6 Managing Water Resources in Dynamic Settings: A Multi-level, Multi-stakeholder Perspective

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Abstract

The aim of the present article is to contribute to the debate on the role of research in sustainable management of water and related resources, based on experiences in the Upper Ewaso Ng'iro and Pangani river basins in East Africa. Both basins are characterised by humid, resource-rich highlands and extensive semi-arid lowlands, by growing demand for water and related resources, and by numerous conflicting stakeholder interests. Issues of scale and level, on the one hand, and the normative dimension of sustainability, on the other hand, are identified as key challenges for research that seeks to produce relevant and applicable results for informed decision-making. A multi-level and multi-stakeholder perspective, defined on the basis of three minimal principles, is proposed here as an approach to research for informed decision-making. Key lessons learnt from applying these principles in the two river basins are presented and discussed in the light of current debate.

Keywords: Water management; scale; level; sustainability; decision-making; contextuality; generalisation; East Africa.

6.1 Introduction

Water poses serious challenges to resource management. Growing populations and increasing economic activity are resulting in greater demand for water-related ecosystem services such as the provision of drinking water, food and energy. At the same time, supply is becoming less predictable as a result of environmental degradation and climate change in many parts of the world. The great dynamics of the changes that affect water supply, coupled with the fact that negative outcomes can occur spatially and temporally removed from their causes, lead to highly unpredictable situations for individual stakeholders. Informed decision-making is therefore a prerequisite for sustainable resource management.

Research is expected to provide a basis for informed decision-making, but there is a growing concern that the results of research are not necessarily useful in making management decisions (FAO 2006; Hermans 2008). The causes cited to explain the lack of relevance and applicability of research results include an incomplete understanding of natural processes (Calder 2002; FAO 2006), issues of scale and resulting challenges (Kiersch 2000; Cash et al 2006), lack of incentives for efficient resource use (Aylward 2004; MA 2005), insufficient participation of and collaboration between scientists and stakeholders (Pahl-Wostl et al 2007), and institutional rigidity (Bohensky 2008).

The Upper Ewaso Ng'iro Basin in Kenya and the Pangani Basin in Tanzania exemplify the complex human–environment interactions that characterise watersheds. These basins have similar physical settings, with humid highlands surrounded by semi-arid lowlands (Figure 1). Favourable conditions in the footzones of the mountains have attracted in-migration and economic development. The resulting increase in water demand is a cause of water scarcity and a source of conflicts between different user groups (e.g. farmers versus pastoralists, or farmers versus hydropower producers) and also within user groups (upstream versus downstream farmers, large-scale versus small-scale farmers). The authorities lack both the information and the financial means to correctly allocate resources and implement rules (Wiesmann 1998; Wiesmann et al 2000; Mbonile 2002; IUCN 2003).

Research carried out by the Swiss National Centre of Competence in Research (NCCR) North-South programme in the two basins offers an opportunity to study the role of research in sustainable management of

