PSJ Policy Studies Journal

The Policy Studies Journal, Vol. 00, No. 00, 2016

Polycentric Transformation in Kenyan Water Governance: A Dynamic Analysis of Institutional and Social-Ecological Change

Paul McCord, Jampel Dell'Angelo, Elizabeth Baldwin, and Tom Evans

Beginning in 2002, Kenyan water governance transitioned from a monocentric, top-down system to one exhibiting traits of polycentricity. In this paper, we investigate the changes made to water policy following the 2002 reform, outcomes produced in a collection of community- and catchment-level user groups in the Mount Kenya region, and the conformance of these changes and outcomes with principles of polycentricity. A new framework is used to capture the complex institutional arrangements and interactions existing before and after the polycentric transformation. Unlike many previous polycentricity studies, the present research focuses primarily on the outcomes of the polycentric shift and determines if these correspond to predictions from polycentricity theory. We utilize survey data collected in 2013 from water managers, as well as archival research to interrogate congruence with principles of polycentricity. This study contributes to the broader discussion on polycentricity in two fundamental ways: (i) It documents the functioning of a water management system following a top-down imposed polycentric reform, and (ii) It empirically inspects whether these polycentric reforms have produced benefits predicted by polycentricity theorists, such as experimentation by local water users, increased collective action, and improved coordination between levels of management.

KEY WORDS: water governance, polycentricity, institutional analysis, Kenya, collective action

Introduction

In 2002, Kenya began to transition from a highly centralized system of water governance to one demonstrating a polycentric order. The country's current regime includes several features that scholars associate with polycentricity and have proposed should lead to effective water management in terms of equitable water distribution and coordination between multiple decision makers. Independent groups of local users are allowed to devise their own water allocation rules in response to changing ecological conditions. Local users also participate in regional, watershed-delineated users' associations that coordinate use throughout a watershed's catchment and impose regionally appropriate restrictions on water use during times of

Published by Wiley Periodicals, Inc., 350 Main Street, Malden, MA 02148, USA, and 9600 Garsington Road, Oxford, OX4 2DQ.

scarcity. Throughout Kenya, user groups are part of an overarching system of national laws that coordinates water governance between local, regional, and national actors.

The Kenya case allows us to examine two areas of research on polycentricity that are rarely addressed. First, we inspect a deliberate national government effort in transitioning toward polycentric resource governance, which few have investigated (exceptions include Andersson & Ostrom, 2008; Baldwin, Washington-Ottombre, Dell'Angelo, Cole, & Evans, 2016). Second, while many polycentricity scholars have developed propositions about why polycentric structures result in improved natural resource governance, few of these propositions have been empirically tested. Therefore, we move beyond a descriptive analysis of the governance structure to investigate whether Kenya's reforms have produced the beneficial outcomes predicted by theory.

In this paper, we combine data from fieldwork and archival research to ask: In a particular social-ecological system (SES), how have actor roles and local-level rules adjusted following the 2002 top-down reform? More specifically, to what extent do Kenya's postreform governance outcomes reflect the benefits predicted by polycentricity theorists? With respect to this research question, we test two hypotheses:

Hypothesis 1: In the postreform period, user groups will experiment with new approaches to governance by adjusting their rules.
Hypothesis 2: Some of this experimentation will correlate with improved local conditions.

In addition to directly testing the above hypotheses, we also draw on survey evidence to examine the way that communication and coordination within Kenya's polycentric system has affected governance within user groups. This inspection provides an opportunity to empirically examine the alignment of formal and informal outcomes with the theorized traits of a polycentric system.

Our investigation will focus on a SES within Kenya's Upper Ewaso Ng'iro basin on the northern and northwestern slopes of Mount Kenya.

To document regional- and national-level drivers leading to water reform, as well as changes to key subsystem variables (i.e., resource system, resource units, governance system, and actors) following reform, we use a new framework: the "combined IAD-SES framework," which was recently developed by scholars affiliated with the Ostrom Workshop of Indiana University (see Cole, Epstein, & McGinnis, 2014). This framework allows us to capture complex social, biophysical, and institutional arrangements and interactions at the regional and national level and explain the Government of Kenya's transition from top-down water governance to an approach in which responsibilities are distributed across multiple levels.

The structure of the remainder of the paper is as follows. First, we review the literature on polycentricity, identifying the key features of polycentric systems and the theoretical mechanisms by which these features might be expected to lead to improved natural resource governance. Next, the combined IAD-SES framework is

described and used to briefly explain the Government of Kenya's transition from centralized to multilevel water governance. The study site is then described, followed by an explanation of the data and methods used in our empirical analysis. We then inspect postreform governance outcomes, including rules-in-use, at the community and catchment-level within the Upper Ewaso Ng'iro basin as of the summer of 2013. Finally, we discuss our empirical findings and their conformance with polycentricity theory.

Polycentricity

Polycentricity was first proposed as a possible approach to governance in the early 1960s. At the time, many metropolitan areas included city, county, and suburban jurisdictions, as well as the presence of state and federal agencies with specialized but limited authority in particular policy areas. Scholars of government tended to presume that such overlapping jurisdictions were chaotic at best and pathological at worst, and called for consolidation of service provision to improve efficiency (Aligica & Tarko, 2012; Cottrell, 1949). Vincent Ostrom, Tiebout, and Warren (1961) countered this argument by proposing that consolidated approaches to service provision were likely to be inefficient, because such "one size fits all" approaches could not account for divergent preferences among different groups of citizens, or differing economies of scale among different public services. In contrast, polycentric systems—with "many centers of decision making which are formally independent of each other"—might actually improve efficiency (V. Ostrom et al., 1961, p. 831).

In the decades since, a growing number of scholars have further developed the concept of polycentric governance, both theoretically and empirically. Much of this literature focuses on polycentric approaches to natural resource governance and development. Not unlike government scholars of the 1960s, many development scholars in the immediate postcolonial period tended to presume that centralized government control was necessary to ensure efficient use of natural resources (e.g., Scott, 1998; Shivakoti & Ostrom, 2001). Numerous scholars—including, most famously, Elinor Ostrom—countered this presumption through empirical documentation of cases in which local resource users were able to manage resources effectively (Agrawal & Gibson, 1999; E. Ostrom, 1990, 1999). As these cases have accumulated, the concept of polycentricity has developed beyond the original conception proposed by V. Ostrom, Tiebout, and Warren.

Polycentricity has been defined in numerous ways, and not all scholars agree about what makes a particular governance system "polycentric," although studies have tended to converge around a few key characteristics. First, polycentric systems always involve multiple, independent centers of decision making (Andersson & Ostrom, 2008). Polycentricity is distinct from decentralization, however, in that mechanisms for coordination and cooperation between decision centers are crucial features of polycentric regimes (Pahl-Wostl & Knieper, 2014). Polycentric systems also feature overlapping jurisdictions that create partially redundant institutions (da Silveira & Richards, 2013; McGinnis, 1999). Overlap can be geographic, perhaps in

the form of nested decision centers (Andersson & Ostrom, 2008), or may be functional, where multiple decision centers have authority in a given policy area (Galaz, Crona, Österblom, Olsson, & Folke, 2012).

Moreover, many scholars of polycentricity have asserted, either implicitly or explicitly, that these structural features give rise to good governance outcomes. For example, the presence of multiple, independent decision centers is thought to allow local decision centers to experiment with informal rules governing resource use, suggesting the possibility of innovation and learning (Andersson & Ostrom, 2008). It also allows local groups to devise rules that respond and adapt to local conditions, theoretically making polycentric systems more resilient to ecological shocks (Galaz et al., 2012). Because local actors best understand local needs and conditions, they may be better positioned to craft informal rules that meet localized needs more efficiently and equitably than government administrators' formal rules (Folke, Hahn, Olsson, & Norberg, 2005; Ribot, Agrawal, & Larson, 2006).

Perhaps more important, however, coordination and overlapping authority among these independent decision centers can enable mutual adjustment among decision centers (V. Ostrom, 1999). Indeed, mechanisms for communication and coordination distinguish between polycentric systems and those that are decentralized (Andersson & Ostrom, 2008; Pahl-Wostl & Knieper, 2014). Such coordination might, for example, allow local user groups to communicate with regional or national policymakers, giving them a "voice" in policy matters that can help improve outcomes (Andersson & Ostrom, 2008). Coordination can also be crucial where multiple local user groups are nested within a shared water basin, forest system, or fishery. Coordination and overlapping authority allows user groups to communicate and adjust their use in ways that benefit the system as a whole, essentially enabling collective action at multiple levels of governance (Cole & McGinnis, 2014).

