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Understanding the Emergence and Functioning of River Committees in a Catchment of the Pangani Basin, Tanzania

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ABSTRACT: In this paper we explore the emergence and functioning of river committees (RCs) in Tanzania, which are local water management structures that allocate and solve water conflict between different water users (smallholder irrigators, large commercial farmers, municipalities, etc) along one river. The paper is based on empirical research of three committees in the Themi sub-catchment. The committees mostly emerged in response to drought-induced competition and conflict over water, rapid urbanisation around Arusha town, and the presence of markets for agricultural produce. The RCs are mainly active during dry seasons when water is scarce.
We find that the emergence of the RCs can be understood by using the concept of institutional bricolage. We then assess their effective functioning with the help of the eight design principles proposed by Ostrom and find that the best performing RC largely complied with five of them, which indicates that not all principles are necessary for a water institution to be effective and to endure over time. The other two studied RCs complied with only three of these principles. All RCs leave the resource boundary open to negotiation, which lowers the transaction cost of controlling the boundaries and also allows future demands to be met in the face of increasing resource variability. All RCs do not fully comply with the principle that all affected must take part in rule creation and modification. In all three cases, finally, the 'nesting' of lower-level institutional arrangements within higher-level ones is inconsistent.
To explain the difference in the performance of the three RCs we need to consider factors related to heterogeneity. We find that the functioning of RCs is strongly influenced by group size, spatial distance, heterogeneity of users and uses, and market forces.

KEYWORDS: Common pool resource, design principles, institutional bricolage, heterogeneity, water conflict, water rationality, water institutions, Pangani river basin, Tanzania

INTRODUCTION

Local water management efforts are not often fully integrated into government water sector institutional reforms, leading to mismatches between the created organisation and locally evolved ones (Campbell et al., 2001; Cleaver and Franks, 2005; Swatuk, 2005). Scholars argue that, for any new water institution to be effective, it must be consistent with both the government and local-level institutions (see for instance Van der Zaag and Bolding, 2009). This however requires good understanding of how local arrangements emerge, evolve and continue to function over time. In addition, understanding the interface between locally developed water institutions and those created by the central government could add insight into the development of integrated catchment management institutions.

In this paper, we explore the emergence, functioning and challenges faced by river committees (RCs) in the Themi sub-catchment, Pangani river basin, Tanzania. RCs are locally developed water management structures that manage water allocation and solve water conflicts between groups of water users (e.g. between irrigation canals, locally known as *mifereji* (singular: *mfereji*) or furrows, commercial farmers, municipalities, etc) of one river but not between individual water users. In the Themi sub-catchment, RCs bring together large- and small-scale users, districts, divisions, wards and village leaders. A committee typically controls only a part of the river watercourse. Several studies have been documented on the evolution and the effectiveness of self-governing water institutions (Fleuret, 1985; Grove, 1993; Ostrom and Gardner, 1993; Ostrom et al., 1994; Potkanski and Adams, 1998). Most of these studies looked at dynamics of water rights in a community's traditional irrigation system; few, if any, document institutional arrangements created by the users to manage water allocation between small-scale irrigation schemes, villages and large commercial estates along one river. Understanding such arrangements can add useful knowledge on local institutions, as well as on the establishment of new intermediate water or river institutions. We use three different scientific perspectives to examine how RCs emerged and currently function in different parts of the Themi sub-catchment.

To understand the emergence and functioning of local institutions, we review (a) the concept of institutional bricolage introduced by Cleaver; (b) Ostrom's eight design principles of long-enduring, self-governing institutions; and (c) the role of heterogeneity and group size. Then we present three case studies of RCs in the Themi sub-catchment. We subsequently analyse the emergence and functioning of these RCs with the help of the three sets of concepts. The concept of institutional bricolage helped to explain the emergence of the RCs but does not provide insight into their effectiveness with regard to resource management. Ostrom's eight design principles provided useful entry points in studying the functioning of the RCs, but these were not sufficient to explain how well the RCs regulated resource use. Surprisingly, three of Ostrom's principles were largely or completely absent. Group size, spatial distance, heterogeneity of users and uses, and market forces were found to pose important constraints to the effective functioning of the RCs.

THEORETICAL FRAMEWORK: INSTITUTIONAL EMERGENCE AND FUNCTIONING

Because of its rivalry and non-excludability characteristics, river water is a common pool resource (CPR) (Ostrom and Gardner, 1993). In addition, because of location asymmetry, appropriation of the water resources leads to potentially conflicting situations between upstream and downstream users, in that upstream users can exercise their claim to water first (Ostrom and Gardner, 1993; Van der Zaag, 2007). Downstream users require the cooperation of their upstream counterparts, which underscores the relevance of collective action over CPR management. However, collective action for CPR management can have various interpretations and may involve a complex set of rules and institutions arising out of historical, ecological and other structural processes (Naidu, 2009; Ostrom, 1993, 2000). In this paper, we define collective action as the contribution users make to allocate, manage and regulate the use of water resources (e.g. in terms of actors' time in attending meetings to discuss water issues, restraining from using the resource out of turn, joining work parties for canal repair and maintenance, and actively monitoring the resource).

Emergence of institution: Bricolage

The concept of bricolage refers to the construction of works (material or immaterial) from a diversity of things available at the time. A person engaged in bricolage is called a *bricoleur*. The concept of institutional bricolage was first elaborated by Mary Douglas in 1987, who extended Levi-Strauss's concept of 'intellectual bricolage' to institutional thinking, and used it to explain how the construction of institutions and decisions to act are rarely made on the basis of individual rational choice (Douglas, 1987 as quoted in Cleaver, 2002). Douglas instead argued that institutions are constructed through a

process of bricolage; and that by using existing arrangements (e.g. norms, rules and traditions) to craft new institutions, the bricoleurs lower the transaction cost of creating institutions. In addition, the use of old rules allows the new institutions to gain easier classification and legitimacy. Douglas uses the concept of institutional leakage to show how sets of rules are metaphorically connected with one another, allowing meaning to 'leak' from one context to another, suggesting a less conscious and less rational/functional formation of institutions (Cleaver, 2002).

Several authors have since used the concept of institutional bricolage to explore local-level resources management and macro-social transformation (Sehring, 2009; Jones, 2011; Theesfeld, 2011). Cleaver, for instance, used the concept of institutional bricolage to argue that the mechanism for resource management and collective action are borrowed or constructed from existing institutions, styles of thinking and sanctioned social relationships (Cleaver, 2000, 2002; Cleaver and Franks, 2005). Cleaver thereby questions and limits the role of human agency in shaping and reshaping institutions. Cleaver (2002) elaborates on three aspects of bricolage – the complex identities and norms of the bricoleurs, the practice of cultural borrowing and adaptation of institutions to multiple purposes, and the prevalence of common social principles which foster cooperation (as well as conflict) between different groups of stakeholders. Galvan (1997) uses institutional bricolage, or what he called syncretism, to reconcile the structure and agency aspects of both culture and institutions (Galvan, 1997).

The central argument is on the unconsciousness and messiness of institutional emergence, as opposed to the completely conscious and rational designing of institutions (Mehta et al., 1999; Cleaver and Franks, 2005; Sehring, 2009). Thus, a newly established institution can only survive and attain legitimacy if it borrows from past arrangements. Over time, new institutions will be subjected to the process of bricolage and evolution, which may either lead to their redundancy or to adaptation and more socially embedded arrangements (Cleaver, 2002). This would also mean any designed institutions may over time evolve to create unintended arrangements. An important aspect of the process of bricolage is the overlapping social identities of the bricoleurs. Actors may call on a variety of attributes (e.g. economic wealth, special knowledge, official positions, kinship and marriage) to justify their institutional position or influence. In a way, an institution emerging through bricolage may not be the appropriate one in the functional sense, but one that serves the interests of certain actors. Thus bricolage relates to the question of power and the role of heterogeneity (Sehring, 2009). Furthermore, legal pluralistic environments may provide fertile grounds for the process of institutional bricolage to take place (Meinzen-Dick and Pradhan, 2002).

Design principles for long-enduring institutions

Ostrom identified eight general design principles (table 1) for long enduring, self-governing CPR institutions (Ostrom, 1993, 2000; Ostrom et al., 1999; Dietz et al., 2003). These eight principles are presented as elements strongly correlated with the success of long-enduring institutions in sustaining a particular CPR and gaining the compliance of generation after generation of resource appropriators to the rules-in-use (Ostrom, 1993; Ostrom and Gardner, 1993; Sarker and Itoh, 2001).

Scholars have criticized the theoretical grounding of these design principles or argued that the principles do not offer a comprehensive solution to CPR problems, or that their application may lead to simplistic attempts to force institutions to conform to the principles regardless of relevance or feasibility under particular conditions (Agrawal, 2001; Cleaver, 2000, 2002; Cleaver and Franks, 2005; Bruns, 2009). Agrawal and Gibson (1999) maintain that particular characteristics of a community, however defined, may not predict outcomes but may rather influence the process of institutional formation. Cleaver and Franks (2005) add that because of complexity, diversity and the ad hoc nature of institutional formation, institutions elude design.

Table 1. Brief review of Ostrom's eight general design principles of self-governing CPR institutions.

