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From Climate Knowledge to Adaptation Action: A Social-Spatial Framework for Integrating Place-Based Values Through a Value Mapping Approach

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Abstract

Despite advances in climate modelling, observation systems, and risk assessment, a persistent gap remains between climate knowledge production and its translation into effective adaptation action. Existing approaches often identify physical hazards and vulnerabilities but provide limited mechanisms for integrating socio-cultural values and place-based conditions into adaptation decision-making. This paper proposes a Climate Knowledge Interpretation Framework that conceptualizes adaptation as a structured process connecting climate information, vulnerability contexts, decision systems, and socio-spatial outcomes. The framework draws on established climate datasets, assessment approaches, and socio-spatial analysis to establish a basis for interpreting climate knowledge within local contexts. It argues that adaptation effectiveness depends not only on the availability of climate information but also on the capacity to incorporate intangible values, relational networks, and place-based knowledge into planning processes. The study proposes Value Maps as a conceptual decision-support tool for revealing socio-spatial infrastructures and relational anchors that contribute to adaptive capacity. The proposed framework provides a pathway for developing more inclusive, context-sensitive, and transferable climate adaptation strategies across diverse climatic contexts.

Keywords: climate adaptation; adaptation implementation gap; adaptation action; adaptive capacity; socio-spatial resilience; socio-cultural values; climate governance; place-based values; value maps; people as infrastructure



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1. Introduction

The central challenge in climate adaptation is no longer the constant production of climate knowledge, but its interpretation into socially and spatially meaningful action. Despite rapid advances in climate modelling [1], risk analytics [2], and Earth observation systems [3], a persistent gap remains between knowledge generation and its application in governance, planning, and design practice.

The current translation shortfall is most visible in how technical datasets [4,5] categorize the environment. To a technician, a hill is a topographic variable, and a tree is a vegetation asset or a carbon sink. However, within the lived reality of a community, that

same tree is a relational anchor: it is where a grandfather was born, a site of intergenerational storytelling, a carrier of social memory. When climate models predict the loss or transformation of such an asset, the associated Erosion of Place Attachment is generally not represented within the climate signal itself. The potential of this framework lies in recognizing that, as an example, if a specific hill or tree is lost, the community's 'human operating system' may be disrupted even if the physical infrastructure is successfully adapted based on climate datasets.

Current approaches to climate adaptation often treat environmental change as a singular material problem rather than as a broader reorganization of socio-ecological life. Climate change involves not only structural stress but also the ecological stress of foundational ecosystems [6–8]: the loss of seagrass, the disappearance of specific mosses, and the forced migration of marine life. For instance, the relocation of a port due to sea-level rise is not merely an engineering challenge; it can also disrupt a coastal economy and erase events and practices that have been rooted in that location for centuries. These are not just ecological data points; they represent disruptions to socio-cultural continuity. Without a translation layer, these intangible infrastructures remain invisible within the processes that convert climate knowledge into planning and policy, creating a critical disconnect between scientific information and adaptation action.

Contemporary approaches to climate adaptation provide increasingly sophisticated methods for identifying hazards and assessing vulnerability [9,10]. However, they remain limited in their capacity to translate climate information into operational decisions within the socio-spatial conditions in which risk is actually experienced [11]. As a result, a persistent implementation misalignment remains, whereby scientifically robust knowledge is insufficient to systematically inform situated adaptation actions.

This paper conceptualizes this misalignment not as a failure of knowledge production, but rather as a structural shortfall in translation between climate knowledge systems and socio-spatial decision systems. Within this divide, critical dimensions of adaptive capacity including socio-cultural values, place attachment, and collective memory are frequently marginalized or rendered invisible, despite their role in sustaining long-term resilience.

The argument advanced is that adaptation science requires not only improved climate information, but a formalized translation layer capable of linking climatic knowledge to the socio-spatial infrastructures through which adaptation is already enacted. Accordingly, this study develops a conceptual and operational framework that connects established climate knowledge with place-based values, relational anchors, and socio-spatial conditions, using Value Maps as a means of making these dimensions visible within adaptation decision-making. The objective of this study is to develop a framework for interpreting established climate knowledge through place-based values and socio-spatial conditions, thereby supporting the translation of climate information into locally meaningful adaptation strategies.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature and establishes the conceptual foundations underpinning the study. Section 3 presents the materials and methods, including the research approach, analytical scope, data sources, and procedures used to develop the proposed framework. Section 4 presents the proposed Climate Knowledge Interpretation Framework and describes its principal components and relationships. Section 5 discusses the implications of the framework in relation to climate adaptation, socio-spatial values, and decision-making. Section 6 presents the conclusions of the study. Finally, Section 7 identifies the principal limitations of the research and outlines directions for future research and empirical development.

2. Literature Review

This study draws on a multi-scale and integrative body of climate, adaptation, and socio-spatial literature to establish the conceptual basis for interpreting climate knowledge within situated adaptation contexts.

Rather than treating climate information as an end product, the study examines how established forms of climate knowledge can be interpreted and connected to situated architectural and urban decision-making. The approach is therefore concerned primarily with the translation of climate knowledge into context-sensitive adaptation action, rather than with the generation or exhaustive presentation of climate-data outputs.

The framework adopts a cross-scalar analytical perspective that considers how climate signals can be interpreted across multiple scales, from material and building performance to urban conditions and broader socio-spatial resilience. This cross-scalar perspective provides the basis for connecting physical climate information with the social and spatial contexts in which adaptation decisions occur. Established climate datasets, indicators, assessment frameworks, and socio-spatial methods are therefore considered as complementary sources of knowledge within the proposed framework.

