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Co-producing actionable science for water utilities

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ABSTRACT

This article explores the efforts of four water utilities to co-produce actionable science by forging partnerships with scientific institutions to explore integrating climate considerations into their specific management context. The experiences of these four utilities and their scientific partners, as part of the Piloting Utility Modeling Applications project of the Water Utility Climate Alliance, provide a wealth of empirical evidence to illustrate some of the core concepts formulated to explain how to produce usable information and how to link research to decision making. Through these four case studies of co-production, we identify three findings that bridge principles and practice: each utility engaged in contextualizing research; in building and leveraging knowledge networks; and in embracing an entrepreneurial approach to their research agenda. In several instances, unanticipated but innovative assessment techniques were developed by science partners in collaboration with water utilities to fit the utility's specific needs. The paper concludes by discussing some of the hard realities of co-production illustrated by these cases that should be kept in mind by people contemplating similar projects.

1. Introduction

Climate variability and change impact the provision of hydrologic services, including both water supply and water quality, and needs to be considered in the planning, management and operations of water utilities (IPCC, 2014; Groves et al., 2008). In order to adapt to, and plan for, climate variability and change, water managers need actionable and useful climate science. Useful information will help clarify options, expand alternatives, and improve outcomes to management decisions (Pielke, 2007). Too often, however, scientists produce too much of the wrong kind of information, not enough of the right kind of information, or fail to deliver useful information in a timely manner (McNie, 2007). According to Kundzewicz and Stakhiv (2010, p. 1085), "the current suite of climate models were not developed to provide the level of accuracy required for adaptation-type analysis" – and yet these models are today a primary source of information sought and used by decision-makers. Climate services are needed to improve the linkage between state-of-the-art climate information, generally from the peer reviewed literature, and users' information needs as they seek to build resilience and develop adaptive capacity to climate variability and change (Vaughan and Dessai, 2014).

Water utilities have been at the forefront of adapting to climate change since at least 1997, when the American Water Works Association, an international nonprofit scientific and educational society dedicated to the improvement of drinking water quality and supply, issued a statement expressing the need for water utilities to begin planning for the consequences of climate change (AWWA, 1997). Since that time, individual water utilities (e.g., EBMUD, 2009; NYCDEP, 2008; Palmer, 2007; Palmer and Hahn, 2002), water research foundations (e.g., Miller and Yates, 2006; Stratus Consulting and MWH Global, 2009; Woodbury et al., 2012), and water utility collaboratives like WUCA (e.g., Barsugli et al., 2009; Means et al., 2010) have pursued a serious agenda of understanding the implications of climate change for water resources that has generated a sizable body of work.

These efforts have culminated most recently in a research effort by the Water Utility Climate Alliance (WUCA)[1] explicitly aimed at exploring the co-production of scientific information that is useful for water utilities planning for climate change (Vogel et al., 2015).

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[1] WUCA is a coalition of ten of the United States' largest water providers that provides leadership in assessing and adapting to the potential effects of climate change through collaborative action, and seeks to enhance the usefulness of climate science for the adaptation community and improve water management decision-making in the face of climate uncertainty. See www.wucaonline.org.

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According to the final report of this research effort, "'co-production'…is intended to convey the idea that science in service of adaptation is not a one-way street, but a collaborative venture between scientists and decision-makers in which the needs and skills of each come into play throughout that collaboration" (Vogel et al., 2015). The authors continue, "Co-production requires an iterative, collaborative process across the borders between science and policy that draws upon the unique needs, experience, and even the limitations of each party, providing the strongest possible underpinning for societal action in response to the consequences of climate change" (Vogel et al., 2015). Effective co-production of information can lead to the development of new forecast products and models to address "real world problems" (Feldman and Ingram, 2010).

The four utilities that participated in the WUCA research experiment in co-production did so specifically to develop what they call "actionable science." WUCA members first presented a definition of actionable science at a 2009 U.S. Environmental Protection Agency adaptation conference (Behar, 2009). Subsequently, the term actionable science (or "actionable information" or "actionable knowledge" or "actionable climate science") has been embraced by the U.S. Army Corps of Engineers (USACE, 2012), a federal agency consortium called the Climate Change and Water Working Group (CCAWWG; Raff et al., 2013),[2] the U.S. Global Change Research Program (USGCRP, 2012), the Global Framework for Climate Services (WMO, 2011), the *President's Climate Action Plan* (Executive Office of the President, 2013) and Executive Orders 13653 (EO 13653, 2013) and 13690 (EO 13690, 2015). The term actionable science was most recently defined by the Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS), appointed to advise the Secretary of the Interior, as follows:

