Chapter 2
Introduction: Science, Technology, and Engineering (Tools and Methods)

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This section features a set of studies in which the role scientific information in complex decision-making is reconsidered in the light of new concepts, methods and technologies. The section includes a range of perspectives, starting with case studies illustrating different approaches and ending with two chapters focuses more on institutional and science management concerns.

The authors come from several different disciplinary backgrounds. But considering the topics addressed and methods used, one would be somewhat hard pressed to guess who was trained in which. The chapters include planners and architects leading projects using large simulation models in projects involving dozens of scientists, and authors trained as engineers conducting research into human preferences and institutional structures. Despite the obvious challenges, I find this to be an optimistic development – dedicated people addressing real world problems have not simply stuck to their disciplinary training and framed all problems to match their professional tools. Instead, you will find here a variety of innovative attempts to develop methods appropriate to the scales and communities where this work occurs.

As later sections will discuss, few people are actually trained to work on wicked social problems, and we cannot wait for formal new disciplines to evolve before commencing the critical work. At the same time, since we are in many cases working outside of our professional comfort zone, it is important to transfer knowledge and methods rapidly from conventional disciplines into these efforts and vice versa. To take one example, none of the investigators working on the climate change research discussed here has formal academic training in climatology. Nonetheless,

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our society needs to figure out ways to plan for climate change which don't require every institution in the country to obtain that expertise as full time staff. To consider the opposite, there is a body of knowledge in the social sciences about how group deliberative and participatory processes differ from the waterfall models of knowledge-action that remain the dominant paradigm in science and engineering circles. If we want to see more effective and rapid incorporation of science into planning and policy-making, this book provides some substantial guidance as well as pointers to some of that literature.

As the latter two papers of this section discuss, people working in these areas face a complex set of institutional constraints which very much limit their activities. Academics risk many sanctions within a system still largely governed by disciplines. Public officials face significant political and career risks. Those working in the private sector face significant financial risks, since planning "with the public" instead of "for the public" cuts to the heart of a tradition of professionalism as black-box expertise. While on the one hand we are tasked with some difficult substantive work at the level of projects and activities, we also face the need to reform the systems within which many of us work so as to create the conditions to expand such efforts to the scales needed to address actual social and environmental challenges.

It is perhaps not coincidental that most of these projects consider either water resources management, biodiversity conservation, climate change planning or some mix of the three. Water resources and species conservation issues have a long history of confounding simplistic management schemes. They are now joined and often compounded by climate change. These are the pre-eminent "wicked" problems of our generation, and have become proving grounds for innovation at a variety of scales.

All three domains involve unintended adverse consequences of human decisions on nourishment, shelter and mobility. These choices are relatively innocuous at individual and small institutional levels, but scale poorly or impose impacts on others or on other systems which are very difficult to account for. A farmer irrigating a field, someone building a house or an individual driving to a meeting – all are going about daily life largely oblivious of the broader consequences on ground water, species habitat or global climate. This is also often true even at the slightly broader scales at which these activities are managed or regulated. The water district, the county, or the Federal regulatory body don't generally have comprehensive systemic performance data in front of them when making decisions. They tend to operate incrementally, limited by jurisdiction or agency scope from even considering cumulative impacts or issues outside of their sector. Not surprisingly, this leads to conventional choices which attempt to optimize or at least satisfice direct constituents within a particular sector or jurisdiction. Absent strong social or institutional requirements to account for systemic impacts, natural systems often suffer a "death from a thousand cuts."

In the types of planning situations involving these three domains, it is impossible to remove consideration of human behavior from the equation – how human beings have behaved and will behave is integral to any sensible discussion. They are very public issues, but also ones which require explicit methods for dealing with complex simulation modeling and with expressing scientific uncertainty. The lack of "standard methods" in addressing these challenges provides a natural experiment. Our authors have taken a variety of creative approaches to the complex set of social and technical issues.

Two new technologies and related ideas have started to change these kinds of circumstances. The first is the advent of near-ubiquitous "information and communications technologies" or ICT, including the cell phone and the internet. These have only been common and cheap for a few years, and the full ripple effects of these have yet to play out. However it is already very clear that they are flattening traditional hierarchies by providing widespread access to both more and better data about the world around us. These data include empirical information about the world around us, such as Google Earth and related technologies. But they also include the ability to instantly transmit feedback about human decisions. A brief example may help illustrate. This author was traveling in Hanoi, Vietnam the day that Google Earth was released, and was sent an email to that effect. Sitting at an internet cafe, he opened the program and browsed several locations. This prompted immediate interest from neighbors in the cafe, who immediately downloaded the program and began looking for their houses and neighborhoods. A week later, every machine in that cafe had a copy of the program and hundreds of people had spontaneously used it and showed their friends. The rapidity of this particular program's adoption surprised everyone at the time, but has now become a common phenomenon. In 1 year, Google Earth attracted more than 100 million users and is now reported to have surpassed 600 million unique installs. To put this in context, geographic information systems (GIS) technology which had been the only prior tool allowing access to this kind of information took 30 years to achieve its first one million users.

