Scenario Development

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WHAT ARE SCENARIOS? The definition by the Intergovernmental Panel on Climate Change (IPCC) best represents scenarios considered in the natural sciences:"A scenario is a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold." Scenarios are descriptions of possible alternatives of the future that take into account the interaction different components of a complex system. Although scenarios are not forecasts or even predictions of the most-likely alternatives, they provide a dynamic view of the future by exploring various trajectories of change that lead to a number of possible alternative futures. Because unique and unanticipated conditions have more chances to occur over a long period of time, long-term scenarios have more uncertainty than short-term scenarios. A scenario typically takes the form of a narrative, with the main component being clearly stated assumptions about the critical forcings of a system – the key variables that largely influence the outcome of a system. One example of a scenario narrative is one labeled "WISHFUL" where there is no significant increase in global mean temperatures, precipitation moves back to the trends of the 1980s, and voluntary conservation of water and energy resources is effective. An alternative scenario might be labeled "DOOMSDAY" where temperatures increase eight degrees C, mean precipitation generally decreases in the southwestern US and becomes even more variable and regional population grows ten percent per year and consumes water and electricty at higher rates than in the past. And of course, there are many more reasonable scenarios somewhere in the middle. How are Scenarios Used? Scenarios are used to assess potential risks and opportunities, understand impacts stemming from alternative outcomes, and identify approaches to respond to risks and opportunities that may occur in the future. They can also be used to identify differences among disciplines in how they "see" the present, as well as future possibilities. Because of the uncertainty inherent in describing the distant future, the precise outcomes of an individual scenario are not as useful as general findings that are consistent across several scenarios. Types of Scenarios Exploratory Scenarios (or Future Forward Scenarios)Exploratory Scenarios describe the future according to known processes of change and extrapolations from the past by incrementally progressing through time. Examples are future trend-based scenarios; i) based on extrapolating trends, cycles, and other patterns that have been experienced over some past period (Projective Scenarios), or ii) incorporating changes in processes or patterns that significantly vary from the past (Prospective Scenarios). Exploratory scenarios rely on logical induction, by using clues from the past and present and working out the pathways that the future may take.Anticipatory Scenarios (or Future Backward Scenarios)Anticipatory Scenarios correspond to a highly subjective specific future that is achievable or avoidable only if certain events or actions take place. These scenarios may begin with a Perfect Future that includes the conditions that people would like to occur, or with a Problematic Future that includes conditions that people would like to avoid. Examples are policy-responsive scenarios based on critical issues and constructed with the desired policy as the targeted future outcome. Anticipatory scenarios rely on logical deduction to work backwards through time to determine combinations of different events or choices that can achieve the envisioned future, although they may be supported by working iteratively from points earlier in time.Strategic ScenariosStrategic Scenarios are aimed at identifying inconsistencies in the approaches used by different disciplines to describe components of a complex system. The emphasis of strategic scenarios is on making explicit the assumptions, patterns, and data selected by each discipline. For example, hydrologists often assume that climate is stationary, while climatologists assume it is non-stationary; each assumption has different implications for describing how the future might evolve in a large river basin. Categories of ScenariosScenarios components typically differ across scientific disciplines:

Climate scenarios: based on climate projections and designed to represent future climate to investigate potential impacts of anthropogenic climate change

Socio-economic scenarios: characterizing demographic driving forces, evolution of institutions, and the sensitivity, adaptability, and vulnerability of social and economic systems

Environmental scenarios: considering future environmental factors/conditions threatening natural ecosystems and environmental consequences of land use and other practices

Water resources scenarios: accounting for water’s importance in human survival, ecosystems management, economic activities, agriculture, power generation, and various other industries HOW SCENARIOS ARE DEVELOPED: PHASES OF SCENARIO STUDIESThe development of scenarios inherently involves substantial stakeholder interactions and/or expert judgments. Scenario development is an iterative process with several progressive phases: scenario definition, scenario construction, scenario analysis, scenario/risk assessment, and risk management. Definition phase identifies the specific characteristics of scenarios that are of interest to decision makers such as the spatial and temporal scales of the scenario effort, whether the future is considered to be merely a trend of the present or have the potential for a paradigm shift in system behavior, and most importantly, identies the critical forcings – the key parameters that drive the systems under study. The driving forces most aligned with a scenario are those that are most relevant to the scenario theme, are very responsive to changes, and have a certain degree of predictability. Some aspects may be restricted by standard practice (such as specific rates of population growth used in economic development studies), while others are determined by predetermined events, boundary conditions, or end states. Effective scenario definition results from discussions among stakeholders and researchers. Post-audits of past scenarios, compared with observations, can identify whether past perspectives were too narrow and should be conceived more broadly. Scenario Construction involves fleshing out the scenario definition with detailed quantitative and/or qualitative

information that will subsequently be analyzed for impact assessment. For exploratory scenarios, the models proceed forward in time from defined boundary conditions. For anticipatory scenarios, models are run iteratively toward defined end states, or proceed backwards from the end states. Important steps in this phase include: definition of the conceptual models, collection and assembly of appropriate data sets, and implementation of suitable computational models. Significant effort is required to collect and process data that can be used by models, including adjusting data to different time or space scales. Scenario Analysis focuses on identifying the consequences of interactions among the boundary conditions, driving forces, and system components. Scenario analysis is primarily a scientific effort, employing a variety of statistical and other analytical techniques to examine the scenarios constructed in the prior phase. Activities include: analysis of model outputs, inspection for data consistency, and the quantification of uncertainties associated with the scenarios. Model outputs are converted into the desired form (such as peak daily streamflows) identified in the scenario definition phase, and adjusted to different time and space scales if required. Scenario analysis also identifies notable system conditions or behaviors, including trends, regimes, thresholds and triggers, discontinuities, and cascading effects. Quantification of uncertainty can take many forms, but should include consideration of model uncertainty, inherent uncertainty, and the dispersion of certainty due to the passage of time. Scenario Assessment includes identifying risk, mitigation opportunities and tradeoffs, presenting results to stakeholders, and implementing and monitoring of scenario plans and strategies. This phase extracts a set of narratives from the outcomes of the scenario analysis phase, and examines the implications for resource management and other decisions. The proper focus is on the patterns identified in the scenario analysis, rather than specific numbers or end states, and cognitive filters that may bias assessment results. Crossing into the realm of risk assessment, scenario assessment uses techniques from that field, including influence diagrams, event trees, outcome matrices, contingency planning, cost/benefit analysis, Delphi techniques, normative tables, and vulnerability assessment, among others. Scenario assessment relies on extensive discussion among stakeholders and researchers, although finding effective ways of presenting information remains a challenge. Risk Management is the responsibility of stakeholders, not scientists. Risk management encompasses the implementation of strategies for reducing vulnerabilities to risk, increasing resiliency to problematic conditions, and positioning resources to exploit opportunities. While many risk management techniques exist, not all may be practical in a specific situation. The risk management options that are available set limits on subsequent scenario definitions. Furthermore, not all risk can be eliminated and some residual risk will remain regardless of management practices.