

Research papers

Using complexity science and negotiation theory to resolve boundary-crossing water issues



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ABSTRACT

Many water governance and management issues are complex. The complexity of these issues is related to crossing of multiple boundaries: political, social and jurisdictional, as well as physical, ecological and biogeochemical. Resolution of these issues usually requires interactions of many parties with conflicting values and interests operating across multiple boundaries and scales to make decisions. The interdependence and feedback among interacting variables, processes, actors and institutions are hard to model and difficult to forecast. Thus, decision-making related to complex water problems needs to be contingent and adaptive. This paper draws on a number of ideas from complexity science and negotiation theory that may make it easier to cope with the complexities and difficulties of managing boundary crossing water disputes. It begins with the Water Diplomacy Framework that was developed and tested over the past several years. Then, it uses three key ideas from *complexity science* (interdependence and interconnectedness; uncertainty and feedback; emergence and adaptation) and three from *negotiation theory* (stakeholder identification and engagement; joint fact finding; and value creation through option generation) to show how application of these ideas can help enhance effectiveness of water management.

1. Introduction

Are we running out of water?
Will water scarcity lead to war?
Is water an economic good?

For some, the answer to these questions may be absolutely yes, and some will emphatically insist the opposite. Yet, many will argue that the answer to each question is: it depends.

Of course, it depends: but on what? Why and how do we get yes and no answers for the same question? For simple problems, where cause-effect relationships are well understood, this search for yes-no solution works very well. However, for complex problems, clear-cut solutions do not exist.

Can we address the supply-demand gap through the lens of water scarcity? Can we provide access to water in urban settlements through the lens of water security? Can we develop adaptation and mitigation strategies for a changing climate through the lens of sustainability? What do these problems have in common, and what makes them complex? When we can't answer these questions with certainty, how should we proceed?

This paper introduces three foundational ideas from complexity

science and three from negotiation theory that can make it easier to resolve complex water management problems in spite of the uncertainty posed by almost all boundary crossing water management situations. We begin by summarizing the Water Diplomacy Framework (Islam and Susskind, 2013). We will then show how key ideas from complexity science and negotiation theory, when used to augment the Water Diplomacy Framework can make it easier for water professionals to manage water resource more effectively.

2. Water Diplomacy Framework

Water, as a limited resource, lends itself to conflicts over how it should be allocated and managed. The origin of many complex water problems is a result of interconnections and feedback among variables, processes, actors and institutions. Efforts to manage water, with an eye toward immediate needs and long-term sustainability, will involve many actors and institutions (with competing interests and values) who demand or expect to be involved in decisions about how resources will be managed. Effective resolution of conflicting values and interests—especially when knowledge of both natural and human systems is uncertain—will require new dispute resolution and collective decision-making methods.

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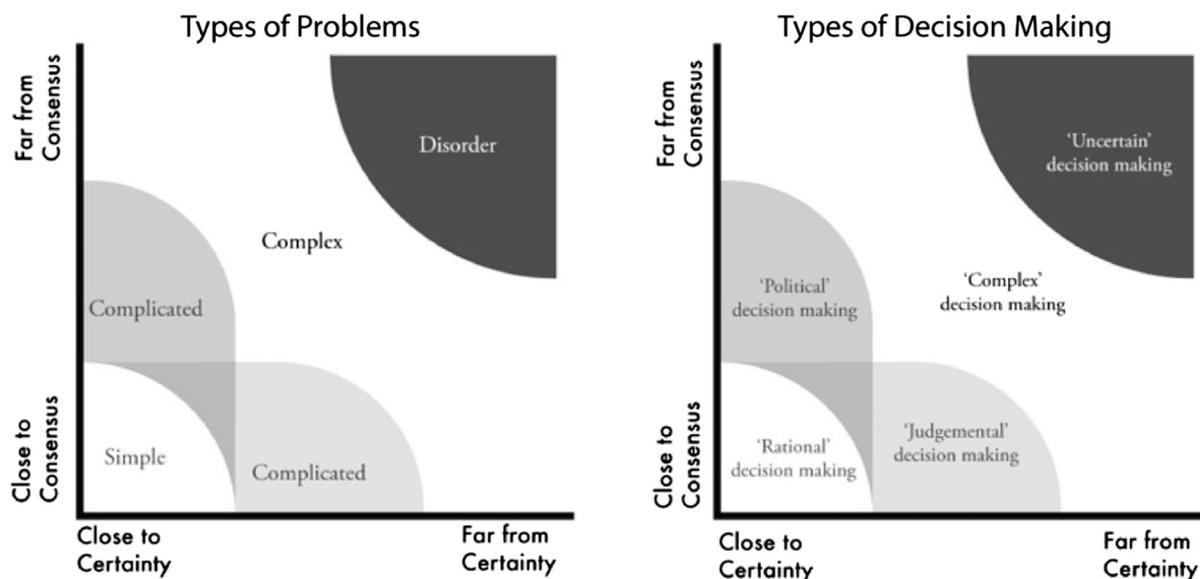


Fig. 1. Degree of certainty and consensus: a lens to describe different types of decision making for different types of problems (Islam and Susskind, 2013).

The Water Diplomacy Framework (WDF) is an alternative to the traditional techno- or values-focused approaches to water governance and management (Islam and Susskind, 2013; Islam and Repella, 2015). The WDF starts by asking: Who decides who gets water and how? The WDF aims to understand and resolve water related problems. It acknowledges that traditional problem-solving frames are adequate to address simple problems where reasonable scientific certainty and consensus about intervention exists (Fig. 1). The WDF hypothesizes that when water challenges stem from complex – interconnected, uncertain, unpredictable, and boundary crossing – system dynamics with feedback, traditional frames for problem solving can be limiting or counter-productive.

A recurrent factor for such limitations is that traditional problem-solving frames often separate the observation-based technical (what is) from the value-based socio-political (what ought to be) dimensions of the problem. The WDF further hypothesizes that when dealing with complex problems, these dimensions cannot be de-coupled. The WDF acknowledges both the limits to knowledge – objectivity of observations and subjectivity of interpretation – and the contingent nature of our action.

