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Carrying Evidence into Design: Translation Infrastructure for Water-Centric Landscape Architecture

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Abstract

Climate responsive landscape design should be drawing heavily on landscape driven analysis (i.e., climate projections, ecological assessments, spatial modeling, etc.). But analytical findings often stop short of design specification, making implementation difficult. An earlier review of 123 studies on coastal landscape interventions found that five (4.1%) documented an explicit link between sea level rise projections and quantitative design parameters. This suggests a disconnect between landscape analysis, design and design implementation. In this study, we develop a provisional translation infrastructure framework through an abductive comparison of four published studies on water-centric landscapes from one research program, covering sites in the United States, China, and several world regions. For each case we record the evidence inputs, the processes or artifacts that received them, the design forms, and the limits the authors report. The pipeline runs through five stages. It traces the scientific evidence, its use within a procedural framework, the translation artifacts, the design specifications, and the testing or evaluation. We read cross scale operability and temporal decision translation as diagnostic gaps, drawing on the limitations and documentation the authors report. We propose evidence to delivery as a theoretical extension. Procedural organization, parameterization, and typology development move work between stages. The framework offers a way to examine whether evidence supporting water sustainability goals remains traceable in landscape specifications and evaluation. The complete pathway has not been independently validated.

Keywords: knowledge mobilization; adaptation pathways; geodesign; decision traceability; ecosystem services

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1. Introduction

Climate responsive landscape design draws on analytical evidence including climate projections, ecological assessments, and spatial models to inform design decisions. Reported projects often describe that evidence without locating its connection to a particular specification or implementation decision. In an earlier meta synthesis of coastal landscape interventions, five of the 123 reviewed studies (4.1%) documented explicit links between climate projections and quantitative design parameters [1].

The science–practice divide in climate responsive landscape architecture might be portrayed as an infrastructure problem rather than a knowledge deficit issue. While the field has expanded its access to environmental data, models, and projections, reliable pathways from analysis to design specification have not kept pace. Without strong pathways, analytical evidence is relegated to shaping the aspirational language used to describe the project

without impacting its final design commitments. In this study, we call that missing pathway 'translation infrastructure'. It refers to the infrastructure of protocols, workflows, artifacts, and institutional support that can carry analytical findings into design decisions and implementation. Research on climate information usability shows that access to information does not ensure its use in decisions [2,3]. Geodesign connects environmental analysis with spatial proposals [4], while adaptation pathways link changing conditions to sequences of possible actions [5]. The trick is incorporating this infrastructure into design processes while preserving creative design latitude.

Water-centric landscapes (coasts, wetlands, and floodplains) make good case studies for this translational infrastructure because they are so directly and severely impacted by climate change (water levels, flooding, and drainage). In Dalian, China, for example, sea level rise projections for the peninsula city show exposure along the coast. The city has steep coastal terrain, but its low lying and reclaimed zones face amplified risk from extreme weather and storm surge. Sea level rise raises the baseline for high tides and surge, and flood exposure rises with it [6]. Translating these potential climate impacts into actionable design parameters requires a connected sequence of ideation, analysis, projection, design rules, and scenario testing.

In this paper, we address this connective sequence and argue for translational infrastructure protocols based on a synthesis of four previous studies in water-centric landscapes. The geodesign study informs procedural frameworks for organizing evidence within a collaborative design process [7]. The wetland carbon study contributes to parameterization by showing how ecological measurements can become comparable design inputs [8]. The coastal meta-synthesis provides the empirical basis for evidence based typologies that organize intervention options [1]. The Dalian study illustrates how these components can be integrated through spatial rules and scenario testing [6]. We argue that translation infrastructure is needed to connect environmental evidence to specific design decisions. It should maintain that connection through implementation and evaluation while preserving professional judgment. We make three contributions to the landscape literature. First, we conceptualize translation infrastructure as a provisional synthesis of existing approaches for landscape design. Second, we specify a five stage pathway for tracing evidence from scientific inputs to testing and evaluation. Third, we distinguish three diagnostic gaps and three interdependent supporting components within that pathway. The pathway holds the evidence source, its transformation, the resulting specification, and the adoption or evaluation status in one view. These elements organize interpretation.

We ask how environmental evidence changes form before entering a landscape decision, and which enabling functions recur across the selected studies. We also ask whether an apparent gap is a documented limitation or a boundary of study scope. The four studies cover the United States, China, and a coastal review spanning several world regions. This range does not make one research program representative of landscape practice.

We present and argue for our translational infrastructure in 5 sections. Following this introduction, Section 2 reviews the relevant literature to identify the gaps that help specify the need for translational infrastructure. Section 3 explains the approach, introducing its empirical basis and comparison used to develop the framework. Section 4 presents the comparison and framework derivation. Section 5 discusses the theoretical contribution, implications, and limitations. Section 6 concludes the study.

2. Literature Review

This section reviews scholarship on knowledge use, co-production, boundary work, and design reasoning. These studies explain how evidence is shared and made usable across

professional boundaries. They also reveal a remaining problem in landscape architecture: how evidence enters specific design decisions.

2.1. Knowledge Use, Co-Production, and Boundary Work

Early utilization research demonstrated that evidence influences decisions in diverse ways, showing that utilization is rarely a simple, linear transfer from research to action [9]. Research within the last 30 years across environmental management, public policy, and implementation science has reinforced this view, confirming that access to evidence is merely one condition for its actual use [10–12]. The recognition that evidence must be usable, relevant, and actionable in decision-making contexts has been developed further within sustainability and climate science. For example, Cash et al. [13] propose that scientific information is more likely to influence decisions when stakeholders perceive it as simultaneously credible, salient, and legitimate. While scientific credibility is essential, information must also be context-sensitive and aligned with the practical needs of decision-makers to achieve real-world utility. McNie [14] highlights a pervasive mismatch at the science-policy interface, where an oversupply of untargeted research fails to meet the specific demands of decision-making contexts.

Climate scholarship often describes this mismatch as a 'usability gap' [2,15]. Even when scientific information is highly accessible, it often remains difficult to apply because the scale, timing, format, or foundational assumptions do not align with the practical decision at hand [2,15]. Consequently, more or even better data fails to resolve this disconnect [14]. As Dilling and Lemos [3] argue, usable science is not an automatic byproduct of research. It depends on the relationship between how information is produced and the specific conditions under which it will be used. Feldman and Ingram [16] reinforce this view, demonstrating that scientific knowledge only becomes actionable through robust knowledge networks that actively connect technical expertise with decision-making environments.

The shift from an information/data supply paradigm to a model of interactive development has brought greater attention to knowledge co-production. Co-production actively engages researchers and users in defining problems and developing knowledge together [17,18]. It starts with the explicit aim of shaping research around the practical decisions the process is expected to inform. More recent scholarship has formalized this by developing core principles for actionable and co-produced sustainability knowledge [19–21]. This literature positions interaction as a core component of the knowledge production process itself. However, the interactive model concept raises a practical question about how intensive interactions can be effectively organized and sustained over the long term.

Boundary work addresses this question directly. Gieryn [22] originally introduced the concept of boundary work to describe the rhetorical and practical efforts through which science is demarcated from other forms of practice. Later scholarship shifted focus toward the structural mechanisms that facilitate exchange across the boundaries between scientific knowledge production and professional practice. At the individual and artifact level, boundary objects provide a shared point of reference for groups possessing divergent forms of expertise [23]. Artifacts such as maps, models, repositories, and classification systems serve this role because they are flexible enough for different communities of practice to use them without requiring complete consensus regarding their meaning [24]. At the institutional level, boundary organizations provide a more durable structure to sustain this exchange [13]. Operating at the interface of scientific and professional communities, they support repeated interaction, translation, mediation, and dual accountability [24]. Within environmental decision-making, such arrangements serve to bridge the gap between scientific knowledge production and the action-oriented organizations tasked with implementation [13]. These concepts explain how evidence becomes usable across professional

boundaries through shared artifacts, repeated interaction, and institutional support. We build on their account of organized work and shared objects to trace how an artifact supports a particular design commitment.

