Masterarbeit

Zur Erlangung des akademischen Grades Master of Science (M.Sc.)

Thema der Arbeit:

A Critical Review of Participatory Approaches in Water Management for Climate Change Adaptation

Studiengang:	Global Change Geography (M.Sc.)
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I am grateful to Dr. Karin Pscheidl for her professional expertise and compassionate medical care throughout this research journey.

The empirical foundation of this review is built upon insights from communities worldwide whose participatory contributions to water governance emerge despite substantial institutional and resource limitations.

Declaration

This thesis is dedicated to my wife and my parents, whose unwavering trust and steadfast support have sustained me through every challenge of this journey. This work is dedicated to their resilience and to my continued healing.

Abstract

Climate change is challenging long-standing assumptions of stable hydrological patterns. Water systems are starting to face an increase in extreme and deeper uncertainty that exposes and amplifies institutional fragmentation, resource limitation, procedural resistance and varying influence on water governance. Agencies often address these pressures by expanding basin committees, stakeholder platforms, and co-management institutions. However, evidence shows mixed results. Even though participation can improve learning and legitimacy, it can also devolve into tokenism, elite capture, and the reinforcement of inequality.

This thesis draws on a critical literature review and realist synthesis to show when participation leads to effective, equitable, and adaptive water governance under climate stress. Findings are synthesised from a systematically screened corpus of 121 documents published between 2009 and 2025, with most publications clustered between 2021 and 2025. Across the literature, recurring barriers have been found to limit the extent to which participatory inputs shape binding decisions. These barriers include institutional resistance, limited resources, knowledge asymmetries, and mismatches between deliberative timelines and urgent climate related decision needs.

The central contribution of this thesis is the Conditional Enabling Framework, a diagnostic tool that treats participation as context-dependent rather than universally beneficial. The framework evaluates participatory governance through four interdependent enabling conditions: Knowledge performance (K), Institutional performance (I), Equity performance (E), and Adaptive performance (A). It follows binding-constraint logic that dimensions are interdependent therefore failure in any one dimension can limit overall performance. This logic makes prioritisation possible by highlighting the key constraint that holds performance back in each specific setting. The framework also includes practical tools such as rubrics and diagnostic sequences to support policymakers, practitioners, and researchers in designing, evaluating, and improving participatory water governance for climate adaptation.

The literature is weighted toward documented case studies in water-stressed regions. English-language coverage and underreporting of implementation failures may reduce generalisability.

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List of Abbreviations

KIEA	Knowledge, Institutional, Equity, Adaptive
K	Knowledge Performance
I	Institutional Performance
E	Equity Performance
A	Adaptive Performance
RQ	Research Questions
IWRM	Integrated Water Resources Management
GWP	Global Water Partnership
OECD	Organization for Economic Co-operation and Development
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
IPCC	Intergovernmental Panel on Climate Change
SDG	Sustainable Development Goal
SES	Social-Ecological Systems
CASP	Critical Appraisal Skills Programme
MDAT	Methodological Design Assessment Tool
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
TS	Topic Search (in Web of Science)
TITLE-ABS-KEY	Title, Abstract, Keywords search (in Scopus)
SIWI	Stockholm International Water Institute
IOM	International Organization for Migration
EU	European Union
US	United States
UN	United Nations

1. Introduction

Climate change undermines the stationarity of hydrological regimes, intensifies extreme events, amplifies uncertainty, and places substantial pressure on water governance systems, thereby eroding established decision-making paradigms (Dias et al., 2022; Prosser et al., 2021). As a result, governance systems have to continually revise regulatory instruments, respond to evolving risk profiles, and maintain institutional legitimacy, even as climate-driven pressures exacerbate fragmentation, resource constraints, and procedural resistance (Azhoni et al., 2018).

In response to these governance pressures, institutionalised participatory mechanisms are widely promoted as tools to enhance legitimacy, integrate knowledge, and strengthen adaptive capacity (Eaton et al., 2021; Reed et al., 2018). This change has ever so increasingly become entrenched in international instruments. The Dublin Principles (International Conference on Water and the Environment (ICWE) et al., 1992), the Aarhus Convention (United Nations Economic Commission for Europe, 1998), and the OECD Principles (*The OECD Principles on Water Governance and implementation strategy*, n.d.) all foreground stakeholder engagement as a cornerstone of effective governance, while Sustainable Development Goal 6 ("Transforming our world," 2015) explicitly mandates the involvement of local communities in the enhancement of water and sanitation management. Participation has therefore moved from a peripheral concern to a near-hegemonic construct within water governance and is frequently presented as an indispensable prerequisite for successful adaptation (Joshua HK., 2025).

However, the empirical record is also very diverse. Reported outcomes range from enhanced social learning and iterative rule refinement to tokenistic consultation, elite capture, and reinforcement of existing inequalities (Aleu et al., 2022; Di Vaio et al., 2021; Joshua HK., 2025). Participation thus emerges as a context-specific governance strategy rather than an intervention that delivers universal benefits (Öjendal, 2023; Reed et al., 2018). Critical scholarship further warns that participatory practices can conceal power asymmetries, legitimise pre-determined decisions, and shift management burdens onto marginalised groups without a corresponding redistribution of authority, resources, or accountability (Aleu et al., 2022; Casali and Tiziana, 2022).

This thesis argues that participatory processes are most likely to facilitate climate adaptation in water governance when four interdependent enabling conditions are at least minimally sufficient, and when no single dimension is severely deficient:

i. Knowledge performance **(K)**,

ii. Institutional performance **(I)**,

iii. Equity performance **(E)**, and

iv. Adaptive performance **(A)**

In case one or more of these conditions fall below minimum sufficiency thresholds, participation is likely to assume a largely symbolic character, engendering deliberation without persisting influence on binding decisions.

The principal contribution of this research is the Conditional Enabling Framework, a diagnostic instrument that delineates the conditions under which participation engenders effective, equitable, and adaptive outcomes. Drawing upon binding-constraint logic, the framework identifies which absent or weakened condition most severely curtails participatory effectiveness within a particular governance context (Eaton et al., 2021; Muwafu et al., 2024).

1.1 The Problem of Non-Stationarity and Governance Pressure

Non-stationarity denotes a state wherein the statistical characteristics of hydrological systems evolve to a point where historical data can no longer provide reliable guidance for future conditions (Dias et al., 2022; Stockholm International Water Institute (SIWI), 2009). This makes governance arrangements on the assumption of stable technical constants in the form of hydrological parameters become unstable and unreliable (Prosser et al., 2021). Infrastructure that is based on historical flood recurrence intervals deteriorates as extremes intensify. Therefore, allocation regimes grounded on historical mean flows become contested when those means no longer hold (Dias et al., 2022). Consequently, planning processes lose their credibility as precipitation timing shifts, seasonal patterns reconfigure, and compound events increase in frequency (Singh et al., 2024; Verkerk et al., 2017).

The transition from stable, predictable hydrological regimes to increasingly uncertain climate regimes fundamentally transform governance requirements (Barreteau et al., 2016). As **Figure 1** illustrates, this shift demands a move from fixed infrastructure and rigid management rules toward flexible, adaptive stakeholder engagement and continuous rule revision (Dias et al., 2022; Frick-Trzebitzky et al., 2023; Verkerk et al., 2017).

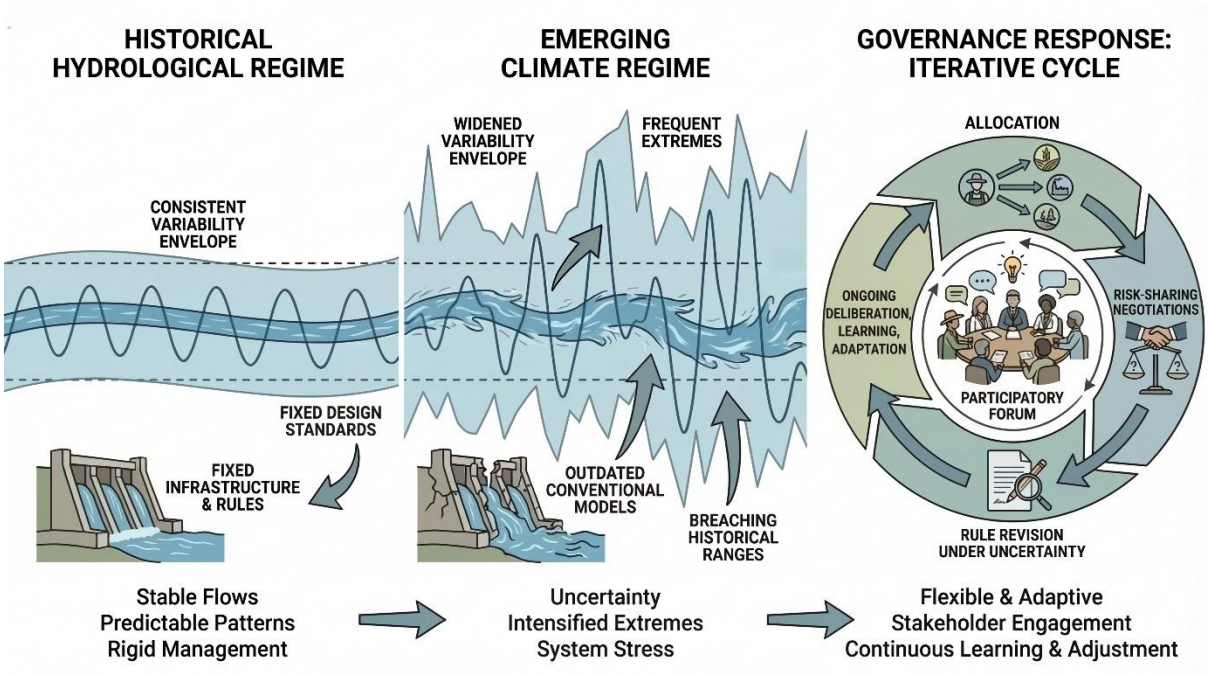

Figure 1: Transition from Stationarity-Based to Adaptive Governance Under Climate Change

This thesis draws upon a systematic review of 121 documents published between 2009 and 2025, with concentration of publications between 2021-2025. **Appendix A** provides details for screening methodology while **Appendix B** explains the detailed corpus characteristics, including document types, geographic coverage, governance scales, hazard types, and participation mechanisms. Through this research it has been verified that when enabling conditions are fulfilled, participatory processes help in enhancing monitoring, offering socially robust rule revision, and more by providing equitable burden distribution (Aceves-Bueno et al., 2015; Colloff et al., 2025). Meanwhile when these conditions are deficient, participation tends to remain symbolic i.e., outputs fail in influencing binding decisions, or participatory arenas start reproducing elite dominance beneath a guise of inclusivity (Casali and Tiziana, 2022; Joshua HK., 2025). These recurrent failure modes are documented in **Appendix C**. The observed variability highlights a need for a diagnostic framework that can identify what enabling conditions are present or missing, and what constraints most severely limits participatory effectiveness within a particular governance context.

1.2 The Contribution: A Conditional Enabling Framework

The present contribution is critical and steps into analysis for the formulation of a Conditional Enabling Framework that integrates empirical evidence from participatory water-governance initiatives subjected to climatic stress into four interdependent performance dimensions. The framework addresses the question: “Under what circumstances do participatory approaches underpin effective, equitable, and adaptive water governance amid climate change?”. The

answer to this question is conditional. Outcomes improve most reliably when all four dimensions are sufficiently met, but the weakest dimension usually determines overall performance. In some setups, other dimensions can partially offset deficiencies, as specified in **Appendix C**'s 0-3 scoring rubric (**C.6**).

This binding-constraint diagnostic logic shifts the analysis from prescription to diagnosis by identifying the most limiting enabling condition in a given context and prioritising interventions where they are likely to have the greatest effect. To operationalise this diagnostic move, the framework specifies four performance dimensions that jointly structure assessment and guide where corrective action is most needed.

Assessment is organised on four dimensions that are interdependent from each other. Knowledge performance captures things related to whether or not the evidence is credible, accessible and available in connection with decisions (Kliskey et al., 2023). Institutional performance touches on whether or not participative outputs are authoritative and feed into binding or not (Reddy and Reddy, 2020). Equity performance captures whether affected groups are meaningfully represented and protected from exclusion, excessive burdens, and elite capture (Muwafu et al., 2024). Adaptive performance captures the extent to which governance is able to revise rules through legitimate procedures which are relates to the monitoring and agreed triggers (Dias et al., 2022). This approach provides us with the following novel contributions:

i. **Conditional Specification:** The framework insists that all four dimensions must achieve simultaneous sufficiency, redirecting the focus from a binary appraisal of participation ("is participation good?") to a nuanced assessment of enabling conditions ("which conditions are present or absent, and which constraints shape outcomes?")

ii. **Binding-Constraint Logic:** By diagnosing the dimension that most limits outcomes, the framework prioritises interventions that are most consequential i.e., an expansion of participatory opportunities alone may fail to improve adaptive outcomes if institutional capacity remains the binding constraint

iii. **Operational Diagnostic Capacity:** The framework supplies scoring rubrics (**Appendix C**), illustrative diagnostic sequences (**Appendix D**), and context-sensitive prioritisation rules (**Appendix E**) for practitioners, thereby advancing beyond normative discourse to structured diagnostic guidance (questions + rubric) that must be locally calibrated

1.3 Scope and Key Concepts

1.3.1 Scope Definition

Empirically, the study focuses on institutionalised, formal participatory mechanisms deployed within water governance for climate-change adaptation. These include: stakeholder platforms, basin committees, participatory planning processes, community monitoring arrangements and co-management institutions that operate from the scale of local irrigation systems to transboundary river basins (the prevalence of these types of mechanisms is documented in **Appendix B**). The thesis investigates how these mechanisms influence adaptation outcomes specifically effectiveness, equity, and adaptive capacity under conditions of non-stationarity and deep uncertainty. Informal collective action which is not affiliated with formalised governance or with climate adaptation pressures, is explicitly excluded from analysis.

1.3.2 Participation, Transdisciplinarity and Knowledge

It is important to differentiate between participation as a concept in governance and transdisciplinary as a model of production of knowledge. Participation relates to institutionalised, formal mechanisms through which stakeholders help design, implement, or monitor water governance decisions, including questions of who has voice and influence (Reed et al., 2018). Transdisciplinarity, by contrast, is concerned with the academic and non-academic knowledge holders participating in the generation of knowledge and raise epistemological questions as to how different knowledge claims are constructed and validated (Kliskey et al., 2023). Although participating in transdisciplinary research can serve as a basis for participating in governance, in this thesis, participatory governance mechanisms are evaluated instead of evaluating the quality of transdisciplinary knowledge production. Where "Knowledge Performance (K)" is assessed, it refers to how diverse evidence is integrated, validated, communicated, and used in decision-making regardless of whether the knowledge was produced through transdisciplinary research.

1.3.3 Key Outcome Concepts

Effectiveness is operationalised as decision uptake and rule revision, measured by the degree to which participatory outputs influence planning documents, budgets, regulations, or operational protocols. Under climatic stress, effectiveness extends to the capacity for iterative rule revision (Iza et al., 2015).

Equity has both procedural and distributional aspects. Procedural equity concerns the composition of participants, the distribution of voice, and safeguards against elite capture (Aleu et al., 2022). Distributional equity deals with questions of how benefits, burdens and

risks can be distributed through the process of adaptation, in which marginalised groups are given special attention (Casali and Tiziana, 2022).

In this thesis, legitimacy refers to stakeholders' acceptance of decisions as procedurally fair and distributively just (not limited to legal terminology), especially under repeated rule revision (Prosser et al., 2021).

Adaptive capacity is operationalised here as Adaptive Performance (A) (adaptive capacity and agency) i.e., the ability of governance systems to monitor conditions and revise rules, allocations, and management frameworks iteratively under non-stationary conditions while maintaining legitimacy (Dias et al., 2022).

1.3.4 Pragmatist Epistemology for Evaluating Participatory Mechanisms in Climate Change Adaptation Governance

Minimum sufficiency thresholds are context dependent (Eaton et al., 2021). For this reason, the framework is diagnostic-first and supports practitioners in identifying binding constraints and minimum sufficiency criteria in their own settings. Any prescriptive implications are conditional, derived from the diagnosis, and must be locally calibrated rather than getting treated as universal best practices.

1.4 Target Audiences and Research Questions

1.4.1 Target Audience

Basin authorities and policymakers can use the framework to design engagement mandates and apply diagnostic tools that assess whether enabling conditions are in place and where investment will be most consequential.

Practitioners and facilitators can use the framework to structure participatory processes amid conflict, uncertainty, and unequal power, clarifying design sensitivities, likely failure modes, and prioritisation logic.

Scholars of water governance and climate adaptation can use the framework to refine theoretical accounts of how participation shapes resilience, operationalise dimension-specific diagnostic guides, and guide future empirical research example can be observed in **Appendix D**.

1.4.2 Research Questions

RQ1: Outcomes and Enabling Conditions. How do institutionalised participatory approaches influence effectiveness, equity, and adaptive capacity in water governance under climate change / non-stationary hydrological conditions, and under what enabling conditions are these effects realised?

RQ2: Mechanisms and Plausible Pathways. Which participatory mechanisms and institutional arrangements most influence adaptation outcomes, and through what plausible pathways (as inferred from patterns in the literature)?

RQ3: Equity and Distributional Justice. How do participatory processes shape procedural equity and distributional equity, particularly for marginalised groups, and what enables equitable outcomes?

RQ4: Conditioning Factors and Binding Constraints. How do power asymmetries, institutional rigidity, and hydrological uncertainty condition success or failure, and which factors act as binding constraints in specific contexts?

RQ5: Long-term Adaptability and Legitimacy. How do participatory arrangements contribute to sustained adaptability under non-stationarity, and what enables legitimacy maintenance during repeated rule revision?

These questions are answered through a desk-based critical literature review and realist-informed synthesis. The findings apply to formal, institutionalised participatory mechanisms reported in the literature, not informal collective action.

These questions help refine the proposal questions to support a conditional and diagnostic synthesis that is aligned with the K, I, E, A., framework.

Chapters 3-7 are a synthesis of empirically based research on outcomes, mechanisms, challenges, and contextual conditioning. Chapter 8 is a chapter that brings evidence into the framework. Chapter 9 gets back to questions, explicitly, giving conditional answers and boundary conditions.

1.5 The Pace Problem: Central Structuring Tension

Climate-related dangers typically require a quick decision to prevent lock-in although meaningful participation demands time for trust-building and deliberation (Azhoni et al., 2018). This creates a recurring “pace problem” in participatory governance, and its implications differ by hazard type. For rapid-onset hazards such as floods, decision windows are compressed

and participation must be organised under tight timelines. By contrast, slow-onset stresses such as groundwater depletion allow for deeper collaboration, but only if resources can be sustained over time. Under chronic non-stationarity, however, the challenge becomes ongoing, since governance must revise rules repeatedly, which can gradually erode legitimacy (Dias et al., 2022).

The pace problem shapes all five research questions. The framework addresses it through Adaptive Performance (A) dimension specifying procedures for legitimate rule revision **Appendix C** and context-sensitive design principles varying with hazard type **Appendix E**.

1.6 Chapter Roadmap

Chapter 2 (Methodology) describes the literature review design, search strategy, and synthesis approach for the critical review. Description available in **Appendices A** and **B**.

Chapter 3 (Climate, Water, Governance) establishes why water governance faces intensified pressure under climate change, synthesising hydrological changes and governance implications.

Chapter 4 (Governance Challenges & Theory) examines institutional and political barriers to water governance, establishes why participation is invoked, and consolidates theoretical lenses informing understanding of participatory governance.

Chapter 5 (Participation Spectrum) describes concrete participatory mechanisms, degrees of influence, and temporal fit with hazard types.

Chapter 6 (Challenges) synthesises structural barriers to effective participation (elite capture, tokenism, institutional resistance, exclusion).

Chapter 7 (Conditioning & Trade-offs) examines how contextual factors shape which K*,* I*,* E*,* A*.,* dimension becomes binding constraint and addresses core design trade-offs.

Chapter 8 (Framework) operationalises the K*,* I*,* E*,* A*.,* framework, defining dimensions, explaining binding constraint logic, and presenting scoring rubric. Detailed diagnostic guidance in **Appendices C, D, and E**.

Chapter 9 (Discussion) answers five research questions explicitly, identifying boundary conditions, alternative explanations, and limits of participation.

Chapter 10 (Conclusion) restates core argument, provides recommendations for policymakers, practitioners, and researchers.

2. Methodology

2.1 Research Design

This thesis employs a critical literature review synthesising evidence from participatory water governance under climate change adaptation. The methodology is grounded in realist synthesis principles, which recognise that interventions operate through context-dependent causal mechanisms rather than producing uniform effects across settings. Mechanisms are evaluated according to their practical effects in concrete governance contexts rather than conformity with theoretical ideals, reflecting the thesis's pragmatist epistemology.

A critical literature review is appropriate for this research because participatory water governance under climate stress is complex, multifaceted, and distributed across diverse disciplinary literatures. Rather than testing a single hypothesis, the review synthesises evidence on mechanisms, outcomes, enabling conditions, and failure modes, integrating insights into the diagnostic framework presented in subsequent chapters. The approach aligns with best practice in evidence synthesis for complex social phenomena.

The review was conducted as a desk-based study between July 2025 and December 2025, with a five-year empirical focus (2021-2025) for most studies and a 16-year historical scope spanning 2009-2025 for all identified literature.

2.2 Review Scope and Delimitation

The review addresses five research questions spanning (1) outcomes and enabling conditions, (2) participatory mechanisms and plausible pathways, (3) equity and distributional justice, (4) conditioning factors and binding constraints, and (5) long-term adaptability and legitimacy maintenance **Section 1.4.2** provides complete overview of these question.

Scope boundaries are documented in detailed in **Section 1.3.1**:

- **Geographic** focus includes all scales i.e., local, basin, national and transboundary
- **Sectoral** analysis is bound to water resources management and allocation like irrigation, supply, hydropower, environmental flows, flood and drought management
- **Temporal** lens lies between 2009-2025 with a concentrated analysis between 2021-2025
- **Participation** is focused on institutionalised, formal mechanisms e.g., platforms, committees, planning, monitoring and co-management

- **Climate** mechanisms are used as a frame for responses to climate change or non-stationary hydrological conditions

2.3 Literature Search and Screening

2.3.1 Search Strategy

The literature search was carried out in three main sources of information namely Web of Science, Scopus, and Google Scholar. Three Boolean search strings were created based on an iterative approach with a focus on sensitivity rather than specificity to maximise capture of relevant literature. Full information about search strings, search procedures, and progressive reduction stages is provided in **Appendix A**. Initial yield comprised of 1010 documents prior to deduplication and filtering of the documents**.**

2.3.2 Screening Process

Documents were screened in two stages to ensure they were relevant and of good quality:

Title/Abstract Screening: 369 deduplicated records were screened using explicit inclusion/exclusion criteria finally 121 records retained while 245 were excluded**.** Full details and exclusion reasons documented in **Appendix A**.