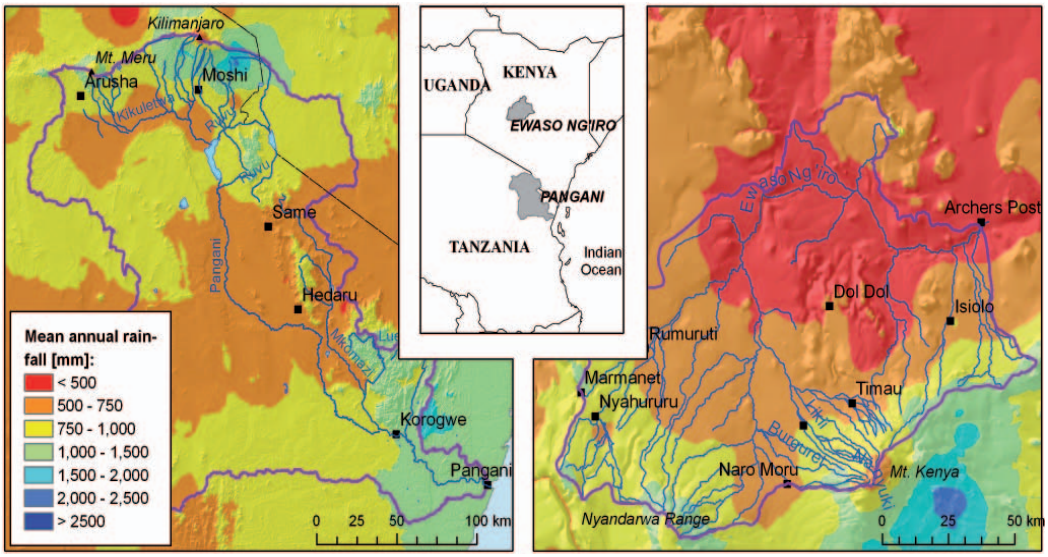

Fig. 1
Overview of the two river basins. (Map by B. Notter; data sources: B. Notter, CETRAD – Centre for Training and Research in Arid and Semi-Arid Lands Development)

water and related resources. Based on practical experience (Wiesmann 1998; Wiesmann et al 2000; Kiteme and Gikonyo 2002; Aeschbacher et al 2005; Ehrensperger 2006; Notter et al 2007) and a review of existing literature, the present article identifies two key challenges posed by: a) issues of scale and level, and b) the normative dimension of sustainability. A multi-level and multi-stakeholder perspective based on three minimum principles is proposed as a way of addressing these challenges, and experience from the application of these principles in research in the two river basins is presented and discussed.

6.2 Challenges for research in watershed management

Various constraints affect the relevance and applicability of research results in the two river basins. These can be attributed to two key challenges: 1) issues of scale and level that arise because different actors and processes are active at different levels and scales and interact across them; and 2) the normative dimension of sustainability, which is defined by differences in the values that actors attach to resources, processes, or institutions.

6.2.1 Issues of scale and level

In the following sections we use the definition of Gibson et al (2000) that differentiates between "scale" as the analytical dimension for assessing a certain phenomenon, and "level" as the respective unit of analysis. The spatial scale ranges from micro- to macro-levels, for example, or from the local to the international level; the temporal scale ranges from short- to long-term, e.g. daily, monthly, annual and inter-annual levels. The fact that processes, actors and perceptions differ between levels or scales and interact across different levels and scales can result in serious constraints on the applicability and relevance of research results.

An *inappropriate spatial and temporal extent or resolution* of assessments limits the applicability of outputs. Hydrological studies typically describe river catchments; national overviews present socio-economic information on countries or provinces; and numerous case studies contain detailed information about specific aspects of small areas. It is very difficult for non-scientist decision-makers to take decisions concerning their unit of responsibility (e.g. a district) based on such research results. Moreover, assessments are often carried out based on time series that are too short to capture long-term variability, resulting in biased resource allocation. Some studies are not explicit about the temporal and spatial timeframes considered, which limits their applicability and re-usability. Finally, the most serious challenges to watershed management, such as declining dry-season flows, resource conflicts or climate change, unfold at spatial and temporal scales covered by few scientific assessments and are thus insufficiently taken into account in decision-making processes (Figure 2).

Lack of awareness of issues of scale and level can be an obstacle to the implementation of research results. For example, most farmers in the footzones of the mountains are unaware of water scarcity at the basin level. Faced with inter-annual variability in rainfall, which they do perceive, they irrigate their fields with river water, thereby unknowingly contributing to problems further downstream.

Finally, *decision-making at inappropriate levels* can be an obstacle to sustainable management. At the temporal scale, decisions are too often taken with a perspective of 5–10 years, depending on the period of time considered appropriate for assessment of decision-makers' success – e.g. an election interval or a project phase. At the spatial scale, a large-scale paddy irrigation

scheme in the Pangani Basin can serve as an illustration for decision-making at an inappropriate level: The scheme was managed by the regional government, which commissioned a foreign consultant to do a study but did not consider the knowledge of district authorities or local stakeholders about ongoing irrigation projects undertaken by villages and clans in upstream areas and about existing downstream water demand. Nowadays, only half of the area covered by this scheme is productive, owing to increased irrigation upstream, while downstream areas have been left degraded by farmers engaging in illegal charcoal production in a nearby forest reserve due to lack of irrigation water for their fields.

