Data-Driven Decision-Management: A Values-focused Approach to Enable Traceable Decision Analytics for Adaptive Climate Resilience

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DOI: 10.6084/m9.figshare.4515722

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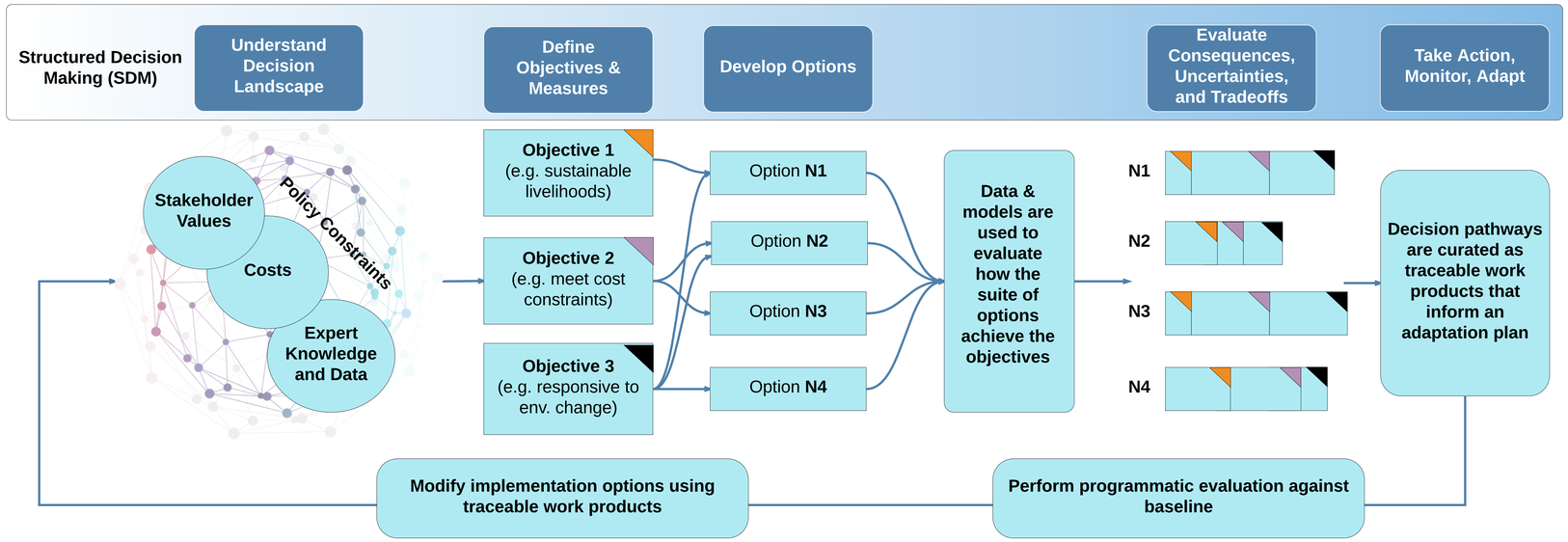
The Challenge

The rapid pace of large-scale environmental changes around the globe underscores the value of long-term data sets for understanding the context of scientific observations, projecting future conditions, and making informed decisions on how to adapt to these large-scale challenges.

However, data and models that provide status and trend information are only as good as the human-mediated processes that utilize these information products for decisions. How do we formulate a stakeholder-driven set of climate resilience solutions that combine stakeholder values, data, and models to guide decisions that are technically defensible? How do we facilitate adaptive management by creating "decision management products", akin to scientific data products, where decision processes are reproducible and traceable? What are the best practices informed by decision science that lend structure to the co-creation of resilience solutions by stakeholders and subject matter experts?

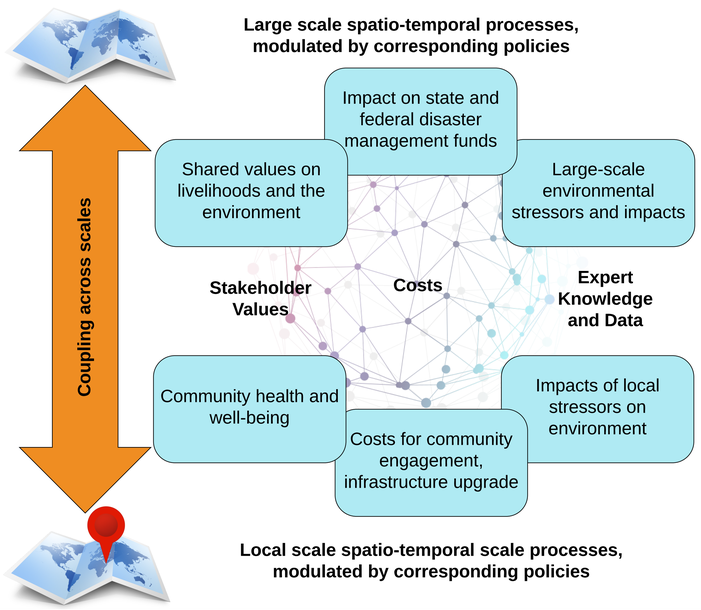
Structured decision making (SDM) (Gregory et al 2012) provides a transparent framework to develop solutions for climate resilience challenges. The diagram on the right depicts an abstract representation of SDM. The boxes below provide an overview of key concepts at the beginning, middle, and end of the SDM process.



