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Supporting adaptation decisions through scenario planning: Enabling the effective use of multiple methods

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A B S T R A C T

Scenario planning is a technique used to inform decision-making under uncertainty, and is increasingly applied in the field of climate change adaptation and policy. This paper describes applications that combine previously distinct scenario methods in new and innovative ways. It draws on numerous recent independent case studies to illustrate emerging practices, such as far stronger connections between researcher-driven and participatory approaches and cycling between exploratory and normative perspectives. The paper concludes with a call for greater support for, and collaboration among, practitioners with the argument that mixed methods are most effective for decision-making in the context of climate change challenges.

1. Introduction

Projecting likely changes in climate and their consequent effects on resources and facilities is a significant focus for climate scientists and adaptation specialists. Using this information, managers can assess threats and more effectively allocate resources. However, projecting future climate always has a degree (sometimes large) of uncertainty, given current capabilities and the realities of complex systems (Kirtman et al., 2013). And while tempting, choosing only to focus on more certain projections limits decision-makers' abilities to effectively and appropriately prepare for climate change. Consequently, decision-makers are embracing scenario planning (SP), a technique that recognizes the limits of projections, acknowledges

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deep uncertainty, and helps managers prepare for future conditions outside currently observed trends (Maier et al., 2016; Walker et al., 2003).

SP is a practical way to explore a range of future states and consider alternative response options (Peterson et al., 2003). The process creates a limited set of alternative futures (scenarios) that span key uncertainties, providing a foundation for discussions about policy development, the relative efficacy of management options, innovation, and community visions. Scenarios are not predictions, and the process does not assign likelihoods to particular future conditions. Rather, SP broadens conversations to include a range of potential responses, encouraging organizations to act despite uncertainty and retain flexibility in preparing for an unpredictable future (Maier et al., 2016; Weeks et al., 2011).

Scenario approaches have proved beneficial to organizations and communities grappling with climate and other global forces (Means et al., 2005), and SP is increasingly recommended in climate change adaptation planning and policy (NFWPCAP 2012, USGCRP 2011). Simultaneously, the diversity of scenario methods poses challenges for practitioners and scientists, creating confusion and often hindering more extensive application. To address this need for clarity and guidance, SP researchers and practitioners from the US and Canada gathered at the University of Arizona in March 2015 to discuss varied and emerging methods of scenario development in climate adaptation planning (Garfin et al., 2015).

Case studies (Table 1) revealed that previously distinct approaches to SP are evolving as practitioners integrate them with other tools to address strategic issues relating to climate change. Participants concluded that scenarios are most effective when they incorporate both divergent and convergent processes, encouraging the generation of multiple possible futures as a prelude to focusing on a preferred future or set of options.

2. Distinct scenario approaches

Given the scope of scenario work and variety of methods, much effort has been placed on creating typologies that emphasize distinctions between scenario approaches (Wilkinson and Eidinow, 2008; van Notten, 2006). We review the essential features of these distinctions, then demonstrate their blending in recent climate change adaptation efforts.

Table 1
SP methods highlighted at the March 2015 workshop.[1]