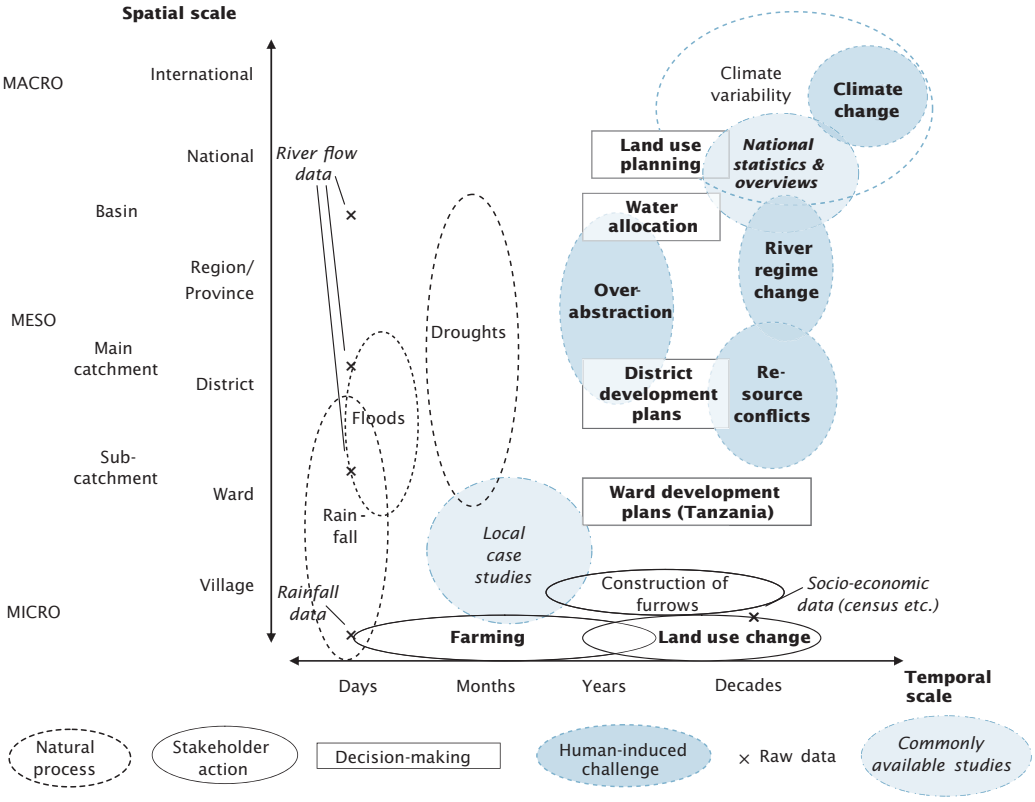

Fig. 2 Visualisation of scale and level challenges in the Upper Ewaso Ng'iro and Pangani river basins. Processes and challenges, as well as institutions and information necessary for decision-making, are found at different levels on the spatial and temporal scales. (Source: Adapted from an original figure by Clark [1987])

6.2.2 The normative dimension of sustainability

"Sustainable development" is a normative concept. Different actors attach different values to resources, processes and institutions. This represents a second key challenge to research for sustainable watershed management, since it implies that sustainable development is driven by values and norms that cannot be identified by scientific research alone but which must emerge from negotiations among relevant stakeholders in a concrete societal and political context (Wiesmann 1998).

Unclear research objectives are a major constraint on the relevance and applicability of research results. Sustainability-related problems are often complex and controversial. A potentially unlimited number of elements could be included in the "system" assessed by a study or research project. This situation, which has been referred to as the "systemic trap of sustainability" (Wiesmann and Messerli 2007), often means that research projects are initiated without a clear aim and with multiple interlinked objectives that are difficult to operationalise and to distinguish from each other. For example, in both river basins, a variety of studies (e.g. Rohr 2003; McMillan and Liniger 2005) aimed to develop a "hydrological model" of the basin or parts of it; however, there was no explicit reflection in each case on what the model should do: Was the primary aim to assess the impacts of change, to gain a better understanding of processes, or to obtain information about unmeasured locations? Who were the stakeholders interested in the outputs, and how were their interests captured by the output variables of the model? At which level and scale were outputs needed? All these questions need to be answered in order to avoid including too high a number or an inappropriate selection of elements in the model structure or system.

The fact that *societal contexts in which sustainability goals can be negotiated change rapidly in time and space* represents another challenge. Each context becomes a unique case, and the concrete aims of sustainable development cannot be transferred from one to another. Correspondingly, we observe a growing number of highly contextualised and frequently local-level case studies (see Figure 2) with clear limitations on generalisation and comparability. This phenomenon has been referred to as the "ideographic trap" of sustainability (Hurni et al 2004). It is a significant cause of limitations on the production of scientific knowledge that informs decision-making at higher levels.

