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Building a mosaic of values to support local water resources management

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Abstract

Water valuation is needed to enable sound and well-informed decisions on the allocation and management of water resources. The existing methods for water valuation have an important potential and need to be further developed. Practical tools are especially urgently needed to aid implementation on the ground. There is a need to expand the scope of existing water valuation methods beyond the focus on economic values to also include social and environmental values. Also, water valuation needs to fit the constraints of data availability and expertise that are typically found in practice and should be stakeholder driven, addressing values that are of relevance to local stakeholders. This paper proposes a stakeholder-driven approach to water valuation, based on the use of different indicators to produce a mosaic of values that support water resources management by local stakeholders. The use of this approach is illustrated by a case study in Tanzania.

Keywords: Economic/social/environmental water values; Local water resources management; Participatory methods; Rural development, Tanzania; Water valuation

1. Introduction

Modern water resources management is based on the Dublin principles for integrated water resources management (IWRM), which recognize water as a valuable resource and which emphasize the need for stakeholder involvement in water management (GWP, 2000). This implies a need to define, assess and explicate the value of water resources to help stakeholders make conscious and well-informed decisions on their use. Explicating and communicating the value of water might furthermore stimulate water users

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to be prudent in their uses, avoiding unnecessary wasting of water resources. As a consequence, attention on water valuation has grown over the past years.

Numerous water valuation methods have been developed and applied, contributing to a better theoretical understanding of the concepts and complexities involved (Gibbons, 1986; NCR, 1997; Rogers *et al.*, 1998; Hoekstra *et al.*, 2001; Ward & Michelsen, 2002; WWAP, 2003; Turner *et al.*, 2004). Despite this progress, several important challenges for water valuation remain, three of which will be addressed in this paper. First, there is the challenge of translating the available water valuation approaches into practical tools that can be used in less than ideal situations. Secondly, there is the challenge of broadening the scope of water valuation beyond economic values alone. Thirdly, there is the challenge to focus on stakeholders' values and to enable participatory implementation of valuation methods. These challenges are particularly relevant for local water resources management in developing countries, where limitations on the availability of reliable data, expertise and funds limit the applicability of existing water valuation methods. Also here the non-economic values of water resources are often of crucial importance, as local economies may be less developed and dominated by subsistence agriculture rather than commercial activities.

This paper discusses the above three challenges and explores a stakeholder approach to water valuation as a possible response, using a suite of tools and methods to produce a mosaic of values that supports water resources management by local stakeholders. The use of this approach is illustrated by a case study for local water resources management in Tanzania.

2. The threefold challenge for water valuation

2.1. Practical feasibility: balancing theoretical requirements with practical constraints

Numerous methods and tools for water valuation have been developed, but progress so far has been mainly academic, while the complexity of most existing valuation methods hinders widespread application (*cf*. WWAP, 2003: 333). Most of the reported applications of water valuation are done as part of scientific studies, where specific expertise is available and where sufficient data can be collected. Studies that focus specifically on developing countries are available (e.g. Georgiou *et al.*, 1997; Hoekstra *et al.*, 2001; Pearce *et al.*, 2002; Koundouri *et al.*, 2003) but these studies tend, unfortunately, to be based on rather complex, expert-driven approaches. Moreover, such applications in developing countries seem to be the exception rather than the norm, as is illustrated by a recent overview of available case studies in water valuation, which contained 285 cases, 272 of which were from North-America, Europe or Australia (Turner *et al.*, 2004).

Although many sophisticated methods for water valuation are available, the scope for objective assessment of water values remains rather limited. There are fundamental constraints on the possibility for objective valuation, as values are intrinsically subjective, based on cultural and social norms and beliefs. Also, we still have a limited understanding of the complex linkages in water systems and therefore we lack the knowledge for an accurate valuation of different water management practices. Furthermore, there are practical constraints related to available data and expertise that are likely to be there in most cases, especially in developing countries (Georgiou *et al.*, 1997; WWAP, 2003: 333; Turner *et al.*, 2004). If one adds the methodological complexities to these practical constraints – recognizing that different methods for water valuation are likely to result in different and incommensurable value estimates – the inevitable conclusion is that water value estimates are necessarily crude and inexact (*cf*. Gibbons, 1986; Daily *et al*., 2000).

Fortunately, even crude and inexact estimations of values can be useful, as in fact: "the most important decisions to get right are those where the benefits greatly outweigh costs or vice versa, and in such cases, complete accuracy is unnecessary" (Daily *et al*., 2000: 396). However, this reduces the comparative advantage of sophisticated methods that put high demands on data and expertise, while nevertheless resulting in crude estimates. It merits a shift in focus towards methods that are more straightforward and relatively easy to understand and to apply. This is especially relevant for the first iterative cycles of an IWRM process, where the emphasis is primarily on identifying the constraints, opportunities and options for water management strategies.

2.2. Broadening the scope of water valuation

Nowadays, there is a general understanding that valuing water should go beyond its economic value alone and take into account also social and environmental values (GWP, 2000; WWAP, 2003; FAO/Netherlands, 2005). Yet, the available methods for water valuation focus predominantly on economic values – reflecting in essence their origins in the field of environmental economics. Only recently attention has shifted to methods that address environmental values, such as environmental base-flows (Brown & King, 2003; Dyson *et al*., 2003). Methods for the assessment of social values remain largely absent altogether, with perhaps the exception of the water poverty index (Sullivan & Meigh, 2003). Generally, social values are included as a secondary step in economic valuations, through an "adjustment for societal objectives" (Rogers *et al*., 1998) or by assessing whether or not economic values are fairly distributed among stakeholders, regions or sectors.

