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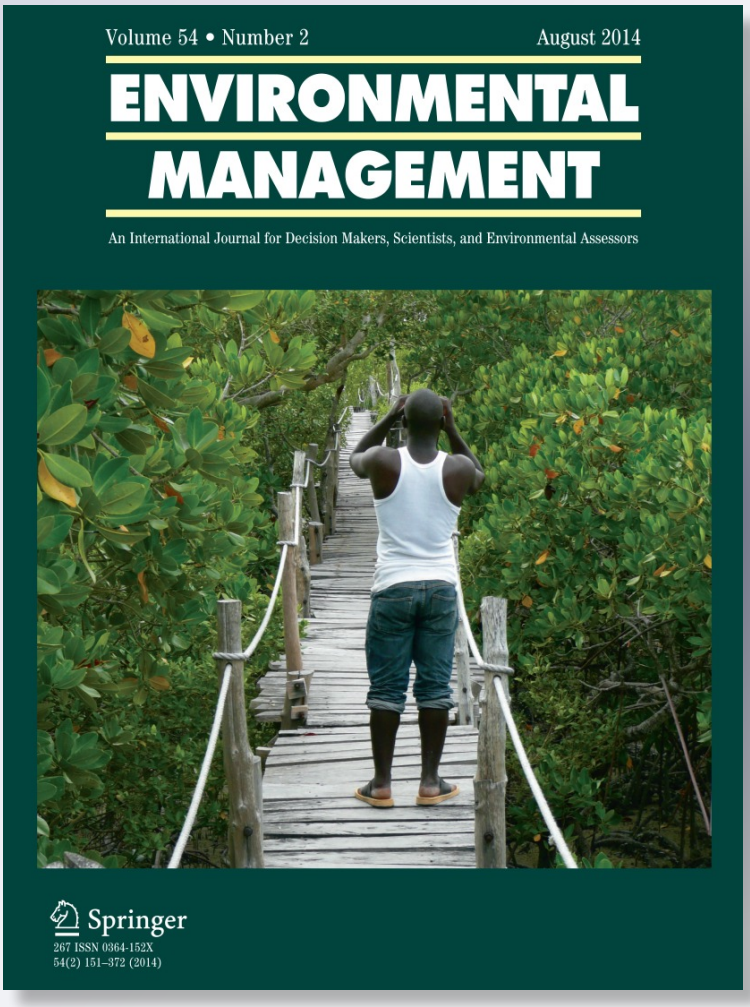

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Sustainability Appraisal of Water Governance Regimes: The Case of Guanacaste, Costa Rica

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Abstract Sustainability appraisals produce evidence for how well water governance regimes operate and where problems exist. This evidence is particularly relevant for regions that face water scarcity and conflicts. In this study, we present a criteria-based and participatory sustainability appraisal of water governance in a region with such characteristics—the dry tropics of NW Costa Rica. Data collection included 47 interviews and three stakeholder workshops. The appraisal was conducted through a collaborative and iterative process between researchers and stakeholders. Out of the 25 sustainability criteria used, seven posed a significant challenge for the governance regime. We found challenges faced by the governance regime primarily clustered around and were re-enforced by failing coordination related to the use, management, and protection of groundwater resources; and inadequate leadership to identify collective goals and to constructively deliberate alternative ways of governing water with diverse groups. The appraisal yielded some positive impact in the study area, yet we found its application provided only limited strategic information to support broader problem-solving efforts. Insights from this study suggest key starting points for sustainable water governance in the Central American dry tropics, including investing in increasingly influential collective organizations that are already active in water governance; and leveraging policy windows that can be used to build confidence and disperse more governing authority to regional and local governing actors that are in-tune with the challenges faced in the dry tropics. We conclude the article with reflections on how to produce research results that are actionable for sustainable water governance.

Keywords Water governance · Sustainability assessment · Impact evaluation · Solution oriented · Costa Rica

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Introduction

Water governance is a set of collective actions that aim toward a common goal and are coordinated among diverse stakeholder groups (Lubell et al. 2008). Sustainable water governance coordinates the supply, delivery, use (including demand management), and outflows of water in a way that ensures sufficient and equitable levels of socioeconomic welfare without compromising the long-term integrity of supporting ecosystems (Rogers and Hall, 2003; Brooks 2006; Langsdale et al. 2009; Wiek and Larson 2012). However, establishing sustainable water governance remains a challenge, and many inadequate governance regimes are driving social–ecological systems toward points beyond which environmental or societal damage may be difficult to correct (Rockström et al. 2009; Galaz

et al. 2012). Inadequate water governance struggles to address the conflicting needs and values of relevant stakeholders; to reconcile different political structures with each other and with ecosystem boundaries; to simplify and enforce rules; and to employ participatory decision-making processes (Pahl-Wostl et al. 2012). Efforts to re-design water governance regimes are needed in order to avoid system failures (Young et al. 2008; Biermann et al. 2012). To aid these efforts, criteria-based and participatory appraisals can help determine how sustainable or how well water governance regimes operate (Wiek et al. 2007). Such appraisals should help clarify what features of water governance regimes deter or foster the sustainability of water systems (i.e., through positive and mutually supporting sustainability effects). In doing so, appraisals can help better align water governance research with real-time problem-solving efforts and with the professional needs of decision-makers (Bakker 2012).

Considering the profound insights on resource governance gained through comparison of comprehensive case studies (Ostrom 2009), there is a need for similar comprehensive and comparable case studies of the sustainability of water governance regimes. This is especially relevant for understudied regions where climate-change threats are imminent, where water conflicts occur, and where impacts from water scarcity are being felt (Pahl-Wostl and Kranz 2010). Few studies address the sustainability of water governance regimes from a comprehensive and actor-oriented perspective (Wiek and Larson 2012; Larson et al. 2013). Even fewer studies include high-risk regions where there is an urgent need for water governance research that yields actionable results. In this paper, we pursue three objectives:

(1) To provide a sustainability appraisal of the water governance regime in Guanacaste, Costa Rica, a region that experiences water conflict, scarcity, and climate change threats.
(2) To reflect on potential impacts resulting from the appraisal in Guanacaste and draw conclusions for future water governance and sustainability research efforts.
(3) To help identify potential challenges and opportunities for water sustainability efforts in the Central American dry tropics.

Case Study Background: Guanacaste Province

Guanacaste is one of the most important agricultural regions in Costa Rica and one of the more lucrative tourism markets in Central America. Agriculture and tourism have continued to expand significantly over recent decades (MINAET 2008; Booth et al. 2010). Guanacaste is a seasonally dry and predominantly rural region where virtually no rain falls half the year. Water is and will likely be much more scarce in the near future. Climate models predict the region will experience significantly drier conditions as soon as the 2020s (Anderson et al. 2008). Water governance is challenged to provide just and fair distributions of water to communities and economic actors, to maintain the integrity of supporting ecosystems, and to mitigate water conflicts. It has thus far struggled to meet these challenges. Ramírez-Cover (2007) documented at least 65 formal water conflicts in Guanacaste over a recent 10-year period.

