

## RESEARCH ARTICLE

# Problem Framing Influences Linkages Among Networks of Collective Action Situations for Water Provision, Wastewater, and Water Conservation in a Metropolitan Region

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Collective action problems are linked together when the outcomes of one collective action situation affect the working components of another. In San Diego, California, solutions to the collective action dilemmas of water provisioning, conservation, and wastewater were found to have influenced each other between 1990 and 2010. Building upon a database of water management-related action situation outcomes, developed from archival documents and interviews with water managers, environmental groups, and other participants, we used McGinnis' Network of Adjacent Action Situations framework and the Politicized IAD framework to analyze how the emergence of different problem frames affected linkages between these three collective action problems. Our research shows that newly introduced frames for thinking about these water management challenges as interconnected contributed to the progressive emergence of new governance strategies by different groups of actors.

**Keywords:** Polycentricity; Collective Action; SES; Water; California; Adaptive Management; Network of Adjacent Action Situations; Politicized IAD

## 1. Introduction

In San Diego, California recurrent climactic shocks and policy surprises since 1990 have shaped water arrangements and challenged how the region organizes resources to meet regional water demand, conserve water, and provide wastewater services to 3 million residents. In social-ecological systems, it is not uncommon for multiple collective action problems to be simultaneously influencing each other and for governance arrangements to be fragmented and ineffective (Kauneckis & Imperial, 2005). The Institutional Analysis and Development (IAD) framework is a tool for analyzing the processes and outcomes of collective action dilemmas and for modeling how actors interact under the influence of different rules (E. Ostrom, 1990). Scholars have built upon the original IAD to extend the framework in two important directions. McGinnis' Network of Adjacent Action Situations (NAAS) accommodates what occurs outside of a single Action Situation (AS) to characterize the linkages that develop between Action Situations. Other scholars have adapted the IAD to incorporate the influences of historical processes, discourses, and political and economic forces (Clement, 2010; Whaley & Weatherhead, 2014), and to analyze interconnections among multi-level action situations (Brondizio et al., 2016; Ruiz-Ballesteros & Brondizio, 2013). The most recent version of the IAD-SES framework embraces the notion of interconnectivity among multiple social-ecological systems (Cole, 2019; McGinnis & Ostrom, 2014).

Advances have also occurred in conceptualizing the processes through which problem frames and the definition of a collective action problem structure the development of institutions to govern resources (Brugnach, Dewulf, Pahl-Wostl, & Taillieu, 2008; Pahl-Wostl et al., 2008). The notion that new problem

frames reveal and incorporate an experiential knowledge of the social-ecological production system has been illustrated for water resources in diverse geographical contexts. Processes have been hypothesized for how problem frames influence the evolution of institutions and contribute to governance arrangements that better reflect social-ecological system (SES) component interdependencies. (Dewulf, Craps, Bouwen, Taillieu, & Pahl-Wostl, 2005; Isendahl et al., 2009; Mankad & Tapsuwan, 2011; Mobley, 2016; Pahl-Wostl et al., 2007; Steyaert & Ollivier, 2007).

Still underdeveloped are methodologies and metrics for evaluating how and when problem frames affect changes in one or more action situations, such as facilitating cross-sectoral solutions to collective action dilemmas. This paper builds upon McGinnis' NAAS framework and the contribution of the Politicized IAD to analyze the influence of problem frames on the management of inter-connected collective action dilemmas related to water management in a metropolitan area. It articulates how problem frames influence the choices available to actors and the positions that actors adopt with respect to each other.

The analysis focuses on the evolution of water management governance in San Diego, California between 1990 and 2010 as it relates to water provisioning, water conservation, and wastewater treatment. A database of water management-related action situations was developed from archival documents and interviews with water managers, environmental groups, and other stakeholders. The database documents the changing patterns of water resource governance in the region. The case illustrates the processes by which actors progressively applied new problem frames and connected previously separated ASs into networks, which enabled governance arrangements to better match the ecological and social realities of the resources system.

Section 2 summarizes the IAD, NAAS, and Politicized IAD frameworks, introduces problem frames as reflections of societal discourses, and discusses their role in connecting together collective action problems. Section 3 introduces the research methods and Section 4 briefly describes the water governance arrangements in San Diego and the four problem frames that were introduced during the study period, and which influenced stakeholder understanding of collective action problems.

Section 5 explores the action situation adjacencies that developed, and the actors, interactions, rules in use, and outcomes of the wastewater, provisioning, and conservation ASs. For each, the sequence of AS evolution is narrated and the strategic choices taken by actors are described with respect to how the introduced problem frames contributed to the interpretation of events. Evidence is presented to show how the formation of new linkages among ASs and changing patterns of adjacencies were the consequence of interactions between the newly introduced problem frames and the strategic options available to AS participants. Section 6 discusses the findings and their broader implications before the article concludes with Section 7, a proposal for directions for future research.

## **2. IAD, Action Situation Adjacencies, and Problem Frames**

The Institutional Analysis and Development (IAD) framework uses a systems perspective to organize the factors and conditions, processes, and rules and norms that affect actions and interactions among actors in a collective action dilemma (E. Ostrom, 1990, 2011). It is a framework for decomposing the focal Action Situation (AS) of interest to the researcher into constituent analytical elements and working components: the rules determining an actor's position in the AS (e.g., consumer of water resources), the set of available actions (e.g., reduce demand through conservation), how an actor interacts with other AS participants, the payoff functions (e.g., preferences affecting water consumption), etc. (McGinnis, 2011b). The IAD framework helps to identify how configurations of rules affect the joint production of an outcome when multiple actors and factors are involved in determining the rules and when incentives and disincentives to cooperation are present.

Two or more collective action problems, even when they relate to different public goods, may not be entirely independent of each other. McGinnis calls these relationships "action situation adjacencies." Two or more ASs are adjacent when the outcomes of one AS directly shape the values of the working components structuring another, independent, AS (McGinnis, 2011b). Adjacencies develop because the same actors are involved in solving different problems, the same resources are affected by (or serve as inputs to) different problems, or the same governance arrangements are used to manage multiple collective action problems.

Digging further into the processes generating action situation outcomes, Clement proposed, and Whaley and Weatherhead further developed, a Politicized IAD framework to consider processes that are grounded in, but lay outside of, the bounded-rationality tradition (Clement, 2010; Whaley & Weatherhead, 2014). Discourse and political-economic contexts affect the position element of the action situation and shape the values, norms, and preferences of AS participants. Whaley and Weatherhead measured the assemblages of words, concepts, and ideas that actors used to evaluate actions and events, which presented as figures of

speech or metaphors. They argued that power relations are reflected in how the dominant discourses interact with the positions that people assign to themselves in social interactions; and they applied their framework to evaluate how power dynamics played out in adaptive co-management interactions and negotiations.