The concern for broadening the scope of water valuation also brings attention to the use of integrated and aggregated values: how to combine economic, social and environmental values in one valuation approach? Various integrative concepts and indices have been developed to aggregate different values of water services into a single overall value estimate or function, such as for instance the concept of total economic value (NRC, 1997; Rogers *et al*., 1998), the water value flow concept (Hoekstra *et al*., 2001) and the water poverty index (Sullivan & Meigh, 2003). These concepts mainly aggregate values using a specific perspective, usually economic, and they depend on the valuation of different goods and services provided by water resources as their building blocks. These building blocks typically require different valuation methods, which easily results "in a heterogeneous set of values which are not necessarily directly comparable" (Gibbons, 1986: 5), which makes integration or aggregation into one single value estimate a difficult task (Daily *et al*., 2000; Turner *et al*., 2004). Furthermore, aggregated value estimates may hide differences and subtleties that could prove to carry essential information for local stakeholders. This warrants a closer look at approaches that provide insight in disaggregated values, in line with the argument made before for the use of a "basket of values" rather than "total value" (Burrill, 1997).

2.3. Focusing on stakeholders' values

Water valuation is generally considered a useful tool to enable transparent, accountable and equitable decision making and to provide decision makers with useful information. Nevertheless, in practice there seems to be a gap between the potential usefulness of valuation studies on the one hand and their actual use in water management processes on the other hand (Hermans & Hellegers, 2005). One possible reason is the difficulty for stakeholders to grasp and to "own" the methods. Another reason is the fact that complex expert-driven valuation methods are at risk of imposing or attributing values that are not shared or accepted by the stakeholders.

IWRM is a stakeholder process, and valuation is an IWRM tool to broker consent among stakeholders on the values and valuation of water in its current and future uses. Water valuation should help stakeholders to generate and share insights into values that are important to them, in line with the current trend towards decentralization and participation in water resources management. Values and norms are elements of the social and cultural system and hence valuation (i.e. expressing values) is intrinsically a social and cultural activity, participatory by nature. This is reflected in the growing belief that water valuation should make stakeholders central, focusing on stakeholders' values to identify solutions to water resources management problems (Hermans & Hellegers, 2005; IUCN, 2005; Nguyen-Khoa *et al.*, 2005).

This should not be taken to mean that stakeholders can solely decide what values should be included in water valuation, as experts should contribute their specific expertise and skills to convince stakeholders of the importance of certain water-related values that stakeholders at first might not recognize. In addition, experts should provide their services in identifying and exploring opportunities for value/productivity increase. However, all-in-all, the resulting process should be stakeholder rather than expert driven.

3. Building a mosaic of values

3.1. Developing a water valuation approach to address these challenges: value mosaics

Broadening the scope of valuation and focusing on stakeholders' values while dealing with gaps in available data and knowledge, imply the need to combine insights on water values from a variety of sources. This can be done by using indicators that reflect the values that stakeholders consider to be relevant and that can be assessed within existing time and resource constraints. Using these different indicators may not be sufficient to apply the more complex and advanced valuation approaches, but may nevertheless sketch a very useful overview of various aspects that contribute to the value of water. The result will be a mosaic of values, sketching a picture based on different pieces of information.

The question then is: what and how to value? How dense, in terms of resolution, and how colourful should the value mosaic be? To address these questions, different steps in building a mosaic of values are proposed, illustrated for a practical case in the Mkoji sub-catchment, a rural area in the southwest of Tanzania, which will be discussed in more detail in a later section of the paper.

3.2. Preparing a background and a first sketch of the value mosaic

If one is to prepare a mosaic of values, then a first step, prior to actually filling in the pieces of this mosaic, is to sketch a background against which to interpret the various values. It is important first to get an idea of the basic characteristics of the river basin or catchment for which the valuation is done, such as its location, the main livelihood activities, land use patterns and existing or emerging water resources management issues. In sketching this background, a water balance that documents water availability and consumption is considered essential to gain some understanding of the interactions and interdependencies between water uses and users. It gives a first indication of the value of water, by indicating the main water using sectors and by indicating when and where water is scarce. This water balance can be more or less detailed and accurate, depending on the available data. As a basic starting point, in most cases it should be possible to obtain at least some indirect observations of the availability of water resources and their main uses.

The information can be obtained from available information sources, complemented by some additional data gathering or modelling activities. In the case of Tanzania, data on land use, hydrology, climatic conditions and main livelihood activities were already available from previous studies and were supplemented by additional data collection and by estimations to allow for modelling of water use and a rough water balance.

3.3. Assessing the required differentiation in valuation

Analysts often focus on aggregated values and optimization at the level of the water system, whereas stakeholders are likely to focus on the gains and losses in relation to their main interests. What is good for one stakeholder, may be bad for another, and in negotiating local water management strategies, most stakeholders are likely to try to claim as much value as possible (*cf*. Sebenius, 1992). This dimension should be included in valuation studies by disaggregating value indicators to provide insight into the values for different groups of stakeholders. Insight into disaggregated values adds the necessary colour to the value mosaic, as it helps to identify potential "winners" and "losers" and the resulting consequences for feasibility of alternatives and possible needs for compensation.

Differentiation between different stakeholder groups can be based on wealth class, economic sector, geographic location, gender, and so on. In the Mkoji sub-catchment, the assumption was made that human water use would be governed by three determinants, which provided the basis for disaggregation. The differences in agro-ecological conditions resulted in a distinction between different geographical zones in the upper, middle and lower part of the catchment. Different farming systems and livelihood activities were identified, such as rain-fed agriculture, irrigated agriculture, paddy growing and livestock keeping. Finally, the socio-economic status of households was used to distinguish between five different wealth classes. The latter was based on a participatory wealth ranking exercise, which enabled stratified random sampling for the household survey.

3.4. Selecting value indicators and map values

Identify and select value indicators. Value indicators provide the pieces that fill the mosaic of values and they can be identified in consultation between stakeholders and experts, by reflecting on the role water resources play in sustaining local societies, economies and ecosystems. The value indicators can be organized into the basic value dimensions to be assessed: the economic, social and environmental dimensions. Table 1 provides an illustration of the different value indicators that were used for the case of the Mkoji sub-catchment, along with short description of the way in which they were assessed.

