Disparity of attitudes and practices on a concept of productivity of water in agriculture in the Great Ruaha River Sub-basin

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ABSTRACT

A study was conducted in the Ruaha River Sub-basin of the Rufiji basin to assess knowledge, attitudes and practices of measuring productivity among stakeholders. Literature review, Participatory Rural Appraisals and structured questionnaire study was used to collect data from the study area. There is lack of general understanding and a wide disparity on the practices related to the concept of productivity of water. The concepts of productivity of water are poorly understood, with inconsistent and incomplete monitoring, reporting and auditing among stakeholders. Policy makers emphasize on water conservation incentives, development projects work to improving supply management. Engineers' practices combine both water supply and demand management in the irrigation schemes with little consideration on productivity of water. The researchers put emphasis on modeling water allocation based on water demand. Smallholder farmers apply own definitions, and descriptions while assessing productivity using relative terms and proxies. Most other stakeholders fix absolute values of productivity of water. This results to lack of realistic analyses of water requirements and water values in various water sectors for fostering and implementing strategies for improved water allocation. Necessary components in the estimation of productivity of water are measured with spatial and temporal inconsistence. Furthermore, the nature of disparity of attitudes and practices calls for considerable efforts to initiate dialogue among stakeholders so as to reach a consensus and to develop the practice further.

Key Words: Stakeholders, productivity of water, Dialogue for water, Water allocation, Water use efficiency.

Introduction

The concept of productivity of water is useful in the context of the Great Ruaha River Basin. The basin exhibits a unique scenario of important water uses and users in the country. The basin supplies water to major hydropower plants producing about 40% of electricity in the country, major irrigation schemes, large forests, game reserves and wetlands supporting unique biodiversity. Before year 1974 it is assumed that there was limited human disturbances in the basin. Thereafter there has been much irrigation development in the Great Ruaha River basin in the Usangu plains, construction of hydropower plants and gazetting of game reserves (SMUWC, 2001). Therefore the importance of water from the basin cannot be overemphasised.

In recent years, competition between water uses and users in the basin has increased and the importance of efficient use of water and productivity as tools for allocating water has emerged. However, there is a wide disparity in definitions and understanding the concept of productivity of water among stakeholders in the basin with few stakeholders aware of the concept. Stakeholders such as smallholder farmers, Water User Associations (WUAs), River Basin Office, Researchers, Natural resources officers, Engineers and irrigation Managers to mentioning but a few of them differ in priority, perceptions and practices on productivity of water. Each stakeholder understands practices and keeps some records, which could be used to piece together an assessment of productivity of water. This paper explores stakeholders' understanding of the concept, and reviews the current practices, methodologies and data kept by the different stakeholders as a basis of dialogue for consensus of definition and choice of tools for assessing productivity of water appropriate for the basin.

Methodology

A study was conducted in the Great Ruaha River Basin in Tanzania to explore attitudes and practices on productivity of water among water users in the basin. An extensive review of grey literature was done to study the practices of various stakeholders in the basin. Participatory Rural Appraisal and questionnaire survey was done in the selected villages in Mkoji sub-catchment of Great Ruaha River Basin. The PRA study employed qualitative approach through focus group discussions in six sampled villages namely; Ikhoho and Inyala in the upper zone; Mahongole and Mwatenga in the mid zone; and Ukwaheri and Madundasi in the lower zones of Mkoji sub-catchment. Structured questionnaires administered in the same villages were used to collect data from the sampled households. The questionnaire included both open and closed - end questions and the intended respondents were household heads in the selected villages. A total of 428 household respondents were interviewed. Data collected using questionnaires were reduced, summarised, coded and entered in the Statistical Package for Social Science (SPSS) computer software for analysis.