Similar to the discourse concept used in the Politicized IAD framework, but with a greater emphasis on cognitive process, problem frames combine mental models of cause and effect with value laden and politically driven positions about how problems should be solved (Nowell, 2010). Problem frames are problem-solving schemata that help individuals interpret experience (Johnston, 1995). Cognitive frame theory defines frames as “mental structures that facilitate organizing and interpreting incoming perceptual information by fitting it into already learned schemas or frames about reality (Dewulf et al., 2009, p. 158).”

Novel ways of thinking about interdependencies among collective action problems can emerge when new problem frames are introduced to connect specific problems to particular cultural frameworks and contemporary discourses (Pahl-Wostl et al., 2008). Sharing alternative perspectives across resource users promotes learning by revising cause-effect assumptions embedded in the processes of decision-making within institutions (Pahl-Wostl et al., 2007). Stakeholders’ framing of water issues has been shown to influence behavioral choices, management decisions, and the development of new institutions (Brugnach et al., 2008; Dewulf et al., 2005; Isendahl et al., 2009; Mankad, 2012; Steyaert & Ollivier, 2007).

The problem frames articulated by stakeholders trapped in a collective action dilemma are a starting point for an IAD analysis focused on the effects of the interactions between culture, interpretation, politics, and those factors that are traditionally considered in the framework (e.g., community context, rules, institutional structures). In introducing his Network of Adjacent Action Situations (NAAS) framework, McGinnis proposes two potential processes through which problem frames influence action situation outcomes, generating adjacencies (McGinnis, 2011b).

Norms encouraging community members to cooperate with those whom they have worked with before, high degrees of shared understanding among actors, and shared identities can affect the designation of particular actors as representatives of collective entities. This can alter how resource users’ preferences are incorporated into decision-making by modifying the position rules of the AS that assign actors to participant roles.

Another potential linking process occurs when epistemologically grounded perceptions about the causes of collective action problems connect two ASs or if two ASs are believed to be caused by the same factor. The choice rules specifying the prescribed actions that actors are able to take in the focal AS may be affected if a relationship emphasized by a problem frame influences the “set of strategies, norms, rules, organizational templates, and other remembered or imagined practices that are readily available to the members of that community for their use in processes of deliberation and implementation” in the focal AS (McGinnis, 2011a, p. 176). If an external AS influences perceptions of the focal collective action problem, or if norms defining feasible options change, the policy options available to focal AS participants may be affected (McGinnis, 2011b).

McGinnis’ NAAS framework has stimulated the development of methodologies for investigating how action situations are linked together. Oberlack et al. examined flows of goods and materials, money, energy, information and ideas, biological agents, and people in telecoupled systems, in which distant ASs affected the land system in the focal region (Oberlack et al., 2018). The team developed a procedure to describe the focal AS, measure the flows linking the focal AS to the distant ASs, and map the network of action situations by answering “[w]hat focal, distant, and flow-centered action situations affect the land use, sustainability, or governance issue in question? What are the linkages between the action situations? [And h]ow do the ecological, socioeconomic, and institutional factors identified...shape the interactions, linkages, and outcomes? (Oberlack et al., 2018, Table 1).”

Villamayor-Tomas et al. hybridized NAAS with Value Chain Analysis to study ASs occurring in different resource sectors. In their research on the water-food-energy nexus, they used an input-output, process-based approach to determine when the inputs in a focal AS were part of a larger value chain (Villamayor-Tomas, Grundmann, Epstein, Evans, & Kimmich, 2015). NAAS analysis has also been applied to identify AS linkages concerning a single common pool good in a single location. In his introductory paper, McGinnis catalogued linkages among different governance tasks for the single good of national welfare delivery services (McGinnis, 2011b). Governance task performance refers to the various tasks that governance arrangements perform related to public goods (i.e., production, provision, allocation, appropriation, consumption, coordination, dispute resolution, enforcement, monitoring, financing, and rule-making).

The analysis of San Diego water management builds upon these previous works. It identifies the linkages among ASs that together involve many public goods and perform multiple governance tasks. Action situation

boundaries are delineated by the categories that water managers and stakeholders involved in water management issues use to think about, discuss, and plan water management. An input-output analysis approach identifying flows into the focal ASs is carried out, but the impacts of these inputs are interpreted with respect to how they interact with the contemporary problem frames to modify position and choice rules in the focal AS. The effects on governance arrangements is evaluated by determining whether different public goods or governance tasks (those not already in the focal AS) became connected to the focal AS.

Organized resource users and advocacy groups in systems characterized by polycentric self-governance participate in the definition of environmental problems. New understandings of the collective action problem and new problem frames that tie together distinct public goods and governance tasks in ways that are meaningful to affected communities may contribute to the reported association between polycentricity and a capacity to adapt to environmental change (Bates, Green, Leonard, & Walker, 2013; Bettini, Brown, & de Haan, 2015; Huitema et al., 2009; Kauneckis & Imperial, 2005; Lubell, M, Scholz, & Mihriye, 2002; E. Ostrom, 2010). In polycentric systems, choice, position, and other types of rules “provide mechanisms for articulating and aggregating demand in the absence of market prices and for the translation of demand into choices about which level of service to be procured,” wrote the Ostroms (E. Ostrom & Ostrom, 1999, p. 85).

### 3. Research Design, Sampling, and Methodology

For the research site of San Diego, California, information was systematically collected about the problem frames applied, the management actions taken, and the action situation outcomes. A database was developed of every proposal, program, policy, and behavior that municipalities, water district agencies, and other stakeholders involved in water management undertook between 1990 and 2010 in San Diego, California.<sup>1</sup> Data were coded from published reports and open-ended interviews with a sample of individuals and stakeholder organizations representing water managers, environmental groups, the business community, the landscaper and real-estate community, and farmers. The interview sample was identified through document review and a snowball sampling of informants and interview subjects. Additional details about the sampling procedure and methodology are provided in Appendix A.

The delineation of the AS boundaries was influenced by the research question of how problem frames contribute to the generation of action situation adjacencies. AS boundaries can be defined in any number of ways: by governance task, by resource system, by stages in a value chain, by stages in the policy cycle, or by nested level from local to global (Oberlack et al., 2018). The authors applied a criteria established by Oberlack et al., the situations of social interaction. “These are distinct patterns of cooperation, coordination, and conflict among particular actors on particular governance issues generating particular outcomes (Oberlack et al., 2018, A Diagnostic Procedure).”