During the early years of modern Costa Rican statehood (e.g., 1948–1970s), public sector organizations substantially increased in order to meet citizen needs (Edelman 1999, p. 70). During this time, many public organizations relevant for water management were formed, such as the Environment, Energy, and Telecommunications Ministry (*Ministerio de Ambiente, Energía, y Telecomunicaciones*, MINAET), which oversees water-related activities in the country. Growing populations in rural areas tested the ability of the national water utility—the Costa Rican Institute of Aqueducts and Sewers (*Instituto Costarricense de Acueductos y Alcantarillados*, AyA), to meet its responsibility to deliver potable water to citizens. As a result, communities increasingly organized in the water sector, with an estimated 1,500+ rural community-run drinking water associations (ASADAs) now operating (Madrigal et al. 2011). ASADAs perform AyA's duties in rural areas, but are governed autonomously by community boards. Two primary pieces of legislation provide the substance of current water management frameworks. Article 50 of the Constitution guarantees healthy and clean environments for citizens. The 1942 Water Law prohibits private ownership of water resources. Accordingly, the authority to govern water in Costa Rica, with the exception of ASADAs, largely remains with state agencies that have expanded their administration through branch offices around the country (Rogers 2002).

In Guanacaste, the growing public sector combined with the increasing numbers of ASADAs has contributed to water governance becoming increasingly fragmented. There are variable technical, financial, administrative, and logistical capacities among agency offices and ASADAs in different places, and water-related regulations (many of which go back to several decades) often do not clearly specify who is responsible to do what in water management (Rogers 2002). Yet, many individuals are active in in the water sector. Some of these individuals are collectively organized, such as the Commission for the Management of the Potrero–Caimital Watersheds (*Comisión para el Manejo de las Cuencas Potrero-Caimital*, PC Commission) in Nicoya. Like similar collective organizations in the region, their efforts are

Fig. 1 Potrero, Caimital, and Upper Nosara sub-basins in Guanacaste Province, Costa Rica. Map created using data from ITCR (2008)

challenged due, in part, to little being systematically known about water systems, their problems, and the potential opportunities to resolve problems. Thus, a water governance appraisal that elaborates normative criteria, that helps clarify what about current water governance negatively or positively impacts system sustainability, and that identifies where problems and opportunities exist in the system could be a useful research endeavor.

We explore such an appraisal in this paper. We focus on three connected sub-basins in Guanacaste: the Río Potrero, Río Caimital, and Upper Río Nosara in Nicoya and Hojancha Municipalities (Fig. 1). The Upper Río Nosara and Río Caimital flow west to the Pacific coast. The Potrero–Caimital Aquifer is located beneath the Caimital and Potrero. During the dry season, groundwater from the Potrero–Caimital Aquifer is transported to the Town of Hojancha. The semi-urban City of Nicoya receives its entire water supply from Río Potrero surface flows. The largest agricultural producer in the region lies over a large part of the Potrero–Caimital Aquifer, upstream from where the City of Nicoya extracts surface water. About 30,000 people live in the area; most reside in the City of Nicoya (INEC 2011). The case presented here affords an opportunity to appraise a water governance regime that shares many common features with regions across the Central American dry tropics such as high uncertainty, complexity, and potential conflicts under changing climate conditions (Rogers 2002; Biswas et al. 2009). Accordingly, this appraisal supports greater understanding of water sustainability in dry tropical regions that experience water scarcity, conflicts, and climate change threats.

Framework for Analyzing and Appraising Regional Water Governance Regimes

A broader notion of "who is involved" distinguishes governance from government or management, which implyies limited sets of actors such as agencies or utilities. Governance includes all people affecting and affected by water systems as potential actors who might coordinate their activities toward collective goals (Ludwig 2001; Ostrom 2007). Actors include diverse sets of state, private, and civil players who are "doing things" with water, including governing water, and who hold some degree of power, rights, or resources (Rhodes 1996; Kemp et al. 2005). This *doing* that is coordinated across groups of actors toward collective goals (e.g., governance) steers or guides water systems (Lubell et al. 2008). Sustainability appraisals, in a water governance context, evaluate how well governance regimes steer water systems towards sustainability, e.g., a direction that ensures "…a sufficient and equitable level of social and economic well-being without compromising the viability and integrity of the supporting hydro-ecosystems in the long term (Wiek and Larson 2012)."

In this study, we use the actor-oriented approach for analyzing and appraising regional water governance regimes proposed by Wiek and Larson (2012). The approach is composed of an analytical and a normative component. The analytical component is similar to the Institutional Analysis and Development (IAD) framework developed by Elinor Ostrom and collaborators (Ostrom 2011 offers a recent review) and the regime analysis framework proposed by Holtz et al. (2008). Both

frameworks have been applied to water systems (e.g., Imperial 1999; Pahl-Wostl et al. 2010). Wiek and Larson (2012) take components from those frameworks, such as institutions (rules, rights, and decision-making processes) and a focus on social actors and their activities, and structure them in a way that mimics regional water systems in order to better synchronize the approach with the day-to-day operations of governance actors. According to a simplified version of this approach, the water governance regime is structured into four activity domains:

1. *Water Supply:* the physical water sources and the systems that support, maintain, and protect them. Also included are the social arrangements, including water, rights for example, which govern water sources.
2. *Water Delivery:* the distribution of water through infrastructure, such as wells, aqueducts, treatment facilities, and post-treatment storage tanks.
3. *Water Use:* consuming, conserving, and managing the demands for water by organizations and individuals in different sectors such as residential, commercial, industry, and agriculture.
4. *Water Outflows:* includes discharging wastewater and other post water-use sanitation-related activities and governing institutions. In Guanacaste, this includes, for example, septic tanks, oxidation ponds, and run-off that flows back into the watershed or water table.

Each of the activity domains contains three interlinked components:

Actors, Activities, and Institutions

This component includes all relevant social actors and their networks, norms, and values. It outlines what they do with water, how they interact with each other, what their mandates or intentions are, what rules govern their actions and interactions, and what decision-making processes are in play.

Interface with the Natural Environment (Hydro-Ecology)

Water activities rely on and impact the environment, including the four basic spheres of earth systems: the hydrosphere (water and precipitation), the lithosphere (land and soils), the biosphere (plants and wildlife), and the atmosphere (air and linked climatological processes) and their interactions. This interface captures various geologic, hydrologic, ecologic, and other environmental attributes and processes.

Interface with the Built or Engineered Environment (Infrastructure)

Water activities include, among others, building, altering, and removing infrastructure and facilities. We capture, for example, extraction and retention facilities linked to water supplies; the physical system for water deliveries, along with the biological or mechanical systems (e.g., wetlands or treatment plants) for cleaning water for various purposes; infrastructure that determines various usages and rates of consumption (e.g., irrigation systems); and recharge basins or other structures for managing outflows from the system or recycling wastewater.

The second part of the approach suggests a set of normative sustainability criteria for appraising the analyzed governance regime, which we focus on here. A range of literature details criteria for good resource governance (Ostrom 1990; Ostrom 1992; Folke et al. 2005; Lockwood 2010) and water governance in particular (Rogers and Hall 2003; Alley and Leake 2004; Pahl-Wostl 2008; Grigg 2010). Criteria based on this literature were synthesized and vetted with stakeholders in this case and others (see Wiek and Larson (2012). These criteria overlap across parts of the water system. Accordingly, criteria interact with each other, which can produce either positive or negative cumulative sustainability effects (Gibson 2006; Larson et al. 2013). Criteria are categorized according to Gibson's (2006) set of sustainability criteria and linked to the framework's activity domains in Table 1.