Results

Stakeholders' knowledge on the concept of productivity of water

Kasele (2005) documents perceptions of stakeholders in Mkoji sub-catchment on the concept of productivity of water. To most of the stakeholders in the Great Ruaha Basin this concept is new. For example most farmers in Mkoji sub-catchment have heard the term 'Productivity of Water' from PWAIS[1] researchers and some from recently conducted courses and seminars organised by the department of the Ministry of Agriculture and Food Security (Kasele, 2005). A survey conducted by PWAIS project after such trainings and interactions revealed (Figure 1) that 87.6% of farmers were still not aware of the concept of productivity of water. However, this does not imply that farmers are not aware of the value of water in agricultural productivity. They assert that water was not an issue to ponder about during the past in the era on plenty of rains and fertile soils. The more recent conflicts and struggle over water in the dry season among farmers is a clear indication of the increasing value they put on water, although, as it will be shown later in this paper, farmers' conceptions and definitions are less formal than those provided by experts. Farmers have their own proxies and jargons to explain and assess productivity and value of water.

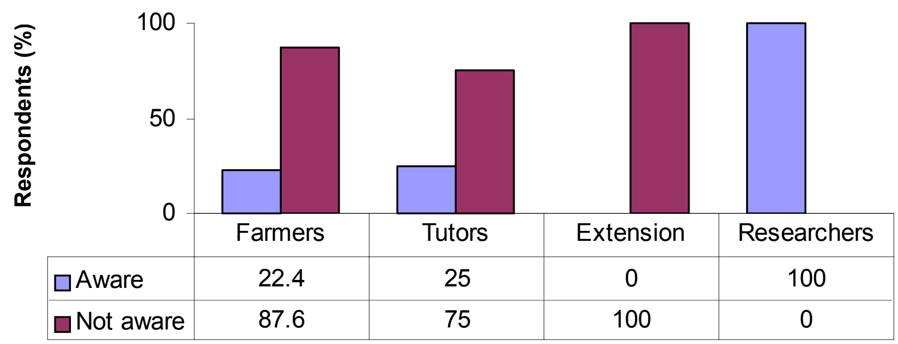
The concept of productivity of water is also relatively new to experts (agricultural tutors, extension officers and some researchers). For example it was found that about 75% of the tutors at MATI Igurusi (Ministry of Agriculture Training Institute responsible for irrigation training at diploma level) were not aware of the concept of productivity of water (Figure 1).

For those who claimed to understand the concept of productivity of water happened to find themselves in two schools of the definitions. The first school hold that productivity is the amount of crops produced divided by volume of water used to produce the crops. The second related the concept of productivity of water with classical irrigation efficiency

[1] Productivity of Water in agriculture and Interacting Systems (PWAIS) a Comprehensive Assessment funded project being implemented in Tanzania and Ethiopia.

described as the ratio of amount of water required for an intended purpose, divided by the total amount of water diverted.

Figure 1. Stakeholder understanding of the concepts of productivity of water



Globally, the understanding and definitions of productivity of water differ amongst scholars. Many researchers in the world use the terms water use efficiency in the context of productivity of water in agriculture (for example Shaozhong et al., 2002, Cox and Pitman, 2002, Cox et al., 2002). In a similar setting, the United States Department of Agriculture (USDA) defines three types of water use efficiencies (Ronald and Marlow, 2002); these are:

i) Water Use (technical) Efficiency: The mass of agricultural produce per unit of water consumed.
ii) Water Use (economic) Efficiency: The value of product(s) produced per unit of water volume consumed.
iii) Water Use (hydraulic) Efficiency: The ratio of water actually used by irrigated agriculture to the volume of water withdrawn.

The technical and economic efficiencies as defined above are measures of productivity of water in keeping with the usual sense of the term, i.e. the *more crop per drop* paradigm. Although several literatures in a wide variety of disciplines refer water use efficiency as to mean productivity of water, productivity of water is more appropriate term (Baker et al., 2003). Even for the agreed definition of productivity of water, the general understanding has not been uniform and is based on background of stakeholder in question. As shown in Table 1 farmers, plant physiologists, engineers and agronomists have different meanings on the terms of the productivity of water equation. It may not be easy to reach a consensus but it may be logical to consider each and every component of the benefits and water use in the process.