Design principles	Critical reviews
1. Clearly defined boundaries (of resource and users)	This principle ensures that appropriators can clearly identify anyone who does not have rights and take action against them. However, scholars argue that this requirement is too rigid, as it may fail to account for resource mobility and variability. Also, for some CPRs, the users' boundaries are not 'waterproof', as they are dynamic over time (Quinn et al., 2007) and at times may include non-resident users (e.g. distant cities relying on a river for hydroelectricity production).
2. Congruence between appropriation and provision rules and local conditions	This principle refers to rules being considered fair and legitimate by the users and also match local conditions, e.g. soils, slope, number of diversions, crops being grown, etc. This is relatively straightforward in the case of an irrigation canal, where labour for maintenance of division gates and canals mediates allocation turns. At the level of a river appropriation rules specifying individual furrow water entitlements are not related to their inputs (no labour, material, and/ or money invested in resource provision). Provision refers to upstream users' willingness to agree to water-sharing arrangement without being compensated. The dissimilarity between provision and appropriation rules makes enforcement difficult.
3. Collective choice arrangements	Individuals affected by the operational rules can participate in modifying these; otherwise some appropriators may perceive their costs as higher than their benefits and cheat whenever an opportunity arises. Cheating increases enforcement costs (Ostrom, 1998). A system where some actors are able to cheat while others conform to the rules is unlikely to survive for long.
4. Monitoring	This principle refers to the presence of monitors who actively audit CPR conditions and appropriator behaviour, and who are accountable to the appropriators or are appropriators themselves. But resource users often get involved in ad hoc monitoring arrangements, e.g. downstream users pay guards to monitor use upstream (Ostrom, 1993; Sarker and Itoh, 2001).
5. Graduated sanctions	Violators are sanctioned by their peers, and get increasingly severe sanctions if they persist. However, this does not often happen. Some actors use a 'forum shopping' approach (see, for instance, Meinzen-Dick and Pradhan, 2002) to settle conflicts (e.g. appropriators use various laws and norms to argue and settle cases, some go to the government court, while other cases get solved by traditional authorities, or at a personal level).
6. Conflict resolution mechanisms	Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.
7. Minimal recognition of rights to organise	The appropriators' rights to devise their own institutions or their legitimacy not being challenged by other authorities.
8. Nested enterprises (hierarchical or interrelated organisation levels)	The principle implies the existence of a direct hierarchical relationship within the group, with other groups, and/or higher-level authorities in a catchment. But local management structures are rarely hierarchical, may be ad hoc, dynamic and frequently renegotiated (Cleaver and Franks, 2005). The principle also claims that nesting each level of organisation within a larger level allows for the externalities that are caused by one group and imposed on others, to be addressed by a higher-level structure. So smaller units can take advantage of economies of scale where they are relevant and to aggregate capital for investment (Ostrom, 1993). However, for RCs nesting may not directly translate to no shirking within a furrow. Individual furrow management is largely independent of the working of the RCs.

Heterogeneity and group size

Although there is a rich body of literature on the role of heterogeneity and group size on collective action for common pool resource management institutions no consensus exists (see, for instance Olson, 1965; Bardhan and Dayton-Johnson, 2002; Poteete and Ostrom, 2004; Ruttan, 2008; Araral Jr., 2009; Naidu, 2009). This section gives a brief overview of the debate, starting with the role of heterogeneity.

Heterogeneity may include sociocultural diversities, wealth inequalities, inequalities in sacrifices members make in cooperating with collective management regimes, locational differences not reflected in landholdings and wealth (e.g. upstream-downstream asymmetry in water access), inequalities in outside earning opportunities (exit options) and benefit heterogeneity (i.e. heterogeneity in economic interests) (Baland and Platteau, 1999; Bardhan and Dayton-Johnson, 2002; Naidu, 2009). While some empirical studies find that sociocultural heterogeneity negatively affects collective actions (Bardhan and Dayton-Johnson, 2002) others report that its impact is positive or in some cases insignificant (Poteete and Ostrom, 2004). Baland and Platteau (1999) argue that economic inequality under certain conditions leads to higher provision of collective goods. Others have argued that economic inequality is most important in initiating collective action but tends to negatively affect full participation (Varughese and Ostrom, 2001; Poteete and Ostrom, 2004; Ruttan, 2008; Naidu, 2009). Some theoretical researchers, however, identify a U-shaped relationship between economic inequality and cooperation, suggesting that both schools of thought may, in part, be correct (Bardhan and Dayton-Johnson, 2002).

To resolve the impasse, Ruttan (2008) proposes that the type of heterogeneity at stake needs to be clearly specified (for instance sociocultural heterogeneity seems to have a more clearly negative effect than economic heterogeneity) and how success is measured has to be made clear – clarifying if success is measured in terms of collective action or in terms of level of collective goods provided (Ruttan, 2008). A question remains whether to lump the effects of sociocultural and economic heterogeneity or study them separately. Naidu (2009) finds that in the presence of benefit heterogeneity, an increase in wealth heterogeneity reduces the extent of collective management. From the literature we find that physical characteristics of the resource and its associated usage are often given limited consideration (Araral Jr., 2009). For instance, in the case of a river, upstream-downstream (location) asymmetry and not economic heterogeneity may have a significant negative impact on collective action: the majority of poor water users located upstream may ignore a rich user located downstream, and the latter is less likely to influence collective action of the former. Similarly, powerful users (in terms of wealth) located upstream are also likely to ignore the downstream poor. Also noted by Bardhan and Dayton-Johnson (2002), an irrigation organisation crossing several village boundaries is less likely to rely on social sanctions and norms to enforce cooperative behaviour than that of a single village (users along a river have different incentive structures with respect to resource provision and appropriation). The impact of market opportunity also receives little attention. Araral Jr. (2009) finds that increasing market opportunity leads to increasing selfish behaviours among actors which lessen mutual dependencies, loosen up traditional social ties, and reduce the interlinkages for possible reprisals in the case of adverse behaviour.

Just like heterogeneity, the role of group size is also mixed. Although group theorists suggest that collective action is more difficult to achieve as group size increases, there is no consensus on how to establish the dividing line between small and large groups, or on the role of context in mediating the effects of group size (Poteete and Ostrom, 2004; Araral Jr., 2009). An increase in group size is said to decrease opportunities for frequent interactions, lower reputation formation, and decrease expectation of future interaction thereby lowering the level of trust among users (Ostrom et al., 1999; Poteete and Ostrom, 2004). Group size is said to affect the calculus and strategy of collective action even if trust is not a limiting factor (e.g. for some individuals the perception that an individual contribution does not make a difference increases with group size) (Poteete and Ostrom, 2004). In addition, Poteete and Ostrom (2004) argue that as group size increases, threats of being punished in future become less

effective as a method of encouraging cooperation. The logic is that an increase in group size increases the transaction costs of resource provisioning, thus raising the costs of initiating collective action. Hence, a large group is less likely to achieve collective action and if it did achieve collective action the level of resource provision will be much lower (Olson, 1965). However, subsequent studies have shown that incorporating income effects leads to significantly different conclusions about the level of collective provision (Poteete and Ostrom, 2004). Others argue that most collective goods are normal goods meaning that individuals who experience an increase in income decrease their expenditure on the goods by less than the amount of the increase in income.

In the following section, we present the case study context and the methodology used. This is followed by a section presenting the emergence and functioning of RCs in different parts of the Themi sub-catchment.

RESEARCH METHODS AND CASE STUDY

Research methods

The objectives of this research were to describe and analyse the emergence and functioning of RCs in a sub-catchment. More particularly, we wished to understand when and why they emerged, how they evolved over time and their interface with government structures. To achieve these objectives, our research was premised on the assumption that network flows of water are dependent upon associations of humans, hydrological systems and the spatio-temporal construction of physical infrastructures. To identify the actors and their networks, we followed the water flow path downstream (Law, 1992; Murdoch, 1998; Latour, 1988, 2005; Kortelainen, 1999; Bolding, 2004) and in the process mapped the hydraulic infrastructures, the users and the institutional network behind them. To trace the emergence of RCs in the Themi sub-catchment, we first identified water users and their infrastructures and then mapped irrigation canals. Locally known as furrows, these divert water from the river and by gravity convey the water to the plots. Periodic maintenance is required to sustain the intake structures (often made of stone, tree logs and mud). Subsequently, furrow committees managing the furrows were identified and finally the RCs active in the sub-catchment. Following the result of spatial mapping and observation, we found that RCs are particularly active in Seliani and Ngarenaro tributaries and in the Lower Themi river.

Meetings were held, first with furrow committees and thereafter with the RCs of Seliani, Ngarenaro and Lower Themi. In Seliani river, meetings were held with four of the 12 furrow committees and one large-scale coffee estate. Two of the furrows were located in the upstream part of Seliani river, one in the midstream and one downstream. The second furrow upstream was recently constructed. For Ngarenaro river, meetings were held with all furrow committees. For the Lower Themi river, however, we only conducted meetings at the level of the RC, and not with the individual furrow committees.

Discussions with furrow committees were conducted as follows. The first part dealt with issues relating to initial investment in the furrow construction, current norms in use, how water is allocated to each furrow drawing from the same river and how this is transformed into water access for individual members of a furrow, understanding the efforts of the Pangani Basin Water Office to create catchment fora, and finally the acquisition of state-issued water rights. The second part of the discussion was on the RC: when it was formed, why it was formed and whose idea or initiative it was. Further questions included: how a furrow group can become a member of the RC, the specific role of this committee, especially with respect to water allocation, its spatial span of control, management structure and election of representatives and leaders. The discussion also focused on the link between the locally established RC systems with government-created water management structures and local government offices. Discussions with the RCs followed a similar format as described above for the second part of the furrow committees. In addition, the RCs were also asked to draw a sketch of the furrow systems under their command.