The WDF actively seeks value-creating options and opportunities to allow conflicting interests to be addressed in a sustainable way and begins by focusing on “Know Why” before prescribing “Know How” (Islam and Repella, 2015). In other words, the WDF builds on the differences among those with contending values and interests, and seeks to engage representatives of these interests in technical and political problem-solving to arrive at a mutually agreeable negotiated resolution. The WDF is based on credible scientific knowledge mediated through equity and sustainability as guiding principles for contextual policy action. The WDF approach emphasizes that, when addressing complex water problems all parties have a legitimate right to have a voice about the evidence used and its interpretation, the past evidence and future implications of an intervention, metrics of equity and sustainability, and the package of actionable solutions. These parties include users and producers of water knowledge, managers, technical experts, policy makers, decision makers, and politicians. Furthermore, the WDF asserts that parties need to seek consensus on guiding principles and mutual value creation when negotiating a resolution.

3. Using complexity science to better understand the nature of water problems

Historically, we have taken nature apart and analyzed its components in ever-increasing detail. This mode of analysis, design and engineering works well for simple systems in which cause-effect relationships are well understood. Complex problems are those where cause-effect relationships are ambiguous; uncertainty, nonlinearity and feedback are inherent; and emergent properties (e.g., Holland, 1998; Pahl-Wostl, 2004; Fromm, 2005; Islam and Susskind, 2013; Section 3.3 for more details on emergence) dominate the system evolution (Fig. 1). For this class of problems, there is likely to be very little agreement about what the definition or cause of the problem is, let alone the best way to resolve it. Furthermore, complex problems are constantly in flux because of natural, societal and political dynamics. Continued use of traditional systems engineering approaches to address complex problems is likely to provide doubtful outcomes (Kauffmann, 1993; Barabási and Bonabeau, 2003; Pahl-Wostl et al., 2007; Miller and Page, 2007; Islam and Susskind, 2013).

Many complex water management problems lie somewhere between certainty-uncertainty and consensus-no consensus spectrum (Islam and Susskind, 2013). The dynamics in this zone of complexity is neither entirely certain nor totally uncertain (Fig. 1). Neither the reproducible certainty of science nor and overwhelming consensus for action exists for problems in this zone. Ideas and tools from *complexity science*—interdependence and interconnectedness; uncertainty and feedback; emergence and complex adaptive systems—may be used to identify the parameters of management problems here (Pahl-Wostl, 2004; Maguire et al., 2006; Maguire, 2011; Cilliers et al., 2013; Islam and Susskind, 2013). Problem solving in this zone is distinct from what works in simple and complicated settings. For complex systems, cause-effect relationships are ambiguous and almost never prospective; prediction is not possible with any reasonable degree of certainty; non-linearity and feedback are inherent; emergent properties dominate system behavior and response. For more details, please see Snowden and Boone (2007); Islam and Susskind, 2013; Islam and Repella (2015). A failure to appreciate these differences among simple, complicated and complex systems could cause us to apply exactly the wrong approach to the right water problem or the right approach to the wrong problem. In general, continued efforts to refine existing tools like cost-benefit analysis and optimization algorithms to address complex problems have not worked (e.g., Ackoff, 1979; Bennis et al., 2010; Stiglitz et al., 2010).

While best practices can be used to address simple problems (such as the design of a household's water system) and systems engineering can be used for complicated problems (such as meeting domestic water demand within a water distribution system for a city), these tools are not suited for complex problems (allocating water for competing and conflicting needs among sectors and uses). We can understand and optimize simple and complicated systems by taking them apart and analyzing the details of their cause and effect relationship; however, for complex systems we do not have similar prospective understanding of cause and effect. Ideas and tools from *negotiation theory*—stakeholder identification and participation; joint fact finding; creative options—may be used to show how complex water governance and management can be operationalized in practice (Islam and Susskind, 2013).

We categorize complex problems to be those (a) that are interconnected with many variables, processes, actors and institutions; (b) that cross scales, domains, and boundaries; (c) for which identification of causal connections is nearly impossible; and (d) for which historical records are not very reliable indicators of the future. For complex water problems, hydrological, climatic, ecological, social and political processes interact nonlinearly – with feedback, tipping points, and thresholds – and render identification of an optimal solution virtually impossible.

Over the last several decades, complexity science has received increased attention from multiple disciplines (e.g., Anderson et al., 1988; Nicolis and Prigogine, 1989; Lewin, 1992; Kauffmann, 1993; Mainzer, 1994; Bar-Yam, 1997; Cilliers, 1998; Pahl-Wostl, 2004; Maguire et al., 2006; Pahl-Wostl et al., 2007; Maguire, 2011; Cilliers et al., 2013). What is usually referred to as “complexity science” is actually a collection of frameworks, theories, models and tools from systems engineering, chaos theory, cybernetics and studies of adaptive systems (Islam, 2017). Complex systems, by their very nature resist prescriptive diagnosis. And this diagnosis is further convoluted by disciplinary jargon. For example, social scientists often focus on how context specific interactions of actors and institutions create complexity while natural scientists explore how nonlinearity and feedback among variables and processes generate complexity. We hope to show how three ideas from complexity science contribute to our understanding of and responses to managing water disputes.

3.1. Interdependence and interconnectedness

Complex systems by their very nature cannot be explained by simple cause-effect relationships. At the heart of a complex system is a collection of interdependent elements: variables, processes, actors, and institutions. The interactions, nonlinearity and feedback among these elements can make the resulting problem definition ambiguous and open to conflicting interpretations. In such situations, opinion dominates facts and ideology takes over hydrology.

Such issues were highlighted during California's recent drought. Agricultural, industrial and residential users and uses of water received heightened attention in assigning blame for the shortage and identifying places to implement steep water reduction. As agriculture is the largest water user, various agricultural products received particularly scrutiny. Alfalfa is the single largest agricultural water user (Cooley, 2015) in the state, but as a feed crop is not of primary economic value, even as an international export. It feeds California cows, and California is the top dairy-producing state in the nation. The value of any crop, or other water-consuming commodity or service, can't be evaluated solely through “water-in-to-dollars-out” comparisons and require understanding the perspectives of and value to the multiple stakeholders for each of these water uses.

Uncertainty about drought duration and intensity further complicates questions about water prioritization and planning. Conventional solutions that seek to “optimize” water use (in terms of economic value, pollution, or calories grown per dollar) lead to reductive analyses that

ignore the interrelationships and second- and third-order benefits—and costs—of water uses and proposed solutions. These limited analyses and opinions highlight that while many in California see the complex interactions and connections between the interests of domestic, industrial, agricultural, and natural systems stakeholders, there are those who hold a singular perspective on the cause and solution to water shortage.

A networked view of the system—described in Islam and Susskind (2013)—surrounding water in California is necessary to both understand and suggest how decisions about sharing water can be made, what criteria need to be considered in those decisions, and who does the deciding. Issues intertwine, but these interconnections also contribute to opportunities for addressing the water challenges, especially regarding agriculture. A more comprehensive perspective that relates analysis of agricultural water use to other issue lenses may lead to improved understanding and decision-making around water policy.