In developing this interpretive basis, the study draws on several established sources of climate, assessment, and socio-spatial knowledge. Atmospheric reanalysis, particularly the ECMWF-ERA5 reanalysis [12–15], provides an established source of climate information, including temperature, wind, solar radiation, and precipitation, used to inform the climate-knowledge component of the framework. Climate-extreme indicators, including the ETCCDI indices [16,17], provide established means of identifying changes in the frequency and intensity of climate extremes. Global assessments, including the IPCC reports [1,7,18] and the European Environment Agency (EEA) assessments [19–21], provide broader conceptual and assessment contexts for interpreting climate-related hazards and vulnerabilities. In parallel, social cartography provides a basis for identifying and representing relational anchors and other place-based values [22].

Together, these sources establish the technical and conceptual evidence base from which the proposed framework develops its interpretive approach. The purpose of the present study is not to reproduce or exhaustively report their underlying outputs, but to examine how established climate knowledge can be interpreted alongside place-based and socio-spatial information.

Previous reviews [22,23] demonstrate that climate adaptation has undergone a significant conceptual shift over the past three decades, transitioning from a primarily technical response aimed at reducing physical vulnerability to a broader socio-ecological process involving governance, learning, and community capacity. International climate assessments and IPCC frameworks emphasize that adaptation is shaped by interactions among environmental processes, institutional arrangements, and social and local knowledge systems [1,4,8]. More recent assessments further emphasize the importance of adaptive capacity, resilience, and context-specific decision-making [18,24–26].

At the same time, the field is supported by increasingly sophisticated climate observation, modelling, and risk-assessment capabilities. Contemporary climate science provides sophisticated climate intelligence, derived from high-resolution datasets such as the ECMWF-ERA5 reanalysis [12,13] and global multi-model ensembles [14,15], capable of identifying and characterizing hazards such as thermal intensification and extreme precipitation at increasingly fine temporal and spatial scales. However, recurring gaps persist in the systematic conversion of this scientific knowledge into situated, decision-relevant action.

A central limitation of existing approaches is a reliance on metric reductionism, where environmental phenomena are reduced to quantifiable variables optimized for global

comparability. While effective for modelling, this technocratic focus often treats environmental change as a singular material problem rather than a broader reorganization of socio-ecological life. Consequently, the literature provides limited evidence of a consistent action-based framework for comparing the technical safety of an engineered intervention against its lived usability or socio-cultural value.

Specifically, the literature reveals a structural deficit in addressing intangible infrastructures, the relational anchors, social memories, and place attachments that sustain community continuity but remain invisible to standard risk assessments. While urban theory has long recognized the role of people and social networks as forms of infrastructure [27] and the importance of informal adaptive practices [28], these dimensions have not been consistently incorporated or evaluated across formal climate planning and decision-making processes.

This paper addresses this translation shortfall by proposing a Climate Knowledge Interpretation Framework. The framework integrates the Time of Emergence (TOE) [16] as a temporal boundary and the Köppen–Geiger (KG) [16,17] classification as a spatial climatic boundary to provide a structured mechanism for mediating between formal climate data and the place-based values captured through the Value Maps approach. In doing so, it reframes adaptation not simply as a problem of information availability, but as a structured process of epistemic conversion through which the relational and socio-spatial dimensions of a place can become visible and operational within governance.

3. Materials and Methods

This study adopts a conceptual framework-development approach rather than an empirical case-study or statistical validation design. The framework was developed through a synthesis of established climate, adaptation, resilience, and socio-spatial knowledge, followed by the conceptual integration of these domains into a structured interpretation and translation framework. Established climate datasets and analytical approaches are considered as sources of methodological knowledge within this framework, while the proposed Value Maps process specifies how these resources could be combined with place-based and socio-spatial information in future empirical applications.

To establish a consistent conceptual vocabulary for the proposed framework, this section defines the principal climate, adaptation, resilience, and socio-spatial concepts used throughout the study. The concepts are organized into three groups: fundamental climate concepts, adaptation and resilience concepts, and implementation and translation concepts. Together, these definitions establish the terminology required to distinguish physical climate risk from the socio-spatial processes through which climate knowledge may be interpreted and translated into adaptation action.

3.1. Fundamental Climate Concepts

To clarify the terminology used throughout the paper, this section establishes the conceptual foundations underpinning the proposed socio-spatial translation framework. It examines the relationships between climate change, adaptation, resilience, and the interpretation of climate knowledge within place-based contexts. The concepts move from the physical dimensions of climate risk towards the socio-spatial processes through which climate knowledge may inform adaptive responses.

Climate change refers to a change in the state of the climate identifiable by changes in the mean and/or variability of its properties that persists for decades or longer, including changes attributed directly or indirectly to human activity that alter the composition of the global atmosphere [6]. Climate variability refers to variations in the average state and other statistics of the climate across spatial and temporal scales beyond those of individual

weather events [17]. Within this context, climate risk is understood as the potential for adverse consequences where something of value is at stake and the outcome is uncertain, arising from the interaction of climate-related hazards, exposure, and vulnerability [1]. A hazard is a potential natural or human-induced physical event or trend, such as flooding or heatwaves, that may cause loss of life, injury, or damage to property, infrastructure, and ecosystems [29]. Vulnerability refers to the propensity or predisposition to be adversely affected and is related to the character, magnitude, and rate of climate change to which a system is exposed, as well as its sensitivity and adaptive capacity [6]. Exposure describes the presence of people, livelihoods, ecosystems, or assets in places that could be adversely affected by climatic variations [30], while sensitivity refers to the degree to which a system is affected, either adversely or beneficially, by climate variability or change [31]. Finally, mitigation refers to human intervention intended to reduce the sources or enhance the sinks of greenhouse gases in order to limit the extent of future warming [32].

