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Aligning Climate Change Adaptation Planning with Adaptive Governance: Lessons from Exeter, NH

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Abstract: Adaptive governance has been recognized as an integrative approach for analyzing the social, institutional, ecologic, and economic aspects of decision-making to build resilience against climate change. Although closely aligned with adaptive co-management and ecosystem management, adaptive governance is a distinct framework that explicitly focuses on decentralized decision-making through social processes such as collaborative learning, networking, and the promotion of cross-sectoral partnerships to enhance adaptive capacity. In this paper, we explore an ongoing engagement process for climate change adaptation planning in Exeter, New Hampshire, and its alignment with key principles of adaptive governance. Climate change poses multiple challenges to Exeter, including increased flooding, reduced low flows, water quality degradation, and associated threats to estuarine ecosystems and public health. Engagement strategies include community conversations, workshops, experiential activities, and a community advisory board comprised of different stakeholder representatives (Citizens' Working Group) collaborating with the scientific team on water resources modeling and scenario analysis. We present important lessons about conveying expectations and timeframes of technical modeling to participants, developing multiple forums for interaction between researchers and other stakeholders, and making climate change locally relevant to residents by drawing connections to the community's experiences, cultural memory, values, and upcoming decisions. This study contributes to the literature on adaptive governance and climate change adaptation by evaluating stakeholder involvement in a local institutional setting, an important arena where adaptation decisions must be deliberated. It is also among the first studies to evaluate the ways in which a climate change adaptation stakeholder engagement process aligns with adaptive governance principles, particularly through boundary objects and experiences.

Keywords: *boundary objects, collaborative planning, community based participatory research, flooding, Integrated Water Resources Management, public health, resilience, transdisciplinary research*

Prior research has described community-based adaptation planning as "a bottom-up strategy that starts with changes and pressures experienced in peoples' daily lives" (Rayner and Malone 1997, 332). Similarly, adaptive governance is a concept that addresses the bottom-up evolution of institutions for the management of shared assets, particularly common pool resources and other forms of natural capital (Hatfield-Dodds et al. 2007). Adaptive governance has been defined as the "evolving and locally context-specific balancing and integration of alternative interests through participatory engagement between governments and communities facilitated by the integration of local and scientific knowledge" (Nelson et al. 2008, 4). It has been recognized as an integrative approach for analyzing the social, institutional, ecologic, and economic aspects of decision-making to build resilience against climate change (Garb et al. 2008; Lynch and Brunner 2010; Raynor and Malone 2000). Although closely aligned with adaptive co-management (Armitage et al. 2007; 2008; Plummer and Armitage 2007) and ecosystem management (Szaro et al. 1998), adaptive governance is a decentralized decision-making process that uses techniques such as collaborative learning, networking, and promotion of cross-sectoral partnerships (Brunner 2010; Kallis et al. 2009). It is a response to the failure of top-down, expert-driven approaches to decision-making to successfully address complex socioecological problems such as climate change. Adaptive governance "suggests factoring the global climate change problem into thousands of local problems, each of which is more tractable scientifically and politically than the global problem" (Lynch and Brunner 2010, 6). Cash and Moser (2000) underscored the critical gap between the top-down assessments of the Intergovernmental Panel on Climate Change (IPCC) that aim to understand large-scale phenomena and the contextualized initiatives that enable local decision-makers to adapt to the local-scale impacts of climate change. They described the need for decision-support processes that provide: "(1) multiple connections between researchers and decision-makers that cut across various levels (polycentric networks)" of governance; and "(2) sustained and adaptive organizations that allow for iterated interactions between scientists and decision-makers" (Cash and Moser 2000, 242).

It is important to emphasize that adaptive governance, like other governance approaches, utilizes science to inform decision-making. However, adaptive governance is distinguished by the types of knowledge considered to be policy-relevant and the engagement processes through which knowledge is integrated with decision-making (Nelson et al. 2008). Although there is no comprehensive synthesis of best practices for researchers wishing to facilitate adaptive governance through their work, Dietz et al. (2003; 2013) and Nelson et al. (2008) provide guiding principles. These include: 1) clarifying common goals with stakeholders; 2) building on local communication and governance structures; 3) seeking out and integrating local knowledge; 4) balancing complementary knowledge systems (e.g., local knowledge and scientific/external knowledge) to inform planning and policy processes; 5) implementing, evaluating, and refining policy in local contexts; 6) transferring lessons learned across local, regional, and national contexts.

While many studies have explored the viability of an adaptive governance framework for complex and uncertain multi-stakeholder resource management problems, very few studies have evaluated its applicability to community-scale climate change adaptation planning. This study contributes to the literature on adaptive governance and climate change adaptation by evaluating stakeholder involvement in a local institutional setting, an important arena where adaptation decisions must be deliberated. It is among the first studies to evaluate the ways in which a climate change adaptation stakeholder engagement process aligns with adaptive governance principles.