It is not a foregone conclusion, however, that polycentric governance structures will always give rise to the beneficial governance outcomes predicted by theory. Indeed, V. Ostrom et al. (1961) were cautious to note that independent centers of decision making may not inevitably give rise to "orderly outcomes"; instead, this is an empirical question (p. 831). Recently, a number of studies have provided empirical evidence that polycentric governance regimes tend to have high performance (Basurto & Ostrom 2009; E. Ostrom, 1999; Pahl-Wostl, Lebel, Knieper, and Nikitina, 2012), particularly when compared with non-polycentric or less-polycentric systems (da Silveira & Richards, 2013; Pahl-Wostl & Knieper, 2014). There has been limited empirical testing, however, of the theoretical propositions that scholars have developed to explain the apparent success of polycentric systems, including experimentation with informal rules and adaptation to local conditions.

In this article, we undertake such empirical testing. We examine a system—water and irrigation governance in Kenya—that has recently adopted reforms instating the three basic features of polycentricity: multiple decision centers at the local, water basin, and national levels; overlapping authority among these decision centers; and formal and informal mechanisms of coordination and communication between these decision centers. Within that system, we examine processes and behaviors adopted by water users, focusing in particular on whether Kenya's polycentric

structure gives rise to processes and behaviors predicted by polycentricity theory, such as local groups experimenting with new rules and adoption of rules in response to local conditions.

The Kenyan case is particularly interesting because whereas most previous studies have focused on polycentric governance systems that evolved over time, some of the structural elements that create a polycentric system in Kenya are the result of national policy changes due to reforms in 2002. Kenya has always had local and national centers of decision making, but the 2002 reforms formalized the creation of regional (water basin level) decision centers; created several formal mechanisms for coordination among local-, regional-, and national-level decision units; and prescribed overlapping authority over water allocation between these decision units. As a result, the Kenyan case provides the researcher with a rare opportunity to examine whether polycentric structures, imposed by national actors, give rise to the local-level behaviors and processes predicted by polycentricity theorists.

We turn now to a description of the Government of Kenya's transition from monocentric to polycentric water governance, which is aided by use of the combined IAD-SES framework.

Transformation from Monocentric to Polycentric Governance

The water governance structure that presently exists in Kenya was largely put in place following the 2002 Water Act (Liniger, Gikonyo, Kiteme, & Wiesmann, 2005). A number of drivers led to water reform, and since reform, significant changes have occurred with respect to the governance system, actor roles, and efforts to match governance responsibilities with hydrological borders. We briefly document these drivers and postreform changes at the national level using the combined IAD-SES framework.

The Combined IAD-SES Framework

The institutional analysis and development (IAD) framework, first described in publication in 1982 (Kiser & Ostrom, 1982), places action situation(s) at its center and uses exogenous biophysical conditions, community attributes, rules used by participants, and interactions among actors and their environments to explain decision making within action situations (Figure 1a). Further, decision making is influenced by the positions held by participants, the allowable actions, information availability, and the costs and benefits of decisions within the action situation. The framework has been described by some as one of the most important institutional analytical frameworks in policy sciences (Sabatier, 2007), and since its development, has been extended to a large and diverse number of empirical settings, including international development (e.g., Gordillo & Andersson, 2004), industrial regulation (e.g., Schaaf, 1989), banking reforms (e.g., Polski, 2003), land tenure (e.g., Mwangi, 2003), problems related to the water–energy—food nexus (e.g., Villamayor-Tomas, Grundmann, Epstein, Evans, & Kimmich, 2015), environmental conflicts (e.g., Dell'Angelo, 2012), and participation analysis (e.g., Bixler, Dell'Angelo, Mfune, & Roba, 2015).

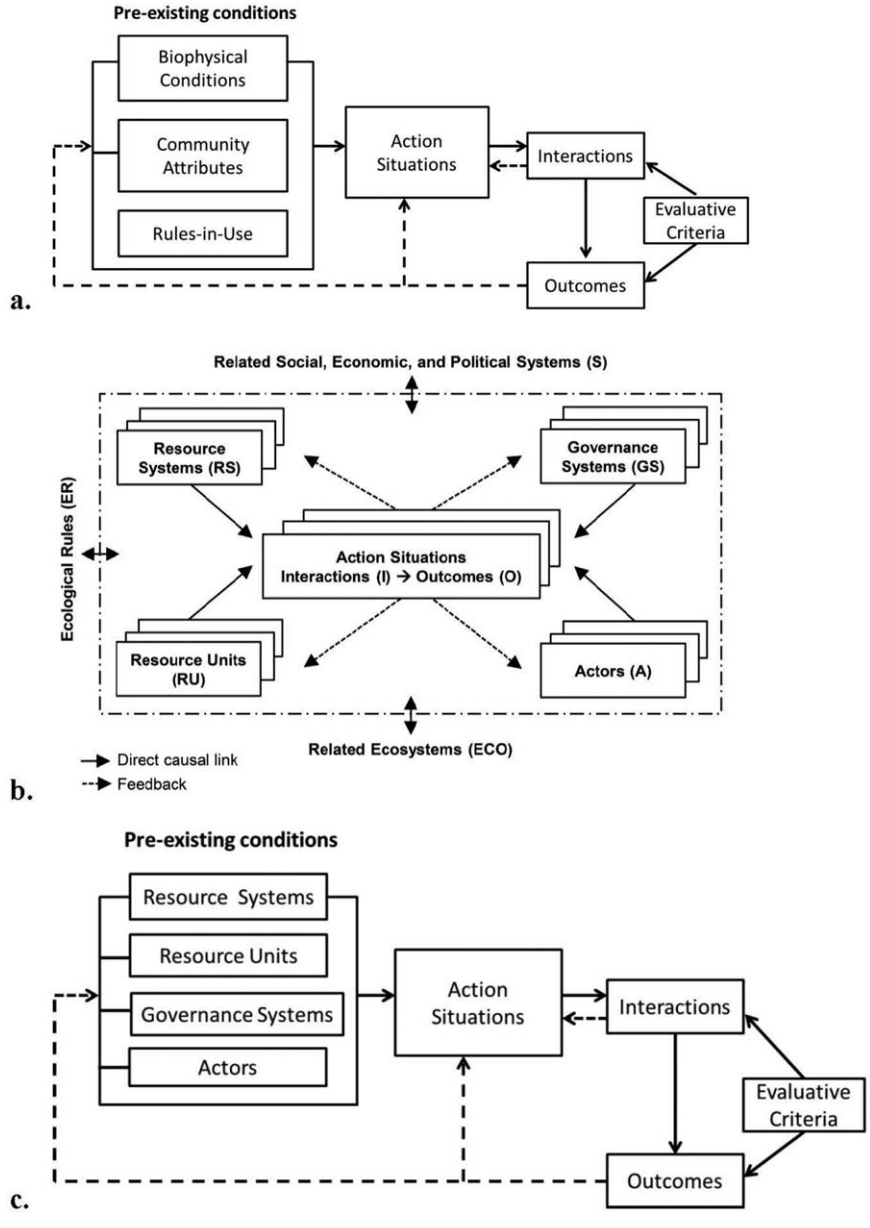

Figure 1. (a) The IAD Framework, (b) the SES Framework, and (c) the Combined IAD-SES Framework.
Source: Adapted from Cole et al. (2014).

Like the IAD framework, the more recently developed SESs framework is structured around a central action situation (Figure 1b). First elaborated in E. Ostrom (2007), the SES framework seeks to identify components of and interactions between resource systems, resource units, actors, and governance systems in producing social-ecological outcomes (McGinnis & Ostrom, 2014). The SES framework operates as a diagnostic tool as it proposes a set of second- and third-tier variables for analysis of SESs (Table 1), and

Table 1. Second- and Third-Tier Variables for Diagnosing SESs

Resource Systems	Resource Units	Governance Systems	Actors
RS1 Sector	**RU1** Resource unit mobility	**GS1** Government organizations	**A1** Number of users
RS2 Clarity of system boundaries	**RU2** Growth or replacement rate	**GS2** Nongovernment organizations	**A2** Socioeconomic attributes of users a. Economic b. Cultural
RS3 Size of resource system a. Area b. Volume	**RU3** Interaction among resource units a. Strong to weak b. Predatory or symbiotic	**GS3** Network structure a. Centrality b. Modularity c. Connectivity d. Number of levels	**A3** History of use
RS4 Human-constructed facilities	**RU4** Economic value	**GS4** Property-rights systems a. Private b. Public c. Common d. Mixed	**A4** Location
RS5 Productivity of system	**RU5** Number of units	**GS5** Operational rules	**A5** Leadership/ entrepreneurship
RS6 Equilibrium properties a. Recharge dynamics b. Recharge rate c. Number of equilibria d. Feedbacks i. Positive ii. Negative	**RU6** Distinctive markings	**GS6** Collective-choice rules	**A6** Norms/social capital
RS7 Predictability of system dynamics	**RU7** Spatial and temporal distribution a. Spatial heterogeneity b. Temporal heterogeneity	**GS7** Constitutional rules	**A7** Knowledge of SES/mental models
RS8 Storage characteristics		**GS8** Monitoring and sanctioning processes	**A8** Importance of resource
RS9 Location			**A9** Technology used

Source: Adapted from E. Ostrom (2009) and E. Ostrom and Cox (2010).

in this way further elaborates upon elements originally appearing in the IAD framework. Since its inception, the SES framework has been applied to a variety of social-ecological settings, such as fisheries (e.g., Basurto, Gelcich, & Ostrom, 2013; Cinner et al., 2012; Gutiérrez, Hilborn, & Defeo, 2011), forests (e.g., Fleischman et al., 2010), and water and irrigation (Cox, 2014; Madrigal, Alpízar, & Schlüter, 2011; E. Ostrom, 2011).