Almonds and pistachios have similar water use intensity as alfalfa and are among the largest agricultural water users in California (Cooley, 2015). These crops bring in high agricultural revenue and are adapted to the local climate. California is the world's largest producer of almonds and the largest U.S. producer of pistachios. Taken in context, supporting nuts and some fruits may be “good” uses for agricultural water in California. Resolving the water crisis will require a substantial shift in agriculture's orientation towards water, but California's complex water problem cannot be treated as simply a local agriculture problem given the national and international role of the state's agricultural sector and cultural importance of agriculture within the state.

Complex systems are formed by connections between elements or smaller systems, and by virtue of this connectedness a change in one element may create a cascading set of changes among other elements. The degree of connectivity varies within and between systems. Systems with high connectivity experience more cascading effects, and systems with low connectivity are more adaptable to change in any one element. The hydrological, ecological, economic, and socio-political challenges posed above need to be “unpacked” and the connections among the domains, scales, and sectors need to be accounted for in problem framing and actions toward problem resolution. Differences in how complex and interdependent systems take shape also suggest that multiple approaches to problem solving are feasible and will remain contingent on the capacity of the system and constraints imposed by the context.

However, it is not possible make a list of interactions to be exhaustive for complex systems (Sterman, 2000; Schlüter et al., 2014). Bounds must be set to develop an effective model but researchers are challenged to objectively define the scope and scale of such modeling studies. Additionally, coupled models cross disciplines and modelers are unable to point to the theoretical framework of any single discipline to defend the relevant scope (Srinivasan, 2015). One needs to simultaneously balance the scope and level of detail in order to create a parsimonious and communicable model. Finally, critical assessment of models is more challenging when the theories, empirical methods and vocabulary drawn upon to create and communicate a model span disciplinary boundaries (Schlüter et al., 2014; Garcia et al., 2015).

A shared understanding of important processes to be included is needed to allow modeling structure, scope and detail to remain contingent on and adaptive to the problem context. Ideas from Negotiation Theory (Section 4) provide a way to develop such a shared understanding for the conceptualization of this class of interconnected problems.

3.2. Uncertainty and feedback

Our knowledge of real world systems is uncertain; we have imperfect information and face a range of unknowns. Uncertainty manifests in complex water disputes partly because the problem space of the

conflict is open. In complex water systems, it is difficult to plan for possible outcomes when there is no reliable way to forecast the impacts and interactions of changing water supply, water quality, and various aspects of human and institutional behaviors. For example, forecasted future flows of the Nile River under various climate change scenarios, ranged from a 78% decrease to a 30% increase (Watson et al., 1997). Recent findings also suggest that climate change could alter inter-annual and intra-annual variability of the Nile flow (Siam and Eltahir, 2017). If future flows can't reliably be predicted, it will be difficult to anticipate and plan for other dependent factors that impact water security.

3.2.1. Different faces of uncertainty

At its simplest: uncertainty describes something that we don't know or know only in an inadequate and imprecise way. However, how uncertainty is defined or approached varies between disciplines: some uncertainty can be identified and quantified, some can be reduced through gathering more information, some can be qualitatively described, and some cannot be identified or reduced through any practical means. Definitions of types of uncertainty range from classification of the source and how it may be reduced, to how uncertainty impacts potential actions or outcomes from an event or decision, to how perception of uncertainty shapes the decision-making process (van der Sluijs, 2005; Webster and Curry, 2011; Islam and Susskind, 2013). We focus on three types of uncertainty (Susskind and Islam, 2012):

- **Uncertainty of Information** relates to assigning probabilities to the likelihood of particular events occurring. This type of uncertainty ranges from zero (in which we are completely confident about the forecasts), to intermediate levels (which involve events with known probability ranges), to high levels of uncertainty (in which we have almost no idea about the future).
- **Uncertainty of Action** relates to situations where cause-effect relationships are not clear, such as whether certain policies or programs will produce expected outcome.
- **Uncertainty of Perception** occurs when people “see” what they expect to see rather than what is actually there, which can happen when questions are framed in ideological or political terms.

It is not possible to eliminate uncertainty completely. However, not all three types are likely to be equally important for a given problem: forecasted Nile flows may be related to uncertainty of information, but given the current state of our scientific knowledge about climate models, additional modeling studies will probably not resolve such an uncertainty in the near future. Yet, we need to plan and manage water in the Nile basin. Policy makers and planners can use the uncertainty to generate opportunities for value creation. Periodic reassessment in light of new data and findings may be used to adapt and ensure desirable outcomes. Moreover, it is important to undertake these scientific analyses together as Joint Fact Finding (Section 4.1) to define the scope of the analysis relevant to particular problem context.

3.2.2. Feedback in a complex system

Feedback processes are embedded in complex systems and influence system behavior. ‘Feedback’ describes how a “change in an element or relationship often alters others, which in turn affect the original one” (Jervis, 1998). Feedback loops in complex systems can be positive – with an increase in one element amplifying a change in the system. An agricultural example illustrates how decreased vegetation can increase erosion, diminish soil quality, may contribute to further vegetative loss, erosion, and worse soil quality. A human systems example of positive feedback is the rate of increase in a viral social media post: more people see and share the item, it becomes more popular until it reaches its peak. Feedback loops can also be negative, in which the system resists the changes imposed by the input. Supply and demand economics uses a negative feedback loop.

As an example of feedback, we look at irrigation efficiency as a tool to conserve agricultural water use in the United States. Public and private institutions funded the development and adoption of irrigation technologies that are more water efficient than current irrigation systems to produce the same amount of food with less water. Ideally, this would slow the depletion of the surface and groundwater resources in the area. As recent research has found, the new irrigation technologies have resulted in more “crop per drop”, but have not resulted in water conservation because the efficiencies achieved has made it profitable for farmers to expand production onto marginal lands or to switch from low-water crops to more water-intensive crops (Ward and Pulido-Velazquez, 2008; Pfeiffer and Lin, 2014). The management decision and financial investment did not achieve the desired result because the feedback and nonlinearity in the system was not considered.

3.3. Emergence and complex adaptive systems

In our assessment, a key difference between predictable systems (simple and complicated systems) and complex systems is rooted in the notion and framing of causality (also referred to as cause and effect; causation; etc.) and conditions for emergence. A paradoxical aspect of emergence is the observation of an effect without an easily identifiable and predictable cause. An emergent property is a part of a complex system and at the same time it cannot be predicted from the elements of the system, it depends on the system because it appears in it and is yet independent from it to a certain degree (Holland, 1998; Fromm, 2005).