2.2. Design as a Distinct Mode of Knowledge Use

Explaining how evidence becomes usable across professional boundaries is not the same as explaining how evidence becomes operative within design. This distinction matters because much of the literature on knowledge utilization has emerged from policy, management, and implementation settings. In these contexts, evidence often supports the selection of a policy option, the adjustment of an existing program, or the implementation of an established practice [10,25]. Design operates differently. It does not begin with a fixed set of alternatives; instead, designers generate, test, and revise possible responses as their understanding of the problem develops [26,27].

The distinction between a fixed set of alternatives and possible responses is well established in design theory. Simon [26] defines design as the activity of changing existing situations into preferred ones. Rittel and Webber [27] show that planning and design problems cannot always be fully defined in advance. Problem definition and solution development influence each other. Buchanan [28] extends this argument to design thinking, where problems are often open and cannot be resolved through a single analytical procedure.

Design knowledge is generative rather than purely selective. Schön [29] characterizes professional design as a process of reflection-in-action, where cognitive understanding develops dynamically through repeated interaction with the emerging proposal. Dorst and Cross [30] similarly demonstrate that the problem and solution spaces co-evolve and are refined together during the design process. Consequently, as Lawson [31] emphasizes, designers operate by generating and evaluating holistic spatial propositions rather than by optimizing a single, isolated criterion.

The understanding of translation as a movement between analytical evidence and design artifacts changes what it means for evidence to be useful in design. Design research shows that evidence must inform the forms through which proposals are developed and evaluated, rather than remain only as background justification [29,30]. Many decision support tools still stop at a diagnostic or comparative stage. Vulnerability assessments, rankings, and priority maps can identify where attention is needed, but do not always specify how a spatial intervention should be configured [32–35].

Some climate adaptation research moves closer to the generative needs of design by introducing thresholds and decision pathways. Kwadijk et al. [36] use 'adaptation tipping points' to identify exactly when current strategies will no longer meet defined objectives. Haasnoot et al. [5] develop 'adaptation pathways' that connect changing future conditions with logical sequences of possible actions. These approaches show how dynamic evidence can be linked to physical decisions through explicit rules, demonstrating that translation requires more than a mere awareness of future change; it requires an explicit connection between that change and a specific response.

2.3. Evidence in Landscape Architecture

The relationship between research and design has long been debated within landscape architecture. The challenge of connecting environmental evidence to specific design actions is especially relevant. Nassauer [37] argues that identifying shared artifacts and boundary work is central to the field's transdisciplinary role and to the relationship between its scientific and design cultures. Milburn and Brown [38] found that research is often valued by practitioners but remains weakly connected to specific design decisions. Other scholarship has argued for a closer relationship between scientific inquiry and design practice. Nassauer

and Opdam [39] describe design as a form of scientific inquiry that can generate and test landscape change propositions. Lenzholzer et al. [40] similarly positions research, connecting it to a systematic investigation within design development. Deming and Swaffield [41] provide a broader methodological foundation for integrating research and design within landscape architecture through grounded practices rather than rigid scientific protocols.

Geodesign offers one of the clearest attempts to operationalize the connection between research and design in landscape architecture. Steinitz [4] structures geodesign as an iterative process that links spatial analysis, evaluation, design alternatives, and decision making. Later work shows that geodesign can support collaborative planning and improve the integration of spatial information into design processes [42,43]. The 6 step geodesign process helps to synthesize disparate forms of data and information in ways that help improve effective communications among stakeholders (and designers) [44]. In addition, a variety of emerging tools have provided platforms for active participation and improved collaboration and usability [45].

Designers and practitioners have long relied on representational practices to translate environmental knowledge into spatial action. McHarg's [46] canonical overlay method provides an influential example of an effort to connect ecological information with planning and design decisions through layered representations that make environmental relationships visible and actionable. Subsequent scholarship has emphasized the active role of representation in shaping design responses. Corner [47] argues that mapping is not simply a descriptive record of existing conditions but a projective practice capable of revealing relationships, generating new understandings, and opening possibilities for intervention. Similarly, Spirn [48] emphasizes that landscapes communicate ecological and cultural processes through spatial form, requiring interpretation and translation as part of the design process. Together, these perspectives suggest that environmental evidence becomes influential not merely through its existence, but through representational forms that allow it to be explored, interpreted, and operationalized.

This representational role is particularly important because environmental evidence frequently originates at scales that differ from those of intervention. Climate projections, watershed analyses, and ecological assessments often describe regional or territorial processes, while design decisions are implemented at the site scale through manipulations of landform, hydrology, vegetation, circulation, and material systems [47]. Maps, diagrams, visualizations, scenarios, and models help bridge these scales by translating broad environmental evidence into forms that can be evaluated and refined through design processes [46–48].

The difference between introducing evidence into design and maintaining its influence through later project decisions (and implementation) is especially important in climate-responsive practice [49]. Evidence may successfully inform site analysis, conceptual strategies, or design narratives while failing to influence the specific thresholds, dimensions, performance criteria, or implementation commitments through which projects are ultimately realized. Landscape architects work with flood models, vulnerability assessments [4,7], ecological performance data [39], and climate projections [50]. The gap lies not in whether climate evidence is considered, but in whether it reaches a form that can guide a design commitment.

Existing landscape architecture scholarship has developed strong approaches for integrating research, ecological knowledge, and spatial analysis into design processes. We ask how an analytical finding stays traceable into a concrete specification. For example, our coastal review found that 95.9% of the 123 reviewed studies acknowledged sea level rise, while five (4.1%) documented explicit links between climate projections and quantitative design parameters [1]. Evidence may inform a project without determining a threshold, dimension, spatial rule, or performance criterion.

Knowledge translation already includes adaptation to local conditions, implementation, monitoring, and sustained use [11]. Geodesign connects analysis, proposed changes, impacts, and decisions [4]. Adaptation pathways link changing conditions to actions and monitoring [5]. Evidence based design connects research interpretation to design hypotheses and evaluation [51]. Spatial design with pathways is a close precedent for translating temporal logic into spatial interventions [52]. We do not claim that translation infrastructure introduces evidence use or implementation as new theoretical territory.

3. Materials and Methods

Our translational framework is developed from four connected empirical studies in water-centric landscapes. The following explains why these studies were examined, how they were compared, and how the framework was derived from that comparison. It also defines the limits of drawing a broader theoretical interpretation from a single research program.

3.1. Abductive Theory Building

We use abductive theory building to develop the concept of translation infrastructure. Abduction builds interpretation by moving between empirical findings and theoretical concepts [53,54].

We developed the framework after the four studies were published. The studies did not test a common hypothesis, and we did not specify the framework in advance. We read across the four studies, identified recurring patterns, and organized those patterns into stages, gaps, and supporting components. The synthesis is not a systematic review and does not test causality. Our coastal meta synthesis used a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guided review, and the synthesis presented here does not repeat that procedure. We treat the four published studies as the empirical basis for provisional theory development.

We selected the four studies purposively because each reaches a different point in the evidence to design sequence. They address procedural coordination, ecological parameter development, intervention classification, and modeled testing. They come from one research program and are not an exhaustive or representative sample. We compare these published findings with scholarship on knowledge use, boundary work, and design reasoning to identify where existing concepts are sufficient and where further development is needed.

In our previous work we found that environmental evidence was often used to justify a project but stopped before shaping a design commitment. Flood analysis informed a planning process without producing a site scale rule. Ecological evidence was translated into measurable values without helping to determine an intervention. The coastal review documented few explicit links between climate projections and quantitative design parameters. We compare these insights with scholarship on knowledge use, boundary work, and design reasoning. We used this comparison to identify where existing concepts were sufficient and where further development was needed.

Each study occupies a different point between environmental evidence and implementation. They cover procedural coordination, parameter development, intervention classification, and scenario testing.

The first study examined geodesign and flood vulnerability in League City, Texas, and the Tohono O'odham Nation in Arizona, United States [7]. The two cases represented different planning and data conditions. In League City, the reviewed planning process projected the Federal Emergency Management Agency (FEMA) 100 year floodplain to 2100 and combined it with block level social and economic data. The process also included four stakeholder feedback sessions over eight months. The study examined how spatial analysis and stakeholder input could be organized within an iterative geodesign process.

The second study examined wetland carbon dynamics across thirteen wetland types in Illinois, United States [8]. It compiled carbon sequestration and emission rates from the peer reviewed literature and linked them to National Wetlands Inventory data. The statewide analysis covered approximately 2.45 million acres. The resulting estimates made carbon performance comparable across wetland types and provided a basis for parameter development.