Organization/agency/lead	Method(s)/ownership of process	Purpose of scenarios
A. National Park Service/Jonathan Star, Leigh Welling (Weeks et al., 2011; Rose and Star, 2013)	Climate Change Response Program: Combines expert climate analysis (development of a climate drivers table and synthesis of projected impacts) with participatory engagement to create, assess, and identify responses to scenarios	Describe several plausible futures that facilitate the definition of goals (desired conditions) and management options under changing circumstances to inform existing planning/decision processes
B. Adirondacks Futures/David Mason & Kathy Hornbach (Mason and Herman, 2012)	Futures Mapping: Participatory process, involving diverse sectors, built from intensive input solicited in advance to develop events used to create pathways to desirable and undesirable end-states	Determine desired outcome(s) for a chosen planning horizon to enable monitoring of events that must occur to lead to that outcome and identify corrective actions to counter undesirable outcomes
C. Southwest Climate Change Initiative/Multiple Applications (Cross et al., 2012, 2013)	Adaptation for Conservation Targets (ACT): Draws on existing climate projections, climate experts and topical research to develop scenarios that are applied in a practitioner-dominated participatory process	Consider impacts of multiple climate change scenarios on species, habitats, processes and their existing conservation goals to determine if and how to alter management
D. New Mexico Mid-region Council of Governments/Aaron Sussman (MTB, 2015)	Land Use & Transportation Planning: Combines normative land-use SP with travel-demand and land-use models (e.g., UrbanSim), plus participatory climate change SP, building from U.S. Bureau of Reclamation projections of future regional climate conditions (2013) (e.g., changes in water supply/demand, flooding, fire risk)	Generate a preferred scenario for 20-year growth that is also resilient to climate impacts, produces low GHG emissions, and improves air quality in the Albuquerque, NM area
E. Utilities in City of Colorado Springs, CO/Casey Brown (Brown et al., 2011; Moody and Brown, 2012)	Decision Scaling: Employs a decision-analysis framework (often participatory) to identify a subset of climate scenarios based on climate sensitivity (stress test) of the decision model from the complete set of GCM projections. Combines quantitative techniques of stochastic analysis to test system performance under a wide range of conditions (decision thresholds) to determine which climate projections to apply in risk estimation	Identify best option for water resource systems, conditioned on the weight of climate-projection-based evidence. Climate projections are used to develop risk-based weightings for prioritizing among options (consequence analysis), rather than characterizing risk
F. Communities in Vancouver Canada area/Stephen Sheppard (Sheppard et al., 2011)	Participatory, community-level involvement in scenario building using structured visualization supported by expert integration of data and modeling, including climate-change projections and local geospatial information	Visualize future climate-change scenarios and their impacts, and explore alternative solutions to facilitate community engagement and build awareness/capacity to support decisions

[1] Presentations are available at the workshop website: http://ccass.arizona.edu/spworkshop.

2.1. Who owns the process?

A key distinction in scenario approaches pertains to *who "owns" the process*.

2.1.1. Researcher-driven processes

In *researcher-driven* approaches, experts drive scenario development, with an objective of providing rigorous descriptions of plausible futures, including details that are well supported by available science. In climate change research, the scenarios familiar to most are climate model projections of changes in temperature, precipitation, and other climate variables (such as in the 2007 Fourth Assessment Report of the IPCC).

Scenarios generated using researcher-driven methods can be quantitative, quantitative, or both, and they can use any combination of models, narratives, and visualizations in their construction. For example, climate-model projections are often referred to as scenarios and are quantitative output from a model, in the form of dynamic sensitivity analysis—the response of the climate system to changes in greenhouse gas emissions. However, qualitative processes can also be used in conjunction: qualitative narratives are often developed as input to the model, representing alternative population growth levels, land use, energy use, and technologies (e.g., for IPCC [Nakicenovic et al., 2000; Moss et al., 2010]); qualitative researcher-driven scenarios can also explore how these future climate conditions might then affect socio-ecological systems.

Qualitative researcher-driven processes were also at the heart of Royal Dutch Shell's pioneering scenario processes—exploring 'what-ifs' and remote possibilities in energy futures to generate innovative thinking rather than prepare narrowly for more probable futures (Shoemaker and van der Heijden, 1992).

The combination of quantitative and qualitative elements can occur through construction of the initial qualitative storylines, in quantitative analysis with respect to their impacts on resources, through integrated analysis of the implications for decisions, or communication of management options and associated monitoring efforts (e.g., Van Delden and Hagen-Zanker, 2009). A more common approach, as noted, is to begin with quantitative projections to stimulate qualitative analyses of the implications for decisions, monitoring, and resource management (e.g., Cross et al., 2013).