Table 1. Examples of definitions of productivity of water by different stakeholders

Stakeholder	**Useful definition**	**Scale**	**Target**
Plant physiologists	Dry matter/transpiration	Plant	Productive utilization of light and water resources
Agronomist	Yield/evapo-transpiration	Field	Higher yields tons/ha
Farmer	Yield /water supply	Field	Higher yields tons/ha
Irrigation engineer	Yield/diverted water	Irrigation scheme	Demand management
Water resources planner	$/total depletion	River basin	Optimal allocation of water resources

Source: Modified from. Bastiaanssen *et al*., 2003

Policy perspectives on productivity of water

The Tanzanian water policy among other things encourages water management approaches and economic incentives, which facilitate efficient and productive water use (URT, 2002). It also recognises the need to conserve water in any form, improving efficiencies of domestic water supply, irrigation efficiencies and hydropower generation among other entities. This has been echoed in the national Agricultural Sector Development Strategy (ASDS), which strived to enhance the efficiency of water utilization though the promotion of better water management practices (URT, 2001). The government also enacted some laws so as to put into force some policy statements. However there is no evidence that the laws have had any impact in increasing productivity of water. Most probably they have not been explicit and robust enough to tackle real field situations. For example, the Water utilization (Control and regulation) Act of 1974 (WU Act) of Tanzania as amended in 1981, 1989, and 1997 and the accompanied regulations of 1975, 1994, 1996 and 1997 are confined to water allocation procedures. The regulatory bodies instituted by this law such as water basin offices have statutory obligations to offer water rights and water fee pricing, which can only work indirectly to influence productivity of water.

Probably the Tanzania Land Policy of 1995, the subsequent Land Act of 1999 and Village Land Act of 1999 could be good start point of complementary apparatus to enhancement of productivity of water. The policy and law tend to offer land tenure security, which create incentives for users and owners to make investments, which are necessary for increasing the productivity of land and water. Nevertheless, most smallholder farmers are not aware of such incentive policies and laws. On the other end a few elites and policy makers have started to make use of the policies and laws. It is not surprising that many of them look for opportunities to acquire fertile lands with access to irrigation water under the pretext of national privatisation and economic reform policy.

Little consideration on productivity of water by development projects

In the few past years there have been several development projects in Tanzania to address the irrigation sub-sector. The projects such as Agricultural Sector Programme Support (ASPS), River Basin Management-Smallholder Irrigation Improvement Programme (RBM-SIIP) and Participatory Irrigation Development Programme (PIDP) had budgets for irrigation improvement (Kamuzora, 2003; World Bank, 1996; JICA/MAFS, 2002; UNOPS, 2001). Under these programmes, emphasis was given to increase water efficiency through the improvement of intakes and provision of canals and training to farmers to enhance infield water management. However, hefty investments were made in the construction and improvement of intake structures and limited lining of main canals, with little effect on in-field management of water. Although the programmes recognised water as a limiting factor there was little provision for facilities and training to monitor the productivity of water. The performance of the programmes was occasionally measured but very much based on improved abstraction and conveyance efficiency of the irrigation projects rather than increased productivity of water from the command area of the irrigated projects.

Smallholder farmers' perspectives on productivity of water

The concept of measuring agricultural production based on water is new among the farmers in the study area. For example, most farmers interviewed in Mkoji sub-catchment (87.6%) indicated that they didn't have any idea on the concept of productivity of water. Those who claimed to understand the concept (22.4%) attributed their knowledge to interactions with PWAIS researchers and training by the Ministry of Agriculture and Food Security. Recent surveys conducted after the interactions and trainings indicated that farmers have their own understanding and interpretation of the concept of productivity of water. As shown in figure 1 most of the farmers (52.8%) define productivity of water as 'producing crops with little amount of water'. Other farmer's definitions are 'good yield' (10.1%), 'water used in agricultural production' (20.1%) and 'cropping strategies during scarcity of water' (17%). All of the definitions carry the context of benefits as per water use. Nevertheless, farmers do not monitor or keep records of productivity of water as they do with returns to land (in bags per acre).

