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The role of scientific expertise in local adaptation to projected sea level rise

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ABSTRACT

Adaptation to sea level rise (SLR) is primarily taking place at the local level, with varied governments grappling with the diverse ways that SLR will affect cities. Interpreting SLR in the context of local planning requires integrating knowledge across many disciplines, and expert knowledge can help planners understand the potential ramifications of decisions. Little research has focused on the role that experts play in local adaptation planning. Understanding how and when local governments undertake adaptation planning, and how scientists and scientific information can be effectively incorporated into the planning process, is vital to guide scientists who wish to engage in the planning process. This study aimed to establish how experts are currently involved in SLR planning, identify any gaps between planners' needs and expert involvement, and determine the characteristics of experts that are perceived as highly valuable to the planning process. We surveyed individuals involved with planning in a broad range of US coastal communities about SLR planning and the role that experts have played in the process. We found that SLR planning is widespread in cities across geographic regions, population sizes, and population characteristics and has increased rapidly since 2012. Contrary to our expectation, whether a SLR plan existed for each city was not related to the percentage of the population living on vulnerable lands or the property value of those lands. Almost all cities that have engaged in SLR planning involved experts in that process. Planners identify atmospheric scientists, oceanographers, economists and political scientists, and geologists as currently underutilized according to planners' needs. Members of these expert disciplines, when involved in planning, were also unlikely to be affiliated with the local planning government, but rather came from other governmental and academic institutions. Highly effective experts were identified as making scientific research more accessible and bringing relevant research to the attention of planners. Results from our dataset suggest that planners perceive local SLR planning could benefit from increased involvement of experts, particularly atmospheric scientists, oceanographers, economists and political scientists, and geologists. Since experts in these disciplines were often not affiliated with local governments, increasing the exchange of information between local governments and academic and other (non-local) government organizations could help draw valued experts into the planning process.

1. Introduction

A great deal of scientific scrutiny has been devoted in recent years to measuring the current effects and modeling the anticipated effects of anthropogenic climate change-induced sea level rise (SLR), which threatens coastal communities worldwide (IPCC, 2013; Nicholls and Cazenave, 2010; Strauss et al., 2015). Population projections coupled with SLR vulnerability estimates predict that 4.2 to 13.1 million people are at risk of coastal inundation from SLR by 2100 in the United States alone (Hauer et al., 2016), with associated mass population movements that would disrupt social systems far removed from the coast (Hauer, 2017). Adaptation planning by communities that can expect to be (or are already) affected by SLR may help to mitigate the socio-economic and ecological impacts of SLR and reduce the vulnerability of the

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public. Effective adaptation planning requires access to relevant scientific information to understand the problem (Adger et al., 2005). However, local governments have not responded rapidly to this potential threat: there were relatively few adaptation plans even in developed countries prior to 2009 (Berrang-Ford et al., 2011; Ford et al., 2011). When planning is undertaken, the interests of the policy and scientific communities often fail to align (Sarewitz and Pielke, 2007), or the available scientific information does not match what is needed by policy-makers (Pielke, 1995). Understanding how many local governments are undertaking adaptation planning, how planning proceeds, and how scientists and scientific information can be effectively incorporated into the planning process is vital to facilitate effective planning and guide scientists who wish to engage in the planning process.

Although effective adaptation planning can and should take place across multiple spatial scales with roles for different levels of government (Adger et al., 2005), thus far, much of the climate adaptation taking place in developed countries has occurred through the efforts of local or regional governments (Wheeler, 2008; Ford et al., 2011; Bierbaum et al., 2013). This local focus is partially a practical necessity: while sea levels are rising globally, both exposure and vulnerability to SLR will be hyperlocal due to geographical differences in physical risk factors and their interactions with local population factors (Hauer et al., 2016). Unlike climate mitigation, which has the greatest effect at the largest possible governance scale, most of the costs and benefits of local adaptation measures will be borne at the local level without necessarily causing spillover effects, either positive or negative, to other jurisdictions (Tol, 2005). In this way, local adaptation aligns more closely with the incentives of the public and local policymakers.