As an example of emergence, we look at Cochabamba, Bolivia famous for its 2000 “Water Wars” in which a popular revolt successfully fought to throw out Bechtel Corporation and rejected the World Bank's privatization scheme for urban water systems in the country. The Bechtel subsidiary had imposed dramatic price increases overnight that led to protests, which escalated and ultimately forced out the company. That successful uprising returned the water to the control of the state-run water system (Shultz and Draper, 2008). By analyzing individual element of Bolivia's water problem – inefficiency of water distribution system, water pricing, involvement of a private corporation, etc. – emergence of an uprising was not predictable, (see Shultz and Draper, 2008; Bakker, 2008 for more details). Below, we explore how emergence and self-organization, two fundamental components of complex adaptive systems, can be used to better understand complex water management problems.

A self-organizing system in the context of complexity science suggests that the whole system is greater than the sum of its elements and their interactions. In this conceptualization, a system is a macro-level entity and an element is a micro-level entity. Simple rules at the micro level may lead to macro level patterns that are emergent but not predictable. Classic examples frequently come from biology. For instance, ants (micro-level entity) follow simple rules for interacting with other ants in their immediate vicinity, and the cumulative effect of these simple behavioral rules is that they organize into colonies (macro-level pattern) that accomplish tasks, such as trailing, or building, that are beyond the capabilities and awareness of any individual members of the colony. One ant with these behaviors will not accomplish any of the ends that the colony achieves; the collective action that emerges is qualitatively distinct from any of their individual actions. Emergence is the process by which lower-level interactions among elements integrate to form new levels of organization and pattern. The principle of self-organization and emergence can be applied descriptively and prescriptively to the management of shared resources such as water. Ostrom (1990, 1993, 2009) pioneered influential work applying the frameworks of complexity and self-organization to the challenge of managing common-pool resources. She argued in her work that communities that meet the conditions of a self-organizing system can (in some cases) avoid the “tragedy of the commons” (Hardin, 1968).

We offer two illustrative and diverging examples from California: groundwater-use in Porterville and surface water in the San Joaquin

Valley. Though residential wells in Porterville have gone dry, agricultural users have invested drilling up to 10 times the depth to reach deeper water to plant profitable pistachio trees. On the other hand, in San Joaquin Valley, the fear that the government might intervene and force steep surface water restriction, led farmers to voluntarily reduce water use by 25% in exchange for assurance that they would not lose water access later (Vanek Smith, 2015). In Porterville, as water became scarce, the effects of supply and demand reward farmers who can access water sufficient to expand their crop with extra profit. The farmers are aware that this will ultimately be a self-defeating pattern, but are caught in the prisoner's dilemma that Hardin described (Hardin, 1968). Further north, the stricter government control of surface water regulations, led valley farmers to give up some short-term profits in exchange for the longer-term collective interest of predictability. In this case, the higher-order system attributes—e.g., protection of water rights and predictability of water availability for the farmers—could not be produced by any individual farmer's action.

The concepts of self-organization and emergence are particularly useful in analysis of complex problems when the effects at the level of the system that we want to manage cannot be predicted by the actions of individual elements. A self-organizing system may be a desirable outcome for water governance, particularly when top-down governance is not effective, or when decision-making around collective interests is especially important. A self-organizing system organizes in response to information and constraints at the local level, not from external direction, though the external environment may create the conditions for the system to self-organize. If we could understand these conditions and related mechanisms, we might try to facilitate its emergence. However, because emergence in water systems is inherently unpredictable, specific prescriptions of how to initiate self-organization must remain contingent (Ostrom, 1993).

It is not clear how (and under what conditions) individual actions turn into collective actions. Arrow (1951) identified this uncertain nature of social choice actions and his theorem demonstrates the impossibility of pre-specification of collective outcomes based on individual preferences for some set of actions. Ostrom (2009) illustrates how, despite the theoretical impossibility of solving these complex social choice problems, empirical evidence demonstrates that individual resource users can and do organize to create new institutional arrangements to manage common pool resource. Ostrom recognized the interdependencies among elements, rules, configurations of rules, and response of variables, processes, actors and institutions. She offered a set of basic design principles found in these self-organizing systems (Ostrom, 1990, 1993). We suggest these guiding principles to open a conversation around questions of how water professionals can encourage self-organization to reframe and perhaps improve water management for boundary crossing water problems by building on key ideas from Negotiation Theory.

4. Using negotiation theory to better manage complex water challenges

We acknowledge that traditional problem-solving frames – primarily rooted in the conventional notion of causality – are adequate to address simple problems where reasonable scientific certainty and consensus about intervention exists. When challenges stem from complex – interconnected, uncertain, unpredictable, and boundary crossing – system dynamics with feedback, traditional frames for problem solving can be limiting or counter-productive. A recurrent factor for such limitations is that traditional problem-solving frames often separate the observation-based technical (what is) from the value-based socio-political (what ought to be) dimensions of the problem. In the absence of an overarching theory of complexity and contingency, we need to explore, experiment and adapt calculus and tools from appropriate disciplines that are contingent but rooted in principles that are transparent, satisficing, and replicable within limits.

In such exploration and experimentation, ideas and tools from multiparty negotiation theory can help us better manage complex water challenges by (1) identifying and engaging relevant stakeholders in decision-making, (2) exploring and integrating scientific input into political decisions through joint fact finding; and (3) generating “value creating opportunities and options.” The Mutual Gains Approach (MGA) to multiparty negotiation offers a way of dealing with disagreements involving many parties, concerned about numerous issues, who often have very different levels of technical experience and skill (Susskind, 2014). We describe three key ideas from negotiation theory that can help water managers deal with complex disputes more effectively.

4.1. Stakeholder identification and engagement

There are numerous benefits to engaging stakeholders in water management decisions. Effective stakeholder engagement tends to improve the quality and durability of agreements (Dietz and Stern, 2008; Innes and Booher, 1999; Susskind and Cruikshank, 1987). Even when agreement is not reached, stakeholder engagement can lead to a better understanding of the implicit conflicts due to competing stakeholder interests; increased political buy-in and legitimacy for decisions; better relationships and more trust among contending parties; identification of mutually advantageous proposals; and learning that has value beyond the process of direct consultation (Innes and Booher, 1999; Connick and Innes, 2003).