Research Design

Appraisal Planning

The appraisal was planned in Costa Rica with collaborators from June through August 2010. This afforded stakeholders and researchers a platform to communicate, align expectations, and to establish long-term collaboration. During this time, a partnership was formed with the PC Commission in Nicoya, which was composed of members from MINET, ASADAs, Nicoya Municipality, and the National University. Through several meetings with PC Commission members and other stakeholders, the appraisal procedure was hashed out. This included vetting the interview protocol, identifying participants, discussing appraisal criteria (which were under development in Wiek and Larson (2012) at the time), elaborating an initial "skeleton" version of the water system map to be used in interviews (to ensure that it resonated with interviewees), and defining the appraisal parameters. Accordingly, a qualitative and visual procedure that used a water systems map based on the framework was formulated. The goal of this procedure was

Table 1 Principles and criteria for appraising the sustainability of water governance regimes, adapted from Wiek and Larson (2012)

Principle	Criteria	Governance domain
1. Social-ecological system integrity	1a. Maintain minimum flows of surface water	1a. Supply
	1b. Maintain or enhance the quality of water resources	1b. All
	1c. Ensure aquifers are not over-taxed to points of instability	1c. Supply
	1d. Recognize/coordinate resource uses and impacts within appropriate physical units	1d. Use
2. Resource efficiency and maintenance	2a. Reduce water-use and/or enhance water-use efficiency	2a. Use
	2b. Reuse water and recycle wastewater for various uses	2b. Use/ outflows
	2c. Eliminate water losses	2c. Supply/ delivery
	2d. Groundwater extraction should not exceed recharge	2d. Supply
3. Livelihood Sufficiency and Opportunity	3a. All people pursuing livelihood activities have access to sufficient quality and quantity of water	3a. Supply/use
	3b. All people pursuing economic activities have access to sufficient quality and quantity of water	3b. Supply/use
	3c. A fair compensation for affected stakeholders in case of insufficient access	3c. Supply/use
4. Socio-ecological civility and democratic governance	4a. Involve all groups who affect or are affected by water governance efforts in decision-making	4a. All
	4b. Elicit the full array of interests and perspectives through various stages of governance	4b. All
	4c. Establish collaborative water governance endeavors	4c. Supply/ delivery
5. Intergenerational and intragenerational equity	5a. Ensure all residents have access to safe water for eating, drinking and sanitation	5a. Supply
	5b. Define and implement a sufficient level of water needs beyond "basic needs"	5b. Use
	5c. Ensure fair distribution of benefits and costs among stakeholders	5c. All
	5d. Facilitate involvement among diverse stakeholders	5d. All
	5e. Ensure representation of future generations (e.g., via groups who consider their interests)	e. Use
6. Interconnectivity from local to regional to global scales	6a. Reduce/eliminate negative impacts on other areas	6a. Supply/ outflows
	6b. Plan within the watershed or groundwater basin context	6b. Supply
	6c. Recognize/coordinate between local and broader scale stakeholders	6c. Supply
7. Precaution (mitigation) and adaptability	7a. Anticipate potential water shortages and water quality problems	7a. Supply
	7b. Mitigate potential water shortages and water quality problems	7b. All/use
	7c. Adapt to water shortages and water quality problems	7c. All

to identify how well the governance regime worked based on a normative set of criteria and to clarify where in the system problems and potential opportunities existed.

Data Collection: Interviews

Forty-seven interviews were conducted with individuals from 40 different government agencies, local governments, service organizations, cooperatives, membership organizations, and businesses (Table 2). Eight additional interviews were conducted with small family farms (businesses). Agrawal's (2008) classification of rural actors was used in the planning phase to help in ensuring all relevant groups were adequately represented in interviews. Ninety percent of organizations originally targeted were interviewed. To ensure that all key actors were interviewed, we asked interview participants to list who they considered to be the two most important organizations (besides their own) for water governance in the region (i.e., Wiek et al. 2007). All of those resulting organizations were interviewed. The interviews first engaged respondents with the sustainability principles and criteria (allowing for comments and alternative suggestions). Each respondent then shared two water-related challenges he or she

Table 2 Selected organizations involved in the study. Classification of actors is based on Agrawal (2008)

Key actors	Description
Agencies	
Acueductos y Alcantarillados (AyA)	National water utility mandated to supply drinking water to the population
Ministerio de Ambiente, Energía y Telecomunicaciones (MINAET)	Environment ministry. Umbrella organization for environmental management. Nicoya and Hojancha are managed as separate sub-regions; "Conservation Area" branches manage protected areas. The Área de Conservación Tempisque (ACT) is the responsible Conservation Area in the study site
Ministerio de Agricultura y Ganadería (MAG)	Agriculture and ranching ministry mandated to promote economic competitiveness of Costa Rican agriculture
Local governments	
Rural water administrators (ASADAs)	Community-run groups that manage rural drinking water supplies and deliveries. Granted power to set and collect water use tariffs.
Municipalities	County-level government that develops land-use guidelines outside of nationally protected areas
Service organizations	
NicoyAgua Foundation	Nonprofit water conservation group in Nicoya administered by the Potero Caimital Watershed (PC) Commission, which promotes basin-level management
National Training Institute	Extension office dedicated to producer training and education
Membership organizations	
Rural development associations	Community-run groups dedicated to securing community well-being and financing local projects
Ranching commissions	Local organizations that disseminate information to producers and promoting collective interests
Cooperatives	
CooPilangosta	Coffee producer cooperative
CoopeGuanacaste	Regional electricity provider
Businesses	
Costeña S.A.	Primarily a melon producer and largest agricultural business in the area

perceived to be critical for the region and located those challenges on the systems map. This information was used to identify the water-related challenges that actors saw as prominent in the region and to then visually compare and group those challenges with the resulting noncompliant criteria in the appraisal on the systems map. Interviews lasted an average of 75 min and were conducted face-to-face from August to December 2010.

Data Collection and Synthesis: Workshops

Three workshops informed the appraisal. The first involved mostly researchers studying water issues in Guanacaste. Researchers were from Costa Rica, Colombia, and the United States. The workshop was held in Palo Verde National Park, Guanacaste in August 2010. Nine participants represented the Organization for Tropical Studies, *Universidad de Costa Rica*, *Centro Agronómico Tropical de Investigación y Enseñanza*, the International Union for the Conservation of Nature, and Arizona State University. Participants broadly evaluated water governance in the region using the criteria and outlined water-related challenges. The second and third workshops were held in Hojanhca and Nicoya in November 2010. The 20 participants in these two workshops represented AyA, MINAET, ACT, ASADAs, MAG, Municipalities, PC Commission, agricultural associations, and producers. Early results of the nearly finished interviews were presented and discussed, which allowed for additional input. Nearly all workshop attendees had participated in the study interviews that had already engaged them with the water system map. This experience helped in supporting the diverse groups to frame the water system using a similar perspective (i.e., its boundaries were defined and the governance domains were clear). In an open discussion format, participants used the criteria across the four domains of the water system to begin appraising the governance regime. The research team facilitated and participated in the discussion.