Each database observation was coded for the actors, the governance tasks performed, the public goods involved, and the action situation that produced it. A database of adjacent action situations was generated by determining when an outcome of one AS affected any of the working components of another AS. Forty-nine outcomes creating adjacencies were recorded and coded for directionality. Each was characterized by whether it 1) modified the representation of collective entities or created new shared identities (related to position rules), 2) changed perceptions of the collective action problem or the policies available to participants (related to choice rules), or 3) demonstrated the influence of norms that encouraged cooperation with groups whom an actor had worked with before or with whom it would continue to have interactions (related to position rules). McGinnis hypothesizes that each of these processes create action situation adjacencies (McGinnis, 2011b).

According to the model, problem frames potentially influence these three processes, affecting the action situation working components, and providing context for interpreting the presence of an adjacency. The problem frames introduced during the study period were generated from interviews with water managers, environmental group representatives, farmers, the business community, and landscapers and the real-estate community. Norms and values (arising from culture, personality, or elsewhere) were not elicited through this process because the research question was focused on the influence of the problem frames applied by participants. The interviews were augmented by document analysis of reports written by water agencies, advocacy groups, and academics. Problems that were mentioned by multiple informants during semi-structured interviews, raised during water planning meetings, or cited in public outreach materials were

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<sup>1</sup> Purely engineering and maintenance related undertakings – pipeline replacement, pumping stations, peak demand management – were not included in the database of adaptations or the analysis. These interventions were not considered adaptations so much as standard operating procedures that were being continued.

identified. These were used as probes in semi-structured interviews with the five types of water users to elicit histories of the evolution of each type of water user's perception of the particular water problem over the 20 year period. The main problem frames that were elicited from and shared by multiple respondents were identified.

A one-mode network (where all nodes are of the same type) of adjacent action situations was produced by connecting ASs when the outcome of one AS affected the working components of another. The effect of the linkage on governance was evaluated by whether the linkage increased the number of unique public goods or governance tasks involved as compared to those in the focal AS.

## 4. Water Management Governance in San Diego

### 4.1. San Diego water governance

San Diego County is characterized by a highly polycentric water governance arrangement with many overlapping governance units influencing outcomes during the study period. The site was selected because the complexity makes the Network of Adjacent Action Situations framework especially useful as a tool for understanding the many water management changes observed. The interactions of the actors are difficult to explain without reference to the problem frames used to understand the problems facing the region. The site is briefly described below, with additional details about the biophysical conditions, the water challenges of the region, and the 18 action situations that developed provided in Appendix A. Appendix B describes the activities performed by each type of water user.

The San Diego County Water Authority (SDCWA) is the wholesale water importer, purchasing water from hundreds of miles away to augment scarce local supplies and selling and transporting water to local water districts via aqueducts. **Figure 1** shows the map of the 23 independent local water district agencies in San Diego that are responsible for water allocation, provisioning, and production decisions for areas of San Diego county with populations greater than 1500 people (the military installation is managed by the federal government). Different jurisdictions exist for sanitation and wastewater services. Each independent water district agency decides about water provisioning on behalf of its own retail clients and is a public entity, either a department of the municipal government, a public irrigation district, or an independent water district with a board of directors elected by the served community. The water district agencies are voting members of the SDCWA.

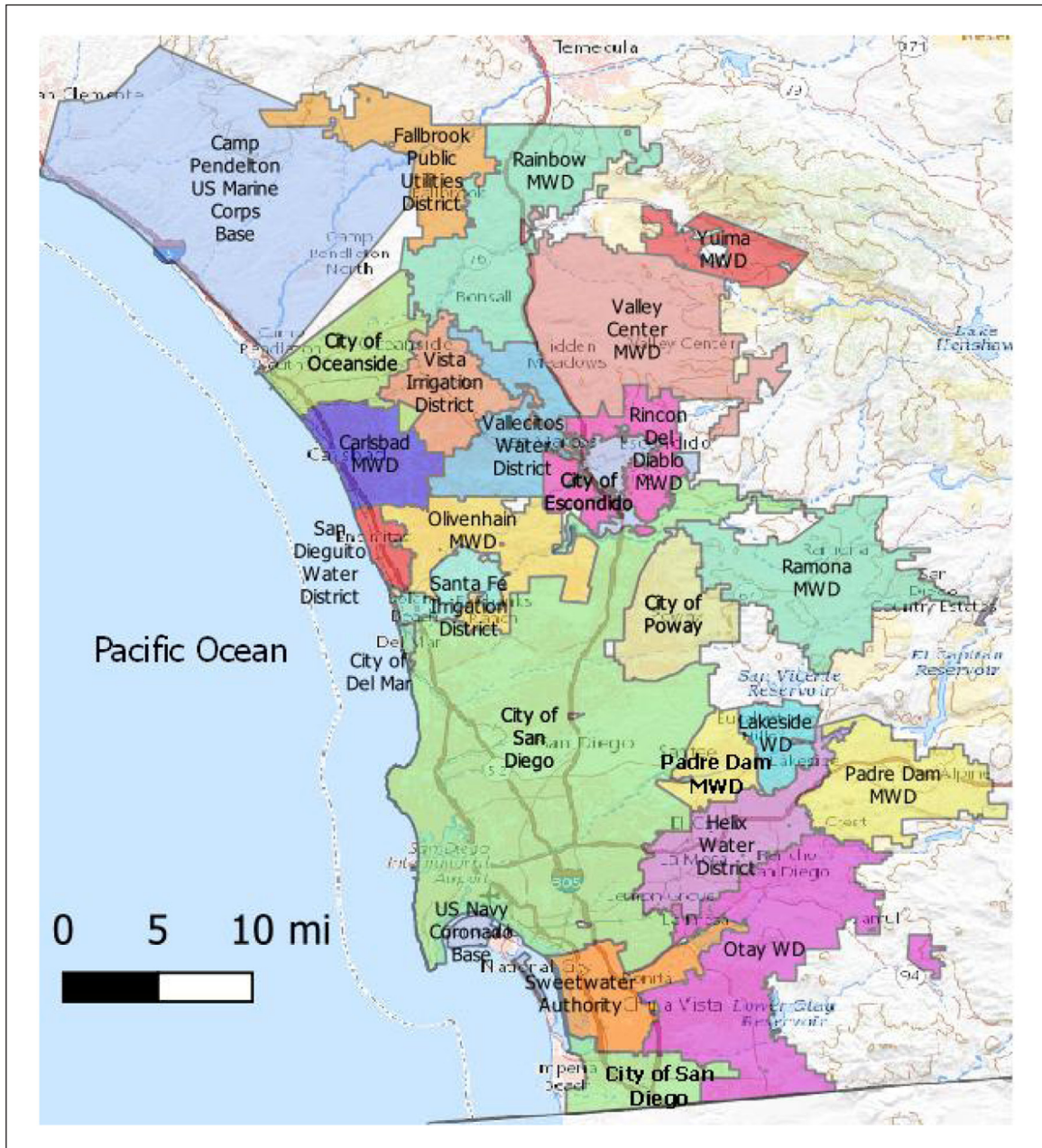
In San Diego, the geographic boundaries of the governance units frequently do not match the boundaries of elements of the water system. Some infrastructure components like water treatment facilities are physically located in one water district but are owned by, and serve, a different district. Various pieces of the water service infrastructure are owned by cities (e.g., pipes), Joint Power Authorities (e.g., water recycling plants), and even private parties (e.g., a desalination plant). Three watersheds traverse multiple water district agency jurisdictions.