Despite the utility of the IAD and SES frameworks in studying, among other things, the sustainability of SESs, each has been criticized for perceived shortcomings: the IAD for insufficient attention to natural systems, and the SES for its inability to provide more than a static list of system components. Recognizing these shortcomings, Cole et al. (2014) devised the "combined IAD-SES framework," which integrates the SES variables entirely into the IAD framework (Figure 1c). The combined IAD-SES framework, therefore, allows the user to employ a multilevel analysis tool that

recognizes the major subsystems of an SES (i.e., the SES framework) in a dynamic manner where temporal institutional variations are accounted for (i.e., the IAD framework). Given these strengths, this framework appears well-suited for detailing the drivers of institutional reform and the outcomes produced through such a reform.

We have chosen to employ the combined IAD-SES framework to detail Kenya's water reform for several reasons. First, separately the IAD and SES frameworks are both meant to incorporate feedback mechanisms; however, in the case of the SES, these mechanisms are not readily identifiable. Using the newly developed framework, we are able to identify not only the existing conditions from the social and ecological realms at the first time step, but also those produced following treatment at a second interval. Second, the interaction of adjacent action situations in producing outcomes has been well-developed within the IAD framework (McGinnis, 2011), but by employing the combined IAD-SES framework, the user's attention is readdressed from looking primarily at outcomes produced from actor preferences and institutional arrangements to the role of broader subsystems in achieving social-ecological outcomes. Finally, as we will highlight, the institutional arrangements within the Kenya context are particularly complex, and to understand the transformation from one governance regime to another, a framework characterizing not only the breadth of interactions across time points but also the depth of interactions at a single time point, such as multilevel dynamics, is particularly useful. We believe the combined IAD-SES framework has been well developed for this purpose.

In describing Kenya's water management reform, we primarily employ information retrieved during the summer of 2013 from the Kenyan National Archives, the University of Nairobi, and the Ministry of Water and Irrigation. We focus on the period beginning just before the 2002 reform and ending at the time of data collection (i.e., 2013). Explanations for variable selection before and after the 2002 reform, as well as action situation dynamics are detailed in the Appendix.

Application of the Combined IAD-SES Framework: Explaining Reform

In the early and mid-1960s as Kenya emerged from colonial rule, the government retained many of the water governance strategies that were put in place by the British. The centralized approach established during colonial rule was poorly suited for the conditions in Kenya and was eventually superseded by reforms at the turn of the twenty-first century (Baldwin et al., 2016). Among other features, these reforms represent a shift from top-down water governance to a polycentric approach by creating decision centers at multiple levels and providing for coordination between regional and local actors. In the paragraphs that follow, we describe the resource system, actors, and governance system in place prior to the 2002 reform. We go on to analyze the way these variables affected appropriation, rulemaking, monitoring, and conflict resolution. We conclude with a discussion of resource and governance outcomes as of 2013. Table 2 summarizes each of the SES subsystems at two time points, while Figure 2 uses the combined IAD-SES framework to dynamically capture forces motivating change, as well as the outcomes produced.

Table 2. Key SES Variables at Two Time Points

Variable (Code)	Time Point 1—Late 1990s	Time Point 2—2013	Summary of Subsystem
Resource System (RS)			
Clarity of hydrological boundaries (RS2)	Clearly defined	Clearly defined	From 1964 to the late 1990s, despite the clarity of hydrological boundaries, water administration took place along political boundaries, which did not compel resource users to consider downstream individuals (A6). Following the 2002 water reform, water management matches hydrological boundaries, which has contributed to improved downstream water access in some locations
Streamflow trend (RS5)	Decreasing	Decreasing, but reports of improved downstream river water access in some locations	
Actors (A)			
Leadership (A5)	Leadership poorly aligned with biophysical units and limited in its consideration of local conditions. Informal user groups providing model for reform in late 1990s	Leadership recognized at multiple biophysical units	Smallholder farmers throughout Kenya are highly reliant on surface water for irrigation purposes. Before the 2002 reform, downstream users were severely disadvantaged due to the poor fit between hydrological scales and governance units, which did not compel upstream users to be overly aware of the catchment-wide consequences of their actions. After reform, leadership became better aligned with hydrological scales and has improved water access in some downstream locations
Norms (A6)	Minimal consideration of downstream users	Increased awareness of downstream users	
Resource dependence (A8)	High resource dependence	High resource dependence	
Governance System (GS)			
Government organizations (GS1a)	Water Apportionment Board, Water Bailiffs	Water Resources Management Authority, Water Resource Users Association	Kenya shifted from a top-down, monocentric style of water management to one with multiple levels corresponding with various hydrological scales after the 2002 reform. This put in place WRMA and the
Network structure (GS3a)	Formal structure: Top-down	Formal structure: Multilevel	
Connectivity between governing units (GS3b)	Minimal connectivity	Improved connectivity	

Table 2. *cont.*

Variable (Code)	Time Point 1—Late 1990s	Time Point 2—2013	Summary of Subsystem
Water appropriation operational rules (GS5a)	Nairobi and region-based permit system. Ineffective operational rules for water appropriation between upstream and downstream users	Regional WRMA offices responsible for issuing water use permits. Operational rules for water appropriation between upstream and downstream users put in place by WRMA and WRUA	WRUAs as regional- and catchment-level managers of water and replaced the WAB and the Water Bailiffs. With the creation of WRUAs, connectivity between governing units improved, since local water users serve on each WRUA's management committee, and WRUAs work closely with their corresponding WRMA office. In turn, this has improved the presence of monitoring personnel and led to rules-in-use aimed at equitably appropriating water between upstream and downstream users
Monitoring (GS8)	Water Apportionment Board personnel and Water Bailiffs significantly underfunded leading to poor monitoring	Local monitoring personnel in the form of WRUA representatives and, in some cases, WRMA staff	

Pre-Existing Conditions before Water Reform

By the late 1990s, the groundwork for water reform was already being laid as, in response to a largely failing national system, NGOs, government representatives, community water projects (CWPs), and individual smallholders created an informal Water Users' Association (WUA) within Kenya's Likii River catchment (A5 in Figure 2—left-hand-side variables) to coordinate upstream–downstream water uses, share information, and resolve disputes (Liniger et al., 2005). This WUA would later be the model for catchment-level user groups following reform (described below). The immediate impetus for these actors in establishing the Likii WUA was a rash of upstream–downstream water conflicts fueled by excessive upstream river water withdrawals. However, the less apparent drivers—although more universal throughout the country—had existed since the colonial era. We now explain these drivers.

