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The Case of Mount Kenya and the Semiarid Upper Ewaso Ng'iro Basin

Mountains play a crucial role in the supply of freshwater to humankind, in highland and lowland areas alike. Increasing demand urgently requires careful management of mountain water resources in order to mitigate growing water crises and conflicts. Monitored river flow was analyzed for 3 selected catchments (Timau, Burguret, and Likii) on the slopes of Mount Kenya from 1960 to 2004. In the 10 years from 1995 to 2004, the extreme low flow (Q95) of the rivers was found to have been reduced to 10%, 23%, and 71%, respectively, of the values for the decade from 1961 to 1970. Water awareness creation campaigns in 1997 and 2004 revealed that the number of abstraction points had more than doubled, and that there was a two- to eightfold increase in the amount of river water abstracted.

The present article documents increasing water abstraction and the difficulties in establishing limits for low flows such as the Q80 value (flow available on 80% of the days per year). The article also presents the role of Water Users' Associations (WUAs) in mitigating water conflicts related to over-abstraction. Evaluation of the activities of 13 WUAs showed that they solved 45 of 52 conflicts. WUAs are also involved in activities such as environmental education, awareness creation, improved irrigation practices, afforestation, and regulating water. The recent restructuring of the government ministry resulted in a formalized role for WUAs. Long-term data on availability, abstraction, and use of water are needed to mitigate water conflicts within and between WUAs, negotiate water allocation, and establish allocation thresholds.

Keywords: *Water abstraction; monitoring; allocation thresholds; water users' associations; conflict mitigation; sustainable regional development; highland–lowland system; Kenya.*

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Introduction

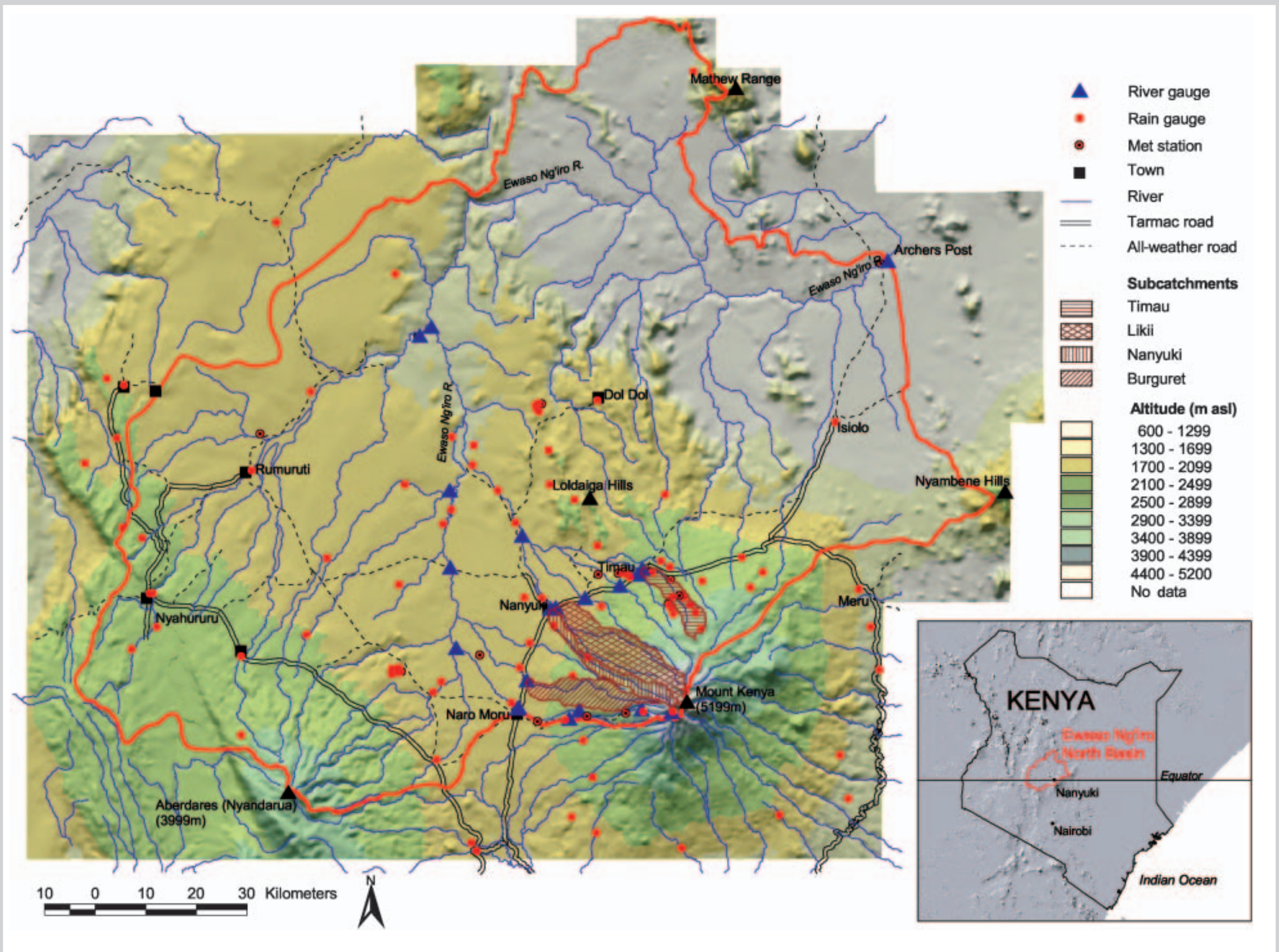
Mountains play a crucial role in the supply of freshwater to humankind, both in the mountains and the lowlands. More than half of humanity relies on the freshwater that accumulates in mountains—for drinking, domestic use, livestock, irrigation, hydropower, industry, and transportation. Mountain areas constitute a relatively small proportion of river basins, yet they provide the greater part of river flow downstream. Case studies illustrate that mountains in humid areas provide 30–60% of downstream freshwater, while this figure rises to 70–95% in semiarid to arid environments (Liniger et al 1998b; Liniger and Weingartner 2000; Viviroli et al 2003). As the demand on water resources increases, the potential for conflict over the use of mountain water grows. Careful management and negotiation of mountain water resources must therefore become a priority in order to mitigate growing water crises and conflicts at the local, national, and international levels.