2.1.2. Participatory processes

In *participatory* approaches with decision-makers or stakeholders, scenarios are both the framework and process to allow groups to reach agreements and make decisions. Another objective is diverse engagement, with attendant benefits of developing common understanding and community-building that fosters broader acceptance of the ultimate outcomes.

Participatory scenario processes engage more people potentially affected by a decision than researcher-driven approaches (Wright and Goodwin, 2009). They facilitate conversation to stretch thinking, overcome mental roadblocks, and dissect complex issues. Most start with clarification of project goals and identification of the most relevant and uncertain drivers of system change. From there, participants create frameworks and develop scenarios. They incorporate what is fairly certain about the future (e.g., warming temperatures), what is less clear (e.g., precipitation amounts or timing, changing development patterns), implications of these future conditions, and the events that might connect them. Because participatory scenario building relies less on probabilistic modeling, the resulting scenarios are not limited by data availability and can focus on extreme outcomes (rather than variation within known bounds based on past experience). Groups apply these alternative scenarios to the challenges facing their organizations and communities, illuminating potential negative consequences and opportunities. The conversations culminate in suggested actions and changes in strategy.

While researcher-driven scenarios are typically given to others to apply, participatory SP yields groups who are more invested in the process and hence more likely to engage in or support suggested actions (Kirchhoff, 2013; Lemos et al., 2012; McNie, 2012, Tang and Dessai, 2012). Joint learning helps stakeholders transition from feeling overwhelmed by the range of possible futures to agreeing on steps forward, as with our Tucson Water case, a municipal utility that used SP to identify solutions to adaptively deal with future uncertainties in water supply/demand (Scott et al., 2012; Marra and Thomure, 2009).

2.2. Why create scenarios?

A second distinction in types of SP approaches concerns the purpose of the approach itself, or *why the scenarios are created*.

2.2.1. Exploratory scenarios

Exploratory scenarios describe a range of diverse, possible futures, with scenario teams working to assess the consequences of specific decision options. A central purpose of such scenarios is to disclose the potential consequences that different futures pose. Typically, the desired outcome is a revised strategy, policy, or perspective, and all created scenarios are deemed plausible and equally considered.

Organizations and communities craft exploratory scenarios to help them prepare for future prospects, no matter how attractive or unattractive the conditions. In this approach they implicitly acknowledge they cannot control the major drivers of change; their task is to identify potential limits to achieving goals and objectives, then prepare or adapt as effectively as possible for a range of futures. Essentially, groups "explore" the consequences of, and identify options to deal with these different futures.

The appeal of exploratory scenario approaches is the potential to identify robust management options—those effective under all or most future scenarios (Lempert and Groves, 2010). This is not always possible, and narrowing a wide range of options is often necessary (van der Heijden, 2005). A strategy that develops a portfolio of management actions responsive to different futures is often useful (Maier et al., 2016) and offers flexibility that transcends sampling from probability distributions. Some options may resemble the current course; others may represent a significant change in direction, such as the revision of management objectives to focus on process, inclusion, and flexibility over specific outcomes (e.g., Caves et al., 2013); others may aim at preserving future options (City of Tucson 2004). Regardless, identifying a portfolio of actions in the face of uncertainty is empowering and ultimately builds capacity to converge on effective adaptation decisions.

2.2.2. Normative scenarios

Normative scenarios, in contrast, work backwards from a collectively preferred future that reflects shared values of diverse stakeholders, identifying courses of action required to create that future. They are common in regional, land-use, and community planning. The process is often termed "backcasting"—identifying what must happen for that future to become a reality (e.g., Kok et al., 2011; Phdungsilp, 2011; Robinson et al., 2011). Kahane (2012) developed this thinking and labeled it *transformative scenario planning*, noting "its purpose is to enable those of us who are trying to change the future collaboratively to transform, rather than adapt to, the situation we are part of."

While normative approaches are a means to reduce uncertainty related to decisions that influence a shared system, there are always uncertainties beyond the control of any organization (such as climate change and economic drivers) which influence the ability to achieve a common vision. Because such external drivers can even hinder the objectives of individual groups/sectors, effective normative approaches must also embed adaptation to current and future conditions.