The Nairobi-based Water Apportionment Board (WAB; GS1a) had several critical responsibilities during British rule and in the years following independence, including permit issuance, sanctioning of water misuse, and placing restrictions on use during periods of scarcity. While the WAB was a national agency based in Nairobi, reforms in the 1970s increased participation by local officials, primarily by opening numerous Water Bailiff offices throughout Kenya to issue permits and monitor permit compliance (GS1a) (Kenya Water Apportionment Board, 1972). These efforts were largely ineffective, however, as final authority remained with the central government. In fact, these adjustments led to a less-efficient permitting process: water users now needed to obtain permits from both local and national officials, and this process could take years to complete (Kenya Ministry of Water Development,

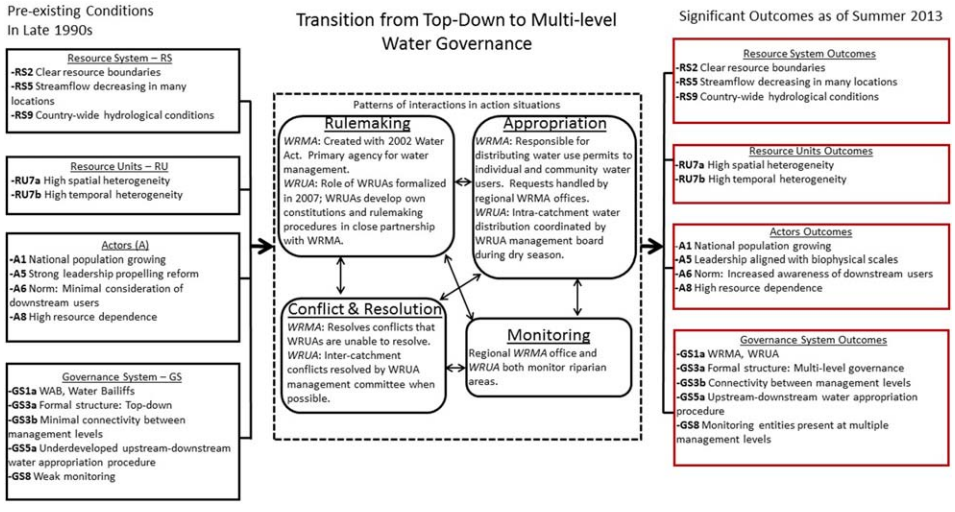

Figure 2. Application of the Combined IAD-SES Framework: Kenya's Transition from Monocentric to Multilevel Water Governance.

1983). The regional Water Bailiff offices were also significantly underfunded and often lacked the financial means to patrol riparian locations for nonpermitted water users (GS8). If water users chose to avoid the permitting process, they ran little risk of detection. Thus, despite efforts to bolster local water governance, Kenya retained a largely ineffective top-down system of management (GS3a) with poor coordination across governance levels (GS3b) up to the turn of the twenty-first century.

Compounding these inefficiencies were incongruities between the hydrological system itself and the individuals charged with officiating the resource system. In their efforts to monitor water use and issue abstraction permits, Water Bailiffs were assigned to jurisdictions based on political (district) boundaries. This complicated management efforts as these water officials had no reason to consider the effects of upstream water use on downstream users so long as the downstream users were within another district (GS5a). Therefore, despite the clear natural borders (RS2) of the hydrological system (i.e., catchment areas), the management of water use led to opaque understandings of downstream water needs (A6); the result of which were frequent downstream water shortages, particularly during dry periods (A8 and RS5) (Liniger et al., 2005).

Kenya's 2002 Water Reform

As these water shortages intensified, efforts took place at both the regional and national levels to reform water management. An informal WUA was established in the Likii River catchment to coordinate use among water users. Following the initial success of this WUA, the Government of Kenya incorporated the WUA concept in its reforms by encouraging the creation of formal Water Resource Users Associations

(WRUAs), which would become independent decision units at the catchment-level. National reforms also created a Water Resources Management Authority (WRMA), responsible for developing overall policy strategies for Kenya, as well as for certain appropriation, conflict resolution, and monitoring activities. The reforms also delineated overlapping and shared responsibilities for rulemaking, appropriation, monitoring, and conflict resolution at the community, WRUA, and national levels. Thus, a multilevel system took hold in which individual or community water users were nested within WRUAs, which were further nested within a WRMA region.

With the opening of regional offices within each of Kenya's water basins, WRMA officials were able to better enforce policy changes enacted after the water reform. From a water appropriation perspective, WRMA now requires users to obtain permits from one of these regional offices, or if the individual belongs to a community user group, the user group needs to collectively possess a WRMA permit. Further, an overlap between the responsibilities of WRMA and WRUA exists since WRMA must consult with the WRUAs on permit issuance. These permits formally limit the timing and quantity of water abstracted, and, in times of water scarcity, require a percentage of water to pass through the catchment to downstream users. Monitoring compliance with the terms of these permits is shared between WRMA personnel and members of the WRUA. Additionally, if the permit terms are violated or disputes arise between upstream–downstream users within the same catchment, WRUA and WRMA may share conflict resolution responsibilities. In cases where upstream–downstream conflicts occur across catchments, WRMA becomes the primary entity responsible for conflict resolution, creating an overlap of authority between WRUAs and WRMA.

The WRUAs did not become formally recognized as catchment-level user associations until 2007; nonetheless, informal WUAs were present in multiple catchments before 2007 and these informal groups provided a blueprint upon which the WRUAs that existed as of 2013 were crafted (Baldwin et al., 2016). A WRUA encompasses all members of a particular catchment that possess a WRMA water use permit, and they operate as truly representative entities, as the management committee for each WRUA is made up of members from the catchment: representatives from community user groups, CEOs of large-scale farms, and individual riparian households, among others.

The primary role of a WRUA is to prevent and resolve conflicts between water users within a catchment area (WRMA & WSTF, 2009), and to this end, they share many responsibilities with the regional WRMA office. In terms of rulemaking, WRUAs are allowed to devise their own constitutions; yet, this is done in partnership with WRMA, often using a template approved by WRMA. Their closest partnership with WRMA, however, arguably occurs with respect to water appropriation during the dry season. As river water becomes scarce, WRUAs are expected to devise a schedule of appropriation among the catchment members. This requires members to keep their river intakes shut on all days that they are not scheduled to receive water. In theory, this program allows a percentage of water to reach downstream users, even during the dry season. Crafting the schedule of appropriation is often done in close consultation with WRMA officials and requires WRMA's approval before implementation. Likewise, monitoring compliance with the dry season regulations and resolving conflicts as

they arise is also typically shared between WRUA and WRMA personnel; yet, WRUAs may entirely defer conflict resolution duties to WRMA if the offense or grievance is deemed best handled at a higher level of governance.

Conditions as of the Summer of 2013

Following this national-level effort to reorient water governance institutions and actor roles, SES conditions as of 2013 indicate that certain features of polycentric governance and adaptive co-management of water resources now exist in Kenya (GS3a in Figure 2—right-hand-side variables). Adaptive co-management suggests that governance responsibilities are most effective when the scope of influence aligns with hydrological borders (Huitema et al., 2009). With the creation of WRUAs, water use activities within and across catchments became better coordinated, particularly during the dry season (GS3b and GS5a), and individual water users became increasingly aware of the consequences of their activities on other actors within and outside their catchment (A6). Our own interviews suggest that, despite these coordination efforts within catchments, the effectiveness of WRUAs in alleviating water disparities have been mixed: some downstream users continue to object to excessive upstream water use, while others feel that postreform water availability has improved (RS5).

In terms of monitoring (GS8), the 2002 reform has created redundancies in some catchments, a trait of polycentric governance. Regional WRMA personnel will patrol riparian zones in search of unauthorized pumping, an effort that is also performed by members of the WRUA particularly when the dry season appropriation schedule has been imposed. This duplication of duties creates a safety net where a failure on the part of one institution is alleviated by the presence of another. While WRMA personnel may not be as prominent in some catchments compared to others, the very presence of a catchment-level governance entity (i.e., the WRUA) suggests leadership will be familiar with local conditions (A5), another important element of adaptive co-management (Huitema et al., 2009).

With the formal transition from monocentric to multilevel management described, we now analyze the outcomes of this nationally imposed polycentric shift on a SES within Kenya's Upper Ewaso Ng'iro basin. We begin by describing the SES of interest and then move on to a description of the data used before inspecting the outcomes of reform.

Study Area

The Upper Ewaso Ng'iro Basin

Both a climatic and social gradient exists in the Upper Ewaso Ng'iro basin (McCord, Cox, Schmitt-Harsh, & Evans, 2015). Nested within the basin are 25 CWPs where fieldwork was conducted. These CWPs span an area of approximately