A critical first step to ensuring ‘good’ stakeholder engagement is to have someone, usually a professional facilitator/assessor, confidentially interview those likely to be directly affected by the policy, program or project being considered. This is usually followed by the same interviewer meeting with a second set of potential stakeholders suggested by the first group. The product of these interviews ought to be a written description of all the categories of stakeholders, their priority concerns and suggestions regarding individuals who might be invited to participate in an organized group consultation to speak for each group. This report to those with the formal authority to act is called a Stakeholder Assessment (Susskind et al., 1999).

Thus, water managers and policymakers need to determine:

- a) Who are the stakeholders?
- b) What are their interests, and are they clearly defined?
- c) How will stakeholders be represented “at the table”?
- d) Is there a credible agreement on the relevant scientific and technical findings, facts and forecasts?
- e) Is there agreement on the values that ought to come into play?

The type of problem being considered, number and range of stakeholders affected, and the diversity of their values and interests will all impact the design of an appropriate stakeholder engagement strategy.

4.1.1. Different types of decision problems require different levels of engagement

Structured problems may best be approached through an advisory committee-type process that allows a small group of stakeholders, selected by a relevant government agency, to familiarize themselves with the issues and respond to whatever questions the agency is puzzling over. If there is disagreement over scientific matters, but high agreement over values and norms (“Moderately Structured Problems”, Fig. 2) a substantial joint fact-finding effort (Section 4.2) may be appropriate. Such problems are likely to require a preliminary stakeholder assessment to be sure that all the relevant groups are invited to participate.

A problem with a wider gap between stakeholders’ interests and values, but with general agreement on the science, will require a different kind of consultation with even broader inclusion at the negotiating table to account for divergent views on how decisions should be made. Joint fact-finding and greater reliance on expert advice won't

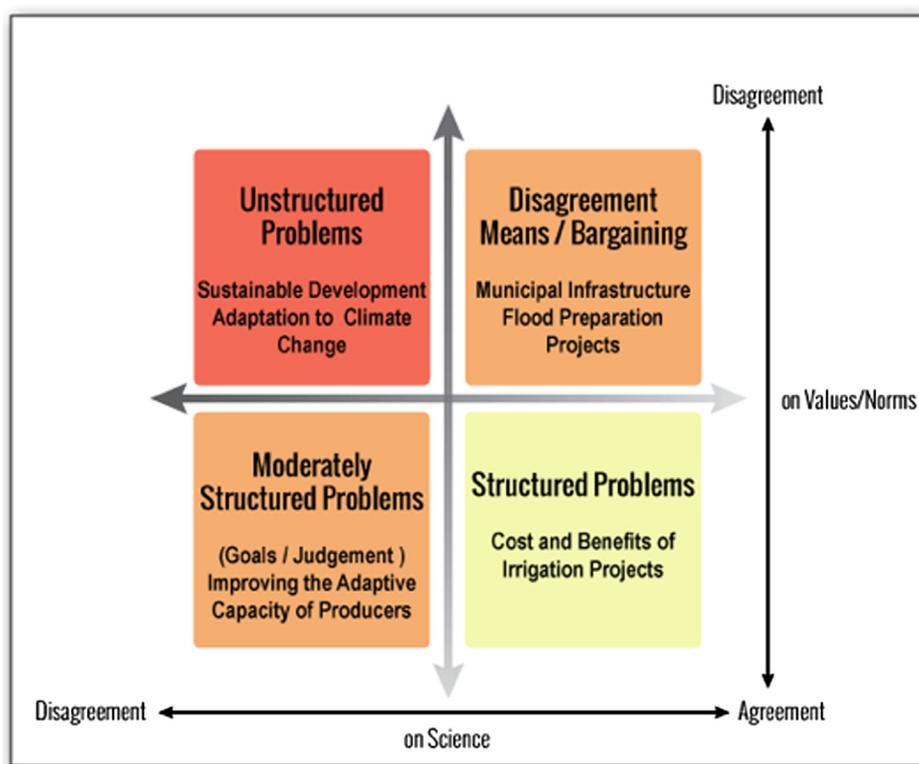


Fig. 2. Types of Problems Identified in Policy Analysis (adapted from Hurlburt and Gupta, 2015).

settle such disagreements. Instead, there is almost always a need for multiple rounds of meetings and facilitated problem-solving.

Finally, for “Unstructured Problems” where values, interests and tools are all contested, an approach to engagement that allows for extensive dialogue, mutual learning and the building of trust among stakeholders is required. This means that a preliminary stakeholder assessment, Joint Fact Finding and facilitated collaborative problem-solving are all necessary.

For example: estimating the costs and benefits of a proposed irrigation project, even if it crosses municipal boundaries, is a structured problem. There is likely to be both general agreement on the underlying science and how costs and benefits in such situations should be calculated. Involving local water users in reviewing such an analysis is crucial, but publishing a draft of a report prepared by technical staff before it is finalized may be sufficient to garner adequate stakeholder response. Deciding how to deal with increased used of desalinated water for multiple uses is a moderately structured management problem. There is likely to be more disagreement about the underlying science and the likely effects of continued desalination on the ecosystem. In these situations, joint fact finding can help the stakeholders understand the sources of uncertainty. Any decision about what action to be taken may be contested, but the underlying legal and cultural basis for decision-making is likely to be accepted by almost all the parties.

When there is strong disagreement among many stakeholders over who should decide or how a decision ought to be made to address a particular problem, the situation moves into the upper right-hand quadrant in Fig. 2. For example, when multiple states share a river but there is no agreement among them regarding the amount of water each has a right to abstract each year, the situation is complex not just in terms of technical questions, but also in terms of who has the right to use how much water. Here the fundamental basis for decision-making is contested. Scientific tools and values tend to intermix, making the problem complex.

The most complex water management problems are those in which there is strong disagreement about the underlying scientific dynamics

of the socio-ecological systems involved as well as the values, interests or legal principles that ought to come into play. Consider how recent ocean warming has made it possible to reach newly open water in the Central Arctic. There are no existing treaties governing the newly opened ocean. The Law of the Sea covers only a small portion of the area. Both maritime and non-maritime states claim that they should have access to the fisheries and oil and gas resources in the Arctic Ocean. It is not clear what principles or governance mechanisms should be used to resolve these conflicting claims. The Arctic Council, an ad hoc organization created by several Arctic nations, has no international legal basis for the policies it would like to impose. Nor is there agreement on how (1) climate change may alter access to the area, or (2) what fisheries or oil and gas resources are present in areas that were formerly inaccessible. In this unstructured realm, where both science and norms are contested, New joint fact finding approaches and collaborative problem-solving are most appropriate.

