

Module 1: uncertainty

| Table 1. Types of Uncertainty From Bojórquez Tapia et al. (2022) | | |
|---|--|------------------------------------|
| Type of Uncertainty | Description | Linked to Sustainability Dimension |
| Knightian | Radical uncertainty; impossibility to know all factors. 'Unknown unknowns' | Systemic |
| Ontological | Ignorance about entities and relationships of the real world; hidden assumptions | Structural |
| Politically induced | Deliberate ignorance by public agencies | Structural |
| Deep uncertainty | Disagreement about models, structures, parameters and probabilities | Systemic |
| Epistemic | Imperfect knowledge; different interpretations of the same body of knowledge | Enabling |
| Linguistic | Ambiguity in terms and expressions; semantic and predicative | Enabling |
| Normative | Impossibility to know future ethical values in relation to current decisions | Enabling / Structural |
| Ambiguity | Coexistence of multiple knowledge frameworks about desirable futures | Structural |

| Table 2. Stages Where Uncertainty Manifests From Merino-Benítez et al. (2024) | |
|--|--|
| Study Stage | Types of Uncertainty Present |
| 1. Problem formulation | Knightian, Ambiguity, Linguistic |
| 2. Analysis (modeling) | Ontological, Epistemic, Deep uncertainty |
| 3. Risk characterization | Normative, Politically induced |

Module 2: Stakeholders

| Table 3. Stakeholder Typology Made from Newton & Elliott (2016) y Luyet et al. (2012) | | |
|--|--|---|
| Stakeholder Type | Main Function | Examples |
| Extractors | Use or extract resources | Fishers, miners, farmers, builders |
| Injectors | Introduce materials or infrastructure | Industry, transport, energy, urbanism |
| Beneficiaries | Benefit from ecosystem services | General public, companies |
| Affected | Impacted by decisions or system use | Local communities, vulnerable groups, NGOs |
| Regulators | Hold formal/legal authority | Governments, environmental agencies, legislative bodies |
| Influencers | Indirectly influence the system or decisions | Media, academics, NGOs, opinion leaders |

| Table 4. Expected or Allowed Participation Levels Made from Luyet et al. (2012) | | |
|--|--|------------------------|
| Participation Level | Techniques Used | Expected Decision Type |
| Information | Reports, websites, bulletins | Unilateral (top-down) |
| Consultation | Interviews, surveys, public hearings | Opinion considered |
| Collaboration | Workshops, participatory mapping | Shared design |
| Co-decision | Citizen jury, multicriteria analysis | Joint decision-making |
| Empowerment | Delegation of power, legal co-management | Transfer of authority |

| Table 5. Participation Moments in the Decision Cycle Made from Pahl-Wostl (2002) y Vink et al. (2008) | | |
|--|--|----------------------------|
| Decision Process Stage | Key Actors to Involve | Examples |
| 1. Problem definition | Top/middle management, affected communities, influencers | Policies, strategy |
| 2. Technical analysis | Academics, regulators, designers | Models, scenarios |
| 3. Solution design | Direct users, extractors, designers, civil society | Workshops, mappings |
| 4. Selection and prototyping | Regulators, local managers, community | Multicriteria tools, pilot |
| 5. Implementation | All actors, especially affected groups and operators | Action plans |
| 6. Evaluation and adjustment | Beneficiaries, academics, external evaluators | Indicators, social audit |

Module 3: Challenges

| Table 6. Epistemological and Knowledge Challenges | | |
|---|---|------------------------------|
| Challenge | Latin America Context | Example |
| Data scarcity | Lack of systematic monitoring, outdated or non-existent databases | Merino-Benítez et al. (2024) |
| Fragmented or disciplinary knowledge | Difficulties integrating local, scientific, and technical knowledge | Haasnoot et al. (2024) |
| Lack of recognition of local knowledge | Community knowledge is underused in technical processes | Merino-Benítez et al. (2024) |

| Table 7. Institutional and Organizational Challenges | | |
|--|--|---------------------------|
| Challenge | Latin America Context | Example |
| Rigid legal frameworks | Outdated or inflexible norms under uncertainty | Haasnoot et al. (2024) |
| Political discontinuity | Government changes interrupt long-term processes | Lai & Stacchezzini (2021) |
| Institutional role confusion | Overlapping responsibilities between government levels | Stanton & Roelich (2021) |

| Table 8. Social and Participation Challenges | | |
|--|--|----------------------------|
| Challenge | Latin America Context | Example |
| Inequality in participation access | Outdated or inflexible participation norms | Dalsgaard (2010) |
| Difficulty scaling participatory processes | Government changes interrupt long-term processes | Haasnoot et al. (2024) |
| Low legitimacy or trust in processes | Overlapping responsibilities between government levels | Molina-Pérez et al. (2024) |

| Table 9. Methodological Challenges in DMDU | | |
|--|---|------------------------------|
| Challenge | Latin America Context | Example |
| High dependency on quantitative modeling | Technical and financial limitations to implement complex models | Merino-Benítez et al. (2024) |
| Lack of context-adapted tools | Qualitative and flexible approaches (e.g., KSIM) required | Merino-Benítez et al. (2024) |
| Difficult translation between models and decisions | Barriers to applying technical outputs to policies | Stanton & Roelich (2021) |

| Table 10. Temporal and Political Scale Challenges | | |
|---|---|--------------------------|
| Challenge | Latin America Context | Example |
| Short-termism | Policies focused on immediate benefits and electoral cycles | Haasnoot et al. (2024) |
| Path dependency | Rigid investments and reliance on inherited solutions | Stanton & Roelich (2021) |