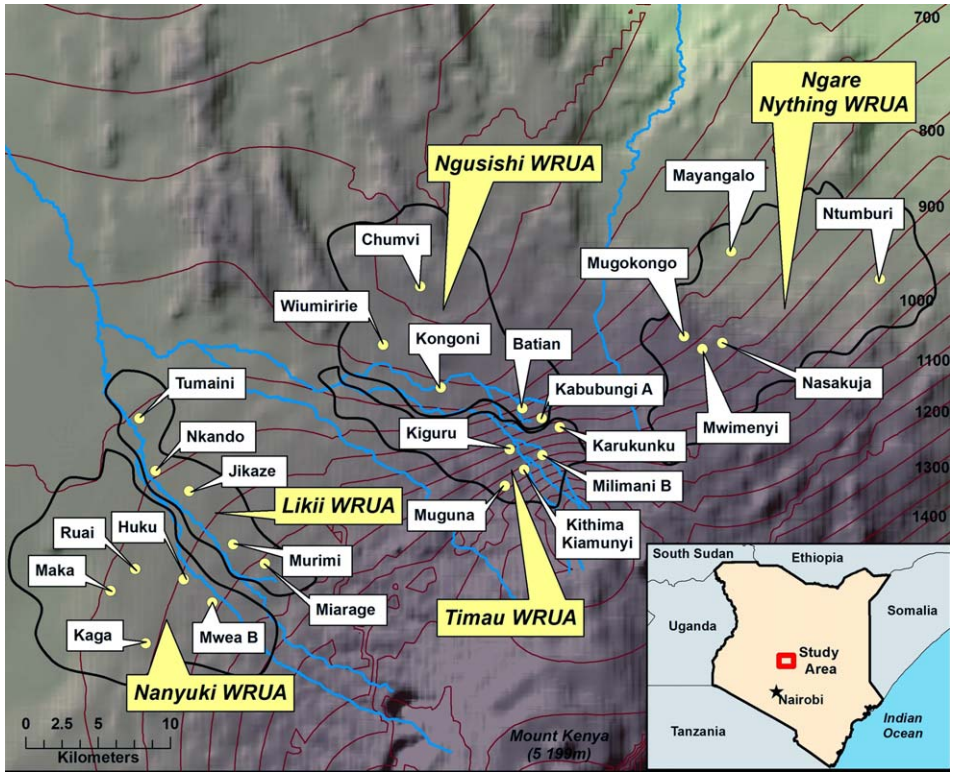

Figure 3. Study Area.
Notes: Isohyets represent average annual precipitation (mm) to demonstrate the region's environmental gradient. Boundaries of WRUAs are approximations. Locations of water projects are represented by the centroid of the water project.

1,800 km^2 and are located predominately on Mount Kenya's leeward side within five WRUAs (Figure 3). The CWPs nearest Mount Kenya, on average, receive greater precipitation totals; however, rainfall events across the region are variable. Throughout much of the study area, either a bimodal or trimodal rainfall pattern exists, with rainy seasons taking place from April to June, October to December, and a more unpredictable rainy season occurring from July to August under the trimodal pattern (Ericksen et al., 2011). This seasonality results in significant variability of surface water availability.

In addition to the study area's environmental gradient, a "social gradient" is also present. Until the early 1900s, much of the study area was occupied by Maasai and Samburu pastoralists (Wiesmann, Gichuki, Kiteme, & Liniger, 2000). Large ranches and farms owned by white settlers that were established during the colonial era (i.e., starting at the turn of the twentieth century) have today largely transitioned to Kikuyu- or Meru-owned small-scale farms, although some large landholdings remain. Many of these large landholdings have been transformed into highly technical horticultural operations producing for international markets (Wiesmann et al., 2000). The Maasai and Samburu pastoralists, who once dominated the area, have

largely been pushed north to the marginal arid and semiarid rangelands (Kiteme, Wiesmann, Künzi, & Mathuva, 1998).

Population growth within the Upper Ewaso Ng'iro basin, which witnessed an increase from 50,000 in 1960 to approximately 500,000 in 2000 according to Ngigi, Savenije, and Gichuki (2007), as well as increases in the number of smallholder farmers, typify the trend throughout much of Kenya during the postcolonial era. These growth processes were encouraged by the Government of Kenya's subdivision of former British ranches to be used for smallholder farms, as well as immigration from nearby densely populated areas in search of locations with high agricultural potential. In the process, population growth has added new pressures to land and water resources. As evidence, multiple rivers within the Upper Ewaso Ng'iro basin have experienced decreasing flows since the early 1960s (Liniger et al., 2005). In some areas, the decrease in river water availability has shifted livelihood practices from smallholder sedentary agriculture to pastoralism.

The Community Water Projects

CWPs are small, member-based irrigation infrastructure projects that allow smallholders to access irrigation water (although the primary goal of CWPs is to provide water for domestic use). Many CWPs were initially funded by government programs or donors, with subsequent management and infrastructure improvements undertaken by the CWP's membership. Some CWPs date back to the colonial era, although the number of CWPs increased rapidly in the postcolonial period supported by government programs aimed at increasing small-scale agriculture.

We focus our attention on 25 CWPs within the Upper Ewaso Ng'iro basin. Each of the 25 CWPs has an intake from either one of the study area's major rivers or from a natural spring as is the case with the CWPs in the Ngusishi WRUA (refer to Figure 3). Intakes can be closed during periods of rationing between CWPs in the same WRUA. After flowing through the intake, water is then gravity-fed to households through a series of buried pipes. CWPs vary in their water use restrictions, as some only allow for irrigation of small plots of land, while others are more flexible. Typically, this is influenced by the number of members within a CWP, which is highly variable and can be related to population growth within an area, as well as decisions made by the CWP's management committee to either restrict membership or allow membership growth.

CWPs have long exhibited autonomy in crafting their own institutions, a tradition dating to the colonial era. Important differences, therefore, exist in management strategies, including water appropriation strategies during the wet and dry seasons. CWP management committees make decisions as to whether or not a CWP will institute a rotation schedule (i.e., alternating water delivery between separate CWP distribution lines on a day-to-day basis) during the wet season and how dry season water shortages will be managed. These decisions are typically influenced by the number of members within a CWP. It is not uncommon for larger CWPs to enforce a wet season rotation in which households receive water three or fewer times in a week, while

CWPs with smaller memberships may be able to forgo a rotation program during periods of high river levels. When river levels decrease in the dry season, household level water availability is typically restricted in both large and small CWPs.

Data and Methods

Data

We use three types of data for this study: survey responses, household-level water-flow measurements, and archival research. Surveys were administered to members of the CWP management committee, which included a set of chairperson surveys (i.e., the manager of the water project; $N = 25$); a set of caretaker surveys ($N = 19$); and a collective survey of the CWP's chairperson, vice-chairperson, secretary, vice-secretary, and treasurer ($N = 19$). Responses from the chairperson surveys revealed the historical context, rules and monitoring policies, and water rotation and rationing strategies within each CWP. Caretaker surveys offered insight into the infrastructural design and repairs made to each CWP's pipe network. And, the collective survey with the CWP management committee was used to better understand group decision making.

Household-level water flow was measured on a weekly basis from July 2013 to January 2014. In smaller CWPs, 10 households were measured on a weekly basis, while in larger CWPs, 20 households were measured weekly. Using a stopwatch, measurements were taken by timing the duration to fill an 18-L bucket; measurements were then converted to liters per minute. In so doing, we have obtained a temporal record of weekly flow measurements in each CWP. The large amount of sediment in the CWP pipes prohibited the use of flow sensors to measure household-level water flow.

Archival research provided an understanding of Kenya's legal water institutions. This research was conducted in Nairobi during June 2013 in the Kenyan National Archives, the University of Nairobi, and Kenya's Ministry of Water and Irrigation, and includes statutes, regulations, and historic documents from Ministry of Water and Irrigation field offices. These three sets of data (i.e., the survey responses, the household-level water flow measurements, and the archival research) will be used in the next section to inspect postreform experimentation with rule changes and how these rule changes correlate with location conditions.

Polycentric Transition Outcomes: Inspection of the Upper Ewaso Ng'iro Basin SES

Hypothesis Testing

In examining the outcomes of water reform, we focus particularly on the rules-in-use within each CWP. We attempt to link CWP governance strategies with propositions from the polycentricity literature and hypothesize the following: First, in the postreform period, user groups will experiment with new approaches to governance by adjusting their rules (hypothesis 1), and second, some of this experimentation will

correlate with improved local conditions (hypothesis 2). We begin our examination of the outcomes following water reform by describing a case in which rule changes have clearly led to an outcome that polycentricity theorists would view as favorable. This is followed with additional evidence (or lack thereof) of outcomes predicted by polycentricity theory.

Monitoring and maintenance roles within CWPs are an element that appear to have been adjusted within at least one WRUA following the 2002 reform. CWPs typically employ a caretaker who is responsible for inspecting CWP pipelines for leaks, responding to complaints of poor water flow by members, monitoring to ensure that no members are taking water illegally, and disconnecting members if rules are violated. However, in the Ngusishi WRUA, CWP monitoring rules differ from the other four WRUAs. Rather than the CWPs of the Ngusishi WRUA employing caretakers, *scouts* are provided by the WRUA to monitor water use activities along the CWPs' main lines. This stands in stark contrast to the other four WRUAs where WRUA officials only patrol the riparian zones, not the CWP's infrastructure. Scouts also make repairs to the main line(s). All sublines and some main lines within the Ngusishi CWPs are also maintained and monitored by representatives from the households along that particular line.

