DRAFT

Science Supporting Decision-Making Under Deep Uncertainty

Delta Independent Science Board

Draft Prospectus

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Motivation

Rapidly changing conditions and increasing uncertainty of future forecasts is increasing the challenges of managing Delta systems to achieve the co-equal goals. Recent extreme weather events (e.g., multi-year droughts and sequential atmospheric rivers) highlight how extreme and hard-to-predict conditions add stress to management systems. Under duress, managers are forced to prioritize some goals at the expense of other goals and may not have time to consider all management options or elicit stakeholder preferences.

While tradeoffs may be unavoidable under extreme conditions, decision systems can be designed to improve system resilience and management preparations in response to extreme events by anticipating future needs. Modeling and pre-planning for unlikely, but still plausible, conditions provide the opportunity for broad stakeholder input on potential solutions and priorities in advance of a crisis. Anticipating extreme conditions can also speed up response time to emergencies, by mentally preparing managers and by allocating responsibilities among agencies and responsible parties. Providing ample opportunity to consider alternative futures can also create new insights about effective preparation for change.

Scientific analysis can be applied to reduce some types of uncertainty to improve the accuracy and the time and space scales of those predictions. However, other types of change have unknown or unknowable likelihoods of occurrence and predictions cannot be improved by short- to mid-term research. Alternatively, some future conditions may be well understood but ignored in management, due to their perceived low probability of occurrence. These conditions exhibit *Deep Uncertainty,* which is system variability that cannot be well characterized with existing data, models, and understanding. Often, there is little or no agreement on how systems are likely to behave or the probabilities of occurrence of events, including the duration, sequence, and co-occurrence of events (Haasnoot et al. 2013; Hallegatte et al. 2012).

Decision-making under deep uncertainty (DMDU) is a set of tools that are used to support stakeholder engaged and anticipatory planning. DMDU uses a variety of tools and techniques to identify and evaluate a wide range of possible futures, assess the robustness of potential decisions under each scenario, and select the decision that minimizes regret. Instead of planning for a single "best guess" future, DMDU approaches aim to evaluate all the conditions under which a policy or plan might fail in order to understand if an alternative approach may be more robust to uncertainty. The Delta Independent Science Board's review of DMDU aims to build understanding of scientific tools and concepts that can improve capacity to anticipate and adapt to growing uncertainty of future conditions in the Sacramento-San Joaquin Delta.

One tool commonly used to support such forward-looking, future-oriented thinking is scenario analysis. Scenario analysis is uniquely valuable among decision support tools in that it can be used to examine different risks and probe deep uncertainties that reach beyond those that have been estimated using existing data and models. For example, California agencies who participated in the ARkStorm (Atmospheric River 1000 Storm) table top exercise to model and plan for a hypothetical scenario of extreme weather event, or "megastorm", reported using results of that storm to improve preparations (Kaplan 2023) and evaluate opportunities to consider using more green approaches to stormwater management (Smith 2022). ARkStorm was originally developed by the US Geological Survey, based on historic data (Porter et al. 2011) but climate change is expected to intensify this effect (e.g., Espinoza et al. 2018). According to one study, runoff in the future extreme storm scenario is 200 to 400% greater than historical values in the Sierra Nevada due to the influence of climate change (Huang and Swain 2022).

Formal techniques have been developed in the interdisciplinary social sciences (especially decision science) to generate scenarios that systematically account for deep uncertainties that can include many stressors, including but not limited to climate change, human behavior, and compounding events. The science of scenario development uses data-informed approaches to understand evidence of change and incorporates horizon scanning activities that identify how the system may be changing in the future. These approaches are particularly valuable for stress-testing policies to understand the conditions under which a proposed approach will fail, rather than only representing the optimal approach for a single best guess future scenario (e.g., Lempert et al. 2004).