### 4.2. Problem frames introduced between 1990 and 2010

San Diego water users experience many water scarcity related problems. The region imports approximately 90% of its supply from watersheds located outside of its physical boundaries (San Diego County Water Authority, 2010), creating reliability issues. Varying local and statewide precipitation and state water policies also affect annual supply. These and other problems generated 4 problem frames that were applied by participants in water-related ASs.

The first frame was *Independence* from the extra-regional wholesale water supplier, the Metropolitan Water District of Southern California (MWD). This frame articulated a normative goal of reducing the de-facto control that 26 other water agencies and cities located outside of San Diego County exerted over regional water management. Through their membership in MWD, the wholesale seller of imported Colorado River and Northern California water to retailers servicing 19 million people, these other water agencies determined the wholesale price of water purchased by SDCWA. As recently as 1999, all water imported into the San Diego region was purchased by SDCWA from MWD.

A desire for water independence first emerged in 1991 after MWD threatened to ration water exports to San Diego despite SDCWA purchasing nearly one quarter of MWD supplies to fulfill 95% of regional water demand. Politicians and water managers panicked as MWD announced a potential 50% delivery rationing for municipal and industrial water users and a 90% reduction in agricultural water deliveries the following year for member agencies (Tobar & Wallace, 1991). While other MWD members could draw upon groundwater aquifers to meet demand, San Diego's reliance on imported MWD water meant that the restriction would



**Figure 1:** Water Districts in San Diego County.

have affected the San Diego region more than any other MWD member. Decades later, water managers still believe that they are being tyrannized by MWD's politicized policymaking process, and this opinion continues to affect infrastructure and long term planning decisions (Pilip-Florea, 2012; Zetland, 2008, 2017).

A second frame was around *Water Reliability*, the notion that water should be available without interruption. This concept was originally proposed by the manufacturing and biotechnology community in 1991 and was quickly adopted as a normative frame by the water district agencies. Water managers in San Diego, like those in other southwestern US cities, considered reliability to be one of their most important organizational values (Lach, Rayner, & Ingram, 2005). As one representative of the business community reported in the late 2000's about his group's support for indirect potable reuse technology, an expensive type of water recycling, "I'd say that shows [a] kinda dedication to that issue of reliability and paying for that reliability." Over time, the business community changed its positions on specific policy proposals like water recycling, but the larger goal of *Water Reliability* always remained a constant, and this framed how the business community approached many of the water-related collective action problems facing San Diego. "Recycling is one of those things that is now clear to most that it's a win-win situation but before that it was *Conservation and Reliability* rates (author's personal communication)."

The third problem frame was around the *Diversification* of suppliers. The concept, publicly introduced in a 2002 SDCWA annual report (San Diego County Water Authority, 2002), was that “[the] unavailability of any one supply source will be buffered because of the diversity of supplies (Water Resources Department, 2011, Section 9-9).” *Diversification* decoupled water supply from climactic variability and from the impacts of policy shocks that could affect the availability of imported water supplies. Proponents of the *Diversification* frame advocated for the development of additional water through conservation and groundwater extraction, the increased use of recycled water, desalination, and the structuring of long-term contracts to purchase water from neighboring irrigation districts.

The fourth frame was around *Conservation*, which became popular in 1990 in the middle of a six-year long drought. Reducing water demand by voluntarily minimizing domestic indoor water consumption was encouraged for the first time through a widespread public outreach campaign. Prior to the drought, San Diegans had never been asked to engage in indoor conservation in a sustained way, only as a very short-term measure. In 1990 the threat of mandatory water cuts potentially affecting farmers, the real-estate community, businesses, and water agency reputations incentivized all kinds of water users to invest in water-saving technologies and to modify their behaviors.

The ethic of water conservation was applied to an increasing number of water use decisions. By 2010 even outdoor car washing and landscaping with grass, once common, were generally scorned because water-efficient alternatives had become widely available. As a *Conservation* frame was increasingly applied by San Diegans, water district agencies progressively cooperated with other types of San Diego water users like landscapers, environmental group representatives, and the architecture community. Local and regional water agencies devoted staff resources to developing and collaborating in new collective action institutions and forums for information sharing among these groups, resulting in the implementation of more projects with local, regional, state, and federal stakeholders.