The third study was a published meta synthesis of 123 studies on coastal landscape interventions [1]. The reviewed studies were identified through a PRISMA guided review and coded by intervention type, project framing, sea level rise integration, implementation outcomes, and monitoring. Coding stability was assessed through temporal recoding. The study identified seven intervention typologies and examined whether climate evidence reached quantitative design parameters or monitoring.

The fourth study examined coastal adaptation in Dalian, China, by coupling sea level rise analysis with the Land Use Evolution and Impact Assessment Model (LEAM) land use model [6]. Sea level rise projections under Shared Socioeconomic Pathway 2 were converted into a depth penalty and incorporated into growth suitability. Intervention types identified in the coastal meta synthesis were represented as spatial rules. Baseline and intervention scenarios were then compared to determine whether those rules changed projected development allocation. The hazard surface was static and did not simulate physical flood attenuation by the proposed interventions. The tested outcome was development allocation within the model.

3.2. Development of the Framework

For each study, we reviewed the published methods, findings, outputs, and stated limitations. We recorded the environmental evidence used, the process or artifact that received it, the form the evidence took in planning or design work, and the furthest point documented in that sequence.

The source study is the unit of comparison. Within each study, an analytical record is a reported connection between an environmental input and a process, artifact, specification, or evaluation, or a stated limitation on that connection. The coastal review was treated as one source study. First order observations describe reported processes, outputs, findings, or limitations. Second order constructs interpret their translational function or difficulty. We compared records by function, for example the organization of evidence use, expression as a parameter, or connection to an intervention. Identical source terminology was not required to identify a shared function.

We reconstructed the connections between observations and constructs as fourteen evidence records. Table 1 presents the source observation, the second order interpretation, the framework assignment, and the evidence status or limitation for each record. The statuses distinguish a documented operation, an explicitly reported limitation, a connection unestablished from the documentation, and a boundary of study scope. Theoretical extensions are identified separately.

B.P. alone carried out the comparison. B.D. was familiar with the source studies as a coauthor and K.L. reviewed the manuscript without comparing the source articles. The comparison therefore rests on one analyst, without duplicate coding or an intercoder agreement test.

Table 1. Source observations, interpretations, and assignments in the development of the framework.

Record and Study	First Order Observation	Second Order Interpretation	Framework Assignment	Evidence Status and Limit
G1 Geodesign [7]	The reviewed League City process used four meetings over eight months to critique and revise design scenarios.	An organized process supports the interpretation and revision of evidence within design.	Procedural organization; evidence use within a procedural framework.	Documented process. It does not validate the proposed translation framework.
G2 Geodesign [7]	Block level social data were summarized into broad categories that constrained detailed site interpretation.	The resolution and representation of evidence may limit its use for a more detailed spatial decision.	Cross-scale operability.	Directly reported limitation concerning social vulnerability representation in one reviewed case.
G3 Geodesign [7]	The review identified incomplete evaluation of the plan across projected future flood conditions.	Future conditions require an explicit connection to the evaluation of present proposals.	Temporal decision translation; testing and evaluation.	Reported evaluation limitation. It does not establish failure of a constructed landscape.
W1 Wetland carbon [8]	Published carbon rates were compared across thirteen wetland types mapped in Illinois, United States.	Ecological findings can be expressed as comparable parameters linked to spatial classifications.	Parameterization; translation artifacts.	Documented analytical output. The estimates do not verify carbon performance at an individual site.
W2 Wetland carbon [8]	The study proposed vegetated wetland configurations and carbon targets as design guidance.	Parameters can inform intervention options and design objectives.	Parameterization linked to design interpretation.	Documented guidance. Adoption at a specific site was not evaluated.
W3 Wetland carbon [8]	The study qualified the transfer of published rates by local variation in hydrology, vegetation, and soil conditions, and noted the lack of extensive field validation.	Applying comparative parameters at a site requires interpretation of local conditions and consideration of the estimates' validation status.	Cross scale operability; testing and evaluation.	Explicit transfer qualification and reported field validation limitation. Neither establishes an implementation failure.
C1 Coastal review [1]	The review organized interventions into seven categories.	Classification connects findings to recurring intervention options.	Typology development; translation artifacts.	Documented classificatory output. Later reuse in Dalian is not independent validation.
C2 Coastal review [1]	The review examined climate projections and their documented links to quantitative design parameters. Five of 123 reviewed studies (4.1%) met the explicit integration criteria.	A future environmental condition was explicitly connected to a design parameter in a small subset of the records.	Temporal decision translation; positive examples of documented connections.	Documentation finding. Missing documentation in other records does not demonstrate non-use of climate evidence.
C3 Coastal review [1]	Monitoring was described ambiguously in 37 studies; two reported an integrated monitoring approach.	Reported evaluation provides limited visibility of connections between evidence, delivery, and outcomes.	Motivation for the evidence-to-delivery extension.	Documentation finding. Reporting categories do not establish absent monitoring or physical failure.
C4 Coastal review [1]	The review reported implementation barriers and included studies from several world regions.	Governance, resources, and reporting conditions affect the context in which translation is examined.	Scope conditions and alternative explanations.	Contextual finding. Geographical coverage does not independently validate the framework or establish causal effects of barriers.
D1 Dalian [6]	Projected flood depths were converted into growth suitability penalties used by the allocation model.	A future environmental condition was expressed as an executable model rule.	Parameterization; operational specifications; temporal decision translation.	Documented operationalization. The static hazard surface did not simulate attenuation by the proposed interventions.

Table 1. *Cont.*

Record and Study	First Order Observation	Second Order Interpretation	Framework Assignment	Evidence Status and Limit
D2 Dalian [6]	Strategies derived from the coastal review were encoded as intervention zones, restrictions, and attraction modifications.	Intervention classes can be translated into spatial specifications within a model.	Typology application; operational specifications.	Documented transfer and model implementation within the same research program, rather than independent replication.
D3 Dalian [6]	Scenarios with identical demand produced different development allocation patterns after spatial rules were changed.	The consequences of operational rules were evaluated through a connected modeling workflow.	Procedural organization; modeled testing and evaluation.	Documented modeled consequence. Adoption in practice and performance after construction were not established.
D4 Dalian [6]	The flood representation did not simulate physical attenuation, and reported model validation was limited to probability surfaces.	Modeled allocation, predictive validation, and evaluation of built performance support different claims.	Boundary of evidence-to-delivery; physical evaluation proposed for future testing.	Explicit scope boundary. Delivery and field verification outside the study's scope are not failed outcomes.

G denotes the geodesign review, W the wetland carbon study, C the coastal meta-synthesis, and D the Dalian modeling study. Bold labels identify individual evidence records within each study. Numbers distinguish the records. For example, G1 is the first record from the geodesign review. Source observations summarize reported findings; the interpretations and framework assignments belong to the present comparison.

Table 1 summarizes the cross study comparison used to derive the framework. The five stages order the forms that evidence took across the four studies. We read the recurring spatial and temporal difficulties as diagnostic gaps. The supporting components name the processes and artifacts that moved evidence between stages. A later stage was not counted as a gap when it fell outside the purpose of the original study. We retained observations that did not fit the emerging pattern, including cases where translation reached further than expected.

Table 2 states the question that defines each diagnostic dimension. We grouped the dimensions by the question a connection raises. Cross scale operability and temporal decision translation both draw on working connections together with reported limitations, transfer qualifications, and documentation patterns. Broad social vulnerability categories limited site interpretation in League City (G2), and the wetland study qualified local transfer of carbon rates (W3). Evidence to delivery asks how a specification stays connected to implementation and monitoring. The four studies motivate this extension without demonstrating a recurring construction failure.

Table 2. Questions for examining connections between evidence and project decisions.

Diagnostic Dimension	Question	Connection to Establish
Cross-scale operability	Can the evidence support the spatial decision at the scale required?	Interpret the analytical resolution and uncertainty in relation to the site or planning unit.
Temporal decision translation	How does a future environmental condition affect a decision made now?	Explain the link between the projected condition and an adopted threshold, design allowance, or trigger for review.
Evidence to delivery (theoretical extension)	How will the adopted specification be carried through implementation and evaluated?	Connect the intended outcome to implementation responsibilities and an appropriate evaluation method.

