural sectors, or geographical regions. Such information supports portfolio management, capital allocation, stress testing, and strategic planning without reducing diverse climate risk profiles to simplistic rankings or averages.

Throughout all financial applications, methodological discipline remains essential. Assessment findings retain their uncertainty annotations, declared scope, and interpretive limitations regardless of the decisions they inform. **Removing this context or converting assessment outputs into automatic pricing formulas, approval thresholds, or exclusion criteria extends the assessment beyond its intended purpose and is inconsistent with the principles of the Framework**.

For this reason, financial decisions informed by Framework outputs always remain the responsibility of the institutions making those decisions. Climate risk assessment contributes structured evidence and comparative understanding, but final lending, investment, insurance, and financing decisions continue to require complementary financial analysis, due diligence, regulatory compliance, and professional judgement.

By integrating climate risk assessment into financial analysis in this disciplined manner, the FTSAI Climate Risk Assessment Framework enables financial institutions to understand climate-related risk more comprehensively while preserving analytical integrity, institutional responsibility, and the distinction between assessment and financial decision-making.

3. Insurance and Risk Transfer Contexts

Two agricultural businesses may report almost identical losses after the same extreme weather event. Yet the mechanisms that produced those losses may be fundamentally different. One business may have been affected by an exceptionally severe hazard despite having invested in adaptation and risk reduction. The other may have experienced similar losses because long-standing vulnerabilities, weak governance, and limited preparedness amplified the consequences of an event that could otherwise have been managed more effectively. **The financial result looks the same, but the climate risk is different**.

This distinction illustrates one of the central challenges of insurance. **Financial losses describe what happened, but they do not necessarily explain why it happened**. Traditional insurance analysis relies on actuarial methods, catastrophe models and statistical analysis to estimate the likelihood and financial consequences of hazardous events. These approaches remain essential for pricing, reserving, capital management, and regulatory compliance. They do not, however, always reveal the structural conditions that transform comparable hazards into very different loss outcomes.

The **FTSAI Climate Risk Assessment Framework** was developed to provide this complementary perspective. Rather than estimating probabilities or expected losses, it examines how exposure, vulnerability, adaptive capacity, and governance influence the way climatic events evolve into operational and financial losses. **The Framework therefore complements established insurance methodologies without replacing them**.

This additional understanding is particularly valuable during underwriting. Organisations operating within the same climatic environment may present substantially different risk profiles because they differ in production structure, operational dependencies, adaptation measures, governance quality, or recovery capacity. Assessment findings help distinguish risks that arise primarily from external hazards from those that are amplified by internal organisational characteristics.

The same analytical perspective supports insurance product design. Understanding how exposure patterns interact with operational vulnerability and adaptive behaviour allows insurers to design coverage that more closely reflects the mechanisms through which losses develop. Deductibles, coverage conditions, complementary adaptation measures, and broader risk-sharing arrangements can therefore be considered within a richer understanding of climate risk.

The value of this perspective extends beyond individual policies. A portfolio containing many geographically dispersed policies may appear well diversified until assessment findings reveal that a large proportion of insured entities depend upon the same vulnerable water resources, production systems, or supply chains. **Risks that appear independent at policy level may therefore become closely connected when viewed from a systemic perspective**. The Framework helps make these hidden concentrations visible.

Emerging insurance instruments may benefit in a similar way. Parametric insurance, index-based products, and hybrid risk-transfer mechanisms depend on appropriate alignment between trigger conditions and the actual mechanisms through which losses occur. Assessment findings help clarify this relationship by distinguishing temporary weather variability from longer-term structural climate vulnerability.

The distinction is also needed for public insurance schemes and mixed risk transfer arrangements. **Some risks can be transferred effectively through insurance, whereas others can only be reduced through adaptation, governance improvement, or structural investment**. The Framework helps identify where risk transfer alone is unlikely to provide a sufficient long-term response.

The Framework nevertheless maintains clear methodological boundaries. **It does not estimate expected losses, calculate premiums, determine reserves, or replace actuarial models**. These functions remain the responsibility of specialised quantitative methods. The Framework contributes structured interpretation that complements statistical analysis by explaining the organisational and governance conditions within which climate-related losses arise.

Across all insurance applications, assessment findings retain their uncertainty annotations, declared scope, and methodological limitations. Removing this context or using assessment outputs as automatic underwriting rules, coverage decisions, or liability determinations extends the assessment beyond its intended purpose and is inconsistent with the principles of the Framework.

Insurance decisions therefore remain the responsibility of insurers, reinsurers, regulators, and other relevant institutions. **The Framework strengthens professional judgement by providing a deeper understanding of the mechanisms that shape climate-related losses while preserving the distinction between assessment and insurance decision-making**.

The **FTSAI Climate Risk Assessment Framework** enables more transparent, resilient and forward-looking insurance and risk transfer decisions by embedding structured climate risk assessment with established insurance practice without changing the respective roles of actuarial analysis, underwriting expertise and institutional responsibility.

4. Policy and Programme Design

Climate policies often succeed in responding to the consequences of climate-related events while failing to reduce the conditions that make those consequences recur. Public resources are mobilized, damaged infrastructure is restored, and affected communities receive financial support, yet similar losses frequently reappear following subsequent climatic events. **Repeated cycles of intervention despite repeated cycles of loss suggest that responding effectively to observed impacts is not, by itself, sufficient to strengthen long-term climate resilience**.

The reason is that observable climate impacts represent only the visible consequences of deeper risk structures. **Similar losses may arise from fundamentally different combinations of exposure,**

vulnerability, governance, and adaptive capacity. Some reflect structural environmental or geographical constraints that cannot be substantially altered through short-term intervention. Others arise because avoidable vulnerabilities remain embedded within production systems, institutions, or governance arrangements. Policies designed primarily around observed impacts therefore risk treating fundamentally different sources of risk as though they required identical policy responses.

Effective climate policy must be designed around the structure of climate risk rather than merely its observable consequences. **Designing policy around impacts alone encourages reactive intervention after losses have occurred. Designing policy around the underlying structure of climate risk enables interventions to address the mechanisms that generate those losses in the first pla**ce. This distinction allows public authorities to differentiate between structural vulnerability which needs long-term support, and managed risk which can be reduced through investment, better governance and adaptive action.

The **FTSAI Climate Risk Assessment Framework** provides the analytical foundation required to support this distinction. Rather than prescribing policy choices, it enables policymakers to examine how exposure, vulnerability, governance, and adaptive capacity interact to shape climate risk across different organisations, production systems, and regions. Assessment outputs therefore support policy design by making the underlying structure of climate risk visible before specific interventions are selected.

This perspective strengthens programme design by shifting attention from uniform policy measures towards differentiated intervention strategies. Assessment findings identify the dominant drivers of climate risk, concentrations of vulnerability, and governance readiness gaps, allowing programmes to be aligned with the conditions they are intended to address rather than relying solely on broad eligibility rules or observed losses. Public resources can therefore be allocated in a manner that reflects both the nature of climate risk and the capacity of beneficiaries to manage it.

The same analytical approach improves programme targeting. **Similar levels of observed damage do not necessarily imply similar policy needs**. Communities experiencing comparable climatic impacts may differ substantially in their exposure patterns, institutional capacity, adaptive behaviour, and long-term resilience. Assessment findings help distinguish between these underlying conditions and support policy interventions that are proportionate to them, without replacing political judgement or statutory decision-making.

The outputs of assessment also help in designing policy incentives. The Framework helps to differentiate between systems that are predominantly based on post-event compensation and those that gradually embed climate risk in planning, investment and governance, helping programmes to promote prevention rather than repeated recovery. Public support can thus facilitate adaptation, organisational learning and governance strengthening rather than inadvertently perpetuate dependence on emergency assistance.

Climate policy also benefits from the understanding that climate risk rarely arises from isolated hazards. Infrastructure, financial support, advisory services, governance arrangements and institutional capacity are undergoing dynamic interaction affecting resilience outcomes. Assessment findings help policymakers understand these interactions, supporting integrated programme design that addresses the structure of climate risk rather than its individual manifestations.

Repeated application of the Framework also enables systematic policy evaluation. **Comparing assessment results over time provides evidence of whether interventions influence exposure, vulnerability, adaptive capacity, and governance readiness rather than merely measuring programme implementation or expenditure**. This creates opportunities for continuous policy learning while recognising that changes in resilience emerge progressively rather than immediately.

Throughout these applications, methodological transparency remains essential. Uncertainty annotations, methodological scope, and interpretive limitations remain attached to assessment findings regardless of how those findings are used in policy processes.

Misuse of the Framework is indicated by selective interpretation of results, suppression of uncertainty or application of the outputs of assessment beyond their intended scope, which undermine analytical credibility. The Framework is intended to complement, not replace, statutory impact assessment, legal requirements and political decision-making. **Governments and public bodies nevertheless remain accountable for policy choices.** The Framework contributes structured evidence that supports clearer reasoning, more transparent resource allocation, and greater consistency across policy design, implementation, and evaluation.

By integrating climate risk assessment into policy and programme design in this disciplined manner, **the FTSAI Climate Risk Assessment Framework enables public interventions to address the underlying structure of climate risk rather than merely responding to its visible consequences**. In doing so, it supports more effective allocation of public resources, encourages proactive adaptation, strengthens governance, and contributes to the long-term resilience of agricultural systems.

5. Certification Readiness and Assurance Schemes

Climate risk assessments and certification processes are often treated as though they perform the same function. An organisation completes a climate risk assessment, and the natural expectation is that the assessment itself should determine whether certification is justified. Although this assumption appears intuitive, it confuses two fundamentally different activities. **Scientific assessment seeks to understand climate risk. Certification determines whether predefined institutional requirements have been satisfied**.

Assessment and certification must therefore remain institutionally independent. A scientific assessment explains the nature of climate risk, identifies its principal drivers, and evaluates the effectiveness of governance and adaptive capacity. Certification, by contrast, applies externally defined standards, audit procedures, and decision rules to determine whether specific requirements have been met. **Merging these functions would compromise both scientific objectivity and institutional accountability**.

The **FTSAI Climate Risk Assessment Framework** has been designed to preserve this distinction. **It provides a structured analytical foundation that certification and assurance schemes may use without becoming a certification standard or compliance checklist**. Assessment findings contribute evidence that strengthens audit quality, but they do not determine certification outcomes.

Within certification processes, assessment outputs support evaluation of certification readiness by providing structured evidence concerning hazard exposure, vulnerability, resilience, **organisational readiness**, and adaptive capacity. These findings enable certification bodies to examine whether management arrangements are proportionate to the climate risk environment in which an organisation operates. The assessment therefore informs the audit process while leaving certification decisions entirely within the authority of the certification body.

This proportionality-based approach is particularly important because organisations operate under very different climatic conditions. High levels of exposure do not necessarily indicate poor management, just as relatively favourable environmental conditions do not automatically demonstrate effective governance. **Certification readiness therefore depends not simply on the level of climate risk but on how systematically that risk is identified, monitored, managed, and incorporated into organisational decision-making**.

The same distinction strengthens assurance activities. Assessment findings provide structured documentation of assumptions, evidence sources, uncertainty, and interpretive boundaries, improving the traceability and consistency of audit conclusions. Rather than replacing professional assurance judgement, the Framework enables assurance providers to evaluate climate risk using a transparent and scientifically coherent analytical foundation.

The Framework is compatible with different assurance arrangements, including first-party, third-party, and staged certification models. Assessment findings may support baseline evaluations, gap analyses, improvement programmes, and periodic reassessments without prescribing audit frequency, certification cycles, or institutional procedures.

Methodological safeguards remain essential throughout certification use. **Assessment outputs must never be interpreted as automatic pass-or-fail decisions, nor should aggregated scores or classifications be treated as certification verdicts**. Certification bodies remain responsible for applying their own standards, evidence requirements, and governance procedures when reaching final decisions.

Licensing and formal recognition arrangements further protect methodological consistency by specifying requirements relating to assessor competence, documentation quality, methodological updates, and disclosure obligations. These arrangements preserve the scientific identity of the Framework while allowing certification schemes to incorporate its analytical outputs in a consistent and transparent manner.

The Framework also supports alignment with evolving scientific and regulatory expectations concerning climate risk governance, transparency, and accountability. This compatibility, however, should not be interpreted as equivalence with any specific certification scheme or regulatory framework. Responsibility for compliance always remains with the relevant certification bodies and regulatory authorities.

Assessment results in all certification applications retain their declared scope, uncertainty annotations and methodological limitations. Certificates or assurance statements therefore should never imply certainty, promise future resilience or imply immunity from climate-related risk. These interpretations go beyond the scientific meaning of the assessment findings, and misuse the Framework.

Within the FTSAI Climate Risk Assessment Framework, there is clear institutional separation between scientific assessment and certification authority. Certification and assurance schemes can be built on a common analytical basis, without prejudice to scientific integrity, institutional independence and professional judgement. Therefore, it increases the credibility, transparency and consistency of climate-related certification, while maintaining the separation of the roles of assessment and certification.

6. Methodological Validation and Empirical Evaluation

A methodological framework cannot establish its validity solely through internal coherence. However logically consistent its architecture may be, the constructs it defines and the assessment conclusions it produces must remain open to systematic evaluation against the organisational and system characteristics they are intended to represent. Validation therefore forms part of the continuing methodological development of the **FTSAI Climate Risk Assessment Framework** rather than a claim established permanently at the point of its design.