Mount Kenya and the adjacent Upper Ewaso Ng'iro Basin form a highland–lowland system in which improved management of mountain water resources and mitigation of water-related conflicts deserve the highest priority. The characteristics of this highland–lowland system and its dynamics and complexity are comparable to and illustrative of many regions in Eastern and Southern Africa (Liniger 1995; Ojany and Wiesmann 1998) and other parts of the world.

Mount Kenya forms a resource-rich island in a savanna-dominated environment, especially to the north and west of this volcanic massif (Liniger et al 1998a). The lowlands—consisting of the semiarid Laikipia Plateau and the dry Samburu Plains—are highly dependent on the water that comes from the mountain and its various ecological zones, in particular the forest belt (Decurtins 1992; Gichuki et al 1998a). Land use in the footzone and the semiarid plateau is very dynamic. It changed from pastoralist use at the beginning of the 20th century to large-scale farming and ranching (so-called White Highlands) during colonial times (Kohler 1987). After Independence in 1963, agropastoral communities immigrated into the region, causing population to increase by a factor of 10 over the next 40 years (Wiesmann 1998). At the same time small and medium urban centers grew in importance (Leiser 1994), and in recent years large-scale horticulture enterprises have been established in the footzone (Schuler 2004). These socioeconomic and land use dynamics (Kiteme et al 1998a), coupled with inadequate policies, planning, and management (Kiteme et al 1998b; Wiesmann and Kiteme 1998), led to a broad range of problems related to natural resource use (Liniger et al 1998a), the most important being over-exploitation of river water resources (Gichuki et al 1998a). Downstream populations, livelihoods, economies, and ecological systems have been heavily affected, leading to a broad range of increasing conflicts (Wiesmann et al 2000).

Against this well-documented background, the present paper aims to show the efforts made in the region to assess scarce water resources and manage them sustainably. It examines the importance of long-term moni-

FIGURE 1 Monitoring network in the Ewaso Ng'iro Basin northwest of Mt Kenya, and overview of the study area. (Source: NRMT 2004; map by Gudrun Schwilch)



toring of the availability and use of river water resources, and the use of this information for the development of a decision support tool for water management. In particular, it elaborates on the assessment of low flows in order to establish thresholds for water use, and on the role of water users and related institutions in resolving conflicts at different sub-basin levels.