Assess values. There are many well documented valuation methods to assess economic values (e.g. Gibbons, 1986; NRC, 1997; Turner *et al.*, 2004), such as market-based analysis, value transfer and

Table 1. Different value components of water and their assessment in the study area.

	Value indicator	Assessment method/ approach	Main source of data	Additional explanation
Economic values	Economic crop water productivity (for zones and crop types)	Market based analysis and value-transfer	Household survey, literature	CROPWAT modelling to simulate actual crop water use, combined with reported yield and farm gate prices. Value transfer from neighbouring catchment for details on rice prices
	Economic water productivity, livestock keeping	Market based analysis	Household survey	Market prices combined with estimates for water consumption tropical livestock
	Willingness to pay for domestic water	Contingent valuation and market prices	Household survey	Triangulated from open-ended questions, bidding game and prices of commercially vended water
Social values	Food security in different zones	Nutritional value of crop production	Household survey, literature	CROPWAT modelling, nutritional values of crops
	Importance of water to sustain livelihoods of different groups	Household sources of income	Household survey	Percentage of income derived from livelihood activities for which water is essential direct input
	Wealth distribution among households	Participatory wealth ranking	Household survey	Qualitatively linking wealth distributions to livelihood systems
	Conflicts over water	Review of reported conflicts	Focus group discussions, literature	Occurrence of conflicts as indicators of social stress inflicted by water management practices
Environmental values	Environmental base flows	Environmental base flow requirements versus actual flows	Focus group discussions, direct observation, literature	Requirements for zones in Mkoji sub-catchment as well as downstream wetlands
	Environmental changes	Changes in the natural environment related to water availability	Direct observation, historical background data	Environmental changes that are related to changes in water availability indicate value of water in maintaining ecosystems

contingency valuation. For social values of water, many fewer methods are discussed in literature, and here one will have to rely more on creativity, common sense and dialogue with local stakeholders and local experts in order to arrive at some suitable indicators, as well as agreed upon ways to assess them. In the case of the Mkoji sub-catchment, this resulted in somewhat more indirect indicators, deriving the social value of water from data on food security, livelihood activities and the occurrence of conflicts over water. The environmental value of water may be difficult to assess accurately when little reliable monitoring data are available, but estimates may be obtained, for instance through the concept of environmental base flows.

The more indicators are assessed, the richer the picture of the resulting value mosaic will be, but one should also take into account practical feasibility. Therefore, the assessment should be done as much as possible using various sources of data, methods and stakeholder inputs, based on practical accessibility, feasibility and the available expertise. In the case of the Mkoji sub-catchment, data sources included a household survey, covering 246 households in six villages, focus group discussions with local villagers and key stakeholders, as well as a three-day participatory planning workshop. Historical data were available from rainfall, climatic and gauging stations and from previous studies. These locally collected data were combined with generally accepted reference data to deal with remaining gaps, for instance in modelling evapotranspiration and in estimating livestock water consumption and human nutritional requirements. Local expertise was available through the staff of the local research station of the Soil-Water Management Research Group of Sokoine University of Agriculture and the RIPARWIN project.[1]

Assess trends and dynamics in water uses and associated values. The availability and uses of water resources change over time and the values of water resources change accordingly. These dynamics may be due to natural causes, such as climatic variability, but also due to demographic, economic or policy changes, such as migration, market trends, or changes in agricultural policies and subsidies. Dynamics may indicate how values fluctuate over different seasons within a year or over relatively wet or dry years. In wet periods, water values may be lower, whereas they may peak during dry periods, especially when these last for an exceptionally long time or occur at unexpected moments. Long-term trends may indicate the direction in which values are developing and the stakeholders who are likely to face increased water-related problems in future. In the Mkoji case study, trends and dynamics were mainly analysed using historic data from rainfall and gauging stations, stakeholder narratives, background documents and local expert knowledge.

3.5. Link valuation to the identification or evaluation of alternatives for water management

Water valuation will be most useful to stakeholder processes if it has a clear link to alternatives. Sketching an estimate of the economic, social or environmental value of water resources may be useful for raising awareness and informing stakeholders, but it does not necessarily help in identifying and discussing strategies for improved water resources management. For instance, the knowledge that the ecosystem services provided by the world's wetlands are valued at US$4.9 trillion annually (Costanza *et al.*, 1997) provides a good argument for their protection, but does not indicate how this protection should be shaped and how it could be balanced with the need for social and economic development.

How alternatives are to be included in water valuation depends on the stage of the decision making process that it intends to support. If stakeholders already have a clear idea of the different alternatives and options for improved water resources management, valuation could include an assessment of how the

[1] RIPARWIN stands for Raising Irrigation Productivity And Releasing Water for Intersectoral Needs. This is a DFID funded project, executed by the Soil-Water Management Research Group of SUA, the Overseas Development Group of the University of East Anglia and IWMI.

different values may be impacted by different alternatives – resulting into a strong analogy with a multi-criteria analysis or impact assessment. For instance, it could look at the impact of water transfers on various values, or the impact on values of the construction of infrastructures such as dams and irrigation channels.

Valuation approaches can also be used to identify key-areas for improvement and to identify promising alternatives when they are not yet identified – complementing insights generated by water valuation with stakeholder dialogue and expert knowledge. This approach was used in the Mkoji sub-catchment, where water valuation provided the basis for the identification of new alternatives (Hermans *et al.*, 2004). This was done through a three-day stakeholder workshop, where the preliminary results were presented and provided the basis for a joint problem analysis and an identification and assessment of preferred solutions. Although the assessment of alternatives during the workshop was limited, it nevertheless resulted in preliminary ranking of preferred solutions, which gave useful information to help decide on future directions for IWRM in the area.

4. The case of the Mkoji sub-catchment in Tanzania

The results of the value mosaic are illustrated using the aforementioned case of the Mkoji sub-catchment. Here, a project was executed to enable local stakeholders to engage in a process towards implementing IWRM principles in the area, based on a solid background analysis of the linkages between local conditions and the value of water, with specific attention to vulnerable groups. The results discussed here are reported in more detail in FAO & SUA (2005).