## 5. Networks of Adjacent Action Situations

### 5.1. The network of adjacent action situations in San Diego water management

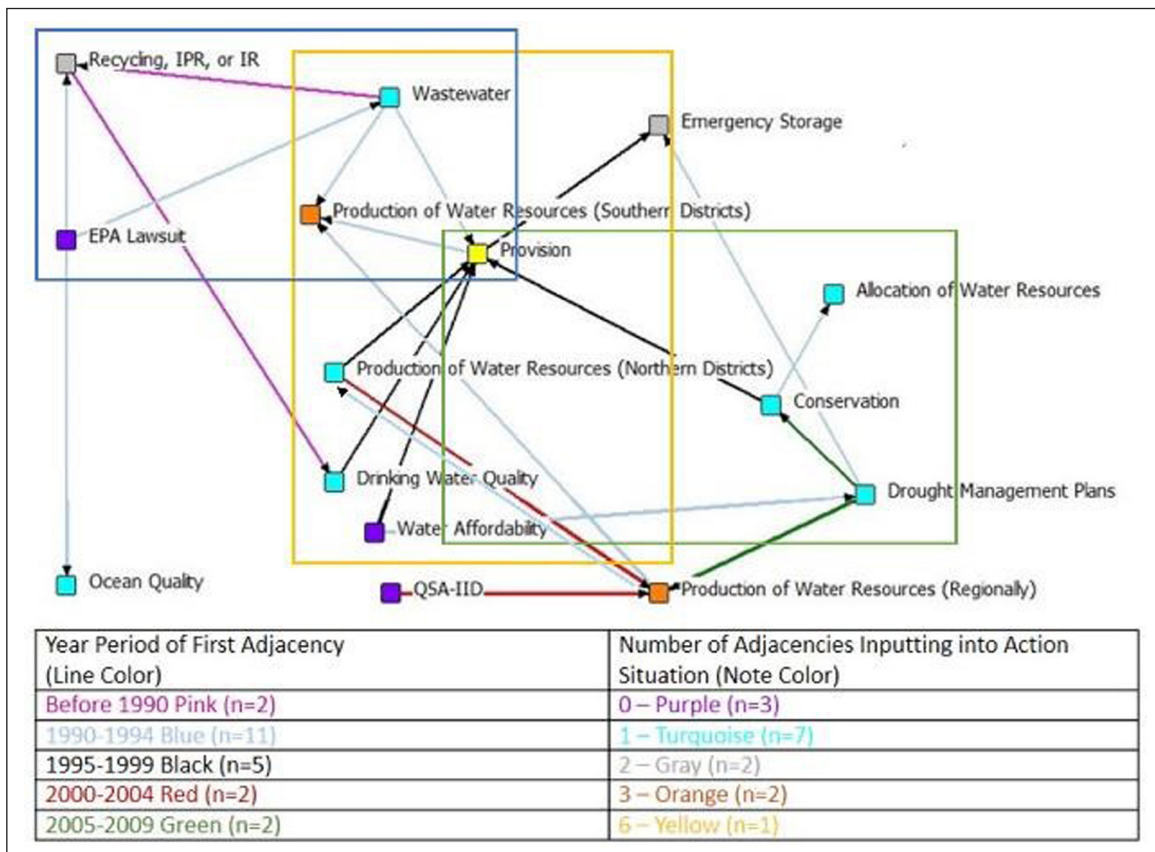
**Figure 2** presents the action situation adjacencies for the 15 water-related focal action situations occurring in San Diego between 1990 and 2010 that were networked together.<sup>2</sup> The 49 action situation outcomes were coded by 5-year period, and some adjacency relationships were repeated over the two decade study period, becoming intermittently dormant and active. This led to 22 unique adjacencies being shown. The evolution of action situation adjacencies for the Wastewater AS, Provisioning AS, and Conservation AS are described in detail below. These 3 ASs most clearly illustrate the influences of two processes that McGinnis proposes generate adjacencies: position rule and choice rule changes. Each also represents a different kind of AS – one with 2 public goods accomplishing few governance tasks, one with 3 public goods accomplishing a moderate number governance tasks, and one with 4 public goods accomplishing many governance tasks. Together, these three ASs have adjacencies with 12 of the 15 ASs in the network.

### 5.2. The wastewater action situation NAAS

In San Diego county, wastewater treatment and disposal is produced and provisioned by 27 autonomous wastewater agencies that are independent of the water district agencies, except for in a couple of instances. Some agencies serve only a part single water districts while other providers’ treatment areas overlap multiple water district boundaries. In addition to many small wastewater agencies, ten cities, two water districts, and one special sanitation district, all in the southern half of the county, participate in the METRO system that utilizes infrastructure the City of San Diego built in 1963, which is managed by a Joint Powers Authority. This system treats and disposes the wastewater of 2.2 of the region’s 3.5 million residents 3 miles offshore (Michael Uhrhammer Communications, 2012). The Wastewater AS illustrates how newly introduced problem frames influence the working components of an AS, affecting interactions and outcomes.

The production, provision, and rule-making governance tasks that contributed to resolving the wastewater collective action problem included sludge processing, sewer line rehabilitation, new sewer pipeline construction, and water pollution rule-making. Cities interacted with each other as well as the enforcers of the federal Clean Water Act, the state regulator (the State Water Resources Control Board) and the Environmental Protection Agency.

<sup>2</sup> Three of the 18 identified action situations were not connected to another action situation. These were recreational use, the production of environmental goods, and the production of cross-sector coordination.



**Figure 2:** Network of Adjacent Action Situations for the 15 Networked Focal Action Situations Related to Water Management in San Diego Occurring Between 1990 and 2010. Nodes are focal action situations. Nodes in the Blue Box are the Wastewater subnetwork, the Yellow Box are the Provision subnetwork, and the Green Box are the Conservation subnetwork. Node color represents the number of adjacencies inputting into the focal action situation. Ties between nodes show an adjacency. Tie color represents the earliest 5 year period that an adjacency was found.

Two major events shaped wastewater management between 1990 and 2010. The first was a governance reorganization of the City of San Diego's Water department, which directly serviced about a third of the county. In 1987 the city began a Clean Water Program and by 1996 wastewater had been spun off from water provisioning with the establishment of a separate Metropolitan Wastewater Department. The cities and agencies that contracted with the City of San Diego to use the METRO system contributed approximately 35% of its revenue. Eventually, they altered the collective choice rules in 1998 by forming a METRO Commission that functioned as an advisory board to the City of San Diego city council. By 2000 the cities and agencies established the METRO Joint Power Authority, an independent authority with proportional voting rules, finally vesting contractors using the METRO system with decision-making authority about system operations, rates, and capital improvement (Michael Uhrhammer Communications, 2012).

The second significant event resulted from the link between the Wastewater AS and the AS related to ocean water quality. Environmental groups working with the federal Environmental Protection Agency (EPA) in 1987 sued the City of San Diego's over its strategy of discharging wastewater effluent treated below federal Clean Water Act (CWA) standards (see the EPA Lawsuit AS in **Figure 2**). In addition to investments in additional treatment technologies, one outcome was a federal law, the Ocean Pollution Reduction Act of 1994, requiring the City of San Diego to build a reclamation plant capable of converting 45 million gallons per day (mgd) of wastewater into non-potable recycled water. A 1990 Consent Decree led to the construction of a 15 mgd plant in the south (constructed in 2002), a 30 mgd plant in the north part of the county (constructed in 1997), and stipulated that the city extend the sewage outfall and monitor benthic communities around the discharge site. The EPA Lawsuit AS outcome generated a connection between the Wastewater AS and the Water Reclamation AS because it required the construction (but not the operation) of water recycling capacity.



At the time it was technically feasible to convert wastewater into additional water supply by treating wastewater to extremely high water quality standards and then holding the product in reservoirs for a period of time, also known as indirect potable reuse (IPR). Recycled water could also be applied to non-potable uses like landscaping. The EPA Lawsuit outcome required that the City of San Diego study IPR, which was a topic that the City's Water Department had previously explored in three pilot projects, beginning the mid-1970s. This AS outcome established a link between the Wastewater AS and the Local Production of Water Resources (for southern water districts) AS, and the Provision AS.