> Actionable science provides data, analyses, projections, or tools that can support decisions regarding the management of the risks and impacts of climate change. It is ideally co-produced by scientists and decision makers and creates rigorous and accessible products to meet the needs of stakeholders.
>
> [(ACCCNRS, 2015)]

Definitions of climate services, in turn, can vary, alternately referencing products and processes. The American Meteorology Society says climate services are "scientifically based information and products that enhance users' knowledge and understanding about the impacts of climate on their decisions and actions. These services are made most effective through collaboration between providers and users" (AMS, 2015). The World Meteorological Organization adds that climate services require strong partnerships between providers and users (WMO, 2015). Vaughan and Dessai (2014, p. 588) describe climate services as the provision of "timely, tailored information and knowledge to decision makers…[and are seen] as an important part of improving our capacity to manage climate-related risk". Therefore, unlike climate information in general, most agree that climate services consists of both information content and a procedural dimension by which the knowledge is co-produced to provide information for decision support. Climate services should "engage decision makers, researchers, and others to ensure that products are relevant [and] uncertainties are explicit…" (Moss et al., 2013, p. 697). This paper reviews the experience of four water utilities to explore the procedural dimension of climate services, which we describe as the co-production of actionable science.

The U.S. Department of the Interior's Advisory Committee published a "how-to guide" for the co-production of actionable science targeted at climate service providers seeking guidance on best practices (Beier et al., 2015). This guide, produced as an appendix to the ACCCNRS's full report and also as a stand-alone document, posited five guiding principles for co-producing actionable science in the climate services arena:

1. Actionable science is most reliably co-produced by scientists and decision makers or resource managers working in concert.
2. Start with a decision that needs to be made.
3. Give priority to processes and outcomes over stand-alone products.
4. Build connections across disciplines and organizations, and among scientists, decision makers, and other stakeholders.
5. Evaluate co-production products, processes, and the actionability of the science produced by projects.

2. Challenges in producing actionable science for climate services

Actionable science has three characteristics. First, it is salient, and context sensitive, reflecting the unique conditions and constraints of the problem in question (Cash et al., 2002). Second, it is credible, in that it was produced and vetted according to accepted standards of excellence and practice, including but not limited to peer-reviewed publications (Cash et al., 2002). And third, it must be legitimate in that the intended users of the information must believe that the information was produced without political suasion or bias. Legitimacy is grounded in the development and maintenance of relationships based on mutual trust and respect (Cash et al., 2002; McNie, 2007). Each of these three qualities needs to exist simultaneously and increasing one does not overcome shortcomings in another quality (Cash et al., 2002). Another dimension of actionable or usable science is that it is iterative, where engagement between producers and users of information must occur early, often, and throughout the duration of the project (Beier et al., 2015; Lemos and Morehouse, 2005) in what has been called a "symbiotic" relationship (Asrar et al., 2013).

Producing actionable science in a climate services environment is difficult to do for many reasons. Integrating climate information into planning processes is difficult because decision makers do not always know what information is best suited to inform their particular problem (Briley et al., 2015). Reconciling the supply of useful climate information with user demands is difficult to do, and often users do not get the information they need to address their unique problem (Moss et al., 2013; Sarewitz and Pielke, 2007). Despite efforts to improve the linkages between supply and demand, gaps between producers and users persist (Bierbaum et al., 2013; Kirchhoff et al., 2013; Vaughan and Dessai, 2014). Poor communication is another challenge in effectively linking climate information with user demands. Traditionally, communication between scientists and users has been one-directional, flowing from scientist to user (McNie, 2007). This "linear model" of science policy and the belief that usable information flows in just one direction has come under great scrutiny in the past 30 years (Kirchhoff et al., 2013). The linear model has frequently been found to fail because it does not connect the research process or its products to the needs of decision makers (McNie, 2008; Sarewitz and Pielke, 2007). A technical, but also cultural issue is that information that scientists produce is often at a temporal or spatial scale that makes it unusable for decision-makers (Asrar et al., 2013; Vaughan and Dessai, 2014). This tension is often accompanied by a corollary set of troubles caused by difficulties in communicating and understanding the uncertainties inherent in any climate projection exercise. And finally, culturally in particular, scientists and decision makers live in very different worlds, with differences in career incentives and promotional conditions, in approaches to

[2] CCAWWG members include the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the U.S. Geological Survey, the Federal Emergency Management Agency, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Environmental Protection Agency.