6.3 A multi-level and multi-stakeholder research perspective

A multi-level and multi-stakeholder research perspective can serve as a possible response to the challenges arising from issues of scale and level and from the normative dimension of sustainability. Its goal is to help bridge the gap between knowledge production and decision-making in sustainable management of water and related resources. Based on the practical challenges and theoretical considerations outlined above, such a perspective can be defined on the basis of the three principles listed in Table 1.

Table 1

The three minimum principles underlying the proposed multi-level and multi-stakeholder research perspective on sustainable river basin management.

Principle	Requirements
Transdisciplinary, value-based system delineation	– System delineation based on collaboration of stakeholders concerned and experts – Elements valued by stakeholders form the core of the system – System boundaries determined by scientific expertise
Explicit reference to multiple levels	– Assessment at multiple levels in order to capture level-specific characteristics and cross-level interactions – Explicitness about level and scale as a prerequisite for integration of findings
Balance between contextuality and generalisation	– Focus on recurring linkages and patterns instead of context-specific characteristics allows generalisation without giving up context-boundedness of sustainability

The NCCR North-South's syndrome mitigation approach (Hurni et al 2004) offers a way of designing research that adheres to these principles. The research projects currently implemented in the Upper Ewaso Ng'iro and Pangani river basins have contributed to application of and experimentation with the syndrome mitigation approach. Experiences and lessons learnt in this process are presented below.

6.4 Experiences in the two river basins

6.4.1 Transdisciplinary value-based definition of system boundaries

Application of the first principle in Table 1 in the Ewaso Ng'iro and Pangani basins indicates that it can yield well-targeted research results if a transdisciplinary definition of relevant values and value scales (see Wiesmann 1998) is used from the beginning of the research programme, involving stakeholders at all levels, and is consequently implemented in spatio-temporal system delineation for individual assessments.

Priority research themes in the East African region were identified at the outset of the NCCR North-South programme in a workshop attended by local scientists and decision-makers (Hurni et al 2004). Multiple levels were considered when it came to the selection of stakeholders to be consulted. A sole focus on local-level participation can be counterproductive, since a given situation will not improve without the commitment of decision-makers and authorities. Workshops at the local and basin levels, involving farmers and government representatives, and surveys in the field confirmed the finding that dry-season water from perennial rivers is the resource that is most highly valued, mainly by stakeholders in the footzones of the mountain ranges, while water-related resource conflicts and pressure on the land are among the most pressing problems (Wiesmann 1998; Kiteme and Gikonyo 2002; Ehrensperger 2006).

Findings from stakeholder consultations were implemented in spatio-temporal system delineation for individual assessments. For example, without stakeholder consultation, watershed boundaries are usually an obvious choice for spatial system delineation in water-related research due to upstream–downstream linkages. Based on data availability, scientists often focus on the drainage areas of existing gauges. Often, however, delineated study areas match neither the areas of greatest stakeholder interest nor decision-making units. In the Upper Ewaso Ng'iro studies, to respond to the needs of stakeholders, additional river gauges were therefore installed in the course of long-term research projects, and a simple hydrological model was developed to estimate flow at ungauged locations (Liniger et al 2005; McMillan and Liniger 2005). With respect to the temporal dimension, statistical flow analyses and model calibration focused on dry-season flows (Aeschbacher et al 2005; Notter et al 2007). This made it possible to obtain

results that directly matched stakeholder-valued resource components (i.e. water in the dry season) and areas of interest (i.e. the lower footzones). In the water use plan for Laikipia District (Upper Ewaso Ng'iro Basin), outputs are not given for hydrological catchments but for planning units (Wiesmann 1998).

6.4.2 Explicit reference to multiple levels

Application of the second principle in Table 1 yields important and sometimes unexpected results for decision-making in the two basins.