One NAAS hypothesis is that norms encouraging community members to cooperate with those whom they have worked with before affect position rules and that this process can generate adjacencies. An outcome of the EPA Lawsuit AS was apprehension among environmental groups and the City of San Diego that every 5 years the two sides would again be forced to interact when the city applied for another federal Clean Water Act (CWA) waiver. Also, at some future point the EPA might choose to enforce the CWA, which would require that the city construct a \$2.5 billion treatment facility. These liabilities led to the establishment of informal bi-weekly meetings between the City of San Diego Water Department staff and local environmental group representatives between 2001 and 2004. The threat of costly interactions every 5 years and the looming threat of CWA enforcement changed the positions of the two actors in the Wastewater AS, making both of them losers if the federal government followed through. One participant in this arrangement described the meetings as a forum for learning and information exchange. Over time a collective identity developed such that in both 2005 and 2009 when the City of San Diego requested another five year waiver, the environmental groups supported them. Third and fourth waivers, once unthinkable, were granted too.

Action situation adjacencies can also develop from problem frame encouraged norms that define feasible options and shape incentives (McGinnis, 2011b). Externally generated norms potentially affect the choice rules, the "set of strategies, norms, rules, organizational templates, and other remembered or imagined practices that are readily available to the members of that community for their use in processes of deliberation and implementation (McGinnis, 2011a, p. 176)." The meetings between environmental groups and the city representatives created an opportunity for new perceptions of the wastewater collective action problem to be informed by the *Water Reliability* and *Diversification* frames that were circulating in the discourse at the time. These concepts had become increasingly central to long-term water planning, but it was the consent order requirement to build water recycling plants that provided the motivation to turn these notions into strategic efforts to identify ways to expand the provision of recycled water.

Wastewater and water districts operating water recycling plants faced the problem of losing money because of high fixed operating costs for the plants, a limited market, and a court consent order requiring production, resulting in unsold water being emptied into the sewer system. The problem frames of *Independence*, *Water Reliability*, and *Diversification*, when presented as goals of equal importance as water price, helped managers establish a rationale for operating the wastewater component in a way that was otherwise in conflict with their fiduciary responsibilities to minimize ratepayers' costs. Recycled water had been underutilized because the high costs of laying a separate pipeline to transport the resource to end users was uneconomic for local water district agencies, who would have to have raised retail prices. Yet, *Water Reliability* and *Independence* were also understood by urban users and water managers as having a financial cost. Paying higher water rates was acceptable if it replaced demand for less reliable imported water with demand for recycled water. The benefits of increased reliability and independence could then be deducted from the expense of expanding the recycled water conveyance network. This norm evolution contributed to action situation adjacencies between the Wastewater AS and both the Local Production of Water Resources (in southern water districts) AS and the Provision AS. The SDCWA produced guidance documents, local water districts and cities generated recycled water demand by requiring that recycled water replace potable water for landscaping uses like public parks, MWD offered subsidies to recycled water users, and a few water districts invested in expanding their conveyance infrastructure.

### **5.3. The water provision action situation NAAS**

Local Water Provisioning is the treatment, storage, and conveyance of water among reservoirs located in different water districts to end user consumers. Resolving the collective action problem requires engineering and infrastructure investments to manage changing daily and seasonal flows of imported water into the system, enabling it to efficiently meet dynamic demand over 24 hour periods. It is an example of an AS that is affected by the outcomes of a linked external ASs, where the external AS but not the focal AS is influenced by newly introduced problem frames.

Actors in the Provisioning AS were local, regional, and extra-regional water agencies. One task was coordinating water storage across reservoirs. MWD, the wholesale seller of imported water to San Diego, stored water during winter months in reservoirs to reduce peaking of the imported water system during the summer and to reduce summer water delivery. Some water districts stored their local supplies in other water agencies' reservoirs. Building a conveyance pipeline network for recycled water and providing technical assistance to potential recycled water users contributed to ensuring that water was reliably transported to end users. Water agencies with water treatment facilities contracted with downstream agencies, and water agencies sometimes shared the capital costs of expanding and building new pipeline networks. The Provision AS accomplished provision, rule-making, allocation, consumption, production, and coordination governance tasks related to water resources.

Outcomes of the Drinking Water Quality AS, the Production of Water (for northern districts) AS, and the Water Affordability AS affected the working components of the Provision AS in expected ways. Production changes such as using a water quality treatment plant for baseload rather than supplemental demand management, increasing treatment plant capacity, and purchasing recycled water for distribution affected water agencies' payoff functions, operational choices, and investments in capacity expansion. Changes to water quality regulations (Water Quality AS) affected the rate at which treated water was delivered into the system, requiring adjustment to the conveyance system operation. Subsidized water prices for agricultural users, part of the Water Affordability AS, contributed to maintaining San Diego's agricultural economy during normal and wet periods. It also helped to keep flow volumes in the conveyance system and contributed to financing the fixed costs of system operation.

In the late 1980s, water managers became increasingly worried about the consequences of an earthquake, flood, or drought on the ability to provision water because the importation aqueducts cross several fault lines. As the problem frame of *Reliability* became popular, demand for a solution grew. By 1989, preliminary studies had been generated for a local Emergency Storage Project (ESP) to protect the region in case of temporary aqueduct disruption, and associated capital improvement projects were coordinated and funded by SDCWA. Additionally, some individual water districts created agreements with neighboring water districts for emergency storage.

The *Reliability* problem frame contributed to the definition of a new collective action problem of Emergency Preparedness, the outcome of which was the ESP. The design and construction of a conveyance system to transport water north and south throughout the San Diego region, and the production of additional reserve storage in the event that water imports were temporarily halted, had collateral impacts on water provisioning. The augmented network created new engineering and management options for handling inter-daily and inter-seasonal variations in the local system by pumping water between reservoirs, and by enabling the bi-directional transport of water both north and south. It also expanded the opportunities for provisioning indirect potable reuse water by enabling a reservoir used for the purpose to service both northern and southern communities.

#### **5.4. The conservation action situation NAAS**

The Conservation AS is an example of how problem frames help to define a collective action problem in the first place, and how the understanding of the problem affects the position and choice rules within a created AS. It also illustrates how a frame-created AS can generate outcomes that affect the choice rules in other AS, in this example the Provisioning AS and the Allocation AS.

A variety of actors were involved in the production, provision, coordination, monitoring, enforcement, rule-making, and financing of conservation efforts: the state, the wholesale seller MWD, SDCWA, water districts, cities, and local stakeholders (the businesses community, landscapers and the real-estate community, and environmental groups). In addition to AS outcomes related to conservation, the outcomes also accomplished governance tasks related to creating a San Diego specific water culture, generating new knowledge of social-ecological system connections, and producing water resources.