Even at the local scale, significant barriers to action may exist. Planners may perceive that climate change consequences are remote (Rasmussen et al., 2017), the public may not perceive sea level adaptation as necessary (Neumann et al., 2000), and although SLR is among the most recognizable consequences of climate change for local planners (Baker et al., 2012), the myriad potential ramifications of SLR for a given locality are not always apparent. SLR planning is a multi-faceted problem that encompasses many different disciplines including the natural sciences, social sciences, law, and governance. A local planner may be aware of the issue but have difficulty analyzing or accessing scientific information to understand the depth and scope of the problem and develop appropriate plans to meet these challenges (Moser and Luers, 2008; Fu et al., 2017). Experts from different disciplines collect scientific information in different ways (Mastrandrea et al., 2010), and transdisciplinary teams have been found to consistently present complementary information that is helpful in the policy process (Mastrandrea et al., 2010; Marshall et al., 2017).

Involving experts is one way that local planners can overcome the complexity of SLR planning and increase their awareness of potential impacts (Moser and Luers, 2008). A case study of coastal managers in California shows they are limited by the time and resources available for their staff to gather and assess relevant information and that they are interested in more interactive forms of learning such as opportunities to meet with scientists (Tribbia and Moser, 2008). However, they are currently more likely to get information from newspapers than scientific journals or local experts (Tribbia and Moser, 2008). It is increasingly recognized that the traditional ways of presenting scientific information are not adequate for the decision-making process but that information is also necessary for the planning process. Investigating the role experts play in SLR planning can expose the ways that scientific knowledge can be better incorporated into local coastal planning.

In this study, we use the term 'scientific information' to refer to any body of knowledge produced through research-based methods of inquiry and generated according to the methods that are broadly considered appropriate by practitioners in that field (Van Kerkhoff and Lebel, 2006). This definition of scientific information encompasses peer-reviewed journal articles produced in the natural sciences and spans literature from the social sciences, policy analyses, and other outputs that have not necessarily undergone a formal peer review. The terms 'scientists' and 'experts' are used herein interchangeably to refer to a wide range of individuals, including natural and social scientists, policy analysts, legal experts, and engineers, among other disciplines that are devoted to generating scientific information. Scientific knowledge historically carried a legitimizing force in the policy process (Weible, 2008), although it is increasingly recognized to be situated (Agrawal 1995). However, to the extent that local knowledge is generated through the same process as the research-based approach described above, it may very well fall within the boundaries of the scientific disciplines and conform to the definition of scientific knowledge used in this paper. As such, we did not explicitly distinguish between scientific and local expertise.

Here we present findings from a survey of city planners on how scientific expertise is integrated into local SLR adaptation plans, with the goals of summarizing the current state of the system and providing guidance on how scientists can best communicate research findings to assist in the planning process. Specifically, our research objectives were to:

(1) Test whether demographic and geographic characteristics of municipalities were associated with SLR planning. Adaptation planning is a function of adaptive capacity, which in turn may be influenced by local factors including education, population, and income (Brooks et al., 2005). Previous research has found (Pitt, 2010) or hypothesized (Cidell and Cope, 2014) that local voting behavior is associated with climate change-related policies. To the extent that populations that are most vulnerable to SLR accurately recognize and accept this vulnerability (Grothmann and Patt, 2005), we would expect to find a positive association between vulnerability to SLR and planning to mitigate this potential risk (Zahran et al., 2008).
(2) Identify expert disciplines currently represented in SLR adaptation planning and those for which there is a perceived shortage among local planners. If local governments are constrained in their capacity for planning to meet a multidimensional challenge like SLR (Moser and Ekstrom, 2010; Moser and Luers, 2008), we would expect local planners to under-utilize input from experts who are primarily affiliated with organizations outside of the local government, including academic institutions and other government organizations, such as state and federal government agencies.
(3) Identify which forms of involvement by scientific experts is most helpful in the planning process. Planners may find it valuable for scientists to explicitly incorporate planning-related questions into scientific research (Sarewitz and Pielke, 2007). In this case, we would expect for planners to place a high value on activities that help connect them to the scientific process, such as early involvement in research design, scientists conducting research at their behest or involving planners when authoring reports or co-analyzing data, and co-authoring reports. Alternatively, scientific experts may be more helpful later in process, playing a valuable role in interpreting scientific information in ways that are relevant for planners (Marshall et al., 2017; van Stigt et al., 2015). The role of the expert as a mediator between the scientific and planning processes may be enhanced if the expert becomes more involved in the broader planning process (i.e., by attending meetings in-person or maintaining regular communication with planners). We sought to determine which roles and activities of scientific experts are most useful for advancing adaptation planning to SLR.

2. Methods

To understand the role of scientific expertise in SLR adaptation planning for cities, we surveyed individuals involved in coastal planning in city governments from a sample of randomly selected coastal

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