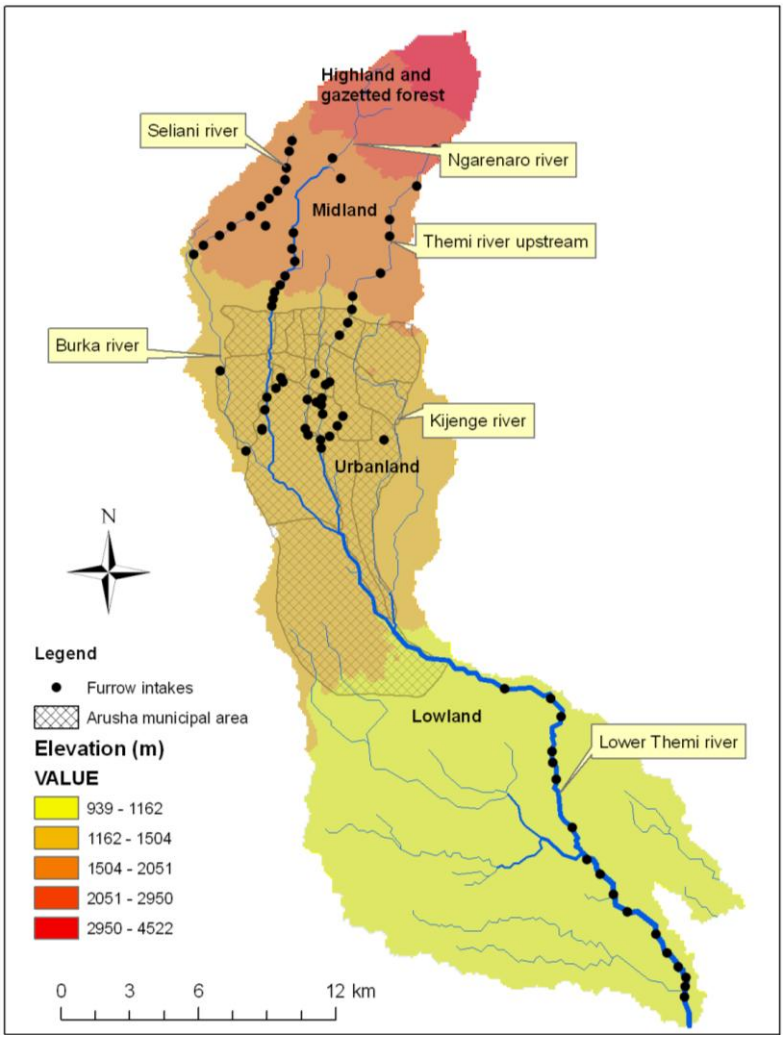
Case study sub-catchment

Biophysical context

Themi is a sub-catchment (figure 1) of Kikuletwa catchment, which in turn forms part of the Pangani river basin, Tanzania. The sub-catchment covers parts of the districts of Arusha Rural, Simanjario and Arusha municipality, comprising 26 administrative wards with a total land area of about 363 km^2 (49% of the area of the 26 wards). Themi, Nduruma and Ngaremotoni rivers all originate from the slopes of Mount Meru (4500 m above mean sea level) and flow into the Shambarai swamp downstream (at about 800 m). Themi river is joined by four main tributaries, viz. Naura Spring, Burka, Kijenge, and Ngarenaro rivers, the latter receiving additional waters from the Seliani and Burka rivers (see figure 1).

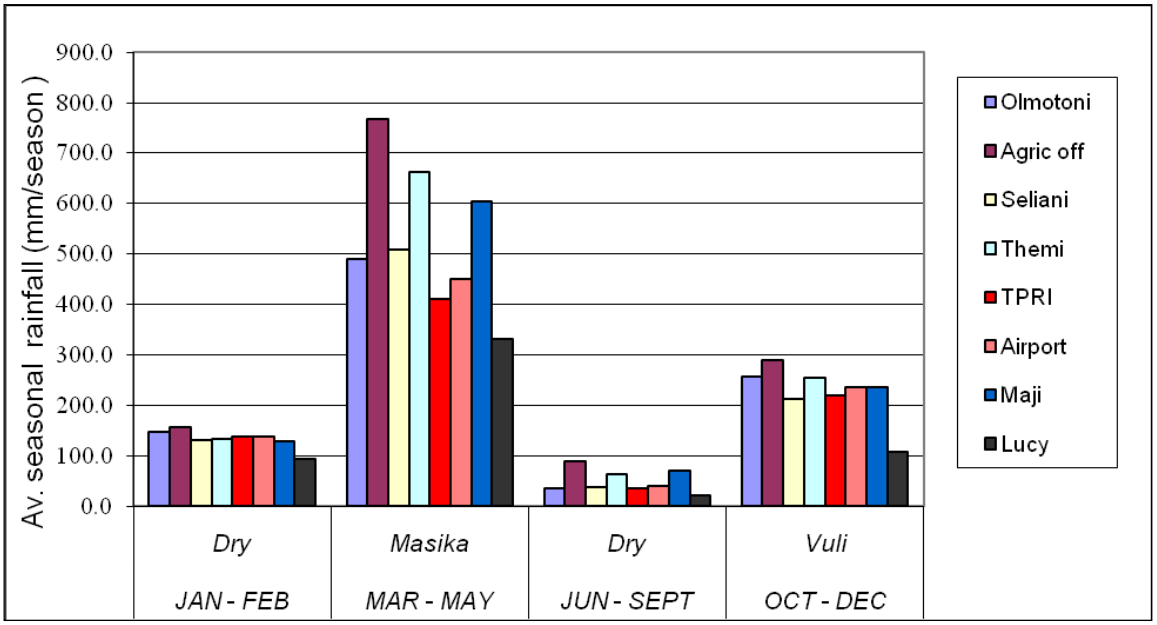
Increasing water demand, water pollution and climate change make the area a potential hotspot of upstream-downstream water conflict. In the sub-catchment, users not previously aware of their mutual dependence on the limited water resource are increasingly being confronted with the need to share water with other users located distant from their area. The increased interdependency among water users has led to institutional innovation in the sub-catchment. Canal irrigation (furrow) groups have adapted their local institutions to the changing availability of the water resources. RCs have been created by farmers and made responsible for water allocation between groups utilising the same river.

Figure 1. Themi sub-catchment river system and furrow diversion points.



The area experiences two rainy seasons per year, one starting in March and ending in May (locally called '*Masika*', also known as long rains) and the other starting around October and ending in December (locally called '*Vuli*', short rains). The average rainfall in the sub-catchment varies from about 1400 mm/yr in the highlands to about 500 mm/yr in the lowland. Inter-seasonal rainfall is relatively low (figure 2).

Figure 2. Seasonal rainfall as measured at different locations in the sub-catchment, 1927-1990; Olmotoni station is in the highlands while Lucy is in the lowlands (Source: Pangani Basin Water Office, Arusha).



Themi sub-catchment can be divided into four agro-ecological zones – highland/forest (over 1700 m above msl), midland (1500-1700 m), urban-land (1300-1500 m) and lowland (below 1300 m). The highlands (rainfall 1000-1400 mm/yr) comprise a gazetted forest reserve with some signs of human encroachment, timber logging and hunting.

In the mid-highlands (rainfall 800-1300 mm/yr) subsistence farming and stall livestock rearing are dominant. Although farmers practice rain-fed farming, canal irrigation is used for supplemental irrigation in the rainy season and full-scale irrigation during the dry seasons. Crops grown include maize, bean, banana, coffee, vegetables, tomato, and onion. In the mid-highlands, there is competition over water needed for the production of vegetables, tomato and onion that are increasingly in demand in the Arusha municipality.

Urban land comprises the built-up areas within the Arusha municipality (rainfall 600-800 mm/yr). Land use includes commercial activities and industries, although agriculture is practised on the outskirts of the municipality. Two coffee estates located in the outskirts of the municipality, and the small-scale farmers in this zone rely on rainfall, river water and municipal wastewater to grow crops. Water problems in this zone include pollution from municipal solid and liquid waste, as well as competition over water, especially between the surrounding villages and the large coffee estates. Furthermore, the increasing urban population puts pressure on the water supply, and the urban water authority (Arusha Urban Water Supply Authority – AUWSA) has to look for new sources both inside and outside the urban land area. This led to violent conflict between the water authority and the neighbouring villages in 2003 (Komakech et al., 2010).

The lowlands receive limited rainfall (less than 600 mm/yr) and farmers here rely heavily on irrigated agriculture. Land use in the lowlands is dominated by subsistence farming and livestock rearing. Large sisal estates can also be found, but many of them have stopped operating, partly because of water scarcity. Whereas sisal is not normally irrigated, water is required for processing its products. In addition to water scarcity, pollution from the Arusha municipality presents a significant problem for lowland farmers.

Socio-economic context

The Themi sub-catchment is mainly inhabited by the Arusha people (a group of agro-pastoralists related to the Maasai), Meru (mainly agriculturalists related to the Chagga of Kilimanjaro) and Maasai. In 2002, the sub-catchment's total population was about 447,000 (URT, 2002). The spatial geography is such that small-scale farmers upstream are confined between the forest belt, the urban centre and estates. Below the urban area and estates, smallholder farmers cultivate marginal lands with low rainfall and poor soil (see Spear [1997] for details on the origin of settlement in Meru). The location of water users close to the growing urban centre of Arusha – Tanzania's third largest city – has resulted in intense water resource use in the sub-catchment. Arusha city is at the core of a vital and relatively wealthy region with productive agriculture, mining activities and a large tourist industry, all of which are sources of intense water resources development and use (Carlsson, 2003). In the sub-catchment, some rivers that used to be perennial have now become seasonal. There is a limited use of groundwater for irrigation, mainly by a few large commercial farmers. The Themi catchment is under the jurisdiction of Pangani Basin Water Board, a government-created basin organisation. The basin water board through its executive basin office (Pangani Basin Water Office – PBWO) is responsible for the allocation and management of water resources in the Pangani basin. So far, efforts by the Pangani Basin Water Office to enforce efficient water allocation remain weak[1] but institutional arrangements developed by farmers to secure supplies and share resources between upstream and downstream neighbours do exist and these arrangements mediate water access between the users.