We retain a shared supporting component when its function is documented in at least two source studies, as Table 3 records. The threshold is an operational support criterion for the reconstruction. It is not a statistical test or an independent replication. Features specific to one study remain in the evidence record and do not become generic framework elements.

Table 3. Retention decisions and qualifications for proposed framework elements.

Proposed Framework Element	Basis for Retention	Decision
Procedural organization (component)	Geodesign organized evidence and stakeholder input within an iterative process (G1). Dalian organized analysis, spatial rules, and scenario testing within a connected sequence (D3).	Retained
Parameterization (component)	The wetland carbon study converted published rates into comparable values across wetland types (W1). Dalian converted flood depth into suitability penalties (D1). The coastal meta-synthesis showed that explicit links between climate projections and quantitative design parameters were infrequently documented (C2).	Retained
Typology development and application (component)	The coastal meta-synthesis organized interventions into recurring classes (C1). Dalian translated those classes into spatial rules for scenario testing (D2).	Retained
Cross-scale operability (gap)	Geodesign revealed a mismatch between broad vulnerability data and site-scale decisions (G2). The wetland carbon study translated published rates to mapped wetland types but qualified their local applicability in relation to hydrology, vegetation, and soil conditions (W3).	Retained
Temporal decision translation (gap)	The coastal meta-synthesis examined whether future sea level rise conditions informed current design parameters (C2). Dalian converted projected flood conditions into model rules (D1).	Retained
Evidence to delivery (gap)	The coastal meta-synthesis documented varied monitoring descriptions (C3). Dalian ended at modeled scenario testing (D3, D4). These records motivate a later delivery and performance question, without establishing an implementation failure.	Retained as a theoretical extension
Stakeholder engagement intensity	This feature was central to the geodesign cases, but the comparison did not establish a common measure of engagement intensity across the four studies.	Not retained
Wetland carbon classification detail	This feature was necessary for the wetland carbon analysis but was specific to that study (W1).	Not retained

Record identifiers refer to Table 1. The supporting components meet the revised reconstruction criterion of a shared function documented in at least two selected source studies. The diagnostic dimensions draw on reported limitations, transfer qualifications, and documentation patterns; evidence to delivery is a theoretical extension. Support within one research program does not constitute independent replication.

This process produced the provisional translation infrastructure framework presented in the Results.

4. Results

The comparison shows that translation can be accomplished at different points between analysis and implementation. Progress at one stage does not guarantee progress at the next. Evidence may enter a planning process without becoming a site scale rule. It may become a measurable parameter without determining an intervention. It may shape a modeled decision without being verified through physical performance. Table 4 summarizes the diagnostic dimensions and their evidence status.

Table 4. Translation diagnostics, their source support, and their implications.

Diagnostic Dimension	Evidence Across Studies	Implication
Cross-scale operability	Geodesign reported coarse social categories; wetland carbon qualified transfer to local conditions.	Evidence may require an additional step before it can guide site decisions.
Temporal decision translation	The coastal review documented few explicit parameter links; geodesign reported incomplete future evaluation; Dalian encoded future hazard conditions.	Climate projections must be connected to explicit decision rules.
Evidence to delivery	Coastal monitoring descriptions and Dalian's modeling endpoint motivate a later delivery question; they do not establish physical failure.	Where delivery is in scope, the specification should remain connected to implementation and evaluation. This is a theoretical extension.

The coastal meta synthesis provides review level evidence about documentation. Among 123 reviewed studies, five (4.1%) documented both a climate scenario reference and a quantitative design parameter [1]. Monitoring was described ambiguously in 37 studies (30.1%), and two studies (1.6%) reported integrated monitoring approaches. These findings show limited visibility of some specification and evaluation connections.

Across the studies, translation depended on whether evidence remained connected as it moved from one stage to the next. The documented connections and qualifications in that sequence inform the empirical basis for the translation infrastructure framework presented below.

The Translation Infrastructure Framework

The comparison organized the changing forms and uses of evidence into five analytical stages. Scientific evidence was the starting point. This included climate projections, ecological measurements, and spatial model outputs. These sources described environmental conditions or expected change, but they did not determine a design response on their own.

At Stage 2, evidence is used within a procedural framework that organizes mapping, stakeholder review, and iterative evaluation. It organizes when evidence enters the project and how it is considered, but it does not necessarily produce a design rule.

Ecological measurements converted into comparable values across wetland types illustrate a translation artifact. Translation artifacts include parameters, thresholds, classifications, and decision rules that make analytical findings usable in later design decisions. Although these artifacts do not determine design outcomes, they enable environmental evidence to be interpreted, debated, tested, and incorporated into the iterative development of spatial design propositions. This preserves evidence as an operative tool as it moves between analytical inquiry and design action.

Design operational specifications connect evidence to a concrete decision, as when flood depth is converted into suitability penalties and spatial constraints that change modeled development allocation. Specifications may take the form of elevations, setbacks, spatial restrictions, performance requirements, or triggers for future action. The final stage is testing and evaluation. It asks whether a specification changes an expected or observed outcome. Modeled scenario comparison and evaluation after construction are distinct forms of support within this stage. Dalian establishes the former, while the latter remains outside its scope.

The comparison informs three diagnostic gaps with different levels of support. Cross scale operability describes cases where broader evidence did not become site scale guidance. Temporal decision translation describes cases where future conditions did not become present rules, thresholds, or triggers. Evidence to delivery is a proposed extension concerning how specifications would be carried through implementation, monitoring, or verification. These gaps identify potential missing connections within a project's intended scope. They do not imply that every project must complete every stage.

The gaps may overlap within one connection. A flood design elevation can require both a spatial transfer from a regional projection and a temporal allowance for future conditions. Delivery asks a further question about adoption, conformity, and evaluation.

The comparison also identified three recurring forms of support. Procedural organization structures how evidence enters the process. Parameterization converts findings into values or relationships that can be evaluated. Typology development and application connect those findings to classes of intervention. These components do not represent separate stages. They support movement between stages in the pipeline.

Figure 1 summarizes the framework. The pipeline marks the analytical positions through which evidence can be traced, and the trace runs back to earlier interpretations as well as forward. The gaps mark where evidence still needs to inform a decision or its evaluation. The supporting components name the structures that connect one stage to the next.

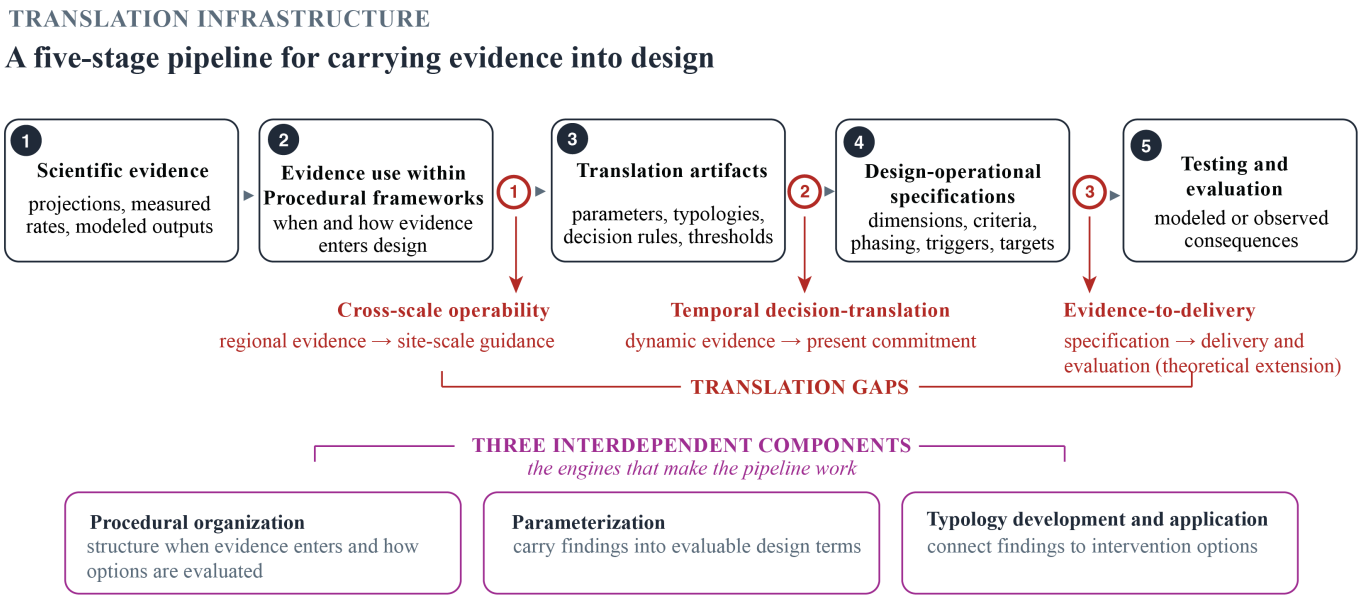


Figure 1. Translation infrastructure framework showing five analytical stages, three diagnostic gaps, and three supporting components. Components support the production and use of artifacts across stages. Arrows indicate analytical traceability, and stages may be revisited iteratively. Gaps may overlap, and their positions are illustrative. Performance in built landscapes requires separate verification.