Validation within the Framework operates at several distinct levels because different methodological properties require different forms of evidence. Construct validity concerns whether assessment modules and indicators adequately represent the concepts they are intended to measure. Evidence used to assess resilience, for example, must reflect the ability of an organisation to absorb disruption, maintain critical functions, and recover through existing capabilities, whereas evidence of adaptive capacity must reflect the ability to modify governance arrangements, technologies, operations, or organisational practices as conditions change. Validation must therefore preserve the conceptual distinctions established by the Framework rather than treating all favourable organisational characteristics as interchangeable indicators of climate readiness.

Reliability provides a separate test. Equivalent evidence evaluated under equivalent methodological conditions should produce materially consistent conclusions across qualified

assessors. Persistent differences that cannot be explained by legitimate contextual judgement indicate weaknesses in assessment criteria, evidentiary requirements, scoring guidance, or assessor interpretation and therefore require methodological investigation.

Discriminant validity examines whether constructs that are analytically distinct within the Framework remain distinguishable when applied in practice. Vulnerability, resilience, and adaptive capacity, for example, perform different explanatory functions within the **assessment architecture**. If repeated applications demonstrate that their measurement does not meaningfully distinguish between these characteristics, the adequacy of the relevant indicators, scoring criteria, or conceptual boundaries must be reconsidered.

Empirical evaluation extends validation beyond the internal operation of the assessment process. Where appropriate observational or longitudinal evidence becomes available, assessment findings should be examined against subsequent organisational and system behaviour relevant to the constructs being assessed. Resilience assessments may therefore be evaluated against observed capacity to maintain critical functions and recover following disruption, while assessments of adaptive capacity may be examined against demonstrated changes in governance, technologies, operations, resource allocation, or other organisational configurations in response to changing climatic conditions. Exposure concentration, redundancy, and vulnerability assessments may similarly be examined against observed patterns of disruption and propagation where sufficiently comparable evidence exists.

Such evaluation does not transform the Framework into a forecasting model. Individual outcomes remain influenced by interacting hazards, organisational decisions, external conditions, and uncertainty, and no single event can therefore confirm or invalidate an assessment conclusion. Empirical validation instead examines whether systematic relationships between assessment constructs and the characteristics or behaviours they are intended to represent remain observable across sufficiently comparable cases and over appropriate time horizons.

The possibility of methodological failure must remain explicit. An assessment methodology is challenged when repeated evidence demonstrates that its constructs fail to distinguish materially different system conditions, when equivalent assessments cannot achieve acceptable levels of inter-assessor consistency, or when assessment classifications systematically fail to correspond with the observable characteristics or behaviours they are intended to represent. Such evidence cannot be dismissed solely by reference to uncertainty or contextual variation.

Methodological failure does not necessarily imply failure of the Framework as a whole. It may identify deficiencies in particular indicators, evidentiary requirements, scoring rules, aggregation procedures, calibration parameters, or conceptual relationships. Validation findings must therefore be examined at the level at which the observed discrepancy arises, allowing methodological weaknesses to be isolated rather than inferred from individual assessment outcomes.

Where systematic validation evidence identifies a material methodological weakness, the Framework requires review, recalibration, or revision through its established governance and versioning procedures. Validation therefore provides a mechanism through which empirical evidence can challenge the methodology itself, ensuring that methodological authority does not become immunity from empirical scrutiny.

The **FTSAI Climate Risk Assessment Framework** consequently treats validation as a continuing scientific process. Implementation experience, independent assessment, comparative applications, longitudinal evidence, and subsequent research collectively provide opportunities to test whether the Framework continues to represent the phenomena it was designed to assess. Its scientific credibility ultimately depends not upon the absence of challenge, but upon its capacity to specify what would constitute meaningful contrary evidence and to evolve when such evidence demonstrates that revision is necessary.

Before subsequent methodological revisions are released, Version 1.0 shall undergo structured empirical evaluation through independent applications, parallel assessments where appropriate, and predefined validation criteria. The purpose of this evaluation is not to establish universal performance thresholds independent of context, but to examine whether the Framework performs consistently with its intended analytical functions across different organisational and sectoral applications. Evidence generated through such evaluation shall inform future methodological refinements, revisions, and controlled evolution of the Framework.

7. Strategic Planning and Investment Decision Support

Strategic planning traditionally begins by asking whether an investment is economically justified, technically feasible, and commercially attractive. These questions remain essential because they determine whether a project deserves to proceed under the conditions that exist when the decision is made. Climate change, however, introduces another question that conventional strategic analysis cannot fully answer: **will the same investment remain effective if the conditions on which its success depends gradually change?**

The difficulty lies not in evaluating the investment itself but in evaluating the environment in which that investment will operate throughout its lifetime. Infrastructure, production systems, supply chains, and natural resources may all be affected by climatic changes that unfold over many years. As a result, a decision that appears strategically sound today may become progressively more vulnerable even though the original investment decision was entirely reasonable.

The opportunity requires a perspective that extends beyond the anticipated financial results. Long-term resilience is not only about projected returns, but also about how exposure, vulnerability and adaptive capacity evolve with changing climatic conditions. **Strategic planning therefore needs to consider whether the assumptions supporting today's decisions are likely to remain valid throughout the life of the investment**.

The **FTSAI Climate Risk Assessment Framework** addresses this question by extending strategic analysis beyond present operating conditions. **Rather than asking only whether an investment performs well today, it examines how that investment may perform if the conditions under which it operates gradually change**. In doing so, the Framework complements financial and operational analysis without replacing either of them.

This broader perspective often changes the comparison between alternative investments. **Two projects may generate similar financial returns while creating very different levels of future climate risk**. One investment may increase dependence on climate-sensitive infrastructure or scarce resources, whereas another may preserve operational flexibility and strengthen the organisation's capacity to adapt. These differences may have little influence on short-term performance but become increasingly important over the lifetime of the investment.

The same logic applies when capital is allocated across competing priorities. Investments in diversification, resilient infrastructure, monitoring capability, governance arrangements or organisational learning may add relatively little to immediate financial performance, but can substantially strengthen long term resilience. These long-term benefits enable organisations to evaluate investments in terms of financial and climate risk.

As investment decisions pile up, climate risk is becoming an increasingly portfolio issue, not just a project-level concern. Assets that seem resilient individually can collectively lead to an over-reliance on the same infrastructure, geographic location, supply chain or governance arrangements. **Viewing the portfolio as an integrated system allows organisations to recognise concentrations of climate risk that remain invisible when projects are evaluated in isolation**.

Climate uncertainty also changes the way long-term strategy is developed. Organisations gain from flexibility and the ability to adapt as conditions change, rather than assuming that decisions made today will be right for the rest of the planning horizon. Some investments open up strategic options for the future, while others progressively close them down by creating irreversible commitments or increasing dependence on climate sensitive assets.

The Framework supports these judgments but does not replace them. It does not prescribe investment decisions, establish approval thresholds, or determine strategic priorities. Those responsibilities remain with organisational leadership. Its role is to improve understanding of how different strategic choices may influence long-term resilience so that decisions are taken with a clearer appreciation of their future consequences.

Used in this way, climate risk assessment becomes an integral component of strategic planning rather than an exercise performed after strategy has already been defined. Organisations are therefore better able to evaluate long-term investments not only according to the conditions that exist today, but also according to the conditions in which those investments are expected to operate throughout their lifetime.

Part VII

Preserving Methodological Integrity Across the Assessment Lifecycle

1. Assessment Scope Definition

Climate risk assessment does not begin with data collection or analytical procedures. It begins with a more fundamental methodological question: what exactly is being assessed? Until this question is answered, neither the selection of evidence nor the interpretation of results can be regarded as scientifically meaningful. **Assessment findings derive their validity not only from the quality of analysis but also from the analytical boundaries within which that analysis is performed**.

For this reason, scope definition constitutes the first methodological step of the **FTSAI Climate Risk Assessment Framework** rather than a preliminary administrative activity. Its purpose is to establish the conditions under which assessment results may legitimately be interpreted and applied. Without explicitly defined boundaries, identical analytical procedures may produce conclusions that appear inconsistent simply because they refer to different assessment objects, temporal horizons, or decision contexts.

Defining these boundaries requires more than identifying the organisation under examination. Every assessment is simultaneously constrained by four interdependent dimensions: **the entity being assessed**, **the temporal horizon** over which climate risk is considered, **the contextual environment** in which risk materializes, and **the purpose for which the assessment is performed**. Together, these dimensions determine the analytical domain within which the resulting conclusions remain valid.

The first dimension concerns the assessed entity. Climate risk cannot be evaluated independently of the organisational system to which it refers. Depending on the objectives of the assessment, the analytical unit may correspond to a single organisation, an operational facility, a portfolio of assets, a cooperative structure, or a geographically defined socio-economic system. Where multiple organisational units are assessed collectively, the aggregation logic is documented explicitly so that the resulting conclusions remain traceable to clearly defined governance and operational boundaries.

The second dimension establishes the temporal horizon of the assessment. Climate-related risks evolve over different timescales, and consequently the analytical perspective changes according to the period under consideration. Short-term assessments focus mainly on operational continuity and sensitivity to weather variability, while medium- and long-term assessments focus increasingly on structural exposure, adaptation trajectories, and the relationship between organisational decisions and changing climatic conditions. **Declaring the assessment horizon therefore prevents short-term operational resilience from being interpreted as evidence of long-term adaptive capacity**.

The third dimension defines the contextual environment within which climate risk emerges. Neither exposure nor vulnerability exists independently of sectoral characteristics, geographical conditions, regulatory requirements, or value-chain configuration. Identical climatic hazards may therefore produce substantially different consequences across organisations operating under different environmental and institutional conditions. Explicit contextualization ensures that assessment findings remain proportional to the conditions under which risk is generated and prevents misleading comparisons between fundamentally dissimilar systems.

The fourth dimension specifies the intended use of the assessment results. Assessment outputs may support strategic planning, internal risk management, financing decisions, insurance applications, policy evaluation, certification readiness, or comparative benchmarking. Although the underlying analytical methodology remains unchanged, the declared purpose establishes the interpretative framework within which assessment findings should subsequently be used.

Once these four dimensions have been established, the analytical boundaries of the assessment become explicit. Equally important, they define the boundaries beyond which interpretation is no longer methodologically justified. **The Framework therefore explicitly rejects scope inflation**. **Assessment results are not intended to support decisions, regulatory claims, financial evaluations, or reputational judgements that extend beyond the scope originally defined unless the assessment itself is formally revised**.

Scope definition also determines the proportionality of implementation. Because organisations differ substantially in complexity, materiality, and climate exposure, the Framework supports assessments of different analytical depth while preserving methodological consistency. **The selected level of assessment is therefore documented explicitly so that differences in implementation intensity are distinguished from differences in organisational performance.** The selected level of assessment is therefore documented explicitly so that differences in implementation intensity are distinguished from differences in organisational performance, as summarized in Table 5.

Finally, any limitations affecting the assessment scope, including restricted data availability, limited organisational access, or phased implementation, are recorded as characteristics of the assessment itself rather than treated as methodological deficiencies. Making these constraints explicit preserves transparency and allows subsequent users of the assessment to interpret the findings within their proper analytical context.

Assessment scope therefore performs a methodological function that extends well beyond defining the object of analysis. It establishes the conditions under which every subsequent stage of the Framework can be interpreted, compared, and responsibly applied. Only after these analytical boundaries have been explicitly defined can climate risk assessment proceed in a scientifically coherent and decision-relevant manner.

2. Data Collection and Input Structuring

Climate risk assessment is frequently expected to begin with the collection of comprehensive data. In practice, however, such conditions rarely exist. Organisations often operate with incomplete records, heterogeneous information sources, uncertain projections, and context-specific knowledge that cannot be fully quantified. Waiting for complete information would therefore postpone assessment indefinitely, making effective decision-making impossible precisely where it is most needed.

The methodological challenge is therefore not how to eliminate uncertainty through additional data, but how to produce credible assessment despite the unavoidable incompleteness of available information. Within the **FTSAI Climate Risk Assessment Framework**, data collection is consequently designed to support disciplined organisational judgement rather than exhaustive information gathering. **The quality of an assessment depends less on the volume of available data than on whether the available evidence is relevant, transparent, and appropriate for the analytical question being addressed**.

This objective immediately raises a second methodological requirement. If assessment relies on evidence rather than data quantity, the evidence itself must be evaluated systematically. No individual source can adequately represent the complexity of climate risk. Instead, the Framework integrates qualitative and quantitative information obtained from internal records, external databases, operational documentation, expert elicitation, stakeholder interviews, monitoring systems, and contextual knowledge. Their contribution is evaluated according to relevance, credibility, and consistency with the assessment scope rather than according to their format or origin.

Because different analytical questions require different forms of evidence, input collection cannot follow a uniform procedure. The information needed to evaluate exposure differs fundamentally from that required to assess organisational resilience, governance capacity, or adaptive readiness. For this reason, **each analytical module specifies its own evidence requirements, acceptable proxies, and documentation standards**.

Table 5. Proportional assessment depth within the FTSAI Climate Risk Assessment Framework.