EMERGENCE OF RIVER COMMITTEES

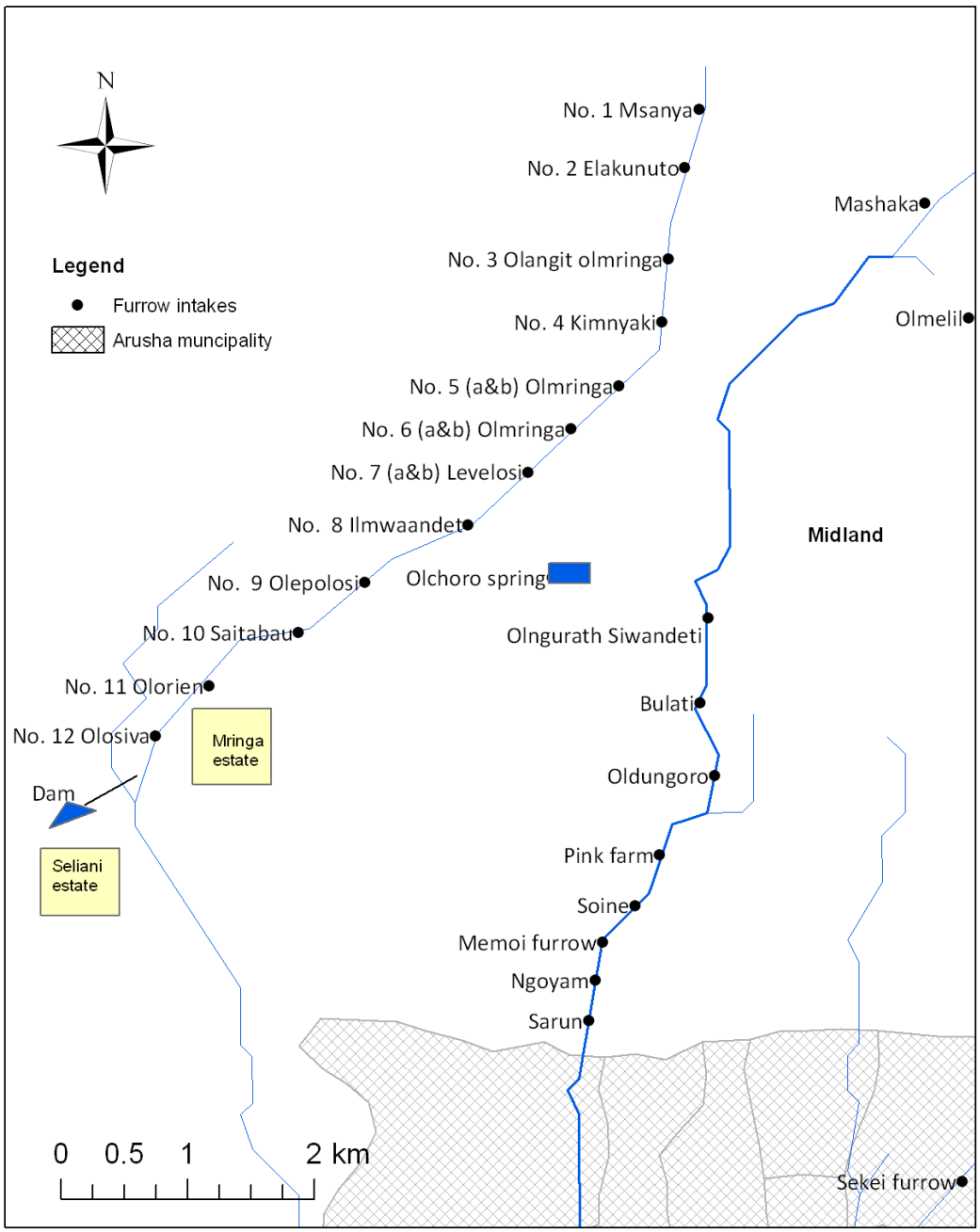
This section presents the findings from three RCs: Ngarenaro River Committee, which is comparatively well organised; Seliani Committee, where stiff competition has reduced the committee's powers; and Lower Themi, where the committee experiences such fierce competition that the local government administrative structures are frequently called upon to settle conflicts. The RCs share a similar structure: they all have a chairman, a secretary, and water guards who are elected representatives of member irrigation canals and to a lesser extent commercial estates. This section describes the conditions under which the three committees emerged, their structure, roles and links, and how they attempt to allocate water and solve conflicts.

Ngarenaro river committee

The farthest upstream village using water from the Ngarenaro river is the Shiboro village. Altogether there are eleven furrows along the Ngarenaro river and its tributary upstream of Arusha (see figure 3). The first furrows in Ngarenaro are said to have been constructed over two centuries ago for watering livestock, domestic water use and small-scale irrigation. The people of Arusha (*Waarusha*) reportedly contracted *Wachagga* from the Kilimanjaro region to construct the furrows. At the time, there was no competition over water and no institution responsible for water allocation between the existing furrows. Elders would inform the chiefs about the intended construction and mobilise labour.

[1] The basin water board currently grants fixed volumetric water rights to users based on assumed existence of average supply. The rights do not take into account seasonal variability.

Figure 3. Seliani and Ngarenaro rivers showing furrow intakes (Source: field notes).



Emergence of the river committee

Ngarenaro ('black water' in Maasai) River Committee (RC) was started around 1945 during a period of extreme drought. A group of elders from upstream and downstream divided the river into two zones, Oldungoro to Ilboru as upstream (referred to as *Oldungoro* by the farmers) and below Ilboru to the Ngarenaro confluence with the Burka river as downstream (referred to as *Burka* by the farmers), and each zone would use water for one week. Simple rules understood by the farmers as well as their leaders were put in place. The rules included fines and punishment for defaulters, and election of committee representatives.

To ensure a fair distribution, a measuring stick was introduced around 1960. The stick was introduced when it became difficult to continue with the weekly water allocation because of increased farming and livestock in the area. The idea of the measuring stick was partly triggered by events on the neighbouring Seliani river, where a farmer reportedly killed another over water. So the elders devised the system to avoid similar incidents on the Ngarenaro river. The measuring stick is kept by the RC chairman but the vice chairman also keeps a copy, which is used only for validation purposes.

The stick is made of bamboo measuring about 70 cm long, with four white markings (stages) used to measure water depth (figure 4). The first ring (from the bottom) corresponds to a water depth of about 11 cm, second one to 13 cm, third 15 cm and fourth 18 cm. Measurement is done at fixed points in each furrow, where the furrow width is about 70 cm (roughly the same as the length of the stick), and where there is laminar flow. Each of the graduations was set according to the population served, area to be irrigated and distance to the furrow command area (somehow taking into account transmission losses). The first three marks from top (water depth of 18, 15, and 13 cm) correspond to water allocation to three upstream furrows of Oldungoro, while the lowest mark (11 cm) is for downstream furrows of Burka. Olngurath furrow, having the biggest command area and traversing a longer distance to the irrigation command area than the other furrows, is allocated the uppermost mark. The second highest mark is for water allocation to the furrow with the second highest population, Bulati furrow. The third highest mark is allocated to the furrow with the third largest population, Oldungoro (Lesia) furrow, while the bottom-most mark corresponds to the water left for Burka's five downstream furrows (Pink farm, Soine, Memoi, Ngoyam and Sarun). The command areas of Burka's furrows are relatively small and are increasingly becoming built-up areas. These five furrows share the flow corresponding to a water depth of 11 cm on a rotational basis and the vice chairman of the RC is responsible for setting the allocation schedule. Whenever there is sufficient flow in the river, water allocation proceeds according to the above procedure. But during periods of drought, water allocation is varied along the marking and depending on the severity of the situation, the markings are lowered for each furrow (e.g. furrow taking 18 cm is now given 15 cm, and the next given 13 cm, etc); this is done until it is no longer justifiable to allocate water between the furrows. At this point, no one is allowed to irrigate anymore. The RC chairman, Mr. Nambua, said "primarily we used the stick during water scarcity; no one is fined when water is enough. The period it is normally used is between January-March and August-October but effectively in the months of September-October, as this is the driest period in our area".

Figure 4. The Ngarenaro RC chairman explains the marking of the measurement stick and demonstrates how it is used.

The committee's institutional structure

Each of the nine furrows is represented at river level by its chairman, vice chairman, secretary, and water distributors. The RC chairman, vice chairman and secretary are elected in a general assembly of all farmers (upstream and downstream). According to the present committee, election is in principle every five years or in case of a major problem, but this rarely happens. In the absence of a problem, the existing committee is maintained and new members join only when the furrow members change their leaders. The last general election was in 1995.

The RC is not registered with the Pangani Water Office, but farmers believe it is nevertheless legitimate. No problems arise with the village governments since representatives of the village government are also members of the RC. Generally, the committee leaders are people holding several positions in the villages and wards. The current RC chairman, for example, is a clan leader and also a veterinary officer.

The roles of the RC include allocating water to member furrows, ensuring that all furrows receive their water turns, and calling for meetings when needed. The committee is also responsible for finding additional water sources during extreme shortage as well as identifying areas with high water losses, and negotiating new arrangements with upstream users who are not necessarily members of the RC. The committee is the only custodian of the measuring stick, and also represents the group in other fora including at the village government level and in other organisations, for instance those created by development NGOs.

Water allocation and enforcement

In Ngarenaro, water allocation between furrows still follows schedules developed in the 1960s. Individual farmers are prohibited from going to the intake unless it is for maintenance of the furrow intake which again must be done under the supervision of the furrow committee. Only furrow leaders are free to check and operate the intake structure. If a farmer has noted that flow into their furrow is significantly low, he must report to the furrow chairman who will discuss the matter with the RC chairman for a possible increase in flow at the intake. There is a minimum flow allocated to each furrow to cover domestic water needs and livestock. For each furrow, all water distributors (a water distributor or '*mgawamaji*' in Swahili is a person responsible for day-to-day allocation of water to farmers within one furrow) are given a written water allocation schedule by the furrow chairman, which makes it easy to find defaulters on any particular day.