There is an obvious and general understanding that water is an important input in agricultural production. As such, farmers relate production of rain-fed agriculture to frequency, intensity and duration of rainfall. These are held to have a direct influence on the yield of crops. Farmers assess the adequacy and shortage of rainfall and not the absolute quantities of rainfall. Thus rainfall is described as less or sufficient and related to low, medium and good yield or crop loss due to drought. Productivity of water is indicated as 'good yield in a good year' or 'bad yield in a bad year'. A good year means high amount of total rainfall with no intense dry spells in sensitive growing stages of the crop and vice versa. This can be well captured in a way farmers classify rainfall seasons as in recent responses by farmers in Mkoji (Fig. 2). While farmers have no practice of monitoring absolute quantities of rainfall, they skilfully monitor quantities of farm produce but there is little use of standard scales. As such they record yield by weight, tins, plastic, bags and crates depending on the type of produce, requirements market and storage. So while a farmer would not tell the absolute quantity of rainfall for the season, he can confidently tell absolute quantity of produce. For example in Mkoji sub-catchment farmers have recorded between 10 – 14 bags of maize per acre with good rains. In the same setting farmers do not monitor the quantity of irrigation water used for producing crops.

Figure 1. Farmers' definitions of productivity of water in Mkoji sub-catchment

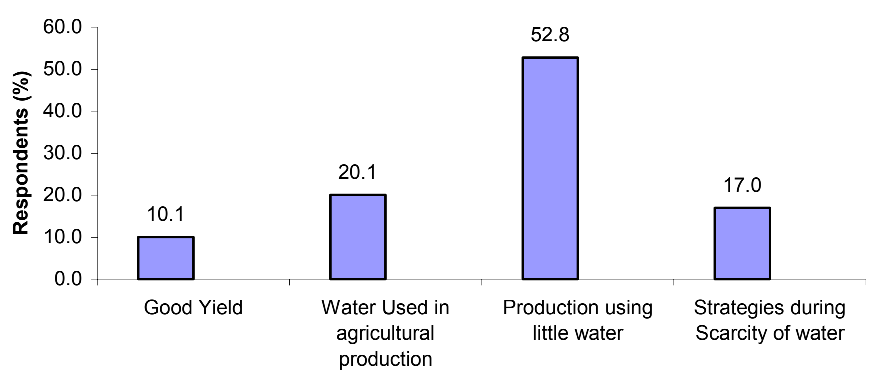
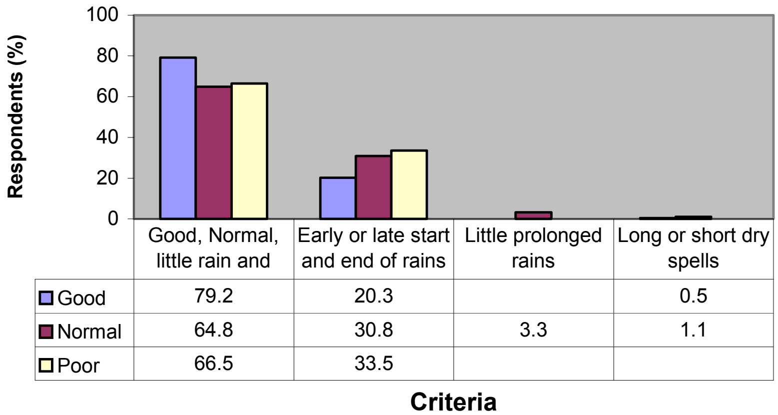


Figure 2. Smallholder farmers' criteria for classifying rainfall seasons in Mkoji sub-catchment



	Good, Normal, little rain and	Early or late start and end of rains	Little prolonged rains	Long or short dry spells
Good	79.2	20.3		0.5
Normal	64.8	30.8	3.3	1.1
Poor	66.5	33.5		

Over 80% of the irrigation systems in the Rufiji basin are farmer managed under irrigation water committees and water user organizations (SMUWC, 2001). In all gravity irrigation systems farmers and Water User Associations (WUA) seldom practice recording the amount of water used or abstracted. In most of the makeshift, traditional irrigation intakes, flow measurement devices are absent. They are installed in the few improved irrigation systems along the main canals only, and very seldom in secondary and tertiary canals. Even in the improved systems, intake flows are not regularly recorded by WUA's because regular monitoring of volume of abstraction for water user fee estimation, which would motivate WUA's to keep flow records, is absent, or because the knowledge to use the structures is missing.