Assessment Dimension	Screening	Focused Assessment	Comprehensive Assessment
Purpose	Determine whether climate risks may be material and whether further analysis is warranted.	Understand key climate risks and opportunities within defined priorities, assets and time horizons.	Provide a comprehensive and integrated understanding of climate risks, vulnerabilities, impacts and adaptive capacity.
Typical Use	• Early-stage decision making • Portfolio or asset screening • Resource allocation decisions	• Investment appraisal • Strategy and planning • Risk management prioritisation	• Strategic planning and transformation • Disclosure and stakeholder reporting • Governance and policy development
Coverage	High-level coverage across broad hazards, exposures and time horizons.	Focused coverage of selected hazards, material exposures and priority time horizons.	Comprehensive coverage across relevant hazards, exposures, vulnerabilities, time horizons and system interdependencies.
Data & Methods	Limited data, qualitative judgement, publicly available information.	Mixed data sources, sector context, simplified or partial quantitative analysis.	Robust data, multiple sources, quantitative analysis, scenario and uncertainty assessment.
Outputs	Initial risk indication and decision on need for further assessment.	Key risk findings, priority areas, recommended actions and data gaps.	Integrated risk profile, impact assessment, adaptation options, prioritisation and implementation roadmap.
What You Can Conclude	**Answer Yes or No.** Are climate risks potentially material and relevant? Is further assessment needed?	**Answer How and Where.** What are the key risks and opportunities? Where are the priorities? What actions should be considered?	**Answer How Much and What Next.** What are the magnitude and implications? What are the best options and trade-offs? How should we implement and monitor?
Limitations	High uncertainty; not sufficient for prioritisation or detailed decisions.	Partial view; some risks, interactions and long-term impacts may be missed.	Resource and time intensive; requires extensive data and stakeholder engagement.

Organizing inputs around conceptual rather than administrative boundaries prevents inappropriate reuse of evidence across analytical dimensions and preserves methodological coherence throughout the assessment.

Incomplete information remains an inherent feature of climate risk assessment rather than an exceptional circumstance. The Framework therefore requires that **missing data, inconsistencies, and low-resolution information be documented explicitly instead of being concealed through unsupported assumptions or artificial interpolation**. Where proxy variables are employed, both their justification and their interpretative limitations become part of the documented assessment record, allowing users to understand not only the available evidence but also its constraints.

The presence of uncertainty extends beyond missing observations alone. Information may be uncertain because of measurement limitations, because the underlying system itself is imperfectly understood, or because future decisions remain inherently unpredictable. The Framework therefore distinguishes between **data uncertainty**, **structural uncertainty**, and **decision uncertainty** at the point of data acquisition. Identifying these forms of uncertainty before analysis begins allows them to be propagated transparently through subsequent aggregation and scoring processes instead of becoming obscured within final assessment results.

Recognizing uncertainty inevitably increases the importance of professional judgement. Climate risk assessment cannot be reduced to mechanical data processing because available evidence frequently requires interpretation within its organisational and environmental context. The Framework therefore assigns assessor judgement an explicit methodological role while simultaneously constraining that judgement through documented reasoning, traceable evidence, and consistency verification. **Expert interpretation thus becomes accountable rather than discretionary**.

Professional judgement within the Framework is structured rather than discretionary. Assessors may interpret context-specific evidence where mechanical rules would be analytically inappropriate, but such interpretation must remain anchored to standardized assessment criteria, defined evidentiary requirements, documented reasoning, and controlled scoring guidance. Equivalent evidence assessed under equivalent methodological conditions should therefore lead to materially consistent conclusions, even where minor differences in professional interpretation remain possible.

Reproducibility within the Framework does not require identical wording or identical professional reasoning. It requires consistency in the analytical meaning of conclusions, classification outcomes, and treatment of material evidence. Where professional judgement materially influences an assessment outcome, the basis of that judgement must remain sufficiently explicit to permit independent review, challenge, and replication by another qualified assessor.

These same principles also determine the proportionality of data collection. Since organisations differ substantially in scale, complexity, and decision context, the intensity of evidence collection should remain proportionate to the purpose of the assessment. In exploratory or screening assessments, lighter evidence structures are acceptable, whereas high-consequence applications require more documentation, stronger triangulation, and more extensive validation. Proportionality therefore reflects methodological appropriateness rather than analytical compromise.

The credibility of assessment ultimately depends on whether every conclusion can be traced back to the evidence from which it emerged. For this reason, the Framework requires systematic documentation of input sources, evidence quality, interpretative rationale, and analytical decisions throughout the assessment process. Traceability enables internal verification, external review, and future reassessment without requiring disclosure of confidential or proprietary information.

Data collection within the FTSAI Climate Risk Assessment Framework is therefore not conceived as an exercise in accumulating information. Its methodological purpose is to construct a transparent body of evidence capable of supporting disciplined judgement under conditions where complete certainty is neither available nor scientifically attainable.

3. Module Application and Iterative Review

A climate risk assessment is often perceived as a procedure that culminates in a final result. Such an assumption may be appropriate where the object of assessment remains stable over time. Climate risk, however, evolves continuously. Climatic conditions change, organisational structures adapt, investments modify exposure, governance decisions reshape adaptive capacity, and new information progressively becomes available. An assessment that remains unchanged while the assessed system evolves inevitably becomes less representative of the reality it was intended to describe.

The methodological challenge is therefore not how to produce a definitive assessment, but how to preserve the scientific validity of the assessment as both knowledge and organisational conditions change. Repeating the entire assessment whenever new information emerges would be operationally impractical, while ignoring evolving evidence would progressively reduce the relevance of the assessment itself. The Framework therefore requires a mechanism that allows analytical evolution without sacrificing methodological continuity.

This mechanism is provided through controlled iterative assessment. **Iteration is not introduced as an optional refinement of the analytical process but as the methodological consequence of recognising that climate risk is inherently dynamic**. The objective is not to replace previous assessments but to update those analytical components whose underlying assumptions or supporting evidence have materially changed while preserving the integrity of the overall **assessment architecture**.

The sequential application of analytical modules provides the structure that makes such controlled iteration possible. **Hazard characterisation** establishes the climatic conditions under consideration. These conditions determine the subsequent mapping of organisational exposure, which in turn provides the basis for evaluating **vulnerability and resilience**. The resulting risk profile is then interpreted through the assessment of **organisational readiness** and adaptive governance. **Each module therefore answers a distinct analytical question while simultaneously providing the foundation for the next stage of the assessment**.

Because these analytical relationships are explicitly defined, reassessment does not necessarily require reconstruction of the entire Framework. Where new evidence affects only a specific component of the assessment, iteration may remain confined to the relevant analytical module while preserving consistency across the remaining structure. **Controlled iteration therefore increases both analytical efficiency and methodological robustness**.

Not all analytical updates, however, have the same methodological significance. Some shifts merely increase the precision of previous conclusions, while others change the very way we interpret organisational risk. The Framework therefore distinguishes between **refinement** and **revision**. Refinement increases the confidence or resolution of an existing assessment without modifying its conceptual structure. Conversely, a revision implies substantive changes because of new information, changed exposure pathways, organisational change, or important changes in adaptive capacity. Maintaining this distinction preserves analytical continuity while ensuring that meaningful structural change remains explicitly recognised.

The need for iteration may arise under several circumstances. Material data gaps may be resolved, internal inconsistencies may become evident, new climatic information may emerge, operating conditions may change, or governance and investment decisions may alter organisational exposure or resilience. Periodic reassessment may likewise trigger iterative review. Regardless of the initiating event, **iteration is always driven by demonstrated analytical relevance rather than by routine repetition**.

Because assessment outputs may influence significant organisational and policy decisions, every iterative modification must remain fully transparent. Changes to module outputs are therefore documented together with their supporting evidence, methodological rationale, and implications for subsequent stages of the assessment. This documentation preserves traceability, enables independent review, and allows future users to reconstruct the evolution of the assessment over time.

The Framework simultaneously recognises that iteration itself requires methodological discipline. **Continuous refinement may appear to increase analytical sophistication, but it does little to improve the quality of decisions.** Iteration is therefore constrained by materiality, proportionality, and relevance to the purpose of the assessment. Analytical effort is directed toward changes capable of influencing organisational understanding rather than toward continual adjustment of inconsequential details.

Controlled iteration therefore represents far more than a procedural feature of the FTSAI Climate Risk Assessment Framework. It constitutes the methodological mechanism through which scientific consistency is preserved while the organisational system, the available evidence, and the climate risks themselves continue to evolve. Without such controlled adaptation, assessment stability would be achieved only by progressively losing correspondence with the reality the Framework is intended to evaluate.

4. Scoring Synthesis and Interpretation

The completion of an assessment does not automatically produce understanding. Although the analytical modules generate structured findings, these findings remain isolated observations until they are interpreted as parts of a coherent representation of organisational climate risk. Numerical outputs alone cannot explain why risk exists, how it develops, or which organisational conditions require attention. **The methodological challenge is therefore not simply to calculate scores, but to transform analytical observations into evidence capable of supporting informed judgement**.

For this reason, **the FTSAI Climate Risk Assessment Framework treats scoring synthesis as an interpretive rather than purely computational process**. The objective is not merely to combine module outputs but to preserve the analytical relationships established throughout the assessment. Synthesis therefore consolidates evidence derived from **hazard characterisation**, **exposure mapping**, **vulnerability and resilience** assessment, and **organisational readiness** while maintaining the contribution of each analytical component to the overall risk profile.

This requirement immediately creates a further methodological constraint. If synthesized scores are to preserve analytical meaning, **aggregation cannot rely solely on mathematical averaging**. Different sources of climate risk do not contribute equally to organisational vulnerability, **nor can critical weaknesses be offset simply because other components perform favourably.**

The Framework therefore aggregates module outputs in a manner that preserves sensitivity to dominant risk drivers, structural dependencies, and threshold conditions, preventing severe vulnerabilities from being obscured within otherwise favourable overall scores.

Even when aggregation is methodologically sound, however, numerical outputs remain incomplete without interpretation. A score acquires meaning only when examined within the conditions under which it was produced. Interpretation therefore considers the assessment scope, temporal horizon, sectoral characteristics, geographical context, and operating environment that define the analytical boundaries of the assessment. **Scores are consequently understood as relative indicators within a specified methodological context rather than as universal measures of organisational safety or risk**.

Interpretation also requires evaluation of the internal coherence of assessment results. Relationships between hazards, exposure pathways, vulnerability characteristics, organisational resilience, and readiness should collectively describe a plausible representation of the assessed system. Thus, **unexpected score combinations or extreme values, apparently contradicting results, are to be regarded as analytical signals for investigation and not as computational errors to be corrected**.

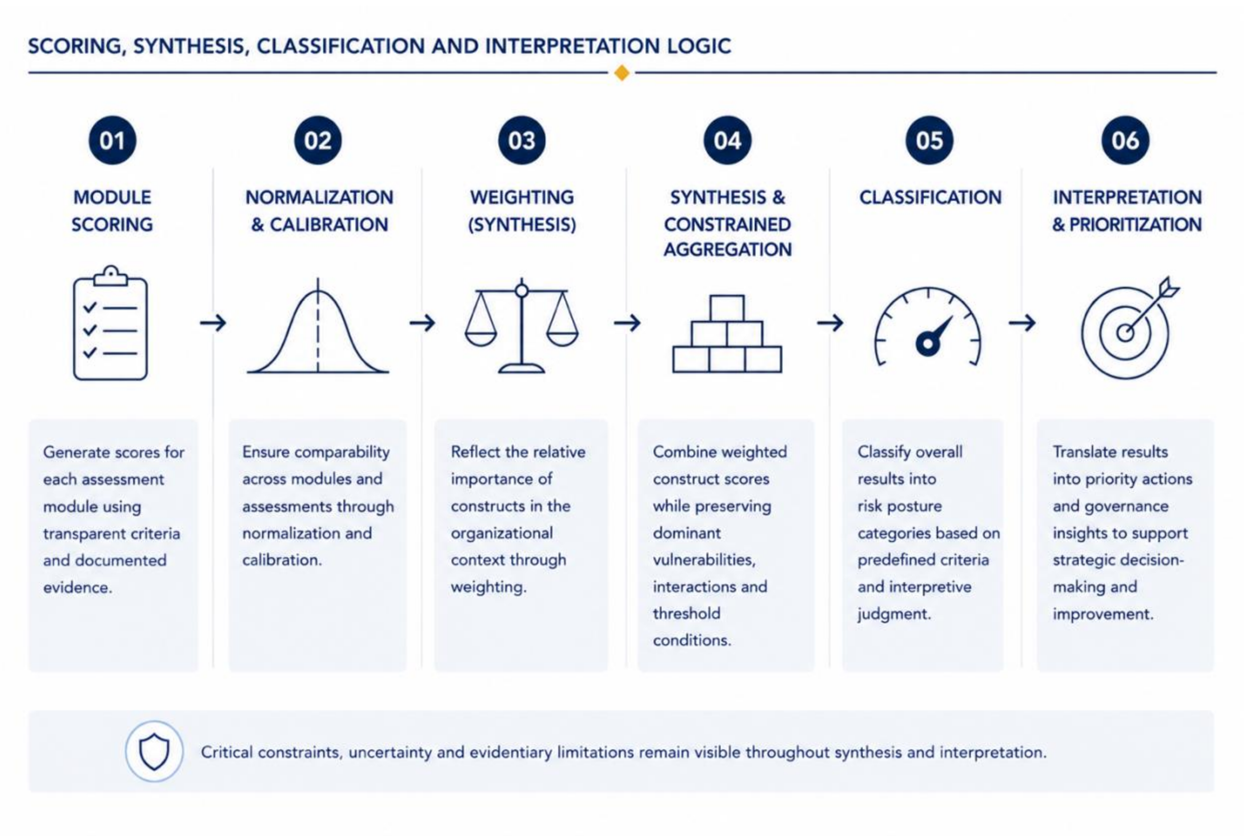

Figure 12. Scoring, Synthesis, Classification, and Interpretation Logic of the FTSAI Climate Risk Assessment Framework.