This Delta ISB review will draw on the interdisciplinary sciences that support decision-making under deep uncertainty (DMDU) by synthesizing current uses of scenario planning in the Delta and examining whether data-informed methods of scenario development may be usefully applied toward Delta management challenges. The ultimate goal of this Delta ISB review is to support planning and management of events that are largely unpredictable or of greater magnitude in outcomes than are typically prepared for in current management practices (e.g., long-term average conditions).

Audience

The intended audiences for this work are those who manage resources or design projects using intermediate to long planning horizons, along with scientific and technical staff at government agencies. We expect the results will be of interest to a wide range of management applications such as salinity management, water supply, and ecosystem restoration goals.

Inputs to the review

Inputs will include information gathered through 1) public seminars; 2) an inventory and synthesis of current scenario development processes in the Delta; and 3) interviews with Delta decision-makers.

Seminars

A public seminar series introducing concepts from the decision sciences, futurism, and other relevant scientific fields will engage stakeholders, rights holders, and other interested and affected parties. The seminar series will feature experts speaking on the science of DMDU, major sources of deep uncertainty in the Delta, and current efforts to address those deep uncertainties. The seminar series will be hosted by the Delta ISB with support from the Delta Science Program.

Inventory and analysis of scenarios

Current Delta scenarios will be identified and synthesized using social scientific methods as a framework to evaluate the development and characteristics of scenarios produced in the Delta. Examples of existing scenario analysis efforts in the Delta include the, “Sacramento-San Joaquin River Basin Robust Decision Making

Case Study" (Kalra and Groves) and the "Future of Agriculture in the San Joaquin Valley" (Escriva-Bou et al. 2023). As part of the Delta ISB review on DMDU, the synthesis will include a characterization of current scenario design and development processes and an assessment of how they incorporate processes, tools, and techniques to address deep uncertainty. The ensuing synthesis will be used to inform recommendations for applying DMDU tools to Delta management challenges.

Interviews

Semi-structured interviews are planned with Delta decision-makers to deepen understanding of how scenarios are being developed and applied to address uncertainty in Delta analysis and decision-making. These interviews will contribute to providing recommendations for the potential application of DMDU tools and concepts to management challenges in the Delta.

Timeframe

Target Date	Benchmark
June 2023	Prospectus finalized
Ongoing (Throughout 2023)	Hold public seminar series to: a) Introduce concepts of DMDU b) Explore/identify deep uncertainties in the Delta as perceived from diverse individual and/or organizational perspectives c) Identify some signals of future change d) Provide other useful background information
Spring-Summer 2023	Survey and qualitative analysis to systematically characterize and critically evaluate existing Delta scenario design and development processes through an interdisciplinary decision science and futurism lens.
Summer-Fall 2023	Interviews with Delta decision-makers to understand use of scenarios to address uncertainty in their decision-making processes.
Winter 2024	Release draft report summarizing information gained through seminar series, scenario inventory and analysis, and interviews, with recommendations to improve science of scenario analysis to inform decision-making under deep uncertainty in the Delta.
Spring 2024	Finalize summary report and findings

Related Reviews

We are not aware of any similar previous or current review efforts. This review is responsive to multiple recommendations produced by the Delta Independent Science Board (Delta ISB) and the Delta Science Program (DSP) that have noted the need for anticipatory management (Delta Independent Science Board 2022; Norgaard et al. 2021; Delta Stewardship Council, Delta Science Program 2019).

Expected Products and Outcomes

Results and insights gained through the inputs described above will be synthesized in a report and shared through public presentations and other methods. The Delta ISB review will provide an exploration of tools, techniques, and recommendations that could be applied to help the Delta science and management community better characterize, prepare for, and adapt to uncertainty for a range of management needs such as salinity management, water supply, and ecosystem goals. Recommendations could inform new analyses, simulations, and approaches for coordinating multi-agency responses to events, strategic scientific planning and collaboration by agencies, and other activities to anticipate and prepare for the future.

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