A stage names the current form or use of evidence. An artifact is the map, parameter, typology, or specification produced. A supporting component is the work that enables its production or use. Parameterization produces or applies parameters, and typology development and application produce or use classifications. Procedural organization holds this work together. These functions operate across stages, and design can begin from a proposed intervention and return to its evidence.

Figure 2 shows how the four study groups inform the five stages, diagnostic dimensions, and supporting components through first-order observations and second-order interpretations. Figure 3 positions each study along the stages and states where its documented sequence or verification scope ends. Supplement S1 locates the twenty stage assignments. Recommendations, review-level reports, reported limitations, and untested outcomes are distinguished; the cells are not completion scores. None of the four studies independently validates the complete pathway.

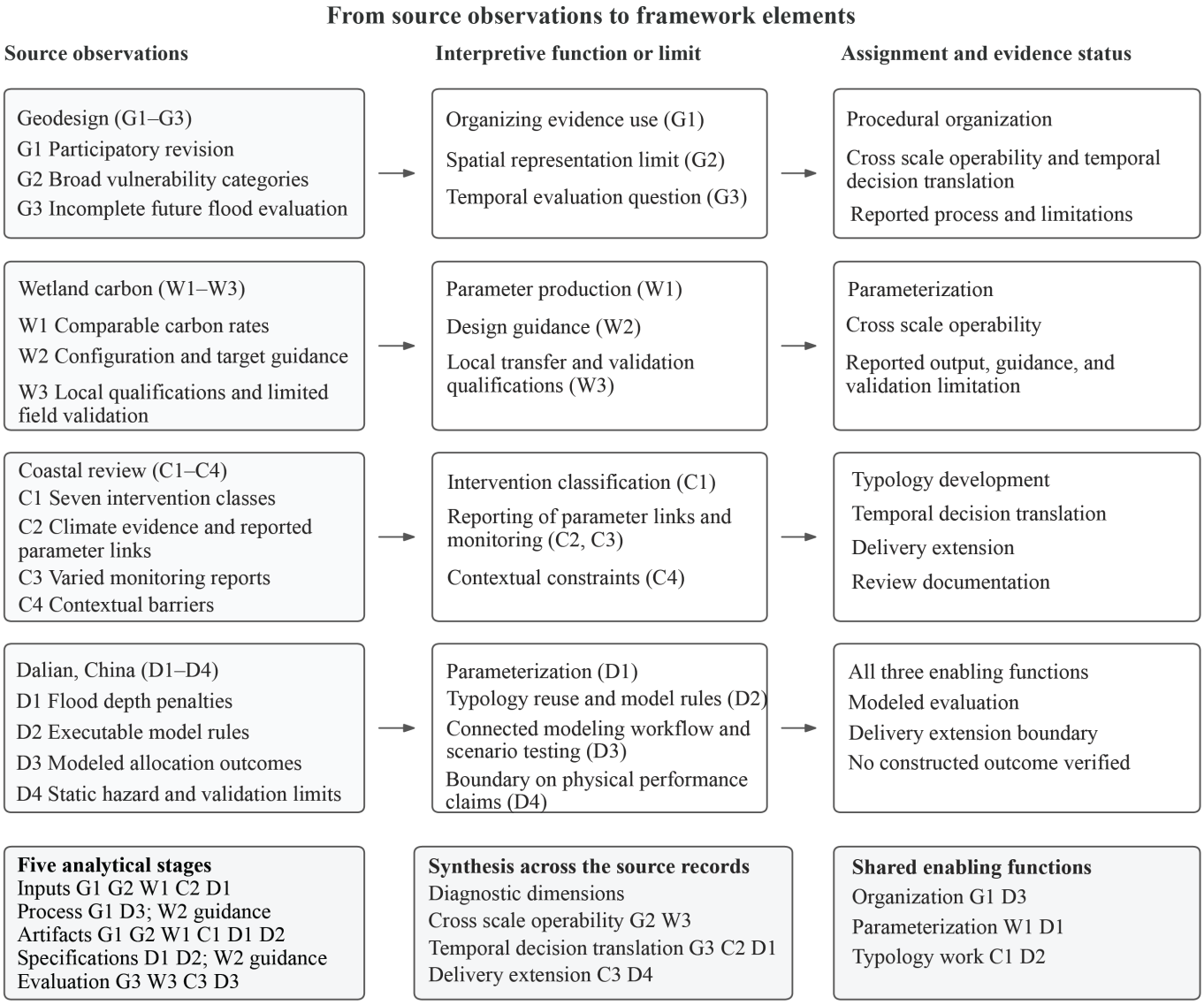


Figure 2. From source observations to interpretive constructs and framework elements. Record IDs refer to Table 1. The delivery extension and modeled evaluation are distinguished from observed implementation failure or built performance.

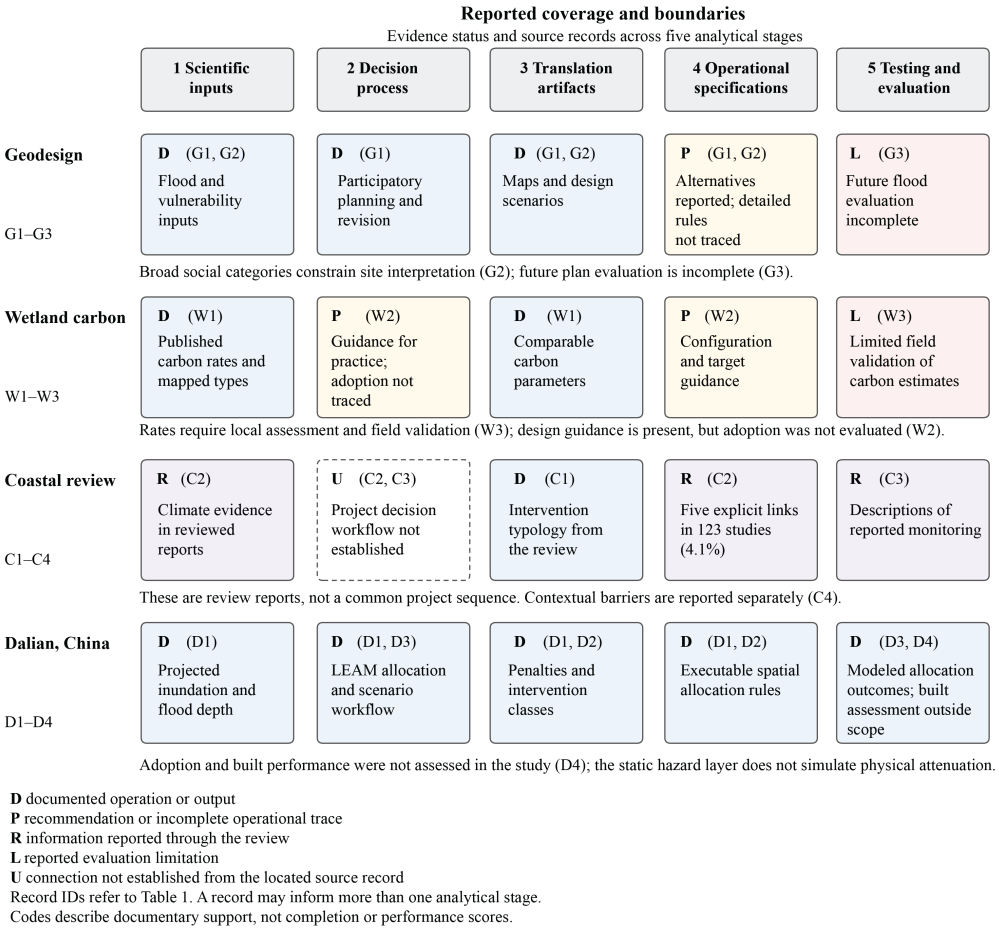


Figure 3. Reported coverage and boundaries across the five analytical stages. Record IDs refer to Table 1. Codes indicate what is documented in the source studies. Unestablished connections and reported limitations may reflect study scope or incomplete reporting. Evaluation in the Dalian study concerns modeled allocation outcomes.