It is unclear if the scout system employed in the Ngusishi WRUA is preferable to the caretaker system within the other four WRUAs. The CWP may benefit by avoiding the cost of employing an individual within the monitor/maintenance position, as the WRUA pays for the scout; however, the scout may also be seen as an "outsider" and not trusted to the same degree as the caretakers within the other WRUAs. A natural experiment may well take place in which other WRUAs trial the approach taken by the Ngusishi WRUA. This experimentation with monitoring obligations in the Ngusishi WRUA confirms our first hypothesis. Additional examples of rule adjustments and experimentation are now explored, as well as the proficiency of experimentation efforts in adapting to local conditions (i.e., hypothesis 2).

To better understand other rule adjustments in response to the 2002 water reform, further background is necessary. The WRUAs and WRMA leverage considerable influence with respect to catchment-level water appropriation, particularly during the dry season. If a WRUA has directed a catchment's member groups to follow the agreed upon appropriation schedule, a CWP's river intake is expected to only be open during the days in which that particular CWP is scheduled to receive water. Before the 2002 Water Act, rationing between CWPs was absent since formal catchment-level regulations did not exist. CWPs had little reason to consider the volume of water withdrawn from the river and upstream CWPs were the *de facto* beneficiaries. Some upstream CWP chairpersons have expressed their longing for the pre-WRUA period, claiming that water rationing has forced them to devise new rotation schedules (or alter existing schedules) within their CWPs, and that these changes have obstructed their abilities to meet the household consumption and irrigation needs of members.

In response, certain CWPs have adjusted their rules-in-use, particularly rules regarding new membership. As of the summer of 2013, 8 of the 25 CWPs had capped their membership (Table 3). In many cases, this was a recent decision made by

Table 3. Community Water Project Change in CWP Membership and CV of Water Flow

CWP	WRUA	Membership Capped	CV of Water Flow[a]
Jikaze	Likii	Yes	0.1935
Miarage		No	0.2592
Murimi		No	0.1824
Nkando		No	0.2066
Tumaini		No	0.2568
Huku	Nanyuki	No	0.1223
Kaga		No	0.5470
Maka		No	0.1860
Mwea B		No	0.4953
Ruai		No	0.4492
Batian	Ngusishi	No	0.8262
Chumvi		No	0.5220
Kabubungi		Yes	0.1201
Kongoni		Yes	0.3022
Wiumiririe		No	0.3747
Mayangalo	Ngare Nything	No	0.8044
Mugokongo		Yes	0.1985
Mwimenyi A		No	0.2230
Nasakuja		No	0.3220
Ntumburi		No	0.3593
Karukunku	Timau	Yes	0.1145
Kiguru		No	0.0773
Kithima-Kiamunyi		Yes	0.1690
Milimani B		Yes	0.1695
Muguna		Yes	0.4641

[a]Calculated from weekly household-level measurements taken from July 2013 to January 2014. Household-level measurements started on a rolling basis where the first CWP visited (i.e., Nkando) had its first measurements taken on July 8, 2013, while the final CWP visited (i.e., Kiguru) had its first measurements taken on September 9, 2013. Thus, the overall total number of visits to each CWP are not equal.

management committees as they struggled to meet the needs of their members in the face of increasing population and water provisioning restrictions. Membership control represents a response to water scarcity and a divergence in the rules-in-use found among the 25 CWPs. It also suggests a divergence in water allocation outcomes. To explore this, we have calculated a single coefficient of variation (CV) value of pipe network water flow for each CWP using the household-level water-flow data from July 2013 to January 2014 (Table 3). To estimate the CV of water flow, the mean flow over time was calculated for each household within each CWP. The average of all household mean flows was calculated as well as the standard deviation of the household mean flows. The CWP-level CV of flow was then generated by dividing the standard deviation of CWP flow by average flow. We have grouped CWPs, as well as their CV of water flow, according to their decision to either cap membership or allow membership to grow. This allows us to compare the two groups based on summation of their CV of water flow ranks using a Mann–Whitney–Wilcoxon test.

This comparison of rank sums suggests that the difference between CV of water flow for CWPs that have capped membership compared to those allowing membership to grow is statistically significant, and that variability is significantly higher in CWPs that allow new members to join compared to those that have limited their

Table 4. Mann–Whitney–Wilcoxon Test Results

Change in CWP Membership in Past 5 Years	Number of CWPs	Rank Sum	Expected Rank Sum
No change (capped membership)	8	70	104
Increase	17	255	221
Total	25	325	325

Note: The test was significant at a critical value of 0.05. The group of CWPs that have capped their memberships (8 CWPs) have actual rank sums that are lower than their expected rank sum and lower than the actual rank sums of the group of CWPs that are allowing membership to increase (17 CWPs). Thus, the CWPs that have capped their memberships have a lower rank in variability of water flow.

membership (Table 4). Thus, households within CWPs that have capped their memberships appear to receive more predictable water delivery. While other factors such as population and infrastructural components almost certainly affect this relationship, the statistical significance of this test suggests that institutions play a role in influencing water allocation outcomes as well. This tends to confirm our hypothesis that experimentation with rules-in-use can lead to successful adaptation to local conditions (i.e., hypothesis 2).

Coordination among Local and Regional Actors

In addition to testing the above hypotheses, we also examine some ways that Kenya's reforms have created or encouraged coordination among multiple levels of management, and how these coordination mechanisms have affected CWP governance. The most notable postreform coordination mechanism exists between CWPs and their respective WRUA. At the local level, the CWP membership elects the individuals who serve on the management board, including the CWP's chairperson. Along with water use decision-making obligations within the CWP, the chairperson also serves on the WRUA's management committee, which makes catchment-wide decisions concerning water appropriation, monitoring, and sanctioning. Thus, coordination between the CWP and WRUA legislative bodies is directly linked by the representative procedure that elects each of the CWP's chairpersons. This process suggests more active and effective dialogue between WRUAs and CWPs, and that CWPs coordinate with WRUA officials when management concerns span community boundaries. For instance, 24 of the 25 CWP representatives stated that coordination with WRUA helps to prevent conflicts, and 15 of these individuals claimed that, of the higher levels of governance, WRUAs are most frequently relied upon to handle disputes between CWPs.

This increased level of coordination between CWPs and WRUAs—as well as between CWPs in the same catchment—has been accompanied by adjustments in institutional and physical infrastructure to ensure that WRUAs are achieving their goal of improving the quantity of water resources to all members of the catchment. For example, both the WRUA and WRMA now expect all CWPs to have a flow-measuring device near their river intake position, and will impose fines if devices

are not installed. Similarly, to ensure that all CWPs withdraw an equal amount of water, WRUAs now tend to require that all CWPs install uniform (6-inch) intake pipes. In addition, WRMA (in partnership with the WRUA) has increased the frequency with which it assesses penalties to CWPs withdrawing water in excess of permits. These new requirements and fees improve efforts to guarantee catchment-wide water access, but they also burden communities with additional financial obligations and water use restrictions. Some CWP chairpersons expressed frustrations related to the increased fees following the 2002 Water Act. One chairperson described the reform as operating in a "commercial way" that has precluded the "normal person" from accessing water if they cannot afford it. Another claimed that the 2002 reform "has not been good" since it has increased costs within CWPs. These and other CWP leaders explained that they have been forced to raise fees in response to the increased financial burden, and in some cases CWPs have increased their memberships to help pay the increased fees.

Discussion

The preceding analysis of Kenya's water reform demonstrates that the government has deliberately created the basic features of a polycentric system: multiple, independent decision centers at the CWP, WRUA, and WRMA levels; overlapping authority over several aspects of water governance; and mechanisms for coordination between governance levels. Arguably, however, the more interesting question is how these changes have affected governance on-the-ground among and between local CWPs and WRUAs, particularly with respect to rule adjustment and experimentation, as well as the emergence of new forms of collective action.

The 2002 reform appears to have provided a stimulus for all CWPs within the Upper Ewaso Ng'iro SES to experiment with their rules-in-use in order to meet the needs of their members. While CWPs had the authority to make their own rules before 2002, the rule experimentation that is now taking place is fundamentally different given that CWPs now occupy rulemaking space with their WRUA, as well as WRMA. A CWP that is nested within a WRMA-approved WRUA—as is the case with all of the CWPs in this study—has representatives who participate in catchment-level decision making about permit issuance, regional scale water allocation, and water conservation strategies. This representation gives CWP leaders a level of legitimacy that they lacked in the past. However, it also requires CWP chairpersons to balance the wants of their members with the requirements specified at higher levels of management. This is precisely where the decision of some CWPs to limit their memberships has originated, since WRUAs mandate a percentage of river water reach downstream users. While balancing the requirements of the WRUA with the wants of CWP members can be challenging, it is important to recognize that by taking on these challenges, CWPs are now provided with a path toward user-group legitimacy, an important trait of a polycentric system and a trait that was glaringly absent before the 2002 reform.