No serious conflicts are reported in Ngarenaro, but in case a furrow ignores the water schedule it is often fined a goat. The chairman stated: "We do not need money; defaulters must bring a bull or goat and everyone enjoys. No fighting over water; conflicts must be brought to the leaders. Those who fight are severely punished; why fight over water when we have the leaders and the rules to follow"? Success of the committee is attributed to its consistency in applying the rules. A committee member said:

> If you give people freedom and later try to change it there will be trouble. Here, we frequently remind our members about efficient water use and about rules in place. If you are making laws do it together with everyone. In Ngarenaro, failure to follow set measurements is strictly punished (defaulters being fined a *dume* [bull]) and all furrow chairmen are responsible, and they must ensure that their intake is protected and members do not open the intake freely.

Pink Farm was reportedly fined a goat for pumping water; the committee thought the owner of the farm was taking more water than allocated. One other furrow, Olngurath, was fined a bull in 2008 for not following the schedules and the set measurement. However, the RC chairman also emphasises that humans do make mistakes; if this appears to be so, the case can either be dropped or the fine reduced to, say, a he-goat (*dafu).* Only Pink Farm is reported to have a state-issued water right but the committee said they plan to arrange for a water right at the river level and then distribute the right to

the individual furrows. Current operational costs are met on demand (i.e. money is collected as and when needed). But some operational costs, such as communication costs are met by the individuals. "This is called 'commitment'", the chairman said.

The major challenge faced by the Ngarenaro River Committee is posed by the upstream village of Shiboro (Mashaka furrow), and Olmelil furrow, which are currently not members. Mashaka and Olmelil furrows say they are not aware of the RC, and that their water is from a different branch of Ngarenaro not used by downstream farmers. However, they do remember the RC chairman coming to request them to allow night flow to downstream farmers. Shiboro village farmers think an RC is only useful when there is a water problem, but say that such a problem does not exist upstream at present. To overcome future upstream-downstream water conflict, Shiboro village is applying for a state-issued water right, which they think will control downstream interference.

Seliani river committee

The source of the Seliani river is located about 2000 m a msl in a gazetted forest area on Mount Meru. The river flows through the administrative wards of Ilkidinga, Kimnyaki and Kiranyi and terminates just before Burka spring on the outskirts of the Arusha municipality. The most upstream village is Shambasa, but this village mainly practices rain-fed agriculture. Two large coffee estates (Mringa estate and Burka estate, formerly Seliani, see figure 2) also use Seliani water for irrigation, although since 2002 they have not received water. Upstream of Burka estate, 12 furrow intakes have been constructed along Seliani's course (figure 3).

The people using Seliani river water include Maasai communities located upstream and a mixture of Maasai, Arusha, and Chagga downstream. This spatial geography of users has been pointed out by downstream farmers as a key obstacle to successful water allocation. Downstreamers are of the opinion that upstream Maasai communities are less likely to share water with the mix of downstream water users; using the Swahili word '*Mchanganyiko*' (which refers to an area settled by people of different ethnicities). During a discussion with the upstream water users, a farmer said "those people down there are not farmers; they are businessmen selling land to other people".

Emergence of the river committee

Furrow number one (*Msanya*) is the oldest, constructed over 200 years ago, first for domestic water supply, fire-fighting and livestock watering and now being used for irrigation. By 1968, there were three furrows using water from the Seliani river. Five more furrows were constructed between 1968 and 1977. Later, four more furrows were constructed, the last one (furrow number two*, Elakunuto*) in 2003. According to farmers, water problems started in the 1950s when the owner of Seliani (now Burka) coffee estate (a Mr Isaac Blaumen) wanted to store water in a dam for his coffee plantation. The plan met stiff resistance from organised upstream farmers (mainly Maasai elders) who refuted Blaumen's claim of having a right to the exclusive use of Seliani water. The district commissioner was later involved and the right of the villages to water was formally recognised. An agreement on rotational water allocation was later reached, whereby upstream villages would use daytime flow and the night flow would be left for the Seliani estate.

It is this organised group of elders that evolved to form Seliani RC. In 1968, the farmers were led by someone named Laanoi, who remained the group leader for 30 years. The final decision to create an RC came around 1976. By then, more furrows had been constructed upstream and also the estates needed more water. There was another water conflict, and the three ward offices traversed by the river (Ilkidinga, Kimnyaki and Kiranyi wards), first assigned to manage the allocation between the estates and the farmers, could not manage the complex water allocation system. So the division secretary, who is at the next level of administrative authority (a division comprises several wards) called for another meeting to solve the downstream-upstream conflict. At the meeting, the parties agreed to create a

committee that would bring all furrows and the estates together and be chaired by Mr Paulo Royand (chairman until 2001).

In 1976, the government warned that no more furrows should be constructed along the river. In addition, a restriction was put in place: to construct a new furrow the intending party would first have to consult the RC, a role previously performed by chiefs and clan leaders. It was also agreed that only the general assembly of the RC could decide on the construction of a new furrow. Despite the warning, more furrows were constructed. According to the current committee chairman, the RC has tried to control the construction of new furrows, but interference from the District authority has complicated matters. The chairman mentioned as an example that the District authority wrote a letter instructing the committee to allow the construction of furrow number two (*Elakunuto*) in 2002. Local politicians saw it as an opportunity to canvas votes in three wards, and furrow number two was built despite the expected negative impact on the system as a whole. Even then, upstream farmers consider their location near the water source to be synonymous with ownership of the river's water. Since they are favourably located upstream, they can ignore the RC: it was reported that the first three furrows (Msanya, Elakunuto and Olangit) did not attend committee meetings for two consecutive years. In a discussion, a downstream farmer remarked: "We need upstream farmers but it is hard to bring them to negotiation terms with us downstream. (Although) we understand their advantaged position upstream, we will guard our water turn whenever possible".

Water allocation and enforcement

Water is allocated on a rotational basis between the furrows. Initially, the villages would share daytime flow, while night flow was for the Seliani estate. Before 1970, allocation to the villages (only three furrows then) was from 6 am to 6 pm: so each of the three furrows could get water for three consecutive days (sufficient for the existing water use). Failure to comply was a fine of a bull. There was strong leadership by the chairman, Paulo Royand, who could enforce the rules. In addition, Seliani estates would meet the cost of furrow rehabilitation and meetings. To reduce water theft, the Seliani estate constructed intake gates with locks on all the furrows upstream and employed a water guard to open and close them. But this never worked, as farmers bribed the guard and water could be used outside the allocated hours. Eventually, the farmers kicked out Seliani and Mringa estates from the RC, citing increased water demand (box 1).

Box 1. Statement of Burka Estate Personnel Officer.

> "Sharing water with smallholder farmers is challenging. Commercial farmers are often seen by small farmers as different and foreign. In meetings, farmers often shift to their local language. How can a commercial farmer have meaningful communication with small upstream users speaking a different language? We used to be members of the Seliani river committee together with Mringa estates but upstream farmers cut us off in 2002. Luckily the spring source feeding the Burka river is located within our farm. We have protected the spring source, invested in groundwater and have been innovating with our irrigation technology. Currently, we are using a variant of drip irrigation, PIDO. It is a simple technology that can easily be moved from place to place".
>
> Source: field notes

According to the RC chairman, by the year 2000 it would have taken 36 days to complete the water allocation cycle. But since the two estates were kicked out of the RC and allocation to the furrows was restructured to day and night it now takes 21 days to complete an irrigation cycle. Current water allocation schedules are being prepared by the RC secretary starting in January each year. In the schedule, upstream and downstream furrows are paired and given one day allocations, which they

share equitably (12 hours for each). The paired furrows take turns irrigating (upstream furrow starts, e.g. during their turn, furrow 6 number starts, irrigates for 12 hours and leaves the water for furrow number 12). Schools within the area are allocated water one day per week (basically Saturday 6 pm to Sunday 6 pm).

Enforcement of the water allocation schedule remains a problem. Water theft upstream, particularly by the first, second and third upstream furrows, as alleged by many downstream irrigators, makes the RC ineffective to downstream users. According to the general rule, violation of the schedule would attract a fine of Tshs70,000 (approximately US$45) but enforcing this rule has proved difficult. There is also an ethnic/tribal dimension: upstream farmers, being mainly Maasai, often speak as one and tend to band together against the mixed ethnicity downstream. Another critical factor is land use change upstream. Upstream Maasai used to be cattle keepers with minimal water demands. But as they have taken to growing crops their water demand has increased significantly. The impact of the RC ineffectiveness is felt downstream, by furrow numbers seven through twelve. Here, irrigators sleep out guarding their water turn. A farmer from furrow number ten stated:

> When it is our water turn, we go upstream at 5 pm to close furrow intakes and remain guarding the intake until 7 am in the morning. Unfortunately, due to transmission losses in the dry riverbed, 7 am is also the time water normally reaches our farms downstream and yet by 4 pm upstream farmers will have opened their intakes. In fact, during our water turn, we only get water for about 10 hours instead of the official 24 hours allocated.

Seliani RC also does not have a formal link with Pangani Basin Water Office (PBWO). Some of the users (e.g. Seliani coffee estate) have acquired water rights from PBWO but the rights are not used in the allocation of water or recognised by other water users.

Lower Themi river committee

Themi river also rises on the slopes of Mount Meru above the forest belt. Its source is called *Emaoi*. The river flows through the villages of Oldonyo Savuk, Kivulul, Moivo, Sekei, and Arusha municipality before being joined by Kijenge and Burka tributaries. Through its course, Themi connects water users from the Arumeru district, Arusha municipality and the Simanjiro district.