Appraisal Scoring

After the workshops, the research team initially appraised the governance regime against each criterion (from Table 1). This first involved filling in the appraisal score sheet (e.g., Table 3 in the results) with evidence from the interviews, the workshops, and the parallel governance analysis research effort (of the same system in Kuzdas et al. 2014). As a part of this effort, the research team also organized information from publicly available sources (i.e., reports, indicators, monitoring data, etc.) for use as additional evidence in the appraisal score sheet. To then score

Table 3 Relative compliance of Guanacaste's water governance regime with criteria

Appraisal criteria	Domain	Appraisal results/score sheet
Principle #1: Socio-ecological system integrity | Relative appraisal score: 6/12–50 %		
1a Maintain minimum surface water flows	Supply	Data are sparse, but from our initial calculations (Kuzdas et al. 2014) it does not appear surface flows are currently overtaxed in the wet season. Careful study is needed of dry season flows, which are minimal, and supply availability in general. New mechanisms for transparently monitoring flows are also crucial **
1b Maintain or enhance water resource quality	Cross-cutting	Residents enjoy regular clean water. MINAET is charged with monitoring ecosystem health and integrity; however consistent monitoring and enforcement is a challenge especially outside voluntary initiatives in the water outflows domain **
1c Ensure aquifers are not over-taxed	Supply	There has never been a groundwater study in the Upper Nosara. The Potrero–Caimital Aquifer was mapped for the first time in 2003 by Costeña, the largest groundwater-user in the region. This study was foundational for the subsequent 2006 and 2008 agency studies on aquifer vulnerability. No reliable information on stocks from an independent source exists and current protection remains inadequate *
1d Coordinate water uses/impacts within appropriate units	Delivery use	ASADAs do not coordinate groundwater extractions or water-use with each other or with Costeña and other agricultural businesses that use the same source. Current rules and regulations do not encourage coordination. No leader facilitates the accumulation of water system knowledge over time *
Principle #2: Resource efficiency & maintenance | Relative appraisal score: 6/12–50 %		
2a Reduce or enhance water-use efficiency	Use	Leadership roles that guide and coordinate public and producer education efforts are missing. Fractured knowledge of water-use across groups and communities makes collective goal setting and identifying, targeting, and evaluating the effectiveness of water-use or demand reduction programs difficult *
2b Reuse water/recycle wastewater	Outflow use	Reuse and recycling projects are gaining interest, evidenced by several recent water re-use and recycling workshops. However lacking coordination and vagueness (who is responsible to do what) in the water outflows domain inhibit program implementation **
2c Eliminate water losses	Supply delivery	Infrastructure is often maintained well enough; however public funds for upkeep are sparse. In the 2010 rainy season for example, AyA took out a large loan to fund infrastructure maintenance. Infrastructure problems periodically leave Hojancha without running water **
2d Groundwater extractions should not exceed recharge	Supply delivery	Although considered to be one of the better water resources in the region, the Potrero–Caimital Aquifer has never been sufficiently studied to identify safe-yield thresholds. Knowledge of groundwater supplies is often considered by agencies to be the major challenge for managing water in Guanacaste *
Principle #3: Livelihood sufficiency & opportunity | Relative appraisal score: 6/9–67 %		
3a Everyone pursuing livelihood activities has sufficient access to water quality/quantity	Supply use	Those covered by AyA and ASADA delivery networks (a majority of people) are generally assured water of sufficient quality and quantity. Legally all residents have the right to drill private wells for domestic purposes. However independent rural farmers relying on private wells are assured neither quantity nor quality and are vulnerable in the dry season **
3b Everyone pursuing economic activities has sufficient access to water quality/quantity	Supply use	Wait times for obtaining water permits for economic uses can be exasperating for small farmers. Illegal water extractions are common, and may be twice as many as recorded legal extractions. Ironically, weak institutions seem to be allowing equal economic opportunity at the moment. Increasing scarcity, poor knowledge of how much water people are using, and weak institutions could turn out to be a detrimental combination leading to tension in the future **

Table 3 continued

Appraisal criteria	Domain	Appraisal results/score sheet
3c Fair compensation for affected stakeholders in case of insufficient access	Supply use	The Environmental Tribunal Court and pathways within MINAET resolve compensation issues for affected stakeholders and semi-public NGOs are available to take action on behalf of people. However case-volume and lengthy litigation processes have limited local access to Courts. Guanacaste communities are well organized and are capable of mobilizing when fair compensation is not available. Communities trust in agencies and government in general has decreased in recent decades (Edelman 1999) **
Principle #4: Socio-ecological civility and democratic governance | Relative appraisal score: 6/9–67 %		
4a All groups who affect/are affected by water are involved in decision making	Cross-cutting	Involving rural communities and large private water-users remains a challenge. Agencies often struggle to involve each other in decision-making, which also creates difficulty involving other groups outside of central government. But there are collective efforts that aim to broaden involvement in governance through the PC Commission/NicoyAgua **
4b Elicit full array of interests/perspectives	Cross-cutting	Despite calls in the 2004 Management Plan to integrate rural community and private sector interests, it did not develop strategies to achieve this. The PC Commission has broadened governance to cover more rural interests in some cases, though this is often administered in ad hoc fashion **
4c Establish collaborative endeavors	Supply delivery	Actors collaborate most effectively in the water supply domain, where civil society (i.e., the PC Commission) is most active. Community-groups have successfully partnered with businesses to purchase land for conservation. Model forest and biological corridor projects are ongoing. Collaboration however decreases in the other domains as no collective goals for the regime have been established **
Principle #5: Inter & intragenerational equity | Relative appraisal score: 11/15–73 %		
5a All residents have access to potable water	Supply	Virtually all residents have access to potable water ***
5b Define/implement a sufficient level of water needs beyond basic needs	Use	Agencies that are most central in the regime (AyA and MINAET) do not typically coordinate or share information to the extent where such levels of need could be fairly decided. Poorly organized data of how much water is going where and for what purpose, the declining legitimacy of national institutions, and corruption in the national government is likely helping to erode the mutual trust needed for effective deliberation and implementation of such decisions *
5c Ensure fair distribution of benefits/costs among stakeholders	Cross-cutting	People in the Town of Hojanhca are charged slightly higher water use tariffs to help cover water transport costs. Accessible and clean water is a right by Costa Rican law, so in theory costs should not disproportionately burden one group over another. However regulatory and enforcement gaps concerning groundwater supplies and in the water outflows domain potentially allow for some communities to share disproportionate costs associated with contamination and groundwater depletion **
5d Facilitate involvement among diverse stakeholders	Cross-cutting	In some cases, collective organizations are filling roles that attempt to connect and involve diverse groups and communities. Continued support and leveraging these organizations is vital, as rural involvement in broader governing processes and decision-making remains limited **
5e Ensure representation of future generations	Use	A number of environmental NGOs (often financed by international donors largely concerned with the survival of rare tropical dry forests) who are involved with the public sector help ensure future generations have a voice in governing processes ***
Principle #6: Interconnectivity from local to global scales | Relative appraisal score: 6/12–50 %		
6a Reduce negative impacts on other areas	Supply outflow	Downstream coastal communities do not usually see negative impacts. ***
6b Plan within the basin context	Supply	Recent uprisings in nearby rural areas over water transfers have made some planning processes more concerned with the basin context. Though water independence is considered important in Hojancha, the role of taking leadership responsibility to achieve this remains unfilled. **

Table 3 continued

Appraisal criteria	Domain	Appraisal results/score sheet
6c Recognize/coordinate between local and broader scale actors	Outflow supply	Coordination with broader, regional water governance is nonexistent and roles that effectively connect to broader scale actors are unfilled. Nearby Coastal communities rely on aquifers that are subject to increasing salinization and demand. Increased connections between local and broader scales actors, and a stronger broader regional approach, will be important. *
Principle #7: Precaution (mitigation) and adaptability | Relative appraisal score: 5/9–56 %		
7a Anticipate shortages/quality problems	Supply	It is widely accepted that dryer or more variable climate patterns will be experienced in the near future. However, procedures that attempt to apply future planning are often not widely available or used. **
7b Mitigate shortages/quality problems	Cross-cutting, use	Reforestation is typically the only strategy used to mitigate problems. There is a lack of constructive and open deliberation processes that are able to devise, compare, and test alternative governance schemes that can more fully mitigate problems. Local management plans are not currently binding, nested into larger governing institutions, or enforceable; which hinders coordinated planning that seeks to mitigate local water problems. *
7c Adapt to water shortages/quality problems	Cross-cutting	Mobilizing resources and responding to change is mostly effective in reforestation contexts; however less evidence indicates that quick and effective change can be implemented in other efforts related to water shortages and quality. With apparent limited options to enhance water supply, there is a need to involve diverse groups to deliberate demand management alternatives **