In this paper, we present a case study of an ongoing engagement process developed for the Climate Adaptation Plan for Exeter (CAPE) project. The overall CAPE project objectives are to: (1) develop a science-based, integrated climate change adaptation strategy for Exeter; and (2) implement, evaluate, and document the collaborative planning process and share the project results as a model for other coastal and estuarine communities. In this paper, we focus on the second objective by examining the extent to which our community engagement process aligns with key principles of adaptive governance. We explore adaptive governance as a framework for adaptation planning because stakeholders themselves identified several principles of adaptive governance as valued outcomes of the CAPE project (e.g., bringing together diverse stakeholders, connecting scientists with citizens and community groups, meeting regularly with citizens, and sharing knowledge). Specifically, we address the following research questions in this paper: 1) what were the challenges and opportunities associated with aligning these engagement strategies with adaptive governance principles, and 2) what lessons were learned that might enhance future adaptation planning efforts in community contexts? Documenting our engagement process in a case study format aids in clarifying the social relationships and institutional factors that will influence the final outcomes of the CAPE project, including which climate change adaptation strategies are ultimately pursued by the community.

Case Study

The Great Bay National Estuary Research Reserve (GBNERR) is located in southeastern NH and includes 20,172 acres of open water, wetlands, and upland zones. The 1,084 mi^2 watershed that drains into the reserve is heavily forested and has extensive wetlands, but is also becoming increasingly urbanized (currently 9% of the watershed area) (Mills 2009). The major climate change stressors in the region include increases in air and water temperatures, sea level rise, and changes in precipitation and runoff patterns, including larger storms and floods.

Our transdisciplinary team comprised of social and biophysical scientists, engineers, and town staff, is undertaking a collaborative planning effort to develop an integrated climate change adaptation strategy for one of the towns situated on a river that drains into GBNERR in order to develop a prototype for managing the developed portions of the watershed under climate change. Specifically, the case study area is the portion of the Town of Exeter in the Exeter/Squamscott River Basin, which includes most of the town's area and is located just upstream of Great Bay (Figure 1). The Squamscott River, tidal in nature, is located downstream of the dam in the center of the downtown.

Exeter's population is approximately 14,000, with over 18% of the population over the age of 65 (U.S. Census 2010). The median household income is $74,350 (NHES 2015), although there is diversity in socioeconomic status and housing conditions. For example, there are approximately