Where such inconsistencies emerge, the Framework requires targeted reassessment instead of unconditional acceptance of numerical outputs. Specific assumptions, supporting evidence, or module interpretations may be revisited to determine whether the observed inconsistency reflects genuine organisational conditions or limitations in the available evidence. Plausibility review therefore functions as an additional safeguard protecting the scientific credibility of the assessment process.

The purpose of interpretation extends beyond assigning an overall level of risk. Decision-making depends primarily on understanding the mechanisms that generate organisational vulnerability. For this reason, interpretation identifies dominant risk drivers, structural constraints, and critical organisational fragilities that may require attention even where aggregate scores appear favourable. Higher overall risk ratings, in contrast, point to areas that must be addressed by the organisation, but do not suggest that negative outcomes are a foregone conclusion. The methodological progression from scoring through synthesis and classification to interpretation is summarized in Figure 12.

This difference also clarifies the relationship between analytical results and interpretive conclusions. **The scoring syntheses offer structured analytic evidence. Interpretation transforms that evidence into organisational understanding capable of informing strategic planning, governance decisions, financing considerations, and other downstream applications**. The two stages therefore perform complementary but fundamentally different methodological functions.

Scoring synthesis therefore does not represent the conclusion of the assessment but the beginning of its interpretation. Numerical outputs acquire scientific value only when they are examined within the analytical structure from which they emerged. Detached from that structure, scores become descriptive statistics; interpreted within it, they become evidence capable of supporting disciplined organisational judgement.

5. Reporting and Communication of Results

Completion of an assessment does not guarantee that its findings will be correctly understood. Once assessment results leave the analytical environment in which they were produced, they become vulnerable to simplification, selective interpretation, and inappropriate application. Numerical scores, executive summaries, or visual dashboards may communicate conclusions efficiently while simultaneously concealing the methodological conditions that gave those conclusions their meaning. **The challenge of reporting is therefore not simply to communicate results, but to preserve their scientific integrity after communication**.

For this reason, **reporting within the FTSAI Climate Risk Assessment Framework is treated as a continuation of the assessment process rather than as a presentation activity performed after analysis has been completed**. Its methodological objective is to ensure that assessment findings retain the analytical context necessary for responsible interpretation, regardless of the audience or reporting format through which they are communicated.

This objective immediately imposes important reporting requirements. **Assessment outputs must always remain inseparable from the conditions under which they were produced**. Every report therefore explicitly documents the assessment scope, temporal horizon, methodological boundaries, underlying assumptions, uncertainty context, and known data limitations. These elements are presented as integral components of the assessment rather than as supplementary technical information because they define the conditions under which the reported findings remain scientifically valid.

Preserving methodological meaning also requires a clear distinction between analytical findings and their possible implications. The Framework identifies observed risk configurations, dominant drivers, structural vulnerabilities, and **organisational readiness** as analytical findings derived directly from the assessment process. **Any discussion of potential organisational responses is presented separately as interpretive guidance rather than as methodological output**. Unless explicitly defined within the agreed scope of the assessment, reports do not prescribe actions, establish decision thresholds, or determine organisational eligibility.

The same distinction applies to the presentation of assessment results themselves. Descriptive reporting communicates the analytical evidence generated by the Framework, including hazard relevance, exposure pathways, vulnerability characteristics, readiness indicators, and synthesized classifications. Interpretation subsequently explains the significance of these findings within their organisational, sectoral, and governance context without implying deterministic conclusions or predictive certainty.

Because summarized information is particularly susceptible to misinterpretation, the Framework discourages reporting formats that isolate aggregate scores from the reasoning that produced them. Executive summaries, dashboards, and visual classifications improve accessibility only when they remain explicitly connected to the analytical explanation supporting them. **Visual communication therefore complements interpretation but never replaces it**.

Comparative reporting requires methodological discipline. Benchmarking, longitudinal analysis, or cross-organisational comparison is meaningful only where methodological consistency has been preserved across assessments. Reports therefore explicitly describe the basis of comparison, the extent of analytical comparability, and the limitations affecting interpretation. Rankings or league-table presentations are excluded unless their methodological validity has been explicitly established.

Effective communication must also recognise that different audiences require different levels of analytical detail without requiring different analytical conclusions. Technical audiences receive comprehensive methodological documentation, uncertainty analysis, and supporting evidence. Governance bodies and strategic decision-makers receive interpretation organised around dominant risk drivers, organisational constraints, and adaptive opportunities. **Although the presentation varies, the analytical meaning remains unchanged**.

Figure 13. Reporting architecture of the FTSAI Climate Risk Assessment Framework, illustrating how a common analytical assessment is translated into audience-specific technical and governance outputs while preserving consistent evidence, methods, scoring, uncertainty, and analytical meaning.

Reporting therefore represents the final methodological safeguard of the FTSAI Climate Risk Assessment Framework rather than the final administrative stage of the assessment process. Assessment findings preserve their scientific value only when the conditions that generated them remain visible after communication. Once those conditions are removed, even technically correct results become vulnerable to oversimplification, misinterpretation, and inappropriate decision-making.

6. Review, Update, and Reassessment

A climate risk assessment does not lose its scientific value because its methodology becomes obsolete. It loses scientific value because the organisational system it represents continues to evolve while the assessment itself remains unchanged. Climate hazards develop, assets are modified, governance arrangements mature, operational practices adapt, and new evidence continuously emerges. An assessment that accurately represented organisational reality at one point in time may therefore become progressively less representative without containing a single methodological error.

The challenge is consequently not whether assessments should be reviewed, but how scientific correspondence between the assessment and the evolving system can be preserved without repeatedly reconstructing the entire analytical process. Repeating every assessment whenever organisational conditions change would impose unnecessary analytical burden, whereas allowing assessments to remain static would gradually undermine their decision relevance. The Framework therefore requires a mechanism that preserves analytical validity while accommodating continuous organisational and environmental change.

This mechanism is provided through disciplined review, update, and reassessment. **These activities are not maintenance procedures performed after completion of the assessment but methodological processes through which the Framework remains aligned with the evolving reality it seeks to represent**. Their purpose is to ensure that analytical conclusions continue to reflect current organisational conditions rather than the historical circumstances under which the original assessment was conducted.

Because organisational change varies substantially in significance, reassessment cannot follow a uniform schedule. **The Framework therefore adopts a trigger-based approach rather than fixed reassessment intervals**. Material changes in operating conditions, significant hazard events, asset or value-chain modifications, governance reforms, regulatory developments, or changes in financial conditions may each justify reassessment when they materially affect the analytical representation of climate risk. This approach avoids both unnecessary reassessment and methodological stagnation.

The nature of the identified change also determines the extent of reassessment required. Some of these developments impact only some of the analytical elements and others alter the overall representation of the organisational climate risk. The Framework therefore makes a distinction between **targeted review** and **full reassessment**. Targeted review updates only the analysis modules directly affected by the observed change. Full reassessment reestablishes the complete analytical representation under revised scope, evidence and organisational conditions. The distinction is made to maintain analytical consistency, and methodological efficiency.

Consistency from one assessment to the next is more than a transition of analytical outputs. Every change must be traceable to the evidence and reasoning that justified it. Changes in scores, classifications, and interpretive conclusions are therefore documented together with the underlying drivers responsible for those changes. Where assessment outcomes differ substantially from previous cycles, the Framework explicitly identifies whether these differences result from changing organisational conditions, improved evidence, revised analytical understanding, or modifications to the assessment scope itself.

Interpreting change requires equal methodological discipline. **Differences in assessment results across successive assessment cycles do not necessarily indicate that the organisation's underlying climate risk condition has improved or deteriorated.** Increased **organisational readiness** may precede observable reductions in vulnerability, and stable aggregate scores may hide growing structural exposure under changing hazard conditions. The Framework therefore emphasizes interpretation of underlying trajectories and causal mechanisms rather than simple comparison of numerical values across assessment cycles.

Methodological continuity must also remain protected throughout repeated applications of the Framework. Core concepts, scoring principles, and interpretive rules remain stable across assessment cycles so that changes in assessment results primarily reflect changes in organisational reality rather than changes in methodology. Where methodological refinement becomes necessary, **version control** and explicit re-baselining preserve transparency while maintaining comparability across successive assessments.

Review, update, and reassessment therefore represent the final mechanisms through which the **FTSAI Framework** preserves **methodological integrity** throughout the assessment lifecycle. **Scientific validity is maintained not because assessments remain unchanged, but because they continue to evolve in parallel with the organisational systems, they are intended to represent**. Without disciplined reassessment, methodological consistency would ultimately be preserved only by allowing analytical validity to disappear.

7. Ethical and Responsible Application

Completion of a scientifically rigorous assessment does not, by itself, guarantee that the assessment will subsequently be used responsibly. Once analytical findings enter organisational, financial, or policy decision-making processes, they may be interpreted, simplified, or applied in ways that extend beyond the methodological conditions under which they were originally produced. **Scientific validity can therefore be preserved throughout the assessment process yet still be compromised during the application of its results**.

The methodological challenge is consequently not whether assessment findings are scientifically credible, but whether their subsequent use remains scientifically justified. The **FTSAI Climate Risk Assessment Framework** therefore extends **methodological integrity** beyond assessment itself to include the responsible application of assessment outputs. **Ethical safeguards are introduced not as external moral principles but as methodological mechanisms preventing scientifically valid evidence from being transformed into scientifically unjustified decisions**.

This objective immediately defines the role of assessment findings. Framework outputs describe organisational climate risk under explicitly defined analytical conditions. **They do not assign fault, attribute responsibility, or express moral judgement**. Elevated risk classifications represent observed interactions between hazards, exposure, vulnerability, resilience, and governance capacity rather than organisational failure or managerial incompetence. Responsible interpretation therefore requires continuous reference to the scope, temporal horizon, evidence quality, and uncertainty conditions that define the limits of every assessment.

Recognising these methodological boundaries also limits the legitimate use of assessment results. Aggregate scores are not intended to function as automatic decision thresholds. For decisions about financing, insurance, certification, regulatory treatment or public support, numerical classifications are not enough; they require interpretation in context. **The Framework therefore prohibits exclusionary decisions based on the aggregate assessment results unless accompanied by explicit interpretive reasoning, proportional safeguards and consideration of the broader organisational context**.

The same principle applies to the relationship between the assessed entity and the assessor. Climate risk is often driven by structural conditions that organisations cannot immediately change. Responsible application therefore requires procedural fairness, opportunities for clarification, and interpretation proportionate to the adaptive capacity realistically available to the assessed entity. **Organisations**

should not be disadvantaged simply because structural constraints limit the speed or extent of feasible adaptation.

Methodological responsibility also extends across time. Assessment findings describe organisational conditions existing at a particular stage of the assessment lifecycle rather than permanent organisational characteristics. Thus, continuing to rely on an outdated assessment after a significant change in the organisation or its environment is a failure of responsible application, not a limitation of the assessment methodology itself.

The Framework also discourages the instrumental use of assessment results to serve reputational purposes that are unrelated to substantive governance improvement. Assessment findings may be used to facilitate communication or stakeholder engagement or public disclosure only when the communication is based on the underlying analytical evidence. Reporting should not imply any guaranties, endorsements, certifications or levels of organisational resilience not specifically established through the assessment process.

Responsible application ultimately requires transparency from all users of assessment outputs. Whenever findings are communicated or relied upon in downstream decision-making, the associated scope, methodological assumptions, uncertainty conditions, and interpretive limitations should remain visible to those using the results. **Scientific evidence preserves its integrity only when the conditions governing its interpretation remain inseparable from the conclusions themselves**.

Ethical and responsible application therefore represents the final safeguard of **methodological integrity** throughout the assessment lifecycle. **Scientific assessment achieves its purpose not when accurate results are produced, but when those results continue to support decisions that remain faithful to the methodological conditions under which they were established**. Without responsible application, even scientifically rigorous assessments may become instruments of exclusion, misrepresentation, or inappropriate governance rather than foundations for informed organisational resilience.

Annex A

Scoring Architecture and Interpretation Logic

Scientific transparency requires that users understand how assessment findings are generated, interpreted, and constrained by methodological assumptions. Such transparency does not necessarily require unrestricted public disclosure of every implementation detail. The methodological challenge is therefore to provide sufficient transparency for informed interpretation while preserving the integrity, consistency, and controlled evolution of the Framework. The purpose of this Annex is to describe the **methodological architecture** governing scoring and interpretation within the **FTSAI Framework**. It does not provide a complete reproduction of all calibration parameters, sector-specific benchmarks, or controlled implementation specifications, which are maintained through the **Framework governance** process and revised through empirical application.

Over time, the empirical value of the scoring methodology depends not only on its formal structure but also on accumulated application experience, sector-specific evidence, calibration knowledge, assessor competence, and comparative datasets generated through repeated assessments. These elements constitute an essential component of methodological evolution under Principles M8 and M9.