Full-Text Eligibility Assessment: All 121 records underwent full-text review against five detailed criteria to ensure empirical engagement, presence of participatory element, climate adaptation framing, outcomes measurement, and sufficient detail for synthesis.

2.4 Data Extraction and Synthesis Approach

2.4.1 Coding Framework

Data extraction was guided through a transparent, structured coding framework designed to capture evidence relevant to the five research questions. The coding scheme was developed and refined iteratively by piloting it against an initial subset of 50 documents, then applying explicit decision rules consistently across the full corpus. Rather than using proprietary qualitative software, the review used a deliberately lightweight but systematic Excel-based workflow linked to a reference manager for reference management and screening. All screening and coding decisions were documented for auditability and documents were processed at the study level including manual review of extracted text and, where necessary, conversion of PDFs to OCR data to capture keywords and to search strings that were missed during the initial text extraction. The synthesis treats all 121 included documents as relevant evidence, while interpretations weight findings more heavily when they derive from more rigorous designs (e.g., longitudinal or comparative studies) than from descriptive project

reports, based on methodological rigor that was noted during extraction. List of all the tools used in this study are mentioned in **Section 2.4.3**.

Primary coding categories:

The research was coded in various categories for better understanding of the problems and their solutions related to adaptation in climate change. This includes:

Governance context that describes the governance scale, hydrological regime, hazard type, institutional structure and political economy

Participatory design that explains the mechanism type, degree of influence, temporal dynamics and the stakeholder composition

Enabling conditions through which institutional support, resource allocation, knowledge infrastructure, equity safeguards and power dynamics can be observed

Mechanisms and plausible pathways that look at how participation influences outcomes

Outcomes that explain the effectiveness, equity, learning, institutional change, adaptive capacity

Conditioning factors that answer what makes participation succeed or fail in context

Success and failure modes explain the documented common patterns across cases

2.4.2 Realist Synthesis

Rather than meta-analytical pooling (unsuitable given heterogeneity), the synthesis used realist synthesis to trace causal mechanisms linking participatory designs to outcomes and to identify contextual factors that enable or constrain them.

Five-stage synthesis process:

Mechanism identification: Identification of recurring mechanisms through which participation shapes outcomes (knowledge integration, inclusive deliberation, institutional embedding, monitoring feedback). Mechanisms are understood here as the underlying reasoning and resources that stakeholders utilize when responding to participatory opportunities like the plausible pathways through which participation influences outcomes.

Context mapping: Mapped contextual conditions that enable or undermine each mechanism. Barriers that can represent either contextual constraints (e.g., lack of funding in low-capacity basins) or disabled mechanisms (e.g., elite domination preventing inclusive deliberation).

Outcome patterns: Linked combinations of enabling conditions to observed outcomes.

Binding constraint identification: Flagged cases where weakness in one K, I, E, A., dimension constrained outcomes despite strength in others.

Framework operationalisation: Patterns synthesised into the Conditional Enabling Framework (K, I, E, A) with operationalisation details in **Appendices C, D, and E**. Coding combined deductive coding phenomena (K, I, E, A., dimensions derived from theory) with inductive identification of emergent barriers and mechanisms from the literature.

2.4.3 Software and Digital Tools

Notes and synthesis planning were supported using Microsoft Journal and Notebook LLM (NotebookLM), which were used to organise reading notes and structure ideas and were not used to generate final thesis text. Document writing and formatting were completed in Microsoft Word, while Microsoft Excel was used for data manipulation and to maintain the extraction and coding tracking sheet (linked to Zotero for reference management and screening). Where required, PDFs were converted to searchable text using OCR (via Adobe) to reduce the risk of missing relevant keywords during extraction. Graphs representing key study characteristics were generated using Python scripts, and flowcharts were generated using Mermaid code. Illustrative figures were created and refined manually in CorelDRAW using publicly available clipart elements and custom edits to ensure consistency and clarity. Generative AI tools were used only for inspiration during figure ideation (e.g., exploring layout options), and no final figures or thesis text were directly generated by AI. Grammarly was used for spell-check and for sentence structuring/paraphrasing during the final editing phase.

2.5 Quality Assurance and Limitations

2.5.1 Quality Assurance

Explicit criteria were applied consistently throughout the screening stages. The comprehensive search across three information sources minimized indexing bias. A formal critical appraisal tool was not used in this review, given the heterogeneity of document types (academic journal articles, grey literature reports, policy documents) which would be difficult to assess on a single standardized rubric.

To maintain evidentiary discipline, claims are expressed with strength proportional to evidence: (i) stronger where multiple rigorous designs converge (comparative/longitudinal), (ii) moderate where patterns recur across descriptive case reporting, and (iii) tentative where claims rely on single or low-detail accounts.

As a result, the synthesis treats all 121 included documents as providing relevant evidence, while interpretations weight findings from rigorous designs (e.g., longitudinal studies, comparative analysis) more heavily than findings from descriptive project reports, based on design quality and methodological rigor noted during data extraction.

The iterative framework of K, I, E, A., was developed, tested against corpus cases, and refined iteratively to ensure coherence with evidence. An Excel-based tracking sheet was created as a deliberately lightweight but systematic alternative to proprietary qualitative analysis software. A custom workflow was developed combining open-source utilities and manual analytical judgment, enabling full transparency and control over qualitative and quantitative dimensions of the data.

Text was manually reviewed, annotated, and translated into structured columns representing analytical dimensions such as design, variables, methods, and findings. This structure supported both interpretive and quantitative analysis. Black-box coding systems were avoided to ensure all analytical choices are visible and auditable. The Excel sheet thus became a transparent bridge between raw literature and higher-level synthesis, integrating qualitative reasoning with structured data management.

2.5.2 Acknowledged Limitations

Publication bias: Published accounts may over-represent successful or well-documented cases while underrepresenting failures or contexts where participation proved counterproductive. Mitigation through grey literature searching and critical review of documented failure modes was performed to avoid this bias however, systematic positive bias cannot be fully excluded.

Geographic bias: Documents concentrated on developing regions facing acute water stress that includes Sub-Saharan Africa and South Asia while high-income countries with mature water governance institutions are relatively underrepresented. However, this concentration is defensible given that water governance challenges under climate stress are most acute in developing contexts.

Disciplinary bias: Corpus draws heavily from development, environmental science, and policy literatures with limited engagement from political economy, legal, or economic analyses. This may bias the synthesis toward institutional design factors while under-emphasising power-based and political economy drivers.

Temporal scope: Most included studies are from 2015-2023 as participatory adaptation in water is still relatively young, with most implementations less than 20 years old. Long-term

outcomes over multi-decadal timescales are not yet observable, limiting assessment of sustained adaptability (RQ5).

Empirical diversity: Corpus is dominated by case studies and review but rigorous comparative designs or experimental evidence are limited. Causal mechanisms are inferred from documented patterns rather than a test using controlled comparison.

Language limitation: Restriction to English-language literature excludes potentially rich evidence from Spanish, French, Mandarin, and other literatures, particularly in Latin America, Francophone Africa, and East Asia. Resource constraints precluded comprehensive translation.

Definition variability: Terms such as "participation," "adaptation," "effectiveness," and "equity" are defined variably across the corpus. The synthesis imposes consistent definitions for analytical purposes, but this standardisation necessarily simplifies original usage.

Scope constraints on reliability: Screening was conducted without independent verification. This limits reliability assessment. However, explicit decision criteria documented in **Appendix A** provide transparency and allow replicability.

Despite these limitations, the corpus represents the most comprehensive and recent evidence available on participatory water governance under climate change adaptation. Therefore, the review's scope provides a sufficient evidence base to identify recurring mechanisms, common failure modes, and enabling conditions.

2.6 How the Methodology Addresses Each Research Question

As stated in **Section 1.4.2**, the methodology addresses five research questions through the following strategies:

RQ1 (Outcomes and Enabling Conditions): Addressed through comprehensive synthesis of outcomes across the 121 document corpus and documentation of enabling conditions associated with different outcome patterns **(Chapters 3-9)**.

RQ2 (Mechanisms and Plausible Pathways): Addressed through identification and tracking of mechanisms across cases, linking specific participatory designs to observed outcomes through plausible pathways **(Chapters 6-9)**.

RQ3 (Equity and Distributional Justice): Addressed through systematic extraction and synthesis of documents explicitly engaging issues of equity, inclusion, and distribution, with particular attention to failure modes and enabling conditions **(Chapters 7-9)**.

RQ4 (Conditioning Factors and Binding Constraints): Addressed through the contextual mapping stage of the synthesis, which documents how power asymmetries, institutional constraints, and other contextual factors shape outcomes **(Chapter 8)**.

RQ5 (Long-term Adaptability and Legitimacy): Addressed through synthesis of evidence on adaptive management, monitoring systems, and sustained legitimacy, while recognizing limitations due to the temporal scope of available evidence **(Chapters 7-9)**.

3. Climate Change, Water Systems, and Governance Pressure

3.1 Hydrological Non-Stationarity as the Core Governance Challenge

As introduced in **Chapter 1**, non-stationarity refers to the breakdown of historical hydrological patterns as reliable guides to future conditions, undermining traditional planning assumptions (Dias et al., 2022; Stockholm International Water Institute (SIWI), 2009). This shifts governance demand from one perfect solution to an iterative rule revision that monitors the linked triggers and legitimizes maintenance under repeated redistribution (Dias et al., 2022; Prosser et al., 2021).

Water governance has historically operated under an assumption of stationarity which assumes the statistical properties of hydrological systems (precipitation patterns, streamflow regimes, seasonal timing, extreme event frequencies) remain relatively stable over decadal timescales that allows the use of historical records to predict future conditions and design infrastructure accordingly (Stockholm International Water Institute (SIWI), 2009). This assumption is fundamental to engineering practise and water law in most jurisdictions but is crumbling under climate change (Rosa, 2022). Non-stationarity refers to the condition where hydrological properties shift systematically such that historical data no longer reliably predict future conditions. As reflected in contemporary water governance literature, non-stationarity is no longer a marginal concern in hydrology but rather it has become the central challenge defining adaptation requirements in water systems globally (Azhoni et al., 2018; Cheng et al., 2022).

Non-stationarity manifests differently across regions and hazard types, as detailed in **Table 1**, and these differentiated shifts drive the governance challenges that subsequent chapters try to address.

Table 1: Regional Manifestations of Hydrological Non-Stationarity and Governance Challenges

Region	Primary Non-Stationary Changes	Key Governance Challenges
Sub-Saharan Africa	Intensifying droughts, increased variability, groundwater depletion (Naazie et al., 2023)	Allocation conflicts, irrigation sustainability, transboundary stress (Naazie et al., 2023)
South Asia	Monsoon variability, glacier decline, timing shifts (Baccar et al., 2021)	Seasonal inflexibility, transboundary disputes, agricultural planning (Baccar et al., 2021)
Southeast Asia	Drought/flood extremes, salinity intrusion (Azhoni et al., 2018; Dias et al., 2022)	Downstream scarcity, hydropower conflicts, transboundary operations (Barreteau et al., 2016)
Latin America	Glacier recession, intensifying droughts (Estrela-Segrelles et al., 2024; Lasage et al., 2015)	Agricultural water loss, hydropower reliability, indigenous rights (Iza et al., 2015)
Middle East & Central Asia	Severe droughts, groundwater depletion (Wang et al., 2016)	Transboundary conflicts, irrigation collapse, desertification (Wang et al., 2016)

3.2 Climate Change Drivers and Hydrological Response

The hydrological non-stationarity documented in **Table 1** is driven by multiple interacting climate change mechanisms. Understanding these drivers is essential for governance because different drivers have different implications for whether adaptation can reduce risk or only manage unavoidable impacts (Azhoni et al., 2018; Rosa, 2022).

3.3 Temperature-Driven Changes

Rising air temperatures impacts water systems in several ways. Increased evapotranspiration implies that increased temperatures will result in higher evaporative demand from soil and from vegetation resulting in lower percentage of precipitation that will convert to streamflow or recharge ground water. In basins with already high shares of evapotranspiration (70-90% of the precipitation flow) especially in arid and semi-arid regions small increases in temperature lead to substantial decrease in water availability (Nikolaou et al., 2020; Wang et al., 2016).

Simultaneously, glacier and snowpack decline occurs in regions where seasonal snowpack and glacier melt historically provided with water storage during the dry seasons (Estrela-Segrelles et al., 2024; Lasage et al., 2015). Warming reduces snow accumulation and accelerates the timing of melt events, with consequences that translates to: (a) reduced dry-season flows when water is most needed, (b) earlier peak flows, disrupting irrigation schedules and hydropower generation timing, and (c) eventual depletion of glacier reserves, shifting basins from glacier-fed to more variable precipitation dependent systems. This is a gradual transition that typically happens over multiple decades, allowing some adaptation time, but the direction is greatly irreversible (Lasage et al., 2015; Prakash et al., 2025).

3.3.1 Precipitation Changes

Unlike temperature change, precipitation change is more spatially variable and makes it more difficult to predict and adapt. Intensification of wet extremes is caused by warmer air holding more water vapor and if and when it rains, the amount of precipitation is more intense (in a more concentrated burst) (Muwafu et al., 2024). This intensification enhances flood risk without increases in total annual precipitation. Shifts in precipitation timing hence disrupt seasonal forecasting and planning on which agricultural systems and water supply depend. Regional precipitation declines in Mediterranean regions, parts of the Middle East, southwestern North America, southern Africa, and Australia create particularly acute governance challenges because these regions typically have limited adaptive capacity (Dias et al., 2022; Verkerk et al., 2017).

3.3.2 Compound and Cascading Impacts

There are multiple changes occurring which translate to compounding effects. Drought intensification occurs when higher temperatures reduce dry-season flows while decreasing the total annual precipitation, creating multiplicative rather than additive impacts (Rosa, 2022). Flood and drought compounding effect produces infrequent but intense wet events alongside prolonged dry periods that undermines storage and management strategies. Meanwhile, ecosystem threshold crossings compromise human water security through loss of natural purification, storage, and buffering functions (Granata and Di Nunno, 2025). Cascading sectoral impacts accelerate competition as agriculture, hydropower, urban supply and environmental flows are stressed simultaneously (Nikolaou et al., 2020; Wang et al., 2016).

3.4 Governance Response Frameworks and Adaptation Requirements

Conventional water governance frameworks emerged under relative hydrological stability and were designed around the assumption of stationarity. Integrated Water Resources Management (IWRM) was developed in the 1990s as a response to water scarcity and allocation conflicts, promoting coordination across sectors and governance levels (Basuki et al., 2022; Dukhovny et al., 2014). As IWRM was not explicitly designed for non-stationary conditions it assumed that through better coordination and planning, water can be allocated to meet all demands. However under non-stationarity, this assumption breaks down as water availability declines and uncertainty increases (Azhoni et al., 2018; Fritsch, 2017).

Climate adaptation in water governance therefore requires moving beyond IWRM styled coordination to explicitly address non-stationarity. Key adaptive governance principles for a better and just governance include:

Embracing flexibility that instead of designing infrastructure and rules for a fixed, optimal allocation, adaptive governance accepts rules must change as conditions shift. This requires both technical flexibility (modular infrastructure) and institutional flexibility (procedures permitting legitimate rule revision) (Dias et al., 2022; Frick-Trzebitzky et al., 2023).

Embedding uncertainty, rather than seeking to reduce uncertainty through better prediction, adaptive governance accepts uncertainty as persistent and designs decision-making procedures that function despite deep uncertainty (Azhoni et al., 2018; Cattoën et al., 2025).

Promoting monitoring and learning that relies on feedback that governing systems have to monitor changing conditions, determine whether previous decisions still apply and update rules based on evidence (Eaton et al., 2021; Zuniga-Teran et al., 2022).

Building legitimacy for distributional conflict, under scarcity and non-stationarity, allocation decisions become more contentious therefore, legitimacy requires that affected stakeholders have voice in how scarcity is distributed (Melo Zurita et al., 2018; Sanchez-Plaza et al., 2021).

Strengthening adaptive capacity of vulnerable populations i.e., non-stationarity impacts are unevenly distributed. Equitable adaptation requires active support for vulnerable populations to build adaptive capacity rather than assuming all actors can adjust equally (Joshua HK., 2025; Naazie et al., 2023).

3.5 Water Scarcity and Distributional Conflict

Non-stationarity typically manifests first and most acutely as water scarcity. This translates to reduced water availability, shorter seasons of adequate supply, or water becoming available at times and in places that do not match human demand. Scarcity creates distributional conflict. As total water availability declines, allocation decisions become zero-sum because water allocated to one user is unavailable to others. This shifts governance from technical optimisation to explicitly political decision-making process (Dias et al., 2022; Melo Zurita et al., 2018).

Physical water scarcity occurs when renewable water availability is insufficient to meet total demand. Economic water scarcity occurs when renewable water is potentially adequate but governance, investment, or institutional capacity constraints prevent access (Prakash et al., 2025). Many developing regions experience economic scarcity where water exists but governance or infrastructure prevents access to the poor, rural, and marginalised communities. This implies that physical scarcity can only be managed with demand reduction

while economic scarcity can in principle be alleviated through institutional reform or infrastructure investment (Azhoni et al., 2018; Basuki et al., 2022).

Water scarcity creates competition across sectors and among users within sectors. Agriculture accounts for the largest share of global water withdrawals (around 70%) which makes the competition for agricultural-urban water especially high (Rosa, 2022; Wang et al., 2016). Within agriculture, competition often pits large-scale irrigators against smallholders and farmers against pastoralists, with outcomes shaped by power asymmetries such that powerful actors tend to secure water at the expense of weaker groups amid scarcity intensification (Bresney et al., 2023; Melo Zurita et al., 2018). The governance challenge is to ensure that scarcity is managed through transparent, legitimate distributional processes rather than defaulting to existing power imbalances.

3.6 Deep Uncertainty and Decision-Making Challenges

Water governance under climate change faces deep uncertainty where multiple plausible futures exist but the probability of these futures is not well-known. This differs from risk, where outcomes are uncertain, but probabilities are well established. Deep uncertainty arises from: (1) emissions uncertainty (future greenhouse gas trajectories not yet determined), (2) climate model uncertainty (regional disagreement among models), (3) hydrological translation uncertainty (complex precipitation-streamflow relationships), (4) socio-economic uncertainty (future water demand depends on population, development, technology), and (5) system sensitivity uncertainty (regional responses vary) (Azhoni et al., 2018; Cattoën et al., 2025).

These conditions create governance challenges that area largely absent under more predictable risk regimes. Infrastructure lock-in arises because large water infrastructure are designed for expected conditions and remains in place for decades (typically 30-100 year operational life). This results in the erosion of rule when allocation rules that are based on contested assumptions about future availability are publicly challenged. Therefore, decision paralysis can emerge when authorities delay action while waiting for certainty. It can also occur when earlier decisions prove maladaptive but are difficult to reverse (Lawless et al., 2024; Prosser et al., 2021).

Hence, adaptive governance approaches are required to address deep uncertainty. This includes robust decision-making, which involves choosing options that perform acceptably across multiple scenarios. It also includes flexibility, which preserves the ability to adjust as information improves. In addition, learning-by-doing is essential through pilots, monitoring, and iterative strategy adjustment. This makes monitoring and participatory deliberation central to these processes (Eaton et al., 2021; Sanchez-Plaza et al., 2021; Zuniga-Teran et al., 2022).

3.7 Governance Transformation: From Stationarity to Adaptation Orientation

Hydrological non-stationarity driven by climate change fundamentally transforms water governance requirements. The shift moves from stationarity-based governance (stable parameters, fixed rules, limited distributional conflict) to adaptation-oriented governance (changing conditions, revisable rules, persistent distributional conflict). This transformation requires:

Technical changes: Moving from fixed infrastructure designed to historical standards toward flexible infrastructure and adaptive management. This includes modular designs and monitoring systems that feed directly into decision-making processes (Frick-Trzebitzky et al., 2023; Granata and Di Nunno, 2025).

Institutional changes: From centralised, technocratic decision-making toward distributed decision-making that involves affected stakeholders. This requires formal mechanisms for participation and procedures for legitimate rule revision (Eaton et al., 2021; Verkerk et al., 2017).

Distributional changes: Changing the assumption that scarcity can be addressed without explicit distributional choices to recognising that scarcity demands such choices. This requires transparent distributive justice processes and explicit attention to equity (Bresney et al., 2023; Sanchez-Plaza et al., 2021).

Knowledge integration: Choosing not to rely mainly on technical expertise and historical data toward integrating diverse knowledge systems. This includes scientific, local, and Indigenous knowledge (scientific, local, Indigenous) (Naazie et al., 2023; Prakash et al., 2025).

Legitimacy: Going from defining legitimacy mainly as legality, where rules are seen as legitimate because they follow formal procedures, toward defining legitimacy as acceptance. Under this view, rules are legitimate because stakeholders accept them and understand the basis for them (Melo Zurita et al., 2018; Teodoro et al., 2020).

These shifts place participation at the centre of governance adaptation. Participatory approaches are therefore promoted as instruments for achieving this transformation. Inclusive deliberation and decision-making can integrate diverse knowledge and support adaptive learning. They can also help in building understanding and acceptance of necessary distributional choices, surface competing interests, and enable negotiation. However, these benefits are not automatic, as the quality and consequences of participation depend on

enabling conditions (Eaton et al., 2021; Joshua HK., 2025; Reed et al., 2018) that are addressed in subsequent chapters.

3.8 From Climate Pressures to Governance Implications

This chapter has shown that climate change intensifies pressure on water governance through hydrological non-stationarity, increasing scarcity, deep uncertainty, and distributional conflict. These pressures raise the demand for governance innovation and help to account for the recurrence of participatory approaches as proposed to respond to them. At the same time, the literature indicates that participation does not generate consistent benefits across settings, particularly with respect to equity, and outcomes depend on whether enabling conditions are present.

The next chapters therefore examine when and why participatory approaches support effective, equitable, and adaptive outcomes under climate change, and when they become symbolic or exclusionary.

4. Governance Challenges and Theoretical Foundations

4.1 Institutional and Political Barriers to Water Governance Under Climate Stress

Conventional water governance faces structural barriers that constrain adaptation to non-stationarity. Understanding these barriers is essential because they explain why participatory approaches are used as a governance innovation and previews the barriers that participation can and cannot address (Azhoni et al., 2018; Melo Zurita et al., 2018).

4.1.1 Institutional Fragmentation

Water governance is typically fragmented across multiple authorities at different governance levels (national ministry, regional basin authority, and local water board) and across sectors (agriculture, urban supply, environment, and energy). Each authority has a different mandate, timeframe, and budget. This creates coordination problems as decisions made by one authority often affect others. However, mechanisms for negotiating conflicts are often weak or absent (Basuki et al., 2022; Lawless et al., 2024). For example, hydropower authorities may prioritise maintaining reservoir levels for electricity generation. Meanwhile, agricultural authorities may instead prioritise releasing water for irrigation. When water is scarce, these interests' conflict and institutional fragmentation prevents coordinated resolution (Dukhovny et al., 2014).

Fragmentation can also be exacerbated by non-stationarity because adaptation requires adjusting rules simultaneously across multiple authorities. If there is a shift in hydrological regime, then the allocation rules need to be changed, but no one authority has the power to impose revision within all others. This leads to the coordination gridlock of proposals for revision being debated in multiple forums. Time for revisions extend and implementation becomes delayed or compromised (Dias et al., 2022).