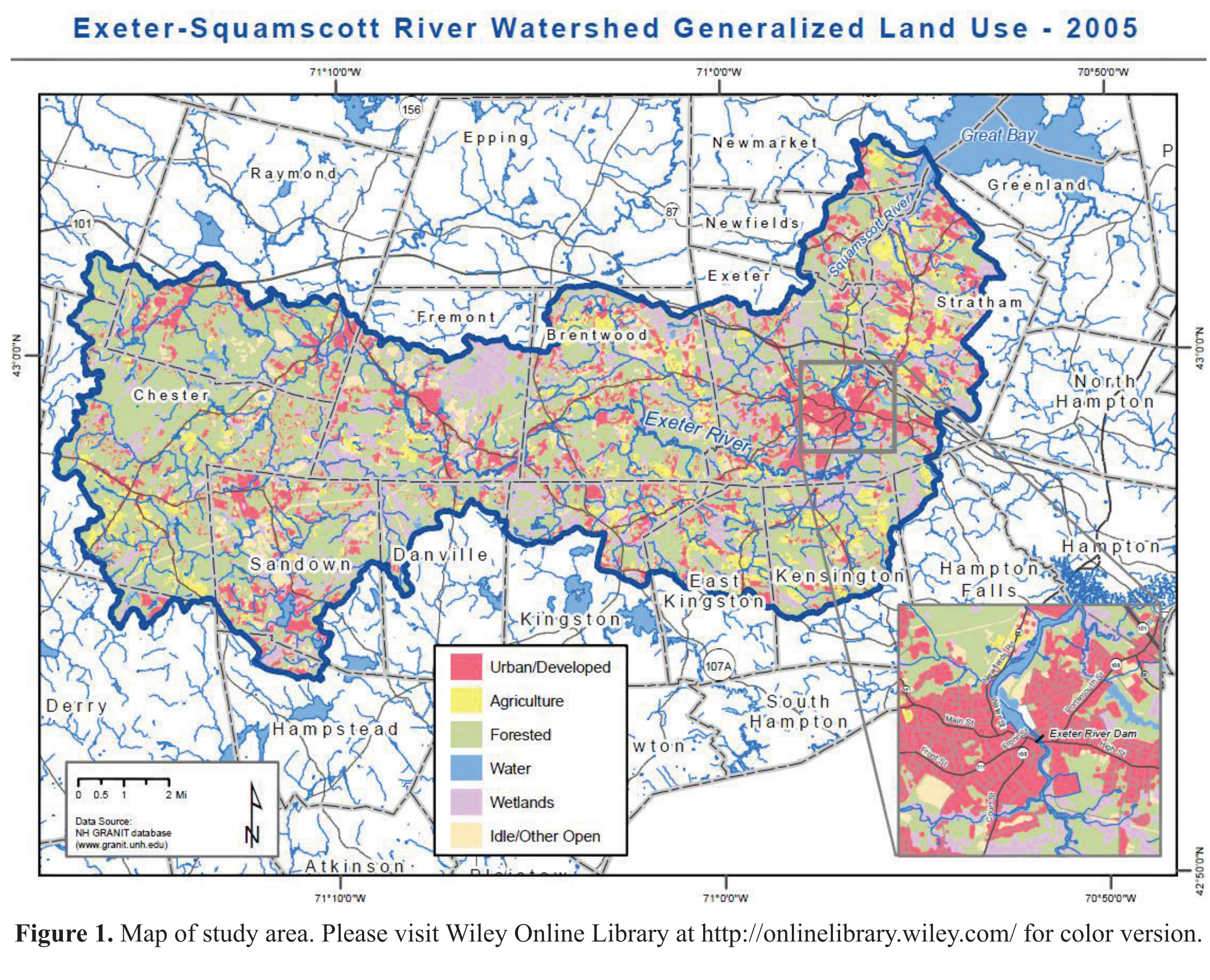

Figure 1. Map of study area. Please visit Wiley Online Library at http://onlinelibrary.wiley.com/ for color version.

901 manufactured housing units, many of which are highly vulnerable to flooding.

Climate change will exacerbate Exeter's present challenges related to: 1) tidal and non-tidal river flooding, 2) stormwater drainage, 3) nonpoint source pollution and water quality, and 4) the protection and restoration of downstream marshes and fisheries. These challenges were identified in the proposal phase by reviewing recent studies for the area (Mills 2009) and consulting with town officials. These stressors related to climate change also have the potential to significantly impact public health (e.g., injuries and illnesses associated with flooding and exposure to contaminated water, the stress associated with possible evacuation, and the risk of being stranded in flooded neighborhoods without access to medical and social services). Since the water-related stressors in the case study area are interconnected, they can be most effectively managed in an integrated fashion. To help translate climate change and sea level rise into impacts on the community, the team employed flood, stormwater, hydrologic, and water quality simulation models. Additionally, they are developing a flood adaptation decision-support tool and an ecosystem process model.

Alignment of Engagement Strategies with Adaptive Governance

To examine the alignment of our engagement strategies with adaptive governance, we will review how each of these strategies functioned as a **boundary object** and/or a **boundary experience**. A **boundary object** is typically described as a product (e.g., map, model, field notes, images, and other types of information) that different stakeholder groups can use in different ways to share knowledge (Bowker and Star 1999) and interact with the study team (Cash et al. 2002; 2006). Boundary objects aid in the translation of information by providing common points of reference for dialogue (Chrisman 1999) and drawing attention to different interpretations and meanings (Fischer and Reeves 1995). Boundary objects can aid decision-making in situations of incomplete knowledge, nonlinearity, and diverse interests (Mollinga 2008; 2010). They can also include intermediate versions of a product that stakeholders can react to and agree upon before the final version is developed (Marick 2014; Star and Griesemer 1989; Wenger 1998). For example, in the CAPE project, several iterations of GIS maps showing locations that were vulnerable to flooding under different climate change scenarios were shared with town staff and other stakeholders. The map content and format were adjusted to reflect stakeholder input, so that the final versions were acceptable to town staff, researchers, and other community members. Boundary objects are flexible enough to adapt to local needs, but retain enough immutable content to maintain integrity across applications (Star and Griesemer 1989; Wenger 1998).

The role of boundary objects in adaptive governance has been widely discussed in the literature (Carlile 2002; Folke et al. 2005; Garb et al. 2008; Fuller 2009; Brunner and Lynch 2010; Crona 2012). Boundary objects are used to develop a shared language that enables stakeholders to cross disciplinary or cultural barriers (Carlisle 2002, 446). They also offer stakeholders a new vocabulary to discuss problems and a foundation for re-framing concepts to align with multiple perspectives (Fuller 2009, as cited in Kallis et al. 2009, 637; Lejano and Ingram 2009). Importantly, this new vocabulary helps to facilitate conversations between scientists and other stakeholders.

A **boundary experience** is a term developed by our engagement team to explicitly call attention to the dynamic and iterative process through which groups of stakeholders share knowledge and co-produce boundary objects with the project team. While this procedural component has been implicit in prior scholarship pertaining to boundary objects (Carlile 2002; Lejano and Ingram 2009; Munaretto et al. 2014), we contend that it is helpful to recognize it explicitly so that the dynamic interplay between process and product - the essence of transformative social learning (Pelling et al. 2008; Parkins and Mitchell 2005) - can be more critically evaluated. We found that some of the greatest challenges and opportunities of our engagement process were situated at this nexus.

Engagement Process

In transdisciplinary research on community resource management problems, there is a growing expectation for community members to be actively engaged in the research process (Commonwealth of Australia, 2008). The CAPE project utilized a Community Based Participatory Research (CBPR) approach (Israel et al. 2005), in which community stakeholders partner with the research team on all aspects of the project including clarifying goals, refining the methodology, and interpreting results. While CBPR is widely utilized in public health to improve the adoption, implementation, and sustainability of community-based interventions, its application to adaptive governance and its relevance for promoting specific researcher-stakeholder interactions supportive of democratic decision-making remains inadequately explored. Thus, we chose CBPR over other approaches to examine its application to a climate change adaptation planning process, and to enable researchers and stakeholders from different disciplines to learn about how engagement approaches commonly used in public health may translate across sectors to inform water-related decisions.