Collectively, these concepts establish the scientific basis for understanding how climate change generates risk through the interaction of hazards, exposure, vulnerability, and sensitivity. They provide the conceptual foundation for interpreting climate impacts, but do not, on their own, explain how climate knowledge is translated into effective adaptation decisions within specific social and spatial contexts.

3.2. Adaptation and Resilience Concepts

To establish a consistent conceptual vocabulary for the proposed framework, this section defines key adaptation and resilience concepts drawn primarily from the IPCC and related climate adaptation literature. These definitions distinguish the principal forms of adaptation, the capacities that support resilience, and the approaches through which societies and ecosystems respond to climate change.

- **Adaptation to Climate Change:** The process of adjustment to actual or expected climate and its effects. In human systems, it seeks to moderate or avoid harm or exploit beneficial opportunities; in natural systems, human intervention may facilitate adjustment to expected climate [29].
- **Autonomous Adaptation:** Adaptation that arises without being intentionally planned as a response to climate change, emerging instead from ecological processes in natural systems or from market, institutional or welfare dynamics in human systems [33].
- **Planned Adaptation:** Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change [10].
- **Incremental Adaptation:** Adaptation actions where the central aim is to maintain the essence and integrity of a system or process at a given scale [34].
- **Transformational Adaptation:** Adaptation that changes the fundamental attributes of a socio-ecological system in anticipation of climate change and its impacts [34].
- **Adaptive Capacity:** The ability of systems, institutions, humans, and other organisms to adjust to potential damage, take advantage of opportunities, or respond to consequences. It is influenced by physical structures, social processes, and institutional norms [35].
- **Climate Resilience:** The capacity of social, economic, and environmental systems to cope with a hazardous event, trend, or disturbance by responding or reorganizing in ways that maintain their essential function, identity, and structure. It includes the capacity for adaptation, learning, and transformation [36].
- **Maladaptation:** Actions that may lead to increased risk of adverse climate-related outcomes, such as increased greenhouse gas emissions or shifted vulnerability, often as an unintended consequence of poorly planned adaptation [37].

- Nature-Based Solutions (NBS)/Ecosystem-based Adaptation (EbA): Actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively, simultaneously providing human well-being and biodiversity benefits. Examples include urban greening, wetland restoration, and coastal mangrove protection [38].

Together, these definitions establish the terminology used in the framework to distinguish adaptation actions, adaptive capacity, resilience, and maladaptive outcomes. They provide the basis for interpreting how different forms of adaptation may interact with the socio-spatial conditions identified through the proposed Value Maps approach.

3.3. Implementation and Foundational Concepts

The concepts in this section define the specific conceptual constructs used to examine the translation of climate knowledge into socio-spatial adaptation action. Unlike the established climate and adaptation terminology above, these concepts describe the interpretive and socio-spatial dimensions developed within the proposed framework. Together, they describe the structural barriers, knowledge limitations, and socio-spatial dimensions that shape the implementation of climate adaptation. In particular, they provide the conceptual basis for the Climate Knowledge Interpretation Framework developed in this study, highlighting the need to bridge scientific climate information with the lived realities, values, and decision-making processes of communities.

- Implementation Gap (or Adaptation Gap): The difference between actually implemented adaptation action and the level of adaptation needed to respond to impacts and reduce climate risks. This gap is projected to grow at current rates of implementation [39].
- Translation Deficit: Defines the implementation gap not as a lack of information, but as a structural underperformance in the conversion process between formalized climate knowledge systems (scientific data) and place-based socio-spatial decision systems.
- Metric Reductionism: A form of knowledge production where environmental phenomena are reduced to quantifiable, comparable variables for modelling and reporting, often excluding intangible socio-spatial factors [40].
- Intangible Infrastructures: Lived dimensions of a place, such as social memory, place attachment, informal spatial practices, and relational networks that sustain community continuity but are often rendered invisible by technocratic risk assessments.
- Relational Anchors: Specific spatial or social elements (like a heritage tree or a communal gathering space) that function as carriers of meaning and social memory, acting as the 'human operating system' of a place.
- Value Maps: A spatially explicit representation of the tangible and intangible values associated with a place, integrating environmental, cultural, social, and relational dimensions that are often omitted from conventional climate risk assessments. Within this study, value maps function as a decision-support tool for translating climate knowledge into locally meaningful adaptation strategies by revealing the relationships between physical vulnerabilities and community values.
- Erosion of Place Attachment (EPA): A proposed interpretative construct describing the progressive weakening of relational value as climate stress renders social and cultural practices increasingly untenable [41].
- Time of Emergence (TOE): A temporal boundary condition that identifies when climate signals move beyond historical variability, indicating when they become relevant for governance and planning horizons [16].
- Epistemic Conversion: The process through which knowledge produced within one knowledge system, such as quantitative climate science, is interpreted and trans-

lated into forms that can be understood, negotiated, and acted upon within another knowledge system, including local, social, cultural, and spatial contexts.

These concepts extend conventional adaptation theory by focusing on the processes through which climate knowledge is interpreted, contextualized, and translated into place-based action. They emphasize that adaptation is influenced not only by the availability of scientific information but also by the social, cultural, and relational characteristics of places that shape decision-making. Together, these concepts form the conceptual foundation of the proposed socio-spatial framework, which seeks to connect quantitative climate knowledge with intangible infrastructures, relational values, and locally embedded knowledge systems.