5. Discussion

The comparison of the four studies provides a provisional basis for examining how environmental evidence informs specific landscape decisions. The framework aims to support water sustainability by making the links between evidence and those decisions explicit and identifying where further interpretation or performance evaluation is needed. The discussion considers the framework's relationship to existing theory and how it could be applied and assessed, with attention to the limits of its empirical support.

5.1. What the Framework Adds to Existing Theory

Translation infrastructure framework does not imply that every break between analysis and implementation is caused by missing translation infrastructure. Data quality, institutional authority, project scope, and resource constraints may also interrupt the process. The framework is intended to identify which decision or evaluation remains unconnected to evidence and what type of connection may be missing at that point. The framework extends existing work on knowledge use by focusing on what happens after evidence becomes available to practitioners. Research on usability explains why information must fit the needs of users and the conditions of decision making [2,13,15]. Boundary work explains how shared tools and institutions support exchange across professional communities [23,24]. These ideas explain important conditions for knowledge use. With knowledge translation, geodesign, adaptation pathways, and evidence based design, they also address action and

evaluation. Table 5 identifies that overlap and the additional detail sought in the proposed trace record.

Table 5. Comparison of representative approaches with translation infrastructure.

Approach	What It Explains	Scope of the Formulation	Focus of the Proposed Synthesis
Usability and co-production [2,13,21]	Salience, credibility, legitimacy, and joint knowledge development.	Does not by itself establish the source and transformation of each spatial specification.	Trace a particular finding into an artifact and specification while retaining context.
Knowledge translation [11]	Local adaptation, barriers, implementation, monitoring, evaluation, and sustained use.	A general action cycle with local adaptation; landscape specifications require contextual development.	Identify the spatial parameter or rule and the status of its adoption or evaluation.
Boundary objects and organizations [23,24]	Shared objects, coordinated work, methods standardization, mediation, and accountability.	An object's existence does not establish its role in a particular design choice.	Record whether it coordinates, generates alternatives, or encodes an adopted rule.
Geodesign [4]	Representation, process, evaluation, change, impact, and decision models within iterative collaboration.	A broad design workflow; downstream delivery detail depends on its application.	Locate the source supporting each specification and distinguish modeled from built evaluation.
Adaptation pathways [5]	Actions, tipping points, signposts, triggers, and monitoring under changing conditions.	Provides temporal logic; each action requires a contextual spatial expression. Spatial design with pathways is a close precedent [52].	Trace the spatial expression of an action and the status of its adoption.
Evidence based design [51,55]	Research interpretation, design hypotheses, baseline measures, implementation monitoring, and post-occupancy evaluation.	The cited healthcare formulation already links design to delivery and assessment.	Organize environmental sources, spatial and temporal fit, and the status of landscape specifications.
Landscape design research [39,40]	Design propositions generate knowledge, with evaluation matched to the knowledge claim.	Does not require one common record for the provenance of every specification.	Retain source, transformation, specification, and evaluation status through revisions.
Translation infrastructure proposed here	Joint examination of evidence forms, supporting functions, and diagnostic dimensions.	A provisional synthesis; the complete pathway and comparative usefulness remain unvalidated.	Distinguish documented connections, reporting limits, recommendations, scope boundaries, and theoretical extensions.

Scope statements are interpretations of these representative formulations, not claims that their applications cannot provide the specified detail. Existing approaches may already supply some or all of this trace record. The comparison is targeted, not a systematic review of the theories.

Tracing how evidence changes form as it moves through design matters because design does not end with selecting an option. Designers develop and revise spatial propositions

through dimensions, materials, grading, planting, and performance criteria [29–31]. Translation infrastructure places these forms and the status of their evidence connections at the center of the comparison. Its additional explanatory value is the distinction between a documented operation, a recommendation, an unestablished link, a scope boundary, and a proposed extension; comparative usefulness remains to be tested.

The framework also provides a more specific way to diagnose problems in evidence use. It names the decision or evaluation still unconnected to evidence, and the support the next transition needs. Cross scale operability concerns whether evidence produced at one scale can guide decisions at another. Temporal decision translation concerns whether future change can inform a present commitment. Evidence to delivery concerns whether design rules remain connected to implementation and evaluation. These gaps extend the usability problem into the sequence of design work.

Procedural frameworks, parameterization, and typologies perform different translational functions, changing how boundary objects can be understood in landscape design. A map or model may support discussion across disciplines, but its value for design depends on what follows. From a design perspective, however, maps, diagrams, visualizations, and models do more than facilitate communication across disciplinary boundaries. They also serve as generative instruments through which evidence is interpreted and transformed into spatial propositions. Their value lies not only in enabling shared understanding but also in supporting exploration, comparison, and iterative design development. These translation artifacts as a result function simultaneously as boundary objects and as design media, occupying a unique position between analytical knowledge and spatial intervention. If the translation artifacts remain a shared reference, it supports coordination. If they are converted into a threshold or rule, they begin to shape design. The framework examines whether the recorded use of an artifact supports coordination, generates alternatives, or changes a design decision; these roles can coexist.

Recognizing how evidence becomes operational within design does not mean that analytical findings dictate design outcomes. In fact, the Dalian study shows the opposite. The flood depth penalty and protection rules changed where development could occur, but they did not determine physical form, planting design, or material treatment. Evidence can establish conditions for design without prescribing the final form. Table 5 compares representative approaches with the proposed synthesis.

5.2. Implications

Identifying which connection is missing helps a project team determine its next task. A team can examine whether an analytical finding became a parameter, whether that parameter entered a design rule, and whether the rule was tested against an outcome. Missing connections may reflect insufficient site detail, an undefined decision rule, or no provision for evaluation. If later stages fall outside the project's stated scope, their absence does not establish a translation failure.

For practice, tracking the connections between evidence and design decisions can make the connection between evidence and design decisions more visible. Regional evidence may require site scale interpretation. Future projections may require explicit thresholds or triggers. Design specifications may require monitoring that can later evaluate performance. Making these connections explicit can also improve review and documentation.

The goal of translation infrastructure is to make evidence influential without making design deterministic. Evidence can establish constraints, thresholds, or performance expectations while leaving room for professional judgment. Maintaining a distinction between informing design and determining design is important because the purpose of transla-

tion is not to replace design reasoning; instead, it is to make important evidence based decisions traceable.

For research, the translation infrastructure framework shifts attention from analytical accuracy alone to what happens after analysis is complete. A model can be technically strong without affecting a design decision. Research can therefore examine whether analytical outputs become usable parameters, whether those parameters enter decisions, and whether the resulting effects can be evaluated.

The framework also provides a basis for comparing different translation methods. Future studies can examine which workflows or artifacts help evidence cross particular stages and where additional interpretation is required.

For education, the translation infrastructure framework can help connect analytical coursework with design studios by making translation an explicit learning objective. Students are often exposed to environmental data, spatial analyses, and performance metrics, yet they may receive less instruction in how to transform this information into design propositions. Translation requires the ability to move iteratively between evidence, representation, and intervention through mapping, diagramming, visualization, modeling, and design exploration. Teaching these translational practices can help students understand not only where evidence originates but also how it becomes operational within design decisions. The framework therefore provides a structure for evaluating whether analytical findings remain connected to the proposals, specifications, and performance goals they are intended to inform.

5.3. Applying and Assessing the Framework

A prospective application can begin with a declared inventory of evidence dependent decisions and their associated specifications. For each decision, record the source and its uncertainty, the spatial and temporal interpretation, the proposed or adopted specification and its version, the responsible actor, and the evaluation object and method. Use the questions in Table 2 to examine each connection, record contested interpretations, and revisit the source or design when review or evaluation requires it. Recommendations, model execution, formal adoption, delivery, and measured performance should have separate recorded statuses.