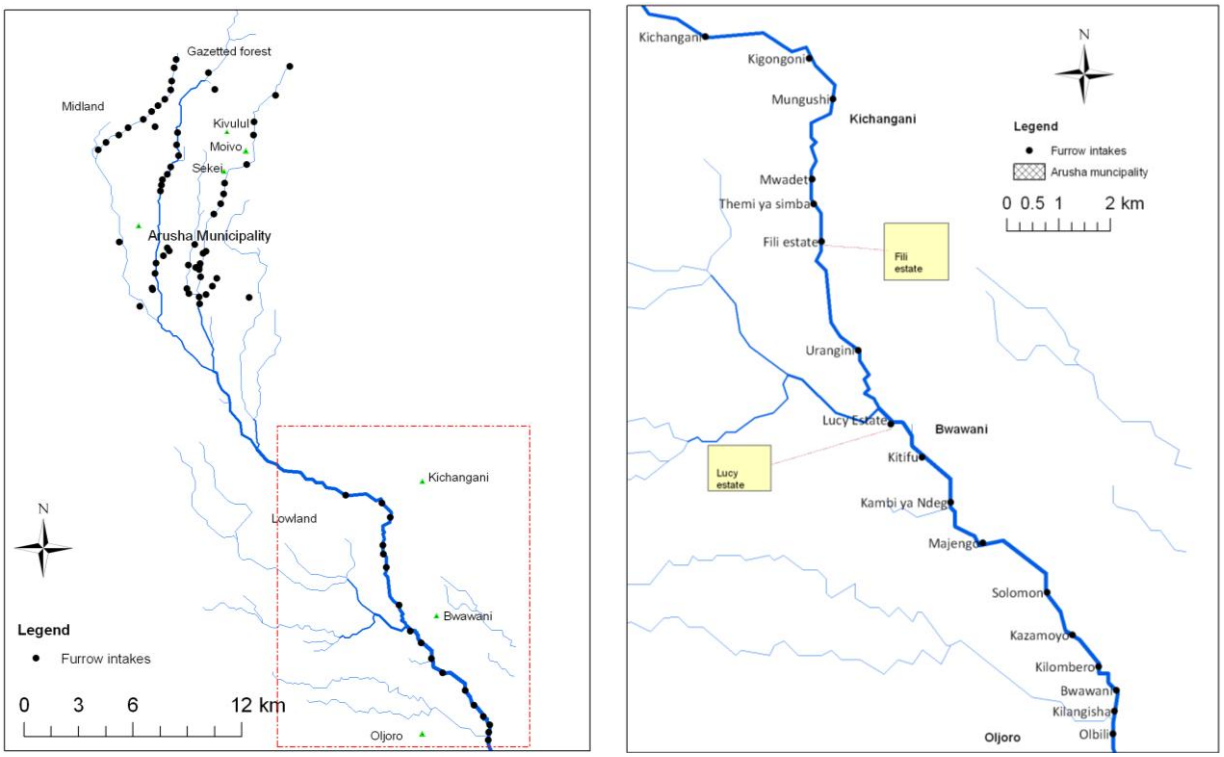
Upstream of Arusha municipality, water is abstracted by three furrow irrigation systems (one in Kivulul village and two in Moivo village) and by Arusha Urban Water Authority. There is no RC in this upstream section of the river. In the village of Kivulul water allocation is managed by the village government through elected representatives from sub-villages served by the furrow. The village executive officer prepares a water turn as a written paper ('*Kibali*') and gives this to the sub-village representative, who issues the water at a fee of Tshs100 per turn (approximately US$0.07). The two furrows of Moivo village do have committees which follow the traditional Maasai age system (called '*Jando*'). At present, all three furrows divert water at the same time. The villagers of the Moivo village believe that the system functions without a central authority because the traditional rule that the river may not run dry since the water is also needed by aquatic animals is still respected; hence none of the furrows divert all river water.

A similar arrangement is found midstream within Arusha municipality. Some of the furrows in this area rely mostly on waste-water effluent and spring sources. Farmers in the midstream are affected more by water pollution from industries such as Tanzania Breweries (a beer factory that uses caustic soda for bottle cleaning).

More furrows – 40 km downstream of the municipality of Arusha – serving the wards of Nduruma (Kichangani village), Bwawani, and Oljoro (Simanjiro district) have been constructed and an RC has been created to coordinate water allocation (figure 5). Water is mainly used for irrigation, as well as for livestock watering. The area also has the largest livestock population in the whole of Arumeru district

and water users from Simanjiro district are also livestock keepers. There are two sisal estates each using Fili and Lucy furrows.

Figure 5. The left panel shows Lower Themi position (indicated by the dotted rectangle) relative to upstream users like Arusha city and Kivulul village. The right panel shows Lower Themi furrows (Source: Field notes).



As the Themi river passes through Arusha municipality it becomes heavily polluted with industrial and municipal waste, and pesticides used by upstream farmers. Nevertheless, its water is used for drinking, cooking and washing by downstream communities including secondary schools. All the wards except Nduruma use Themi water for domestic water supply.

Emergence of Lower Themi RC

Prior to 1992, there were not many water users in Lower Themi. Due to in-migration and natural population growth, more land was put under cultivation, furrows were extended and new furrows were added, thereby increasing water shortages. The idea of an RC started around 1992 when the river flow was no longer sufficient for all furrows to divert at the same time. There were conflicts over water and the division secretary, a retired military officer, together with the village elders, initiated the RC system to overcome the problem. The first agreement was verbal, with no written rules. But in 1999, another meeting was held between the local government and the RC, during which byelaws were drafted, forming the RC constitution, copies of which were distributed to all the ward offices. According to the committee secretary, people are often motivated to work together when there is not enough water and this was the driving force for creating the RC. The estates downstream were given orders to join the committee and because water is required for sisal processing, they were motivated to become members. According to the farmers, the RC is essential in resolving water conflicts during water scarcity. The committee produces an allocation schedule for all 17 furrows in Lower Themi (i.e. from Kichangani to Olbili furrow, indicated in figure 5, right panel).

Water allocation and enforcement

During the rainy seasons, water is not formally allocated. According to the chairman, during *masika* (long rains), sufficient water is available to satisfy all needs, so all furrows can get water each day and still some balance remains in the river. During the dry season, allocation is based on turn-taking. Depending on water availability, upstream furrows use water for 2days and downstream furrows for the next 2 days. Rotational allocation is reported to start in July and end on the 30 September every year. After September until the onset of the *vuli* (short rains) season, no one is allowed to divert water for irrigation purposes. The flow is left in the river to be used by livestock. Whenever there is an increase in river flow (e.g. from early rains upstream), the committee revises the allocation schedule. Depending on climatic conditions, rotational allocation may start and/or stop early or late. In August 2009, while mapping the furrows together with the RC Secretary, an elderly Maasai livestock keeper complained that the ban on irrigation use needed to be brought forward to 31 August[t]. He said their livestock had been without water for 2 days and threatened to send young Maasai boys upstream to destroy all furrow intakes if they did not get water. These are not mere threats; in 2008, Maasai youth reportedly destroyed all furrow intakes, and also destroyed crops along Kichangani and Kigongoni furrows.

The allocation schedule is enforced by water guards who routinely patrol the river to prevent violation. Each water guard is paid Tshs4000 (approximately US$2.50) per day for the work and two or three water guards are deployed every day. Water guards are reportedly selected by the villages and elected in a general assembly (each village nominates two names, one of whom is elected). Presently, all the water guards are from downstream, as upstream villages are reluctant to pay for the water guards.

Some of the furrows have a government granted water right (e.g. Kichangani, Mungushi (expired), Kigongoni, Themi ya shimba, and Fili and Lucy estates). The other furrows are in the process of acquiring water rights. Water is allocated according to local norms and in case of a problem, the committee assumes responsibility. Holders of government issued water rights are not given priority or favoured and the fixed discharges defined in these permits are ignored.

Along the Lower Themi river, there are frequent conflicts over water. According to the committee, there were conflicts in 2005, 2008, and 2009. In all of them, the police got involved. Problems arose from lack of water downstream and people often destroyed intakes and sometimes crops or even beat up farmers. The allocation system is reported successful only when there is sufficient water in the river. But during extreme scarcity, some users, especially upstream furrows, divert water without respecting the water schedule set by the committee. The RC secretary stated that it is often the upstream furrows of Kigongoni, Mungushi and Kichangani that cause problems during water shortages. The Kichangani and Mungishi furrow intakes are problematic, as the whole river needs to be blocked before water can enter these furrows, thereby affecting downstream users. The intakes also require several man-days to reconstruct, so whenever downstream farmers go to clear the obstructions created by these intakes, conflicts arise. During interviews, we were told that the committee had taken Kichangani furrow to the government court because of violating the schedule. We also observed that one of the large sisal estates used its power to influence the RC and a nearby local police post. They often pay the water guards to patrol the river and buy fuel for the motorcycle used by the police to arrest upstream violators.

A traditional fine system is supposed to be in place; a bull or its equivalent of Tshs100,000 (approximately US$65) is levied when a furrow closes the river completely thereby causing water shortages downstream. The RC has tried to enforce this rule, but no one pays. The committee observed that it was not easy to get money from people. According to the committee secretary, this is because the upstream furrows have been in existence for a long time; moreover, some farmers have acquired water rights from the Pangani Basin Water Office and used to pay annual water use fees to the central government (currently, no furrow pays the yearly water fees); finally, some of the upstream furrows are

located in a ward of another district which makes it even more difficult for the committee to fine them. "So we have to accommodate upstream disturbance somehow. Sometimes we destroy the intakes but also we do understand that it takes so much time and labour to reconstruct". Downstream furrows are not lined and use traditional intakes made of stones, mud and logs. Equipping the furrow intakes with gates is considered by the Lower Themi RC as a solution as these are believed to reduce leakage and improve effective allocation to the furrows.