Methodology

This study builds on long-term integrated and collaborative research efforts in the region which date back to the mid 1970s and deal with environmental, land use, and socioeconomic dynamics, with a focus on more sustainable development in this highland–lowland system (Ojany and Wiesmann 1998). At the core of these efforts stands a natural resource monitoring network (Gichuki et al 1998b) that covers the whole Upper Ewaso Ng'iro Basin to Archers Post (Figure 1) and has provided river and rainfall data for the 3 selected catchments presented in the first part of this paper (Burguret, Likii, and Timau; Figures 1 and 2). The data are based on recordings from meteorological stations daily-measured rainfall stations, and river gauge stations that have been collected daily since 1960, and with chart recorders since the early 1980s. In the 3 catchments from the upper part of Mt Kenya selected to present the change of water availability and use since 1960, monitoring of river flow was carried out using OTT R16 water level recorders, from which daily discharge values were calculated using discharge rating curves (Decurtins 1992; NRMT 2004). All data are stored in a database; the analysis was done using standard hydrological statistical methods (NRMT 2004).

Whereas the monitoring network provides information on changes in the water balance, water abstraction assessment campaigns in selected catchments were used to establish detailed information about river water use (Aeschbacher et al 2005, in this issue). These campaigns were carried out in 1997 and in 2002/2004, with the aim of inventorying water abstraction points, water infrastructure and equipment, management, and types

FIGURE 2 The upper Timau catchment north of Mt Kenya, with the forest belt where river water is generated, and the large-scale and small-scale farming area where water is abstracted and used. (Photo by HP Liniger; end of dry season, 27 March 1997)

of water use, and assessing the amount of water abstracted at each abstraction point. The campaigns were carried out by teams of researchers and staff of the Ministry of Water, in partnership with the local Water Users' Associations (WUAs), with a view to building their capacity in water management. All along the river from the up- to the downstream areas, each abstraction point and its particulars were systematically inventoried and subsequently entered into the NRMT database. For the present study the full inventory of three rivers—Likii, Burguret, and Nanyuki—was evaluated, covering 92 abstraction points in 1997 and 224 abstraction points in 2002/2004 (Figure 1).

With a view to establishing the grassroots-based potential for improved management of scarce water resources and endogenous conflict resolution, all 13 existing WUAs in the Upper Ewaso Ng'iro Basin were studied during a field investigation in 2003. This investigation was part of a larger study carried out with 227 respondents (a structured random sample of population in all the sub-catchments of the Upper Ewaso Ng'iro Basin). It looked at water management information needs and development priorities in the basin, and at the role, effectiveness and sustainability of local institutions in promoting conflict resolution and more sustainable development. Structured questionnaires and open interviews were used to gather information on the history, composition, functions, activities, opinions, and roles of the 13 existing WUAs, and the nature of the conflicts they addressed. The investigation also covered the WUAs in the 4 catchments—Timau, Likii, Nanyuki, Burguret—that are at the core of this study (Figure 1).