The literature on polycentricity also suggests that coordination among local, regional, and national actors should encourage mutual adjustments and the

undertaking of collective action at multiple levels. Our examination of the Upper Ewaso Ng'iro basin shows that, postreform, CWPs are reducing their water use to ensure water availability for downstream users. However, they are doing so to comply with rules imposed upon CWPs in a top-down fashion, with some resistance from CWP managers. It thus may be premature to consider water allocation arrangements within WRUAs to be "collective action" in the classic sense; WRUA members communicate and coordinate their water use, but actual reductions in CWPs' water allocations have come about due to formal legal requirements rather than due to bottom-up strategies. Nonetheless, the coordination mechanisms created by the reforms—particularly the creation of the WRUAs—have helped to ensure that CWPs will comply with the requirements and that the mandates will achieve the intended result of increased water availability.

Key understandings with respect to the literature on polycentricity have been revealed from this study. We have found evidence that a deliberate push for polycentric resource management *can* encourage local decision making and rule experimentation, especially as local chairpersons respond to policy changes from decision makers at higher levels of management. While additional experimentation may occur over time, we conclude that Kenya's top-down reforms *allow*, rather than *encourage*, experimentation, adaptation, and learning.

Similarly, while CWPs have autonomy to craft their own rules, this is primarily limited to internal matters, and WRMA retains the right to impose rules in top-down fashion—for example, mandating certain infrastructure investments. However, it appears that local-level rule diversification would actually be quite minimal within the 25 CWPs without these top-down policy-induced changes. Additionally, it is possible that simply not enough time has elapsed since the 2002 Water Act, and that with the passage of time more experimentation will naturally occur. In this vein, we may be witnessing the less-than-optimal institutions established by local resource managers as they grapple with the complexity of their system (E. Ostrom, 2005).

Finally, our examination of the 25 CWPs, and their respective WRUAs, suggests that a polycentric system is developing not solely on paper, but on-the-ground as well. Yet, while some beneficial conditions have arisen following the 2002 reform, other governance outcomes predicted by theorists have been slow to emerge, and the actual benefits of these outcomes may fall somewhat short of those predicted by theory. It additionally remains to be seen whether the conditions in our study area are pervasive across Kenya and whether other CWPs have experienced a similar level of interaction with regional and national actors.

Conclusion

This study set out to identify how actor roles and local-level rules have changed following the 2002 water reform, and to determine the extent to which the postreform governance outcomes reflect benefits predicted by polycentricity theorists. With regards to this inquiry, we hypothesized the following: (i) In the postreform period, user groups will experiment with new approaches to governance

by adjusting their rules, and (ii) some of this experimentation will correlate with improved local conditions.

We found evidence—albeit limited—in support of these hypotheses. Kenya's polycentric shift may have provided a "shock" which led to rule changes and a divergence in rules-in-use employed by CWP chairpersons, particularly those rules related to user-group membership and monitoring. These adjustments appear to be ongoing and indicate some amount of experimentation with management strategies. We also found evidence that the coordination mechanisms created by the reforms have prompted CWPs to curtail water use to the benefit of other CWPs; however, this has largely occurred by way of a top-down approach that may not fully match theorists' predictions about collective action.

By taking an empirical approach, this study has addressed critical questions concerning the institutional dynamics that are involved in a national water governance polycentric transition. In the process, it has raised topics that are ripe for future research, including the different and often contradictory features of polycentric reforms and the barriers to on-the-ground deployment of polycentric principles when, formally, multiple centers of governance exist. Further investigation into these topics will advance the governance community's understandings of polycentric resource governance.

Appendix

Selection of variables to be included in the combined IAD-SES framework at the prereform time step was guided by the following steps:

1. An understanding of the water management system as of 2013 was obtained through review of information gathered during archival research. From this understanding, we worked backwards to the time step just before 2002 reform to identify SES framework variables where it was possible to make a causal connection to 2013 outcomes.

2. In identifying these pre-reform SES variables, we first focused on isolating second-tier variables for each subsystem that could either help characterize the pre-reform landscape, or function as a direct driver of reform, or both.
   a. Before selecting a variable, a "yes" response was required of the following question: "Is this variable critical to understanding the SES in the context of Kenyan water governance, or is this variable a driver of water policy reform?"
3. Where greater detail was needed, we unpacked the identified attributes into third-tier variables by repeating steps 2 and 2a for each variable previously identified.

To characterize the dynamics within the adjacent action situations that produced the postreform conditions, we adhered to the following steps:

1. An assessment was made of which broad action situation processes could be reasonably articulated using the pre-existing conditions from the prereform time step.
2. Given our understanding of the water management system as of 2013, a narrowing of potential action situations was performed by identifying decision-making processes that reasonably led to the 2013 conditions.
3. To demonstrate the connectivity within the adjacent action situations, the elements identified for each action situation needed to both influence and be influenced by the other decision-making strategies within the web of action situations.

Selection of the combined IAD-SES framework postreform conditions was guided by the following steps:

1. Tracking the steps of reform from prereform conditions to the adjacent action situations, an assessment was made of the SES framework variables that were directly altered during this course of development.
2. After acknowledging these second- and third-tier variables, we further detailed the postreform conditions by referring to information collected through 2013 archival research.

Paul McCord is a PhD candidate in the Department of Geography at Indiana University and is a student at the Vincent and Elinor Ostrom Workshop in Political Theory and Policy Analysis, Indiana University.
Jampel Dell'Angelo is a postdoctoral fellow at the National Socio-Environmental Synthesis Center (SESYNC).
Elizabeth Baldwin is assistant professor at the School of Government & Public Policy, University of Arizona.
Tom Evans is professor in the Department of Geography at Indiana University and is affiliated faculty at the Vincent and Elinor Ostrom Workshop in Political Theory and Policy Analysis, Indiana University.

Note

We gratefully acknowledge support from the U.S. National Science Foundation (grant SBE1115009). We also thank three anonymous reviewers for their valuable input.

References

Agrawal, Arun, and Clark C. Gibson. 1999. "Enchantment and Disenchantment: The Role of Community in Natural Resource Conservation." *World Development* 27: 629–49.

Aligica, Paul D., and Vlad Tarko. 2012. "Polycentricity: From Polanyi to Ostrom, and Beyond." *Governance* 25 (2): 237–62.

Andersson, Krister P., and Elinor Ostrom. 2008. "Analyzing Decentralized Resource Regimes from a Polycentric Perspective." *Policy Sciences* 41 (1): 71–93.

Baldwin, Elizabeth, Camille Washington-Ottombre, Jampel Dell'Angelo, Daniel H. Cole, and Tom P. Evans. 2016. "Polycentric Governance and Irrigation Reform in Kenya." *Governance* 29 (2): 207–25.

Basurto, Xavier, Stefan Gelcich, and Elinor Ostrom. 2013. "The Social–Ecological System Framework as a Knowledge Classificatory System for Benthic Small-Scale Fisheries." *Global Environmental Change* 23 (6): 1366–80.

Basurto, Xavier, and Elinor Ostrom. 2009. "Beyond the Tragedy of the Commons." *Economia delle fonti di energia e dell'ambiente* 52: 35–60.

Bixler R. Patrick, Jampel Dell'Angelo, Orleans Mfune, and Hassan Roba. 2015. "The Political Ecology of Participatory Conservation: Institutions and Discourse." *Journal of Political Ecology* 22: 164–82.

Cinner, Joshua E., Tim R. McClanahan, M. Aaron MacNeil, Nicholas A. J. Graham, Tim M. Daw, Ahmad Mukminin, David A. Feary, et al. 2012. "Comanagement of Coral Reef Social-Ecological Systems." *Proceedings of the National Academy of Science* 109 (14): 5219–22.

Cole, Daniel H., and Michael D. McGinnis, eds. 2014. "Introduction to Volume I." *In Elinor Ostrom and the Bloomington School*. London: Lexington Books, xxxiii–xlvii.

Cole, Daniel H., Graham Epstein, and Michael D. McGinnis. 2014. "Toward a New Institutional Analysis of Social-Ecological Systems (NIASES): Combining Elinor Ostrom's IAD and SES Frameworks." Indiana Legal Studies Research Paper, No. 299; Indiana University, Bloomington School of Public and Environmental Affairs Research Paper, No. 2490999. Available at SSRN: http://ssrn.com/abstract=2490999.

Cottrell, Edwin A. 1949. "Problems of Local Governmental Reorganization." *The Western Political Quarterly* 2 (4): 599–609.

Cox, Michael. 2014. "Applying a Social-Ecological System Framework to the Study of the Taos Valley Irrigation System." *Human Ecology* 42 (2): 311–24.

da Silveira, Andre R., and Keith S. Richards. 2013. "The Link Between Polycentrism and Adaptive Capacity in River Basin Governance Systems: Insights from the River Rhine and the Zhujiang (Pearl River) Basin." *Annals of the Association of American Geographers* 103 (2): 319–29.