During mapping, we noticed that some of the furrows, which previously had intakes with lockable gates installed had been destroyed. When asked why they could not maintain the weirs, the RC secretary claimed the intakes, constructed between 1992 and 1994 when the government introduced the water rights system, were destroyed by the farmers because they did not agree with the government water rights and ownership system. He also said, however, that farmers now understand the system well, and that a recent change from the water rights system to a water use permit system is considered acceptable. The new Tanzania Water Act of 2009 abolished the system of granting water rights and instead introduced water use permits. The permits grant access to beneficial use of water and does not confer full ownership over the water (URT, 2009).

Operational costs of the RC are met by water user's contributions and fines. These contributions are derived as follows: every member furrow contributes Tshs10,000 per year (approximately US$6.50). The furrows get the money from their individual member farmer's contribution (normally between Tshs1000-2000 about US$0.65-1.30). But most money is collected on the spot whenever there is a need. Each furrow chairman has to contribute Tshs4000 (approximately US$2.50) per day for paying water guards. Since the committee is not formally incorporated as an association, it does not have a bank account; any balance is kept by the treasurer.

Currently, the Lower Themi RC does not communicate with users in the upper part of Themi sub-catchment. In 2008, the committee members visited the Pangani Basin Water Office (PBWO) sub-office in Arusha to find out how they can reach upstream users. PBWO advised that the committee would be called for a meeting with the other users in early 2009. By the time of our interview, the PBWO had just started consultation processes over the creation of the Kikuletwa Catchment Forum of which Themi sub-catchment forms part. Catchment fora are envisaged to provide an arena for users to dialogue on water allocation and management issues at an intermediate level (between furrow and basin).

DISCUSSION: EMERGENCE AND FUNCTIONING OF RIVER COMMITTEES

This section discusses the drivers for the river committee formation, and assesses the emergence of these institutions using the concept of institutional bricolage. It then analyses the RCs endurance over time using Ostrom's eight design principles. In addition, we examine the impact of heterogeneity and group size on the functioning of the RC system.

From the preceding accounts, four drivers can be identified as the main triggers for the RC formation in the Themi sub-catchment: (a) increased frequency of low flows in the area, which has increased competition and sometimes violent conflict over water; (b) natural population growth, which put more pressure on land and water resources in the catchment (see Mbonile, 2005); (c) the availability of markets for agricultural produce – Arusha, being a fast growing city with a good road network to Dar es Salaam and neighbouring Kenya, provides market opportunities to nearby farmers and this in turn leads to agricultural intensification and competition over water resources; and (d) colonial and, later, the independent Tanzanian government policies; for instance, the Tanzanian government '*ujamaa*' in the 1970s settled pastoralist Maasai, especially along the Seliani river and intensified agricultural water use leading to fierce competition with the downstream coffee estate. These four factors contributed to rendering existing local water sharing arrangements ineffective. Thus, institutional innovation became a necessity and the RC emerged to solve coordination challenges that the ward offices could not.

The concept of institutional bricolage contributes to explaining the creation process of RCs in the Themi sub-catchment. The RCs benefited from the already existing arrangements such as the principle

of good neighbourliness, the rationale of local water allocation, and traditional conflict resolution mechanisms. This underscores the argument that new institutions often benefit from the legitimacy of past arrangements (Cleaver, 2002). The aspect of the multiple identities of the bricoleurs is well illustrated, as the creation process included, among others, local politicians and the district commissioners (DCs). The DC reports directly to the president's office and his/her responsibilities include maintaining security and peace in the community. Although it was always the downstream users that initiated cooperative arrangements, villages, wards and division offices played significant roles in the creation of the committees as well, e.g. through the efforts of division secretaries, which underscores the importance of non-users in local water conflict resolution. The farmers themselves have multiple identities and roles. Adaptation of the traditional age-group system (for example, the Maasai '*jando*' system, where certain age groups are responsible for resource management) to manage water allocation between villages is illustrative of the multipurpose nature of local institutions and of cultural borrowing as argued by Cleaver (2002). Although bricolage provides for understanding how such a change occurred, it does not answer why it was necessary to adapt existing arrangements at some point in time. Nor does it explain how the institutions function. To understand how the RCs endure over time we assess the three case studies using Ostrom's eight principles of long-enduring self-governing local institutions (table 2).

Unlike Ostrom's claim that well-defined boundaries are needed, in Themi the boundary definitions used are context-dependent, ambiguous and fluid. In all three cases, boundaries follow the extent of the downstream users' claim to water at the time, as the three RCs comprise currently only members from a maximum of three administrative wards even where the river is also being used by other wards (Ngarenaro and Themi being good examples). Membership is not entirely closed to outsiders. Non-members can seek permission and, if allowed, pay entrance fees – a mechanism that lowers the cost of controlling the boundary. Though not necessarily the intention at the time, by leaving the boundaries open to negotiation future demands can be met in the face of increasing resource variability (e.g. in Ngarenaro one of the RC's roles is to negotiate with upstream users who are currently non-members in cases of extreme shortages). The boundary principle is frequently violated by upstream users, as illustrated by the case of Seliani, where upstreamers and their local politicians invested in more furrows without the consent of the RC. It is not immediately clear whether the ambiguous boundaries of all three RCs studied should be considered a weakness. However, given that one RC performs quite well (i.e. Ngarenaro) demonstrates that having well-defined boundaries is not a universal condition.

The second principle of congruence between appropriation and provision rules and local conditions applies, but only to a certain extent. The RCs have developed varied levels of water allocation. The Ngarenaro committee, for example, invested in proportional allocation using a marked measurement stick and clear rules on its use as well as punishment for defaulters. The other RCs (Seliani and Lower Themi) have continued with rotational allocation but as the number of furrows increases, the schedule becomes increasingly complex leading to an increase in water theft, which triggers the involvement of the national police. Although the government's system of water rights is well known to the actors, it is not being used to guide water allocation. Instead, farmers seek to acquire water rights only to strengthen their claim of ownership, but actual water allocation does not follow the government-allocated right. Given the rules developed by the RCs, upstream users are expected to forego immediate benefits without receiving (direct) compensation from downstream users. This, however, is not easily enforced, which culminates in frequent water theft and rule violation by upstream users as seen in the case of Seliani and Lower Themi RCs. Thus, the second principle may partially explain Ngarenaro's success.

Table 2. Applying Ostrom's design principles to the three river committees.

Design principles	Seliani RC	Ngarenaro RC	Lower Themi RC
1. Clearly defined boundaries (of resources and users)	*Resources:* All administrative wards crossed by the river involved. *Users:* Initially, all users were involved but two large downstream users were removed by the upstream users, citing increased water demands upstream.	*Resources:* Not all wards crossed by the river are involved. Boundary remains flexible, and is often enlarged when water gets scarce. *Users:* Not all furrows are members. Downstream furrows within Arusha and the most upstream village (Shiboro) do not participate.	*Resources:* Upstream and midstream section not involved in the downstream RC. *Users:* Only users from the lower section of the river are involved in the RC. Upstreamers have developed their own arrangements.
2. Congruence between appropriation and provision rules and local conditions	Water allocation is by turn-taking but individual farmers guard their water turns.	Uses a robust proportional system to allocate water – clearly marked stick used and violators fined.	Allocation is by turn-taking but water guards paid by downstreamers monitor allocation. Police often involved in settling conflicts.
3. Collective choice arrangements	Large estates excluded by upstream farmers. Rules not always enforced. Frequent theft. Upstream reluctant to participates in modifying rules.	Not all affected are involved, but existing groups strictly follow the rules-in-use. Cheating is punished with a fine. First time offenders often pardoned.	Frequent rule violation occurs upstream, conflicts emerge and police frequently involved.
4. Monitoring	RC is responsible for monitoring but ineffective. Initially, the downstream estate employed a guard. Farmers do self-monitoring by going upstream.	Chairman of the RC and his team are responsible. But all furrow members monitor water use, who report flow reduction to the chairman.	Water guards are employed to monitor water use along the river. The guards are also farmers, mainly from downstream, and paid by other users.
5. Graduated sanctions	Defined but proved difficult to implement. Violation of schedule would face a fine.	Clear sanctions in place and being followed. Minor violator warned or fined a goat, major ones fined a bull.	Clear sanctions defined but not in use; instead government police is drawn in.
6. Conflict-resolution mechanisms	RC is responsible for conflict management but is sometimes ineffective; local politicians also involved.	RC is responsible for conflict management. If unsuccessful, other forms of traditional conflict-resolution methods are used. If this also fails, the case is taken to local government offices but this rarely occurs.	RC is responsible for conflict management. Clear procedures are defined but not strictly followed. Some users go directly to government courts, others resort to violent conflict, and still others use their resources to pay water guards and/or local police and access water outside their turns.
7. Minimal recognition of rights to organise	The RC's right to organise is strongly affected by local politics. Ward councillors and executive officers interfere with RC operations. RC is not formally recognised by the basin water board.	Traditional leaders play a strong role in RC operation. Local politics not an issue. RC is not formally recognised by the basin water board but some of the leaders are government employees.	The RC right to organise is strongly affected by local politics. Ward councillors and executive officers interfere with the RC operations. RC is not formally recognised by the basin water board.
8. Nested enterprise (hierarchical or interrelated organisation levels)	Nesting is not uniform. RCs comprise elected furrow representatives. Allocation systems vary between furrows. Higher local-administrative levels are involved in an ad hoc fashion during conflict.	Not all furrows involved. Mixed within traditional structures. Leaders are furrow representatives. Not linked to higher water-management levels. Local administration involved in an ad hoc fashion.	Leaders are furrow representatives. Not linked directly to any administrative or higher water management level. RC only responsible at the river level and not involved in individual furrow management.