4.1. Background information on the Mkoji sub-catchment

Location and main activities in the area. The Mkoji sub-catchment (MSC) covers an area of about 3,400 km^2 in the southwest of Tanzania. It drains into the Great Ruaha River, which in turn is part of the larger Rufiji River basin (see Figure 1). The Mkoji sub-catchment is a rural area, characterized mainly by smallholders' low input – low output agricultural activities. The nearest major urban centre is the city of Mbeya, a rapidly growing city with some 270,000 inhabitants, located just outside the sub-catchment on the west.

The Mkoji sub-catchment has a single rainy season, from November to April, and hardly any rain falls in the rest of the year. Within the area, three agro-ecological zones can be identified, each with distinct climatic conditions and differences in the availability of land and water resources: the upper, middle and lower zones. From the upper to the lower zone, the landscape changes from highlands in the upper part to a central plain in the lower part of the sub-catchment. Elevation ranges from 1,100 m in the plains up to 2,400 m above mean sea level in the highlands.

The upper zone of the sub-catchment is characterized by a mountainous landscape and a semi-humid to humid climate with relatively favourable conditions of water availability. There is year-round cultivation, consisting of high value rain-fed agriculture with supplementary irrigation in the lower parts of the zone. Maize is grown as the dominant cereal crop, supplemented by horticulture for cash crops and some small-scale livestock keeping.

The middle zone is dominated by paddy rice cultivation, which is possible in large parts of this area owing to the presence of suitable soils. The agricultural activities in the parts of the middle zone that are not suitable for paddy rice cultivation are quite similar to the upper zone activities, although climatic

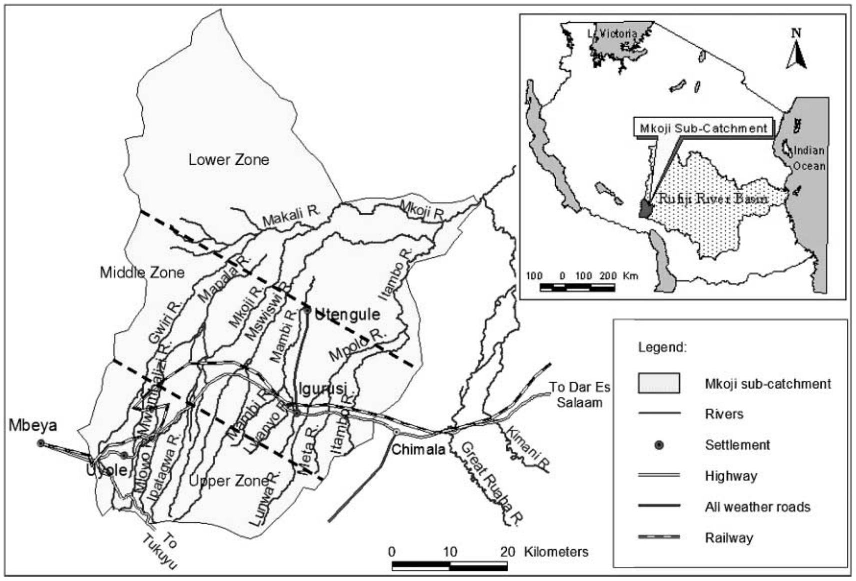

Fig. 1. Location map of the Mkoji sub-catchment.

conditions in the middle zone are somewhat less favourable. Furthermore, this zone is located along a major transportation route, which increases access to markets and attracts economic activity. As a result, the upper part of the middle zone (the corridor along the highway) has the highest population density of the three zones in the Mkoji sub-catchment.

The lower zone consists mainly of semi-arid plains and it has a low population density. The area is inhabited by pastoralists who raise their cattle in the plains of the Mkoji sub-catchment during the wet season, when some rain-fed agriculture is also practised. During the dry season, the surface water streams do not reach the lower zone, as they dry up a few kilometres downstream of the highway in the middle zone. There is no dry season agriculture and most cattle-holders migrate to seasonal grazing grounds in wetlands outside the lower zone. In recent years, problems have arisen when the government of Tanzania declared an important part of these wetlands to be a national park, making dry season cattle grazing there illegal.

Table 2 illustrates the above characterization of the zones with some basic data on population, area and land use.

Water balance. The available data do not allow for the construction of a detailed water balance for the Mkoji sub-catchment, but only for a rough estimation of water supply and main water uses. Although far from sufficient, these figures can nevertheless serve to provide a first impression of the availability of water.

Table 3 shows the main water uses associated with human activities, as well as some estimates of evapotranspiration by natural vegetation. It shows that during the wet season, the water supplied through rainfall exceeds the water use, leaving a significant part of the water available for groundwater recharge and run-off to downstream areas. It also shows that dry season water consumption exceeds the seasonal rainfall, using some of the wet season water stored in soils and available river flows and drawing on water from elsewhere, for instance through the use of available groundwater (mainly for domestic uses)

Table 2. Basic characteristics of the different zones in the Mkoji sub-catchment.

Characteristic	Upper	Middle	Lower	Total MSC
Population	59,234	55,509	18,725	133,468
Total area (ha)	59,606	125,662	154,875	340,143
Cultivated area (% of total)	55	34	6	25

and migration of livestock to seasonal grazing grounds outside the sub-catchment. The deficit increases from the upper to the lower zones, illustrating that the situation gradually worsens when moving from upstream to downstream in the sub-catchment. Rainfall varies considerably, with the coefficient of variation ranging from 34% to 100% for the months in the rainy season, which means that the actual situation differs from year to year.