4.1.2 Institutional Rigidity and Path Dependency

Water governance institutions are mostly shaped by past hydrological conditions. Many of their core rules, mandates, and investments are designed around historical flow patterns. For example, water laws codify allocation rules based on long-run flow averages, while agency mandates and budgets reflect earlier policy priorities. Long-lived infrastructure can further reinforce these arrangements by creating expectations of continued use. When hydrological conditions shift, these inherit systems can become poorly aligned with new realities, yet changing them is often politically and institutionally difficult (Lawless et al., 2024). This persistence reflects path dependency, where early choices, such as where dams were built or which sectors received priority, continue to constrain future options because they are costly to reverse and politically entrenched (Casali and Tiziana, 2022).

Institutional change is possible but is slow and politically difficult. It involves the need to modify law, redraw conflicting interests, and adopt costs to some groups. The governance challenge is to achieve institutional adaptation quick enough to match the pace of hydrological change while maintaining legitimacy and managing distributional conflict (Azhoni et al., 2018; Fritsch, 2017).

4.1.3 Resource Constraints and Funding Cycles

Water governance institutions in many settings operate under severe resource constraints. Limited staff, expertise gaps, incomplete monitoring systems, and sparse data reflect high information and transaction costs that shape which institutional arrangements are feasible (Ostrom, 2010). From an institutional economics perspective, investments in governance capacity such as hiring staff, conducting hydrological surveys, and maintaining monitoring networks require stable, long-term budget commitments. Meanwhile, funding is often project-based and time-limited and leads to cycles of capacity accumulation and loss when projects end (Sadik et al., 2022).

Different governance designs embed different cost structures, since coordination, information generation, and enforcement all compete with infrastructure and service delivery for scarce resources. Participatory mechanisms draw on the same constrained budgets. Their viability

therefore depends not only on their desirability, but also on whether their ongoing costs fit within short political and donor funding cycles that often shape water-sector finance (Aceves-Bueno et al., 2015; Reddy and Reddy, 2020).

4.1.4 Decision-Making Under Deep Uncertainty

Conventional decision-making relies on identifying a single best option based on predictions about future conditions. Under deep uncertainty, this approach breaks down because multiple futures are plausible and their probabilities are unknown. In such contexts, no single prediction is reliable enough to guide decisions (Cattoën et al., 2025). Yet many institutions still operate on this predictive logic. Engineers design infrastructure to meet expected specifications, policymakers adopt rules that assume future conditions will resemble those expectations and stakeholders expect decisions to be justified through clear forecasts.

When predictions become unreliable, this decision-making framework loses credibility. Stakeholders start questioning whether decisions are scientifically sound. Different stakeholders favour different precautions (some favour investing in large infrastructure to hedge against worst cases while others might favour maintaining flexibility). These disagreements can stall action because there is no shared approach for deciding under deep uncertainty (Dias et al., 2022; Pahl-Wostl et al., 2007a).

4.1.5 Legitimacy Deficits

As hydrological change becomes visible (droughts intensify, floods exceed historical records, seasonal patterns shift), water governance loses legitimacy. Allocation rules assume certain water availability but when availability starts to decline, rules are contested. Decisions that are made by technocrats without stakeholder input are increasingly questioned. Communities affected by allocation decisions often lack voice in how scarcity is distributed. As legitimacy erodes, compliance with governance rules declines and conflict intensifies. This can create a vicious cycle. Weak legitimacy reduces compliance and lower compliance then increases the need for enforcement. Increased enforcement can then further undermine legitimacy (Bresney et al., 2023; Melo Zurita et al., 2018).

4.1.6 Power Asymmetries and Unequal Adaptive Capacity

Adaptation to climate stress is not evenly distributed. Wealthy actors (large-scale farmers, industrial water users, urban utilities with capital) have the capacity to invest in technology (irrigation efficiency, alternative sources, water-saving equipment), diversify their livelihoods, and access information about adaptation options. Meanwhile, poor and marginalised actors lack these capacities. As scarcity intensifies, powerful actors use their advantage to secure water supply at the expense of weaker actors (Aleu et al., 2022; Casali and Tiziana, 2022;

Singh et al., 2024). Without governance intervention, adaptation reinforces the existing inequalities. This vicious cycle can be observed in **Figure 2**.

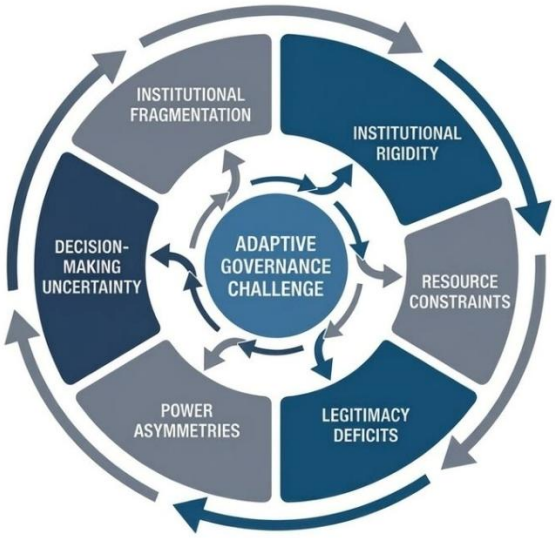

Figure 2: Institutional Barriers to Adaptive Water Governance

4.2 Why Participatory Approaches Are Invoked

Faced with these barriers, participatory approaches are often presented as a governance innovation. The core claim is that participation can help address several constraints at once i.e.,

- It can reduce **fragmentation** by creating cross-sectoral platforms that coordinate across authorities and sectors (Basuki et al., 2022).
- Counter institutional **rigidity** by using inclusive deliberation to surface the need for rule revision and build support for change (Dias et al., 2022; Fritsch, 2017).
- That participation may ease **resource constraints** by mobilising local knowledge and capacity, which can reduce demands on limited institutional resources (Aceves-Bueno et al., 2015).
- Under deep **uncertainty**, it can improve decision quality by bringing diverse perspectives into deliberation and clarifying trade-offs and priorities (Cattoën et al., 2025; Pahl-Wostl et al., 2007a).
- Participation is also expected to strengthen **legitimacy** by building acceptance for difficult distributional choices (Melo Zurita et al., 2018).
- Participation can also help address **power asymmetries** by surfacing equity concerns and supporting safeguards against elite capture (Aleu et al., 2022; Bresney et al., 2023).

However, it should be noted that participation does not automatically overcome these barriers. Whether participation addresses them actually depends on enabling conditions examined in subsequent chapters. Participation can fail to reduce fragmentation if it operates only within one sector. It can fail to overcome rigidity if institutional power concentrates in deliberative spaces. It can become costly rather than cost-saving if not resourced. It can obscure rather than clarify uncertainty if diverse views are not synthesised. It can undermine rather than build legitimacy if perceived as tokenistic. It can reinforce rather than challenge power asymmetries if elite actors dominate deliberation (Casali and Tiziana, 2022; Dewan, 2022).

4.3 Theoretical Foundations for Understanding Participatory Governance

Understanding how participation operates and what conditions enable effectiveness requires engaging multiple theoretical perspectives. It should be noted that no single theoretical lens fully captures the complexity of participatory water governance under climate stress. This section outlines four complementary theoretical lenses of participatory governance **Sections 4.3.1-4.3.4** and synthesises them into the K, I, E, A., framework **Section 4.3.5**.

4.3.1 Adaptive Governance and Social-Ecological Systems

Adaptive governance emphasises the capacity to revise management frameworks iteratively as conditions change and learning accumulates (Dias et al., 2022). Adaptive governance systems are commonly characterised by three features. First, they monitor the conditions and outcomes of the systems. Second, they include procedures to enable rules to be changed when the conditions change. Third, they encourage learning mechanisms that associate the results of monitoring with decision-making. This approach has been developed by observing that static management frameworks can become misaligned with changing system conditions, which increases the likelihood of regime shifts or system collapse (Azhoni et al., 2018).

In water governance, adaptive governance involves establishing monitoring systems that track hydrological and social change. This creates procedures that enable allocation rules to be revised when needed and ensures that learning from outcomes help inform future decisions. The approach recognises that perfect prediction is not possible so management must be flexible and responsive (Colloff et al., 2025). This is a departure from the traditional engineering methods which rely on infrastructure and rules devised to meet standards of the past to remain optimal over time.

Social-ecological systems (SES) theory provides additional conceptual grounding by framing water systems as coupled human and natural systems in which hydrological processes, ecosystems, and human institutions interact (Dias et al., 2022; Melo Zurita et al., 2018). Changes in one area can hence result in cascading changes in another area. Therefore,

governance should consider these interactions instead of seeing water as either physical or social (Dias et al., 2022).Using these theories, this thesis binds adaptive governance and its associated systems as Adaptive Performance (A).

4.3.2 Social Learning and Knowledge Integration

Social learning refers to processes through which stakeholders develop shared understanding of problems and solutions through interaction and dialogue (Kliskey et al., 2023). While knowledge integration refers to combining diverse knowledge systems (scientific, local, Indigenous, practitioner expertise) to develop more robust understanding than any single system alone. Both concepts emphasise that governance benefits from incorporating diverse perspectives and forms of knowledge rather than relying on their expertise alone (Brugnach and Özerol, 2019; Kliskey et al., 2023).

The learning process is also not automatic. Knowledge integration requires mechanisms for translation across knowledge systems so that participants with different expertise can understand each other (Renner et al., 2013). This requires validation processes to determine which evidence is credible. The requirement process also includes a commitment to use knowledge in decision-making rather than collecting it without any action (Colloff et al., 2025). When these mechanisms are absent, Knowledge Performance (K) becomes a binding constraint. Stakeholders may participate, but if diverse evidence is not integrated, credible, or traceable to decisions, participation becomes disconnected from actual decision-making (Eaton et al., 2021; Kliskey et al., 2023).

4.3.3 Political Ecology and Power Analysis

Political ecology perspective emphasises that water governance is not purely technical but is deeply political. It assumes that allocation decisions distribute resources and power that serve the interest of one stakeholder at the expense of another (Casali and Tiziana, 2022). Understanding governance requires analysing who benefits and who bears costs from decisions, which interests have power to influence outcomes, and how power asymmetries shape governance processes and results (Aleu et al., 2022; Casali and Tiziana, 2022).

Political ecology highlights that participation can sometimes legitimise decisions that ultimately benefit powerful actors. Inclusive deliberation may create an appearance of fairness while benefits and burdens remain unevenly distributed (Aleu et al., 2022; Morinville and Harris, 2014). Governance analysis therefore must examine more than the formal inclusion of participation. It must also assess whether participatory processes shape meaningful outcomes or remain largely symbolic (Peng, 2010). It has been observed throughout the literature that when equity safeguards are weak or absent, participation may appear inclusive while

distributional outcomes continue to reproduce inequality. Therefore, in this thesis Equity Performance (E) emerges as a binding constraint to reflect equity.

4.3.4 Institutional Economics and Transaction Costs

Institutional economics argues that governance effectiveness depends on institutional design because different arrangements produce different operating costs, incentive structures, and distributional consequences (Ostrom, 2010). Therefore, participatory mechanisms can be explained as institutional arrangements with associated costs (time, resources, staff to facilitate) and benefits (better information, greater buy-in, more legitimate rules) (Sadik et al., 2022).

The impact of this in terms of effectiveness has to do with whether benefits outweigh costs in specific contexts. This perspective alerts to the possibility that participatory mechanisms may not be cost-effective in all contexts. Where stakes are low, benefits of participation may be small relative to costs. Places where decision timelines are compressed like rapid-onset hazards, extensive deliberation may not be feasible (Aceves-Bueno et al., 2015). Institutional Performance (I) becomes a binding constraint when participatory outputs lack formal authority or clear pathways into binding decisions.

4.3.5 Integrating Theoretical Perspectives into the K, I, E, A., Framework

The four theoretical lenses clarify why each K, I, E, A., dimension **Figure 3** matters for participatory water governance and how it is specified later in the thesis.

Social learning theory emphasizes diverse knowledge integration, shared understanding, and co-produced problem framing, which informs **Knowledge Performance (K)**, operationalized in **Section 8.1.1** as credible, accessible evidence translated across knowledge systems and linked to decision-making.

Political ecology and power analysis foreground distributional justice and the risk of elite capture, which informs **Equity Performance (E)**, operationalized in **Section 8.1.3** as substantive representation of affected groups and safeguards against capture.

Institutional economics stresses that governance design choices embody different transaction costs and incentive structures, which informs **Institutional Performance (I)**, operationalized in **Section 8.1.2** as the formal authority of participatory outputs and their pathways into binding decisions.

Adaptive governance and social-ecological systems thinking highlight feedback, learning, and rule revision under non-stationarity, which informs **Adaptive Performance (A)**,

operationalized in **Section 8.1.4** as procedures that link monitoring to rule revision through pre-agreed triggers.

It is important to note that mechanism type alone is insufficient to explain outcomes. Performance depends on design features and whether institutional, equity, knowledge, and adaptive conditions are met.

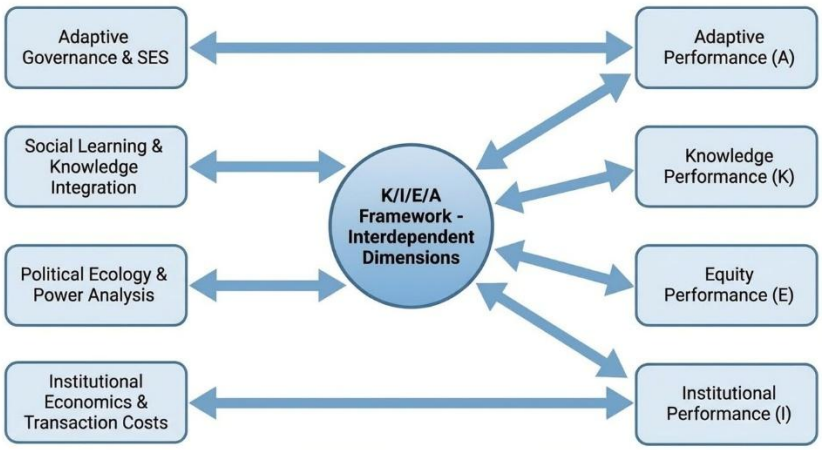

Figure 3: Theoretical Foundations and K, I, E, A., Dimensions

5. The Participation Spectrum

5.1 Defining Participation in Water Governance

Participation in water governance exists along a spectrum, from minimal stakeholder consultation to full shared decision-making authority. The extent of influence that participants have over outcomes varies widely across governance contexts and participatory mechanisms. (Arnstein, 1969) "ladder of participation" is a basic typology of participation that starts with manipulation (no real voice for one's views) and progresses through informing, consulting and cooperating (increasing levels of influence) to citizen control (real power over decisions) (Reed et al., 2018). While Arnstein's ladder has been critiqued for its linear assumptions, it still is useful in distinguishing between mechanisms in which stakeholders have genuine influence over processes and those which are essentially extractive exercises or legitimising exercises.

For this thesis, participation is defined operationally as formalised mechanisms through which stakeholders engage in designing, implementing, or monitoring water governance decisions. This definition emphasises three elements: (1) formalised, meaning mechanisms are institutionalised rather than ad hoc, (2) stakeholder engagement, meaning multiple affected parties have some role (not just expert advisors or government officials), and (3) intended influence on decisions. Empirically, mechanisms range from advisory consultation to co-

decision. Where influence is limited, the thesis codes this as low Institutional Performance (I) / tokenism rather than excluding it from “participation”.

Participation differs from other related concepts. **Co-management** typically implies shared authority between government and community, with formal power-sharing arrangements (Iza et al., 2015). Participatory **planning** emphasises stakeholder involvement in developing plans, budgets, or strategies (Baccar et al., 2021). While participatory **monitoring** emphasises stakeholder involvement in tracking outcomes and providing feedback on implementation (Aceves-Bueno et al., 2015). Stakeholder platforms or multi-stakeholder forums bring together the diverse actors (government, water users, civil society, research institutions) for deliberation and collective decision-making via participation (Melo Zurita et al., 2018). Although these distinct mechanisms operate at different governance scales and serve different functions, they share the core element of formalised stakeholder engagement (Kliskey et al., 2023; Verkerk et al., 2017).

5.2 Participation Mechanisms in Water Governance Under Climate Stress

Multiple participatory mechanisms are employed in water governance to address climate adaptation and non-stationarity challenges. Five mechanisms appear most frequently in the literature reviewed for this thesis.

5.2.1 Basin Stakeholder Committees and Platforms

Basin committees bring together representatives of water-dependent sectors such as agriculture, urban supply, hydropower, and environmental interests, along with government agencies at multiple levels and, in some cases, civil society organisations and research institutions (Basuki et al., 2022; Melo Zurita et al., 2018). Operating at the basin scale, which is the hydrological unit most relevant for managing shared water resources, these platforms provide coordination mechanisms where competing sectoral interests can be discussed and allocation trade-offs negotiated (Verkerk et al., 2017). In contexts of high water stress and multiple competing users, basin committees provide forums where such conflicts can be surfaced and addressed through deliberation rather than unilateral imposition (Lawless et al., 2024).

Basin committees function most effectively when they have:

- A clear mandate specifying their role and authority
- Representation that is substantive (stakeholders have capacity to participate) and equitably balanced (no single interest dominates) (Bresney et al., 2023)

- Connection to binding decision-making processes (recommendations influence allocation decisions) (Joshua HK., 2025)
- Technical support (access to hydrological data, analysis capacity) (Kliskey et al., 2023)
- Sustained funding and staff support (Sadik et al., 2022)

Meanwhile, when these conditions are absent, basin committees become symbolic forums that are time-consuming and produce limited influence on actual allocation decisions (Aleu et al., 2022; Casali and Tiziana, 2022).

5.2.2 Community-Based Water Management and User Associations

At local scales, participatory approaches often take the form of community-based management or water user associations (Naazie et al., 2023; Reddy and Reddy, 2020). These arrangements are particularly widespread in irrigation systems, where users organise themselves in order to control distribution, facilitate dispute resolution over allocation and maintain common infrastructure. In many cases, they are based on local knowledge and devolved decision authority with government agencies playing more of a supporting role rather than being the agencies that direct day-to-day management (Lasage et al., 2015).

There are, however, recurring challenges to the community-based approaches. Elite capture can occur when powerful users, such as large farmers or wealthier households, dominate decision-making and bend rules in their favour (Aleu et al., 2022). Exclusion can also persist even when marginalised groups are formally included, for example when women, landless labourers, or ethnic minorities are constrained by local norms or unequal voice (Naazie et al., 2023). Collective management can be further undermined by free-riding, the use of the system by its users with no responsibility of contributing labour, fees or compliance. Finally, long-term sustainability can be fragile due to drop in participation over time, and with institutions falling into inaction (Reddy and Reddy, 2020). Addressing these risks usually requires equity-centred design, such as transparent procedures, enforceable safeguards, accessible dispute resolution and institutional support over time (Bresney et al., 2023; Joshua HK., 2025).

5.2.3 Participatory Planning and Scenario Development

Participatory planning engages stakeholders in developing medium and long-term water management strategies under uncertainty (Baccar et al., 2021; Colloff et al., 2025). It is particularly relevant for climate adaptation because it brings together different perspectives on future availability, sectoral needs, and feasible adaptation options. Scenario development adds to this process by getting participants to consider multiple plausible futures and identify strategies that will continue to work regardless of the future we may face, as opposed to attempting to rely on a single future forecast (Cattoën et al., 2025; Eaton et al., 2021). This

process helps make assumptions explicit and it can build shared understanding of trade-offs. In practise, participatory planning is resource intensive. It requires skilful facilitation, commitment of time by participants over time periods and technical support for data analysis and scenario modelling (Baccar et al., 2021). It also requires the need for updating on a continuous basis when conditions change, rather than following plans as fixed documents. Without sustained resourcing and institutional follow-up, participatory planning risks becoming a one-off exercise that produces reports but has little ongoing influence on decisions (Aceves-Bueno et al., 2015; Sadik et al., 2022).

5.2.4 Participatory Monitoring and Community-Based Monitoring Systems

Participatory monitoring engages communities and water users in collecting hydrological, social, and ecological data that informs adaptive management (Aceves-Bueno et al., 2015; Jollymore et al., 2017). Rather than relying solely on government hydrological networks (which are often sparse in developing countries), participatory monitoring mobilises local observations, combines them with scientific measurement, and uses integrated data to inform management decisions and rule revision (Kliskey et al., 2023; Webster et al., 2022).

A key contribution of participatory monitoring is that it can support feedback loops that are central to adaptive governance. Stakeholders observe results, compare them to expectations, work out when rules no longer apply to conditions and contribute to revising these rules (Colloff et al., 2025). When integrated into institutional procedures, participatory monitoring transforms participation from information provision to learning and adaptation. However, these systems need investment in training, equipment, data management and clear procedures to translate results from monitoring into decisions rather than having results of monitoring and leaving them used (Aceves-Bueno et al., 2015; Walker et al., 2021).

5.2.5 Transboundary Water Commissions

Where basins cross national boundaries, transboundary water commissions are a common interstate coordination and conflict prevention mechanism (Goulden et al., 2011; Iza et al., 2015). They are usually conducted with representatives of government of the riparians, and sometimes with input from representatives of civil society and water users. Their functions are often represented as data sharing, infrastructure operation coordination, dispute resolution, negotiations in allocation rule (Basuki et al., 2022).

Transboundary commissions have specific limitations e.g., sovereign authority issues can affect willingness to accept binding rules, especially when water is constructed as a strategic national resource. Meanwhile power asymmetries also shape outcomes, since upstream or wealthier states often have greater leverage and capacity. Competing national priorities may

increase tensions, such as when upstream hydropower goals run up against downstream irrigation demands. Enforcement often is limited, since agreed rules can be hard to force without external pressure or robust mechanisms for ensuring compliance (Lawless et al., 2024). As a result, participatory elements are often weaker in transboundary governance than in domestic settings which results in mechanisms staying primarily state-centred (Iza et al., 2015).

5.3 Temporal Fit: Participation and Decision Timescales

Participatory approaches work in different ways according to the timeframe of decision and the rate of hydrological change. The pace problem introduced in **Section 1.1** is therefore expressed differently across participation mechanisms (Azhoni et al., 2018; Dias et al., 2022). **Figure 4** summarises how participatory feasibility varies across decision timescales and highlights the participation formats that best fit rapid-onset events, slow-onset change, and chronic non-stationarity.

Rapid-onset hazards (flash floods, severe droughts, unexpected rainfall patterns) demand compressed decision timelines (Muwafu et al., 2024). Emergency response often leaves little time for inclusive deliberation, and participation can become difficult to organise during crises as stakeholders might be unavailable leading to escalation without time for negotiation. However, participation can still have value before crisis occurs. Inclusive planning can be used to support early warning systems, pre-agreed emergency protocols and evacuation arrangements during non-emergency periods given that deliberation is feasible (Cattoën et al., 2025; Singh et al., 2024).