For this reason, **the FTSAI Climate Risk Assessment Framework distinguishes between methodological transparency and disclosure of controlled implementation details**. This Annex explains the conceptual logic through which assessment findings are generated without disclosing controlled calibration parameters, implementation specifications, and computational procedures that constitute governed components of the Framework.

The Framework applies a multi-dimensional scoring architecture in which qualitative and quantitative evidence is evaluated across successive analytical modules. Assessment inputs are transformed into structured scores through standardized evaluation procedures designed to preserve internal consistency and comparability across assessments while remaining sensitive to differences in organisational context. The evaluation logic remains documented and governed within the Framework's methodological control system.

From the perspective of Framework users, scoring outputs are not intended to function as isolated numerical results. They are interpreted together with the underlying analytical dimensions, evidence base, uncertainty annotations, scope conditions, and contextual factors that determine their meaning. The purpose of scoring is therefore not to replace analytical judgement with a numerical classification, but to provide a structured representation of assessment findings that supports comparison, prioritisation, monitoring, and informed organisational decision-making.

These module-level assessments are subsequently integrated through controlled aggregation processes that preserve the analytical relationships established throughout the Framework. **Aggregation is explicitly designed to prevent critical organisational weaknesses from being obscured through compensatory averaging** (consistent with Principle M3 — **Non-Compensatory Interpretation**) while maintaining consistency between **hazard characterisation**, exposure, vulnerability, resilience, **organisational readiness**, and adaptive capacity.

Overall climate risk and readiness profiles emerge through controlled synthesis across the analytical architecture. Weighting may be used to represent differences in the relative analytical significance of assessment components, but it operates within non-compensatory constraints that preserve critical vulnerabilities, threshold conditions, interaction effects, and dominant risk drivers. **Weighting therefore influences the relative contribution of assessment components without allowing favourable performance in one dimension to mechanically offset material weakness in another**. The specific weighting and aggregation mechanisms may be adapted **within controlled methodological boundaries** to sectoral characteristics, assessment purpose, or temporal horizon, provided that these non-compensatory principles remain unchanged. Where independent verification, validation, audit, conformity assessment, or certification activities require examination of controlled methodological specifications, such access shall be provided under appropriate governance arrangements as described in the Framework.

Controlled methodological information, including detailed calibration parameters, weighting structures, threshold values, and implementation specifications, is maintained under the **Framework governance** process. Such information remains accessible to authorised independent parties where required for implementation, verification, validation, audit, conformity assessment, or certification-related examination under applicable governance and contractual arrangements. Such controlled access ensures that methodological transparency, independent examination, and scientific accountability remain compatible with the need for consistent application and controlled evolution of the methodology.

Annex B

Methodological Treatment of Uncertainty

B.1 Purpose and Scope of the Annex

Climate risk assessment is frequently expected to reduce uncertainty by producing increasingly precise estimates of future conditions. **Such an expectation reflects a misunderstanding of both climate risk and scientific assessment**. While improved evidence may reduce specific knowledge gaps, **uncertainty itself cannot be eliminated because it arises not only from incomplete information but also from the dynamic, adaptive, and non-linear behaviour of the systems being assessed**.

The methodological challenge is therefore not how to remove uncertainty, but how to ensure that uncertainty remains visible throughout the assessment process without preventing meaningful decision-making. **Suppressing uncertainty creates false confidence, whereas allowing uncertainty to dominate interpretation results in analytical paralysis**. The **FTSAI Climate Risk Assessment Framework** therefore adopts a third position: **uncertainty is treated as an explicit analytical object whose identification, documentation, propagation, and interpretation form integral components of the assessment methodology**.

Accordingly, this Annex establishes the methodological principles governing the treatment of uncertainty throughout all analytical modules and application contexts of the Framework. Its purpose is not to quantify uncertainty for its own sake, but to ensure that assessment conclusions remain scientifically credible by remaining consistent with the evidentiary limits from which they are derived.

B.2 Conceptual Positioning of Uncertainty

Within the FTSAI Framework, uncertainty is understood as a permanent characteristic of climate risk assessment rather than a temporary analytical deficiency. Climate systems evolve, organisational responses remain adaptive, and many causal interactions cannot be observed directly. Consequently, **uncertainty is generated by the nature of the assessed system itself rather than solely by limitations in available evidence**.

This distinction has important methodological consequences. **Additional information may reduce forms of uncertainty, but it cannot eliminate uncertainty as a structural feature of complex socio-technical systems**. **The Framework therefore explicitly rejects approaches that attempt to create an appearance of certainty through excessive parameterization, unwarranted quantification, or probabilistic extrapolation unsupported by available evidence**.

Rather than concealing uncertainty behind increasingly complex analytical models, the Framework requires uncertainty to remain explicit throughout interpretation. **Scientific credibility is strengthened not by claiming greater certainty than the evidence permits, but by ensuring that analytical conclusions remain proportional to the confidence that the available evidence can legitimately support**.

B.3 Categories of Uncertainty

Recognizing uncertainty as an integral component of climate risk assessment immediately raises a further methodological question. If uncertainty arises from multiple sources, can it be treated as a single analytical construct? The **FTSAI Framework** concludes that it cannot. **Different forms of uncertainty originate through different mechanisms, influence assessment in different ways, and require different interpretive responses**. **Treating uncertainty as a single undifferentiated concept would therefore obscure information that is itself analytically significant**.

For this reason, the Framework distinguishes three complementary categories of uncertainty. The distinction is not intended to fragment interpretation but to preserve clarity regarding the origin of uncertainty and the way in which it influences assessment results.

Data uncertainty reflects limitations in the available evidence. It arises from incomplete, inconsistent, outdated, or low-resolution information, including missing historical observations, reliance on proxy indicators, spatial aggregation, or restricted temporal coverage. Its primary consequence is uncertainty regarding the empirical description of the assessed system.

Structural uncertainty arises from ignorance about the system itself. Climate risk occurs through complex interactions, feedback, threshold effects and non-linear processes where causal relationships cannot always be observed directly. This form of uncertainty therefore reflects limitations in explanatory understanding rather than deficiencies in available data.

Decision uncertainty originates from the adaptive behaviour of organisations and institutions. Governance reforms, behavioural responses, strategic decisions, policy interventions, and organisational learning continuously reshape future risk trajectories. Because these responses cannot be determined in advance, uncertainty also emerges from the evolving decisions of the assessed system itself.

A further source of uncertainty arises from interpretation itself. Interpretive uncertainty may occur where available evidence requires professional judgement, contextual interpretation, or expert assessment before conclusions can be established.

Although each category originates through a different mechanism, they are never interpreted in isolation. **Climate risk assessment requires their combined consideration because the overall uncertainty surrounding an assessment reflects the interaction of evidential limitations, structural complexity, and adaptive decision-making**.

B.4 Documentation and Traceability of Uncertainty

Once uncertainty has been distinguished according to its origin, a second methodological requirement follows naturally. **Uncertainty cannot influence interpretation unless it remains visible throughout the assessment process**. **If uncertainty disappears during documentation or aggregation, subsequent conclusions may appear more certain than the available evidence justifies**.

For this reason, the Framework requires explicit documentation of uncertainty at both module and analytical layer levels. **Every assessment output is accompanied by uncertainty annotations identifying the source of uncertainty, its underlying category, and its potential implications for interpretation**. This requirement is consistent with Principle M2 — **Evidence Traceability**. These annotations are considered part of the assessment, not just technical notes to go along with it.

Documentation is about transparency and traceability, not completeness. The objective is not to quantify every possible source of uncertainty but to preserve sufficient information for subsequent interpretation and independent review. **Accordingly, uncertainty is never collapsed into a single composite indicator or confidence score**. Keeping the different sources of uncertainty visible maintains auditability and prevents the illusion of certainty from being created by aggregation alone.

B.5 Propagation of Uncertainty through Assessment Stages

Explicit documentation alone is insufficient if uncertainty is subsequently ignored during analysis. **Once identified, uncertainty must accompany the assessment throughout its entire analytical progression**. **Otherwise, downstream conclusions may appear increasingly precise despite depending upon evidence whose limitations remain unchanged**.

The Framework therefore treats uncertainty as a property that propagates through successive stages of assessment. Uncertainty identified during **hazard characterisation** influences the interpretation of **exposure mapping**. Exposure-related uncertainty conditions subsequent evaluation of **vulnerability and resilience**, while uncertainty associated with these assessments ultimately shapes interpretation of overall climate risk and **organisational readiness**.

This propagation is intentional rather than incidental. **The Framework explicitly discourages analytical practices that truncate uncertainty during aggregation or replace uncertainty with artificial precision as assessment progresses**. Instead, uncertainty remains continuously visible and is incorporated into interpretive guidance at every stage of the analytical process.

Uncertainty therefore evolves together with the assessment itself. It is neither resolved through aggregation nor diminished by analytical progression. **By preserving uncertainty throughout successive stages of assessment, the Framework ensures that final conclusions remain consistent with the evidentiary limits from which they were originally derived**.

B.6 Interpretation under High Uncertainty Conditions

Recognising uncertainty as an integral component of climate risk assessment inevitably changes the way assessment findings should be interpreted. If uncertainty reflects the nature of the assessed system rather than a defect of the assessment itself, then **the presence of high uncertainty cannot automatically invalidate analytical conclusions**. To do so would imply that meaningful assessment is possible only under conditions that rarely exist in complex climate-risk environments.

The methodological challenge is therefore not whether conclusions produced under high uncertainty should be accepted or rejected, but how they should be interpreted responsibly. **The Framework addresses this challenge by replacing certainty-oriented interpretation with conditional reasoning**. Assessment under high uncertainty focuses on identifying dominant risk drivers, recognising structurally plausible system behaviour, and evaluating the sensitivity of conclusions across alternative but credible configurations.

Accordingly, **high uncertainty does not justify analytical paralysis. Instead, it requires greater interpretive discipline**. **Assessment findings remain decision-relevant provided that their evidentiary limitations remain explicit and the conditions governing their interpretation are communicated transparently**.

B.7 Relationship between Uncertainty and Robustness

This distinction immediately raises a second methodological question. If uncertainty remains high, can assessment conclusions nevertheless be considered reliable?

The Framework concludes that uncertainty and robustness address fundamentally different analytical questions. **Uncertainty describes the limitations surrounding available evidence and system understanding. Robustness evaluates whether the principal conclusions remain stable despite those limitations**.

For this reason, **high uncertainty should not be interpreted as evidence of low robustness**. Assessment conclusions may remain robust when their essential interpretation remains consistent under reasonable variation of assumptions, inputs, or plausible future conditions. **Robustness therefore reflects the stability of analytical reasoning rather than the precision of numerical estimates**.

The Framework consequently evaluates robustness qualitatively, emphasizing directional consistency of conclusions rather than requiring mechanical sensitivity metrics as the only basis for evaluating robustness. Confidence in the assessment therefore does not arise from the absence of uncertainty, but from demonstrating that the interpretation remains justified despite the uncertainty surrounding the available evidence.

B.8 Misuse of Uncertainty in Climate Risk Assessment

Recognising uncertainty appropriately also requires recognising the ways in which it may be misused. **Once uncertainty becomes explicit, it can itself become a source of analytical distortion if interpreted selectively or strategically**.

The Framework therefore distinguishes between legitimate acknowledgment of uncertainty and inappropriate exploitation of uncertainty. Common misuse includes treating uncertainty as justification for inaction, **overstating analytical precision to support predetermined decisions**, **reducing uncertainty to misleading confidence scores**, or **ignoring the uncertainty created by adaptive organisational behaviour**.

These practices share a common characteristic. They substitute analytical convenience for methodological discipline. **Responsible assessment therefore requires uncertainty to remain proportional to the available evidence without allowing it either to disappear through artificial certainty or to dominate decision-making through unjustified scepticism**.

B.9 Implications for Certification, Financial, and Policy Use

The methodological treatment of uncertainty has direct implications for practical application of the Framework. **Because uncertainty remains visible throughout the assessment process, downstream users can evaluate not only assessment findings but also the evidentiary conditions under which those findings were established**. This approach complements the controlled scoring logic described in Annex A by ensuring that methodological synthesis does not conceal evidentiary limitations.

For certification readiness, explicit uncertainty documentation strengthens transparency without weakening the credibility of assessment conclusions. **Uncertainty provides a basis for differentiated interpretation, proportionate decision-making, and precautionary governance in financial and policy contexts, while avoiding the false confidence created by overstated precision.**

In each application, uncertainty serves the same methodological purpose: it aligns the strength of analytical conclusions with the strength of the evidence supporting them.

B.10 Summary of Methodological Position

Within the FTSAI Climate Risk Assessment Framework, uncertainty is treated neither as an analytical deficiency nor as an obstacle to decision-making. **It is recognised as an inherent characteristic of climate risk that must remain visible throughout assessment, interpretation, and application**. By distinguishing its sources, preserving its propagation, and integrating it explicitly into interpretation, the Framework avoids both false precision and analytical abdication. **Scientific credibility therefore arises not from eliminating uncertainty, but from ensuring that every assessment conclusion remains proportionate to the evidentiary limits from which it is derived**.

Annex C

Scenario Logic without Forecasting

C.1 Purpose and Positioning of Scenario Analysis

Climate risk assessment is frequently expected to answer a seemingly straightforward question: What is most likely to happen in the future? Such an expectation naturally encourages the use of forecasting techniques that extrapolate historical observations into future conditions. While this approach may be appropriate in relatively stable systems, it becomes increasingly problematic where future system behaviour is shaped by non-linearity, feedback mechanisms, adaptive decision-making, and evolving climatic conditions.