Current water resources management issues. The expansion of irrigation in the upper parts of the sub-catchment has led to increased competition and conflict over the past years. The resulting drying up of streams halfway through the catchment during the dry season has severe consequences within and outside the sub-catchment. Within the sub-catchment, the lower zone pastoralist communities and the natural seasonal wetlands suffer from seasonal droughts. Outside of the Mkoji sub-catchment there are major concerns over the drying up of the Great Ruaha River downstream of the MSC, which has caused important problems in the Ruaha National Park and which have received high political attention on the national level, resulting in increasing pressures on the communities in the Mkoji sub-catchment and the neighbouring Usangu plains to release more water to the Great Ruaha River (*cf*. SMUWC, 2002).

Currently, responsibilities for planning and management of water resources are being transferred from the national to the local levels, through river basin water organizations and water user associations, as

Table 3. Seasonal water availability.

Water uses/rainfall	Upper	Middle	Lower	Total MSC
Wet season uses (Mm^3)				
Rain-fed agriculture	10.8	12.3	19.4	42.5
Paddy rice		14.6	20.5	35.1
Livestock*	0.2	0.3	1.0	1.5
Domestic	0.4	0.3	0.1	0.9
Natural vegetation**	208.5	506.8	725.7	1441.0
Total wet season use	219.9	534.3	766.7	1521.0
Wet season rainfall	604.3	1051.4	808.0	2463.7
Dry season uses (Mm^3)				
Irrigated agriculture	7.5	4.9		12.4
Livestock MSC*	0.3	0.5	0.4	1.1
Migrated livestock*	0.1	0.3	2.0	2.4
Brick making	0.1	0.1	0.0	0.2
Domestic	0.4	0.4	0.1	0.9
Natural vegetation**	8.6	15.2	2.4	26.2
Total dry season use	17.0	21.4	4.9	43.2
Dry season rainfall	15.6	6.4	0.5	22.5

*Livestock water use figures here are related only to direct drinking needs and hence do not reflect the true total water use, which is difficult to assess – see the discussion in the next section.
**Crude estimates, based upon CROPWAT modelling.

platforms for dialogue and negotiation. These decentralized management structures are still being formed and/or strengthened, working towards increased involvement of local stakeholders in the process of integrated water resources management. At this moment, some problems remain to be solved in this new institutional set-up (Sokile *et al.*, 2004). The lower zone lags behind in the formation of water user associations, as there are fewer existing local water management institutions to build upon in these pastoral communities. This introduces the risk that lower zone water users are under-represented in the catchment level user platform. Also, the formal system of water rights that has been introduced by the river basin water office is not without problems. Wet and dry season water rights are issued in absolute rather than relative terms, that is, in litres per second rather than a percentage of available flow. There is currently a discrepancy between the issuance of water rights and the restricted knowledge base on available water resources and actual water use. This results in an over-allocation of water rights, especially during dry years, which favours upstream users over downstream users.

4.2. Assessment of the economic value of water

Economic crop water productivity in different zones. Figure 2 contains an overview of economic crop water productivity for the three different zones in the MSC. Generally, the economic productivity decreases from upstream to downstream, with the exception of rain-fed vegetables. This decline in economic productivity is explained by the climatic conditions that are more favourable in the upstream parts of the MSC and the fact that irrigation modernization has been more widespread in the upper zone villages.

Economic water productivity across water using sectors. Average economic water productivities of different water using sectors are compared in Figure 3. It should be noted that they cover higher level estimates for all sectors, as they refer to gross income derived from water using activities, based on reported farm gate or market prices[2].

The high productivity value for domestic uses is commonly observed in cross-sectoral water productivity estimates (Turner *et al.*, 2004: 91–92) and is due to the fact that domestic uses are directly linked to human health and are relatively low in terms of volume (*cf*. Cornish *et al.*, 2004). Nevertheless, the value shown is thought to indicate an upper limit, expressing a willingness to pay. The reported household income levels suggest that it will not be possible for the majority of the households actually to pay such prices for their domestic water all year round. This indicates a discrepancy between the households' *willingness* to pay and their *ability* to pay.

The high value of livestock water productivity is explained by the high market value of cattle and the fact that the productivity estimates are based only on water withdrawal for *direct* consumption, excluding the water needed to produce the food for the cattle. The exact economic water productivity for livestock in agro-pastoral farming systems is difficult to estimate owing to the relationships and overlaps between different water using activities. Livestock consumes a considerable amount of water through

[2] The values exclude estimates for production costs, the bulk of which would consist of labour costs for working the land, herding, fetching water and other activities. These labour costs are especially difficult to estimate for the rural economy of the Mkoji and therefore, it has been decided to omit production costs altogether to allow for at least comparable output in terms of water productivity based on gross income.

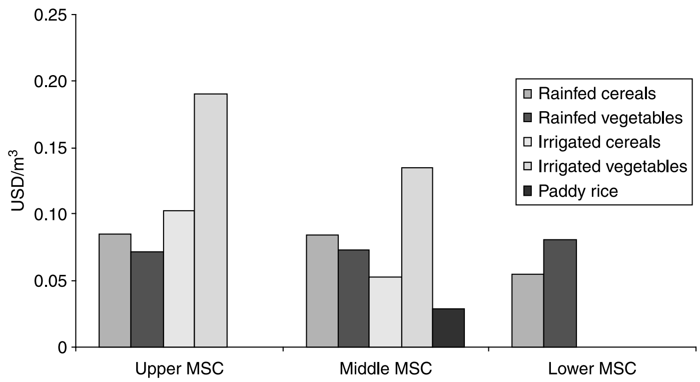

Fig. 2. Economic crop water productivity in different zones.

the water embedded in its fodder, but part of these may be crop residues that would otherwise be lost. Complications are further introduced by seasonal migration, as cattle herds are taken outside the Mkoji sub-catchment during the dry season. This causes competition for water with the wildlife as well as the import of a considerable amount of "virtual" water from outside the sub-catchment.

Dynamics in economic water productivity. The economic value of water for crop production fluctuates, based on the timing of planting and marketing the crops, owing to the impact of price volatility. For instance, the price of rice fluctuates considerably over the year, in direct relation to the quantity of produce offered on the market. Rice that is marketed early in the season (April/May) fetches a price that can be up to three times as high as the average price per bag later in the season (July/August). This results in fierce competition for water early in the growing season.