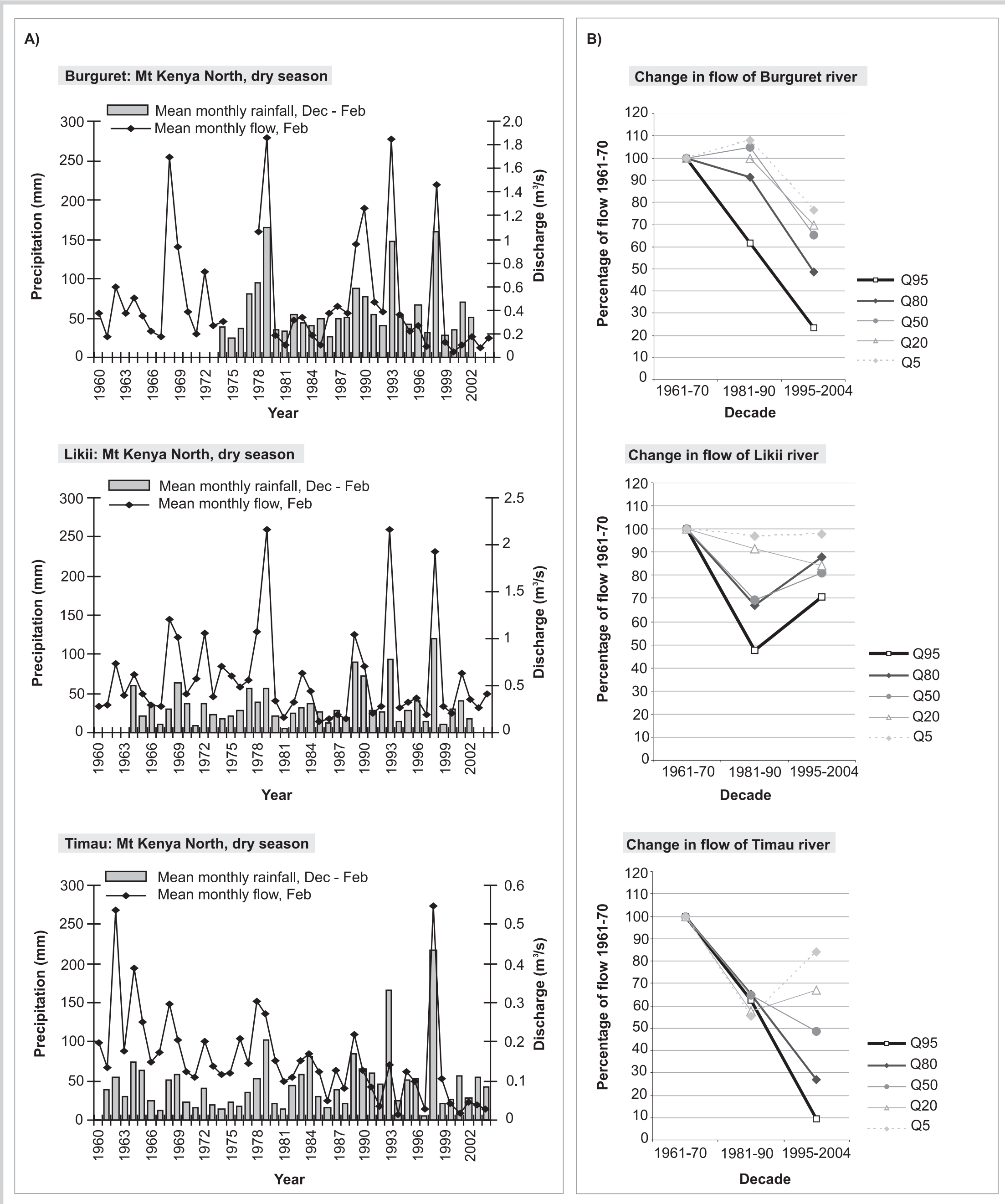
Long-term trends in river water resources

Figures 3a and 3b present the results of river monitoring since 1960 in the selected Burguret, Likii and Timau catchments of Mt Kenya. Figure 3a shows that rainfall from 1960 to 2002 for a 3-month period—from the end of the short rains in December to the driest month of February—varied considerably in all 3 catchment areas. From 1989 to 1998, December to February rainfall seems to have been above average, although no trends can be observed. This corresponds to the results of a detailed rainfall analysis (Gichuki et al 1998a; Sturm 2002) that showed periods of above- and below-average rainfall without long-term trends.

Contrary to rainfall, the Timau River shows clearly decreasing flow over the entire period from 1961 to 2002, which indicates that the change in river flow cannot primarily be attributed to a change in rainfall. The Burguret shows severe low values from 1980 to 1985, then a period of increased flows till 1994, followed by a heavy decline, especially for the very low flows. The Likii had very low flows during and after the severe dry years from 1980 to 1988. Several peaks in the February flows during high rainfall seasons can be observed. The last extreme event was recorded during the El Niño year (end of 1997 to early 1998). However, all 3 rivers show decreasing minimum flows over the study period from 1960 to 2002, except for the The Likii River, where the flows in 1981 and from 1985 to 1988 were the lowest.