Specific engagement activities utilized during the first 18-month phase of the project included community conversations, workshops, and experiential activities (e.g., walking groups and field tours). In addition, we created a Citizens' Working Group (CWG) that provided direct feedback to the scientific team on water resources modeling and scenario analysis. Details about specific engagement strategies are described below, and in Table 1.

Community Conversations

The first community-wide CAPE engagement event was held in the spring of 2013, at Exeter High School. This was a "community conversation" in which team members from New Hampshire Listens (NH Listens) designed a deliberative dialogue entitled "Floods, Rains, and Rivers" to explore the community's values and perceived vulnerabilities associated with climate change. NH Listens works with local and statewide partners to bring people together for productive conversations that complement traditional forms of government meetings, such as town hall or school board meetings (NH Listens 2014). Recruitment was conducted through email, announcements at public meetings, advertisements, and personal contact. Additionally, project staff met with several key communities of interest prior to the event. **Communities of interest** are a community of people who share a common interest, goal, or knowledge about an issue (Henri and Pudelko 2003). These included a local retirement community, a resident-owned manufactured housing community, high school students, conservation groups, and a group of mothers with young children. In addition, staff of NH Listens trained a group of high school students as facilitators who helped to lead each small group discussion.

The participants (n=63) were split into nine groups, each of which was led by a facilitator from NH Listens and a youth facilitator to explore different issues and challenges facing the Exeter community. This event was designed as an opportunity for stakeholders to clarify goals, identify local assets, and discuss ideas to effectively plan for a changing climate. The narratives from the conversation were analyzed qualitatively and grouped into themes. Evaluation surveys indicated that the community conversation served as an effective boundary experience in terms of enabling participants to consider different perspectives and become better informed about local climate change issues. Of the survey respondents (n=40), 75% reported that they would participate in another community conversation.

Another activity initiated at this event was a mapping exercise in which participants identified "areas of importance" or locations where they perceived vulnerabilities for people, infrastructure, and natural resources. Participants marked these locations on large paper maps, which were subsequently developed into a GIS. This activity provided a visual snapshot of town assets and resources that could be impacted by flooding, and also generated a discussion in which at-risk populations (e.g., older adults) who might suffer stresses associated with extreme weather events were identified.

These tangible products served as starting points for developing indicators such as the location, depth, and areal extent of flooding of infrastructure, natural resources, and community places to inform the flood modeling. They have also proven useful

Table 1. Summary of lessons learned regarding engagement strategies, their function as boundary objects/experiences, and alignment with adaptive governance principles.

Engagement Strategy	Role as Boundary Object/Boundary Experience	Alignment with Adaptive Governance Principles
Community Conversations	• Explores the community's values and perceived vulnerabilities associated with climate change • Provides a forum for stakeholders to share perspectives, identify local assets, needs, and ideas to effectively plan for a changing climate • Generates interest in more sustained participation for subsets of stakeholders (e.g., Citizens' Working Group) • Promotes inter-generational dialogue • Initiates co-production of boundary objects such as maps, narratives, and inputs for models	• Clarifies common goals and different perspectives with stakeholders. • Promotes collaborative learning and social networking • Develops a foundation for analytic deliberation (structured dialogue involving scientists, end-users, and interested citizens, informed by analysis of key information about socio-ecological systems (Dietz 2003, 2013)
Workshops with Town Staff	• Enables the team to check in regularly with town decision-makers, and to identify individuals who wish to be more involved in certain stages of the modeling process (e.g., checking discrepancies) • Provides a mechanism for piloting and refining boundary objects (e.g., testing educational materials, explaining preliminary model results) • Promotes opportunities for the CWG and the research team to interact with town leadership	• Builds on local governance and communication structures • Enables climate change adaptation planning to be linked to specific local decisions • Supports multiple connections between researchers and decision-makers • Helps to ensure that scientific outputs will be viewed as credible, legitimate, and salient (Cash et al. 2002)
Experiential Activities	• Connects technical and non-technical stakeholders • Provides a 'bridge' to link various boundary objects with lived experiences (e.g., by connecting scientific information with community values and cultural memories; creating a diverse portfolio of activities that are not entirely dependent on model results) • Aligns with Carlile's (2002) pragmatic view of boundary objects as a means of representing, learning about, and transforming knowledge to support a public policy process	• Integrates complementary knowledge systems (e.g., local knowledge and scientific/external input) to inform planning and policy processes • Promotes collaborative learning and networking • Supports iterative interactions between scientists and decision-makers
Citizens' Working Group (CWG)	• Provides a forum for 'vetting' boundary objects and experiences and tailoring them for different groups • The CAPE CWG expressed interest in learning about what other communities in the state are doing in terms of hazard mitigation and climate adaptation planning. For example, other communities have enrolled in the National Flood Insurance Program's Community Rating System, which reduces insurance premiums in jurisdictions in which flood hazard mitigation activities are implemented (FEMA, 2014)	• Clarifies common goals and different perspectives with stakeholders. • Builds on local communication and governance structures • Facilitates connections between researchers and decision-makers across institutional levels (e.g., Board of Selectmen, Town Staff, clergy, and representatives of manufactured housing communities) • Integrates complementary knowledge systems • Supports transfer/exchange of knowledge with other communities
Modeling and Scenario Analysis	• Provide a scientific basis for adaptation planning; highly valued by stakeholders • Models may be communicated and shared with diverse groups by 'nesting' them within a portfolio of boundary experiences (e.g., community conversations, experiential activities, workshops) and linking them to other boundary objects, such as a decision support tool • Nesting may support adaptive governance by allowing stakeholders to connect future scenarios to past and present experiences, cultural memories, and town values	• Integrates complementary knowledge systems • Provides a foundation to support policy implementation and evaluation