The methodological challenge is therefore not simply how to improve forecasts, but whether prediction itself remains an appropriate analytical objective under conditions of deep uncertainty (Lempert et al., 2003; Walker et al., 2004). As uncertainty increases, the apparent precision of forecasts often exceeds the evidentiary support available to justify them. **Greater numerical sophistication may therefore create greater confidence without necessarily producing greater scientific reliability**.

For this reason, the **FTSAI Climate Risk Assessment Framework** adopts a fundamentally different analytical perspective. **Rather than attempting to predict the future, the Framework uses scenarios to explore how different but plausible future conditions may influence organisational exposure, vulnerability, resilience, and adaptive capacity**. **Scenario analysis therefore supports disciplined reasoning under uncertainty without claiming knowledge of which future will ultimately emerge**.

Accordingly, this Annex establishes the methodological principles governing scenario reasoning throughout the Framework. **Its purpose is not to improve prediction, but to provide a structured analytical approach capable of supporting robust judgement where prediction itself becomes methodologically unreliable**.

C.2 Conceptual Distinction between Scenarios and Forecasts

Once prediction is no longer regarded as the primary objective of climate risk assessment, a second methodological question immediately follows. If scenarios are not forecasts, what distinguishes them?

The distinction lies not in the analytical techniques employed but in the scientific questions being addressed. **Forecasting attempts to estimate future states by extrapolating existing trends, model structures, or probabilistic relationships. Its objective is to determine what is expected to occur**. **Scenario reasoning pursues a fundamentally different objective. It explores how systems may behave if combinations of climatic, organisational, and governance conditions arise, without claiming that those conditions will actually occur**.

Scenarios are internally consistent descriptions of possible future environments, not predictions of future reality (IPCC, 2022; van den Heijden, 2004). The value of their analysis lies in their ability to uncover structural vulnerabilities, adaptive constraints, and possible directions of organisational response under varying stress configurations.

This distinction has important methodological consequences. Scenario outputs are never interpreted as predictive statements, probability estimates, or forecasts of future events. **They function instead as analytical lenses through which the behaviour of complex systems can be examined under conditions where prediction alone cannot provide reliable guidance**.

C.3 Principles Governing Scenario Construction

Accepting scenarios as instruments of structured reasoning immediately constrains how they should be constructed. **If scenarios are intended to support interpretation rather than prediction, their scientific quality depends not on the number of scenarios considered but on the methodological discipline governing their selection**.

The Framework therefore adopts four complementary principles.

The first is **plausibility**. Every scenario must remain internally coherent and consistent with credible climatic, institutional, and behavioural assumptions. A scenario need not be probable, but it must remain scientifically defensible.

The second is **relevance**. Scenarios are selected because they illuminate meaningful exposure pathways, vulnerabilities, governance challenges, or adaptive responses rather than because they represent extreme or unusual events.

The third principle is **parsimony**. Increasing the number of scenarios does not necessarily improve analytical understanding. A carefully selected set of scenarios capable of revealing distinct mechanisms of system behaviour provides greater interpretive value than an extensive collection of marginally different alternatives.

The fourth principle is a **non-probabilistic posture**. Scenarios are assigned no probabilities, likelihoods or statistical weights. They do not seek to order the possible futures by estimated frequency, but to extend analytical understanding.

These principles, collectively, serve to keep scenario construction focused on the methodological goal of disciplined reasoning under uncertainty, as opposed to the prediction of future outcomes.

C.4 Scenario Dimensions and Stress Configuration

The principles governing scenario construction also determine how scenarios are differentiated. **If the objective is to understand system behaviour rather than to predict individual events, variation must occur along those dimensions capable of altering the structure of climate risk itself**.

The Framework therefore constructs scenarios through controlled variation of analytically significant dimensions, including **climatic conditions, hazard interactions, governance capacity, adaptive constraints, market developments, and external policy environments**. **These dimensions are selected because they influence the mechanisms through which climate risk emerges rather than because they represent isolated variables of interest**.

Emphasis is placed on interaction effects. **Climate risk rarely develops through single causal pathways**. However, **the most important organisational implications tend to emerge when multiple stresses interact, reinforce each other or cross critical thresholds**. This means that scenario building favours compound and sequential stress configurations and discourages analytical approaches based on single variable changes.

Scenario reasoning is therefore neither a simplified forecast nor an unconstrained speculative exercise. It offers a disciplined analytical framework to explore how complex systems might respond under alternative, but scientifically plausible, conditions when prediction alone is insufficient to support responsible decision making.

C.5 Use of Scenarios across Assessment Modules

Abandoning prediction as a primary aim of scenario analysis leads to an immediate practical methodological question. If scenarios are not intended to forecast future events, how do they contribute to climate risk assessment?

In the FTSAI Framework, scenarios affect how results are interpreted, not how they are calculated. **Their role is not to modify assessment results mechanically but to examine how existing analytical conclusions behave under alternative yet plausible future conditions**. **Scenario reasoning therefore strengthens understanding of organisational climate risk without altering the underlying methodological structure of the assessment**.

This interpretive role extends across successive analytical modules. During **hazard characterisation**, scenarios provide alternative stress environments through which hazard relevance can be examined without redefining the hazards themselves. During **exposure mapping**, they reveal how exposure pathways respond to changing climatic, operational, or governance conditions. Within **vulnerability**, **resilience**, and **readiness assessment**, scenarios explore the capacity of organisations to maintain adaptive performance under progressively demanding stress configurations.

Because scenario reasoning operates across the entire analytical architecture, it contributes to understanding the behaviour of the assessed system rather than to recalculating module scores. **Its purpose is to reveal organisational sensitivities, adaptive limitations, and potential trajectories of risk that remain hidden when assessment is confined to a single reference condition**.

C.6 Scenario Logic and Non-Linearity

The analytical value of scenarios becomes particularly evident once climate risk is recognised as a non-linear phenomenon. **Many climate-related impacts emerge not through gradual change but when interacting stresses exceed critical thresholds or activate reinforcing feedback mechanisms**. **Such behaviour cannot always be identified through incremental analysis of isolated variables**.

Scenario reasoning therefore provides a methodological means of exploring conditions under which systemic behaviour changes qualitatively rather than quantitatively. Alternative stress configurations allow the Framework to examine conditions associated with potential **threshold effects**, **cascading impacts**, **and reinforcing mechanisms** that may remain invisible when assessment focuses exclusively on average or expected conditions (IPCC, 2022; Scheffer et al., 2009).

The objective is not to identify the moment at which such transitions will occur, but to understand how organisational resilience may change should these conditions emerge.

C.7 Scenario Interpretation Discipline

Recognising the exploratory purpose of scenarios also determines how their results should be interpreted. **If scenarios are analytical instruments rather than predictions, their conclusions cannot be evaluated according to probability or desirability**.

The Framework therefore interprets scenario-informed findings through structural reasoning. Interpretation is aimed at finding **the dominant sensitivities, the leverage points for decisions, the constraints on adaptation and the robustness of organisational responses** in a variety of plausible conditions. **Conclusions are stated conditionally and describe how the evaluated system may behave under explicit assumptions, not asserting what will happen in the future**.

The discipline also protects against selective interpretation. The Framework discourages the use of isolated scenarios selected solely because they confirm preordained narratives or preferred policy positions. **The value of science is not to confirm prior expectations, but to make systematic comparisons under plausible conditions**.

C.8 Relationship between Scenarios and Uncertainty

Scenario reasoning does not reduce uncertainty; it changes the way uncertainty is examined. **Whereas uncertainty identifies the limits of available knowledge, scenarios provide a structured means of exploring the consequences of those limits under alternative but plausible conditions**.

The relationship between the two is therefore complementary. **Uncertainty defines why prediction becomes unreliable, while scenario reasoning provides a disciplined analytical response once prediction is no longer methodologically sufficient**. **Rather than replacing uncertainty with apparent certainty, scenarios make uncertainty analytically visible and therefore more effectively incorporated into organisational judgement**.

C.9 Misuse of Scenario Analysis

Precisely because scenarios resemble descriptions of possible futures, they are particularly vulnerable to misuse. **Their scientific purpose becomes distorted whenever they are interpreted as forecasts, assigned unsupported probabilities, or selectively employed to justify predetermined conclusions**.

The Framework therefore identifies several forms of inappropriate application, including the **treatment of scenarios as predictive statements**, **attribution of implicit likelihoods without evidentiary support**, **deliberate selection of extreme scenarios to exaggerate perceived risk**, and **omission of governance or adaptive responses that materially influence organisational behaviour**.

These practices share a common methodological error: they transform exploratory reasoning into unjustified prediction. Responsible application therefore requires preserving the non-predictive posture that defines scenario analysis throughout the Framework.

C.10 Implications for Certification and Decision Support

The practical use of scenarios and forecasts is also determined by the methodological difference between them. Within certification **readiness assessment**, scenarios are used to examine whether organisational capabilities remain adequate under different stress conditions. They do not modify the certification criteria, thresholds, or conformity requirements established by the Framework.

Within financial and policy environments, scenario reasoning expands strategic understanding by examining alternative pathways through which climate risk may evolve. **It therefore informs contingency planning, adaptive governance, and long-term resilience without replacing actuarial analysis, economic forecasting, or other predictive modelling techniques**.

Scenario reasoning consequently improves decision quality not by identifying the most likely future but by broadening understanding of the range of plausible futures that responsible decision-makers should be prepared to manage.

C.11 Summary of Methodological Position

Within the FTSAI Climate Risk Assessment Framework, scenario analysis is not conceived as an alternative forecasting technique but as a distinct mode of scientific reasoning under deep uncertainty. **By separating exploratory analysis from prediction, the Framework preserves methodological integrity, avoids false precision, and enables organisations to examine how resilience, vulnerability, and governance may respond across multiple plausible future conditions**. **The value of scenario reasoning therefore lies not in predicting what will happen, but in strengthening understanding of what could become organisationally significant if different futures were to emerge**.

Annex D

Agricultural Production Archetypes

D.1 Purpose and Analytical Role of Archetypes

Agricultural production systems exhibit substantial diversity in their physical characteristics, organisational arrangements, governance structures, and patterns of resource dependency. At first sight, such diversity appears to require that every production system be assessed as a unique case. While this approach may capture local detail, it creates a fundamental methodological difficulty. If every system is treated as entirely unique, meaningful comparison, consistent interpretation, and cumulative analytical learning become increasingly difficult.

The methodological challenge is therefore not how to eliminate diversity, but how to preserve the structural characteristics that influence climate risk while avoiding unnecessary dependence on local idiosyncrasies. The **FTSAI Climate Risk Assessment Framework** addresses this challenge using agricultural production archetypes.

Archetypes are not simplified case studies, performance benchmarks, or normative models. **They represent recurring structural configurations that capture the principal organisational characteristics influencing climate risk behaviour across different agricultural contexts**. **Their purpose is to support consistent interpretation, analytical comparability, and methodological coherence without sacrificing sensitivity to meaningful structural differences**.

Accordingly, archetypes provide an interpretive layer linking the general analytical architecture of the Framework with the structural diversity observed in real-world agricultural systems. They reduce unnecessary complexity while preserving the characteristics most relevant to understanding climate risk.

D.2 Principles of Archetype Construction

Accepting archetypes as methodological rather than descriptive constructs immediately determines how they should be developed. **If archetypes are intended to support interpretation rather than classification, their scientific value depends on the principles governing their construction rather than on the number of archetypes themselves**.

The Framework therefore applies four complementary principles.

The first is structural relevance. Archetypes describe enduring organisational characteristics that shape climate risk rather than temporary operational decisions or short-term management practices.

The second principle is neutrality of analysis. Archetypes neither prescribe desirable production models nor imply superior organisational performance. They exist solely to facilitate consistent interpretation across heterogeneous production systems.

The third principle is internal coherence. Every archetype represents a logically consistent combination of production characteristics, exposure pathways, governance arrangements, and adaptive capacities capable of generating recognisable patterns of climate risk.

The fourth principle is scalability. Archetypes may be applied at the level of individual farms, cooperative organisations, or broader territorial production systems, provided that the structural characteristics defining the archetype remain analytically meaningful.

Together, these principles ensure that archetypes function as methodological reference structures rather than simplified descriptions of agricultural reality.

D.3 Key Dimensions Differentiating Agricultural Archetypes

Once archetypes are understood as structural representations rather than empirical classifications, a further methodological question follows naturally. Which characteristics are sufficiently important to distinguish one archetype from another?

The Framework answers this question by selecting only those dimensions that materially influence the behaviour of climate risk within agricultural production systems. The objective is not to describe every aspect of agricultural activity but to identify the structural characteristics that consistently shape exposure, vulnerability, resilience, and adaptive capacity.

These dimensions include **production structure**, reflecting differences in scale, specialization, and concentration of productive assets; **resource dependency**, capturing reliance on water, energy, and external production inputs; **temporal rigidity**, expressing sensitivity to seasonal timing and biological production cycles; **governance configuration**, distinguishing patterns of individual and collective decision-making; and **market integration**, reflecting dependence on logistics, processing infrastructure, and external market conditions.

These dimensions are not interpreted independently. Climate risk emerges through their interaction, and it is this interaction that determines the distinctive behaviour represented by each agricultural archetype.