3. Evolution toward 'Mixed Methods'

Past scenario approaches were often distinct and discretely applied. Participatory approaches seldom used expert-driven scenarios, while researcher-driven scenarios generally paid little attention to involving wider groups of participants (Wright and Goodwin, 2009). Normative and exploratory approaches co-existed, but were kept separate. However, climate-change practitioners are now combining these into "mixed-methods" approaches (Fig. 1).

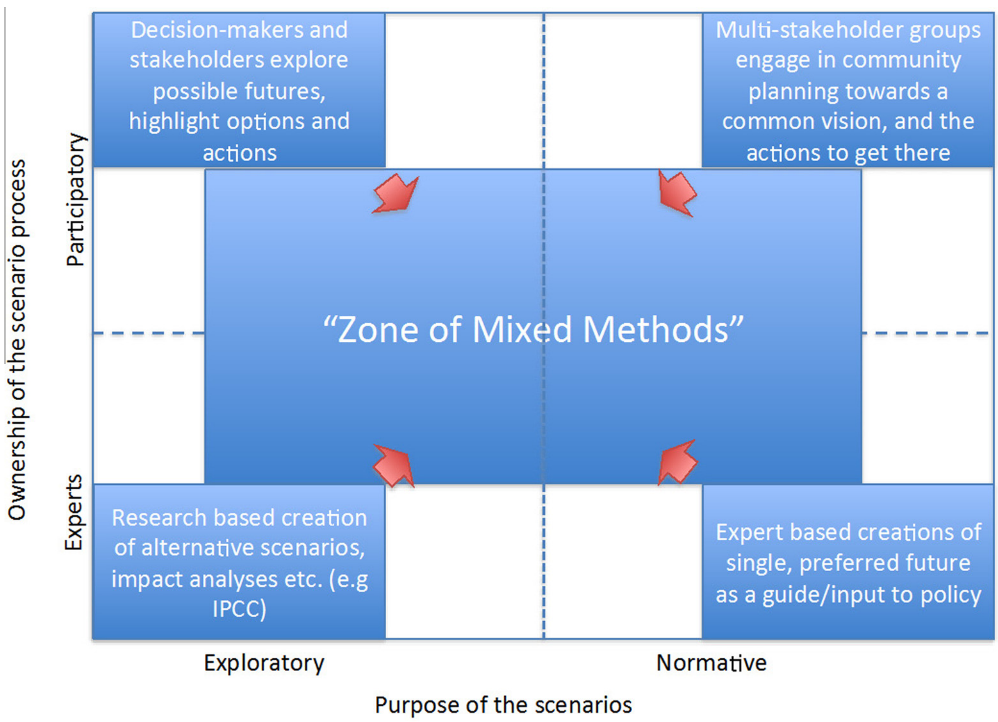

Fig. 1. The blending of previously distinct exploratory and normative scenario development into expert-driven and participatory SP processes to address climate change.

3.1. Case studies of combined approaches

Many of the cases studies reviewed in our workshop illustrate the emergence of mixed-methods applications, highlighted in Table 1.

For example, the Climate Change Response Program (CCRP) of the National Park Service (NPS) engages in SP efforts centered on park units across the United States (Weeks et al., 2011; Rose and Star, 2013). Provision of climate science/expert analysis integrated with input from park managers and other stakeholders is central to this work, improving communication and understanding between scientists and managers. NPS achieved this through expert-created "drivers tables," describing future projections for elements of climate and including forecast confidence assessments. This information supported participatory exercises in which park managers created and developed place-based scenarios, using these to test existing management approaches and identify future management options for their parks. Applications are shaping park management decisions on issues ranging from wildlife management to facility design.