4.3. Assessment of the social value of water

Water for food. The yearly production of cereals in the Mkoji sub-catchment can be reviewed for its nutritional value in terms of energy and compared to the annual energy requirements, which are about

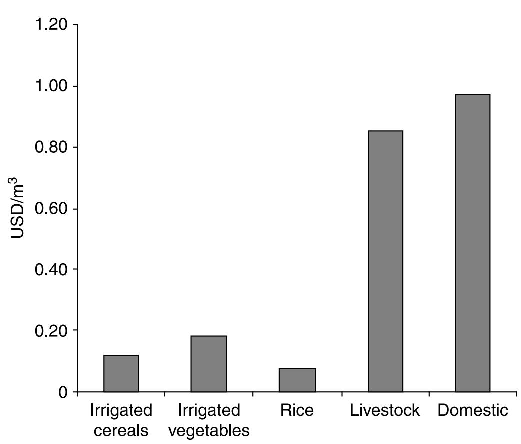

Fig. 3. Economic water productivity of different water withdrawing sectors in MSC.

2550 kcal per day or $0.9 \cdot 10^6$ kcal per year for an average active adult (Latham, 1997)[3]. Although this is a very rough estimate and there are more requirements to a healthy and balanced diet, the results in Table 4 provide a first indication of the food security situation.

The table indicates that on annual basis, enough food is produced in the sub-catchment to meet basic energy requirements, but that the margins are not very high, especially in the upper zone. Here, the food security situation seems precarious for a considerable number of the poor and very poor households that are below the average levels shown in the table, especially if one takes into account the risks involved in maize storage and production (e.g. maize streak and vagaries of rainfall).

Households in the middle and lower zones are almost entirely dependent on wet season food production, which means that they have to bridge an important period using their wet season harvests and non-agricultural livelihood strategies, but currently possibilities are limited for this, and are mainly restricted to the selling-off of cattle-stock. Using storage facilities or increasing access to markets may help to improve the food security situation and thus address the social value of water, even if these measures at first sight may seem to have little to do with water resources management.

Water to support livelihood activities. Table 5 summarizes the contribution of water-related activities to the income of average households. It shows that more than 90% of household incomes in the MSC depend on water as a critical input. However, poor households are relying more on off-farm activities as sources of income than the average households, which is probably owing to their limited access to land and water resources. This confirms the pattern that emerges from other studies in semi-arid areas in Tanzania, where the poor are more and more relying on off-farm livelihood diversification (Morris *et al.*, 2002).

In the lower zone a shift in livelihood activities has been observed recently. The cattle holders used to graze their herds on the pastures in the neighbouring plains during the dry season, but since the Government of Tanzania gazetted the Usangu Game Reserve, livestock grazing is no longer permitted in these plains. Simultaneously, the diminishing floods during the wet season allow for the reclamation of flood plains into agricultural land. As a result of these two developments, a shift towards rain-fed agriculture can be observed.

Household wealth distribution and access to water. A participatory wealth ranking exercise was executed, using different criteria for household wealth, identified by the local stakeholders. The results show that the middle zone has relatively the largest strata of poor to very poor households. This is the most densely populated zone of the Mkoji sub-catchment and here land and water resources are increasingly under competition. In the upper and the middle zone, access to land is an important determinant for the income-generating capacity of households, whereas in the lower zone, the size of the livestock herd is the main determinant. In this lower zone, the extremes are more dominant, with a relatively small group of medium households and a relatively large group of rich and very rich households, with herds of 15 to 200 or more cattle.

[3] The reference energy requirements cited here were calculated based on body weights from a sample low-income country (Cameroon).

Table 4. Food security situation in the different zones of the MSC (in 10^6 kcal/cap/y).

Output	Upper	Middle	Lower	Requirement
Dry season cereals	0.5	0.1	0	0.45
Wet season cereals (incl. rice)	0.9	1.6	3.9	0.45
Total cereals	1.4	1.7	3.9	0.9

The participatory household wealth ranking indicates that access to water is one of the factors that influence household wealth, but that other capital assets such as the ownership of land and livestock are much more dominant, Figure 4.

Conflicts over water. Information about conflicts over water provides an indication of the social value associated with the existing water management practices. If many severe conflicts occur, this indicates that existing water management practices contribute to social instability. Table 6 shows that in the MSC, water-related conflicts occur during the dry season and at the onset of the wet season. The conflicts concentrate in the middle zone, where conflicts between farmers who are competing for irrigation water, and between farmers and pastoralists, may even erupt into violent fights.

4.4. Assessment of the environmental value of water

Environmental base flows. Environmental base flow requirements are regarded as the minimum flows to ensure sustainable river environments and flora and fauna. A specific environmental base flow requirement could not be assessed for the Mkoji sub-catchment within the time, resource and information constraints of the project, but, as the streams used to be perennial, it is safe to assert that at least a constant minimum flow is required throughout the year. In the MSC, the existing base flows have been impacted by increased river abstractions in the past years and in the lower zone there is no water flowing in the dry season. This indicates that the current practices have a negative value for sustaining the existing environment.

The lack of base flows is also apparent further downstream of the Mkoji sub-catchment, in the Usangu plains and in the drying up of the Great Ruaha River. In the case of the Mkoji, the values for conservation of nature are externally imposed, since the restoration of the dry season flows of the Great Ruaha River was made a priority by the national government (*cf.* SMUWC, 2002). Pressure is put on upstream water users, including the MSC, to use less water. Moreover, measures have been taken to protect wildlife through the establishment of game reserves, which directly affect communities in the MSC.

Table 5. Percentage of income derived from water-related activities in MSC.