In practice, water is allocated among farmers in terms of duration and frequencies of irrigation and not the specific volume of flow. As shown in figure 3, farmers use five major factors in deciding duration and frequencies of irrigation. However, three of them namely; crop type, availability of water and weather are the most important factors in setting frequencies and duration of irrigation. Frequent data kept by WUA's and irrigation committees; include a list of farmers in the scheme, designated acreages, irrigation turns and yield that each farmer gets (Tarimo *et al*., 2004). Figure 4 show the typical data of total irrigation turns, irrigation duration and irrigated acreage as recollected from farmers in Mkoji sub-catchment. This set of data is theoretically essential to estimate the water user fee each farmer is supposed to pay, of which is remotely related to actual water use. When Chemka (1996) was assessing productivity of water in the smallholder Kapunga rice farm, the only data he could retrieve from farmers' records were yield and acreages and not the water used or diverted. Hence for smallholder farmers, productivity of water is not understood by an absolute measure but by relative measure of water use, For example, they refer productivity as good or poor yield and further relate to good or poor access to irrigation water.

It is only in micro irrigation systems in which most farmers have to carry and irrigate with buckets and other small containers, that the amount of water is measured in the process of use. Since farmers use a lot of energy in carrying water they tend to count and memorize the counts of buckets or containers they use per irrigation turn. In this case farmers can possibly tell how much water has been used to produce a certain crop output. Even though, it will take some effort to extract such data from them. In summary, smallholder farmers in the Mkoji were not observed to monitor and record water use and water productivity but there are several implied means of assessment suitable for their own situation.

Figure 3. Factors influencing setting duration and frequency of irrigation

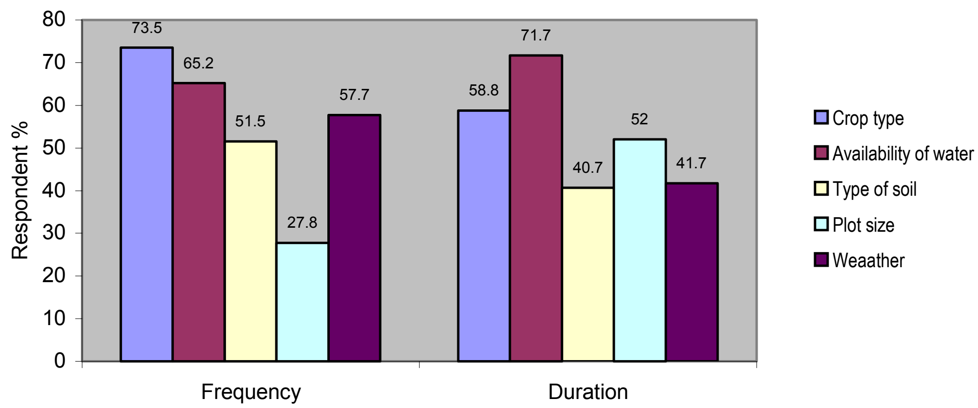
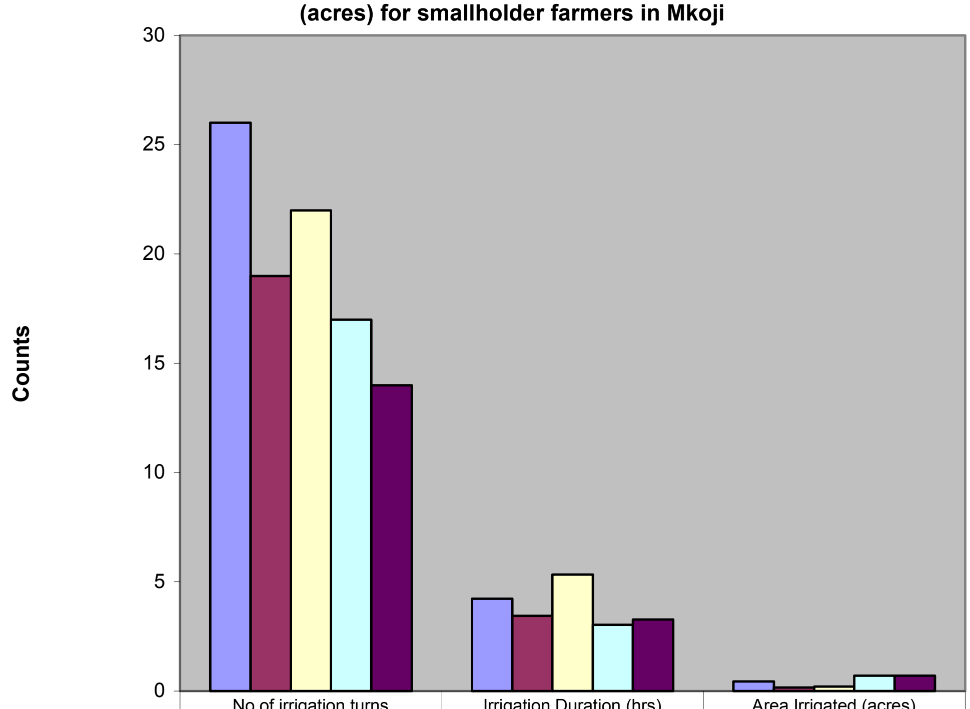