Scoring key: * Noncompliance, ** Some compliance, *** Full compliance

the appraisal, we applied a three-tier metric (denoted by asterisks), which indicates (one*) noncompliance, (two**) some compliance, or (three***) full or nearly full compliance of the governance regime with a given criterion. Relative compliance of each sustainability principle was then calculated by dividing the summed score of individual criterion within a given principle by the maximum possible score. We used the resulting average scores as a way to differentiate three groups of principles that were, relative to each other, in either high, medium, or low compliance (Fig. 2). As specified during the appraisal-planning step, the scoring assumed that each criterion is equally important for principles, and each principle is equally important for sustainability. Averaging scores for each principle was used, despite the categorical variables, in order to provide guidance and initial differentiation among principles for targeted discussions with stakeholders on the principles/criteria that may require more urgent attention than others. This technique supported the clear communication of appraisal results and provided a concise way to summarize the detailed information contained in the appraisal.

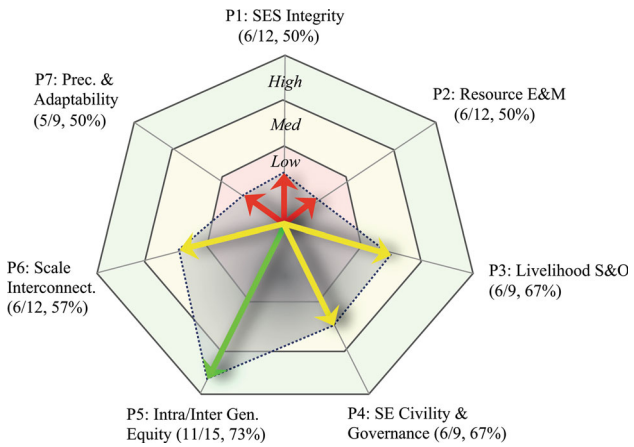

Fig. 2 Comparing and differentiating relative compliance among sustainability principles. Length of *arrows* represents relative sustainability compliance (*green* high; *yellow* medium; *red* low, in online/PDF version) of individual principles in comparison to others

Mapping the Appraisal

Criteria that scored as relatively noncompliant (e.g., one*) were then placed onto the finalized systems map. To place criteria onto the map, we used the framework that specifies which domain(s) each criterion is relevant, along with the detailed information found within the appraisal itself. The perceived water-related challenges (from interviews) were aggregated and grouped using content analysis techniques. Each of those aggregated groups was then assigned a code (A–F) and paced into the part of the water system map where respondents most often mentioned the water-related challenges (that were included in the grouping) as occurring. This step provided a visual picture of the appraisal results in comparison to the perceived water-related challenges, as well as providing indications as to where in the water system both tend to cluster and which actors (already on the finished map) were implicated.

Examining Problem Clusters, Opportunities, and Finalizing Results

Starting in early 2012, appraisal scoring was vetted and finalized in an iterative process with partners in the PC Commission in order to promote relevance of the results. The PC Commission reviewed a draft document describing the initial appraisal scoring. After receiving feedback on the document, we used the marked systems map to visually group the challenges and noncompliant criteria into clusters (based on the same actors involved in the same part of the water system map) in order to explore underlying problem drivers, which if corrected, could help in mitigating several noncompliant criteria and water-related challenges linked to a particular cluster. Accordingly, this step afforded initial qualitative insight into the negative effects of interactions among criteria and water-related challenges within "problem clusters" that were relevant for the regional water system. This step also provided further insight into existing opportunities that already produced positive sustainability effects (as identified in the appraisal) and could potentially be capitalized on to further increase those effects. The research team, PC Commission members, and a number of other stakeholders from civil society, agricultural businesses, and ASADAs examined and synthesized the identified clusters and opportunities in a series of meetings. This process occurred throughout March 2012 in Costa Rica. In April 2012, an executive summary and final report for the completed appraisal was distributed to stakeholders in the region.

Appraisal Results

Overview

Of the 25 criteria used to appraise the sustainability of the water governance regime, for 7 criteria, the regime was rated as noncompliant (*), for 15 criteria, rated as somewhat compliant (**), and for 3 criteria, rated as compliant (***). The scoring and appraisal results are detailed in the score sheet found in Table 3, which includes illustrative evidence. The relative scores and differentiation of each principle in comparison to others is illustrated in Fig. 2.

The regime scored relatively low ($\sim$50 %) compliance against four principles—P1: Socio-ecological system integrity; P2: Resource efficiency and maintenance; P6: Interconnectivity across scales and P7: Precaution and adaptability (Fig. 2). For two principles—P3: Livelihood sufficiency and opportunity and P4: Socio-ecological civility and democratic governance—the regime received relatively medium (67 %) compliance scores. By law, citizens are entitled to basic levels of social services and wellbeing. Article 50 of Costa Rica's constitution guarantees clean and healthy environments for citizens. Implementing the mandate of Article 50, however, has become a challenge for agencies below the provincial-level, which struggle to coordinate with each other and involve local communities in decision-making processes. Communities increasingly seek the power and rights to govern local and regional resources amidst a historical planning context of top-down control, which may create friction and, at times, tension in governing processes. Many of these communities (and large agricultural businesses) rely on groundwater reserves that are poorly understood and potentially already taxed. Noncompliant criteria in the appraisal often related to three interlinked issues: the current lack of coordinated groundwater management and protection among groundwater users and governing actors; the limited available options for enhancing future water supplies (i.e., surface flows are minimal in the dry season); and, the limited capacity to effectively deliberate alternatives to current water governance schemes due to groundwater users and some rural groups that are not involved or that may not trust current governing processes.

For one principle—P5: Intra and intergenerational equity—the regime earned a relatively high (73 %) compliance score. Nearly all citizens have access to clean drinking water in the region. Some collective efforts already collaborate across local branches of government agencies that typically do not coordinate with each other, which helps in increasing general collaborative activities in some places within the governance regime. These efforts allow for the inclusion, although informally, of some rural community water-user associations (e.g., ASADAs) within the region that would otherwise be disconnected from the governance regime.

Problem Perceptions, Locations, and Clusters

In the interviews, governance actors identified a variety of perceived water-related challenges ranging from water quality issues (contamination, monitoring, etc.) to poor aquifer protection. We tabulated and grouped the perceived challenges and where in the system actors marked that they occur as shown in Table 4.

Figure 3 illustrates *where* in the water system noncompliance with criteria (from the appraisal score sheet in Table 3) and the aggregated water-related challenges (Table 4) occur. Based on a visual inspection of the marked system map in Fig. 3, we see that the perceived water-related challenges (triangles in Fig. 3) tend to group with noncompliant criteria from the appraisal (squares in Fig. 3) in the system. The locations of these "problem clusters" helps us identify not only where, but also in particular *who* is active in the part of the water system where problems or

Table 4 Perceived water-related challenges in the region and where they were most often mentioned as occurring in the water system

Perceived water-related challenge		% Of interviews mentioned	In which domain mentioned most?
A	Contamination, water quality, monitoring and enforcement	38	Supplies (groundwater) and Outflows
B	Unregulated demand growth & deforestation	34	Use (ecosystem, agriculture)
C	Climate change	9	Supplies (Potrero–Caimital Aquifer)
D	Lack of education & awareness	9	Use
E	Scarcity and drought	6	Supplies
F	Poor aquifer protection	5	Supplies (groundwater)
–	Distribution inequalities	1	Delivery [not mapped in Fig. 3]

challenges tend to occur. The system noncompliance with criteria and the perceived challenges were found to cluster around four aspects of the regional water governance regime (Table 5).