	Irrigated agric. (%)	Intermediate agric. (paddy) (%)	Rain-fed agric. (%)	Livestock keeping (%)	Total sum (%)	Total for poor households (%)
Upper zone	45	0	44	1	90	50
Middle zone	6	39	24	23	92	75
Lower zone	0	9	19	69	96	92

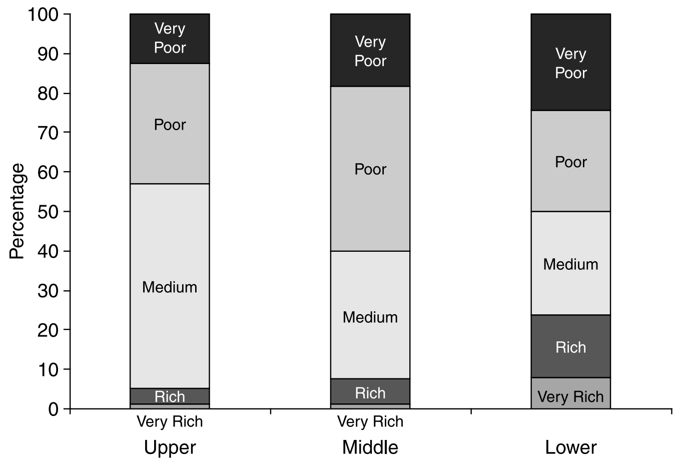

Fig. 4. Household wealth distribution in the Mkoji sub-catchment.

It should be noted, however, that similar trends in neighbouring catchments have resulted in marked changes in the hydrological cycle of the wider Usangu plains. This further complicates and aggravates the situation. It is thereby doubtful whether the limited contribution of the Mkoji sub-catchment alone can have any significant impact on restoring the dry-season base flow of the Great Ruaha River.

Observed environmental changes. Another indication of the environmental value of existing water management practices is provided by the observed changes in the ecosystems of the MSC. Such changes are most noticeable in the lower zone, where an observed reduction in seasonal flooding allows for the reclamation of floodplains for agricultural purposes. Although this might be a positive development in socio-economic sense, it also indicates that the current flow regimes are not sustaining the original ecosystems in the lower zone.

Table 6. Water-related conflicts in the different zones.

	Upper zone	Middle zone	Lower zone
Typical conflicts	Upstream – downstream conflicts within and between irrigation schemes	Conflicts within and between irrigation schemes. Conflicts between irrigators and cattle holders	Conflicts among cattle holders over grazing lands. Conflicts of lower zone cattle holders with water users or authorities in other zones
Occurrence	During dry season	During dry season, and at the onset of the wet season (peak)	During dry season
Severity	Low – usually solved informally or through irrigation committee	High – several court cases reported, sometimes violent fights	High – mostly with middle zone over water and pasture; a lack of local level conflict resolution mechanisms is observed

4.5. Insights obtained from disaggregated values

The different components that make up the value of water show results that may seem contradictory at first. A closer look into these apparent contradictions among the indicators generates useful insights, which would have been missed if the indicators had been aggregated into one overall figure. For instance, water for rice does not have a very high economic value compared with other crops. Nevertheless, the social value assessment shows that water for rice is one of the main sources of conflict in the sub-catchment, indicating a high social value. Apparently, this high social value is explained by other factors that make rice a desirable crop, outside economic water productivity. Looking at the broader picture of rural livelihoods indicates that rice is preferred because it is a non-perishable crop that is relatively easy to market and provides a more reliable source of income, regardless of its water needs.

Another interesting observation is the observed shift from cattle holding to rain-fed agriculture in the lower zone. The water used for cattle in the lower zone has a high economic value when compared to rain-fed agriculture but still a shift away from cattle holding can be observed in the lower zone. This relates to the political decisions to close off the outside wetlands for grazing, but also to the distribution of water resources within the MSC, where all the (little) water available in the dry season is used in the upstream parts. As a result, an economically highly valued water use is currently under threat in the sub-catchment.

4.6. Using the value mosaic to identify alternatives for improved IWRM

The value mosaic helps to identify different promising areas of action to improve water resources management in the MSC. During the focus group discussions and the final stakeholder workshop, several options were identified that can be linked to the different dimensions of the value mosaic. These options include the construction of small dams to make more water available for productive uses[4] and the training of farmers in on-farm water management techniques to increase crop water productivity.

Furthermore, the value mosaic also indicates the usefulness of options that at first sight may not seem directly related to water management, but that do help farmers to generate more value per unit of water. These options are, for instance, increasing farmers' access to storage facilities and low-cost farm inputs such as agro-chemicals, and supporting farmers' associations. In particular, rice producers' associations, which coordinate the joint marketing of rice, may benefit the region. If farmers can agree on a system of sharing the benefits of coordinated marketing, they can increase their income and income stability, compared with the existing competitive model that is conflict prone and adds social risk factors to the already significant natural risk factors. Finally, there is, of course, also the option of "shifting" water uses from low to high value crops, although this would require several supporting measures.

To increase the social values of current water uses, options were identified to increase fairness, equity and social stability. Stakeholders expressed a desire to review the existing system of water rights allocation and management as well as the continued formation of local water user associations throughout

[4] Under normal circumstances preference would be given to the use of ground water during the dry season, which can be replenished during the wet season. Unfortunately for the water users of Mkoji, no easily and economic feasibly extractable ground water is available during the dry season for depths up to 60–80 m, except for some places where small quantities for domestic purposes are available.

the catchment. Specific attention would be needed for lower zone communities where currently the formation of local water user associations is lagging behind.

To increase the environmental values, some arrangement for the continuous release of base flows would be required. Such options have in fact been implemented in the past, through an arrangement with a large rice farm just outside the sub-catchment, which drains into the sub-catchment. Here, a base flow of $2\,m^3/s$ is maintained throughout the year with the intention of covering the basic water needs of downstream households. However, this water does not reach the lower plains for unknown reasons – perhaps there are (illegal) abstractions downstream, or maybe water dissipates into the soil, evaporates or is consumed by natural vegetation. This illustrates the existing gaps in knowledge that exist when it comes to the functioning of the current natural system and generates questions about the effectiveness of similar measures of conserving more water upstream to cover environmental needs downstream.