Figure 3b depicts the change in river flow for extreme low flows (Q95), low flows (Q80) reached on 80% of the days, the median flow (Q50), high flows (Q20), and flood flows (Q5). It illustrates that the

FIGURES 3A AND 3B Low flow during the month of February and rainfall from 1960 to 2002 (A), and change in low flows Q95 and Q80, median flow Q50 and high flow Q20, and flood flow Q5 for 3 decades (1961–1970, 1981–1990 and 1995–2004), for Burguret (west of Mt Kenya), Likii (northwest) and Timau (north). (Source: NRMT 2004)



worst decline compared with the period 1961–1970 was in extreme low flows. The Q95 flow available in the last 10 years from 1995 to 2004 was reduced to 10%, 23%, and 71% of the values in 1961–1970 for the Timau, Burguret, and Likii rivers, respectively. For the Likii River, Q80 and Q95 first had a strong decrease from the 1960s to the 1980s, and then a slight increase in the most recent decade. The reasons could not be established. One possible explanation is that rating curves for the low flows in the natural riverbed of the Likii River were not updated regularly, and that considerable measuring errors can occur during low flows. There were far fewer changes in flood flows than in low flows. Flood flows in the last decade were still 87%, 76%, and 98%, respectively, of the flows recorded from 1961 to 1970. Whereas river water decline is dramatic during the low flows, the potential to use floodwater is still high.

TABLE 1 Number of abstraction points according to type of system, and total dry season water abstraction amounts for selected rivers in the study area. (Source: NRMT 2004)

Type of system	Likii		Burguret		Nanyuki	
	1997	2002/4	1997	2002/4	1997	2002/4
Fixed pump	1	4		5	10	22
Furrow	2	1	5	2	2	6
Furrow to pipe		1				
Gravity pipe	3	11	2	4	5	12
Hydram		2		2		
Portable pump	9	19	36	100	17	33
Total number of abstraction points	**15**	**38**	**43**	**113**	**34**	**73**
Total abstraction amount in l/s	43	343	113	240	123	197

River water abstractions: the main cause of low flows

Table 1 shows river water abstractions (withdrawals) for 1997 and 2002/04. The number of portable pump abstraction systems is high and has been increasing extremely fast. Operation of portable pumps varies greatly in time and space, making an accurate assessment of water resource use difficult. However, these pumps account for only 2–22% of the total abstractions for the different rivers. Piped gravity conveyance systems, predominantly in community water supply projects, account for 30–70% of total dry season water abstractions. Furrows are the biggest water abstractors. Their number has decreased along the Burguret River but increased on the Nanyuki. Total river water abstraction has increased dramatically in the past 7 years. The number of abstractors (abstraction points) for the 3 rivers presented above has more than doubled in all cases. The amount of water used also shows a two- to eightfold increase in 7 years (Aeschbacher 2003).

The vicious cycle of Q80 abstraction permits

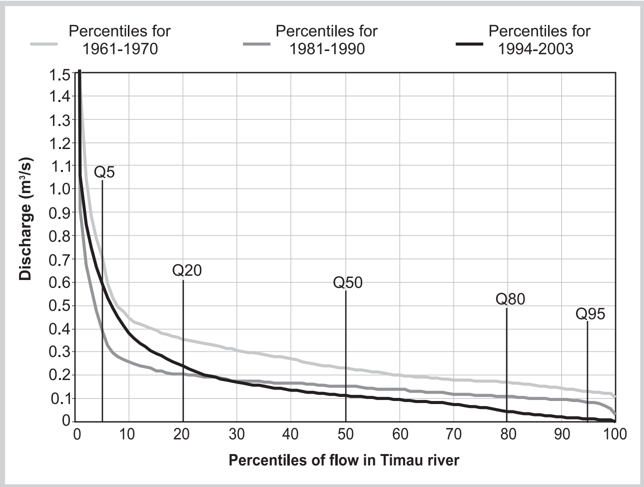
The fast-growing river water abstractions partly explain the extreme reductions in the low flows, Q80 and Q95, shown in Figures 3a and 3b. As most water use is for irrigation, the highest abstraction rates occur during the dry season, when river flows are low. Thus Q80 was reduced from the 1960s to the period from 1995 to 2004 to about half for the Burguret and a quarter for the Timau River. Q95 flow has even declined to a quarter and less than a tenth for the two rivers. Further investigations are needed to explain the increase of Likii River flow in the last decade, as compared to the 1980s.

Water abstractions have also reduced flood flows since the 1960s, however to a much lesser extent than during low flows. The reasons are lower water demand during flood flows and little to no water storage in dams. The Timau River showed an increase in flood flow in the last decade, from 1995 to 2004 (Figure 3b), after a heavy decline from the 1960s to the 1980s. This could be explained by land use change in the upper catchment, where the entire forest belt at 2800–3000 m has been converted to cropland. After this change several floods occurred where floods had not been recorded before. The impact of ground cover and land use change on river flow has been investigated using test plots, catchment studies and modeling (Liniger and Thomas 1998; Notter 2003; MacMillan and Liniger 2005) and might require more detailed analysis of the rainfall–land use–river flow relationship.