as boundary objects because they translate local knowledge that the technical team can incorporate into scientific modeling efforts. The technical models have provided quantitative details about the depth and damage caused by present and potential future flooding, which augments this qualitative local knowledge.

This dynamic interplay of knowledge was iteratively improved through subsequent meetings and field tours with town staff. Other locations in the town where flood damages occur or could occur were identified, enabling the list of vulnerabilities to be continuously expanded and specified. For example, some of these additional locations included sewage pump stations, recreation areas, several culverts, and the new Gilman Pond well. Town emergency management staff identified areas that are cut off from emergency services during flood events. The team also mapped wetlands that will be threatened by increased riverine and coastal flooding as well as permanent sea level rise. Additional indicators of flood damages under present and future climates include the direct expected value of property and content damage costs to buildings, as well as indirect costs, such as evacuation expenses and lost work time.

Citizens' Working Group (CWG)

The CWG is a local stakeholder advisory board (n=20) designed to meet with the CAPE team on a regular basis. It includes representatives from the Exeter Select Board, local businesses, non-profits, faith-based organizations, the Exeter River Study Committee, and residents of various neighborhoods. Residents from manufactured housing communities, among the most vulnerable to flooding, are also represented. Participants were recruited at our community conversation; anyone interested was invited to join. Additional members were recruited through the University of New Hampshire's Cooperative Extension program.

This citizen input group was designed to enable the CAPE modeling team to develop products that are legitimate, credible, and salient for the community in order to align with the functions of boundary objects described by Cash et al. (2002). This resulted in boundary products that were useful for priority audiences: the town's decision-makers and the town boards that advise them. Nine meetings were held over the first 18 months of the project. Evaluation surveys demonstrated that the overall response to the CAPE team's preliminary models was good; the team scored an average of '4' on a scale ranging from 1 (poor) to 5 (best). Notably, participants reported substantial improvement in the researchers' use of clear language over the 18 months (e.g., less technical jargon, more understandable words). Prior research has shown that clear language is a key feature of successful boundary objects (Clark et al. 2011). Respondents commented that the information being produced by the CAPE project was extremely important to the town.

Workshops with Town Staff

In 2012 and 2013, the CAPE team held meetings with town staff and CWG members. The 2012 meeting provided an opportunity for stakeholders and researchers to interact and discuss prior research about the impacts of climate change to the region. In 2013, the CAPE team hosted a half-day meeting at Exeter Town Hall to present the project's progress during its first year. This included reviewing the first year's engagement activities, discussing preliminary findings, and envisioning next steps. The primary audience was town officials, staff, and civic leaders, with approximately 25 people attending each workshop. Survey data (n=18) indicated that participants felt the meetings were successful overall. For example, using an ordinal rating scale, participants at the 2013 meeting reported that CAPE was very successful at promoting greater communication between groups in Exeter, increasing awareness of natural resources and how they relate to climate change impacts, and improving communication between scientists and citizens. Survey results also indicated that the workshop enabled participants to better comprehend both technical and outreach components of the project. When asked, "How can CAPE help you do your work/become a more informed citizen?", common themes among answers were to provide more information about the effect of climate change on natural resources such as tidal marshes, and provide information regarding the economic and social costs of storm impacts. Participants also wrote in suggestions for improving graphs and educational presentations that the team has since adopted. Another outcome has been the growing involvement of other town staff (such as emergency services personnel) fostered through informal networking opportunities at these workshops (Figure 2).

Experiential Activities

Aligning with Lejano and Ingram's (2009) view that successful collaboration depends upon continuous trust-building activities the CAPE team engaged in several activities to connect climate change to local experiences, cultural memory, and values. Two examples are described below.

a) ***Tour of Vulnerable Locations with Exeter Assistant Fire Chief.*** In August 2014, the Exeter Town Planner arranged a tour of the town with the Assistant Chief of the Exeter Fire Department to review vulnerable flooding locations. The group spent several hours identifying roads and homes that had experienced flooding since 1995. This tour was very valuable to the technical team because it enabled them to ground-truth the model results regarding the extent and depth of floods. Additionally, this tour provided important information about the flood response actions of residents that informed the development of an adaptation decision-support tool that the team is currently completing. For instance, the tour revealed some home flood-proofing measures that residents had adopted (e.g., sump pumps), which can be incorporated into the tool as an adaptation option. In addition, the tour enabled the project team to learn about the emergency services the town provides during floods, such as boats, rafts, swift-water rescue operations, and a limited number of generators to deal with power cuts that often coincide with flood events. During recent storms, residents living in certain neighborhoods have been stranded due to flooding of surrounding roads (Figure 3).