Decision-Management for Climate Resilience

SDM begins with a comprehensive understanding of the **decision landscape** (e.g., programmatic objectives, desired outcomes, possible implementation options, regulatory aspects of the decision). **Stakeholders and decision-makers** are actively involved at all stages of the decision-making process. They are the custodians of community values, defined as principles for evaluating the desirability of possible alternatives or consequences. Values-focused thinking focuses on the essential activities that **must occur prior** to determining how to solve a decision problem (Keeney 1994).

The decision landscape for climate adaptation may also been seen through the lens of social, economic, and environmental causes-and-effects coupled across spatio-temporal scales modulated by policies at the appropriate level. Socio-ecological systems, or coupled human-environment systems (Chapin et al 2009), are a useful framework for analyzing complex climate resilience challenges.

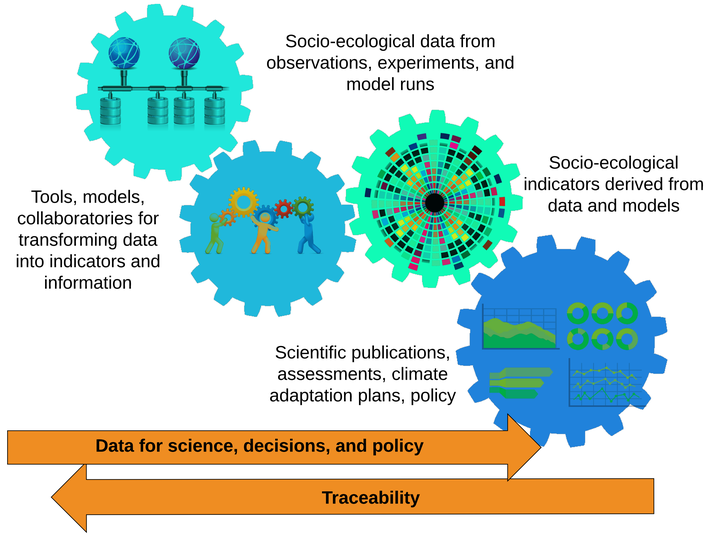


Data, Models, and Information Interoperability

Data-driven decision-management has its roots in "science-informed policy" and "data-intensive science". The latter is facilitated through a rapidly evolving open ecosystem of interoperable repositories for data, models, and information.

Many US federal agencies have invested in technologies that enable better discoverability and accessibility of such repositories. Inter-agency bodies like the US Global Change Research Program and the US Group on Earth Observations have actively promulgated best data management practices through the US government. These practices range from adopting e-infrastructure technical standards to producing electronic scientific assessments that allow users to trace scientific findings back to computer models and repository data.

In the data-intensive sciences, **traceability** facilitates reproducibility. In data-driven decision-management, traceability facilitates technical defensibility, accountability, transparency, and adaptive management.

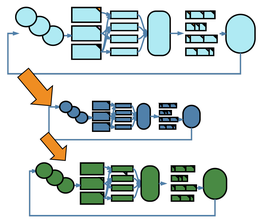


Adaptive Climate Resilience

Neptune used SDM for a Coastal Community Resilience Planning and Decision Making project in Dania Beach, Florida. The project included quantitative assessments of how different combinations of environmental management options impacted objectives derived from stakeholder values and cost constraints. That information was captured with a web-based decision-support software that linked objectives, implementation options, performance measures, models, and data into a cohesive structure. These deliverables may be easily assembled into an electronic "**decision-management package**".

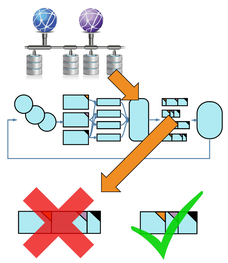
The increased emphasis on **reproducibility, transparency, and traceability** has changed the way science is done. Publications are increasingly released with accompanying data and code, often freely web accessible. The public would be well-served if the same paradigm is applied to climate resilience planning. If a resilience plan is released with an accompanying electronic decision-management package ("Package") that can be archived and distributed, the **decision-provenance** (a formalized, canonical representation of how decisions are made) embedded in a Package enables:

GitHub for Climate Resilience Decision-Management



Other communities can disover, re-use, re-purpose, and contribute Packages. An existing Package is used to structure and bootstrap a climate resilience plan. Stakeholder values, data, models, and other decision parameters are modified as appropriate.

Programmatic Evaluation and Adaptive Management



"What-if" scenarios are re-run against an existing Package using updated socio-ecological data. Programmatic evaluations are conducted on an existing project using the decision- provenance captured in a Package. Leverage points for improvements are identified.

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