Taken together, these concepts establish the conceptual vocabulary through which the proposed framework interprets the relationship between climate information, physical vulnerability, adaptive capacity, and socio-spatial values. The following section applies this vocabulary to the proposed Climate Knowledge Interpretation Framework and its Value Maps component.

This paper consequently reframes adaptation as a process of socio-spatial translation. Rather than viewing adaptation as a linear progression from climate science to policy implementation, it argues that climate information is interpreted, negotiated, and translated as it moves across different actors, institutions, and spatial contexts. Understanding adaptation therefore requires attention not only to the production of climate knowledge, but also to the processes through which that knowledge acquires meaning and becomes actionable within specific socio-spatial contexts.

A central premise of this paper is that no universal bridge exists between climate knowledge and adaptation action. Adaptation does not emerge through the automatic application of scientific information to policy or design. Rather, the connection between knowledge and action is constructed through interactions among institutions, communities, cultural values, spatial practices, governance structures, and material conditions. What ultimately becomes adaptation is therefore shaped not only by what is known, but by how knowledge is interpreted, prioritized, and enacted within specific socio-spatial contexts. This perspective shifts attention towards the social and spatial processes through which knowledge is interpreted, negotiated, and implemented, conceptualizing settlements and cities not simply as physical containers of risk, but as complex assemblages of relationships, practices, institutions, and material infrastructures through which resilience is continuously produced and reproduced.

Drawing on urban theory that understands infrastructure as socially produced and enacted through everyday practices [27,28], adaptation is conceptualized as emerging from distributed and relational systems of practice rather than from fixed technical structures. In this sense, urban resilience is not solely an outcome of formal planning systems, but also of the everyday social, cultural, and spatial practices through which communities sustain life under conditions of uncertainty.

This perspective aligns with views on subaltern and informal urbanism [42], which position informal systems not as deviations from formal governance, but as constitutive elements of how cities function and adapt. Within this framing, adaptation is understood as an interpretive process connecting formal climate knowledge systems with informal socio-spatial infrastructures. The proposed framework conceptualizes this translation process through a sequential interpretive chain:

Climate Driver → Physical Hazard → Architectural Vulnerability → Adaptation Mechanism → System Resilience.

This sequence represents a conceptual translation pathway through which climate knowledge may inform adaptation across scales of governance and spatial practice. It

shifts the analytical focus from optimization of responses to the structuring of translation between knowledge domains.

Within this framework, two main structuring conditions define the operational space of translation:

First, the Time of Emergence (TOE) [16], which functions as a temporal boundary condition that distinguishes near-term from long-term adaptation priorities under non-stationary climate dynamics. It identifies when climate signals move beyond historical variability and therefore become governance-relevant within planning horizons.

Second, the Köppen–Geiger climate classification (KG) [16,17], which functions as a spatial boundary condition that enables comparison and transfer of adaptation knowledge across climatically similar regions, independent of administrative or political boundaries. This allows adaptation knowledge to serve as a transferable resource across shared climatic regimes, while requiring translation into locally appropriate socio-spatial responses.

TOE and KG are therefore used within the proposed interpretive framework to establish temporal and climatic-spatial boundaries for interpretation, rather than as standalone predictive or empirical outputs of the present paper. Their role is to define the conditions within which established climate knowledge can be interpreted alongside place-based values and socio-spatial conditions.

4. Proposed Climate Knowledge Interpretation Framework

Building on the conceptual foundations established above, this section develops the Value Maps component of the proposed Climate Knowledge Interpretation Framework. The purpose is not to report empirical findings from a completed case study, but to specify how place-based values and socio-spatial infrastructures can be incorporated into the interpretation of climate knowledge and subsequent adaptation decision-making.

Although related approaches have been explored through concepts such as environmental-sensitive mapping [43], social mapping [22], participatory mapping [44,45], and cultural mapping [23], Value Maps are proposed in this research as a specific socio-spatial translation framework for climate adaptation [46]. While existing mapping practices primarily aim to document community perceptions, meanings, and relationships with place, Value Maps focus on the systematic integration of these socio-cultural dimensions with climate knowledge to address the loss of place-based values during the translation from climate science to adaptation policy and spatial decision-making.

This paper introduces Value Maps as a conceptual and operational approach for addressing this limitation. Value Maps are designed to make visible the socio-spatial infrastructures through which adaptation is produced and maintained in everyday urban life. Rather than representing only physical exposure or climatic risk, Value Maps identify place-based values, cultural practices, social relationships, and collective meanings that contribute to adaptive capacity and socio-spatial continuity.

Within this framing, features such as communal gathering spaces, vegetation with cultural significance, or informal meeting places are not treated as ancillary landscape elements, but as relational anchors that structure collective resilience. Their loss or transformation during adaptation processes therefore represents not only a material change, but a reconfiguration of socio-spatial capacity. Value Maps thus operate as a counter-mapping system to technocratic risk representation, revealing dimensions of adaptation that are otherwise frequently reduced or deprioritized during translation.

In operational terms, the Value Maps framework consists of a layered mapping process that identifies and spatializes socio-cultural assets, practices, memories, and relationships associated with a place, allowing them to be considered alongside climatic risks and adaptation interventions (Figure 1).