These images and narratives help capture the town's 'cultural memory' of these events. The experiences and images shared by the Assistant Fire Chief during the tour are types of boundary objects that will enable diverse stakeholders and the modeling team to consider how climate change may directly impact residents' daily lives.

b) ***Marsh Walk for Flood Elevations.*** In November 2014, the CAPE team led a walk with the CWG at a community park along the tidal Squamscott River to mark flood elevations with different colored flags representing three different sea level rise and coastal flooding scenarios (Figure 4).

This activity served as a very meaningful boundary experience. Several CWG members commented on the importance of being together outdoors, sharing knowledge about the importance of the marsh for ecosystem health, and using the flags to visualize the effects of different scenarios on this critical community resource.

Figure 2. The CAPE team delivers a Year 1 in Review presentation to the town on December 12, 2013.

Figure 3. Emergency personnel on Court Street during the March 16, 2010 storm.

Figure 4. The CAPE team and CWG members mark current and future flood height elevations associated with different climate change scenarios at Swasey Parkway.

This activity not only helped the team to connect with the CWG, but also created an interactive process that reinforced the community's values. During the initial community conversations, residents emphasized the importance of the marsh ecosystem as a nursery for fish and other wildlife (including the alewife, the town's symbol) and identified Swasey Parkway as an important place to exercise, spend time outdoors, and enjoy nature. Evaluation of experiential activities was conducted using visual analysis methods (Knoblauch et al. 2008) in which photographs were interpreted by participants and members of the research team.

Modeling and Scenario Analysis

As described previously, several hydrologic, hydraulic, water quality and ecosystem models are being developed by the CAPE team with input from CWG members and town staff to describe present conditions and how they might change under various climate and land use change scenarios (Figure 5). The models will also be used to explore adaptation strategies that the town can employ to respond to changes in climate and land use in the Exeter-Squamscott River watershed over time.

During the first 18 months of the project, the CWG was primarily involved with evaluating outputs from the models that predict the riverine and coastal flooding, urban drainage, water quality, and ecosystem impacts of climate change without any additional control or adaptation measures. Figure 5 displays the modeling sequence employed to determine climate change impacts to Exeter and the linkages with a decision-support tool to guide adaptation decisions. Since few municipal-scale climate-change adaptation projects have integrated models of flooding hazards of riverine, stormwater and coastal origin combined with water quality, land use, and ecological sub-models, our analysis of stakeholder participation throughout the modeling process is critical for guiding subsequent integrated modeling efforts (Figure 5).

The involvement of the CWG and other local experts (such as the town's engineer, planner, and public works staff) in the model review process enabled discrepancies in the model results to be identified and corrected. For instance, these consultations prompted the team to collect water surface elevation data in the Squamscott River as well as use a different hourly rainfall distribution for the 24-hour design storms used to simulate flooding from extreme precipitation events under different climate change scenarios. While this complex integrated modeling approach helps to provide credible scientific inputs to the adaptation planning process, delays in the modeling process have also made the engagement process more challenging.

Discussion

Several important lessons from this ongoing study could benefit future climate change adaptation studies at the community scale. For example, various actions could have been taken