The third principle (collective choice arrangements) is not strictly adhered to, as not all the river users are members of the RCs, and those who are currently members, particularly upstream, may still object to rule changes by absconding from meetings (as illustrated by the case of Seliani where upstream users refused to ratify a new constitution).

Monitoring (principle four) within these systems is an important activity in all RCs but not systematically organised. Farmers do self-monitoring but in some cases guards are hired and paid exclusively by downstream users. This is illustrated by the cases of Seliani and Lower Themi where farmers have to invest extra resources such as money, time in guarding water or even force (e.g. destruction of upstream furrow gates by downstream livestock keepers) to secure allocation.

Although mechanisms for graduated sanctions (principle five) are in place, frequent violations occur even in the most stable RC (in this case Ngarenaro). Other factors such as the presence of markets seem more important than trusted relationships – for instance, the demand for agricultural produce (e.g. vegetables) in Arusha municipality promotes a different kind of water rationality (cf. Alam, 1998), in that upstream users now value water more as a commodity than as a common good, loosening underlying principles such as good neighbourliness.

We found that with respect to conflict resolution mechanisms (principle six) only one of the three RCs largely succeeds in managing conflicts itself. The conflict management capability of the other RCs is limited and conflict management is often quite a messy process, whereby sometimes individuals take cases directly to the police or the courts, and in which local politicians frequently interfere.

On the need for minimum recognition of the users' right to organise (principle seven), it may be concluded that such recognition occurs differently at the different administrative levels of government (village, ward, division, district, region and state), that the RCs as such have not been formally recognised administratively, but that the National Water Act of 2002 does recognise the water users' right to organise themselves at the river level.

Nesting (principle eight), finally, is poor as not all catchment users are considered and there is no formal link with both the larger basin organisation and the national policy level. Since only some of the users are involved, an RC can best be described as a structure for bridging relations between competing wards rather than as a nesting structure of all water users of a particular river.

The foregoing discussion can explain the performance of the most successful RC (Ngarenaro) by referring to five of Ostrom's eight design principles: (1) congruence between appropriation and provision rules and local conditions; (2) monitoring; (3) graduated sanctions; (4) conflict resolution mechanisms; and (5) minimal recognition of rights to organise. Apparently, not all eight design principles are required for a water institution to be effective. However, it remains unclear why even the two less-successful RCs, which lack clear collective choice arrangements, and effective mechanisms for sanctions and conflict resolution, have endured over time and have not collapsed.

The difference in the performance of the three RCs cannot be explained by Ostrom's eight design principles alone. We also need to consider factors related to heterogeneity as reported in the CPR literature. Table 3 profiles the three cases against factors of heterogeneity and group size. The following points related to the impacts of heterogeneity and group size on collective action can be drawn from the cases.

Table 3. Comparison of the cases in terms of heterogeneity and group size.

Factors	Seliani	Ngarenaro	Themi
Group size – number of users sharing a tributary	12 furrows	8 furrows	40 furrows in total, one urban water supply intake and about 17 furrows in the lower Themi river
Heterogeneity of wealth – differences between the users in terms of size of water use (commercial vs. subsistence)	Mostly small-scale subsistence farmers. Two large coffee estates	Mostly small-scale subsistence farmers. One estate that is beginning to fail	Majority are small-scale subsistence farmers; Arusha water supply, two sisal estates but one is out of production
Heterogeneity of type of water use (irrigation, livestock, domestic)	Irrigation, domestic, livestock	Irrigation, domestic, livestock	Irrigation, livestock, domestic, urban water supply
Membership of communities, administrative units and different ethnic groups	Maasai, Waarusha, Chagga	Mainly Waarusha	Mixed communities, formerly migrant workers to sisal estates
The spatial distance between the users (most upstream and downstream)	8 km	8.3 km (14 km between the most extreme users of the Ngarenaro river)	15 km (45 km with most extreme user of the Themi river)
The institutional distance between the users	Three wards, all within one district	Three wards, all within one district	Three wards from three districts

We find that location (hydraulic) asymmetry, and not economic heterogeneity (wealth), impacts negatively on the ability of river users to maintain well-functioning collective action institutions. All the upstream users in the three cases interviewed believe that their advantageous location is synonymous with ownership of the water and a licence to use more. It is even more complicated to enforce local water allocation rules with increasing external markets that foster individualism among actors thereby lessening mutual dependencies, loosening traditional social ties, and reducing the interlinkages for possible reprisals in the case of adverse behaviour (Araral Jr., 2009). In Seliani river, upstream ownership claims have become much stronger with the availability of attractive and reliable markets for agricultural produce, and upstream users say they know the monetary value of water. It can be concluded that a rich user located downstream is less likely to influence collective action when the majority of the users are located upstream, even if they are comparatively poor (Seliani RC is a good example): here the downstream Burka coffee estate, despite its wealth of resources, has not been able to skew water allocation to its advantage. The estate constructed lockable furrow gates upstream and employs more than 400 farm workers from upstream villages but this did not pave the way for cooperation from the less-wealthy small-scale farmers upstream. Instead, estates were seen as foreign and different. In Lower Themi the downstream sisal estate often provides fuel to government police and bribes committee leaders to get more water. In addition, the heterogeneity of the users (e.g. in terms of ethnicity) seems to play a critical role in the instability of water-sharing arrangements. Seliani users cite the coalition of upstream Maasai/Waarusha users as the cause of the RC's weakness, while the Ngarenaro committee is said to be effective because of its relatively homogeneous Waarusha user community.

In line with the above, we conclude that an RC crossing several villages is less likely to rely only on social sanctions and norms to enforce cooperative behaviour than that used by a single village. This is illustrated by the Lower Themi committee with users from three wards, each from another district, which relies more on the government courts than on local conflict-resolution mechanisms to solve

water conflicts. Bardhan and Dayton-Johnson (2002) reported similar findings for irrigation organisations in Nepal, southern India and central Mexico.

Finally, although the RCs are active in the same sub-catchment, they operate independently of one another, and more surprisingly, they do not presently communicate with one another. Hence, there is no awareness of how the other committees operate, foreclosing possibilities for mutual learning. It may be hypothesised that the larger the spatial extent between upstream and downstream users, the more difficult it is for such institutional arrangements to emerge from bottom-up. The RCs work more closely with the village and ward offices and are not formally linked to the official basin administrative structures. It is only recently that the Pangani Basin Water Office has tried to establish nested water management structures (e.g. water user associations created under sub-catchment fora/committees) but again, the new structures do not explicitly aim to build on or start from the RCs; they often duplicate the roles and functions of these locally developed arrangements.

CONCLUSIONS

This paper set out to describe and analyse the emergence and functioning of RCs in a sub-catchment of the Pangani river basin. In particular, it discussed when and why they emerged, how they evolved over time and their interface with government structures. RCs in the Themi sub-catchment emerged in response to competition and conflicts over limited water induced by, among others, increased frequency of low flows, natural population growth, markets for agricultural produce, and government policies. It is notable that the idea to create an overall and self-governing body responsible for water allocation along a particular watercourse was partly the work of parties who were not direct resource users (e.g. the District Commissioner, and Regional Commissioner) but who directly had interests in the peaceful coexistence of the user community. This notwithstanding, the RCs were created on the principle of already existing arrangements and thus benefited from the legitimacy of past arrangements (cf. Cleaver, 2002). Currently, the committees operate in a pragmatic manner, depending on situation-specific climatic and hydrological conditions. They are active during dry seasons and in times of extreme water shortages, but in the event of (unexpected) rainfall even planned meetings may be abandoned.

Ostrom's eight design principles provided useful entry points in studying the functioning of the RCs. The best performing RC in the Themi sub-catchment largely complied with five of the eight design principles (Ostrom, 2002), which indicates that not all these principles are necessary for a water institution to be effective and to endure over time. The other two RCs, which performed less effectively, only adhered to three of the eight principles. All three RCs, however, leave the resource boundary open to negotiation. Boundaries are fluid and change over time and are thus not clearly defined. By not entirely closing the resource boundary, the users lower the transaction cost of controlling the boundaries and also allow future demands to be met in the face of increasing resource variability. In addition, the success of the boundary definition is dependent on the capacity of the committee to motivate upstream users (Seliani and Lower Themi cases illustrated how upstream users frequently violated the rules and constructed more furrows or used water outside their turns). All three RCs also do not fully comply with the principle that all affected must take part in rule creation and modification. Moreover, not all the water users are currently members of the three RCs. Also, members may consciously abscond from meetings to avoid ratifying binding agreements. Monitoring is at best ad hoc as downstream farmers have to invest extra resources to secure allocation. In all three cases, finally, the 'nesting' of lower-level institutional arrangements within higher-level ones was inconsistent, but this did not necessarily hamper their functioning.

We could not explain the difference in the performance of the three RCs by referring to Ostrom's eight design principles alone. We also needed to consider factors related to heterogeneity, which were shown to be putting the RCs' operations under increasing stress. The functioning of RCs is strongly influenced by: (1) the number of users sharing a tributary; (2) differences between the users in terms of type of water use (irrigation, livestock, domestic) and size of water use (commercial vs. subsistence); (3)

sociocultural differences between the users, e.g. different ethnic groups; (4) location (hydraulic) advantage and spatial distance between the users; (5) the crossing of administrative boundaries; and (6) the presence of markets for (high-value) agricultural products.

The entrepreneurial farming opportunities in Arusha municipality promote a new kind of water rationality. Whereas in former times water users seem to have defined their self-interest in terms of broader social, spatio-temporal interdependencies (Van der Zaag, 2007, after Alam, 1998), this is now changing. Upstream users now view water as a source of private wealth, rather than a resource that requires collective action to generate a stream of benefits.

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