5. Discussion of some of the lessons learned about the challenges for water valuation

5.1. Safeguarding practical feasibility

Safeguarding practical feasibility does not necessarily conflict with maintaining analytic integrity or policy relevance. In the Mkoji case, a relatively simple and straightforward approach allowed for a meaningful and comprehensive analysis of water values. This was instrumental in the identification of a diversified set of alternatives that were feasible within local constraints and that targeted specific issues, thus adding to the practical usefulness as a tool for local stakeholders.

An advanced degree in economics is not required in order to build a mosaic of values, and this is considered to be an important advantage over other approaches, as most water practitioners do not hold such advanced degrees. This allows water professionals and local stakeholders jointly to assess the social, economic and environmental values of water, without necessarily becoming experts in those fields. This is not only helpful in increasing the practical feasibility of the approach, but also in enabling stakeholders to be fully involved in the valuation process.

5.2. Broadening the scope of water valuation

Economic values are commonly aggregated into one overarching "total economic value". Broadening the scope of water valuation to include social and environmental values raises the question of how to combine these elements into one overall valuation. The water valuation for the Mkoji sub-catchment joins different dimensions of water valuation loosely together in a mosaic of values. This contrasts with the literature on water valuation, which considers combined and integrated applications of "coupled hydrological economic models" (Turner *et al.*, 2004: 87) or "integrated ecological-economic-social approaches" (Daily *et al.*, 2000: 396) to have most potential for the near future. However, in the Mkoji sub-catchment, the mosaic of values generated sufficient insight to support local water resources management. The added value of integrating the different components of the value mosaic into one overriding value seems questionable, given their incommensurability, and might not be very efficient. There is no urgent need to bring them all under a common nominator; if a structured comparison of different components were to be required, this could be done through (basic) multi-criteria analysis methods such as score cards or impact tables.

In fact, aggregation may mean that some important insights are lost. Given the current complexity of IWRM, one often has to look for incremental solutions and diversified strategies that address specific constraints. This is especially true in areas such as the Mkoji sub-catchment, where the existing situation only allows for piecemeal improvements that are feasible within the marginalized livelihoods system. The identification and evaluation of such diversified strategies is more likely to be supported by a value mosaic rather than an aggregated value or integrated value function. It also better serves the purposes of raising the awareness and insight of stakeholders in the different uses of water, mapping their interdependencies and consciously deliberating upon alternatives.

5.3. Focusing on stakeholders' values

Through focusing on stakeholders' values, the case study findings underline what was already known, but what water professionals nevertheless tend to forget easily: water is not always the main driving force for stakeholders' behaviour, not even in water-scarce environments. Access to water is critical, but it is not the only factor and not always the most important one in the perception of the local stakeholders. This means that water values need to be considered in the broader livelihood context. For instance, in the case of the Mkoji, the choice for rice production was not driven by a desire to maximize economic returns on water use, but by relatively stable production and market conditions that allowed for a relatively secure source of income. Also, access to land, labour and/or cattle were just as important as access to water in securing local livelihoods. This reinforces the importance of focusing on stakeholders' values.

Tools for participatory problem analysis, such as focus groups discussions and participatory workshops, will help to involve local stakeholders in the valuation process, but will not be sufficient to ensure its usefulness for decision making by local stakeholders. For this, water valuation studies will also have to take into account the institutional context. The discussion of the Mkoji case showed that well functioning water management institutions are required to enable stakeholders to manage water in a way that reflects its value. Especially for the social values of water uses, institutional structures need to be in place to ensure that water management contributes to social stability, equity and fairness. Unfortunately, more often than not there are no adequate institutional structures, or institutions are only at the beginning of a long process of development or reform.

Therefore, the identification and establishment of links with the existing institutions and planning processes are crucial to ensure that the valuation process is indeed linked to decision making by local stakeholders. Moreover, the participatory application of water valuation activities could help stakeholders to improve their functioning in existing institutional structures, by offering them a channel to communicate and reflect upon the different values involved in managing local water resources. In the case of Mkoji, this entails linking the water valuation to the work of the River Basin Water Office and to the District Agricultural Development Plans of the District Authorities.

The stakeholder orientation is considered one of the main strengths of the value mosaic approach, but it also introduces certain limitations and challenges. These are related, for instance, to the possibilities for comparing the outcomes of different value assessments across time and space. Including some basic indicators that are the same across these cases would make it easier to use and compare results of different valuation studies and to upscale water valuation results from the local to the regional and national level. This would reduce the need to start from scratch again with every valuation study, but it would require further experience to design a framework that balances predefined indicators with room for flexibility and stakeholder input. It is likely that physical ratios and indicators, as well as a water balance, can in most cases serve the purpose of comparison, while the relative importance attributed to such indicators will always have to be grounded in contextual values and preferences.

6. Conclusions

Water valuation is crucial to enable sound and well-informed decisions on the allocation of water resources in line with modern principles of IWRM. The existing methods for water valuation have an important potential and need to be developed further, but several challenges remain. These relate especially to fitting water valuation better to practical constraints, to broadening the scope of water valuation to include social and environmental values and to focusing on the usefulness of valuation for local stakeholders.

Building a mosaic of values, combining participatory methods with more classic valuation techniques, may offer a useful approach to address these three challenges. Its application in a case in Tanzania showed its feasibility in practice, using a stakeholder-driven approach to produce a transparent assessment on a broad range of value indicators. However, the value mosaic approach sketched here offers no detailed blueprint for guaranteed success. In its application, additional challenges surfaced, related, for instance, to the institutional dimension and the balance between stakeholder orientation and comparability across time and space. Notwithstanding these new challenges, the first experiences with the approach suggest that it allows water professionals and local stakeholders jointly to assess the value of water. There is much need to arrive at a valuation approach that supports local water users in discussing, analysing and addressing the complex and pressing problems before them. Building a mosaic of values might well provide some further steps to getting there.

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