Slow-onset changes (increasing water scarcity, glacier decline, gradual vegetation shifts) permit deeper participation and deliberation (Dias et al., 2022; Estrela-Segrelles et al., 2024; Lasage et al., 2015). Stakeholders can construct collective definitions of problems, debate trade-offs and reach consensus about making problematic allocations. However, slow-onset changes demand sustained participation over years or decades as initial participatory processes lose momentum if it is not embedded in ongoing governance procedures (Nikolaou et al., 2020; Prosser et al., 2021).

Chronic non-stationarity creates a different governance demand. When rules have to be revised on a very repetitive basis as a relation evolves, the participation has to be institutionalised rather than a sort of periodical consultation (Azhoni et al., 2018; Dias et al., 2022). This typically requires routinised forums, established procedures for rule revision, and agreed decision triggers linked to monitoring. Although, long-term institutional commitment

and sustained funding are also necessary so that participation can continue beyond short project cycles (Colloff et al., 2025; Reddy and Reddy, 2020).

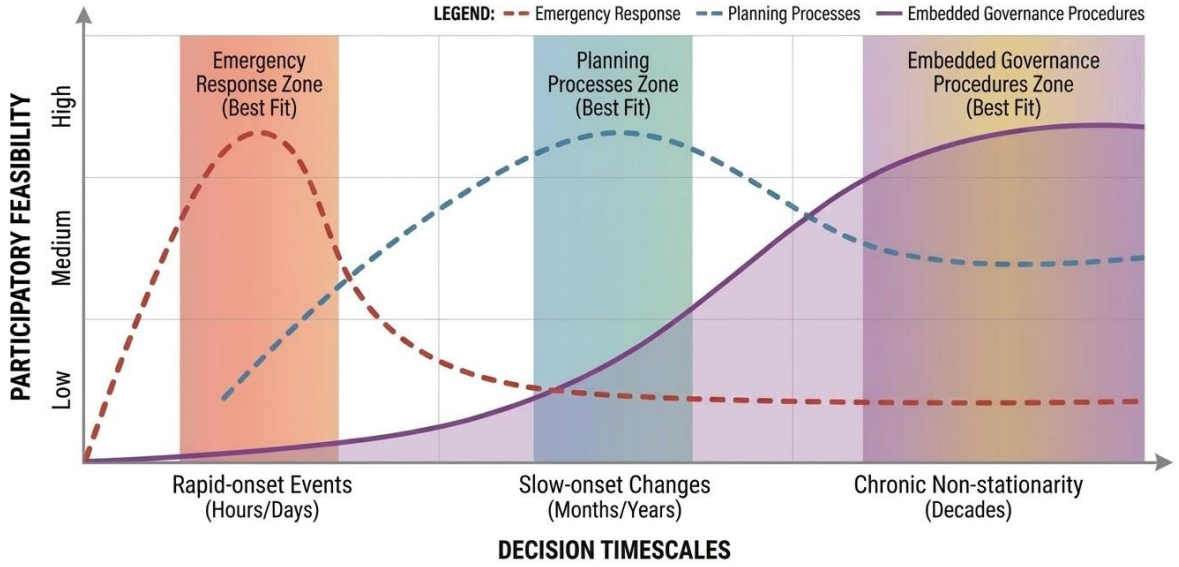

Figure 4: Temporal Fit: Participation Feasibility vs Decision Timescales

5.4 Challenges and Limitations of Participation Across Mechanisms

Across participatory mechanisms, recurring constraints often limit effectiveness. These include resource and capacity shortfalls, risks of elite capture and exclusion, tokenistic procedures with limited influence over final decisions, and institutional resistance that weakly embeds participatory outputs in formal decision-making structures.

Chapter 6 examines these constraints in detail and analyses their effects on K, I, E, A., performance in a cross-case comparison.

5.5 Synthesis: Participation as Conditional Governance Strategy

Participation in water governance is not a universal solution. Rather, it is a governance strategy that can generate benefits under specific conditions and can produce negative outcomes when those conditions are missing (Joshua HK., 2025; Reed et al., 2018). The mechanisms described in this chapter, including basin committees, community-based management, participatory planning, participatory monitoring, and transboundary commissions, are institutional forms through which participation operates. **Table 2** summarises how these mechanisms typically perform across the enabling-condition dimensions used in this thesis (K, I, E, A), based on patterns in the reviewed literature.

Their effectiveness depends on enabling conditions examined in **Chapter 4**, and severe entails that deficit in any one dimension can limit overall performance. Key dimensions include

whether diverse knowledge is integrated (Knowledge Performance, K), whether participatory outputs influence binding decisions (Institutional Performance, I), marginalised groups are substantively represented as a condition of legitimacy rather than an add-on (Equity Performance, E), and if governance systems can revise rules through legitimate participatory procedures (Adaptive Performance, A).

Table 2: Performance matrix comparing participatory mechanisms across K, I, E, A., enabling-condition dimensions

	K: KNOWLEDGE PERFORMANCE	I: INSTITUTIONAL PERFORMANCE	E: EQUITY PERFORMANCE	A: ADAPTIVE PERFORMANCE
BASIN COMMITTEES	**Mixed**; integrates technical data, but often lacks local/indigenous knowledge.	**Strong**; formalizes structures, clarifies mandates, and fosters coordination.	**Poor**; power asymmetries often exclude marginalized voices and downstream interests.	**Moderate**; can facilitate long-term planning but slow to respond to rapid changes.
COMMUNITY-BASED MANAGEMENT	**Strong**; deep local ecological knowledge and context-specific data collection.	**Variable**; effective locally but often lacks legal recognition and external support.	**Strong**; high potential for inclusive decision-making and fair resource distribution.	**Moderate**; highly adaptive locally but vulnerable to external shocks and scale mismatches.
PARTICIPATORY PLANNING	**Strong**; integrates diverse perspectives and co-produces actionable knowledge.	**Mixed**; creates good plans but implementation often hindered by bureaucratic hurdles.	**Variable**; inclusion efforts exist but can be tokenistic or bypass deep power dynamics.	**Strong**; forward-looking, scenario-based, and builds capacity for future changes.
PARTICIPATORY MONITORING	**Strong**; real-time data, increased trust, and shared understanding of trends.	**Mixed**; data collection is good but linking results to formal policy action is challenging.	**Variable**; empowers participants but access to monitoring technology and training can be unequal.	**Strong**; enables rapid feedback loops and timely adjustments to management actions.
TRANSBOUNDARY COMMISSIONS	**Mixed**; relies heavily on technical and aggregated data, often overlooking local realities.	**Strong**; essential for legal frameworks, conflict resolution, and international cooperation.	**Poor**; national interests dominate, frequently marginalizing local communities and ecosystems.	**Strong**; robust mechanisms for long-term cooperation and managing shared risks across borders.

COLOR KEY: Green = Typically Performs Well; Yellow = Mixed/Variable Performance; **Red** = Typically Performs Poorly. (Based on documented evidence patterns).

6. Challenges of Participation in Water Governance

6.1 Structural Barriers to Effective Participation

While participatory approaches offer potential benefits for addressing governance challenges identified in **Chapter 4**, substantial barriers prevent participation from functioning effectively in many contexts. These barriers are not merely practical inconveniences but often represent fundamental constraints on participatory governance capacity.

6.1.1 Elite Capture and Power Domination

Elite capture occurs when wealthy, educated, and politically connected actors dominate participatory forums and use them to advance their interests at the expense of marginalised groups (Aleu et al., 2022; Casali and Tiziana, 2022). Large-scale farmers, industrial water users and urban elites have advantages within participation mechanisms as they have the capital to spend on representation, technical expertise to participate in the complex water management issues and political networks to push through outcomes, and time to take part in forums on a regular basis. Meanwhile, small farmers, pastoralists, landless labourers and poor urban dwellers do not enjoy these advantages (Naazie et al., 2023; Reddy and Reddy, 2020).

When elite capture becomes imminent, participation becomes a mechanism through which powerful actors secure water allocation and legitimise their dominance under a mask of inclusivity. Communities see participation as theatre where stakeholders are included in forums, contribute their point of view about problems, then are able to sit and watch decisions be made without any changes (Aleu et al., 2022; Dewan, 2022). This can produce outcomes that are perceived as less legitimate than transparent technocratic decision-making, because elite capture can erode trust, suppress minority interests, and convert participation into symbolic validation of pre-existing power. This erodes trust, increases cynicism, and embeds resentment within communities (Bresney et al., 2023; Morinville and Harris, 2014).

Addressing elite capture requires explicit design measures like including quotas to ensure the representation of marginalised groups, capacity building for disadvantaged participants, separate forums for marginalised groups to coordinate positions before joint deliberation, independent facilitation preventing elite domination of discussion, and dispute resolution mechanisms protecting minority interests (Bresney et al., 2023; Joshua HK., 2025). Without such measures, participation amplifies rather than addresses power asymmetries.

6.1.2 Exclusion and Marginalisation Within Participation

Even when formal inclusion procedures exist, substantive exclusion can often be observed through social and cultural mechanisms. Women are kept out of participation in managing water due to cultural norms and household or care responsibilities which limits the time availability to join these conversation (Naazie et al., 2023; Singh et al., 2024). Indigenous peoples and ethnic minorities face similar exclusion due to language barriers (forums conducted in national language, not local languages), cultural differences in decision-making norms, and discrimination by dominant groups (Naazie et al., 2023; Prakash et al., 2025).

Landless labourers and casual workers are also excluded as operations of participation tend to be conducted during working hours thus restricting access to those who are dependent on daily wage labour. Poor households do not have the resources (cost of transportation, time away from income generating activities) to participate regularly (Aleu et al., 2022; Reddy and Reddy, 2020). Youth are often excluded due to the control mechanisms for participation by elders. Pastoralists are not included in extra modes of participation as stipulated for settled communities of agriculture (Jat et al., 2023).

The result is that participation mechanisms are transformed into arenas for the negotiation of the least marginalised of communities i.e. wealthier, educated, socially connected individuals by government and water management elites (Casali and Tiziana, 2022; Joshua HK., 2025). Participation is an aggregation of interests of the stakeholders who are already represented

while marginalising the latter most. This produces decisions that appear legitimate (communities participated) while perpetuating or deepening inequality (Aleu et al., 2022; Bresney et al., 2023).

6.1.3 Tokenism and Symbolic Participation

Tokenism occurs when government authorities create participatory mechanisms to appear inclusive and democratic without genuinely sharing power (Aleu et al., 2022; Morinville and Harris, 2014). Stakeholder inputs are sought in the form of forums, surveys, or consultation meetings. Information is collected, recorded and displayed. But decision-making goes through the bureaucratic channels without much visible link to stakeholder input. Stakeholder issues are recognised but not acted upon. Recommendations from participatory processes are implemented selectively, reflecting government preferences rather than stakeholder priorities (Dewan, 2022; Joshua HK., 2025).

Communities recognise tokenism. Participation is felt as time persecuting obligation but not as meaningful engagement. Stakeholders expend effort to explain concerns, ponder on options and develop recommendations. If the recommendations are ignored, resentment develops (Aleu 2023). Trust in governance institutions is reduced as communities become less inclined to participate in future processes (Morinville and Harris, 2014; Peng, 2010).

Distinguishing authentic participation from tokenism requires examining institutional embedding like questioning, do participatory outputs have formal authority and pathways into binding decisions? Are decision-makers required to justify departures from stakeholder recommendations? Do participatory procedures include appeal or revision mechanisms if stakeholders object to decisions? (Joshua HK., 2025; Ostrom, 2010). Without such institutional backing, participation is often experienced as performative facade (Aleu et al., 2022; Fritsch, 2017).

6.1.4 Resource Constraints and Participation Costs

Participation is resource consuming. Meaningful involvement of diverse stakeholders requires long-term investment of time, money and organisational capacity at each stage that brings different stakeholders together, facilitate dialogue, synthesis of knowledge, and translation of inputs into decisions and ongoing engagement over long timescales (Aceves-Bueno et al., 2015; Sadik et al., 2022).

Trained and paid facilitators are required to be onboard. Venues have to be rented or maintained. Participants must be paid for being away from their livelihoods and especially in case of low-income participants who are unable to afford unpaid time (Reddy and Reddy,

2020). Technical support for example data analysis, hydrological modelling and scenario development requires expertise and equipment (Baccar et al., 2021). Knowledge synthesis like documenting, analysing and integrating stakeholder inputs into governance decisions requires skilled staff. Dispute resolution mechanism needs skilled mediators. Ongoing communication (newsletters, radio announcements, mobile phone updates) requires sustained funding (Kliskey et al., 2023). Therefore, facilities must be accessible and equipped with audio, visual, and translation support (Bresney et al., 2023).

In resource-constrained developing country, these costs are substantial relative to water governance budgets. A well-facilitated participatory process can cost several thousand dollars, while water governance institutions may have annual budgets of only tens of thousands (Azhoni et al., 2018; Sadik et al., 2022). As a result, extended deliberative participation can consume a large share of limited funds and potentially crowd out monitoring and implementation (Aceves-Bueno et al., 2015).

The mismatch between participation costs and annual budget cycles is particularly acute. Budgets are approved one year at a time, yet effective participation requires multi-year engagement as understanding develops, conditions change, and climate impacts evolve (Dias et al., 2022). Communities experience “start-stop” participation with intensive engagement during externally funded projects, followed by abandonment when funding lapses (Dewan, 2022). This pattern erodes trust and willingness to participate in future processes (Aleu et al., 2022).

When participation is under-resourced, it becomes poorly facilitated and exclusionary. Stakeholders travel long distances with no transport support. Meetings are held in uncomfortable venues. Facilitators often lack training. Technical questions go unanswered. Translation between local languages and national language is absent. Vulnerable participants cannot afford to attend (Joshua HK., 2025; Reddy and Reddy, 2020). Under-resourced participation produces poor quality deliberation, reinforces power imbalances, and generates stakeholder frustration (Bresney et al., 2023; Sadik et al., 2022).

In practice, resource constraints interact with institutional authority and equity safeguards. When budgets are tight, participation is often compressed, increasing the risk of symbolic consultation and elite capture rather than substantive influence (Casali and Tiziana, 2022; Fritsch, 2017).

Resource constraints can therefore become a binding limit on participatory effectiveness, since sustained funding is often a prerequisite and, without it, even strong political commitment

and good design are unlikely to deliver meaningful participation (Azhoni et al., 2018). When budgets are constrained, participation may be abandoned altogether, leaving governance to technocrats and elites (Lawless et al., 2024). The irony is that participation often costs less than the conflicts and legitimacy crises that arise when marginalised groups lack voice (Bresney et al., 2023; Melo Zurita et al., 2018).

6.1.5 Institutional Resistance and Bureaucratic Inertia

Water management institutions are often resistant to participatory approaches. Bureaucrats trained in technical expertise and hierarchical decision-making perceive participation as threatening to professional authority (Fritsch, 2017; Ostrom, 2010). Participatory processes produce messier decision-making (more voices, more conflict, longer timelines) than technocratic approaches. Communities sometimes challenge bureaucratic decisions through participatory mechanisms, creating friction with institutional leaders (Aleu et al., 2022; Peng, 2010).

Institutional resistance manifests through subtle mechanisms. Participation mechanisms are created on paper but given no real authority (Lawless et al., 2024). Participatory forums are convened irregularly. Community representatives are not provided information needed to contribute meaningfully. Decisions are made in bureaucratic forums before participatory consultation, leaving participation as post-hoc rubber-stamping (Joshua HK., 2025; Morinville and Harris, 2014). Staff are not trained or incentivised to work with participatory processes. Participatory outputs are filed away rather than integrated into planning (Fritsch, 2017).

Overcoming institutional resistance requires leadership commitment where senior decision-makers visibly support participation, reward staff who engage with communities, allocate authority and budgets to participatory mechanisms, and use participatory outputs in actual decision-making (Aleu et al., 2022; Dias et al., 2022; Eaton et al., 2021; Reed et al., 2018). Without such commitment, participation remains peripheral to governance.

6.2 Participation Challenges Specific to Climate Adaptation

Beyond generic barriers, participation in climate adaptation confronts specific challenges arising from the nature of climate change and non-stationarity.

6.2.1 Deep Uncertainty and Community Engagement

Participatory processes assume communities can meaningfully contribute to governance decisions. But under deep uncertainty (multiple plausible futures, unknown probabilities), meaningful contribution becomes difficult (Cattoën et al., 2025; Pahl-Wostl et al., 2007a). Communities are asked to deliberate on water availability in a future characterised by multiple

possible climate scenarios, each with uncertain probability. Technical experts disagree on scenarios, leaving communities uncertain whom to trust (Colloff et al., 2025).

When technical experts present contradictory information (some models project increased precipitation, others project decreased precipitation for the same region), community members become confused or sceptical. They may dismiss participation as exercises in incompetence rather than genuine deliberation (Cattoën et al., 2025). Participatory processes can amplify rather than resolve uncertainty, reducing rather than building confidence in governance decisions (Pahl-Wostl et al., 2007b).

Addressing uncertainty in participation requires: (1) honest acknowledgement of uncertainty rather than false precision, (2) scenario-based deliberation where communities develop strategies for multiple futures rather than betting on single predictions (Baccar et al., 2021), (3) adaptive management procedures where rules are revised as conditions clarify (Colloff et al., 2025), and (4) technical support helping communities understand probability and uncertainty (Kliskey et al., 2023). Without such support, participation under deep uncertainty produces frustration.

6.2.2 Pace Mismatch: Participation Timelines and Climate Urgency

Meaningful participation requires time for communities to build shared understanding, deliberate and negotiate, and reach decisions or consensus (Eaton et al., 2021; Reed et al., 2018). However, climate change creates urgency, since some decisions such as dam construction or irrigation infrastructure have long lead times and delays can deepen adaptation deficits, while others such as drought response or flood emergency management require rapid action on compressed timelines (Muwafu et al., 2024).

Rapid-onset hazards particularly challenge participation. When floods occur within hours or droughts emerge suddenly, inclusive deliberation is impossible (Muwafu et al., 2024). Emergency response requires immediate action by authorised actors. But participation in planning for rapid-onset hazards (developing early warning systems, emergency protocols, evacuation procedures) can be effective during non-emergency periods (Singh et al., 2024). The challenge then becomes to maintain community engagement between emergencies as sustained participation requires regular practice and reinforcement.

Sustained engagement between emergencies is hampered by resource constraints as observed in **Section 6.1.4**, making it difficult for institutions to maintain participatory forums during quiet periods (Dias et al., 2022; Sadik et al., 2022).

Slow-onset changes (glacier recession, increasing water scarcity) permit deeper participation (Estrela-Segrelles et al., 2024; Lasage et al., 2015). But these must be addressed within political and planning timeframes (5-10 year planning cycles, budget cycles). Communities need time to adjust to changing realities and participate in developing responses. Resource constraints often force institutions to compress participation into short bursts (Azhoni et al., 2018). Meanwhile, rushed participation produces poor decisions but overly delayed participation creates adaptation deficits (Dias et al., 2022; Fritsch, 2017).

6.2.3 Technical Complexity and Knowledge Asymmetries

Water governance under climate change is technically complex and requires drawing on hydrological modelling, climate science, hydro-engineering, irrigation design, and ecological assessment (Rosa, 2022; Wang et al., 2016). Communities often lack formal training in these areas, while technical experts such as hydrologists, engineers, and climate scientists hold knowledge that communities need in order to participate meaningfully but may communicate it in ways that are difficult for non-specialists to understand and implement (Brugnach and Özerol, 2019; Kliskey et al., 2023).

Knowledge gaps can also translate into power imbalances within participatory processes. When decisions are framed as purely technical, experts may present conclusions as settled facts, for example by arguing that the models show a particular outcome and therefore a specific intervention is necessary, leaving limited space for community input beyond endorsement (Dewan, 2022). Communities without technical training can find it difficult to scrutinise these claims or to propose and defend alternative options (Peng, 2010).

Bridging knowledge asymmetries requires: (1) capacity building for community participants in relevant technical domains, (2) co-production of knowledge where experts and communities work together to develop analysis (Kliskey et al., 2023), (3) transparent presentation of technical information with explicit discussion of assumptions and uncertainties (Brugnach and Özerol, 2019), (4) valuing local and Indigenous knowledge as legitimate input alongside technical expertise (Prakash et al., 2025), and (5) employing community members in technical roles (hydrological monitoring, data collection) building their capacity and ownership (Jollymore et al., 2017). However, these approaches require ongoing investment in technical support staff and sustained resourcing (Aceves-Bueno et al., 2015; Walker et al., 2021). When resources are limited, the gap between expert and community knowledge often remains, and participatory processes continue to reflect those imbalances.

6.3 Context-Dependent Success and Failure

Across the literature reviewed for this thesis, participation can succeed or fail under identifiable conditions. Success is not predetermined by participation mechanism type but emerges from specific enabling conditions.

Participation succeeds when: (1) diverse knowledge is credible, accessible, translated across systems, and traceable to decisions (**K**) (Brugnach and Özerol, 2019; Kliskey et al., 2023), (2) participatory outputs have formal authority and pathways into binding decisions (**I**) (Bresney et al., 2023; Joshua HK., 2025), (3) affected groups are substantively represented with equity safeguards preventing elite capture (**E**) (Aleu et al., 2022; Casali and Tiziana, 2022), and (4) governance can revise rules through legitimate, reviewable procedures linked to monitoring (**A**) (Azhoni et al., 2018; Colloff et al., 2025). When all four conditions are present, participation supports effective, equitable, and adaptive outcomes.

Participation fails when one or more conditions are absent. Absence of K means deliberation produces poor quality decisions disconnected from evidence. Absence of I means participation is symbolic with no influence on actual governance. Absence of E means participation amplifies power asymmetries and deepens inequality. Meanwhile, absence of A means participation produces static rules that become misaligned with changing conditions.

These four conditions are not independent. In many contexts, a severe weakness in any one dimension becomes the main constraint on overall performance, even when the other dimensions are strong, although in some situations strengths in one area can partially offset weaknesses in another as explained in **Section 5.4**. **Figure 5** visualises the K, I, E, A., framework and shows how the weakest dimension can constrain overall effectiveness.