4.2. Joint fact-finding

Joint fact-finding (JFF) brings experts, policymakers and stakeholders together to analyze scientific or technical data and try to draw conclusions. Instead of each party or participant generating evidence or arguments to support their prior assumptions (and political interests), the stakeholders jointly select one or more qualified advisors to help them sort through various sources of evidence. This increases the chances that “science” will not be pushed aside in favor of politically convenient arguments favored by the most politically powerful parties. JFF requires face-to-face dialogue and movement toward consensus by continually narrowing areas of scientific disagreement (McCreary et al., 2001). It usually precedes or is part of a larger collaborative decision-making process in which the results are agreements in the form of recommendations to elected or appointed decision-makers.

JFF can also be a helpful way to build trust and enhance relationships among parties, even those who have a long history of disagreement and mistrust (Ehrmann and Stinson, 1999). This is sometimes key

to the success of subsequent joint problem solving efforts. In some instances, a decision-making body may decide to commission a technical study, such as an environmental impact assessment. Under most circumstances, an agency chooses the consultant it favors and becomes the client for the assessment. When such studies are re-framed as opportunities for JFF, however, the agency seeks the input of all the parties (following a Stakeholder Assessment) in both selecting the experts to do the forecasting or analysis. The parties are engaged throughout the process not only in responding or reacting after the study has been completed.

Parties may choose to conduct a JFF process even after an agency has commissioned an Environmental Impact Assessment in the traditional way. This can help ensure that the public and the stakeholder groups that are most concerned have confidence in the assessment or forecast being used as a basis for decision-making (Matsuura and Schenk, 2017). JFF following an agency study doesn't need to duplicate all the earlier work, but it does need to sort through disagreements over the way forecasting was done or analyses were interpreted. The goal, again, is to narrow disagreements among the parties (on technical assumptions and interpretations) before the agency draws on the results to justify policy choices.

In March 2016, as an illustrative example of how JFF may help, Ethiopia and Sudan signed a Declaration of Principles (DoP) on the Grand Ethiopian Renaissance Dam (GERD), signaling a concrete expression of the three parties desire to move beyond political posturing and previous threats regarding the often contentious discussion of how water is shared and utilized in the Eastern Nile Basin.

As we have argued water stress in Africa and in the Middle East – particularly in the Nile Basin- is likely to lead to a range of conflicts; more importantly, complexity of transboundary water sharing needs learning from other basins and adapting to local situations by creating mutually beneficial options (Islam and Susskind, 2015). Moving forward from the signing of the DoP, there are opportunities to make this initial cooperation into lasting water security for the Nile. There are also many potential pitfalls that may lead to renewed enmity between parties. While there has been many optimistic and pessimistic speculations in regional and international press on what the DoP *means*, there is a void of suggestion on *what to do next*.

Regardless of whether this DoP is representative of the willingness for political compromise or the beginning of a clear and productive relationship, this declaration cannot achieve much without further informed conversation and clarification to hammer out the details to act and move forward an agreement on how to develop and share the Nile waters for an equitable and sustainable future for the region.

This Declaration has different meaning to champions, critics, and pragmatists. Champions argue that this is a new beginning that builds on the principles of cooperation, recognizes and respects the development, equity, and sustainability concerns of the three countries, and diminishes the possibility of military conflicts. Critics question the absence of any mention of earlier water treaties and the related water security implications for Egypt and Sudan. Pragmatists express that it binds three countries with two principles from international law: not to cause significant harm in utilizing the Nile and prioritizing equitable and reasonable use of this shared resource. Irrespective of these views, one point is clear: this signing will not instantly change or reduce the complexity of Nile water issues that were shaped by the histories, myths, and mistrusts among Nile nations and cultures for centuries. This declaration however, opens the door for a new beginning and JFF may help in this regard.

JFF will not reveal an incontestable 'truth.' In the case of the Nile River, for example, no amount of joint fact-finding will make it fully certain how much water Egypt and Sudan can count on from the Nile while the Grand Ethiopian Renaissance Dam GERD is being filled. The GERD is the largest dam ever built in Africa. Ethiopia needs to decide how quickly it will fill the dam. If Ethiopia fills the dam too quickly, the amount of water continuing on to the High Aswan Dam, Egypt's

primary source of water for almost all uses, will be seriously constrained. Estimates of the impact of filling the GERD rest on a range of subjective judgments (including how much water will be available in the Nile; how quickly to fill it; etc.).

In the end, especially after a JFF process generates forecasts under a range of assumptions, participants will have an appreciation why and how forecasts are contingent on subjective judgments. While more scientific analysis will not completely eliminate the uncertainties involved, JFF can produce a more sophisticated understanding of contingent results for which there is scientific consensus and distinguish it from claims that do not have a defensible scientific basis.

Due to the uncertainty inherent in real-world situations, Schenk (2017) suggests that the best we can hope to achieve through joint fact-finding is to identify "facts for now" and "facts for use". "Facts for now" are "contextually appropriate, specific and more or less ephemeral" (Schenk, 2017), and recognize the changing nature of many complex situations along with the need for adaptive management informed by continuous monitoring, data collection and analysis. "Facts for use" include information or forecasts that stakeholders can use to make decisions. These facts may be imperfect, but are bracketed appropriately (to take into account different types of uncertainty and the impact of subjective judgments) to allow action to proceed.

The end goal of joint fact-finding is to arrive at an agreed-upon understanding that is both scientifically sound and publicly credible so that stakeholders and decision-makers can then move on to collaborative problem-solving (Karl et al., 2007). JFF, when organized properly, makes it explicit about what is knowable objectively and what needs to be discussed subjectively (Susskind and Cruikshank, 1987; Ehrmann and Stinson, 1999; Schenk et al., 2016).

4.2.1. Essential steps of joint fact-finding

Specifically, JFF involves six essential steps described in Fig. 3.

Step 1. Assess the need for JFF: The decision-making agency (or group of agencies) decides whether or not there is a scientific or technical issue that requires more clarity and, if so, takes on the role of the convener. The convener helps identify stakeholders, calls meetings and provides financial and (sometimes) technical support throughout the process. This should be managed by a professional facilitator to establish a neutral and inclusive process. The facilitator should conduct a pre-JFF assessment that identifies the stakeholders, information and knowledge gaps, and stakeholders' incentives to participate in JFF.