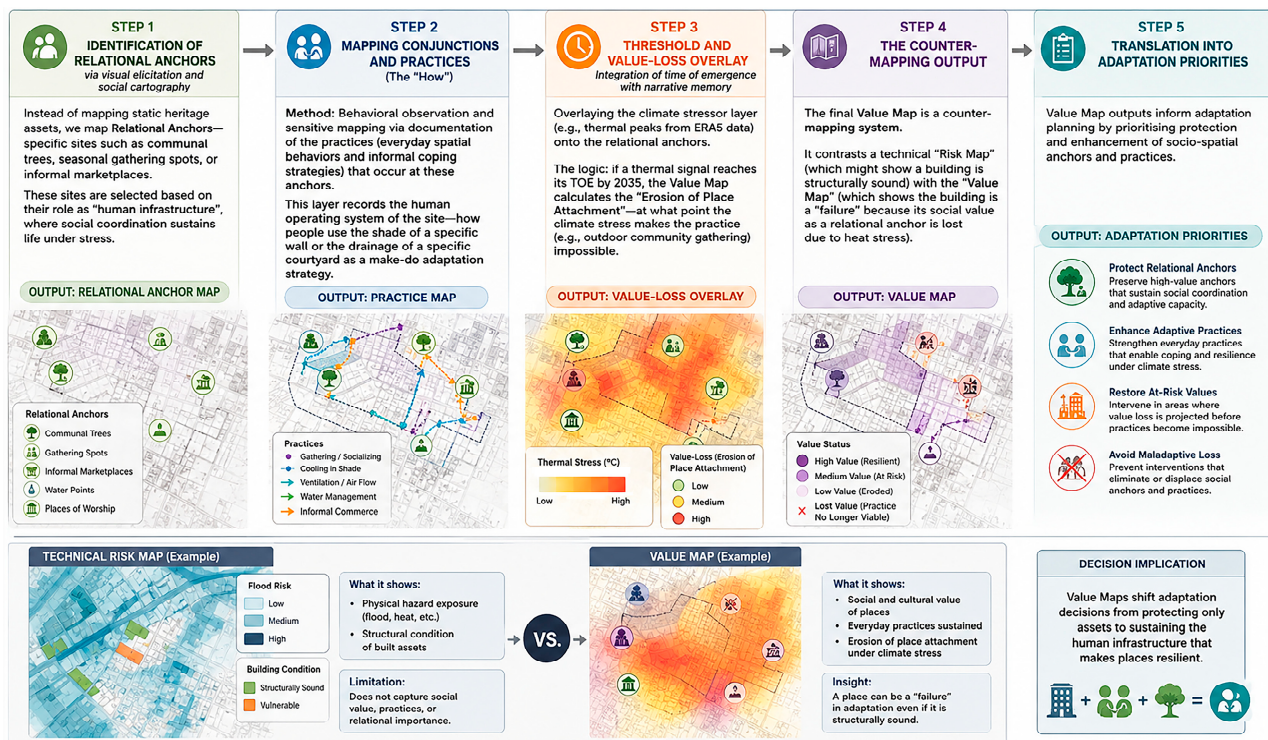


Figure 1. Value Maps: a proposed socio-spatial translation framework for climate adaptation. Value Maps build upon related practices of environmental-sensitive mapping, social mapping, and participatory mapping by integrating socio-cultural knowledge with climate information. The figure illustrates the proposed five-step translation process through which place-based values and relational infrastructures could be identified and considered alongside climate knowledge in policy and spatial decision-making. The figure is conceptual and does not represent empirical or site-specific data (Image created by the authors with Generative AI assistance).

Within the proposed framework, Value Maps would be developed through a five-step process:

Step 1: Identification of relational anchors via visual elicitation and social cartography.

Rather than mapping only static heritage assets, relational anchors are understood as specific sites, such as communal trees, seasonal gathering spots, or informal marketplaces. These sites are selected based on their role as human infrastructure, where social coordination sustains life under stress. To bridge the gap between technical climate data and lived experience, the Value Mapping process integrates social cartography and visual elicitation techniques (including participatory sketching, drawing, and narrative mapping) to engage multiple knowledge systems. Rather than relying exclusively on expert-driven assessments, the framework recognizes that adaptive capacity is distributed across communities and embedded within everyday spatial practices, memories, and relationships.

In an applied implementation of the framework, data collection could be stratified across relevant age groups, genders, cultural backgrounds, livelihood groups, and patterns of residency. This approach would enable the identification of values, dependencies, and ‘ways of knowing’ among elders, youth, and informal navigators, integrating these perspectives as potential components of adaptive capacity that are frequently absent from conventional climate risk assessments. Some examples are:

- Elders and long-term residents could contribute narrative memory and historical benchmarks, helping identify places, practices, and relationships that have sustained community continuity across generations.

- Gendered spatial knowledge could reveal how different groups experience, access, and utilize space through distinct relational networks. Mapping these everyday geographies could help identify vulnerabilities and adaptation opportunities that may otherwise remain invisible within standard planning processes.
- Indigenous and cultural knowledge custodians could contribute understandings of ancestral, symbolic, and spiritual relationships to place. These perspectives would extend beyond material assets and help reveal the cultural meanings, identities, and senses of belonging embedded within landscapes.
- Informal residents including residents operating within informal settlements, marginal spaces, or alternative economies, could provide critical insight into adaptive practices developed under conditions of scarcity, uncertainty, and institutional neglect. Their experiences would reveal how resilience is often generated through informal networks and everyday improvisation.
- Transient, migratory, and newly arrived populations could contribute perspectives on place formation, displacement, and adaptation in contexts of mobility and environmental change. Their experiences would help identify both emerging vulnerabilities and new forms of socio-spatial attachment.
- Local communities and environmental systems could contribute knowledge of the functional relationships between environmental systems and everyday survival. For fishers, farmers, port workers, and other resource-dependent groups, ecological processes are not external environmental conditions but essential components of social and economic infrastructure.
- Intergenerational perspectives could reveal how places function as repositories of memory and identity. A tree, courtyard, or public gathering space may simultaneously operate as environmental infrastructure, cultural landmark, and site of personal and collective memory. Their preservation therefore would contribute not only to ecological resilience but also to continuity of identity across generations.
- Youth and younger generations could provide insight into emerging practices, changing aspirations, and evolving forms of adaptation. Their perspectives would help identify how socio-spatial systems are being reconfigured under contemporary climatic and social pressures.