Three indicators are proposed for testing. Documentary coverage is the proportion of evidence dependent specifications in the declared inventory that have both a located source and a recorded transformation. Delivery continuity is the proportion of adopted specifications within the declared delivery scope and due by the assessment date that have delivery conformity records. Evaluation coverage is the proportion of planned evaluations due by the assessment date that have been completed with a recorded result and a review decision. Report the numerator, denominator, assessment date, exclusions, and unknown items separately. A measure with a zero denominator should be reported as not applicable. These indicators measure documentary completeness and can support accountability. They do not directly measure translation quality or environmental effectiveness. Site outcomes require separate measures, such as inundation depth and duration, access under stated water levels, or carbon flux, each with a baseline and a suitable evaluation method. The indicators have not been validated and should be reported separately.

Water sustainability requires attention to ecological function, resource use, social needs, and change over time. A single performance target does not capture these concerns [39,56]. A flood rule may affect habitat, public access, and the distribution of risk. Adaptive water management links continuing learning to institutional capacity [56]. The proposed trace record can make assumptions and revisions visible, but a documented connection does not establish a sustainable outcome.

Institutional authority, stakeholder priorities, and financial feasibility affect whether a technically supported proposal is adopted. A trace record should identify who has authority to approve a rule, who delivers and maintains it, the budget for implementation and evaluation, and how contested priorities are considered. Stakeholder conflict or a justified change in priorities may alter a design without indicating failed translation. Designers must use professional judgment to weigh flood protection, ecological function, access, cultural values, costs, and uncertainty. Recording the rationale makes that judgment reviewable. It does not replace professional judgment with a single environmental parameter.

5.4. Limitations and Future Work

The four derivation studies originate from one research program. Their coverage of the United States, China, and several world regions does not establish representativeness or universal transfer. Institutional, cultural, resource, and project scope conditions may change which connections are feasible. A single analyst performed the comparison, and the reconstructed assignments have not undergone independent duplicate coding. The documentary illustrations in Supplement S2 broaden the examples without validating the pathway or its effectiveness. Future studies should apply the framework to independent projects, compare assignments among independent readers, assess usefulness relative to existing methods, and follow evidence through adoption, construction, maintenance, and field evaluation. These tests should distinguish reporting quality, design reasoning, delivery conformity, and environmental outcomes.

6. Conclusions

Climate responsive landscape architecture has access to increasingly detailed environmental evidence. This paper develops translation infrastructure as a provisional synthesis to help examine how environmental evidence can be carried into landscape design. The comparison identifies procedures that organize evidence use, parameters that express analytical findings in design terms, intervention types that connect evidence to possible action, and scenario testing that evaluates modeled consequences of design decisions. These functions inform a proposed traceable path from environmental analysis to design and evaluation. Cross scale and temporal diagnostics have support in reported limitations, transfer qualifications, documentation, and working connections; evidence to delivery remains a theoretical extension.

For landscape architects, this translation is important for understanding how scientific findings affect spatial form. A sea level rise projection, for example, describes an expected environmental condition, but it does not by itself specify a design elevation. Designers must interpret the projection in relation to site conditions and performance objectives before expressing it as an elevation, spatial rule, or other design parameter. Because of this, we argue that this translation should be treated as an explicit part of design reasoning. A successful translation maintains the connection between evidence and design decisions as a project develops. Translation infrastructure does not prescribe design form or replace professional judgment. It makes visible how evidence supports particular choices and where further interpretation or evaluation is required.

The proposed framework is a theory building interpretation developed from a single research program focused on water-centric landscapes in the United States, China, and several world regions. Its complete pathway and comparative usefulness have not been independently validated, and the scenario studies examine modeled planning and design decisions rather than performance after construction. Future research should test the framework in independent projects and other environmental settings. Following evidence

through design, construction, and performance evaluation will show whether the proposed connections occur in practice and where the framework requires revision.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/su182111032/s1. Supplement S1 contains Table S1: Stage assignments and supporting evidence records, which records the twenty stage assignments shown in Figure 3, together with their supporting evidence records and qualifications. Supplement S2 presents external documentary illustrations from Nijmegen and Eddleston Water [57,58]. It includes six field criteria (Table S2: Criteria for the external documentary fields), twelve documentary assignments with source locations and qualifications (Table S3: Located external documentary assignments), and interpretations across the five analytical stages (Table S4: Interpretation of the external connections across five stages).

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References

1. Pang, B.; Deal, B. Bridging Design and Climate Realities: A Meta-Synthesis of Coastal Landscape Interventions and Climate Integration. *Land* **2025**, *14*, 1709. [CrossRef]
2. Lemos, M.C.; Kirchhoff, C.J.; Ramprasad, V. Narrowing the climate information usability gap. *Nat. Clim. Change* **2012**, *2*, 789–794. [CrossRef]
3. Dilling, L.; Lemos, M.C. Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy. *Glob. Environ. Change* **2011**, *21*, 680–689. [CrossRef]
4. Steinitz, C. *A Framework for Geodesign: Changing Geography by Design*; Esri Press: Redlands, CA, USA, 2012.
5. Haasnoot, M.; Kwakkel, J.H.; Walker, W.E.; Ter Maat, J. Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Glob. Environ. Change* **2013**, *23*, 485–498. [CrossRef]
6. Pang, B.; Deal, B. Integrating Land-Use Modeling with Coastal Landscape Interventions: A Framework for Climate Adaptation Planning in Dalian, China. *Sustainability* **2025**, *18*, 370. [CrossRef]
7. Pang, B.; Deal, B. A Review on the Use of Geodesign Processes in Managing Flood Vulnerability. *Land* **2024**, *13*, 723. [CrossRef]
8. Pang, B.; Deal, B. Wetland carbon dynamics in Illinois: Implications for landscape architectural practice. *Sustainability* **2024**, *16*, 11184. [CrossRef]
9. Weiss, C.H. The many meanings of research utilization. In *Social Science and Social Policy*; Routledge: London, UK, 2021; pp. 31–40.
10. Davies, H.T.; Nutley, S.M.; Smith, P.C., Eds. *What Works? Evidence-Based Policy and Practice in Public Services*; Policy Press: Bristol, UK, 2000.
11. Graham, I.D.; Logan, J.; Harrison, M.B.; Straus, S.E.; Tetroe, J.; Caswell, W.; Robinson, N. Lost in knowledge translation: Time for a map? *J. Contin. Educ. Health Prof.* **2006**, *26*, 13–24. [CrossRef]
12. Fazey, I.; Evely, A.C.; Reed, M.S.; Stringer, L.C.; Kruijsen, J.; White, P.C.; Newsham, A.; Jin, L.; Cortazzi, M.; Phillipson, J.; et al. Knowledge exchange: A review and research agenda for environmental management. *Environ. Conserv.* **2013**, *40*, 19–36. [CrossRef]
13. Cash, D.W.; Clark, W.C.; Alcock, F.; Dickson, N.M.; Eckley, N.; Guston, D.H.; Jäger, J.; Mitchell, R.B. Knowledge systems for sustainable development. *Proc. Natl. Acad. Sci. USA* **2003**, *100*, 8086–8091. [CrossRef]
14. McNie, E.C. Reconciling the supply of scientific information with user demands: An analysis of the problem and review of the literature. *Environ. Sci. Policy* **2007**, *10*, 17–38. [CrossRef]