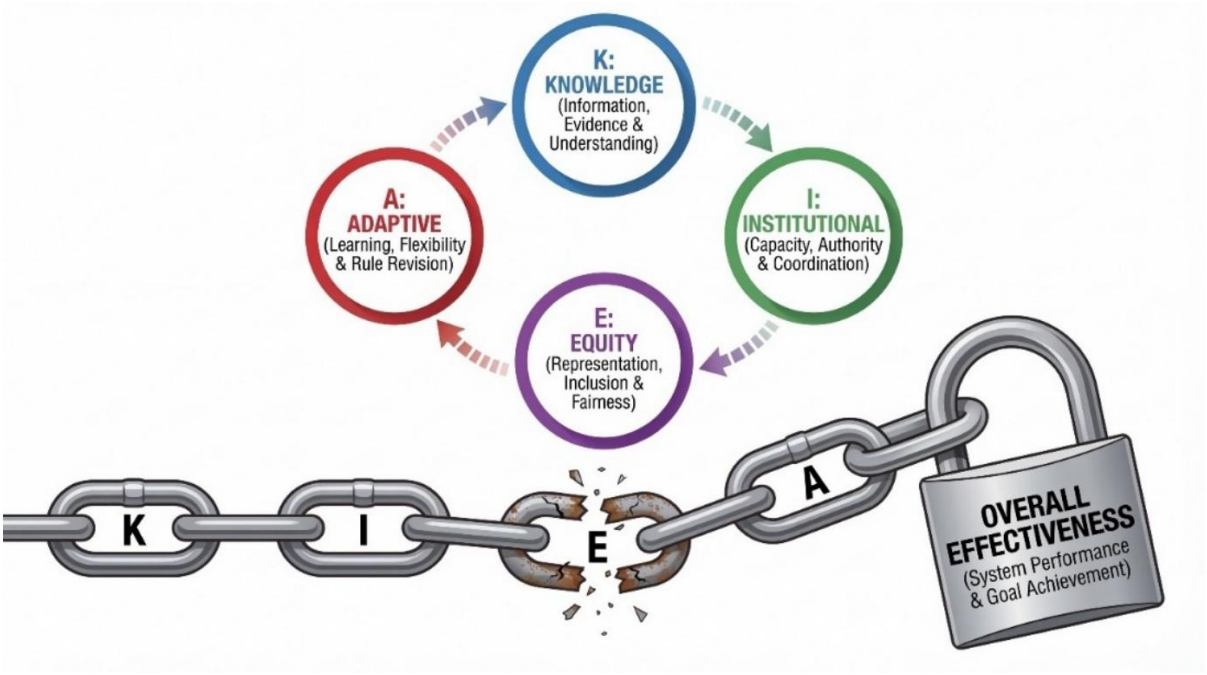

Figure 5: K, I, E, A., dimensions. Weakest link constrains overall effectiveness.

6.4 Synthesis: Understanding Failure Modes

Understanding why participation fails in specific contexts is essential for improving participatory governance. Common failure modes include:

Capture failure: Participatory mechanisms are captured by elites and used to advance elite interests (Aleu et al., 2022; Casali and Tiziana, 2022). Communities are formally included but substantively excluded. Decisions appear legitimate because they emerged from inclusive processes, but benefits are distributed to powerful actors (Dewan, 2022; Morinville and Harris, 2014).

Embedding failure: Participatory processes occur in isolation from institutional decision-making (Fritsch, 2017; Lawless et al., 2024). Communities deliberate and develop recommendations that are filed away. Meanwhile, actual governance decisions proceed through separate bureaucratic channels. Participation is disconnected from power (Aleu et al., 2022; Joshua HK., 2025).

Knowledge failure: Participatory processes surface diverse perspectives but do not synthesise them into actionable understanding (Eaton et al., 2021; Kliskey et al., 2023). Deliberation produces confusion rather than shared analysis. Communities lack confidence in resulting decisions (Brugnach and Özerol, 2019; Pahl-Wostl et al., 2007a).

Adaptation failure: Initial participatory processes establish rules that become misaligned with changing conditions (Azhoni et al., 2018; Dias et al., 2022). Governance mechanisms lack

procedures for legitimate rule revision. Rules persist despite evidence that they no longer serve their purpose. Communities lose confidence in governance (Colloff et al., 2025; Prosser et al., 2021).

Pace failure: Participation timelines mismatch decision urgency (Cattoën et al., 2025; Fritsch, 2017). Decisions are either rushed without adequate deliberation or delayed so long that adaptation opportunities are lost. Communities experience participation as either token or futile (Muwafu et al., 2024; Singh et al., 2024).

Understanding which failure mode is occurring in a specific governance context enables targeted intervention. If capture is the problem, equity safeguards and independent facilitation should be prioritized. If embedding is the problem, institutional reform strengthening participatory authority should be considered. If knowledge failure is occurring, technical support and co-production should become the priorities. If adaptation failure is evident, procedures for rule revision must be established. If pace failure is occurring, participation mechanisms must be matched to decision timescales. There is no one-size-fits-all solution. Effective participation depends on identifying the specific constraints in a given context and responding with targeted measures.

7. Contextual Conditioning and Design Trade-offs

7.1 How Context Shapes Which Enabling Conditions Become Binding Constraints

Participatory water governance operates in diverse contexts that differ in hydrological regimes, governance scales, institutional capacity, and hazard types. **Chapter 6** catalogued the barriers to participation. This section explains when specific barriers become the defining bottleneck. Context determines the binding constraint. This is the specific K, I, E, or A dimension that, if unresolved, severely limits the returns from improvements in other dimensions. Understanding this hierarchy is essential for sequencing interventions because solving a non-binding constraint yields minimal returns if primary bottleneck remains. These constraints are well represented through **Appendix C**.

7.1.1 Hydrological Context and Participation Requirements

Hydrological characteristics shape the fundamental nature of participation and determine which performance dimension is most likely to fail.

In **high-scarcity basins**, Equity Performance (**E**) becomes the binding constraint. As water allocation in these contexts is inherently zero-sum, the distributional conflict is intense. Even with high Knowledge (**K**) and strong Institutional Authority (**I**), the process is highly likely to fail

if it cannot manage the power imbalance between wealthy allocators and marginalized users. Practitioners therefore must prioritize equity safeguards. Independent facilitation should happen before expanding participation, as generic consultation in scarcity contexts typically ratifies dispossession (Aleu et al., 2022; Bresney et al., 2023; Casali and Tiziana, 2022).

This judgment reflects cross-dimension comparison where **K** is typically adequate for diagnosis but contested in allocation, **I** is often moderate and constrained by enforcement capacity, **E** falls furthest below sufficiency under scarcity-driven power asymmetries meanwhile **A** is variable.

In high-variability basins (extreme inter-annual volatility), Adaptive performance (**A**) becomes the binding constraint. Rigid allocation rules, even if fair (**E**) and based on good science (**K**), become catastrophic when conditions shift outside historical norms. The constraint is the speed of rule revision. Participation here must focus on establishing pre-agreed triggers for drought and flood protocols rather than static quota negotiations.

This judgment reflects cross-dimension comparison when **K** is often adequate for monitoring variability, **I** can be moderate, but rule-change procedures may be slow, **E** may be mixed meanwhile **A** falls furthest below sufficiency where rules are static and triggers are absent.

In high-uncertainty basins (divergent climate projections), Knowledge Performance (**K**) becomes the binding constraint. When stakeholders hold conflicting definitions of the problem, standard consensus-building stalls. The bottleneck is not authority but the inability to synthesize diverse epistemic perspectives into a shared decision framework. Practitioners should therefore prioritize scenario-based deliberation to make uncertainty manageable.

This judgment reflects cross-dimension comparison where **K** falls furthest below sufficiency where projections diverge and translation to decision-relevant knowledge is weak, **I** may be present but struggles to justify choices, **E** may be contested and **A** depends on whether learning loops exist.

7.1.2 Governance Scale and Participation Design

The scale of governance dictates the distance between decision-makers and users. This shifts the constraint profile.

At **local scales** (villages, irrigation associations), Equity Performance (**E**) becomes the binding constraint. While coordination is easier, community elites are highly visible and can leverage social proximity to dominate marginalized groups. Unlike higher scales where bureaucracy is

the barrier, here the barrier is informal social power. Practitioners must implement strict representation quotas and secret balloting to overcome the binding constraint of elite capture.

This judgment reflects cross-dimension comparison as **K** is often rich but unevenly recognised, **I** might be informal or weakly embedded, **E** could fall furthest below sufficiency through exclusion and local power hierarchies while **A** varies with rule revision capacity.

At basin scales (regional commissions), Knowledge Performance (**K**) becomes the binding constraint. The sheer complexity of hydrological interdependencies often exceeds the lay knowledge of local representatives. Without mechanisms to translate technical data into accessible formats, participation becomes symbolic observation. Binding constraints here are resolved by investing in independent technical advisors for stakeholder groups.

This judgment reflects cross-dimension comparison as **K** falls furthest below sufficiency due to complexity and translation burdens across sectors, **I** may exist but coordination is costly, **E** is often secondary in design and **A** depends on monitoring-linked revision.

At transboundary scales, Institutional Performance (**I**) becomes the binding constraint. National sovereignty acts as a structural barrier to binding participatory outcomes. Even if stakeholders agree (**K, E**) and are adaptive (**A**), their input lacks a formal pathway into interstate negotiations. Practitioners must be realistic and frame participation as parallel advisory input rather than expecting binding decision-making power.

This judgment reflects cross-dimension comparison as **K** can be available but politicised, **I** falls below sufficiency where sovereignty blocks authority and dispute resolution, **E** is hard to enforce across borders and **A** is constrained by slow renegotiation.

7.1.3 Institutional Capacity and Resource Constraints

The maturity of the convening institution determines whether the constraint is political will or administrative feasibility.

In **low-capacity institutions** (under-funded agencies, project-based mandates), Institutional Performance (**I**) is the binding constraint. Even well-designed participatory forums fail because the institution lacks the budgetary and administrative stability to sustain them. Designing complex deliberative processes in this context is futile. The binding constraint must be addressed first by securing basic operational funding and statutory mandates.

In high-capacity institutions, Equity Performance (**E**) often becomes the binding constraint. Well-resourced technocracies often possess strong data (**K**) and authority (**I**) but may view

participation as an efficiency hurdle. The constraint is not ability but the willingness to cede power to non-experts. Here, practitioners must prioritize accountability mechanisms that force the integration of stakeholder views into final decisions.

7.1.4 Hazard Type and Participation Timescales

The temporal nature of the water hazard determines whether the constraint is speed of response or the duration of engagement.

Rapid-onset hazards (flash floods) creates a binding constraint on Adaptive performance (**A**). Real-time deliberation is impossible during an emergency because rule revision cannot happen fast enough. Participation becomes non-functional if attempted during the crisis. The implication is that participation must be shifted upstream to the planning phase (early warning protocols) to make the system “fail-safe” rather than attempting to consult during failure.

Slow-onset hazards (glacier recession, aquifer depletion) makes Institutional Performance (**I**) the binding constraint. These challenges unfold over decades and far exceed typical political cycles. The bottleneck is the institution’s inability to maintain focus and funding over the necessary timeframe. Participation requires institutionalization into permanent statutes rather than ad-hoc projects to ensure governance endures as long as hazard is unresolved.

7.2 Design Trade-offs in Participatory Governance

Participatory governance design involves multiple trade-offs as improving performance in one dimension often limits performance in another. Effective design depends on recognising these tensions and making deliberate, context-specific choices.

7.2.1 Inclusion versus Deliberation Quality

This trade-off forces a choice between breadth of participation and the depth of analysis (Bresney et al., 2023; Eaton et al., 2021). High inclusion increases legitimacy but dilutes deliberation. Large forums often default to superficial statements or lowest common denominator consensus because there is insufficient time for every voice to be heard deeply. Conversely, small groups allow for sophisticated debate and rapid consensus but risk elite capture and lack broader legitimacy.

Practitioners must match the design to the goal. For complex technical planning, smaller representative bodies may be necessary provided they have clear feedback loops available to a wider public. For broad vision-setting, wide inclusion is superior despite lower deliberative quality. Structural solutions like tiered participation attempt to balance this. In these systems,

local assemblies feed into regional representatives, though this introduces information loss as data moves up the hierarchy.

7.2.2 Speed versus Legitimacy

Meaningful participation is inherently time-intensive because it requires periods for notification, education, debate, and consensus-building (Colloff et al., 2025). However, water governance often demands immediate action. A fundamental tension exists between the efficiency of technocratic command & control and the legitimacy of participatory outcomes. Rapid decisions save time but often fail during implementation due to lack of community buy-in or local misalignment.

Context determines the priority. In rapid-onset emergencies like flash floods, speed supersedes participation. Command structures are necessary, with accountability mechanisms applied retroactively. In slow-onset challenges like aquifer depletion or infrastructure planning, legitimacy is the binding constraint. Here, “going slow to go fast” applies. Investing time in upfront deliberation prevents costly social resistance and non-compliance late. Therefore, practitioners should not attempt deep participation for emergency response nor streamlined technocracy for long-term adaptation.

7.2.3 Technical Sophistication versus Accessibility

Water governance increasingly relies on complex hydrological models and climate scenarios (Rosa, 2022; Wang et al., 2016). While technical sophistication improves the analytical rigor of decisions, it creates significant barriers to entry for non-experts. A heavy reliance on jargon and modelling can functionally disenfranchise stakeholders. This turns participation into a lecture rather than a dialogue. Conversely, over-simplifying data to maximize accessibility risks producing decisions that are popular but scientifically unsound.

Practitioners must navigate this by investing in knowledge translation and co-production. Rather than dumbing down the science, effective designs use intermediaries to translate technical constraints into accessible trade-offs. For example, using visual scenarios rather than raw data tables helps bridging the gap. Where trust is low, Joint fact seeking becomes essential. This allows stakeholders to define the questions that technical experts answer. The goal is “accessible rigor” where the logic of the decision is transparent even if the underlying mathematics is complex.

7.2.4 Equity Safeguards versus Operational Efficiency

Implementing substantive equity is resource intensive. Safeguards such as translation services, travel stipends for the poor, separate caucuses for marginalized groups, and dispute

resolution mechanisms all increase the administrative burden and cost of governance (Aceves-Bueno et al., 2015; Sadik et al., 2022). There is a direct friction between the operational efficiency of a streamlined process and the justice of an inclusive one. “Efficient” processes that skip these safeguards almost invariably default to reproducing existing power hierarchies.

Practitioners must explicitly budget for equity as an operational necessity rather than an optional add-on. While streamlined processes often appear as cheaper upfront, they mostly incur higher long-term costs through grievance mechanisms and social unrest. In contexts of high inequality, efficiency must be sacrificed for equity. In routine administrative tasks, efficiency may take precedence which leads to the error in thought process that assumes that a single process can maximize both of simultaneously without specific resource allocation.

7.3 Diagnostic Framework for Contextual Assessment

Effective participatory design requires context-specific diagnosis in assessing hydrological context, governance capacity, institutional arrangements, hazard types, and political economy. This diagnosis identifies which enabling conditions are most constraining in specific settings and where targeted intervention will be most consequential.

Diagnostic questions to guide context assessment:

Hydrological Context:

- How water-scarce is the basin? (Ratio of demand to renewable supply)
- How variable is precipitation? (Coefficient of variation year-to-year)
- How uncertain are climate projections for this basin?
- How complex is the competing demands and ecosystem requirements?

Governance Context:

- What is the institutional capacity of water authorities? (Staff, expertise, budgets)
- What governance scales are relevant? (Local, basin, transboundary)
- What is the political commitment to participation?
- What is the power structure among water users? (Concentration of power vs. distributed)

Social Context:

- What are the key equity issues? (Gender, class, ethnicity, geographic)
- What is the literacy and technical capacity of communities?
- What is the history of participation and trust in governance institutions?
- What are the primary livelihoods dependent on water?

Hazard Context:

- What are the primary water-related hazards? (Floods, droughts, scarcity)
- What are the timescales of hazards? (Rapid-onset, slow-onset, chronic)
- What are historical frequencies and intensities?

Assessment of these contextual factors identifies which enabling conditions are most constraining and where investment will be most consequential. **Figure 6** and **Figure 7** translate these questions into a stepwise pathway to identify the likely binding constraint.

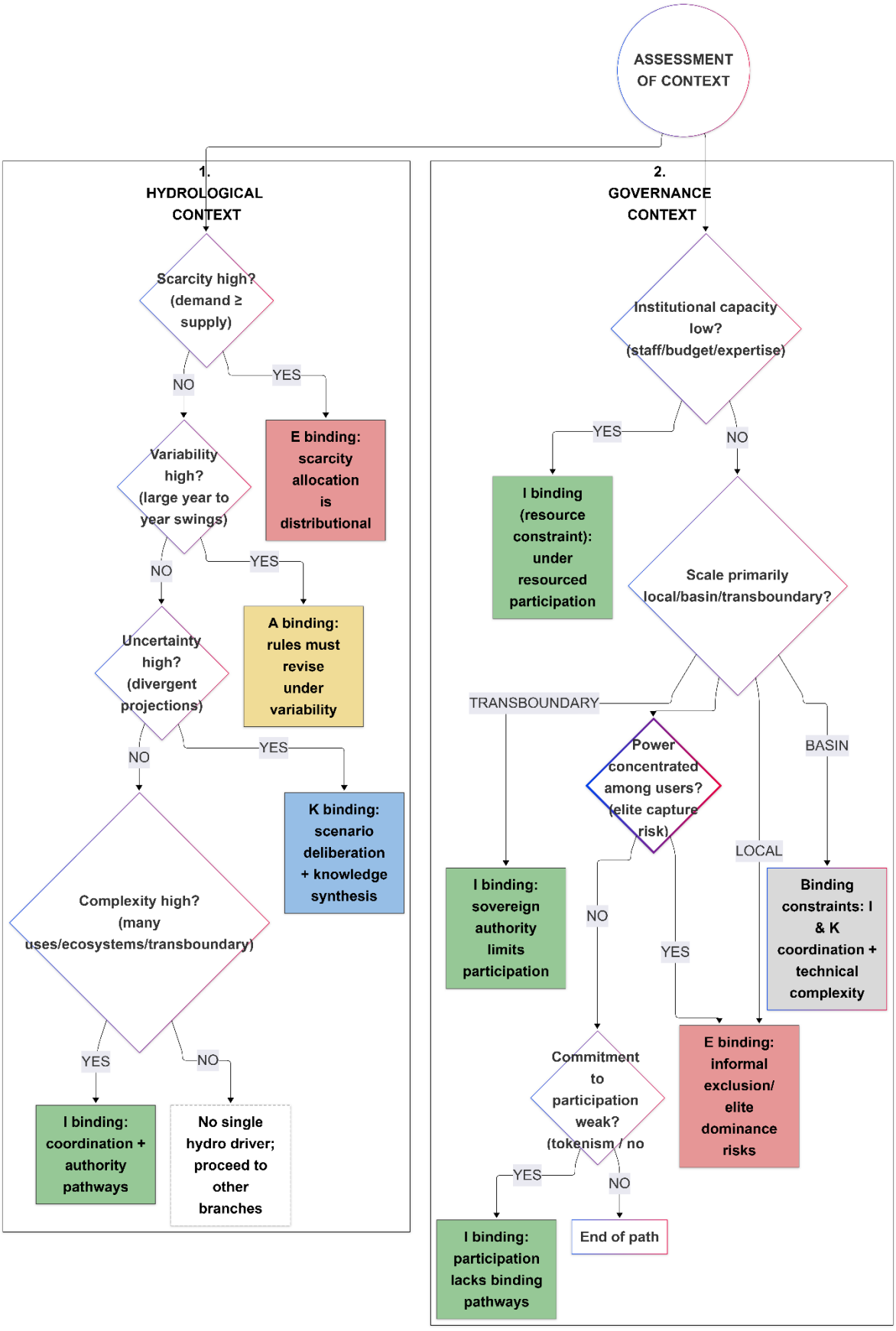

Figure 6: Assessment of Context → Binding Constraint (K, I, E, A): Hydrological and Governance diagnostic pathways.

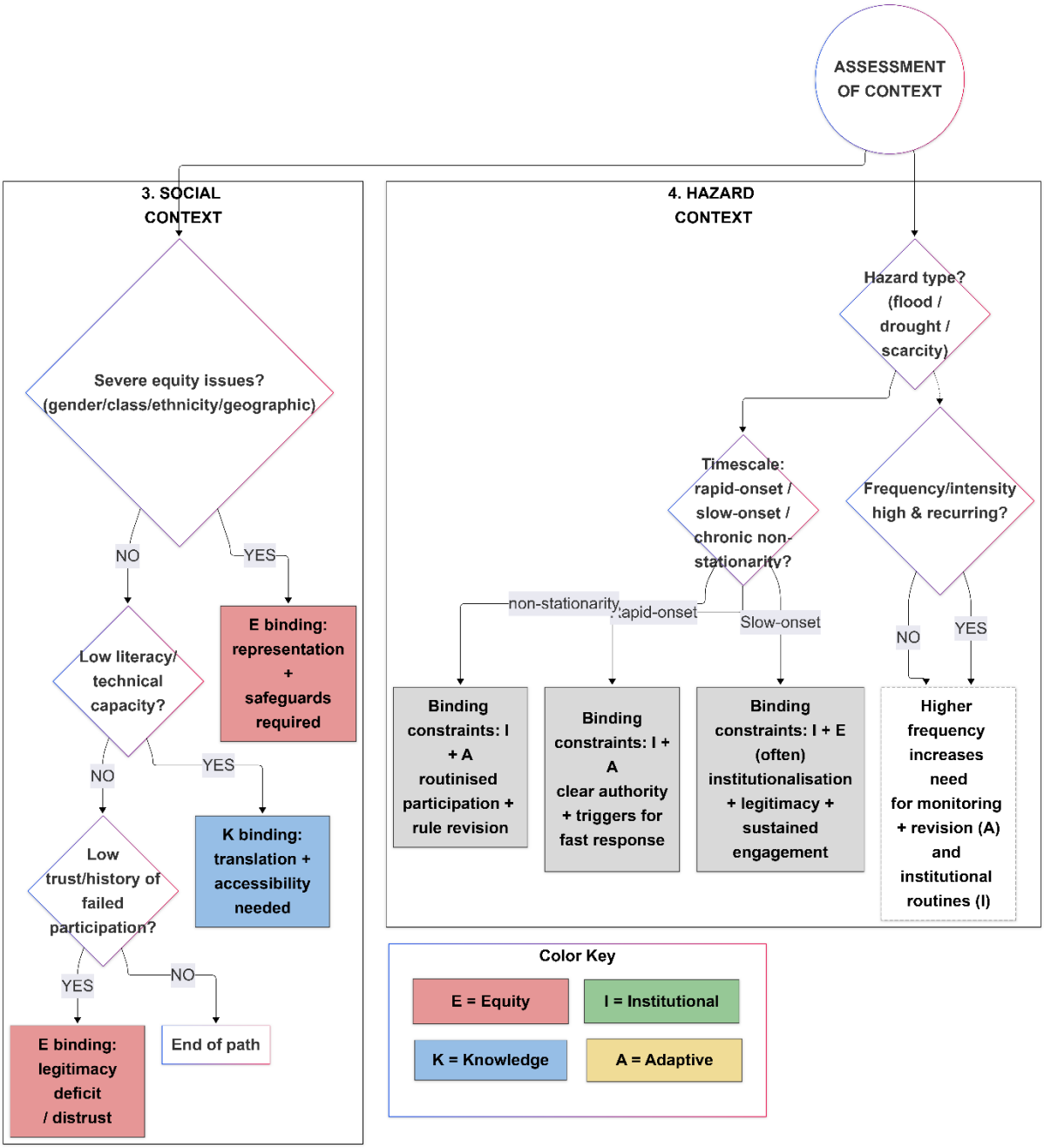

Figure 7: Assessment of Context → Binding Constraint (K, I, E, A): Social and Hazard diagnostic pathways.