Modelling the influence of land-use and climate change on river discharge, for example, has indicated that deforestation on the slopes of Mt. Kenya would have little overall impact on dry-season flows at the catchment level. However, model outputs at the grid cell level (50–500 m resolution) suggest that forests at high elevations have a potential to sustain base flow, while forests at lower altitudes drain more water from soils by transpiration than they cause to infiltrate during storms. At the temporal scale, climate change scenarios show an expected overall increase in annual discharge; disaggregation to the monthly level reveals that rainy seasons may shift in time and cause destructive flood flows, while periods of drought may be prolonged with discharge reduced almost to zero for several consecutive months (Notter et al 2007). These modelling results are made possible and supported by long-term monitoring – not only of trends in climate, discharge, and water use from plot to basin levels, but also of population and settlement dynamics (Mungai et al 2004). Based on such results, decision-makers can elaborate spatially differentiated land-use policies and plan for increased water storage capacity in priority locations, the urgency of which would be less perceivable if assessments were carried out at single or discrete levels on the spatial and temporal scales.

6.4.3 Balance between contextuality and generalisation

The third principle in Table 1 can be illustrated by a conceptual model of processes related to watershed management in the two river basins (Figure 3). It represents a synthesis of findings from studies already completed in both basins in the areas of natural science, socio-economics and governance (Wiesmann et al 2000; Ngana 2001, 2002; Kiteme and Gikonyo 2002; Aeschbacher et al 2005; Ehrensperger and Kiteme 2005; Gitonga 2005; Liniger et al 2005; Notter et al 2007), as well as the experience of the authors, who are

currently working in the area. The conceptual model is an attempt to strike a balance between contextuality and generalisation by opening up the context of interest from specific watersheds to a more general context that could be defined as "East African river basins with an ecological gradient from humid to semi-arid". Consequently, patterns and processes that are present in both the Upper Ewaso Ng'iro and Pangani basins, and which are also likely to be present in other basins conforming to the context definition – although some might be more pronounced in one basin than in another – are included in the model. This allows for a transfer of findings concerning patterns that lead to problems, on the one hand, and potentials for mitigation, on the other hand, to areas that may not have been subject to sustainability-related research so far. The following paragraphs provide an explanation of the selected problems and potentials in Figure 3, and show how processes currently considered to be problems could be transformed into future potentials.

On the problem side, declining dry-season river flows due to expanding agriculture, population pressure and environmental change are presently leading to conflicts between different water user groups. These problems are compounded by conflicting policies between different government sectors, over-allocation of water due to limited and fragmented databases and inadequate stakeholder representation, and weak law enforcement. Irrigation infrastructure is poorly maintained, leading to water losses and higher abstractions.

On the potential side, technical innovations such as drip irrigation, rock and roof catchments, and mulching, as well as support from NGOs and the authorities for expanding water storage capacity, are helping to ease the pressure on dry-season water resources. If such innovations can be scaled up, the 'irrigation infrastructure and techniques' element could also be transformed from a problem into a potential. The formation of Water Users' Associations (WUAs) fosters self-regulation, improves participation by stakeholders in decision-making, and helps farmers to secure technical support. The procedure of allocating water could become a potential rather than a problem if farmers were represented by WUAs in the process. Alternative sources of income that do not rely on river water can also help to provide adequate livelihoods and ease pressure on this scarce resource. Education and awareness are needed, however, for farmers to take advantage of these sources. Most such potentials rely on or benefit from a comprehensive and reliable knowledge base. The same knowledge is also needed to allocate available resources equitably and to design coherent government policies.

In the Upper Ewaso Ng'iro Basin, the Centre for Training and Research in Arid and Semi-Arid Lands Development (CETRAD), the main partner institution of the NCCR North-South in East Africa, has been actively working to enhance such potentials, with activities ranging from database maintenance and awareness creation campaigns to supporting the formation of WUAs and lobbying for their formal recognition during the process of reforming Kenyan water policy (Ehrensperger and Kiteme 2005; Liniger et al 2005).

6.5 Conclusions

The Upper Ewaso Ng'iro and Pangani river basins are faced with considerable challenges but also share important potentials for sustainable development. Research in the framework of the NCCR North-South has shown