By integrating these diverse ways of knowing, Value Maps would move beyond static inventories of heritage or risk, revealing the relationships, practices, dependencies, and meanings through which adaptation is enacted in everyday life. In doing so, they would provide a translation mechanism capable of linking climate knowledge to the socio-cultural infrastructures that sustain resilience across time and space.

Step 2: Mapping Conjunctions and Practices

This step moves from identifying relational anchors to documenting the situated practices that activate them. It is not concerned with static spatial use, but with the conjunctions between environment, body, and social coordination that emerge in everyday life.

In an applied setting, this step would use behavioural observation, participatory documentation, and situated mapping, including walk-along methods, photo-elicitation, and narrative interviews, to examine how space is operationalized under ordinary and stress conditions. The focus would be on adaptive improvisation and the micro-strategies through which environmental constraints are negotiated in real time.

Relational anchors are therefore understood not as passive sites, but as functional interfaces between climate exposure and social life. For example, a shaded wall is not simply a microclimatic feature, but a social condenser where waiting, resting, informal exchange, and intergenerational interaction occur. A courtyard drain is not merely infrastructure, but

part of a distributed system of water management enacted through everyday awareness and adjustment.

This step effectively maps the ‘human operating system’ of place, revealing how environmental conditions are continuously interpreted and acted upon, how informal adaptation strategies emerge without formal planning, how spatial behaviours cluster around microclimatic affordances, and how social life reorganizes itself in response to heat, rain, wind, or scarcity. The intended outcome is a practice-layered spatial register in which each relational anchor is paired with its lived operational logic, capturing what the place does, rather than simply what it is.

Step 3: Threshold and Value-Loss Overlay

This step introduces a temporal-climatic stress lens to evaluate the durability of relational anchors and the practices they support.

Climate stressors (e.g., heat extremes, flood recurrence, humidity thresholds) are integrated with high-resolution datasets (such as ERA5 or downscaled projections) and overlaid onto the mapped relational system. In an applied implementation, climate stressors (e.g., heat extremes, flood recurrence, and humidity thresholds) could be integrated with high-resolution datasets, such as ERA5 or downscaled projections, and overlaid onto the mapped relational system. This would provide a means of identifying when and how frequently relevant climatic thresholds may be crossed.

A central concept here is the Time of Emergence (TOE) of climate signals. When a climate stressor exceeds a locally relevant threshold (e.g., unbearable thermal comfort limits for outdoor gathering), the framework would evaluate not only physical exposure, but also the potential disruption of socio-spatial practices associated with that condition.

The proposed framework introduces the concept of Erosion of Place Attachment (EPA) as a potential interpretive construct. EPA describes the progressive weakening of relational value as climate stress renders practices increasingly untenable. Importantly, this is not conceived as a binary loss but as a gradient of disconnection, in which practices may become temporally restricted (e.g., usable only at night or within seasonal windows), social interactions may become displaced or fragmented, informal coping mechanisms may become increasingly overburdened, and relational anchors may shift from active use towards symbolic or residual presence.

In this sense, climate change is interpreted not only as environmental degradation, but as a systemic disruption of socio-spatial continuity. The proposed overlay is intended to produce a dual reading of physical exposure and potential relational degradation, allowing the two dimensions to be considered as co-evolving over time.

Step 4: The Counter-Mapping Output

The Value Map is intended to complement conventional risk-based spatial intelligence by introducing a parallel representation of relational resilience. Whereas standard climate and hazard maps prioritize structural integrity, exposure probability, and infrastructural resilience, the Value Map considers failure not only in terms of material performance, but also in terms of the loss of conditions that sustain social life, meaning, and place-based practices.

The proposed counter-mapping output is structured as a dual-layer diagnostic system, combining a conventional Risk Map Layer, which identifies physical vulnerabilities such as building stability, flood exposure, and heat hazard zones, with a Value Map Layer, which identifies socio-cultural degradation, including the loss of gathering spaces, disruption of informal economies, and erosion of memory sites.

The analytical tension between these layers is critical. A structure may appear ‘safe’ in engineering terms while simultaneously representing a functional failure in relational terms

if it can no longer support the practices that define its social role. For example, a structurally sound plaza may become unusable due to thermal stress, effectively severing its role as a civic gathering space. In such cases, the framework could classify the site as a form of relationally compromised infrastructure, even in the absence of physical degradation.

The counter-mapping output therefore reframes climate adaptation planning by making visible the divergence between technical safety and lived usability, the hidden losses of social infrastructure under climate stress, the spatial distribution of cultural and relational fragility, and the mismatch between engineering resilience and socio-ecological resilience. Ultimately, Step 4 is intended to provide a critical epistemic inversion of mapping practice, where value, rather than structure alone, becomes a key unit of vulnerability assessment.

Step 5: Translation into Adaptation Priorities

In the proposed framework, the information generated through the Value Map would be translated into adaptation priorities that address both physical assets and socio-cultural continuity. Rather than prioritizing interventions solely according to physical risk, adaptation actions are evaluated according to their capacity to maintain relational anchors, everyday practices, and collective memory under changing climate conditions.

This step identifies which relational anchors are most vulnerable to climate stress, which social practices are at risk of disruption or disappearance, what adaptation measures can preserve both environmental performance and socio-cultural function, and how adaptation priorities should be sequenced according to climatic urgency and social significance.