8. Operationalisation The Conditional Enabling Framework

8.1 Operationalising K, I, E, A as Measurable Enabling Conditions

The **K**, **I**, **E**, **A** framework identifies four dimensions that are essential for effective participatory water governance under climate stress. To make the framework usable in practice (rather than purely conceptual), each dimension needs (i) operational definition, (ii) observable indicators

that show whether the condition is present, and (iii) a scoring rubric that supports consistent assessment across cases.

This rubrics below provide a structured guide for evaluation. What counts as “adequate” performance should be defined locally as the sufficiency thresholds depend on legal requirements, prevailing norms, and stakeholder expectations.

Taken together, the four dimensions form a linked chain. Knowledge must be integrated and usable (**K**), institutional arrangements must be able to carry participatory outputs into binding decisions (**I**), participation must be substantively fair and protected from domination (**E**), and governance must be able to learn and revise over time as conditions shift (**A**). The following sections operationalise each dimension in turn.

8.1.1 Knowledge Performance (K): Operationalisation and Assessment

Definition: Knowledge performance measures whether diverse knowledge systems are integrated into governance decisions, whether this integration produces a credible shared understanding, and if that understanding is traceable to governance outcomes.

Core criteria for assessing K:

Knowledge Integration: Multiple knowledge systems are incorporated into governance processes, including scientific hydrological expertise, local and Indigenous knowledge, practitioner experience, and community observations. Integration should be generative, meaning that knowledge sources are combined to develop analysis, rather than merely consultative, where input is collected and then ignored.

Indicative evidence includes formal procedures that require knowledge synthesis, documentation showing how multiple sources informed analysis, and stakeholder testimony confirming that their knowledge was incorporated.

Credibility of Knowledge: Evidence sources are subject to validation processes that assess reliability and applicability. Scientific data is subject to review, local knowledge is validated through community verification, and assumptions and uncertainties are made transparent. Stakeholders should understand why particular evidence is treated as credible.

Indicative evidence includes documented validation procedures, transparent discussion of assumptions and limitations, stakeholder confidence in evidence quality, and an absence of cases where contested evidence determines outcomes.

Accessibility and Translation: Knowledge is communicated in ways that non-experts can understand without oversimplifying and distorting meaning. Technical complexity is explained, jargon is translated, and the assumptions underlying expert claims are made explicit. Communication can use multiple formats, such as written reports, diagrams, oral presentations, and interactive tools.

Indicative evidence includes the use of multiple communication formats, feedback from non-expert participants confirming comprehension, and independent assessment that translation was appropriate.

Traceability to Decisions: Governance decisions are explicitly linked to the evidence discussed in participatory processes. When decision-makers depart from stakeholder-integrated knowledge and provide clear reasons. Stakeholders can see how their input influenced outcomes or understand why it did not.

Indicative evidence includes documentation linking evidence to decisions, decision justifications that reference participatory analysis, and stakeholder perception that evidence mattered.

These criteria translate into a practical scoring rubric for K, summarised in **Table 3**.

Table 3: Assessment Rubric for K

Score	Integration	Credibility	Accessibility	Traceability
Strong	Multiple knowledge systems formally integrated through generative synthesis	Validation procedures in place, assumptions transparent, stakeholders trust evidence	Knowledge shared in accessible formats, translation verified, non-experts understand	Clear evidence-to-decision links, departures justified, stakeholders can trace influence
Moderate	Some integration but inconsistent or mainly consultative, limited synthesis	Some validation but incomplete, transparency gaps, mixed confidence	Mainly expert-led communication, limited translation, some accessibility issues	Evidence sometimes referenced, traceability unclear, stakeholders uncertain of influence
Weak	Minimal integration, process driven mainly by technical experts	Limited validation, assumptions opaque, stakeholder distrust	Highly technical presentation, little translation, non-experts confused	Decisions opaque, no traceability, stakeholders perceive evidence was ignored

8.1.2 Institutional Performance (I): Operationalisation and Assessment

Knowledge integration alone does not ensure participatory influence. For participatory outputs to matter, they must move through institutions that recognise them, act on them, and revise decisions when warranted. Institutional performance captures that enabling role.

Definition: Institutional performance measures whether participatory outputs have formal authority and clear pathways into binding decisions, and whether procedures exist for reviewing and revising decisions in response to participatory input.

Core criteria for assessing I:

Authority and Binding Decision-Making: Participatory forums produce outputs with formal status in decision-making. Stakeholder recommendations have weight, and decision-makers explain departures or show how input shaped outcomes.

Indicative evidence includes formal authority granted to participatory forums, legal or administrative requirements to consider outputs, and documentation showing how input influenced decisions.

Institutional Pathways and Procedures: Clear procedures connect deliberation to binding decisions. Recommendations are transmitted through formal channels, decision timelines are specified, and processes are documented and accessible to stakeholders.

Indicative evidence includes written procedures, stakeholder understanding of pathways, and records showing the transfer of outputs to decision-makers.

Review and Revision Mechanisms: Procedures allow decisions to be reviewed and revised in light of new evidence or changed conditions. Stakeholders should request review where grounds are specified, and make revisions as an expected part of governance rather than an exception.

Indicative evidence includes documented review procedures, evidence of stakeholders using them, and cases where decisions were revised following participatory requests.

Formal Authority for Rule Revision: Participatory arrangements include authority to revise allocation rules, management procedures, and governance arrangements as conditions change. Rule revision must follows institutionalised triggers and procedures rather than ad hoc responses.

Indicative evidence includes formal rule revision procedures, participatory involvement in setting triggers, and documented instances of revision through these procedures.

These criteria are operationalised in the rubric in **Table 4**.

Table 4: Assessment Rubric for I

Score	Authority	Pathways	Review Mechanisms	Rule Revision
Strong	Outputs formally authoritative, departures must be justified	Clear written procedures, explicit pathways, timelines specified, stakeholders understand process	Formal review procedures used in practice, decisions are revisable	Participatory role in revision, procedures institutionalised, revision is routine
Moderate	Outputs influence decisions but are not binding, some justification for departures	Procedures exist but are unclear or inconsistently applied	Review mechanisms exist but are rarely used, revision possible but uncommon	Revision occurs but is ad hoc, participatory role inconsistent, procedures undocumented
Weak	Outputs advisory only, no requirement to justify departures	Pathways absent or opaque, decision-making disconnected from participation	Review mechanisms absent or inaccessible, decisions rarely revised	Revision rare, participation absent, authority unclear, procedures undocumented

8.1.3 Equity Performance (E): Operationalisation and Assessment

Even when knowledge is strong and institutions have pathways, participatory governance can still fail if participation is exclusionary, dominated, or burdensome for disadvantaged groups. Equity performance captures whether participation is substantively inclusive and protected against capture.

Definition: Equity performance measures whether affected groups, especially marginalised communities, are substantively represented, whether participation burdens are reduced for disadvantaged participants, and whether safeguards prevent elite capture and domination.

Core criteria for assessing E:

Substantive Representation of Marginalised Groups: Affected groups, including poor households, women, indigenous people, ethnic minorities, landless labour, and other marginalised populations that participate in governance forums. Representation should be substantive, meaning that participants have the capacity to speak and be heard, are not

excluded through social mechanisms such as gender norms, language barriers, or discrimination, and can influence outcomes.

Indicative evidence includes demographic composition of forums, participation rates, documented instances of marginalised members contributing meaningfully, and the absence of exclusion mechanisms.

Mitigation of Participation Burdens: Costs such as time, transport, and foregone income are reduced for disadvantaged participants. Support must include compensation, accessible scheduling, transport provision, childcare, and accessible venues.

Indicative evidence includes burden mitigation mechanisms, improved access through timing and location, increased participation when support is offered, and participant feedback on accessibility.

Safeguards Against Elite Capture: Design includes measures that prevent wealthy or powerful actors from dominating forums and steering outcomes toward elite interests. Safeguards can include representation quotas, separate coordination spaces for marginalised groups, independent facilitation, dispute resolution that protects minority interests, and transparent decision procedures.

Indicative evidence includes documented safeguards, visible constraints on dominance in discussion, protection of minority interests, and the absence of recurring elite capture patterns.

Equity Outcomes: Beyond fair process, outcomes are equitable. Marginalised groups' water access and livelihoods are protected, and the distribution of costs and benefits reflect equity principles.

Indicative evidence includes improved allocation outcomes for poorer households, reduced disproportionate burdens on marginalised groups, protected livelihoods, and improved inequality indicators.

These criteria are reflected in the rubric in **Table 5**.

Table 5: Assessment Rubric for E

Score	Representation	Burden Mitigation	Elite Safeguards	Equity Outcomes
Strong	Marginalised groups substantively represented, active participation, influence on outcomes	Comprehensive mitigation through compensation and accessibility, participation increases	Multiple safeguards in place, elites constrained, minorities protected, transparency strong	Distribution is equitable, access improves for marginalised groups, vulnerability declines
Moderate	Formal inclusion with mixed substantive participation and uneven influence	Partial mitigation, support inconsistent	Some safeguards but inconsistent constraint, mixed minority protection	Some improvements but uneven outcomes, some groups still disadvantaged
Weak	Marginalised groups absent or tokenised, minimal influence	Minimal mitigation, high costs persist, barriers remain	Few safeguards, elite dominance visible, minorities unprotected, opaque processes	Inequitable outcomes, marginalised groups disadvantaged, vulnerability increases

8.1.4 Adaptive performance (A): Operationalisation and Assessment

The final enabling condition concerns time. Under climate stress, governance needs to learn, adjust, and revise rules repeatedly. Adaptive performance captures whether the system can monitor changing conditions, translate learning into decisions, and sustain those learning cycles beyond one-off projects.

Definition: Adaptive performance measures whether governance embeds monitoring of system conditions and outcomes, allows legitimate rule revision as conditions change, and maintains learning loops that connect monitoring to decision-making.

Core criteria for assessing A:

Monitoring Systems: Governance includes monitoring of hydrological, social, and ecological conditions relevant to water management. Monitoring covers precipitation, streamflow, storage, allocation, efficiency, water quality, ecosystem health, and socioeconomic conditions. Data collection is regular, methods are documented, and data access supports stakeholder analysis. Monitoring can also combine scientific measurement with community-based observation.

Indicative evidence includes formal monitoring programmes, regular data collection, documented protocols, accessible data, and community participation in monitoring.

Legitimacy of Rule Revision: Procedures allow legitimate modification of allocation rules, management practices, and governance arrangements as conditions change. Revision procedures then specify grounds for revision, inclusive decision processes, and formal authority. Revision is therefore embedded in routine governance rather than treated as exceptional.

Indicative evidence includes documented revision procedures, clearly stated grounds for revision, required participatory involvement, and evidence that revisions occur without crisis conditions.

Learning Feedback Loops: Systems connect monitoring to decisions. Monitoring results inform deliberation, deliberation generates recommendations, decisions implement revisions, and then outcomes are monitored and fed into the next cycle. Learning is continuous rather than episodic, and loops are supported through procedures and budgets.

Indicative evidence includes documented cycles, formal presentation of monitoring results to stakeholders, deliberation that references monitoring, decisions that reflect evidence, and records of repeated cycles.

Adaptive Capacity Over Time: Governance maintains the capacity to revise rules across multiple cycles as conditions continue to change. Later revisions build should on earlier learning, and institutions must sustain adaptive functions through commitment and funding rather than allowing them to fade once projects ends.

Indicative evidence includes multiple successful revision cycles, evidence of learning across cycles, institutional continuity of adaptive procedures, and sustained funding.

These elements are scored using the rubric in **Table 6**.

Table 6: Assessment Rubric for A

Score	Monitoring	Rule Revision Legitimacy	Learning Feedback	Long-term Capacity
Strong	Comprehensive monitoring, regular data, community participation	Revision procedures documented, grounds specified, participatory involvement, revisions occur	Feedback loops explicit, monitoring informs deliberation, decisions tracked, cycles repeat	Multiple successful revisions, learning evident, institutional commitment, sustained funding
Moderate	Monitoring exists but with gaps, irregular data, limited community role	Revision possible but procedures unclear, revisions infrequent, participation inconsistent	Feedback loops informal, monitoring sometimes informs decisions, cycles uneven	Some revisions, mixed learning, commitment uncertain, funding variable
Weak	Minimal monitoring, sparse data, no community role	Revision rare or ad hoc, no formal procedures, participation absent	No feedback loops, monitoring disconnected from decisions, responses ad hoc	Few revisions, little learning, commitment absent, funding ends

8.2 The Conditional Enabling Framework: Diagnostic and Prescriptive Use

Operationalising K, I, E, A supports two uses. The first is **diagnostic**, assessing which enabling conditions are present or absent in a specific context. The second is **prescriptive**, identifying where targeted investment is most likely to improve participatory effectiveness. The logic is straightforward. Once performance can be assessed consistently, weaknesses can be identified, compared, and prioritised.

8.2.1 Diagnostic Use: Assessing Participatory Governance

The rubrics support systematic evaluation. For each dimension, evaluators score performance as strong, moderate, or weak based on evidence that core criteria are met. Assessment can draw on document review of procedures and outputs, stakeholder interviews, observation of participatory events, and outcome analysis that checks whether decisions reflect participatory input and whether equity and adaptation outcomes are realised.

A diagnostic assessment produces a governance profile that summarises relative strengths and weaknesses e.g.:

- Basin committee in region A: **K** is moderate, with good technical analysis but limited integration of local knowledge. **I** is strong, with clear authority and institutional embedding. **E** is weak, with signs of elite capture and exclusion. **A** is moderate, with monitoring present but rule revision uncommon.

- Community water association in region B: **K** is weak, with minimal technical analysis. **I** is weak, with no formal authority. **E** is moderate, with representation present but burdens on poorer participants. **A** is strong, with active learning and rule revision.

The profile helps identify which enabling condition is most constraining and, in many cases, which one is binding.

8.2.2 Prescriptive Use: Targeted Intervention

Prescriptive implications are conditional and depend on local knowledge and political feasibility. The framework indicates what to strengthen, but it cannot specify exactly how to do so in every setting.

The diagnostic profile guides intervention priorities. Conditions scored strong require maintenance. Conditions scored moderate often benefit from targeted strengthening. Conditions scored weak frequently represent binding constraints and usually warrant priority attention, although compensation is possible in some configurations.

For K dimension constraints: Invest in knowledge integration through co-production, capacity building, and structured synthesis forums. Improve transparency through clearer communication, explicit assumptions, and uncertainty reporting. Strengthen traceability by documenting how evidence informed decisions.

For I dimension constraints: Strengthen institutional embedding through formal authority, clear procedures linking participation to decisions, and define revision powers. Establish review and appeal mechanisms, and allocate budgets that allow sustained operation.

For E dimension constraints: Invest in equity safeguards such as representation quotas, separate coordination spaces for marginalised groups, and independent facilitation. Reduce participation burdens through compensation and accessibility measures, and adopt explicit anti-elite-capture procedures.

For A dimension constraints: Invest in monitoring systems that combine scientific and community-based approaches, ensure data access, and establish legitimate rule revision procedures with regular cycles. Formalise feedback loops that connect monitoring, deliberation, decisions, and follow-up monitoring.

Improvements in a constraining dimension often require changes beyond the participatory mechanism itself. If institutional performance is limiting because participatory outputs lack authority, improvement might require legal reform, administrative changes, or dedicated

budget allocations. If equity is limiting because of exclusion or elite capture, improvement may require confronting underlying power structures and social norms, not only procedural adjustments. If adaptive performance is limiting because governance is rigid, improvement may require broader institutional transformation that enables rule revision rather than only focusing on better monitoring.

This helps explain why participation can fail even when the forum is well-designed. The binding constraint may sit in wider governance institutions or entrenched power relations. Effective intervention depends on identifying what is binding and targeting the constraint directly, even when that extends beyond participation itself.

8.3 Application Guidance and Framework Limitations

8.3.1 When Is the Framework Most and Least Useful

As the framework is designed to diagnose why participation is effective or ineffective (rather than to argue for participation in all circumstances), it is most useful where participatory arrangements exist or are feasible and where improvement is realistically on the table.

The K, I, E, A framework is most useful in the following settings:

- Mid-range governance systems where multiple K, I, E, A., dimensions are present at Moderate levels, and targeted strengthening of constraining dimensions offers high payoff.
- Contexts where participation is already institutionalised (participatory mechanisms exist, need refinement rather than creation from scratch).
- Settings with technical and institutional capacity for implementing improvements (resources, expertise, institutional will exist or can be mobilised).
- Adaptation-focused assessments where the question is how to improve existing participation rather than whether to introduce participation from zero.

The framework is least useful in the following settings:

- Contexts where participation is absent and the question is whether to introduce participation at all (framework assumes participation exists, focuses on improving it).
- Highly constrained contexts where multiple binding constraints cannot be addressed due to political or economic limitations (framework guides intervention but cannot overcome fundamental constraints).

- Emergency or rapid-response situations where deliberative participation is infeasible and the question is rapid decision-making, not participatory governance improvement.
- Highly corrupt governance systems where participatory procedures are tools for elite manipulation and no procedural change will improve outcomes without addressing corruption itself.

8.3.2 Limitations and Caveats

The framework has important limitations that evaluators must acknowledge:

Measurement challenges: K, I, E, A include elements that are difficult to quantify, such as deliberation quality, legitimacy, and substantive equity. Assessment therefore requires qualitative judgement and triangulation across evidence sources. Results can be contested by stakeholders who hold different perspectives.

Dimensionality assumption: The framework treats K, I, E, A as core dimensions of participatory effectiveness. Other factors, such as political economy, cultural fit, and historical relationships, can be decisive in specific settings but are not explicitly represented.

Interdependence complexity: The framework recognises interdependence, but it does not fully specify how dimensions interact in every context. In some settings, weakness in one dimension constrains all others. In others, partial compensation occurs. Practitioners need local understanding to anticipate how strengthening one dimension will affect the rest.

Prescriptive limitations: The framework identifies priorities but cannot provide a universal blueprint. Effective improvement strategies require local knowledge, stakeholder input, and attention to political feasibility.

9. Discussion: Addressing the Research Questions

The findings of this study apply to formal, institutionalised participatory mechanisms documented in the literature. They do not generalise to informal collective action or to contexts where participation is absent.

This scope matters for how participation is interpreted throughout the chapter. In the reviewed studies, participation is not an informal or spontaneous social process. It is a designed and resourced governance arrangement that operates through mandates, procedures, and decision pathways. The discussion therefore treats outcomes as the product of participation and the conditions that enable it to function in practice. Building on the synthesis in **Chapters 3-8**, and particularly through the operational rubrics developed in **Chapter 8** the sections

below address each research question by linking observed outcomes to the enabling conditions that shape whether participatory inputs become consequential over time.

9.1 RQ1: Outcomes and Enabling Conditions

RQ1 examined how participatory approaches influence effectiveness, equity, and adaptive capacity in water governance under climate stress, and the enabling conditions under which these effects are realised. Across the evidence synthesised in **Chapters 3-8**, participation supports decision uptake, legitimate rule revision, and fairer processes only conditionally. Outcomes improve when minimum sufficiency is reached across all four dimensions over time, while prioritising the dimension that is currently most binding across four interdependent performance dimensions: Knowledge (**K**), Institutional (**I**), Equity (**E**), and Adaptive performance (**A**).

The evidence suggests that each dimension enables outcomes in a different way. Knowledge performance shapes the quality and credibility of what is deliberated. Institutional performance determines whether deliberation carries authority into binding decisions. Equity performance conditions who influences the outcomes and whether participation reduces or reinforces inequality. While, adaptive performance determines whether governance can keep revising rules legitimately as non-stationarity intensifies.

Knowledge Performance (**K**) enables outcomes by ensuring that governance decisions rest on credible and integrated understanding rather than narrow technocratic expertise or uninformed opinion. When diverse knowledge systems (scientific hydrological analysis, local and Indigenous knowledge, practitioner expertise, and community observation) are formally integrated, subjected to transparent validation, communicated accessibly, and traceable to actual decisions, participation can produce decisions grounded in robust evidence. The synthesis also shows why **K** cannot be treated as separate from participation itself. Participation without knowledge integration risks poorly informed deliberation. Knowledge integration without participatory embedding risks decisions that are disconnected from lived realities. Effective participation therefore requires both. Therefore, diverse knowledge must be intentionally synthesised through participatory processes and then carried into decision pathways.

Institutional Performance (**I**) enables effectiveness by granting participatory outputs through formal authority and by embedding them in binding decision-making procedures. Where stakeholder recommendations carry real weight in plans, budgets, regulations, or operational protocols, and decision pathways are clear, reviewable, and enforceable, participation influences governance rather than remaining symbolic. The literature repeatedly distinguishes

between participation that is consequential and participation that is performative. Participation without institutional embedding is frequently reported in the corpus as symbolic consultation. Conversely, institutions without participatory input risk legitimacy deficits, especially under climate stress when decisions impose costs and redistributions. Effectiveness therefore requires institutional structures that create participatory forums with genuine authority and connect deliberation to binding decisions.

Equity Performance (**E**) enables effective adaptation by ensuring marginalised groups, whose water security and livelihoods are often most exposed to substantively shape governance outcomes. When affected groups are substantively represented (not merely formally included), participation burdens are mitigated, elite capture is prevented, and result in safeguards that protect minority interests. Under these conditions participation can address, rather than amplify the power asymmetries. The synthesis also shows what happens when equity is treated as secondary. Inequitable participation can create the appearance of legitimacy while perpetuating or deepening inequality. Effective climate adaptation therefore requires explicit equity performance. Participation must not only occur. It must occur in ways that protect vulnerable populations from further disadvantage.

Adaptive Performance (**A**) enables effectiveness under climate stress by embedding monitoring, legitimate rule revision, and learning feedback loops in governance procedures. When governance systems monitor conditions, revise rules as non-stationarity manifests, and learn from adaptation experience. They maintain alignment with changing hydrological realities. Here, the evidence again shows why one-sided designs fail. Adaptive governance without participation may impose rule changes without stakeholder acceptance. Participation without adaptivity risks producing static agreements that become misaligned as conditions shift. Effectiveness under climate stress therefore requires participatory procedures that sit inside adaptive governance systems and that they can revise rules through legitimate, inclusive processes.

These four conditions are not independent. Severe weakness in any one dimension often constrains overall performance, even when other dimensions are strong, though partial compensation can occur in some contexts as mention in **Appendix D and E**. A system with strong technical analysis (**K**) and institutional embedding (**I**) but weak equity safeguards (**E**) may be efficient yet unjust and contested. A participatory process with strong engagement (**E**) but no institutional authority (**I**) may be legitimate yet inconsequential. Participation is most likely to support effective, equitable adaptation when K, I, E, A are jointly sufficient over time.

This conditional answer to RQ1 leads directly to RQ2. If outcomes depend on enabling conditions, the next question is which participatory mechanisms and institutional arrangements tend to build those conditions, and through what pathways.

9.2 RQ2: Mechanisms and Plausible Pathways

RQ2 examined which participatory mechanisms and institutional arrangements most strongly influence climate adaptation in water governance, and through which plausible pathways they shape outcomes. Across the reviewed evidence, mechanisms including stakeholder platforms, basin committees, participatory planning processes, community monitoring arrangements, and co-management institutions have been observed to influence adaptation through a recurring set of pathways that map directly onto the four performance dimensions.