D.4 Archetype A: Highly Specialized, Input-Intensive Production Systems

Specialization radically changes the unfolding of climate risk in agricultural production systems. By concentrating productive activity on a limited range of crops, livestock, or production processes, organisations simultaneously increase operational efficiency and reduce the diversity through which climatic disturbances can be absorbed. **Climate risk therefore becomes concentrated rather than dispersed, making organisational performance increasingly dependent on the uninterrupted functioning of a relatively small number of critical activities**.

This concentration influences several dimensions of climate risk simultaneously. **Exposure tends to become focused on a limited number of hazard pathways closely aligned with narrow biological cycles, production windows, or supply-chain dependencies**. **Vulnerability increases because specialized production frequently relies on external inputs whose disruption offers few immediate substitution possibilities**. Climatic shocks affecting either production or supply therefore have the potential to propagate rapidly throughout the system.

The same structural characteristics, however, also generate important adaptive strengths. **Specialized production may provide stronger incentives and economic capacity for investment in technology, monitoring systems, technical expertise, and financial resources that may substantially improve organisational resilience**. Recovery following disruption may therefore be faster than in less capitalized production systems, provided that the underlying production model itself remains viable under changing climatic conditions.

The principal limitation of this archetype lies in its adaptive flexibility. Structural specialization reduces the number of feasible adjustment pathways available once environmental conditions change beyond the assumptions upon which the production system was originally designed. **Adaptation consequently becomes increasingly dependent upon strategic rather than operational decisions**.

Governance reflects this concentration of structure. Decision-making often is concentrated to coordinate highly integrated production processes and to efficiently allocate specialized resources. **Such coordination may strengthen rapid organisational response under stress, yet it also concentrates responsibility and increases the systemic consequences of delayed or inappropriate strategic decisions**.

D.5 Archetype B: Diversified, Resource-Constrained Production Systems

In resource-constrained agricultural systems, production is frequently distributed across multiple crops or activities rather than concentrated in a single form of production. Fields, orchards, livestock, or small complementary activities may coexist within the same operation. At first sight, this may appear less efficient than specialization. From the perspective of climate risk, however, it serves a different purpose.

When production depends on only one activity, a single drought, flood, pest outbreak, or heatwave can threaten the entire season. Spreading production across several activities changes that situation. One activity may perform poorly while another continues to generate income or support production. **Climate hazards do not disappear, but their consequences are less likely to affect the whole system simultaneously**.

This pattern is found most often where access to capital, modern technology, or large infrastructure investments is limited. Producers cannot always reduce climate risk by installing new irrigation systems, replacing equipment, or investing in advanced monitoring technologies. **Adaptation therefore relies more heavily on reorganizing and diversifying existing resources and production activities.** Diversification becomes a practical response to limited resources rather than an attempt to maximise productivity.

Resilience in such systems may develop gradually through accumulated experience, knowledge of local environmental conditions and the continual adaptation of farming practices from one season to the next. **Knowledge acquired through repeated observation becomes at least as important as financial investment**.

The same logic shapes governance. Decisions are usually taken close to daily operations by people who observe changing conditions directly and can respond quickly as circumstances evolve. **Such local flexibility supports rapid adaptation, but its effectiveness may become limited when climatic disturbances extend beyond the boundaries of the individual farm and require coordinated responses across producers, infrastructure, or shared resources.**

D.6 Archetype C: Cooperative and Collective Production Systems

Some climate-related disruptions extend beyond the adaptive capacity of individual farms because they affect resources, infrastructure, and services shared across the wider production system. When water becomes scarce, roads are damaged, or processing facilities stop operating, neighbouring producers quickly discover that many problems can no longer be solved individually.

For this reason, farmers often begin to work together. They share machinery, irrigation equipment, storage space, technical advice, or simply help each other complete urgent work before conditions become worse. **What no single farm could manage alone becomes possible through cooperation**.

Working together, however, is not always straightforward. A shared irrigation system is of little value if nobody agrees when water should be released. Machinery cannot be used efficiently if several farmers need it at the same time. Even the best technical advice is of limited use if it arrives after the critical decisions have already been made.

The strength of these production systems therefore lies not only in what is shared but in how people work together. Farms that communicate well, trust each other, and coordinate their actions are often able to cope with climatic pressures more effectively than producers acting alone. **The benefits of pooling resources start to diminish rapidly as collaboration weakens**.

D.7 Archetype D: Capital-Intensive, Technologically Managed Systems

Capital-intensive agricultural systems are distinguished by extensive reliance on technology, automation, and digitally supported production processes. Irrigation systems operate automatically, sensors continuously monitor temperature and soil conditions, machinery performs tasks with little manual intervention, and production decisions are increasingly supported by digital information.

These technologies allow producers to manage many climate-related pressures more effectively than traditional production systems. Irrigation can respond before crops show signs of stress, environmental conditions can be adjusted as they change, and emerging problems may be detected long before they become visible in the field. **As a result, many climatic disturbances have a smaller immediate impact on day-to-day operations**.

The same technologies, however, also create new forms of dependence. When monitoring systems fail, software stops working, electricity is interrupted, or critical equipment becomes unavailable, the effects may spread quickly through the production process. **The whole system is tightly coupled. Issues that start in one component rapidly spread to many others**.

For this reason, **resilience in technologically managed production systems depends not only on advanced equipment but also on the ability to keep that equipment operating under difficult conditions**. **Backup systems, maintenance, financial resources, and timely technical support become as important as the technologies themselves**.

Managing such systems therefore requires a different style of decision-making. Clear procedures are followed in daily operations, responsibilities are clearly defined and unexpected events are dealt with through established processes. **These sorts of arrangements encourage consistency and reliability. But they can also reduce the room for improvisation when circumstances evolve beyond the assumptions embedded in existing procedures.**

D.8 Archetype Interaction and Hybrid Configurations

Few agricultural systems fit perfectly into a single category. A farm may combine intensive greenhouse production with open-field cultivation, participate in a cooperative while remaining largely family-managed, or rely on advanced technology for some activities but traditional practices for others. Such combinations are common rather than exceptional.

For this reason, the Framework does not require every production system to be assigned to a single archetype. Instead, the assessment begins by identifying the characteristics that are most visible within the system while recognising that important secondary features may also be present.

The objective is not to label farms but to understand how different structural characteristics influence climate risk. **Under normal conditions, one set of characteristics may dominate system behaviour. During prolonged drought, flooding, or market disruption, however, a different combination of features may become more influential**.

Hybrid configurations are therefore treated as an expected feature of real agricultural systems rather than as exceptions to the classification. **The Framework uses archetypes as reference points for interpretation, while recognising that actual production systems frequently combine characteristics drawn from more than one category**.

D.9 Use of Archetypes in Assessment Interpretation

After completing an assessment, different production systems may receive similar scores while reaching them for entirely different reasons. One farm may be highly exposed because it specializes in a single crop, another because it depends heavily on shared infrastructure, and a third because its production relies almost entirely on technology. **Looking only at the final scores would hide these important differences**.

Archetypes help explain why apparently similar assessment results may reflect very different underlying conditions. **They provide a structured way of interpreting the pathways through which climate risk develops, allowing assessors to recognise the dominant characteristics shaping each production system**.

For this reason, archetypes are not used to calculate scores or determine classifications. Those outcomes are generated by the assessment itself. Archetypes are introduced afterwards to help interpret the results, compare production systems with similar structural characteristics, and understand why different systems may respond differently to the same climatic pressures.

They also make assessment findings easier to communicate. Farmers, advisors, financial institutions, and policymakers can often relate more easily to recognizable production patterns than to abstract analytical categories. Archetypes therefore provide a common language for discussing climate risk while preserving the analytical discipline of the Framework.

D.10 Limitations and Responsible Use of Archetypes

No two farms are exactly alike. Even neighbouring producers cultivating the same crop may differ in their soils, water availability, management practices, financial resources, or access to technology. Any attempt to describe all these differences within a single category would inevitably overlook important local characteristics.

For this reason, **archetypes should be understood as reference models rather than exact descriptions of individual production systems**. **Their purpose is to highlight recurring structural patterns, not to replace detailed assessment of specific farms or farming communities**.

Using archetypes as fixed templates for evaluation, policy decisions, or direct performance comparisons would therefore be inappropriate. Meaningful interpretation always depends on the evidence collected during the assessment and on the environmental, economic, and organisational context in which the production system operates.

The value of archetypes lies in helping assessors recognise recurring patterns while remaining attentive to the characteristics that make every production system unique.

D.11 Summary of Methodological Position

Without common reference points, recurring structural patterns across agricultural production systems would have to be interpreted independently in each assessment, even where similar configurations repeatedly emerge. Comparison would become more difficult, communication less consistent, and interpretation increasingly dependent on individual judgement.

The archetypes introduced in this Annex provide those common reference points. **They do not replace detailed assessment, nor do they simplify the diversity of agricultural systems into rigid categories**. Instead, they offer a structured way of recognising recurring patterns that help explain why different production systems respond differently to climatic pressures.

By linking observed production characteristics with recurring patterns of climate risk, the Framework strengthens the consistency, interpretability, and practical usefulness of climate risk assessment while preserving sensitivity to the diversity of real agricultural systems.

Annex E

Common Misuse Patterns in Climate Risk Assessment

E.1 Purpose and Preventive Role of the Annex

Climate risk assessments are often used long after the assessment itself has been completed. A report prepared to support strategic planning may later be consulted during financing decisions, cited in policy discussions, or referenced in certification processes. **As assessment results move between different users and different purposes, the risk of misinterpretation increases**.

Most of these problems do not arise because the assessment is technically incorrect. They arise because the results are asked to answer questions they were never designed to address. **Scores may be interpreted as forecasts**, **classifications may become approval criteria**, or **individual indicators** may be examined without considering the broader **assessment from which they were derived**.

This Annex was developed to reduce such misunderstandings before they occur. **Rather than correcting mistakes after they have influenced decisions, it identifies the most common patterns of misuse and explains why they are inconsistent with the methodological principles of the FTSAI Climate Risk Assessment Framework**.

The guidance applies to all users who rely on Framework outputs, including analysts, auditors, financial institutions, policymakers, certification bodies, and other users responsible for interpreting assessment results.

E.2 Misuse Pattern 1: Treating Assessment Results as Forecasts

Two organisations may receive the same climate risk assessment and use its findings in fundamentally different ways. One uses the results to explore where climate-related vulnerabilities deserve closer attention. The other treats the same assessment as a prediction of future losses. Although both organisations rely on identical information, they reach different conclusions because they interpret the assessment in different ways.

This misunderstanding appears frequently in climate risk assessment. **Scores, classifications, and scenario-based analyses are sometimes interpreted as forecasts of future events or estimates of the losses that will eventually occur. The Framework does not support such conclusions**.

Assessment results describe how a system is positioned under the assumptions, evidence, and conditions considered during the assessment. They identify structural sources of climate risk and highlight areas where greater attention may be required. **They do not predict what will happen, when it will happen, or how severe future impacts will necessarily become**.

Keeping this distinction clear is essential for responsible use of the Framework. **Assessment supports judgement; it does not replace it**. Understanding current risk conditions is fundamentally different from forecasting future outcomes, and confusing these two purposes can lead to decisions that extend well beyond what the assessment can support.

E.3 Misuse Pattern 2: Collapsing Multi-Dimensional Risk into a Single Metric

Two agricultural systems may receive the same overall climate risk score while exhibiting substantially different underlying risk profiles. At first glance, their overall risk conditions may appear comparable. A closer examination, however, reveals a very different picture. One system performs well in most areas but has a serious weakness in water availability. The other has moderate weaknesses in several different dimensions. Their overall scores are the same, but their challenges are fundamentally different.

This illustrates one of the most common mistakes in climate risk assessment. **A single number is often treated as if it fully describes the condition of the system**. **Overall scores summarize information; they do not replace it**. **Looking only at the result can hide critical weaknesses, obscure important interactions between different sources of risk, and encourage comparisons that overlook the reasons why similar scores were obtained**.

For this reason, the Framework does not treat aggregate scores as self-contained conclusions. **Assessment results are intended to be interpreted together with the underlying module outputs and the context in which those results were produced**. Only by examining the complete assessment can the dominant sources of climate risk be properly understood.

E.4 Misuse Pattern 3: Ignoring Uncertainty Annotations

Assessment reports often contain sections describing uncertainty alongside the main findings. During decision-making, however, these sections are frequently skipped in favour of the final scores or summary conclusions. **What appears to be a minor omission can substantially change the meaning of the assessment itself**.

A result supported by extensive evidence and a result reached under significant data limitations may look similar on paper, yet they should not be interpreted with the same degree of confidence. **Uncertainty provides essential information about the conditions under which assessment findings should be understood**.

For this reason, **uncertainty annotations are not supplementary comments or technical appendices. They form part of the assessment itself**. Ignoring them separates conclusions from the evidence on which those conclusions depend and creates a level of confidence that the assessment was never intended to provide.

E.5 Misuse Pattern 4: Using Classifications as Exclusionary Thresholds

A bank has two loan applications from agricultural businesses. They share the same climate risk classification, **but their underlying conditions differ substantially.** One business has already invested in water saving technologies, improved its emergency planning and started to adapt its production practices. The other has made few changes despite facing comparable conditions. Treating both applications in the same way simply because they share the same classification overlooks information that the assessment was designed to reveal.