In order to assess how much water is available in the rivers and determine the amount that can be allocated without threatening the minimal residual discharge necessary for downstream users and for ecological functions (eg in the National Parks and Game Reserves in the Archers Post area, which are of national and international importance), there is a need to set criteria for thresholds of water abstraction. One criterion often used by water authorities is that the Q80 value should be guaranteed. This means that water should only be abstracted when the flow exceeds the discharge reached on 80% of the days in a year.

As illustrated in Figure 3b, assessing Q80 (or any other threshold value) is rather problematic. In the case of the Burguret, Q80 for the period 1961–1970 was 329 l/s, whereas it was about half (159 l/s) for the past 10 years. The Q80 value for the period 1961–1970 was only reached in about half of the days from 1995 to 2004. For the Timau River, the assessment of Q80 for 1995–2004 gives a threshold value of 45 l/s that should

FIGURE 4 Flow duration curve for the Timau river for different decades: 1961–1970, 1981–1990 and 1995–2004. Percentile curves indicate on how many days a value is reached or exceeded (eg for Q80, on 80% of all days per year). (Source: NRMT 2004)



remain in the river. However, as illustrated in Figure 4, for the monitoring period from 1961 to 1970, Q80 would have given a threshold value of 169 l/s, ie almost 4 times more. From 1995 to 2004, this amount was reached during less than 30% of the year.

If the threshold for water abstractions had been fixed for the period 1961–1970 when only little water was abstracted, water abstraction would be permitted only during 30% of the year. In other words, if Q80 is calculated including more and more abstractions, the threshold value becomes smaller and smaller. This means continuous reduction of guaranteed river flows and an increase in "justifiable" water allocations for abstraction—a vicious cycle.

In order to establish the threshold for river water use, long-term data are needed to assess climatic variability and the flow regime of the rivers. In the Mt Kenya region, where rainfall is very erratic and highly variable, there is an even greater need for a sufficient time span and for quality data. Additionally, if a statistical value like Q80 is used as a threshold for allocation of water, amounts of water abstracted from the rivers above the measuring and monitoring sites should be taken into account, and the water abstracted should be added to the measured river flows in order to make a statistical analysis. This process is referred to as "naturalizing river flow." This naturalizing allows a more appropriate and valid Q80 assessment, even when the data are only available for a limited time span.

These reflections show the need for a water accounting system with real-time information about total water use and availability, and for a decision support tool to set limits for water abstractions. Due to rapid land use change and increasing water abstraction, these data need to be updated regularly in order to reflect the current situation and recent trends. They are needed to determine river flow conditions—the indispensable basis for informed water management and determining water abstraction limits, and for WUA negotiation processes. This has become even more urgent with the recent development of irrigated export-oriented horticulture since 1993 (Schuler 2004). The growing pressure on water resources has increased the need to clarify the situation regarding availability, the amount of water use, and allocation and procedures for guaranteeing low flows for downstream users.

Emerging Water Users' Associations (WUAs)

In addition to knowledge-based control, management and conflict resolution based on institutions and organizations rooted in the concerned communities and involving all major stakeholders, are important components in a strategy for more sustainable water use and management in the region.

Such grassroots-based organizations have emerged in the form of WUAs formed at the sub-basin level, covering catchments of tributaries of the Ewaso Ng'iro. WUAs are a relatively new strategy for water resource management in Kenya (Kiteme and Gikonyo 2002). They were established as a follow-up to recommendations developed during an intensive water awareness creation campaign (conducted by CETRAD, NRMT, and 6 government ministries) among all the water-related stakeholders in the Upper Ewaso Ng'iro Basin in the first half of the 1990s (Kiteme and Gikonyo 2002).