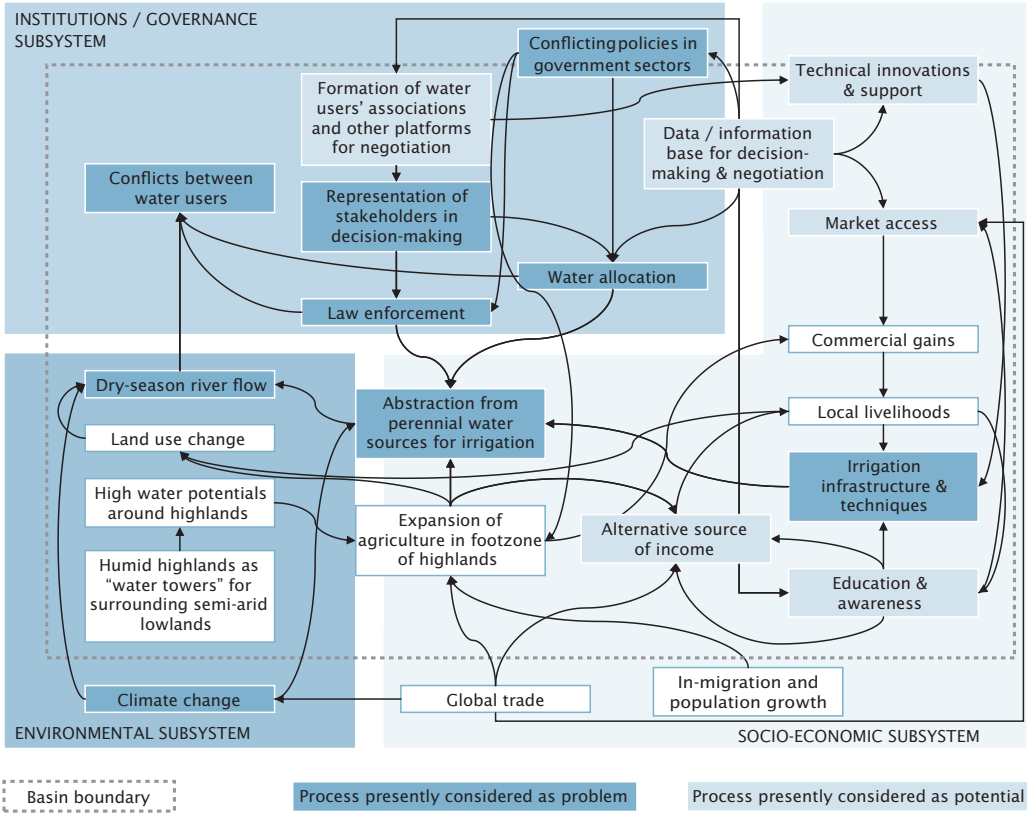

Fig. 3
Patterns of potentials and problems identified as common to both the Upper Ewaso Ng'iro and Pangani basins.

that a perspective which considers multiple stakeholders at multiple levels is required and can lead to more relevant and applicable outputs. At the same time, the normative dimension of sustainability and the resulting complexity of values, dimensions and contexts represent a challenge that has to be met by striking a balance between contextuality and generalisation.

Although these findings largely concur with the substance of current discourses in watershed management, some important differences can be identified. First, systems processes and dynamics can only be meaningfully investigated with a clear analytical scope. As this scope cannot be defined by researchers alone, it is crucial to collaborate with the stakeholders concerned. However, the goal should not be merely to include stakeholders, but to establish which components of the environment are valued in which way, so that research outputs can be tailored to these interests. Second, processes and the ways in which they are perceived and valued by stakeholders have very specific manifestations in time and space, i.e. they refer to a specific context. These contexts are often not congruent, and hence the context of water-related problems may not be identical with an overlapping context of economic development, the sphere of influence of a specific stakeholder, or the extent of a new land-tenure policy. Therefore, the a priori choice of the watershed as the relevant context for water development should not be an imperative, as more important opportunities for achieving sustainable development in a region may emerge from a different definition of the context of the human–environment system. Finally, while newer-generation watershed management approaches (e.g. FAO 2006) underline the importance of multi-stakeholder collaboration in a framework of light institutions, as opposed to bottom-up or top-down approaches under heavy donor or government programmes, experience in the Ewaso Ng'iro and Pangani basins demonstrates the need for a more careful focus on knowledge-based decision- and policy-making. Merely by ensuring participation, supporting negotiation, and building multi-level institutions, the resulting knowledge base will be nothing more than the sum of individual contributions. Fragmented and need-based knowledge can be an obstacle to successful negotiation processes and collaborative management. Experience in the Ewaso Ng'iro and Pangani basins underlines the importance of producing scientific knowledge that: a) not only focuses on immediate needs but also on long-term requirements; b) strives for a balance between specialisation and generalisation by studying patterns of problems and potentials; and c) pursues system boundaries that are identified in a transdisciplinary manner rather than by a priori choices relating to watersheds.

Endnotes

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