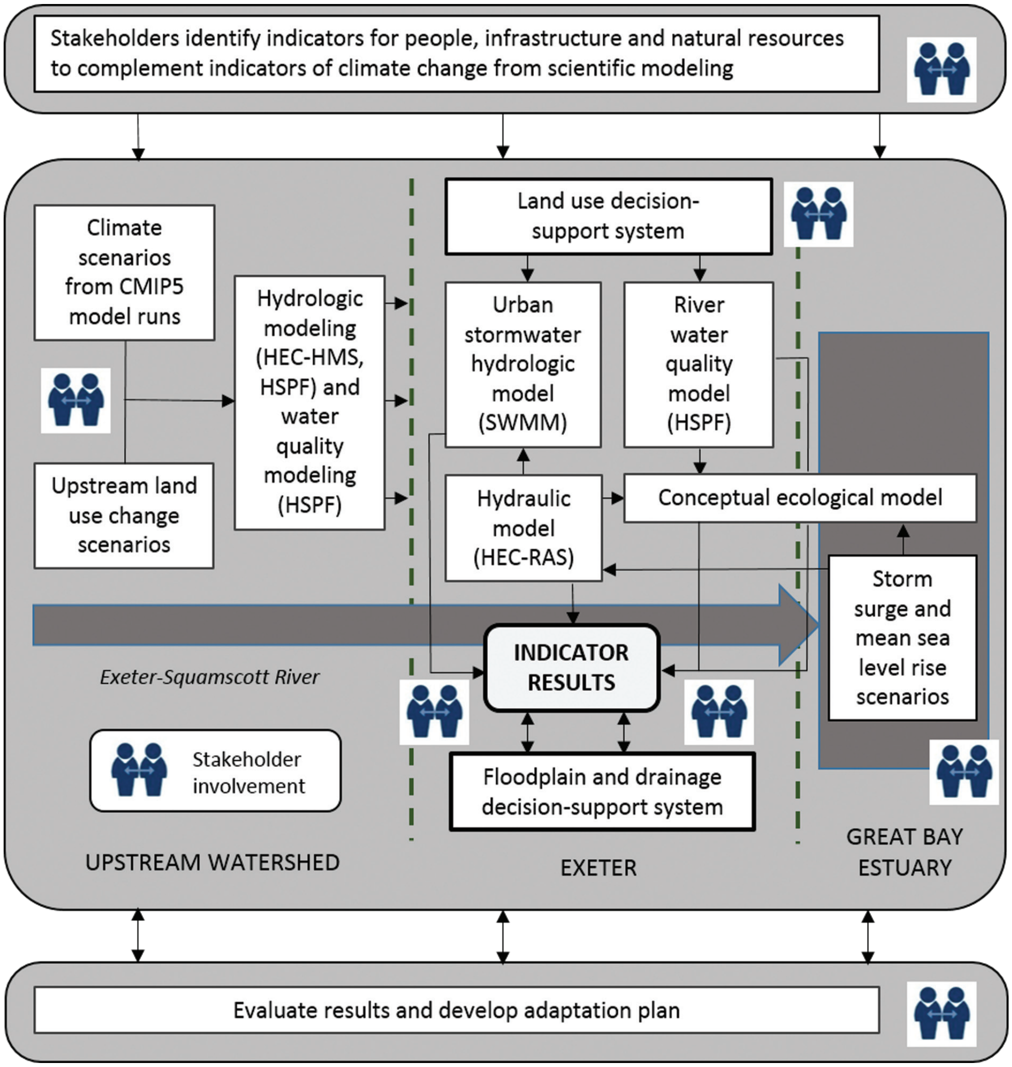

Figure 5. Stakeholder involvement with simulation modeling and decision-support tools - flow chart.
- CMIP = Coupled Model Intercomparison Project
- HSPF = Hydrological Simulation Program – Fortran
- HEC-HMS = Hydrologic Engineering Center – Hydrologic Modeling System
- SWMM = USEPA Stormwater Management Model
- HEC-RAS = Hydrologic Engineering Center – River Analysis System

earlier to better manage stakeholder expectations during the intensive modeling process. Since our initial framing of the CWG's role emphasized the simulation modeling component, many stakeholders came to view the completion of modeling as a necessary condition for any meaningful dialogue about the project. In addition, many CWG members perceived their primary role to be verifying the models and interpreting the results, thus limiting their participation in other aspects of the project in which their contributions would have been beneficial. Because of this perception, when model results were not still complete by the fall of 2014 due to the complexity of model integration and calibration, the CWG requested that meetings be suspended until results were complete.

An important lesson from this experience was that we unintentionally focused on a particular set of boundary objects (the models) to such an extent that they became barriers to designing boundary experiences instead of enabling them. Notably, neither the tour with the Assistant Fire Chief nor the flood elevation walk were predicated on complete model results, and these types of boundary experiences could have been intentionally designed into the engagement process from the beginning.

A related issue is that although the town's interest in scientific models was a catalyst for bringing stakeholders together, it was sometimes challenging to engage the CWG and other stakeholders in sharing their local knowledge and cultural memories. In accordance with adaptive governance principles (Dietz et al. 2003; Nelson et al. 2008; Nilsson and Swartling 2009; Simonsen 2010; Brunner 2010), the CAPE team believed that local knowledge and shared experiences would be essential to the development and implementation of the adaptation plan. However, as observed in other studies (Dietz 2013; Dietz et al. 2003), stakeholders may have been more familiar with a top-down, expert-driven process in which scientific outputs are viewed as a panacea for resolving complexities and reducing uncertainties, rather than as inputs for analytic deliberation.

Other scholars provide valuable lessons pertaining to the challenges inherent in aligning collaborative planning with adaptive governance in local contexts (Porthin et al. 2013; Proctor and Drechsler 2006; Simonsen 2010; Lynch and Brunner 2010; Borisova 2012). For example, Bronen and Chapin (2013) examined governance and institutional strategies for climate-induced community relocations in Alaska. They learned that community residents and government agencies concurred that relocation was the only adaptation strategy that can protect lives under extreme environmental threats. The authors identified policy changes and components of a toolkit that could facilitate community-based adaptation when environmental events threaten people's lives. Policy changes included the creation of an adaptive governance framework to offer communities a continuum of responses ranging from protection in their current location to relocation to new sites. In alignment with adaptive governance, key components of the toolkit included local leadership and integration of social and ecological well-being into adaptation planning.