We qualitatively synthesized the underlying features of the regional governance regime that relate to the perceived water-related challenges, system noncompliance with criteria, and their interactions with each other, which cluster around the four following aspects described in the paragraphs below. Actions, investments, and governing strategies that address key issues found in these problem clusters could have positive effects on the relative compliance of several criteria.

Potrero–Caimital (PC) Aquifer

The absence of management coordination and poor information sharing of water extractions among communities and groups that share the PC Aquifer bring about several challenges. Law mandates that agencies should coordinate with each other (in the water sector) and with local organizations, but how exactly this ought to be organized and who is

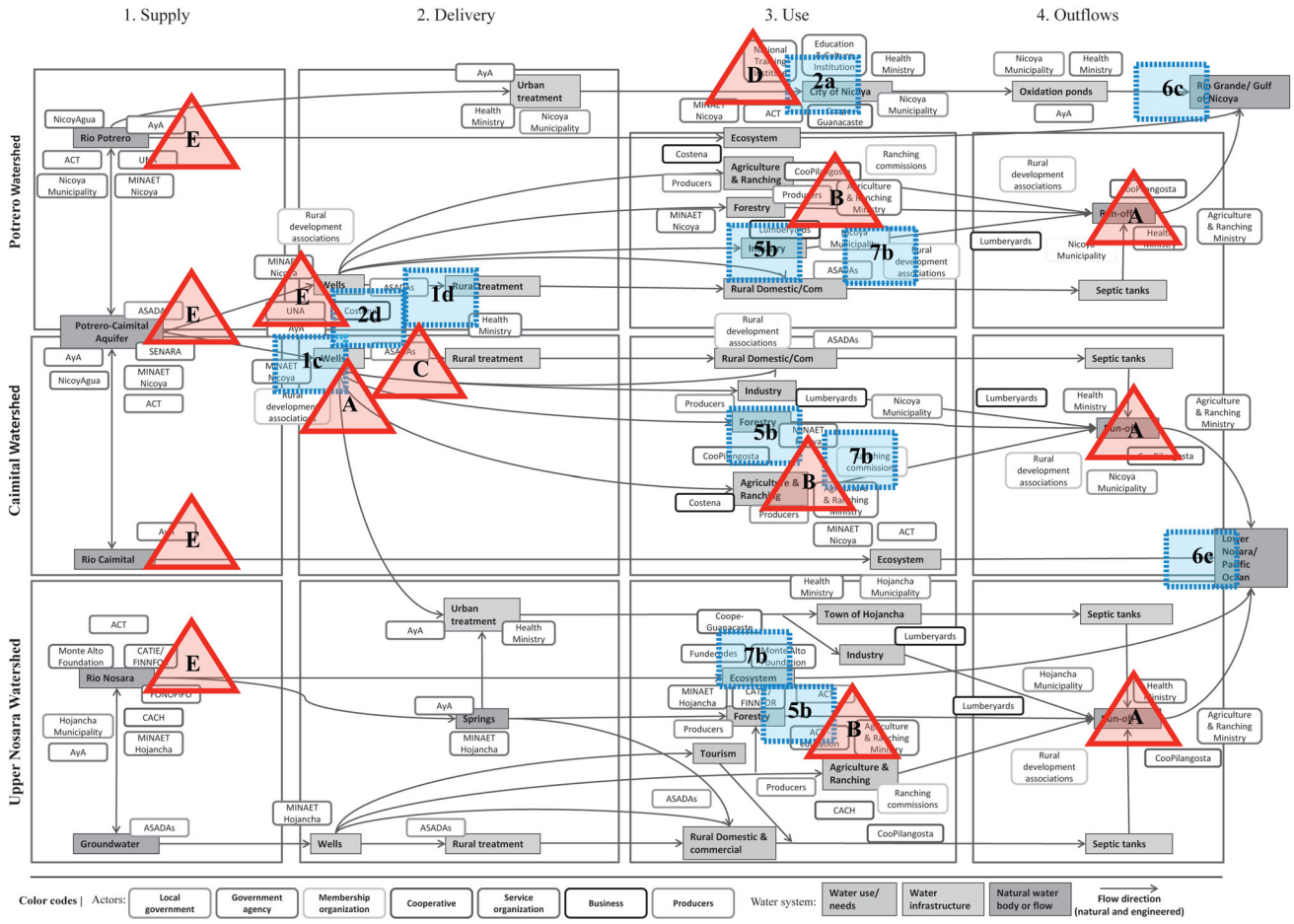

Fig. 3 Results from the appraisal score sheet and perceived water-related challenges are mapped onto the water system. *Squares* indicate relatively noncompliant criteria from the score sheet (1a–7c). *Triangles* indicate water-related challenges perceived by actors (A–F)

Table 5 Problem clusters in the regional water system grouped from the water system map (Fig. 3)

Problem cluster	Appraisal criteria	Actor perceptions	Who is implicated on the water system map?
I. Potrero–Caimital Aquifer	1c, 1d, 2d, 7b	A, C, E, F,	MINAET, AyA, ASADAs, SENARA, Development Associations, Costeña, NicoyAgua,
II. Regulating institutions, water management frameworks	5b, 7b,	A, B	MINAET, AyA, Municipalities, ASADAs, MAG, Health Ministry, Producer Associations, Private enterprise/agriculture
III. Institutional leadership, goal setting, water-use education	2a	D	UNA, MINAET, ACT-Education, MAG, Education and Culture Institution, National Training Institute, NGOs, NicoyAgua
IV. Downstream integration	6c	A	Rural communities, national agencies, Potrero–Caimital Aquifer users and ASADAs

responsible to do what is not defined. This is a challenge for creating accessible and coherent knowledge about water quantities being stored, moved, and used. Local actors indicated that the majority of perceived water-related challenges in the region involve the PC Aquifer (Table 4). In the past, stakeholders have struggled to establish effective groundwater management schemes, despite recognition that other options for viable water supplies are minimal. As indicated in interviews and the appraisal, levels of mutual trust between actors (especially among rural community groups and agencies), which would be needed to execute collaborative management plans in rural areas where diverse groups rely on groundwater, appear to be low. Uncertainty regarding water supply and use of groundwater reserves, combined with inadequate regulatory institutions, makes reconciliation among these groups difficult as demonstrated in recent nearby water conflicts.

Regulatory Institutions/Water Management Frameworks

Inadequate rules that regulate and monitor groundwater and post water-use drive stakeholder concerns regarding water quality. A third of interviewees indicated that contamination/water quality (especially dealing with groundwater and in the water outflows domain) is the most important water-related challenge in the region (Table 4). In the study area, all central governing actors are national agencies with the exception of the PC Commission. Institutional frameworks that dictate how these central actors operate do not clearly specify who is responsible to do what in the region. This vagueness allows for excessive repetition of some responsibilities and leaves voids concerning others. For example, in Hojancha, many actors use organizational resources in duplicated efforts such as reforestation-related activities—and promoting tree farming—often without a broader understanding of its hydrological impacts in the area, while few or no efforts address groundwater issues or relevant issues in water outflows. There is no standard for cooperation between Nicoya and Hojancha, despite Hojancha relying on the PC Aquifer (in Nicoya) for water supplies. In the study area, the first Management Plan (Morataya 2004) aimed to create stakeholder networks—a critical goal considering gaps in broader institutional frameworks. Results of the first management plan have been mixed though, since such plans are not legally enforceable.

