DRAFT

Science supporting decision-making under deep uncertainty: A proposed joint activity of the Delta Independent Science Board and the Delta Science Program

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Summary

The goal of this effort is to build understanding of scientific tools and concepts that can inform management and policy decision-making under rapid change and increasing uncertainty of future forecasts. *Deep uncertainty* is system variability that cannot be well characterized with existing data, models and understanding. The proposed effort will draw on the interdisciplinary sciences that support decision making under deep uncertainty (DMDU) by expanding the methods used to create future scenarios, analyze scenarios in modeling, and design projects and policies that are robust to future uncertainty (Marchau et al. 2019). Activities will include public seminars and workshops, a survey and analysis of current uncertainty and scenario planning efforts in the Delta, and discussions with members of the Delta scientific and management communities. Insights gained through these activities will be summarized in a report with recommendations to interested scientists and managers for improving preparation for alternative plausible futures. This effort 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). The intended audiences for this work are those who manage resources or design projects using intermediate to long planning horizons, as well as scientific and technical staff at government agencies. We expect the results will be of interest to a wide range of management needs such as salinity management, water supply, and ecosystem goals.

Background

The Sacramento-San Joaquin Delta is undergoing continual and often rapid change. Predicting and preparing for those changes is challenging, as the past is an inadequate model of future variability. Anticipating change is critical for effective management of the Delta. Science can be applied to make reasonable predictions of some future conditions, and much scientific effort aims to improve accuracy and the time and space scales of those predictions (e.g., of responses to climate change). However, many changes cannot be scientifically forecasted. Others may be forecasted but largely ignored due to their perceived low probability of occurrence. More recently, climate change and other drivers have been characterized as deeply uncertain where there is little or no agreement on models and or probability distributions of key variables Haasnoot et al. 2013; Hallegatte et al. 2012).

Ignoring uncertainty can lead to inefficient investments since the solution that is optimal under a “best guess” future is not necessarily the one that performs best under diverse plausible future conditions (Wainger et al. 2021, Groves et al. 2019). As recent events have helped us realize, preparing for low probability events with potential high consequences for water supplies, ecosystems or human well-being is needed for effectively managing risks. Anticipating unlikely, but still plausible, future conditions has been demonstrated to speed up responses during crises, improve resilience, and can create new insights about effective preparation for change.

One tool commonly used to support such forward-looking, future-oriented thinking is scenario analysis, in which future, plausible scenarios are collaboratively developed and used to evaluate how well alternative policies, scientific capabilities, or projects perform under various conditions. The exercise of developing and comparing alternative future scenarios reveals research gaps and management or policy needs, improving decisions by increasing capacity to prepare for, respond and adapt to rapid change. Such scenario building can be supported by horizon scanning activities that seek to identify early signs of change in the behaviors of ecological and social systems.

Scenario analysis is uniquely valuable among decision support tools in that it can be used to probe uncertainties beyond those that have been estimated using existing data and models. Scenarios are the only way to include so-called *deep uncertainty*, which is system variability that cannot be well characterized with existing data, models and understanding. However, scenario analysis does not incorporate deep uncertainties inherently or by default. In fact, the use of scenarios to plan in the face of deep uncertainty can be challenged by numerous *cognitive biases* (i.e., patterned psychological responses that developed in the evolutionary environment and continue to influence, among other things, the ways humans process and respond to information). Examples include biases that lead us to discount future impacts; biases that lead us to selectively accept or reject information to protect pre-existing beliefs and values; and biases that lead us to resist change in favor of the status quo. These and other cognitive biases may inhibit the development and use of scenarios that meaningfully account for low-probability events or other sources of deep uncertainty.

The influence of cognitive bias may be counteracted with awareness and intentional design. To advance more anticipatory approaches to environmental planning, formal techniques have been developed in the interdisciplinary social sciences to generate scenarios that systematically account for deep uncertainty, e.g., by representing uncorrelated drivers and extreme changes. These approaches differ from scenarios that explore sensitivity to known variability in that they are often used to stress-test policies to understand the conditions under which a proposed approach will fail, rather than understanding the optimal approach for a specified set of (uncertain) future conditions (e.g., Lempert et al. 2004).

Overview of Proposed Activities

The scientific approaches that have been developed to structure future thinking can be applied to inform the range of future possibilities that we consider in scenario analysis in the Delta and assist us in avoiding typical mental traps such as a focus on incremental, rather than rapid, change. **The overarching purpose of the proposed project is to raise awareness of these scientific approaches and provide recommendations for incorporating them into scenario analysis to better account for deep uncertainties in the Delta.**

Stakeholders, rightsholders and other interested and affected parties will be engaged from the outset through a public seminar series introducing concepts from the decision sciences, futurism, and other relevant scientific fields (Activity 1). The seminar series will also invite dialogue identifying and exploring sources of deep uncertainty confronting the Delta. Concurrent with the seminar series, there will be a survey and analysis of current scenario planning efforts in the Delta (Activity 2). The survey will employ social scientific methods of qualitative analysis and draw on concepts and frameworks from the decision sciences, psychology, and futurism to systematically explore and characterize organizational-level treatments of uncertainty in scenario planning processes. Discussions with diverse interested or affected parties will complement this survey to elucidate additional contextual variables that shape the design and implementation of scenario analysis exercises, and also generate further understandings of how deep uncertainty is understood at the individual level by scenario planning experts and stakeholders (Activity 2). Further analysis will explore linkages between individual-level concepts and organizational-level treatments of deep uncertainty in current programs and planning processes (Activity 3).

Results and insights gained through the first three activities will be summarized in a report, along with recommendations 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 (Activity 4). Recommendations could inform new analyses, simulations, and strategic scientific plans by agencies and other activities to anticipate and prepare for the future. Finally, the capstone of this initiative will be an interactive workshop designed to increase understanding of techniques from the decision sciences, futurism, and related fields (Activity 5). The workshop will provide training and concrete skills that can support applications of these scientific techniques and/or implementations of recommendations made in the report.

1. Public seminar series to:
    a. Introduce concepts of future thinking
    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
2. Survey and qualitative analysis systematically characterizing and critically evaluating existing Delta scenario planning exercises through an interdisciplinary decision science and futurism lens.
3. Discussions with parties who are interested or involved in developing and/or using scenarios (e.g., scientists, managers, policymakers, planners, Tribes, community activists/organizers, etc.).
4. Joint Delta ISB-DSP report synthesizing findings of activities 1-3 above, with recommendations to improve science of scenario analysis to inform decision-making under deep uncertainty in the Delta.
5. Interactive workshop to engage interested or affected parties in understanding/exploring applications of futurism and implementation of recommendations made in the report.

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