Dell'Angelo, Jampel. 2012. *Abusing the Commons? An Integrated Institutional Analysis of Common-Pool Resource Governance in Conflict Situations*. PhD diss., Sapienza University of Rome and Autonomous University of Barcelona.

Ericksen, Polly, Mohammed Said, Jan de Leeux, Silvia Silvestri, Lokman Zaibet, Shem Kifugo, Koert Sijmons, et al. 2011. *Mapping and Valuing Ecosystem Services in the Ewaso Ng'iro Watershed*. Nairobi, Kenya: International Livestock Research Institute.

Fleischman, Forrest D., Kinga Boenning, Gustavo A. Garcia-Lopez, Sarah K. Mincey, Mikaela Schmitt-Harsh, Katrin Daedlow, Maria Claudia Lopez, Xavier Basurto, Burney Fischer, and Elinor Ostrom. 2010. "Disturbance, Response, and Persistence in Self-Organized Forested Communities: Analysis of Robustness and Resilience in Five Communities in Southern Indiana." *Ecology and Society* 15 (4): 9.

Folke, Carl, Thomas Hahn, Per Olsson, and Jon Norberg. 2005. "Adaptive Governance of Social-Ecological Systems." *Annual Review of Environment and Resources* 30: 441–73.

Galaz, Victor, Beatrice Crona, Henrik Österblom, Per Olsson, and Carl Folke. 2012. "Polycentric Systems and Interacting Planetary Boundaries – Emerging Governance of Climate Change – Ocean Acidification – Marine Biodiversity." *Ecological Economics* 81: 21–32.

Gordillo, Gustavo, and Krister Andersson. 2004. "From Policy Lessons to Policy Actions: Motivation to Take Evaluation Seriously." *Public Administration and Development* 24 (4): 305–20.

Gutiérrez, Nicolas L., Ray Hilborn, and Omar Defeo. 2011. "Leadership, Social Capital and Incentives Promote Successful Fisheries." *Nature* 470 (7334): 386–89.

Huitema, Dave, Erik Mostert, Wouter Egas, Sabine Moellenkamp, Claudia Pahl-Wostl, and Resul Yalcin. 2009. "Adaptive Water Governance: Assessing the Institutional Prescriptions of Adaptive (Co-)Management from a Governance Perspective and Defining a Research Agenda." *Ecology and Society* 14 (1): 26.

Kenya Ministry of Water Development. 1983. *Annual Report, Meru District*. Kenya National Archives.

Kenya Water Apportionment Board. 1972. 1972 Water (General) Rules. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=016336&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed June 7, 2016.

Kiser, Larry L., and Elinor Ostrom. 1982. "The Three Worlds of Action: A Metatheoretical Synthesis of Institutional Approaches." In *Strategies of Political Inquiry*, ed. Elinor Ostrom. Beverly Hills, CA: Sage Publications, 179–222.

Kiteme, Boniface P., Urs Wiesmann, Erwin Künzi, and Joseph M. Mathuva. 1998. "A Highland-Lowland System under Transitional Pressure: A Spatio-Temporal Analysis." *Eastern and Southern Africa Geographical Journal* 8: 45–54.

Liniger, Hanspeter, John Gikonyo, Boniface Kiteme, and Urs Wiesmann. 2005. "Assessing and Managing Scarce Tropical Mountain Water Resources: The Case of Mount Kenya and the Semiarid Upper Ewaso Ng'iro Basin." *Mountain Research and Development* 25 (2): 163–73.

Madrigal, Róger, Francisco Alpízar, and Achim Schlüter. 2011. "Determinants of Performance of Community-Based Drinking Water Organizations." *World Development* 39 (9): 1663–75.

McCord, Paul F., Michael Cox, Mikaela Schmitt-Harsh, and Tom P. Evans. 2015. "Crop Diversification as a Smallholder Livelihood Strategy within Semi-Arid Agricultural Systems near Mount Kenya." *Land Use Policy* 42: 738–50.

McGinnis, Michael D. 1999. *Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis*. Ann Arbor, MI: The University of Michigan Press.

———. 2011. "Networks of Adjacent Action Situations in Polycentric Governance." *Policy Studies Journal* 39 (1): 51–78.

McGinnis, Michael D., and Elinor Ostrom. 2014. "Social-Ecological System Framework: Initial Changes and Continuing Challenges." *Ecology and Society* 19 (2): 30.

Mwangi, E. N. 2003. *Institutional Change and Politics: The Transformation of Property Rights in Kenya's Maasailand*. PhD diss., Indiana University.

Ngigi, Stephen N., Hubert H. G. Savenije, and Francis N. Gichuki. 2007. "Land Use Changes and Hydrological Impacts Related to Up-Scaling of Rainwater Harvesting and Management in Upper Ewaso Ng'iro River Basin, Kenya." *Land Use Policy* 24: 129–40.

Ostrom, Elinor. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge, UK: Cambridge University Press.

———. 1999. "Coping with Tragedies of the Commons." *Annual Review of Political Science* 2: 493–535.

———. 2005. *Understanding Institutional Diversity*. Princeton, NJ: Princeton University Press.

———. 2007. "A Diagnostic Approach for Going Beyond Panaceas." *Proceedings of the National Academy of Sciences* 104 (39): 15181–87.

———. 2009. "A General Framework for Analyzing Sustainability of Social-Ecological Systems." *Science* 325 (5939): 419–22.

———. 2011. "Reflections on 'Some Unsettled Problems of Irrigation.'" *The American Economic Review* 101: 49–63.

Ostrom, Elinor, and Michael Cox. 2010. "Moving Beyond Panaceas: A Multi-Tiered Diagnostic Approach for Social-Ecological Analysis." *Environmental Conservation* 37 (4): 451–63.

Ostrom, Vincent. 1999. "Polycentricity." In *Polycentricity and Public Economies*, ed. Michael D. McGinnis. Ann Arbor, MI: University of Michigan Press, 52–74.

Ostrom, Vincent, Charles M. Tiebout, and Robert Warren. 1961. "The Organization of Government in Metropolitan Areas: A Theoretical Inquiry." *American Political Science Review* 55 (4): 831–42.

Pahl-Wostl, Claudia, and Christian Knieper. 2014. "The Capacity of Water Governance to Deal with the Climate Change Adaptation Challenge: Using Fuzzy Set Qualitative Comparative Analysis to Distinguish Between Polycentric, Fragmented and Centralized Regimes." *Global Environmental Change* 29: 139–54.

Pahl-Wostl, Claudia, Louis Lebel, Christian Knieper, and Elena Nikitina. 2012. "From Applying Panaceas to Mastering Complexity: Toward Adaptive Water Governance in River Basins." *Environmental Science & Policy* 23: 24–34.

Polski, Margaret M. 2003. *The Invisible Hands of US Commercial Banking Reform: Private Action and Public Guarantees*. Boston, MA: Kluwer.

Ribot, Jesse C., Arun Agrawal, and Anne M. Larson. 2006. "Recentralizing while Decentralizing: How National Governments Reappropriate Forest Resources." *World Development* 34 (11): 1864–86.

Sabatier, Paul A. 2007. "The Need for Better Theories." In *Theories of the Policy Process, 2nd ed*., ed. Paul A. Sabatier. Boulder, CO: Westview Press, 3–17.

Schaaf, Jeanne. 1989. Governing a Monopoly Market under Siege: Using Institutional Analysis to Understand Competitive Entry into Telecommunications Markets, 1944-1982. PhD diss., Indiana University.

Scott, James. 1998. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven, CT: Yale University Press.

Shivakoti, G., and E. Ostrom. 2001. *Improving Irrigation Governance and Management in Nepal*. Oakland, CA: ICS Press.

Villamayor-Tomas, Sergio, Philipp Grundmann, Graham Epstein, Tom P. Evans, and Christian Kimmich. 2015. "The Water-Energy-Food Security Nexus through the Lenses of the Value Chain and the Institutional Analysis and Development Frameworks." *Water Alternatives* 8 (1): 735–55.

Wiesmann, Urs, Francis N. Gichuki, Boniface P. Kiteme, and Hanspeter Liniger. 2000. "Mitigating Conflicts over Scarce Water Resources in the Highland-Lowland System of Mount Kenya." *Mountain Research and Development* 20 (1): 10–15.

WRMA, and WSTF (Water Resources Management Authority and Water Services Trust Fund). 2009. *Water Resource Users Association Development Cycle (WDC)*. Nairobi, Kenya: Water Services Trust Fund.