Figure 4. Mean seasonal irrigation turns, duiration (hrs/day) and acreage (acres) for smallholder farmers in Mkoji



	No of irrigation turns	Irrigation Duration (hrs)	Area Irrigated (acres)
Maize	26	4.23	0.44
beans	19	3.45	0.17
Onion	22	5.33	0.21
Tomato	17	3.03	0.7
Round Potato	14	3.28	0.7

The role of SMUWC and RIPARWIN projects[2]

Most probably the SMUWC and RIPARWIN projects may be the first pioneers trying to assess productivity of irrigation and interacting systems based on water accounting procedures (SMUWC, 2001). SMUWC's concept was that irrigation water produces crops and other interacting products within the irrigation system. Furthermore, drain water is used down stream in the flood plains and swamps to enhance environmental productivity. The notion was picked up by RIPARWIN project which went further to assess productivity of irrigation water in multiplicity of uses within the schemes together with the productive roles of the water in the wetlands downstream (Kadigi *et al.,* 2004). It is the SMUWC project, which introduced the concept of multiplicity of uses of water, associated productivity and water reuse; a scenario exhibited in the Kapunga water system (SMUWC, 2001).

Water management based on demend and supply

To the large extent irrigation water management in the Ruaha River basin is based on distribution and allocation, with little or no measurement of water allocated to users. This is mainly because most of the schemes depend on gravity water supply systems. Thus, managers care little in the amount of water they divert from rivers and distribute to the fields, because there is little direct cost of water incurred (i.e. in terms of labour to open and close the gates). So despite of well calibrated flow gauges in most of the improved schemes there in very sparse record of main canal flows (SMUWC, 2001). Measurement of water diverted in these systems is neglected because the only major cost known is annual water user fees of which is not regularly paid. Monitoring system for water abstractions and enforcing water user fee (by the Rufiji Basin Water Office) is not efficient enough to motivate managers to keep data for assessing productivity of water (SWMRG-FAO, 2003). Productivity of water in such farms is gauged by cost benefit analysis (e.g Chemka, 1996), which considers annual water user fee as a minor component cost in the analysis. It is in pumped irrigation water supply systems in which cost of pumping water is a high input in the farm cost where water use is monitored. Even though this does not influence the absolute amount to be distributed because, the cost of water is included in the land rent. Once paid the amount of water given to the farmer may not necessarily reflect price of water paid because it is seldom measured.

On the other hand engineers do not consider concepts of productivity of water when designing irrigation systems. They rather work on the principles of water demand and supply management. In practice irrigation efficiency rather than productivity is the major factor in the irrigation design (Halcrow et al. 1992, FAO, 2001, URT-NAFCO 1979). Also performance of irrigation systems in the Great Ruaha Basin has mostly been assessed based on efficiency of water use (i.e. ratio of volume of water required by plant to volume of water supplied) (Chancellor, 1997, Tarimo, 1994, Chemka, 1996). For example, Tarimo (1994) used measures of classical efficiency to assess performance of smallholder irrigation systems in the Usangu plains.