The first WUA was founded shortly after the concluding event in a water awareness creation campaign in early 1997, and was based on a former self-help group. Subsequently, WUAs were established in the Ewaso Ng'iro Basin in most of the Mt Kenya catchments, but only one was established in the Aberdare Mountains (Figure 1). Table 2 reflects this stronger influence of the awareness creation campaign on the Mt Kenya side, and the role of horticultural firms with large-scale irrigation, which were instrumental in initiating many of the associations (6 of 13 WUAs were co-founded by horticultural firms, and these firms are involved in 2 others). The heavy involvement of large firms was in most cases motivated by the need to maintain access to water resources without facing conflicts with neighboring smallholder communities. By the end of 2003, 13 WUAs had been established, 9 of them (69%) within the last 2 years (Table 2). The reasons given for their formation were:

a) Persistent water shortage and attendant conflicts during the dry spell (9 of the 13 WUAs; 69%);
b) Water pollution and catchment degradation (31%); and

c) Creation of a platform for local resource mobilization to support community water projects (15%).

However, until very recently, WUAs had not been formalized in legislation or in water policy in Kenya. This explains why only 2 associations were founded as a result of changed legislation, whereas all the others were formed on a purely voluntary basis.

Conflict resolution through Water Users' Associations

A wide range of conflicts occur in catchments covered by the WUAs. Most common are conflicts that involve aspects of water shortage and increased competition among users (such conflicts are reported in 12 out of 13 associations), resulting in manipulation or destruction of river courses, water intakes, furrows, and pipes. Illegal and/or over-abstraction of river water is the second major cause of conflict (occurring in 7 WUAs), as individual users compete to meet needs and expectations. Table 2 illustrates that WUAs have developed great skills and efficiency in addressing these water-related conflicts. Nine of the 13 WUAs had dealt with more than 52 different cases of conflict by the end of 2003, mainly through arbitration and negotiations between the conflicting users (conflicts taken to the WUA for arbitration). 87% (45 cases) were successfully addressed, with the remaining 13% (7 cases) waiting for further attention from either the Executive Committees of the WUAs or a court of law.

However, the interviews revealed that WUAs did not limit their operations to solving water conflicts. They have also emerged as important grassroots institutions with a broad range of additional activities. 54% of WUAs engage in activities such as environmental education and awareness creation; 46% in water conservation through better irrigation practices such as drip irrigation, rainwater harvesting, and improved river water storage; and 23% in catchment protection through afforestation. The WUAs themselves consider these interventions to be remarkable contributions to:

- Reducing water use conflicts and wasteful water utilization (in 62% of the WUAs);
- Enhancing catchment protection (38%);
- Regulating river flow to ensure availability of water to all, especially during the dry spells (23%); and
- Raising general awareness about the water resource situation in their respective catchment areas (23%).

WUAs see their potential limited by constraining factors such as lack of finances (83%), technical skills and means (31%), logistical support (31%), and limited managerial and leadership capacities (31%).

The changing policy and legislative environment

The national government recently introduced new institutional arrangements for water resource management. These include a government policy shift from delivering water infrastructure to the communities, to an emphasis on regulatory and enabling functions—ie improving overall conditions and ensuring availability of the means to develop and implement legislation. The government thus clearly promotes integrated approaches and supports the private sector as well as community participation in the management of water resources in the country (GoK 1999).

Based on the substantial restructuring of the ministries' functions and institutions (GoK 2002a, 2002b, 2002c), WUAs have been formally recognized since 2004 as institutions dealing with water resource management at the grassroots level. Although this recognition does not confer any explicit legal power to the WUAs, it nevertheless gives them motivation to operate and, more importantly, obligates and encourages their formation. Legitimacy and guaranteed facilitation by the government will officially establish the WUAs' activities and consolidate the results elaborated in the preceding discussions, in the interest of promoting long-term sustainability. It can therefore be assumed that their role in awareness creation and conflict resolution will be enhanced beyond the promising initial experiences in the Mt Kenya region.

Conclusion

As river water abstractions continue to increase, water resources are becoming scarcer and conflicts over water resources are growing. In a dry environment with erratic and poorly distributed rainfall, there is need for proper monitoring of water availability and accounting of water use as a basis for more equitable sharing of water. However, defining criteria for water allocation and thresholds still poses a challenge to research and to water users. Long-term monitoring has revealed the great importance of sound, long-term data and information as the basis for developing pathways to more sustainable water management in the region. These pathways require adequate institutions for monitoring and transfer of information, especially as a basis for conflict resolution at the level of actual water users. WUAs can provide such an institutional basis. They have shown positive overall results in the Mt Kenya region, not only in relation to resolving water use conflicts but also in promoting a broad range of community- and catchment-related functions. It must also be noted, however, that the composition of many WUAs includes a significant power imbalance