*Conservation* as a normative problem frame became established in 1990, in the middle of a six year drought, when reducing water demand by voluntarily minimizing indoor water consumption was encouraged for the first time through a widespread public outreach campaign. It increased the options available to SDCWA and local water district agencies, and these actors developed water conservation plans. The City of San Diego Water Department established a water conservation advisory committee which "deliberated the merits of long term conservation programs (City of San Diego Water Utilities Department, 1999, p. 73)," and in 1991 engaged in the "city-wide implementation of water conservation programs designed to promote permanent water savings...(City of San Diego Water Utilities Department, 1996, p. 106)."

In 1990 and 1991 farmers experienced water rationing despite having already invested in water-efficient drip irrigation technology. When MWD planned an additional reduction in agricultural water allocations (eventually rescinded after heavy spring rains), water district agencies in urban areas implemented mandatory urban water restrictions to offset the proposed cuts. This was the first time that an explicit connection had been made between urban users' water demands and the needs of other types of water users in San Diego.

The promotion of a water conservation ethic among urban users by state and local water agencies temporarily reduced water demand. In the 1990s conservation efforts initially targeted urban water users' indoor demand from toilets, washing machines, dishwashers, showerheads, and personal-hygiene practices (e.g., showering, dental hygiene routines). Outdoor water conservation was soon added and MWD and SDCWA offered homeowners financial incentives to replace grass with synthetic turf (the former) and provided free water audits for outdoor landscapes (the later). When financing ended after the drought, the improvements in domestic landscape water efficiency reversed. In the 1990s conservation was perceived mainly as a tool to reduce acute water scarcity during drought. Over time as more permanent options (e.g., xeriscaping, irrigation devices to reduce soil evaporation) became available, a more permanent change in users' relationships to water resources occurred. By 2013, two years after the 2007–2009 drought, water district agencies discovered that water use behavior had undergone a permanent shift toward reduced per-capita demand.

The *Conservation* frame helped generate new kinds of actors in the AS who over time influenced choice rules. In 1999 two local water district agencies established the Water Conservation Garden, a public education initiative showcasing landscaping flora and producing educational programs for the public. The Garden influenced domestic outdoor landscaping preferences by providing homeowners an opportunity to interact with climate-appropriate (i.e., drought tolerant) flora. During the ensuing droughts when the Water Conservation Garden was heavily promoted, water-intensive domestic landscapes began to be perceived as luxuries that took resources away from agriculture and other valued uses. Partly because of the *Independence* and *Water Reliability* frames promoted by SDCWA and local water district agencies, domestic landscapes became an area in which conservation was expected to be practiced. Many of the water districts began working with landscape experts and cities to design ordinances and drought response plans targeting outdoor water use. The Drought Management Plan AS was also linked to the Conservation AS because many of the ordinance changes and conservation programs that generated conservation results were originally developed as part of emergency drought responses intended to be enacted only during declared drought conditions. The ordinances were eventually adopted by water agencies and districts when they were found to be effective and popular among water consumers.

The model ordinances promulgated a new kind of water culture in public spaces, one that valued water-efficient xeric landscapes, and they contributed to modifying cultural preferences about domestic outdoor landscapes. The presence and success of the Water Conservation Garden contributed to the high demand for a SDCWA rebate program to help homeowners afford to replace grass with turf and to invest in water-efficient appliances and irrigation systems. The production and provision of new knowledge about drought tolerant landscapes contributed to the production of a new water culture for San Diego, motivated and promoted in part by water districts' and agencies' programs to economically incentivize a change in behavior.

The *Conservation* frame also contributed to the participation of actors that had not previously participated significantly in San Diego water management. In 1991 only a handful of landscape designers and architects advised the SDCWA and local water districts. This changed in 2002 when the professional landscaping community began to self-organize and share information in an informal professional networking group eventually called the Conservation Action Committee (CAC). They developed strategies to reduce outdoor demand and educated commercial and large-scale landscapers like Home Owner's Associations how landscapes could become sources of conservation. Within a short time SDCWA offered the group a meeting space and an agency staff member to serve as secretary. CAC was very active between 2004 and 2009 and it was especially sought out by cities and water agencies after the 2006 California Water Conservation in Landscapes Act was passed requiring land use planning agencies to implement water-efficient landscape ordinances for new developments. Water agencies relied on CAC's working groups for expertise on establishing outdoor conservation goals, drafting model landscape ordinances, engaging in public education, and reaching out to the landscaping industry. The increased application of the *Conservation* frame, and the understanding of water conservation as a collective action problem, led to the creation of domestic outdoor water audits, individualized water budgets for households, requirements to irrigate certain landscapes with recycled water, and targeted public education.

The Conservation AS also led to outcomes that affected the Allocation of Water Resources AS and the Provision AS by generating new policy options for participants. Before the 1987–1992 drought, the value of conservation technologies such as stormwater capture, landscape conversion, and bathroom retrofits were typically estimated as the cost per acre-foot of conserved water at the current price. Many conservation projects were uneconomical when calculated this way. Over time, the marginal benefit of averted water demand began to be included in how projects were valued, and these savings were communicated to the public. Conservation programs became more desirable when valued by the benefit of reducing future demand, which was higher because the marginal cost of water rises in the future when projected increased demands are met by more costly water sources like recycling, IPR, and desalination. This accounting method contributed to establishing conservation as an integral component of solving other collective action water problems.

The logic established a new option for participants in the Water Allocation AS. A 2001 state law requiring that large multi-family developments create additional water supplies in order to meet the increased water demand that they would generate illustrates the impact of the new choice option. Because conservation could be considered as supply, the law's requirement could be met by designing water drainage systems to recycle landscape water, investing in water-conservation projects, or paying farmers to improve water conservation infrastructure or fallow water intensive crops. Conservation ordinances requiring the use of recycled water for non-potable uses also affected the payoff functions of participants in the Provision AS regarding how they calculated the value of investments to expand the recycled water conveyance network.

## 6. Discussion

The problem frames of *Water Reliability*, *Independence*, *Diversification*, and *Conservation* helped make evident the interdependencies between and among action situations occurring in the San Diego water management social-ecological system. The emergence of new problem frames articulating how two or more resources were ecologically or socially connected contributed to different goods and tasks being managed together in ways corresponding more closely to the complexity of the system. Connections across adjacent action situations that were made explicit by particular problem frames influenced the set of feasible options and policy choices that were available, the designation of particular actors as representatives of collective entities, and the degree of shared understanding among AS participants (McGinnis, 2011b).