Institutional Leadership and Goal seing

The lack of institutional leadership, which helps us drive collective goal setting and deliberation across boundaries, is evident. Results highlight, for example, that various water-use education efforts in the region lack a clear objective. No actor fills leadership roles that guide environmental/water demand education efforts in a unified direction, which is a reflection of the larger issue of unclear governing objectives. Coordinated efforts for sustainable water governance would involve a constructive process to deliberate and identify collective goals and alternative ways of governing water, which in turn requires engagement of diverse stakeholder groups. Effective stakeholder engagement will require enduring leadership and commitment, which spans institutional and administrative boundaries and scales, which is currently not present. MINAET and AyA are the two organizations in the positions, at the moment, to drive goal-setting efforts. However, these two agencies operate in different domains and largely do not coordinate their activities. Having two prominent public actors that do not coordinate their primary functions presents an obstacle for efforts that seek to define goals and to deliberate and implement collective actions to meet those goals.

Downstream and Regional Integration

Poor integration of downstream rural communities, including a lack of clear and accessible vertical

accountability mechanisms, presents challenges especially when considering recent conflict events in nearby areas. If the future does require deliberation processes over new infrastructure, downstream integration will be important for open and fair deliberation processes. At the moment, many of these processes in Guanacaste do not adequately consider demand management perspectives that could in some cases provide an alternative to large water infrastructure and transfer projects (i.e., Gleick 2003). Such approaches would stand in contrast to the traditional supply-enhancement-focused methods of water resources planning in Guanacaste, which (as evidenced by recent conflicts) is a process that is often closed and is viewed with suspicion by many rural communities (Kuzdas 2012). Building downstream integration, especially through improved vertical accountability and through open deliberation of demand management alternatives, may help in avoiding future conflicts and prove important for sustainability efforts.

Opportunities

The appraisal procedure also yielded four existing opportunities that already have positive sustainability effects, but could be further expanded on to multiply those effects:

New Partnerships for Information Sharing

The will to establish venues and science-decision-maker partnerships to support improved information sharing, regarding, for example, water extractions and needs, is demonstrated by recent efforts by the *Universidad Nacional* (UNA) in Nicoya. UNA has initiated work to synthesize water-use information from ASADAs, and it has also hosted workshops aimed at promoting water reuse and recycling in the region. Active institutional leadership for the region could feasibly be fostered or developed in partnership with UNA's programs.

Opportunities for Facilitating Coordination

Grassroots efforts, such as the PC Commission and its affiliate NicoyAgua, are in a unique position to increase participation and coordination among ASADA communities—as well as strengthen ties between AyA and MINAET. The PC Commission is the only actor in the study area with professional ties to both MINAET and AyA, and it already has attempted to better include some rural groups in water governance through informal means. Facilitating better coordination and unified leadership between the regional offices of these two central actors (AyA and MINAET) would be one feasible near-term objective that collective efforts could strive for in order to boost efforts to develop collective goals and deliberate alternative governing options.

Transfer Potential

With adequate strategic planning, the coordination efforts by the PC Commission and other nonstate organizations could serve as a model for grassroots water governance efforts throughout Guanacaste and beyond. Operationally, aiming to be this type of model for the region could feasibly be a powerful motivation and visioning tool for devising alternative ways of governing water. It could also function as a visible learning platform for water governance efforts, and it might inspire new and enduring leadership in the region.

Existing Management Plan as Starting Point

The 2004 Management Plan established the need to include more diverse actors into decision-making. An updated Plan could feasibly be more effective and authoritative if developed in conjunction with more diverse actors. The basis of a new Plan could specify and help establish a localized governing system that offers rural groups formal practical avenues to participate and provide input into water governance processes A modified governing process established by a new Plan could also aim to build consensus through open deliberation of management objectives, to outline responsibilities to monitor system-sustainability compliance, and to provide the means to adjust governance strategies as needed.

Discussion

Appraisal Impacts: Utility, Limitations, and Ways Forward

There is increasing recognition that water governance research largely struggles to integrate with the needs of decision-makers and practitioners; and thus often makes little contribution in terms of directly aiding problem-solving efforts (Bakker 2012). The Guanacaste case demonstrates that with the right local partnerships, and with the right timing, sustainability appraisals could be a promising research endeavor that can aid some problem-solving efforts. We found that the participatory step of mapping challenges onto the water system resonated with stakeholders. More exploration of mapping challenges and opportunities onto water governance regimes could prove beneficial. The criteria-based appraisal was appreciated for its transparency that allowed stakeholders to engage in

structured discussions. As discussed below, the appraisal was applied in the study area. But, its application was also limited in the face of deeply rooted and broader issues. We argue below that, for research efforts to adequately address these broader issues, integration with subsequent solution-oriented research is required.

During the appraisal procedure (2010–2012), the update process to the Regulatory Plan for the Municipality of Nicoya was underway. Regulatory Plans contain legally enforceable policies and designations for land-use zoning and development in areas that are not nationally protected. Under the supervision of the Nicoya Regulatory Plan (NRP) Commission, the two-year update process was initially completed in February 2012 and followed by a 10-day public comment period. Local communities largely deemed the plan inadequate due to the vague rules regarding what can and cannot be done on land over groundwater resources, which many rural communities rely on for their drinking water. In response to these objections, the NRP Commission granted an additional 45-day comment period beginning in April.

During the additional comment period, the PC Commission presented the results of this appraisal to the NRP Commission. The focal point of the presentation was the PC Aquifer "problem cluster." The PC Commission argued for limiting development that utilizes water from the PC Aquifer until better coordination could be achieved and neutral studies commissioned to accurately determine water supply and needs. As a result, the new Regulatory Plan strongly limits new development (for the time being) that uses water from the PC Aquifer. The PC Commission considers this step to set the stage for collectively formulating goals and alternative ways of governing groundwater resources in the area. They are using the momentum for continuing efforts to consolidate a biological corridor in the region and to begin identifying standards (information sharing, reporting back, transparency, etc.) for future research collaborations (i.e., "new partnerships for information sharing" opportunity in Sect. 4.3) in order to promote the relevance of research conducted in the region. However, core issues for water governance remained unresolved.

The root of the contentions over the Regulatory Plan update—the lack of open participation and engagement of communities in governing processes—was not resolved. Some rural communities were not able to personally lobby the NRP Commission as the PC Commission did. One such community group submitted a 10-page document to the NRP Commission outlining faults within the Plan that might allow for new development that the community's only (ground)water source could not support. Governing groundwater resources—and engaging communities in processes that determine their use, conservation, and management—remains a significant challenge in the broader region. The Regulatory Plan update illustrates that, in spite of the moderate success of the PC Commission to put the appraisal to use in policy making, a critical need for long-term and sustainable water governance is still missing: the need for diverse groups to constructively deliberate, devise, and implement alternative water governance schemes in the region.

The PC Commission noted that the appraisal, while providing some focus for their efforts, did not fully establish how they should go about those efforts. The appraisal also did not fully clarify who would need to do what, where, when, etc., in order to address problems and ultimately implement alternative ways of governing water—which would not only require normative, but *instructional/actionable* knowledge (Wiek et al. 2012). While the need to constructively and openly deliberate alternative governing options, as mentioned in the appraisal, is now being considered in planning that involves the PC Commission, the appraisal in itself did not automatically result in people "governing water differently" (Wiek and Larson 2012). Importantly though, the appraisal did allow the need for "governing water differently" to be articulated among a variety of local groups, which offers a valuable starting point for subsequent and integrated solution-oriented water governance research (Pahl-Wostl et al. 2013).