15. Kirchhoff, C.J.; Carmen Lemos, M.; Dessai, S. Actionable knowledge for environmental decision making: Broadening the usability of climate science. *Annu. Rev. Environ. Resour.* **2013**, *38*, 393–414. [CrossRef]
16. Feldman, D.L.; Ingram, H.M. Making science useful to decision makers: Climate forecasts, water management, and knowledge networks. *Weather. Clim. Soc.* **2009**, *1*, 9–21. [CrossRef]
17. Lemos, M.C.; Morehouse, B.J. The co-production of science and policy in integrated climate assessments. *Glob. Environ. Change* **2005**, *15*, 57–68. [CrossRef]
18. Mauser, W.; Klepper, G.; Rice, M.; Schmalzbauer, B.S.; Hackmann, H.; Leemans, R.; Moore, H. Transdisciplinary global change research: The co-creation of knowledge for sustainability. *Curr. Opin. Environ. Sustain.* **2013**, *5*, 420–431. [CrossRef]
19. Beier, P.; Hansen, L.J.; Helbrecht, L.; Behar, D. A how-to guide for coproduction of actionable science. *Conserv. Lett.* **2017**, *10*, 288–296. [CrossRef]
20. Wyborn, C.; Datta, A.; Montana, J.; Ryan, M.; Leith, P.; Chaffin, B.; Miller, C.; Van Kerkhoff, L. Co-producing sustainability: Reordering the governance of science, policy, and practice. *Annu. Rev. Environ. Resour.* **2019**, *44*, 319–346. [CrossRef]
21. Norström, A.V.; Cvitanovic, C.; Löf, M.F.; West, S.; Wyborn, C.; Balvanera, P.; Bednarek, A.T.; Bennett, E.M.; Biggs, R.; de Bremond, A.; et al. Principles for knowledge co-production in sustainability research. *Nat. Sustain.* **2020**, *3*, 182–190. [CrossRef]
22. Gieryn, T.F. Boundary-work and the demarcation of science from non-science: Strains and interests in professional ideologies of scientists. *Am. Sociol. Rev.* **1983**, *48*, 781–795. [CrossRef]
23. Star, S.L.; Griesemer, J.R. Institutional ecology,'translations,'and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–1939. In *Scaffolding: Selected Contributions of James R. Griesemer to History, Philosophy, and Biology*; Springer: Cham, Switzerland, 2025; pp. 125–153.
24. Guston, D.H. Boundary organizations in environmental policy and science: An introduction. *Sci. Technol. Hum. Values* **2001**, *26*, 399–408. [CrossRef]
25. Damschroder, L.J.; Aron, D.C.; Keith, R.E.; Kirsh, S.R.; Alexander, J.A.; Lowery, J.C. Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science. *Implement. Sci.* **2009**, *4*, 50. [CrossRef]
26. Simon, H.A. *The Sciences of the Artificial*; MIT press: Cambridge, MA, USA, 1996.
27. Rittel, H.W.; Webber, M.M. Dilemmas in a general theory of planning. *Policy Sci.* **1973**, *4*, 155–169. [CrossRef]
28. Buchanan, R. Wicked problems in design thinking. *Des. Issues* **1992**, *8*, 5–21. [CrossRef]
29. Schön, D.A. *The Reflective Practitioner: How Professionals Think in Action*; Routledge: London, UK, 2017.
30. Dorst, K.; Cross, N. Creativity in the design process: Co-evolution of problem–solution. *Des. Stud.* **2001**, *22*, 425–437. [CrossRef]
31. Lawson, B. *How Designers Think: The Design Process Demystified*; Routledge: Oxford, UK, 2006.
32. Cutter, S.; Boruff, B.; Lynn Shirley, W. Social vulnerability to environmental hazards. *Soc. Sci. Q.* **2003**, *84*, 242–261. [CrossRef]
33. Adger, W.N. Vulnerability. *Glob. Environ. Change* **2006**, *16*, 268–281. [CrossRef]
34. Berke, P.R.; Stevens, M.R. Land use planning for climate adaptation: Theory and practice. *J. Plan. Educ. Res.* **2016**, *36*, 283–289. [CrossRef]
35. Preston, B.L.; Yuen, E.J.; Westaway, R.M. Putting vulnerability to climate change on the map: A review of approaches, benefits, and risks. *Sustain. Sci.* **2011**, *6*, 177–202. [CrossRef]
36. Kwadijk, J.C.; Haasnoot, M.; Mulder, J.P.; Hoogvliet, M.M.; Jeuken, A.B.; van der Krogt, R.A.; van Oostrom, N.G.; Schelfhout, H.A.; van Velzen, E.H.; van Waveren, H.; et al. Using adaptation tipping points to prepare for climate change and sea level rise: A case study in the Netherlands. *Wiley Interdiscip. Rev. Clim. Change* **2010**, *1*, 729–740. [CrossRef]
37. Nassauer, J.I. Transdisciplinarity and boundary work for landscape architecture scholars. *Landsc. J.* **2023**, *42*, 1–11. [CrossRef]
38. Milburn, L.A.S.; Brown, R.D. The relationship between research and design in landscape architecture. *Landsc. Urban Plan.* **2003**, *64*, 47–66. [CrossRef]
39. Nassauer, J.I.; Opdam, P. Design in science: Extending the landscape ecology paradigm. *Landsc. Ecol.* **2008**, *23*, 633–644. [CrossRef]
40. Lenzholzer, S.; Duchhart, I.; Koh, J. 'Research through designing'in landscape architecture. *Landsc. Urban Plan.* **2013**, *113*, 120–127. [CrossRef]
41. Deming, M.E.; Swaffield, S. *Landscape Architectural Research: Inquiry, Strategy, Design*; John Wiley & Sons: Hoboken, NJ, USA, 2011.
42. Gu, Y.; Deal, B.; Larsen, L. Geodesign processes and ecological systems thinking in a coupled human-environment context: An integrated framework for landscape architecture. *Sustainability* **2018**, *10*, 3306. [CrossRef]
43. Newman, G.; Malecha, M.; Yu, S.; Qiao, Z.; Horney, J.A.; Lee, J.; Kim, Y.J.; Lee, R.J.; Berke, P. Integrating a resilience scorecard and landscape performance tools into a Geodesign process. *Landsc. Res.* **2020**, *45*, 63–80. [CrossRef]
44. Wilson, M.W. On the criticality of mapping practices: Geodesign as critical GIS? *Landsc. Urban Plan.* **2015**, *142*, 226–234. [CrossRef]
45. Ervin, S.M. Technology in geodesign. *Landsc. Urban Plan.* **2016**, *156*, 12–16. [CrossRef]
46. McHarg, I.L. *Design with Nature*; American Museum of Natural History: New York, NY, USA, 1969.

47. Corner, J. The agency of mapping: Speculation, critique and invention. In *The Map Reader: Theories of Mapping Practice and Cartographic Representation*; John Wiley & Sons: Chichester, UK, 2011; pp. 89–101. [CrossRef]
48. Spirn, A.W. *The Language of Landscape*; Yale University Press: New Haven, CT, USA, 1998.
49. Moosavi, S.; Hurlimann, A.; Nielsen, J.; Bush, J.; Warren-Myers, G.; March, A. Transforming the agency and influence of landscape architects in climate change actions: An empirical analysis of barriers and facilitators. *Landsc. Urban Plan.* **2023**, *234*, 104735. [CrossRef]
50. Ahern, J. From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world. *Landsc. Urban Plan.* **2011**, *100*, 341–343. [CrossRef]
51. The Center for Health Design. About EBD: What Is Evidence-Based Design (EBD)? Available online: https://www.healthdesign.org/certification-outreach/edac/about-ebd (accessed on 17 October 2026).
52. Zandvoort, M.; Kooijmans, N.; Kirshen, P.; van den Brink, A. Designing with pathways: A spatial design approach for adaptive and sustainable landscapes. *Sustainability* **2019**, *11*, 565. [CrossRef]
53. Dubois, A.; Gadde, L.E. Systematic combining: An abductive approach to case research. *J. Bus. Res.* **2002**, *55*, 553–560. [CrossRef]
54. Timmermans, S.; Tavory, I. Theory construction in qualitative research: From grounded theory to abductive analysis. *Sociol. Theory* **2012**, *30*, 167–186.
55. Ulrich, R.S.; Zimring, C.; Zhu, X.; DuBose, J.; Seo, H.B.; Choi, Y.S.; Quan, X.; Joseph, A. A Review of the Research Literature on Evidence-Based Healthcare Design. *HERD Health Environ. Res. Des. J.* **2008**, *1*, 61–125. [CrossRef]
56. Pahl-Wostl, C. Transitions towards adaptive management of water facing climate and global change. *Water Resour. Manag.* **2007**, *21*, 49–62. [CrossRef]
57. H+N+S Landscape Architects. Room for the River Nijmegen. Available online: https://hnsland.nl/en/projects/room-river-nijmegen/ (accessed on 17 October 2026).
58. Black, A.; Peskett, L.; MacDonald, A.; Young, A.; Spray, C.; Ball, T.; Thomas, H.; Werritty, A. Natural flood management, lag time and catchment scale: Results from an empirical nested catchment study. *J. Flood Risk Manag.* **2021**, *14*, e12717. [CrossRef]

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