Step 2. Convene the stakeholders: If the convener and facilitator decide that JFF would be valuable, they convene a representative group of stakeholders (based on the results of Step 1). The facilitator helps this group draft ground rules, roles, responsibilities and a timeline. The group generates general scientific or technical questions that they would like to address through JFF (with the help of agreed upon technical advisors independent of the convening agency staff).

Step 3. Define the scope of the study: The group defines the scope and objectives of the JFF effort and translates general questions into a small number of precise research questions. By the end of this stage, the group should agree on (i) key research questions; (ii) the analytic methods to be used to answer those questions; (iii) the type of expert advice required for analysis and interpretation; and (iv) a timeframe for the work to be completed (Susskind et al., 2017).

Step 4. Conduct the JFF study: The representative group defines the sources of data (e.g. indigenous, quantitative, qualitative, etc.) that should be included before their expert advisors conduct the study.

Step 5. Evaluate the results of the study: Afterwards, the experts communicate their findings to the representative group, identify any remaining sources of uncertainty and discuss their confidence in their findings. These results are combined into a single technical report. Assuming the stakeholders understand and accept the results of the studies, they can use the findings to continue a joint problem-solving effort aimed at generating policy recommendations for the convening agency.

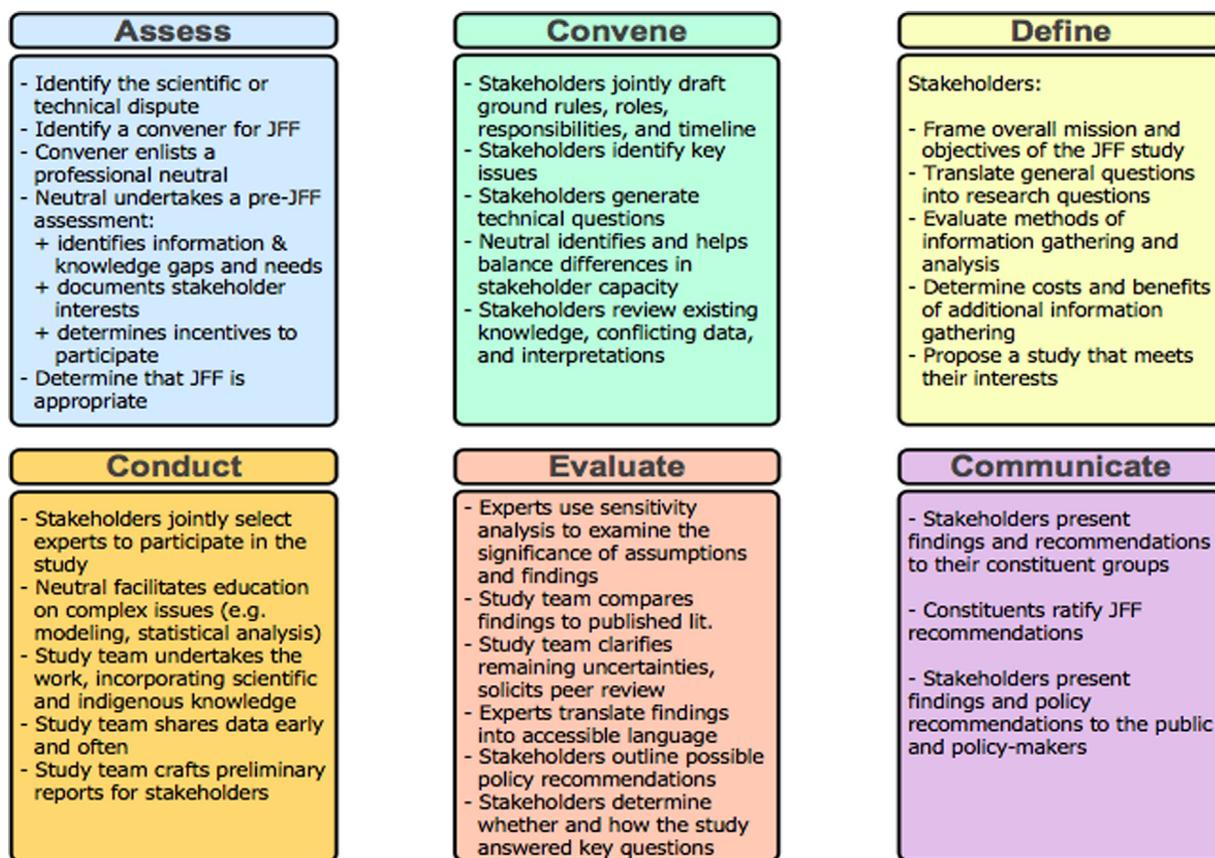


Fig. 3. Essential Steps of Joint Fact Finding (Source: Consensus Building Institute).

Step 6. Communicate the results of the JFF process: In the final step, stakeholder representatives communicate the findings of their JFF effort to the broader public and to policymakers. If appropriate, this becomes the first step in a longer consensus-building or problem-solving process in which the full group of stakeholders has an opportunity to collaborate with the JFF task force in developing a final set of policy recommendations.

An example of joint fact finding, facilitated by Concur, Inc, involving the Guadalupe River Flood Control Project Collaborative illustrates how a large number of stakeholders avoided adversarial legal proceedings and instead jointly agreed upon project objectives and performance criteria (Karl et al., 2007). The focus was how to resolve disagreements over flood mitigation for the lower Guadalupe River in downtown San Jose in California. Mutually agreed-upon experts evaluated alternatives based on chosen criteria, objectives, metrics and indicators, and worked with stakeholders to explain their findings. The multi-year process informed stakeholders, balanced technical and financial disparities and created an acceptable management strategy. At the Collaborative’s final meeting, one of the environmental group’s attorneys withdraw their citizen suit. The agreement on project redesign produced efficiency gains that cut \$100 million from the original mitigation project cost. Relationships were improved and the first agreement was followed by an ongoing collaborative adaptive management effort

4.3. Creating value through the generation of Mutually- advantageous options

Historically, most water negotiations assume a fixed quantity of water (based on an average of past water levels over a chosen time period). For example, the 1959 Nile Agreement on the Full Utilization of the Nile Waters assumed that a fixed amount of water (84 BCM)

would be allocated between Egypt (55.5 BCM) and Sudan (18.5 BCM). When the parties assume a fixed amount of water in a particular location, it is easy to further assume that negotiations must take a zero-sum format. This outlook often leads to hard bargaining, or a “test of will,” and drives out the possibility of cooperation or the invention of mutually advantageous outcomes.