TABLE 2 Nature and location of water users' associations (WUAs) in the Upper Ewaso Ng'iro Basin, and number and type of conflicts addressed. (Source: field data 2003)

Name of WUA	Year founded	Horticultural firms[a)]	Role and support of horticultural firms	
1. Ngusishi River	1998	8	Co-founder; financial; logistics and technical	
2. Mt Kenya East (Timau)	2002	4	Moral support	
3. Mia Moja Water Association	1990	0	–	
4. Ontulili River	2003	3	Co-founder; financial; logistics and technical	
5. Likii River	2002	2	Co-founder; financial; logistics and technical	
6. Nanyuki River	2001	0	–	
7. Rongai River	2003	0	–	
8. Burguret River	1999	2	Co-founder; logistics and technical	
9. Naro Moru River	2003	2	Moral support	
10. Ngare Nything/Sirgon	1997	3	Co-founder; financial; logistics and technical	
11. Ngare Ndare	2001	4	Co-founder; financial; logistics and technical	
12. Isiolo River	2003	0	–	
13. Ewaso Narok	2003	0	–	

[a)] Number of horticultural firms that are members of the WUAs.

	Cases of conflicts handled by WUA: number and status; causes of conflict	Location within the Upper Ewaso Ng'iro Basin; major land use and water users
	20 cases, all solved Water shortage (water rationing program, timing of abstraction among different user groups, issuing water use guidelines), pollution; splinter groups; destruction of vegetation cover.	***Location:*** Upper reaches of the Upper Ewaso Ng'iro Basin, side of Mt Kenya, covering zones from alpine zone to footslopes of Mt Kenya ***Use:*** Large-scale horticultural irrigation; small-scale horticultural out-growers; agropastoralists, including major urban settlements in the catchment.
	4 cases, 3 solved Diversion of water by individual water users; destruction by other users.	
	5 cases, 4 solved Illegal abstraction; blocking of canals; gravity leveling; interference by non-members.	
	2 cases, all solved Over-abstraction leading to water shortage; destruction of water catchment.	
	None	
	Approximately 8, all cases solved Water shortage and scarcity problems during the dry spell in combination with over-abstraction.	
	None	
	5 cases, 4 solved Over-abstraction; blocking of furrows; pollution; destruction of abstraction; irrigation issues.	
	3 cases, all solved Downstream water shortage due to over-abstraction; members felling trees along the river; illegal car wash contaminating the river.	
	10 cases, 9 solved Members using different pipe sizes (leading to over-abstraction); water shortage.	***Location*:** Middle reaches of the Upper Ewaso Ng'iro Basin, side of Mt Kenya, covering footzones and semiarid savanna. ***Use:*** Large-scale commercial ranching and horticultural firms; smallholder agropastoralists and pastoralists.
	None	
	3 cases; all pending Wasteful water use (leading to over-abstraction); felling of indigenous trees.	***Location:*** Lower parts of the Upper Ewaso Ng'iro Basin, side of Mt Kenya: savanna ***Use:*** Recently settled smallholder agropastoralists; pastoralists and small-scale horticultural irrigation.
	None	***Location:*** Middle reaches covering savanna and swamps; only WUA on the side of Nyandarua Ranges! ***Use:*** Smallholder agropastoralists; pastoralists; medium-scale horticultural irrigation; large-scale commercial ranching. Specific focus on wetland management.

between large-scale horticultural firms and agropastoral smallholders. To some extent this can be seen as positive, as the large-scale firms are instrumental in developing WUAs. On the other hand, this imbalance could lead to dependencies and unbalanced negotiation processes that might jeopardize the sustainability of conflict resolution. At present it is not possible to determine whether the new legislation, with its formal recognition of WUAs, will attenuate or increase potential power conflicts within and among the various catchments in the highland–lowland system of Mt Kenya.

While WUAs have made a contribution to solving water disputes among the members of a WUA, there is still a need to address conflicts and problems that occur between different catchments, and between upstream and downstream parts of the basin and downstream users in cases where users are not yet organized in WUAs. Further research is needed to support WUAs in the monitoring and use of water resources, and in addressing allocation procedures and limits, as well as in mitigating water-related conflicts. This can only be done through integrated transdisciplinary approaches at multiple scales involving multiple stakeholders and actors.

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