Software that is distributed over the internet or over phone networks has the important characteristic of combining static data, a program, and a user community. The idea that users can contribute valuable content is commonly known as "web 2.0." Creating programs which can propagate through and develop social networks has become the second wave of ICT, and this will have effects on planning and management at least as important as the provision of static information. Most current science and management techniques are based on their idea of scientists or government authorities gathering their data for a specific purpose, then analyzing it, then formally publishing their analyses – but not the underlying data. This model will probably continue to occur for some time. But layered on top of it today is a veritable tsunami of "volunteered information" much of it containing geographic components. This is already much larger than the universe of officially and intentionally collected information, and is growing at a much higher rate. Therefore, the next years are likely to see a very large increase in systems and methods which are able to harvest and repurpose messy information collected for other purposes, or the use of volunteered information in new contexts. Some early examples include a variety of citizen science and citizen activism projects in which the locations of treasured scarce resources or social and environmental problems are tracked by individual volunteers. Cell phones with GPS and cameras allow many people to contribute observations over large areas. An example of this was the recent Gulf oil spill, in which thousands of GPS'd pictures of wildlife and beaches being affected by oil were amalgamated into a real-time response map.

The second major component of ICT which is having profound consequences on planning is the widespread use of simulation technologies. While simulation models have existed for years "in the lab," they have historically been design by scientists and engineers largely for themselves. What is new is the connection of such models to visual interfaces which can be understood by much broader audiences, and their release "into the wild" in the form of decision support tools for managers, or web services for general public use. Many of the projects in this chapter are examples of attempts to use these new capabilities to build public understanding, or to mediate discussions about management options. This is a more profound transition than many people realize since participation in the activity of modeling has two non-trivial consequences. First, it is deeply engaging. A variety of studies have shown that people pay more attention to information when it is embedded in interactive forms than when presented statically. Second, it can involve very important aspects of learning, particularly social learning across traditional disciplines and social barriers.

The first two chapters outline the recent research work of this author and colleagues, which update stakeholder-based scenario planning methods to leverage new information technologies. Both chapters draw from the same case – climate change adaptation planning for conservation in South central Florida. The first chapter, by Vargas-Moreno, focuses on the use of participatory spatial simulation as a method for tractably managing the propagation of uncertainties inherent in long-range planning. The second chapter, by Flaxman, considers the methodological challenge of developing planning recommendations despite the uncertainties and differences of opinion made explicit in scenario planning.

The Florida studies considered a large region, and worked with a stakeholder group composed largely of managers and professionals working for Federal, state and local governments. By contrast, in Chap. 3, Kirshen and colleagues describe work addressing similar climate change adaptation issues, but in a completely different social context. This group worked at neighborhood scale with residents of a disadvantaged community. The methods used were almost completely different. In many ways, this was completely appropriate, since the decisions to be made by the two groups were also vastly dissimilar. In the first case, those participating were representatives of institutions and agencies actively responsible for managing billions of dollars of public assets and for rule making across large areas. In the second case, the group participating were mostly local resident renters acting individually, most lacking full control even of the structures they inhabited.

If even modest future climate change projections come to bear, both of these groups will need to take adaptation actions. In both cases, we might like to see their actions informed by appropriate science, technology and engineering. One can even imagine them drawing on a common scientific base, for example in providing accurate estimates of sea level rise and storm surges. But it is hard to imagine a single set of planning and deliberative methods being appropriate across this range of scales and audiences. This sets up one of the recurring themes of this section, which is that while science may strive for universal truths, science-informed management must inherently address application domains that can vary more widely than their process descriptions might indicate. Both Vargas-Moreno and Kirshen characterize their approaches as participatory and stakeholder-based, but it is perhaps part of the nature of such processes that they are targeted and responsive to the audiences they seek to serve and the scales at which they seek to intervene.

This issue is perhaps implicit in the guidance of the National Research Council to "(1) begin with users' needs" (NRC 2009). However, the characterization of appropriate user groups remains as much an art as a science, and there is also little guidance available on appropriate spatial scales of intervention. One method does not fit all, but it is also clearly infeasible to generate unique processes for every imaginable group and scale. How do we decide? We will be on shaky ground until we have better empirical information on how user groups' values and decision-making processes vary.

The work of Barreteau (Chap. 6) deepens this discussion by inviting us to consider not only the role of models as "boundary objects" but even more broadly the role of "modeling" as a boundary institution. If simulation is as important to the future of planning and management as our authors indicate, then the strong implication is that new types of social institutions will be needed. The infrastructure required to support modeling as a purely technical activity conducted exclusively by scientists and engineers is almost completely different from that needed to broadly support citizen engagement in participatory modeling.

In the final chapter in this section, Matso brings this issue strongly into focus, coming from the perspective of someone responsible for managing the funding of collaborative science research. The process by which such science is reviewed and funded is critical to the ultimate success of such efforts. Matso's work sheds considerable light on just how tricky such processes can be to set up, and certainly why they remain the exception rather than the rule.