MGA style negotiation involves all sides looking for opportunities to reach an agreement that is mutually beneficial (Susskind, 2014). It requires parties to think of options in which each gets their most important interests met in exchange for helping the other side(s) to achieve their top priorities. For example, if one side is mostly concerned about having more water in the dry season, they don’t necessarily need an overall increase in their share of the total supply for the whole year, they just need a guarantee that they will have more water during drier months. The other side might have more storage capacity and could promise to release a substantial amount of water during the dry season, while retaining its annual overall share of the total supply. They might jointly invest in new infrastructure to make such an agreement work. This kind of integrative solution to meeting the interests of the two sides requires trust and cooperation. The goal of a MGA is to reach a negotiated agreement that is more beneficial to both sides than what each might expect if there were no agreement or each pursued their own interests unilaterally.

4.3.1. Value creation in boundary crossing water disputes

In the case of boundary crossing water negotiation, value creation may occur in several ways: first, by redefining the issues on the agenda (i.e. scale, scope, number, etc.); second, by “creating” more water; and third, by recognizing the full bundle of benefits (sometimes on a range of related issues) that could be gained by new levels of cooperation.

Value creation may be achieved by increasing the scale or scope of water management. Usually, a watershed is taken as the unit of

planning to achieve ‘optimal’ water use. Increasing the scale of water planning, however, beyond the boundaries of a watershed, can allow parties to incorporate additional issues into their negotiation, such as water for agricultural production, energy production and domestic use in neighboring watersheds. Adding issues to the agenda makes it easier to find packages that are mutually advantageous. For example, a country might invest in a hydroelectric dam in a neighboring country in exchange for discounted electricity. Considering multiple issues simultaneously is often the key to value creation in boundary crossing water negotiations (Grzybowski et al., 2010). However, when governance boundaries and hydrologic boundaries don’t overlap, implementation problems arise. This means that negotiated agreements, if the scope of the discussion broadens, may require creation of new institutional arrangements.

The Water Diplomacy Framework suggests that value creation requires thinking about and managing water as a flexible, not a fixed, resource (Susskind and Islam, 2012; Islam and Susskind, 2013). There are several ways of creating “more water” by treating water as a flexible resource: for example, through reclassification of water for different purposes, investment in new technology or more efficient water usage, distinguishing between blue and green water, or through recognition of virtual water (Allan, 2011).

One such example of creating flexibility through MGA is found in Israel and Jordan’s 1994 Peace Treaty. Jordan had no water storage capability on its side. Israel agreed to store water for Jordan in Lake Tiberius during the wet season and release it to Jordan during the dry season. Israel also agreed to help construct new transport infrastructure, to reduce water loss en route to Jordan. Israel got the peace treaty it wanted while Jordan found a way to meet its water needs during the dry season (for more details, please see Susskind and Islam, 2012). Clearly, more expanded discussion with case studies would help us make a stronger argument about the applicability of WDF within the context of complexity science and negotiation theory. However, given the limited space requirement of this journal, we refer to the range of case studies we have compiled on how to resolve water conflicts using complexity science, negotiation theory, and water diplomacy framework as described in detail in several papers and books (e.g., Ibrahim and Islam, 2017; Pohl and Swain, 2017; Islam and Madani 2017; Choudnury and Islam, 2018) AquaPedia <http://aquapedia.waterdiplomacy.org>. We also refer to six blog pieces that describe several case studies discussed in this paper: <http://blog.waterdiplomacy.org/2015/08/water-diplomacy-issues-of-complexity-science-and-negotiation-theory/>.

5. Concluding remarks

Many of our current and emerging water governance and management issues are complex. Case examples, like those discussed above from Bolivia, California, Egypt, Israel and Jordan illustrate how complexity manifests in water management. These real-world examples exhibit attributes of complex systems through their interconnected nature, feedback, and emergent patterns. For many of our water problems, interconnectedness is accelerating; often they seem to entail impenetrable webs of cause and effect. In such situations, instead of looking at systems in isolation (i.e., rather than looking at elements, focus on interactions and interdependencies among elements) insights from complexity science prompts us to step back and look at how elements interact to create emergent patterns. Unexpected patterns will continue to emerge and we will not know where the next one will come from and how it will affect water access, allocation and use. This, of course, means that all water agreements need to be adaptable to a changing and unpredictable future. Embracing these concepts from complexity science will require rethinking and reframing of some basic assumptions about water management, including moving away from politically-convenient boundary setting that ignores system interconnections, adopting contingent and easily modifiable water sharing

agreements that emphasize adjustments to uncertainty and feedback; and building stronger relationships among involved parties so that joint problem solving in the face of emergent patterns is easier.

Our challenge is to prepare and design natural, societal and engineered systems that are able to recover quickly from unexpected events and adapt to the constantly changing nature of complex systems. Insights from complexity science may be helpful in this regard. Complex water systems are neither random nor perfectly predictable. It is the recognition of the balance between degree of flexibility (too much flexibility among interacting elements make the system random) and constraints (a highly constrained set of interacting elements may make the system simple and predictable but vulnerable to unexpected event) may help in addressing complex water issues. To analyze, complex systems can be decomposed in many different ways (e.g., choice of number of elements and their nature of interactions in addressing water use among alfalfa and almonds and their relationships with the economy and other use of water in California) and the insights gained by different decomposition will be different. All decompositions, however, are not equally valid or relevant. In fact, decomposition is a choice and it has consequences. More importantly, this choice is contingent for a given problem context. This is where negotiated choice of decomposition becomes an essential component of understanding, governing, and managing complex water systems.

We will not have complete knowledge of complex systems; yet, we need to act with limited and uncertain information by choosing a framework. Such choices, however, need not be arbitrary. Admittedly, knowledge for complex systems will always remain limited and contingent; understanding these limits, though, can lead to decisions that are neither relativistic nor vague but negotiated through a carefully crafted framework based on a set of agreed upon guiding principles.

A recurrent factor in traditional problem-solving for water management is the separation of “what is” from “what ought to be” dimensions of the problem. The WDF emphasizes that when dealing with complex problems, these dimensions cannot be separated. The WDF acknowledges both the limits to knowledge – objectivity of observations and subjectivity of interpretation – as well as the contingent nature of all action as an effect of complexity. Furthermore, the WDF asserts that parties need to seek consensus on guiding principles and mutual value creation when negotiating a resolution of their differences. We hope the combination of ideas and tools illustrated here with the included references will encourage and motivate water professionals to seek to blend insights from complexity science with tools from negotiation theory to address the most pressing complex water problems of our time.

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