For the Provision AS, the processes connected the goods of water resources and knowledge of the social-ecological system to the goods of conservation, wastewater, water quality, and water culture. For the Conservation AS, they created adjacencies connecting the good of wastewater to the goods of water resources, conservation, water culture, and knowledge of the SES. For the Waterwater AS, problem frames did not connect new resources; rather, the processes linked new governance tasks: enforcement and rule-making for the good of wastewater and enforcement for the good of water resources. In contrast, in the Provision AS, the processes did not connect new governance tasks to the focal goods. Appendix C presents a table showing the good types and governance tasks performed in the focal action situation as compared to the adjacent situations for each of the three examined ASs.

Kauneckis and Imperial warn that conflict and ineffective governance arrangements can arise when a “*complex organizational network [is] responsible for rule-making,...[there are] high levels of diversity of perceptions of the value and appropriate use of the resource being managed,...[and] multiple, interrelated resources require intervention in order to address the problems facing the principle resource of interest* (Kauneckis & Imperial, 2005, p. 5).” Nevertheless, over time the authors found that trust development, policy-oriented learning, and a recognition of shared interests could overcome these conditions. Likewise, in San Diego the emergence of new problems frames helped modify action situation working components, leading to effective governance outcomes despite network complexity and a diversity of values.

A hallmark of polycentric systems are the patterns of organization that enable independent elements to make mutual adjustments for ordering their relationships to each other (V. Ostrom, 1999). The order that develops is not spontaneous and is not an emergent property. Rather, polycentric systems are dynamic and full of actors searching for new opportunities (McGinnis, 2015). Many changes in the number of actors performing governance tasks for each public good were observed over the 20 year period (see Appendix D). Public entrepreneurs and communities of resource users, acting with regards to institutional arrangements and responding to societal discourses, generated meaningful order in the system (Huitema & Meijerink, 2010). The research findings support McGinnis' assertion that successful governance systems instill incentives and moral values, “*the right kind of moral repertoire,*” that promote minimizing the costs of bringing groups of people together to solve their own problems (McGinnis, 2015, p. 22).

## 7. Conclusion

In San Diego, the emergence of new problem frames related to water management contributed to the formation of collective identities, facilitated shared understandings, affected the strategic interactions of actors, and introduced new policy choices to deal with the problems of water provisioning, conservation, and wastewater. The findings demonstrate that the introduction of new problem frames through which the collective action problems were understood contributed to governance arrangements that better reflected the interdependencies of the ecological and social components in the social-ecological system.

Even when actors try to resolve a specific collective action problem, the policy options that they select among frequently have implications beyond the immediate focal action situation. The results demonstrate how a combined Politicized IAD – Network of Adjacent Action Situation analysis can contribute to understanding how cultural, normative and discursive processes interact with the flows of materials, resources, and information that output from external action situations. Nevertheless, refinements of this analytical procedure will be necessary before the technique can be applied in agent-based modeling, for policy analysis, or for policy prediction. As implemented, the procedure made assumptions about actors and the social system that are relatively simplified, generalized, and unrealistic.

Additional research in six areas is recommended. First, an improved understanding of the relationship between problem frames and cultural norms and values is needed. The applied procedure did not identify, distinguish, or model the application of norms or values (arising from culture, personality, or elsewhere). These were subsumed within the problem frames variable applied by participants. Second, all action situation actors were presumed to have the potential to apply the same repertoire of problem frames, which is unrealistic, as the problem frames that an actor employs depend on his unique constraints, knowledge, and previous experiences. The analysis procedure needs to be refined to better incorporate variation in how enthusiastically actors apply specific problem frames.

Third, the analysis should incorporate the presence of different actors applying different payoff rules and having access to different information in each focal AS. This may also require revising the stepwise analysis procedure to better handle the temporal component of action situation evolution, since within a focal action situation the same actors can be assigned to different positions over time. Fourth, the analysis would benefit from distinguishing more clearly among multiple governance levels (constitutional, collective choice, and operational) and examining how the levels interact. This omission is related to a fifth problem – the delineation of action situation boundaries. The decision to define action situations by the smallest number of goods and governance tasks was promising but insufficient. The boundaries were informed by the research question but ultimately additional grounding of the boundary criteria will be beneficial, and will inform how different levels of analysis are incorporated. Lastly, the evaluation criteria, whether a governance system accurately matched the physical realities of a resource system (or demonstrated a good fit to it), will improve as scholars continue to refine measurement methods and metrics.

Despite the limitations, the presented case study demonstrates the promise of the Network of Adjacent Action Situations framework for analyzing change in complex governance systems. NAAS has been applied to topics ranging from water, food, and energy value chains (Villamayor-Tomas et al., 2015) to modeling irrigation-related AS networks as ecologies of games where actors achieve configurational equilibria conditions (Kimmich & Tomas, 2017). It has been used to understand the public and private co-production, provision and financing of welfare service delivery (McGinnis, 2011b) and the development of liquefied natural gas infrastructure in the Baltic Sea (Gritsenko, 2018). The framework has even been valuable for explaining unexpected outcomes, such as the emergence of procedural and distributional justice inequalities in a Sierra Leone biofuel production project, despite efforts by telecoupled cross-continental actors to incorporate inclusive governance arrangements and to incorporate community perspectives (Oberlack et al., 2018). The San Diego case study extends the NAAS framework to the topic of local municipal water governance. It also demonstrates how NAAS can be integrated with the Politicized IAD framework to explain change with respect to processes, like problem framing, that lie outside of the tradition of bounded-rationality. It provides new pathways for Narrative Policy Framework research on the role of story-telling in motivating policy change (Jones & McBeth, 2010), the study of value controversies as a driver of learning in action situations (Milchram, Märker, Schlör, Künneke, & van de Kaa, 2019), and research occupied by the challenge of understanding collective action under conditions where configurations of bundles of policies are necessary to effectively address complex collective action problems around environmental or social problems (Villamayor-Tomas, Thiel, Amblard, Zikos, & Blanco, 2019).

## Additional Files

The additional files for this article can be found as follows:

- **Appendix A.** Sampling, Methodology, and Detailed Description of Water Management and Governance in San Diego. DOI: <https://doi.org/10.5334/ijc.974.s1>
- **Appendix B.** Water-related Activities Performed by Actors in San Diego, Characterized by Type of Governance Task Performed. DOI: <https://doi.org/10.5334/ijc.974.s2>
- **Appendix C.** Goods and Governance Tasks Performed in the Three Focal Action Situations and Their Associated Adjacent Action Situations. DOI: <https://doi.org/10.5334/ijc.974.s3>
- **Appendix D.** The Number of Actors Performing Governance Tasks for Each Good, Compared Across 5-Year Periods from 1990–2010. DOI: <https://doi.org/10.5334/ijc.974.s4>

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## Competing Interests

The authors have no competing interests to declare.

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