5. Discussion

Addressing the recurrent implementation gap in climate adaptation requires more than incremental improvements in planning tools; it demands a structural reconfiguration of how knowledge is produced, translated, and operationalized across institutional domains. At present, governance systems remain largely organized through siloed epistemic regimes in which climate science, spatial planning, infrastructure engineering, and cultural heritage management operate as partially disconnected fields. This fragmentation produces a critical disjunction between climate intelligence and actionable territorial governance, particularly at the scale of everyday urban and peri-urban life [10,29,47].

The proposed Value Mapping framework intervenes directly in this gap by reframing adaptation not as a problem of information availability, but as a problem of knowledge mediation across socio-spatial and institutional scales. In this sense, the central challenge is not the absence of data, but the absence of processes capable of converting climate knowledge into situated decision-making capacity [10,39].

A key implication is therefore the need to shift institutional focus from knowledge production to knowledge interpretation ecosystems. This requires the establishment of intermediary systems that can operate across disciplinary, administrative, and community boundaries, ensuring that climate intelligence is not only generated but made legible, actionable, and socially grounded [22,23,44,45].

Three core governance mechanisms are proposed from this reframing:

(a) Climate literacy development across professional domains

Rather than treating climate data as a specialized technical input restricted to environmental scientists, climate literacy must become a cross-sectoral competency embedded within planning, architecture, public administration, and heritage governance [10,29,47,48]. This involves enabling practitioners to interpret climate projections not as abstract metrics, but as spatially embedded stress conditions that directly affect socio-spatial functionality, everyday practices, and infrastructural performance. Climate literacy, in this sense, is

not informational awareness but interpretive capacity for spatial decision-making under uncertainty.

(b) Citizen-engaged monitoring and co-production systems

Adaptation governance must move beyond the exclusive reliance on technical expertise and embrace multiple ways of knowing, recognizing that climate adaptation is shaped not only by scientific evidence but also by the lived experiences, cultural values, and everyday practices of communities [6,23,44,45]. Citizen-engaged monitoring systems extend beyond participatory consultation models by embedding local actors within continuous cycles of observation, interpretation, and feedback. This enables the integration of situated knowledge, seasonal patterns, microclimatic perception, informal coping strategies into formal adaptive planning systems [46]. Importantly, this shifts governance from a top-down model of expertise to a relational model of environmental intelligence, where resilience is co-constructed through everyday practice [35].

(c) Enhanced spatial communication and interpretation tools

A critical bottleneck in current adaptation practice lies in the opacity of climate datasets for non-specialist actors. Even highly resolved datasets such as ERA5 reanalysis or IPCC-derived indices remain largely inaccessible in decision contexts due to their abstraction from lived spatial experience [1,13,16,17]. The development of advanced spatial communication tools, including interactive mapping systems, value overlays, and narrative-geospatial interfaces is therefore essential. These tools must translate complex climate signals into decision-relevant, socially interpretable formats that preserve both technical integrity and experiential meaning [22,23,43,44].

These mechanisms are therefore proposed as components of an interpretation system through which different forms of knowledge can be more effectively connected in support of climate adaptation [22,23,44,45].

Crucially, this framework exposes a persistent epistemological limitation in dominant climate-data regimes. Contemporary datasets and risk indices are often grounded in what can be described as a form of metric reductionism, where environmental phenomena are translated into quantifiable variables optimized for comparability, modelling, and policy reporting [40]. While this approach is essential for global climate governance, it systematically underrepresents or excludes the intangible socio-spatial infrastructures that determine whether adaptation is socially viable [6,22,23,41,46].

These missing dimensions include social memory, cultural attachment, informal spatial practices, relational networks, and place-based identity systems, precisely the elements that the Value Mapping approach seeks to render visible and operational [22,23,44,45]. Their exclusion produces a governance blind spot in which adaptation is optimized for material risk reduction while neglecting relational continuity [6,41,46].

The potential implications of this gap are significant. Without an integrative translation layer, adaptation interventions risk achieving technical resilience while simultaneously generating social disarticulation, where places remain physically intact but lose their functional and cultural capacity to support community life [6,35,46,49]. In extreme cases, this produces a paradoxical condition of ‘successful adaptation failure’: infrastructures are protected, but the socio-spatial systems they sustain are incrementally eroded [37].

Within this context, Value Maps operate as a corrective epistemic device, reintroducing relational and experiential dimensions into climate governance. They enable institutions to recognize that resilience is not solely a property of assets or systems, but an emergent condition of continuity between environmental processes, spatial practices, and collective meaning structures [6,35,36].

From this perspective, an important governance implication is that effective climate adaptation requires not only better data or stronger institutions, but a redefinition of what counts as relevant knowledge in spatial decision-making [10,29,47]. Without this shift, adaptation policy risks remaining structurally aligned with physical resilience while remaining blind to the socio-cultural infrastructures that determine whether places remain inhabitable in any meaningful sense [6,41,46,49].

Beyond its governance implications, the proposed framework also contributes conceptually to the climate adaptation literature by repositioning Value Maps from a predominantly participatory instrument to a socio-spatial mechanism for translating climate knowledge into planning practice. Rather than functioning solely as repositories of local perceptions or community preferences, Value Maps are shown to support the integration of scientific evidence with place-based values, enabling climate information to become more meaningful within local decision-making processes [22,23,44,45]. This perspective broadens their role beyond stakeholder engagement and highlights their potential to strengthen the relationship between knowledge production and adaptation action [10,39].