Similar findings have been reported internationally (e.g., Kallis et al. 2009). For example, in a study of adaptive governance in Pakistan, Mian (2014) noted that overall flood governance may not improve unless there are better cross-linkages between key actors and networks across the disaster prevention/management continuum. The authors noted the importance of strong leadership from a local champion for promoting adaptive governance in communities. We learned a similar lesson in the CAPE study, as the Town Planner and the Assistant Fire Chief played critical roles in facilitating linkages between various stakeholder groups and the research team.

Young and Lipton (2006) studied social relationships and civic participation in an Andean community facing climate change impacts to their agricultural livelihoods. They found that participation in local institutions was invaluable for both individual households and the community's social capital (Young and Lipton 2006; Mayer 2002). Furthermore, they found many informal institutions operating within the community through personal ties and mutual assistance. High levels of civic participation and informal ties were also found in the CAPE project, as evidenced by the high number of community organizations in which the stakeholders participated (including town government, conservation committees, religious groups, youth leadership organizations, education, and emergency response). Social network analysis is being used to further evaluate these relationships. Research suggests that this capacity for collective action through community institutions may play an important role in plan implementation and compliance (Robbins 1998).

In a study focused on developing a water management plan in Florida, Borisova et al. (2012) designed a collaborative process to build a better understanding of stakeholder perceptions of water quality problems and water policy. The authors found that stakeholder conflicts were associated with perceived flaws in the structural and procedural characteristics of the stakeholder engagement process (e.g., suboptimal watershed stakeholder representation on committees, limitations in information sharing between stakeholder groups). Notably, the CAPE project achieved good representation from town staff and certain community groups initially, but faced similar challenges and trade-offs in sustaining participation from these groups while simultaneously trying to extend outreach efforts to other groups (such as local businesses) who were under-represented.

Mollinga (2008; 2010) and White et al. (2008) emphasize that transdisciplinary research projects require the integration of modeling, mapping, and communication products to support adaptive governance, and that such integration requires a concerted, long-term effort. Although the CAPE team made concerted efforts to develop these different types of boundary objects concurrently, it was a challenge to do so within a two-year time frame given the complexity of the modeling process.

Lastly, we turn to the question of transferring lessons learned from the CAPE project to other contexts. Although Exeter is a relatively small community, there is a diversity of stakeholder interests, including homeowners and businesses with high-value waterfront properties, other large land owners, conservation groups, citizen cooperatives, and manufactured housing communities. Thus, many of the lessons learned from the CAPE project may apply to other communities with similar interest groups. However, one group that is notably absent in CAPE is the agricultural sector, which can be a powerful voice in other communities (Young and Lipton 2006) and would have added complexity to the outreach process. Similarly, we did not face challenges associated with non-English speaking populations or other literacy barriers, which would require additional resources.

Another benefit of working in a geographically small community that may limit the transferability of our experiences to other contexts is that the travel time required to meet with different stakeholder groups is minimized. The CAPE team was able to visit different locations easily, and the community has a distinct town center that provides accessible meeting places for engagement activities. In larger or more dispersed communities, this may be significantly more challenging.

To facilitate learning across contexts, the CAPE team participated in a Science Collaborative Transfer Project workshop funded by NOAA's National Estuarine Reserve Research System (NERRS). One of the key lessons shared was the importance of making climate change locally relevant (e.g., using boundary objects and experiences to draw connections to local decisions and values). However, we also learned that it is important to be sensitive to possible negative connotations that can arise from media portrayals of "flood-impacted communities" and potential economic losses in real estate value.

One strategy that can be helpful regardless of community size is to seek out individual "point-persons" who are trusted members of the community and/or represent particular stakeholder interests. We recommend taking adequate time at the beginning of a project to identify important social networks and point-persons, so that engagement resources can be targeted towards cultivating these relationships. For example, in the CAPE project, the Town Planner, the CWG, clergypersons, Cooperative Extension professionals, and representatives of manufactured housing communities played critical roles in extending outreach efforts.

Conclusion

The CAPE project has generated many learning opportunities for stakeholders and the project team due to the complex subject matter and the necessity of coordinating intensive technical modeling with community engagement. The engagement process aligned with several important principles of adaptive governance, including clarifying common goals with stakeholders, building on local communication and governance structures, and balancing the informational needs of different stakeholders through boundary objects and experiences that integrate complementary knowledge systems. Other adaptive governance principles, such as implementing, evaluating, and refining policy in local contexts and transferring lessons learned across contexts, were not as evident during the first phase of the project and will require more time to assess as the project evolves. For example, we have not yet reached the stage of the project in which we review the complete model results with the community and discuss adaptation options.

In summary, lessons learned from the CAPE project underscore the importance of having contingency plans to keep participants engaged if models are delayed, creating multiple forums for interaction between researchers and community members, and making climate change locally relevant through a dynamic interplay between boundary objects and boundary experiences (e.g., drawing connections to local experiences, cultural memory, values, and upcoming decisions).

By developing a more comprehensive portfolio of boundary objects, as well as emphasizing the importance of designing boundary experiences for analytic deliberation, our team can better support Exeter in its climate adaptation planning efforts while simultaneously enabling other communities to learn from this process.

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