Sheppard's scenario visualization case study also illustrates an effective combination of expert and participatory approaches. Sheppard and colleagues (2011) realized that participant engagement was an important objective in itself and invested in novel ways to present information for local decision-makers. They combined participatory scenario building with expert-driven data/model integration and multidimensional visualizations. For example, a snowpack animation converts a graph to an image of average snowline on the North Shore Mountains on a given date, promoting joint understanding of future threats and opportunities.

We also reviewed cases that combined normative and exploratory approaches, such as the Adirondack planning effort (Case B in Table 1). This process integrates stakeholder and expert perspectives to identify multiple plausible end states and the sequences of events that could yield such conditions. As groups discuss possible futures, they often converge on a preferred future that forms the basis of a community vision. In the Adirondacks, many citizens initially held conflicting positions but ultimately arrived at a path forward that facilitated improved outcomes in subsequent decisions.

3.2. Why this trend and to what benefit?

This integration of approaches is a logical evolution, given the complexities of dealing with climate change amid multiple other stresses. The breadth of affected communities, organizations, and other parties, and the need for methods tailored to a local area or issue (Maier et al., 2016; Rickards et al., 2014; Wilkinson et al., 2013) have fostered flexibility and innovation. Linking content experts in climate and impacts science with stakeholders who have contextual knowledge improves the identification of potential consequences and suitable responses. Merging scenario methods centered on the science with those aimed at fostering engagement and interactions simultaneously bolsters the credibility, salience, and legitimacy of information by (respectively) customizing technical inputs, including local knowledge, and acknowledging decision-making needs upfront (van Delden and Hagen-Zanker, 2009). Creating views of the future through combined engagement makes climate change more tangible than through consideration of quantitative outputs alone.

Many SP efforts for climate change adaptation *begin* with expert-created climate projections, globally or regionally downscaled (see Table 1, Cases A, C, E, F). Because scenarios created from climate variables alone generally lack the contextual details for decisions — from natural resource management (e.g., wildlife populations or water delivery) to community planning (e.g., ensuring a viable economy in agricultural communities) — researchers working in climate change adaptation are generating scenarios that integrate climate, socioeconomic, and environmental uncertainties. Integrating multiple sources of information and presenting them in a manner to encourage participation at local or landscape scales helps overcome perceptions that climate challenges are gradual and will not be felt for decades (Sheppard et al., 2011; Weeks et al., 2011; Cross et al., 2013).

In an increasingly complex world, the most effective SP practitioners will employ diverse methods to tailor scenario-based efforts to local climate challenges and decision needs. Complexity will surely remain in a future without precedent, while resources to create scenarios and generate adaptation strategies will be limited. Under high-complexity/low-resource conditions, it is important to design flexible scenario processes that draw on experience with a wide array of scenario approaches. Ideally lessons from one assessment process will feed into another, as envisioned for the sustained U.S. National Climate Assessment and as employed by other groups applying a climate change lens to their existing work (Wall et al., 2015). Financial and time constraints will require streamlined scenario processes, made into transferable products where practical. "Modular" process components for sharing among SP efforts can improve efficiency, if created to support practitioners in integrating approaches without causing confusion or undermining credibility of the process. NPS, for example, encourages the creation of regional climate scenarios for use by multiple park units. Future approaches will also benefit from connecting scenarios more closely with other decision tools, such as structured decision-making (Gregory et al., 2012; Nydick and Sydoriak, 2011; Martin et al., 2011).

4. Conclusions

'Mixed methods' that combine researcher-driven and participatory scenarios processes with normative and exploratory approaches hold great promise for climate change adaptation, with benefits already realized. These developments are in their infancy, as SP transitions from more effectively "making sense of a puzzling situation" (Bradfield et al., 2005) to developing strategies for climate change adaptation (Rickards et al., 2014). Given the developing nature of the field, both experienced SP facilitators and the growing number of practitioners new to SP will need to expand their knowledge of methods and applications.

These innovations in scenario approaches will enhance conversations and critical relationships among scientists, managers, and stakeholders, yielding new insights, and supporting the decision processes of organizations and communities grappling with climate change.

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