The paper argues that effective climate adaptation depends not only on the availability of robust climate information, but also on the capacity to connect that knowledge with the social, cultural, and spatial characteristics of place [1,6,10]. By integrating scientific evidence with locally embedded values through a structured socio-spatial framework, the proposed approach contributes to bridging the persistent gap between climate knowledge and adaptation practice [10,39]. In doing so, it offers a transferable framework capable of supporting more context-sensitive, inclusive, and operational forms of climate adaptation planning across diverse territorial settings.

6. Conclusions

The principal challenge in contemporary climate adaptation is no longer the production or availability of climate knowledge, but the systematic translation of that knowledge into spatial and governance decisions capable of sustaining socio-cultural resilience under conditions of climatic uncertainty. Despite significant advances in climate modelling, remote sensing, and risk analytics, a persistent implementation gap remains between environmental intelligence and the lived realities of places where adaptation is actually enacted.

This paper has argued that this gap is not primarily technical, but structural and epistemological in nature. It reflects a misalignment between formalized climate knowledge systems, optimized for abstraction, comparability, and global scalability, and the socio-spatial conditions through which adaptation is grounded in everyday life. These conditions include relational networks, informal practices, cultural memory, and place-based knowledge systems that are rarely captured within conventional risk or vulnerability assessments.

The conceptual framework proposed in this paper identifies three principal findings. First, climate adaptation requires a translation layer capable of connecting climatic information with the spatial and socio-cultural systems in which climate impacts are experienced. Second, conventional risk and vulnerability approaches can underrepresent relational dimensions of vulnerability, including the disruption of social practices, cultural attachment, collective memory, and place-based identity. Third, Value Maps have the potential to function as a socio-spatial interface through which climatic information and place-based values can be brought into a common decision-making framework. In this role, Value Maps move beyond their conventional use as participatory or representational tools and become a means of interpreting climate knowledge through the lived conditions of place.

A central shift advanced by this work is therefore the reorientation of adaptation planning away from a purely infrastructural or technocratic logic toward what can be described as the ‘human operating system’ of place. Resilience is not reducible to the

optimization of physical systems under stress, but emerges from the interaction between environmental conditions, spatial practices, and collective meaning structures. Climate impacts may consequently generate forms of ‘invisible vulnerability’, in which relational anchors and socio-cultural continuity are progressively weakened even where physical infrastructure remains functional.

The practical implication is that climate adaptation planning should not replace conventional climate-risk assessment, but complement it with a structured assessment of place-based values and social practices. Value Maps could be used alongside conventional risk maps to identify where climatic exposure intersects with culturally or socially significant places, practices, and relationships. Such an approach can support the prioritization of adaptation measures according to both climatic urgency and socio-cultural significance, while also providing a spatial communication mechanism through which scientific information can be interpreted by planners, communities, and other decision-makers.

The framework therefore presents climate adaptation as a translational governance challenge rather than solely an environmental or engineering problem. Its contribution is conceptual rather than empirically validated: it provides a structured basis for connecting climate science, spatial planning, and place-based knowledge, while establishing propositions that can subsequently be tested through case-based applications. Ultimately, effective adaptation depends not only on producing increasingly sophisticated climate information, but also on developing the institutional and spatial capacity to translate that information into the relational, cultural, and environmental conditions that sustain life in place over time.

7. Limitations and Future Research

The proposed Climate Knowledge Interpretation Framework and Value Maps approach have several limitations that should be considered in future applications.

First, the five-step Value Maps process may be time and resource-intensive, particularly where visual elicitation, social cartography, behavioural observation, narrative interviews, and climate-data analysis are undertaken in combination. The level of engagement required will therefore depend on the scale, complexity, and resources available within a particular application.

Second, the identification of relational anchors involves an interpretive component. The significance attributed to a particular place, practice, or spatial element may differ between researchers and stakeholder groups, creating potential challenges for consistency and reliability. Future applications should therefore establish transparent identification criteria and use triangulation across multiple sources of evidence to document and substantiate the identification of relational anchors.

Third, socio-spatial values are not necessarily shared or internally consistent. Different stakeholder groups may attribute different, and potentially conflicting, values to the same place. The framework therefore does not assume that a single or objectively determined value can be assigned to each relational anchor. Instead, differences and conflicts between values should remain visible within the mapping process and be addressed through participatory deliberation, transparent comparison, and context-specific decision-making rather than reduced to a single value ranking.

Finally, the framework has not yet been empirically validated through a completed case-study application. The five-step process, including the integration of climate thresholds and the proposed concept of Erosion of Place Attachment (EPA), should therefore be understood as a conceptual and operational proposition requiring further testing and refinement. Future research should apply the framework across different climatic and socio-spatial contexts to evaluate its reliability, scalability, stakeholder acceptability, and capacity

to support adaptation decision-making. Such applications could also provide the basis for operationalizing and testing EPA as an assessment metric, including the development of appropriate indicators, scales, and data requirements.

Potential indicators for future evaluation could include the reliability and consistency of relational-anchor identification, stakeholder agreement and representativeness, changes in the temporal and spatial availability of valued places, disruption or displacement of associated social practices, changes in patterns of use, and the extent to which Value Map outputs alter or improve adaptation priorities compared with conventional risk-based assessments.

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Abbreviations

The following abbreviations are used in this manuscript:

IPCC	Intergovernmental Panel on Climate Change
EEA	European Environment Agency
ERA5	ECMWF Reanalysis v5 (technical dataset from the European Centre for Medium-Range Weather Forecasts)
ETCCDI	Expert Team on Climate Change Detection and Indices
SNR	Signal-to-Noise Ratio
TOE	Time of Emergence
KG	Köppen–Geiger (Climate Classification)
EPA	Erosion of Place Attachment
NBS	Nature-Based Solutions
EbA	Ecosystem-based Adaptation

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