First, mechanisms are influential when they enable knowledge integration and translation (**K**). Joint fact-finding, participatory modelling, scenario deliberation, and community monitoring can widen the evidence base and strengthen the legitimacy of knowledge used in decision-making. These effects depend on transparency, accessibility, and traceability into decisions.

Second, mechanisms matter when they create institutionalised decision pathways (**I**). Basin committees and formal stakeholder forums tend to be influential when their outputs have defined routes into binding instruments. These instruments include planning documents, operational rules, budgets, licensing conditions, drought plans, or allocation protocols. Influence is also stronger when mandates specify how recommendations are processed and how disagreement is handled. Where advisory bodies lack authority, or where uptake is discretionary and opaque, influence is typically weak.

Third, mechanisms shape outcomes through equity safeguards and representation structures (**E**). Institutional arrangements that specify who participates, how representation is ensured, how facilitation is conducted, and what protections exist against capture decides whether participation will reduce or reinforces inequality. This is especially clear where arrangements mitigate participation burdens, such as time, travel, language, and technical barriers.

Finally, mechanisms support adaptation when they embed monitoring-linked review procedures (**A**). Arrangements that tie decisions to indicators, establish review cycles, and define triggers for revision enable governance to adjust to non-stationarity without appearing arbitrary. Without these procedural links, participatory decisions often harden into static agreements that lose fit as conditions change.

Overall, the most influential mechanisms are those that combine deliberation with credible knowledge synthesis, clear institutional authority, equity safeguards that translate voice into

influence, and explicit procedures for adjustment. This implies that “which mechanism works” cannot be answered by mechanism-type alone. Influence depends on how the mechanism is institutionally embedded and procedurally designed.

This leads into RQ3. Equity repeatedly emerges as a decisive point of failure or success, so it requires separate attention beyond general mechanism design.

9.3 RQ3: Equity and Distributional Justice

RQ3 examined how participatory processes shape both procedural inclusion and distributional justice, with particular attention to marginalised groups. The synthesis shows that equitable outcomes depend on more than formal representation. They require substantive influence, burden-sensitive design, and safeguards against elite capture.

Procedural equity improves when participant selection prevents dominance. Facilitation redistributes voice, makes information accessible, and helps in decision rules to ensure if inclusion translates into influence. Where participation is nominal, meaning attendance without impact, procedural equity becomes symbolic. Distributional equity is most likely when participatory arenas have genuine leverage over allocation rules, risk distribution, compensation mechanisms, and priority-setting. This links equity outcomes to institutional authority and highlights **E-I** interdependence. Without institutional pathways into binding decisions, equity claims may be voiced yet ignored.

The evidence also points to recurring equity failure modes. Elite capture prevents equity performance by enabling powerful actors to dominate forums and frame “consensus” around their interests. Exclusion may persist despite formal inclusion where barriers such as language, time, technical complexity, or social norms restrict effective participation. Participation burdens can be regressive. Those who are unable to spare time or resources are often those most affected by water insecurity, and this can skew deliberation toward the already-empowered benefactors. In such cases, participation can legitimise inequitable outcomes by creating the appearance of consultation while embedding existing power relations.

Equitable outcomes are enabled when participation design includes explicit safeguards. These include representation rules that ensure affected groups’ presence, facilitation that redistributes voice, burden-mitigation supports (stipends, childcare, travel support, translation, timing), and enforceable protections against domination. Importantly, equity is not an optional add-on. Without equity safeguards, participatory adaptation may reproduce vulnerabilities instead of reducing them.

RQ4 then broadens the lens. Equity dynamics, like K, I, and A, are shaped by wider contextual conditions that determine which constraints become binding in practice.

9.4 RQ4: Conditioning Factors and Binding Constraints

RQ4 examined how contextual conditions, especially power asymmetries, institutional rigidity, and hydrological uncertainty, shape success or failure, and which conditions become binding constraints in practice. The central finding is that participatory processes are not self-sufficient interventions. Their effects are conditioned by the broader political economy of water, the legal-administrative capacity to implement outcomes, and the hazard regime (rapid-onset, slow-onset, and chronic non-stationarity). These contextual forces determine which dimension (K, I, E, A) becomes the most limiting constraint or generate recurring design trade-offs.

9.5 Structural and adaptation-specific barriers

Recurring structural barriers operate across contexts as elite capture, exclusion, tokenism, resource constraints, and institutional resistance as identified in **Chapter 6**. Elite capture undermines Equity Performance by enabling wealthy actors to dominate deliberation. Exclusion prevents substantive representation despite formal inclusion. Tokenism undermines Institutional Performance by creating forums without decision authority. While resource constraints undermine all dimensions by weakening facilitation quality, knowledge synthesis capacity, and sustained engagement.

Climate adaptation pressures exacerbate these barriers. Deep uncertainty can undermine Knowledge Performance where expert predictions are contested and stakeholder perspectives instead of complementing each other. Pace mismatch can strain Institutional and Adaptive Performance when decisions must be rapid but legitimate revision requires time and procedure. Meanwhile, technical complexity can undermine both Knowledge and Equity Performance by excluding non-experts and empowering technical elites.

9.5.1 Context-dependent binding constraints

Context shapes which barriers become binding as observed in **Chapter 7**. In high-scarcity basins, equity barriers frequently become binding because zero-sum allocation intensifie power conflicts and distributive stakes. In high-variability settings, adaptive barriers become binding because without legitimate rule revision procedures, governance collapses during extremes. In high-uncertainty settings, knowledge performance becomes binding because decisions cannot be justified or contested fairly without credible, shared evidence practices. In low-capacity settings, resource constraints become binding because participation cannot function consistently regardless of political commitment.

The diagnostic implication is that barriers are not universal in their effect. Practitioners must identify which constraint is binding in their context before selecting interventions.

9.5.2 Design trade-offs shaped by context

The synthesis also highlights core trade-offs that cannot be eliminated but can only be navigated.

- **Inclusion versus deliberation depth:** broader inclusion may reduce depth unless supported by tiered structures, separate caucuses for marginalised groups, and adequate time and facilitation resources.
- **Speed versus legitimacy**: emergency response may require rapid decision-making, whereas slow-onset stress permits deeper participation as chronic non-stationarity requires routinised procedures that balances responsiveness and legitimacy over repeated revisions.
- **Technical sophistication versus accessibility**: complex analysis can improve decisions but exclude non-experts using co-production, capacity-building, and transparent translation this tension can be reduced.
- **Equity safeguards versus operational efficiency**: safeguards add complexity but are essential in high-inequality contexts therefore equity must be designed from within the outset rather than appending later.

The framework helps make these trade-offs explicit. In rapid-onset hazards, speed may dominate. In high-inequality contexts, equity safeguards must dominate. In low-capacity contexts, feasibility constraints may dominate unless external support is secured. In each case, the binding constraint logic clarifies where effort is most consequential.

These constraints and trade-offs set the stage for RQ5, which focuses on whether participatory arrangements can sustain legitimacy and adaptability through repeated rounds of rule revision.

9.6 RQ5: Long-term Adaptability and Legitimacy

RQ5 examined whether and how participatory arrangements contribute to sustained adaptability under non-stationarity, and what enables legitimacy to be maintained through repeated rule revision. The synthesis indicates that long-term adaptability depends less on one-off participation and more on institutionalised procedures for monitoring, review, and adjustment that remain legitimate over time.

Sustained adaptability is most plausible when governance establishes: (i) monitoring systems that are trusted and publicly intelligible, (ii) pre-agreed indicators and triggers that justify adjustment, and (iii) legitimate reviewable processes for revising rules, allocations, and operational protocols. These features stabilise expectations while allowing change. They help governance avoid the perception that revisions are arbitrary, politically manipulated, or selectively imposed.

Long-term legitimacy is also threatened by the pace problem. Repeated revisions can create fatigue, erode trust, and intensify conflict, especially when burdens fall unevenly. Participatory arrangements contribute to legitimacy maintenance when they distribute revision burdens fairly, provide transparency about why changes occured, preserve avenues for contestation and appeal, and demonstrate that revision processes are consistent across groups and over time.

Where Adaptive Performance is weak, meaning there are no clear revision procedures, no monitoring-linked triggers, or no institutional authority to implement changes, participation may produce agreements that rapidly lose fit as conditions shift. In such settings, repeated ad hoc changes can undermine legitimacy even if participation initially generated trust. Conversely, when adaptive procedures are institutionalised and linked to participatory oversight, governance can revise rules iteratively while sustaining acceptance, even under deep uncertainty.

9.7 Practical implications and synthesis

9.7.1 Using the K, I, E, A framework diagnostically

This section summarises how the K, I, E, A., framework can guide improvement in participatory water governance. The framework operates through diagnostic logic. Practitioners identify which dimension is binding, then target interventions where they are most consequential.

The Conditional Enabling Framework operationalises K, I, E, A., through measurable enabling conditions, assessment rubrics, and diagnostic sequences, mentioned in **Chapter 8**. Diagnostic application involves systematically assessing whether each enabling condition is present. Practitioners score Knowledge, Institutional, Equity, and Adaptive Performance based on evidence from documents, stakeholder interviews, observation of participatory practice, and outcome tracing (for example uptake in plans, budgets, regulations, or operational protocols). The resulting governance profile identifies which enabling conditions are present and which are absent or weak.

Prescriptive implications follow from the diagnosis. Conditions scoring strong require maintenance. Moderate conditions require strengthening. While weak conditions often represent binding constraints and typically warrant focused action. Different constraint types require different interventions. **K** constraints require knowledge integration and translation mechanisms. **I** constraints requires institutional embedding and formal authority pathways. E requires safeguards against elite capture and burden mitigation. Lastly, **A** requires monitoring that is linked to review procedures and legitimate rule revision pathways.

Critically, some constraints cannot be resolved solely through participatory design. If **I** is binding because outputs have no authority, improvement requires institutional reform. If **E** is binding because power asymmetries overwhelm safeguards, improvement may require broader political and distributive reforms beyond the participatory arena. The framework is therefore most useful as a diagnostic tool. Rather than calling for more participation, it helps in identifying the main barrier and shows where targeted investment would make the biggest difference.

9.7.2 Why participation is conditional, not universal

Understanding participation as conditional is essential for honest dialogue with water governance stakeholders. Participation improves governance most consistently when enabling conditions are present. In their absence, it can become symbolic and may erode legitimacy.

Therefore, the practical implication is to shift away from generic prescriptions toward context-specific diagnosis and targeted intervention. The K, I, E, A., framework enables this shift by helping practitioners identify which enabling condition is most constraining and focus scarce resources where they matter most.

10. Conclusion

10.1 Summary of Key Findings

The central finding of this thesis is that participation is not a universal solution but a conditional strategy. It improves water governance outcomes most reliably when Knowledge, Institutional, Equity, and Adaptive performance are at least minimally sufficient, and when the most constraining dimension is strengthened. Severe weakness in one dimension often limits overall performance, though partial compensation can occur in specific configurations.

Finding 1: Participation effectiveness depends on the simultaneous presence of all four enabling conditions.

Finding 2: Context determines which enabling condition becomes the binding constraint.

Finding 3: Barriers are not universal but context-specific.

Finding 4: Design trade-offs cannot be eliminated, only navigated.

Finding 5: The K, I, E, A., framework functions as a diagnostic tool, not a checklist.

10.2 Theoretical and Practical Contributions

This thesis contributes to both scholarly understanding and practitioner guidance for participatory water governance by shifting the focus from normative advocacy to diagnostic rigor.

Theoretical contribution: This thesis contributes to water governance theory by demonstrating that participation is conditional rather than universal.

Practical contribution: Practically, the thesis provides a diagnostic tool (K, I, E, A., framework with rubrics and assessment guidance in **Chapter 8**) that enables practitioners to identify which enabling condition is binding in their context.

Policy contribution: For policy-makers, the thesis offers a scaffold for designing climate-resilient institutions.

10.3 Limitations and Research Gaps

This review has documented limitations (**Section 2.5.2**) that includes, geographic concentration in water-stressed developing regions, restriction to English-language literature, and a focus on case studies over comparative experimental designs. The framework also has inherent limitations in measuring qualitative dimensions (**Section 8.3.2**).

These limitations affect confidence in specific findings. Claims about what works in particular contexts (e.g., “participatory monitoring succeeds in high-uncertainty basins”) are stronger than claims about universal principles or optimization questions. Furthermore, long-term sustainability cannot be firmly assessed because most documented implementations are less than 20 years old.

Future research should prioritize four specific areas to address these gaps:

1. **Longitudinal studies:** Track K, I, E, A., dimensions in the same governance systems over 5-10 years to understand how enabling conditions evolve as climate impacts intensify.

2. **Implementation failures:** Systematically document cases where participation failed and why. This is currently under-reported in the literature due to publication bias.

3. **Comparative case analysis:** Test the K, I, E, A., framework across diverse contexts (tropical vs. temperate and wealthy vs poor) to refine threshold values and contextual guidance.

4. **Transboundary analysis:** Examine how the framework applies to transboundary water governance where participation is severely limited by national sovereignty concerns.

10.4 Recommendations for Water Governance Practice

The recommendations below are conditional. They apply when a specific K, I, E, A., dimension is identified as the main bottleneck, and when there is enough political support, legal scope, and funding to act on it.

Based on this research, recommendations for improving participatory water governance are organized by binding constraint:

For Knowledge Performance (K) Constraints:

- **Who:** Basin authorities and technical agencies.
- **What:** Establish standing “Joint Fact-Finding” forums where hydrologists, user representatives, and indigenous knowledge holders co-validate data before modelling begins. Use visual decision-support tools (e.g., localized Shared Socioeconomic Pathways) to make uncertainty explicit.
- **When:** Conduct seasonally, prior to allocation cycles.
- **Decision Hook:** Where feasible, require that all allocation decisions include a “Statement of Evidence” citing specific outputs from the participatory forum, explaining how diverse knowledge sources shaped the final choice.

For Institutional Performance (I) Constraints:

- **Who:** National ministries or legislative bodies.
- **What:** Where legally feasible, codify participatory input into statutory decision-making procedures. Move from “consultation” (discretionary) to “co-decision” (mandatory) for specific triggers.

- **How:** Amend water acts or basin charters to stipulate that if a participatory body rejects a management plan by a supermajority, the authority must provide a written public justification or enter binding mediation.

- **Trigger:** Annual budget approvals, political shift or 5-year basin planning cycles.

For Equity Performance (E) Constraints:

- **Who:** Independent facilitators or oversight committees.

- **What:** Implement structural safeguards like guaranteed seats for marginalised groups, funded separate caucuses for these groups to prepare positions, and compensation for lost labour time.

- **How:** Allocate a ring-fenced budget line for equity enablement sized through local costing (stipends/compensation, travel, translation, childcare, accessibility, and facilitation), and review it annually against participation burden and representation outcomes.

- **Monitoring:** Establish an independent ombudsperson to audit participation demographics and intervene if elite capture is detected (e.g., speaking time dominance).

For Adaptive performance (A) Constraints:

- **Who:** Basin commissions and emergency response units.

- **What:** Pre-negotiate “trigger-based” rule revisions. Instead of debating rules during a crisis, stakeholders agree in advance on specific hydrological thresholds (e.g., reservoir levels <40%) that automatically trigger specific rationing protocols.

- **How:** Formalize these triggers in the basin management plan.

- **Monitoring:** Set hazard-appropriate trigger-based rule revisions with predefined decision rights and rapid implementation windows that match the tempo of the hazard (hours-to-days for rapid-onset events and longer for slow-onset change), so emergency action does not depend on ad hoc consensus-building.

For Policy-Makers and Donors:

- **What:** Require a K, I, E, A., diagnostic assessment before approving funding, instead of imposing generic “participation” mandates.
- **Where:** All water governance and climate adaptation projects, especially in resource-constrained contexts.
- **How:** If the diagnostic shows missing equity safeguards or weak institutional authority, fund those structural reforms first (for example, safeguards, legal pathways, institutional embedding) before funding participatory mechanisms.
- **Monitoring:** Track whether funded projects address the diagnosed binding constraint and whether operational funding and staffing remain in place across implementation, not just during consultation.

10.5 Final Reflection

Water governance under climate stress requires moving beyond conventional technocratic decision-making toward approaches that integrate diverse knowledge, adapt to changing conditions, address distributional equity, and build institutional legitimacy. Participatory approaches offer potential for achieving these goals. However, participation is not automatically effective. The effectiveness of participatory governance depends on specific enabling conditions being present and functioning together.

This thesis provides a framework for understanding when participation supports effective water governance and when it falls short. The framework acknowledges that participation involves inherent trade-offs, that context shapes which enabling conditions are most constraining, and that some governance challenges lie outside participatory mechanisms themselves.

For practitioners confronting water governance challenges in the context of climate change and non-stationarity, the core message is to diagnose the context carefully, assess which enabling conditions are present or absent, identify binding constraints, and direct intervention toward addressing those constraints. Participation, when well-designed and appropriately resourced, can improve governance. But it is no substitute for fundamental governance effectiveness, and it cannot overcome severe institutional dysfunction or resource constraints. Therefore, honest assessment of what participation can and cannot accomplish, and committing to address enabling conditions when they are absent, is essential for improving water governance under climate stress.

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12. Appendices

A. Literature Search and Screening Methodology

To ensure transparency and reproducibility, a systematic search was conducted across three primary academic databases and targeted grey literature sources. The search protocol focused on the intersection of participatory governance, water management, and climate adaptation.

A.1 Database Search Parameters

Table 7:Database Search Parameters

Database	Platform	Years Covered	Search Fields
Web of Science	Clarivate Analytics	1900-present	Title, abstract, keywords
Scopus	Elsevier	1960-present	Title, abstract, keywords
Google Scholar	Google	All years	Full-text indexed
Grey / Repositories	IPCC, UNEP, etc	2009-2025	Full-text, websites

A.2 Table 2: Search Strings and Hit Counts

Table 8: Search Strings and Hit Counts

Source	Search Query	Hits (Refined)
Web of Science	TS = ((“participatory governance” OR “stakeholder engagement” OR “collaborative management” OR “co-production”) AND (“water management” OR “water governance” OR “river basin” OR “flood risk”) AND (“climate change” OR “adaptation” OR “resilience” OR “vulnerability”))	423
Scopus	TITLE-ABS-KEY ((“participatory planning” OR “community-based water management” OR “co-design” OR “coproduction”) AND (“water resources” OR “water adaptation” OR “river basin management”) AND (“climate” OR “drought” OR “flood” OR “hydrological change”))	298
Google Scholar	“Participatory water governance” + "climate change adaptation” (and iterations)	200*
Grey Literature	Targeted search (IPCC, UNEP, World Bank, GWP, SIWI, IOM) & Preprints	89
Total	**Unique records processed after initial deduplication**	**369**

*Restricted to first 200 most relevant results per query.

A.3 Screening and Selection Process

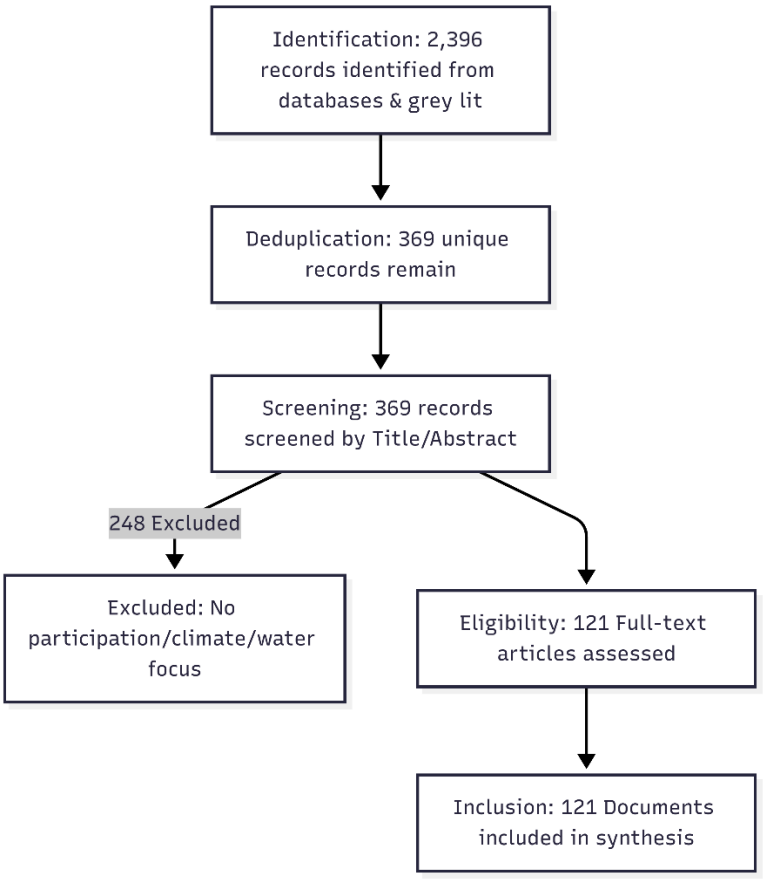

Figure 8: PRISMA Styled Flow Diagram

Screening Stages:

1. **Deduplication:** 1,010 records were deduplicated within a transparent, Excel-based workflow linked to Zotero for reference management and screening, with all screening decisions.

2. **Title/Abstract Screening:** 369 deduplicated records were screened and excluded if they did not explicitly mention: (1) participatory mechanisms AND (2) water/basin contexts AND (3) climate/adaptation focus.

3. **Full-Text Eligibility:** 121 documents were used to provide sufficient detail on governance contexts and report evaluative outcomes.

A.4 Final Corpus Summary

Table 9: Final Corpus Composition

Document Type	Count	%	Definition
Empirical Articles	57	47.1%	Original research with primary data
Reviews / Syntheses	43	35.5%	Systematic reviews, conceptual frameworks, and theoretical syntheses.
Technical Reports	15	12.4%	Reports from agencies (IOM, SIWI, World Bank) and working papers
Theses & Books	6	5.0%	PhD Theses and Book Sections.
Total	121	100%	

B. Corpus Characteristics and Descriptive Analysis

B.1 Document Types

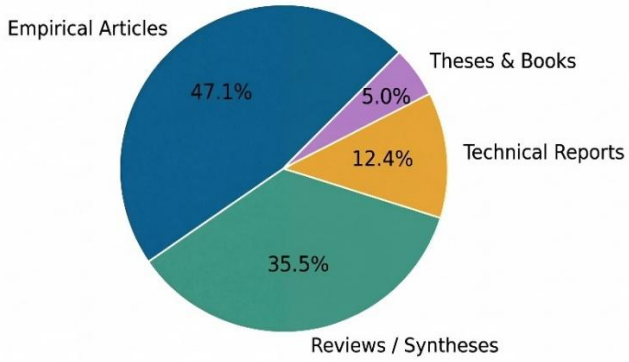

Figure 9: Distribution of Document Types, the corpus is anchored by empirical case studies (47%), supported by a strong foundation of reviews and conceptual papers (35%). Technical reports (12%) and theses (5%) provide grey literature context.