Linking subsequent solution-oriented water governance research to current, engaged research efforts like we presented above offers a potential path for research to better support the re-design of inadequate governance regimes. For example, the PC Commission is especially concerned with the identified problem cluster of institutional leadership. They initially argued AyA should lead, since it currently holds a large amount of formal authority. Although AyA technically holds a seat on the PC Commission, at the time of the appraisal, AyA was often absent. Efforts were explored to engage with AyA in new ways; however, the PC Commission noted that the appraisal provided little guidance on how to do this or how to develop leaders. The point here is that the appraisal was limited in its ability to inspire *new ways of addressing* challenges. For example, while AyA might be the default legal choice to lead—it may not be the *best* choice. The best choice may not yet exist. How an innovative leadership scheme, which may require an alternative governance regime and other preliminary steps, could best be implemented over time is beyond the scope of an appraisal. For this, solution-oriented research would be necessary. Research has noted that robust options for solving or addressing complex problems cannot be deduced from only analyzing or describing complex problems (Sarewitz et al. 2012; Wiek et al. 2012). Others have concluded that water governance research in

particular would highly benefit, in terms of its impact and utility, from solution-oriented approaches (Bakker 2012; Pahl-Wostl et al. 2013). This appraisal in Guanacaste validates these perspectives. The appraisal in Guanacaste proved useful for local groups that were closely involved with the appraisal procedure. But, further constructive and solution-oriented research efforts that, for example, investigate what alternative governance schemes best address different problems and that devise the steps to implement and adjust those schemes over time (Reed and Kasprzyk 2009), could offer the actionable knowledge needed to fully address complex water problems. We conclude that descriptive–analytical research efforts are best carefully integrated with, rather than separated from, subsequent solution-oriented research.

Considerations for Sustainable Water Governance in the Central American Dry Tropics

Based on this appraisal, we would expect *Principle #1: Social–ecological system integrity* to be a focal point for sustainable water governance. Like Guanacaste, many parts of the dry tropics in Central America increasingly rely on groundwater as an important water resource. Expected drier conditions could severely affect these resources, while also limiting the viability of relying on substitute surface flows for water supplies. Coordinating the sustainable use, management, and protection of groundwater reserves is a critical challenge for sustainability efforts—especially considering the typically vague regulatory context of the use, management, and protection of groundwater reserves in the broader region (Ballestero et al. 2007). Accordingly, developing and implementing fair governing processes in line with *Principle #4: Socioecological civility and democratic governance*, i.e., processes that involve the rural groups that rely on these threatened groundwater reserves, will be an important endeavor for sustainability efforts in the broader region.

Achieving compliance with *Principle #4* though presents challenges for much of Central America. For example, the low engagement and involvement of rural communities in decision-making processes, especially those that concern contested groundwater reserves, has been found to be an important driver of escalated water conflicts in Guanacaste (Paniagua and Stocks 2008; Kuzdas 2012). Reconciliation with such rural groups through new governing processes and mechanisms, in addition to helping in improving system compliance with *Principle #4*, could also allow for positive sustainability effects via the promotion of more effective deliberation with alternative demand management strategies (which would require the involvement of rural groups that use groundwater) (Brooks and Holtz 2009). Such demand management strategies (as opposed to supply-enhancement strategies) could in turn also help support positive, mutually reinforced sustainability effects related to *Principle #1: Socioecological system integrity* (via better-coordinated groundwater management and protection) and *Principle #2: Resource maintenance and efficiency* considering, in Guanacaste, citizen's concerns over potentially taxed groundwater supplies, the limited options for other water supplies in dry seasons, and increasing water demand (e.g., Table 4).

In order to promote such positive sustainability effects along the lines mentioned above, many water governance regimes in Central America will need to confront deep social inequalities, lingering poverty, histories of exclusive control, and rapid political economic changes that have in some areas fostered deeply rooted feelings of disenfranchisement and distrust toward broader governing institutions (Edelman 1999; Booth et al. 2010). Multifaceted and committed efforts working toward reconciliation (i.e., peace and trust building processes), capacity building, and renewed investment (i.e., technical, financial, and administrative resources) in these rural, dry tropical regions offers a start on the path toward addressing key issues for more sustainable water governance regimes. The Guanacaste case affords insight into two potential opportunities for water governance regimes in the broader region to get started on this path.

While economic liberalization in the broader region has generated concerns over public sector capacity (Eakin et al. 2011), there has been a growing influence of private enterprise and civil society organizations in decision-making (Bebbington 2005). In Guanacaste, we found that the efforts of the PC Commission had positive sustainability impacts where public sector roles were diminished. These roles helped in spurring some coordination across institutional and jurisdictional boundaries and facilitated the informal participation of some rural groups in governing processes. These actions made the water governance regime relatively more open, just, and collaborative in the parts where the PC Commission was active. Grassroot organizations are common in the broader region (Booth et al. 2010), and although their capacities vary, they do offer an investment opportunity that, combined with the right partnerships and in appropriate settings, could produce positive impacts.

The second opportunity that we might expect are "policy windows" that can potentially be used to distribute more governing authority to local, regional, and basin-level planning efforts that already occur, but with limited formal authority, in many places (Rogers 2002). Despite not being a silver bullet, well-designed and alternative schemes that better disperse authority could potentially allow for decision making that is more in-tune and responsive to the challenges that more rural, dry tropical regions face such as

governing groundwater in a climate threatened and socially contested context. These "windows" may come unexpectedly and seem limited, as the Regulatory Plan update process in Guanacaste illustrates, but may, nonetheless, be a first step. For example, the PC Commission reported its lobbying efforts during the Plan update helped in increasing its confidence and in solidifying its position as a respectable governance actor in the area, which it considers a positive a step toward utilizing the "transfer potential" opportunity that is described in Sect. 4.3. Other "windows" may take on different forms. For example, Eakin and Lemos (2010) note the trend has been for smaller-scale managers and administrators to experiment with new policy instruments such as "risk atlases" and "ecological ordinances." Scenarios and basin-scale plans have been used in Guanacaste communities, and they could feasibly build on sustainability appraisal efforts in order to support groups to constructively engage with, devise, and test alternative ways of governing water (Kuzdas et al. 2013). These "policy windows" offer opportunities that could support and strengthen the collective organization of local actors to more effectively confront and positively influence broader governing issues that currently promote negative sustainability effects on dry tropical water systems.

Conclusion

The sustainability appraisal was a valuable tool that provided normative knowledge of how well water governance in Guanacaste operated. While results suggested well-targeted efforts could help people remedy interlinked problems, the appraisal in itself provided limited evidence-based instructions that would address how to go about resolving those problems over time. Additional and expanded efforts are critically needed to deliberate, implement, and test alternative ways of governing water that can overcome broader governing issues. Accordingly, water governance research that integrates descriptive–analytical components, solution-oriented components, and real-time problem-solving efforts is a high priority that could help support sustainable water governance in Guanacaste and beyond. As a start for these efforts, the Guanacaste appraisal suggested two critical points for sustainable water governance in the Central American dry tropics: (1) devising alternative governance schemes for improved groundwater management and protection; and (2) renewed efforts and investments to reconcile with rural communities, especially those that rely on groundwater reserves. Two existing opportunities that could be leveraged to start addressing these critical points include (1) investing in existing grassroots organizations that already make positive sustainability impacts; and (2) leveraging "policy windows" to gradually disperse more decision-making, planning, and monitoring authority to local, regional, and basin-scale actors that already attempt to innovate water governance practices, policies, and normative principles.

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