Climate risk classifications are intended to support judgement, not replace it. **They indicate how risk is currently understood, but they do not capture the full context in which that risk has developed, or the actions already taken to manage it**. **Using classifications as automatic thresholds for financing, certification, or policy decisions transforms an interpretive tool into a mechanical filter**.

The Framework therefore treats classifications as the starting point of informed evaluation rather than the final basis for acceptance or rejection. The broader assessment, the direction of change, and efforts underway to strengthen resilience and adaptive capacity need to be taken into consideration to make a meaningful decision.

E.6 Misuse Pattern 5: Overinterpreting Short-Term Indicators

A farm completes the season with an excellent harvest despite an unusually warm summer. Looking only at this result, it is tempting to conclude that the production system has become resilient to climate change. The following year, however, a prolonged drought produces severe losses. Nothing fundamental changed between the two seasons except the conditions under which the farm was tested.

That is why short-term results can be misleading. **Climate risk may accumulate gradually, with repeated stresses accumulating before their effects become fully visible.** Just as a poor season does not necessarily indicate structural weakness, a favourable season may reflect temporary circumstances.

Therefore, the Framework considers climate risk over relevant time horizons rather than individual observations. **Judging performance from a single season provides a less reliable basis for interpretation than examining how the system evolves over time.**

E.7 Misuse Pattern 6: Treating Readiness as Compliance

It appears that all is in order. Climate policies have been approved, responsibilities have been assigned, training sessions have been completed, and every required document is available for inspection. Yet climate-risk findings remain disconnected from investment decisions, resource allocation, operational planning, and managerial review. Projects continue to be approved without systematic consideration of changing exposure, emerging vulnerabilities, or adaptation requirements.

The problem is not the absence of documentation. The problem is the assumption that documentation alone demonstrates readiness. **Procedures describe what should happen; they do not guarantee that people will act effectively when unexpected events occur**.

For this reason, the Framework distinguishes readiness from compliance. **Compliance confirms that formal requirements have been addressed. Readiness can only be demonstrated where governance arrangements enable timely decisions, coordinated action and effective adaptation under real operating conditions**.

E.8 Misuse Pattern 7: Cherry-Picking Scenarios or Indicators

Two analysts review the same climate risk assessment but arrive at completely different conclusions. One highlights only the indicators suggesting that climate risk is limited. The other focuses exclusively on the most severe scenarios. **Neither interpretation reflects the assessment, yet both appear to be supported by selected pieces of evidence**.

The problem does not lie in the assessment itself but in the way its results are presented. **Individual indicators, scenarios, or module outputs can be used in isolation to support conclusions that the full assessment would not justify**.

For this reason, the Framework requires assessment findings to be interpreted as an integrated body of evidence rather than as a collection of independent results. **Where indicators receive greater emphasis, the reasons for doing so should be explained explicitly rather than assumed**.

E.9 Misuse Pattern 8: Applying the Framework Outside Defined Scope

A climate risk assessment prepared for vineyards in one region is later used to support decisions affecting a different agricultural sector operating under different climatic conditions. **Although the assessment itself may be technically sound, the conclusions no longer rest on the assumptions under which the analysis was originally conducted**.

Assessment findings remain meaningful only within the boundaries established when the assessment begins. **These boundaries define the sectors, locations, time horizons, and decision contexts for which the results can reasonably be interpreted**.

For this reason, the Framework discourages extending assessment results beyond their declared scope without a new assessment or explicit methodological justification. Conclusions drawn under specific conditions should not be extended beyond those conditions where doing so would support decisions the assessment was never designed to inform.

.

E.10 Consequences of Misuse

Misuse rarely begins with an intention to distort results. More often, it starts with a seemingly harmless shortcut. A single score is treated as the whole assessment, uncertainty is overlooked, or conclusions are applied in situations for which they were never developed. **Each step appears reasonable on its own, yet together they gradually change the meaning of the assessment**.

Once this happens, decision quality begins to deteriorate. **Resources may be directed towards the wrong priorities, organisations may be evaluated unfairly, and confidence in climate risk assessment may decline even though the underlying methodology remains sound**.

This Annex seeks to reduce these risks by clarifying how assessment findings should be interpreted and where the boundaries of responsible use lie.

E.11 Summary of Responsible Use Principles

Every assessment represents a particular system under defined conditions, and its findings remain meaningful only when interpreted with the same methodological discipline under which they were produced. Ignoring uncertainty, isolating individual indicators, extending conclusions beyond their intended scope, or replacing judgement with mechanical rules progressively separates assessment findings from the reality they were designed to represent.

Responsible use of the **FTSAI Climate Risk Assessment Framework** therefore requires more than technical accuracy. It requires explicit treatment of uncertainty, contextual interpretation, adherence to methodological boundaries, and conclusions that remain proportionate to the evidence supporting them.

The principles are embedded within the Framework and are intended to protect the integrity of the assessment process and to allow for consistent, transparent and well-informed decisions on climate risk across institutional settings.

Table 6. Common misuse patterns and their implications for the responsible application of the FTSAI Climate Risk Assessment Framework.

Misuse pattern	Description
Treating scores as certifications or guarantees	Presenting scores or classifications as definitive judgments, certifications, or guarantees of resilience or safety.
Using the Framework outside its scope	Applying the Framework to decisions, contexts, or systems for which it was not designed or not properly adapted.
Ignoring uncertainty and assumptions	Presenting results without acknowledging key uncertainties, assumptions, and data limitations.
Confusing correlation with causation	Interpreting associations or co-movements as causal relationships without sufficient analytical justification.
Over-aggregating or oversimplifying results	Aggregating results in ways that obscure important risk drivers, dependencies, and structural constraints.
Presenting partial analysis as complete	Presenting incomplete assessments or partial module coverage as full assessments.
Cherry-picking scenarios or indicators	Selecting only favourable scenarios, indicators, or results while ignoring others that are equally relevant.
Applying outputs mechanically in decisions	Using results without professional judgement, context consideration, or alignment with decision objectives and risk appetite.

.

References

Adger, W. N. (2003). Social Capital, Collective Action, and Adaptation to Climate Change. *Economic Geography*, *79*(4), 387-404. https://doi.org/10.1111/j.1944-8287.2003.tb00220.x

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268-281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

Adger, W. N., Lorenzoni, I., & O'Brien, K. L. (Eds.). (2009). *Adapting to Climate Change: Thresholds, Values, Governance*. Cambridge University Press. https://doi.org/10.1017/CBO9780511596667.

Arthur, W. B. (1989). Competing Technologies, Increasing Returns, and Lock-In by Historical Events. *The Economic Journal*, *99*(394). https://doi.org/10.2307/2234208

Berkhout, F., Hertin, J., & Gann, D. M. (2006). Learning to Adapt: Organisational Adaptation to Climate Change Impacts. *Climatic Change*, *78*(1), 135-156. https://doi.org/10.1007/s10584-006-9089-3

Field, C. B., Barros, V., Stocker, T. F., Qin, D., Dokken, D. J., Ebi, K. L., Mastrandrea, M. D., Mach, K. J., Plattner, G.-K., Allen, S. K., Tignor, M., & Midgley, P. M. (Eds.). (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation: A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Field, C. B., Barros, V. R., Dokken, D. J., Mach, K. J., Mastrandrea, M. D., Bilir, T. E., Chatterjee, M., Ebi, K. L., Estrada, Y. O., Genova, R. C., Girma, B., Kissel, E. S., Levy, A. N., MacCracken, S., Mastrandrea, P. R., & White, L. L. (Eds.). (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. https://doi.org/10.1017/CBO9781107415379.

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society*, *15*(4). https://doi.org/10.5751/es-03610-150420

Hall, J. W., Lempert, R. J., Keller, K., Hackbarth, A., Mijere, C., & McInerney, D. J. (2012). Robust climate policies under uncertainty: a comparison of robust decision making and info-gap methods. *Risk Anal*, *32*(10), 1657-1672. https://doi.org/10.1111/j.1539-6924.2012.01802.x

Hatfield, J. L., Boote, K. J., Kimball, B. A., Ziska, L. H., Izaurralde, R. C., Ort, D., Thomson, A. M., & Wolfe, D. (2011). Climate Impacts on Agriculture: Implications for Crop Production. *Agronomy Journal*, *103*(2), 351-370. https://doi.org/10.2134/agronj2010.0303

Hatfield, J. L., & Prueger, J. H. (2015). Temperature extremes: Effect on plant growth and development. *Weather and Climate Extremes*, *10*, 4-10. https://doi.org/10.1016/j.wace.2015.08.001

Holling, C. S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics*, *4*(1), 1-23. https://doi.org/10.1146/annurev.es.04.110173.000245

IFRS Foundation. (2023). *IFRS S2 climate-related disclosures*. IFRS Foundation.

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Cambridge University Press.

ISO 14090. (2019). ISO 14090:2019 Adaptation to climate change—Principles requirements and guidelines. In (Vol. ISO 14090:2019). Geneva, Switzerland: International Organisation for Standardization.

ISO 14091. (2021). ISO 14091:2021 Adaptation to climate change—Guidelines on vulnerability, impacts and risk assessment. In (Vol. ISO 14091:2021). Geneva, Switzerland: International Organisation for Standardization.

ISO 17065. (2012). *ISO/IEC 17065:2012 Conformity assessment — Requirements for bodies certifying products, processes and services*.

ISO 31000. (2018). ISO 31000:2018 Risk management—Guidelines. In (Vol. ISO 31000:2018). Geneva, Switzerland: International Organisation for Standardization.

Lempert, R. J., Popper, S. W., & Bankes, S. C. (2003). *Shaping the Next One Hundred Years: New Methods for Quantitative, Long-Term Policy Analysis*. RAND Corporation.

Messick, S. (1989). Validity. In R. L. Linn (Ed.), *Educational Measurement*. Macmillan.

Meuwissen, M. P. M., Feindt, P. H., Spiegel, A., Termeer, C. J. A. M., Mathijs, E., Mey, Y. d., Finger, R., Balmann, A., Wauters, E., Urquhart, J., Vigani, M., Zawalińska, K., Herrera, H., Nicholas-Davies, P., Hansson, H., Paas, W., Slijper, T., Coopmans, I., Vroege, W.,...Reidsma, P. (2019). A framework to assess the resilience of farming systems. *Agricultural Systems*, *176*. https://doi.org/10.1016/j.agsy.2019.102656

Munda, G. (2005). "Measuring Sustainability": A Multi-Criterion Framework. *Environment, Development and Sustainability*, *7*(1), 117-134. https://doi.org/10.1007/s10668-003-4713-0

Notre Dame Global Adaptation Initiative (ND-GAIN). (2026). *ND-GAIN Country Index Technical Report*.

OECD/EC-JRC. (2008). *Handbook on Constructing Composite Indicators: Methodology and User Guide*. OECD Publishing.

Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, *19*(3), 354-365. https://doi.org/10.1016/j.gloenvcha.2009.06.001

Renn, O., Klinke, A., & van Asselt, M. (2011). Coping with complexity, uncertainty and ambiguity in risk governance: a synthesis. *Ambio*, *40*(2), 231-246. https://doi.org/10.1007/s13280-010-0134-0

Scheffer, M., Bascompte, J., Brock, W. A., Brovkin, V., Carpenter, S. R., Dakos, V., Held, H., van Nes, E. H., Rietkerk, M., & Sugihara, G. (2009). Early-warning signals for critical transitions. *Nature*, *461*(7260), 53-59. https://doi.org/10.1038/nature08227

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282-292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Task Force on Climate-related Financial Disclosures. (2017). *Recommendations of the Task Force on Climate-related Financial Disclosures*.

Turner, B. L., 2nd, Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. *Proc Natl Acad Sci U S A*, *100*(14), 8074-8079. https://doi.org/10.1073/pnas.1231335100

Unruh, G. C. (2000). Understanding carbon lock-in. *Energy Policy*, *28*(12), 817-830. https://doi.org/10.1016/s0301-4215(00)00070-7

van den Heijden, K. (2004). *Scenarios: The Art of Strategic Conversation*. Wiley.

Vogus, T. J., & Sutcliffe, K. M. (2007). Organizational resilience: Towards a theory and research agenda. 2007 IEEE International Conference on Systems, Man and Cybernetics, 3418–3422. https://doi.org/10.1109/ICSMC.2007.4414160

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. P. (2004). Resilience, Adaptability and Transformability in Social-ecological Systems. *Ecology and Society*, *9*(2). https://doi.org/10.5751/es-00650-090205

World Bank. *Climate and Disaster Risk Screening Tools: Background on the screening methodology*. https://climatescreeningtools.worldbank.org/background-screening-methodology

Zscheischler, J., Westra, S., van den Hurk, B. J. J. M., Seneviratne, S. I., Ward, P. J., Pitman, A., AghaKouchak, A., Bresch, D. N., Leonard, M., Wahl, T., & Zhang, X. (2018). Future climate risk from compound events. *Nature Climate Change*, *8*(6), 469-477. https://doi.org/10.1038/s41558-018-0156-3

FTSAI

Financial Technology & Strategic Artificial Intelligence Laboratory (FTSAI)
Department of Accounting and Finance
University of Macedonia
Thessaloniki, Greece

FTSAI Climate Risk Assessment Framework

Version 1.0 · August 2026

Scientific Authority and Framework Governance
Financial Technology & Strategic Artificial Intelligence Laboratory (FTSAI)