B.2 Publication Timeline

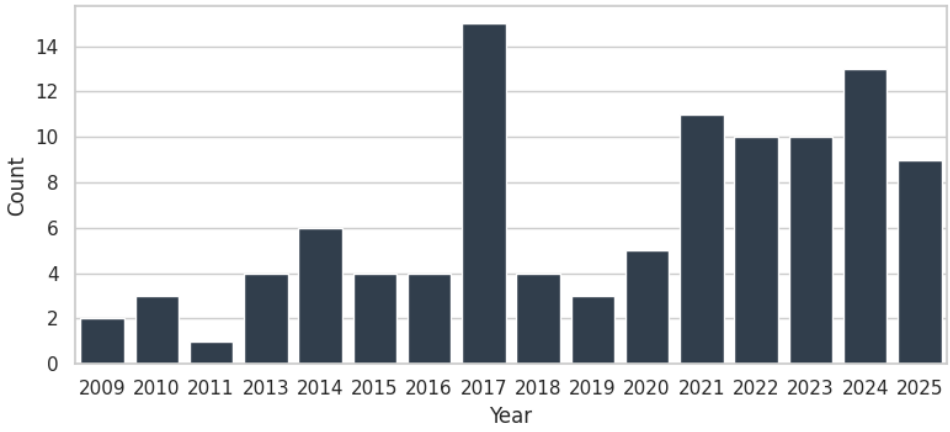

Figure 10: Annual Publication Count (2009-2025). While interest has grown steadily since 2014, the corpus reveals a significant surge in 2021-2025, indicating high current relevance.

B.3 Geographic Distribution

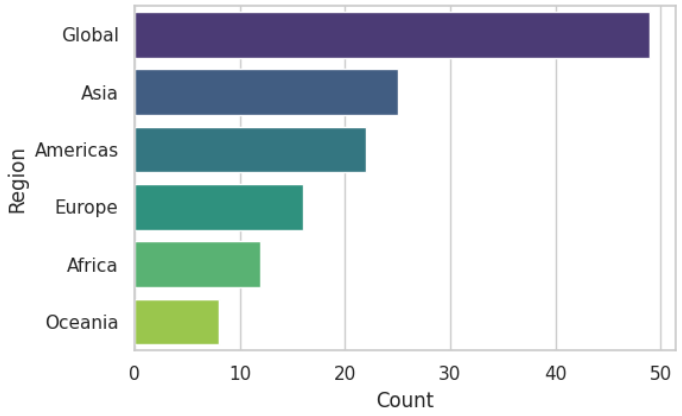

Figure 11: Geographic Focus of Studies. While many studies take a Global perspective (n=49), regional studies cluster heavily in Asia (e.g., Bangladesh, Nepal) and the Americas (e.g., Andes, Mesoamerica), followed by Europe and Africa.

B.4 Governance Scales

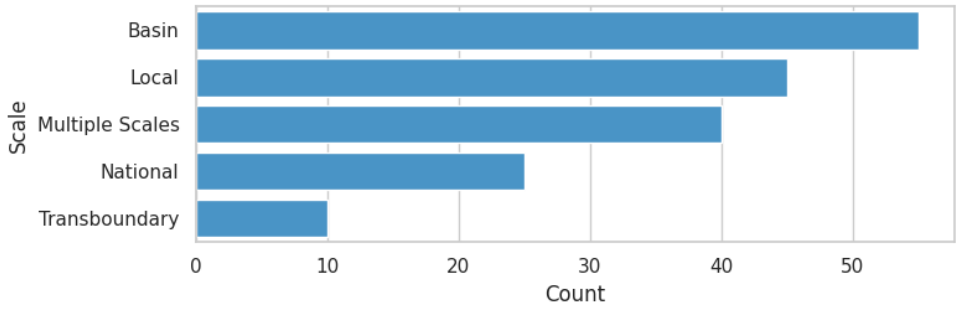

Figure 12: Governance Scales Examined. Basin-scale and Local-scale governance are the most frequently examined levels, reflecting the operational reality of IWRM and community-based adaptation.

B.5 Climate Hazards Addressed

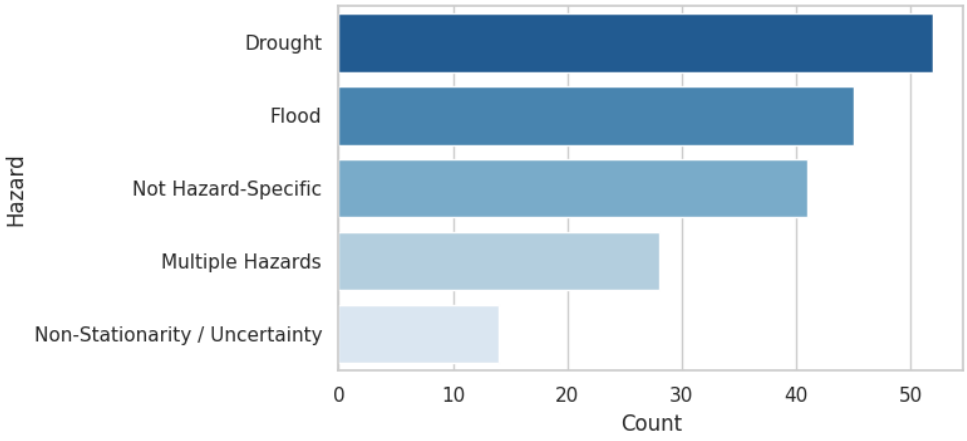

Figure 13: Primary Climate Hazards are dominated by droughts and floods. However, a large portion of the literature addresses multiple hazards or only deals with governance and uncertainity.

B.6 Participation Mechanisms

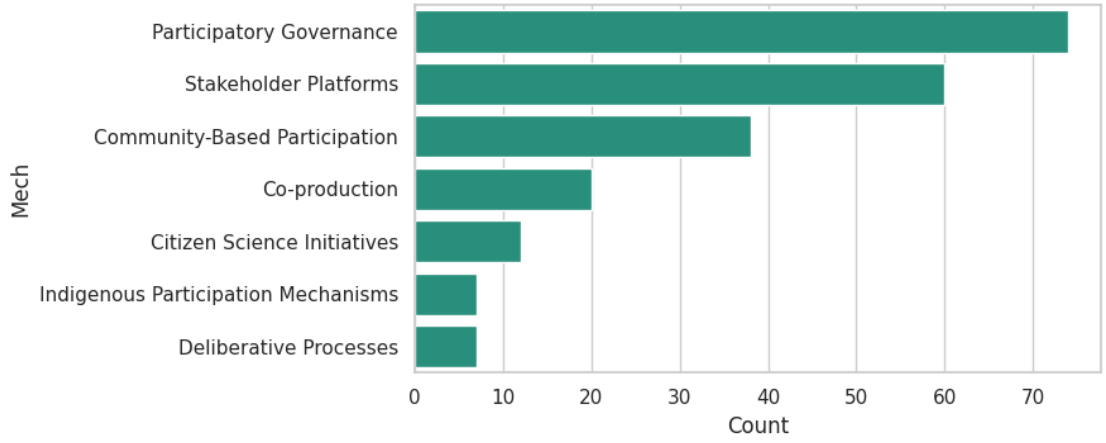

Figure 14: Participation Mechanisms

B.7 Institutional Contexts

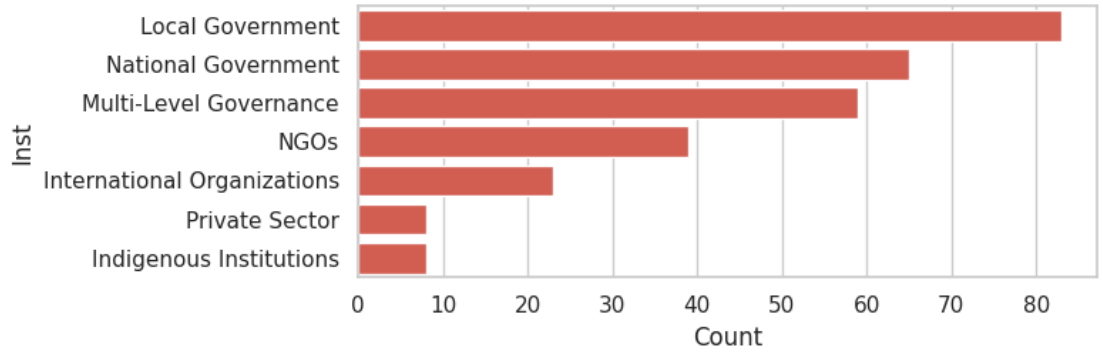

Figure 15: Institutional Involvement.

B.8 Research Approaches

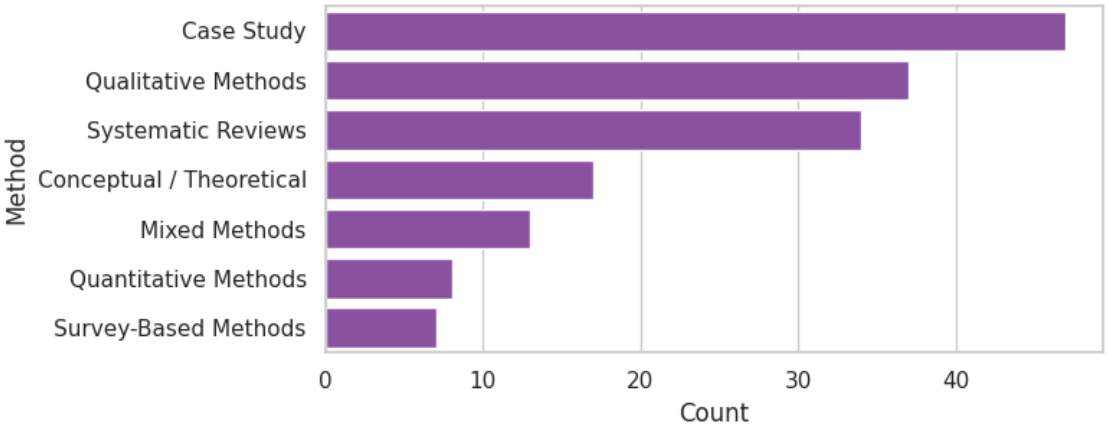

Figure 16: Methodological Approaches.

C. Participatory Governance Performance Framework (K, I, E, A)

C.1 Framework Overview

The K, I, E, A., framework views participatory water governance not as a linear process but as an integrated system requiring performance in four distinct but interacting dimensions.

Drawing on the theory of binding constraints, the framework treats the most limiting dimension as a practical starting point for diagnosis

C.2 Knowledge Performance (K)

Theoretical Foundation: Knowledge Performance refers to the quality, credibility, accessibility, and integration of diverse forms of evidence in decision-making. Strong **K** means that diverse knowledge holders contribute credible evidence, evidence is mutually understood, and participatory deliberation demonstrably shapes what gets decided.

Minimum Sufficiency Criteria:

- Diverse sources: Scientific, local, and Indigenous knowledge are actively engaged.
- Credibility: Evidence is assessed for reliability and trusted by participants.
- Translation: Key concepts are mutually intelligible across expertise levels.
- Traceability: Participants can link decisions to specific evidence.

Diagnostic Questions:

- Sources: Who holds relevant knowledge? Are Indigenous or local holders represented?
- Credibility: Which evidence do decision-makers trust? Where is credibility contested?
- Translation: Do participants understand the technical evidence presented?
- Traceability: Can a decision be traced back to the evidence that supported it?
- Iteration: Does the system generate new knowledge (monitoring) over time?

C.3 Institutional Performance (I)

Theoretical Foundation: Institutional Performance refers to the formal authority, mandate clarity, resource allocation, and accountability mechanisms that empower participatory bodies. Without **I**, participation is purely advisory and often ignored.

Minimum Sufficiency Criteria:

- Formal Recognition: Bodies are established by statute or regulation, not just voluntary association.
- Binding Pathways: Recommendations have defined routes into binding instruments (plans, budgets).
- Resources: Dedicated budget and staff exist independent of donor cycles.

- Coordination: Clear procedures connect local decisions to national authorities.

Diagnostic Questions:

- Formal role: Is the body's authority defined in statute or regulation?
- Pathways: What happens to recommendations? Do they disappear into administrative silence?
- Resources: Is there a dedicated budget line for operations?
- Accountability: Are there consequences if institutions ignore participatory decisions?

C.4 Equity Performance (E)

Theoretical Foundation: Equity Performance addresses procedural fairness (who participates/influences) and distributional justice (who benefits/loses). Strong **E** prevents elite capture and ensures adaptation does not worsen existing inequalities.

Minimum Sufficiency Criteria:

- Substantive Representation: Vulnerable groups (poor, women, minorities) are present beyond tokenism.
- Voice Distribution: Procedures prevent elite capture and help minority voices influence outcomes.
- Burden Mitigation: Costs of participation (time, travel) are addressed.
- Distributional Assessment: Adaptation decisions are analysed for impact on inequality.

Diagnostic Questions:

- Presence: Who is missing from the room? Is it choice or barrier?
- Voice: Whose voices dominate the discussion?
- Burdens: Who bears the cost (time/money) of participating?
- Outcomes: Who wins and who loses from the proposed adaptation?

C.5 Adaptive performance (A)

Theoretical Foundation: Adaptive Performance is the capacity to revise rules and allocations iteratively under non-stationary conditions. It moves governance from static planning to iterative learning.

Minimum Sufficiency Criteria:

- Monitoring: Continuous tracking of hydrological and social variables.
- Revision Procedures: Clear, pre-agreed processes for changing rules when conditions shift.
- Triggers: Objective thresholds (e.g., "if flow < X") that trigger automatic review.
- Learning Loops: Outcomes of past adaptations are reviewed to inform future decisions.

Diagnostic Questions:

i. Monitoring: Is data collected regularly? Is it used?

ii. Revision: Can rules be changed without a crisis?

iii. Triggers: Do stakeholders know in advance what conditions will trigger a cutback?

iv. Learning: Does the system stop making the same mistakes?

C.6 Integrated K, I, E, A., Scoring Rubric

Table 10: Consolidated Scoring Matrix

	Label	Knowledge (K)	Institutional (I)	Equity (E)	Adaptive (A)
0	**Absent/ Limited**	Single source, no translation, no link to decisions.	No authority, advisory only, no budget, ignored by agencies.	Elite-dominated, marginalised absent, no safeguards, inequality worsens.	No monitoring, static rules, crisis-only revision, no triggers.
1	**Minimal/ Fragmented**	Token diversity, weak translation, sparse or unused monitoring.	Exists but vague authority, unfunded mandate, weak coordination.	Tokenistic inclusion, high barriers, unequal burdens.	Sparse monitoring, ad hoc revisions, reactive, no learning.
2	**Adequate/ Partial**	Multiple sources, functional translation, some traceability.	Defined role, some influence, limited budget.	Substantive representation, some burden support, grievance mechanism.	Moderate monitoring, revision possible but cumbersome, some triggers.
3	**Strong/ Integrated**	Co-produced knowledge, clear traceability, learning embedded.	Statutory authority, binding pathways, sustained budget, integrated coordination.	Proactive inclusion, burdens offset, distributional equity enforced.	Comprehensive monitoring, automatic triggers, learning loops embedded.

C.7 Dimension Interactions

Table 11: Two-way interaction effects across K, I, E, and A

Interaction	High (3) with Low (0–1)	Low (0–1) with High (3)
K × I	High K, Low I: Knowledge is strong, but it does not enter decisions, participation becomes symbolic.	Low K, High I: Decisions are binding, but weak knowledge drives confident mistakes.
K × E	High K, Low E: Knowledge looks rigorous, but elites dominate, outcomes stay unequal.	Low K, High E: Inclusion is strong, but evidence is thin, decisions are poorly informed.
K × A	High K, Low A: Evidence exists, but rules do not update, learning does not translate into change.	Low K, High A: Rules can change fast, but weak monitoring means changes are made blindly.
I × E	High I, Low E: Authority is strong, safeguards are weak, capture becomes entrenched.	Low I, High E: Participation is fair, but it has little power, equity claims are not implemented.
I × A	High I, Low A: Institutions are strong but rigid, rule change is too slow under climate stress.	Low I, High A: Adaptation procedures exist, but weak authority means revisions do not stick.
E × A	High E, Low A: Process is fair, but nothing adapts, trust erodes as conditions worsen.	Low E, High A: Frequent adjustments without safeguards shift burdens onto the vulnerable, trust collapses.

C.8 Common Failure Modes

- **Expert Capture (K):** Local/Indigenous knowledge dismissed as anecdotal.
- **Unfunded Mandate (I):** Responsibility defined but no budget provided.
- **Multi-level Gridlock (I):** Local/national conflict paralyzes action.
- **Tokenism (E):** Presence without voice and decisions that reflect elite consensus.
- **Static Planning (A):** Rules fixed at baseline that are unable to pivot when climate shifts.
- **Crisis Reactivity (A):** Revisions happen only after disaster, eroding trust.

C.9 Design Principles

- **Pluralism with Standards:** Validate multiple knowledge systems transparently.
- **Statutory Integration:** Embed participation in law, not just policy.
- **Affirmative Inclusion:** Actively recruit and resource marginalized voices.
- **Pre-agreed Triggers:** Define adaptation rules before the crisis hits.
- **Embedded Learning:** Make monitoring and revision routine, not exceptional

D. Diagnostic Protocol and Implementation Guide

D.1 Overview

This protocol guides practitioners in applying the K, I, E, A., framework diagnostically to identify the “binding constraint” that must be addressed first.

D.2 Step-by-Step Diagnostic Process

Figure 17: The 7-Step Diagnostic Protocol

D.3 Worked Examples

Example 1: Basin Committee in Drought (Binding Constraints: I & E).

> **Diagnosis:** High scientific monitoring (K=2) but committee has no authority (I=1) and Indigenous groups are marginalized (E=1).
>
> **Strategy:** Formalize Indigenous role in allocation decisions (I+E). Establish Indigenous-led monitoring of sacred springs (K+E).

Example 2: Post-Conflict Flood Warning (Binding Constraint: E).

> **Diagnosis:** Deep distrust of officials (E=0) and no early warning authority (I=1).
>
> **Strategy:** Start with Equity. Facilitate dialogue with IDPs. Train IDPs to lead community monitoring (building K and E simultaneously).

Example 3: Data-Poor Groundwater (Binding Constraint: A).

> **Diagnosis:** No data (K=1) means no adaptation (A=0).
>
> **Strategy:** Build K through participatory farmer-monitoring (Aceves-Bueno et al. 2015) to enable basic Adaptive allocation triggers.

E. Context-Specific Prioritization Guidance

E.1 Introduction

The "ideal" governance arrangement varies by context. This appendix adjusts the framework for specific hazard types and governance realities.

E.2 Context-Specific Threshold Matrix

Table 12: Comparative Threshold Adjustments

	Normal	Rapid Onset	Slow-Onset	Equity-Intensive	Data-poor	Rationale
K	2-3	1-2 (event), 2-3 (post)	2-3 Required	2-3 (+Indigenous)	2-3 (Local)	Slow-onset needs trends, Rapid relies on pre-existing data.
I	2-3	2-3 Required	1-2 Initial	2-3 (Adapted)	1-2 Initial	Emergencies need clear authority chains immediately
E	2-3	1-2 (event), 2-3 (post)	2-3 Required	3 Required	2-3 Required	Inequity-intensive contexts, lack of E destroys legitimacy

A	2-3	2-3 Required	2-3 Required	1-2 Initial	2-3 Required	Adaptation is the priority in data poor / high uncertainty zones.

E.3 Decision Support Tool

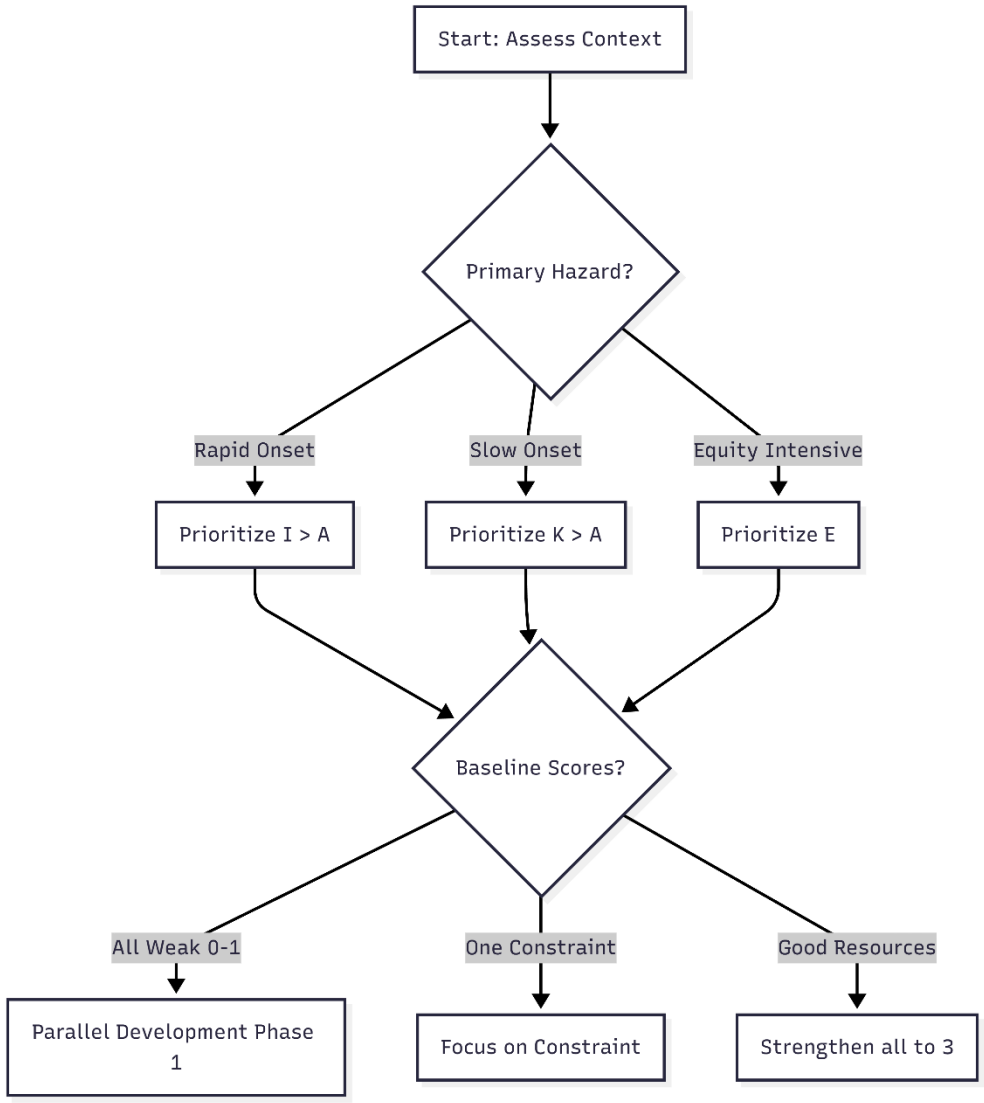

Figure 18: Context Prioritization Decision Tree

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27. Dezember 2025

Datum

Unterschrift