Influence of type of irrigation system

Type of irrigation system has influence on the level of management and type of data collected for monitoring productivity of water. Drip and sprinkler systems demand higher management levels than surface irrigation systems. Kibena Tea Estate (KTE) in Njombe, Tanzania is a good example to use a high level of management over the sprinkler and drip irrigation systems it operates compared to management level offered to the gravity irrigation systems in the Rufiji Basin. As opposed to the latter, irrigation managers in the estate collect

[2] Sustainable Management of the Usangu Wetlands and Catchment (SMUWC) and Raising Irrigation Productivity And Releasing Water for Intersectoral Needs (RIPARWIN) are both DFID funded projects designed to explore alternatives to water management in the Usangu plains. .

and use the whole range of weather data required for determination of crop water requirement and irrigation scheduling together with other data for assessing farm productivity (Kibena Tea Estate, 2001, 2002, 2003). The Kibena piped irrigation system is equipped with gauges and gadgets for measuring amount of water, constantly monitoring irrigation application uniformity, yield and above all the cost of pumping water. The management gives high weight to management of water to justify water pumping bill and profit optimisation. As such they have incorporated in their management system a way to assess productivity of water because it is a very important input to the estate. But still the productivity of water is not featuring in the management audit reports.

Potential and constraints of the practice of assessing productivity of water

From the preceding sections it is evident that there is little consistency in monitoring and reporting of productivity of water along the continuum of stakeholders. Much of the data required for assessing productivity is not regularly collected. Table 2 show a summary of commonly measured parameters for assessing productivity of water in the Great Ruaha River basin by different stakeholders. It can be seen that the data collection has poor spatial and temporal consistency. For example hydrologists and researchers do record data such as deep percolation, rainfall, evapotranspiration, runoff and river flows. It is not always practicable for the farmers to keep and use these records. Even the researchers collect such data only when there is a research demand. The hydrometric stations are normally sparsely distributed and some have been long out of service. Consequently, gaps of missing data for the many hydrometric stations are common. The practice has been to use data from nearby stations or generate data from common databases (e.g. CLIMWAT for CROPWAT)

Furthermore, any of the parameters required for monitoring crop productivity such as deep percolation and evapotranspiration are difficult to measure and most of the times are modelled. As such it is unlikely that the farmers will assess productivity of water based on consumptive use. Use of precise facilities for the measurement of soil water balance components such as weighing lysimeters is limited to high cost of construction and operation (Allen et al., 1998). Use of GIS and remote sensing are considered expensive and technologically removed from farmers' experiences and knowledge. In such situations it may be appropriate for rainfed farmers to continue estimate relative rainfall amounts instead of encouraging them to measure absolute amounts of rainfall and water use. For them, most important issue is whether there has been adequate or inadequate rain to meet crop demand rather than the accuracy of rainfall measurement.

In case of irrigation, farmers care whether they have access to irrigation water long enough to meet crop demand but do not translate this into water measurement. The crop yield is most widely measured component of the equation of productivity of water among farmers, researchers and administrators. Almost all farmers keep records of economic yields of crops in every season although not as accurate as done by researchers. Researchers' records are more accurate but less frequent and depends on a research objective. Administrators keep aggregate records of crop production levels at regional and district levels for the purpose of planning for food deficits. In summary, the existing regularly collected data is spatially and temporally inconsistent and thus it requires considerable effort for dialogue and consensus on methodologies to assess productivity of water.

Table 2: A summary of commonly measured parameters for assessing productivity of water

Parameter	Normally Recorded or estimated by:	Spatial consistency issues	Temporal consistency issues
Rainfall	Hydro-meteorologists	Rain gauges are sparsely located	The most frequently and consistently measured weather parameter
Evapo-transpiration	Researchers	Full climatic stations are sparsely distributed	Many climatic stations have data gaps. Extrapolated climatic data is normally used
Runoff and river flows	Hydro-meteorologists	Runoff is measured only during research trials. River flows are regularly recorded at gauge stations	Gauged stations are sparsely located
Soil-moisture	Researchers	Measured only during a research trial. Sparsely distributed	Measured only during a research trial.
Deep percolation	Researchers	Difficult to measure and sometimes modeled	Irregular
Diversion to irrigation schemes	Water officers	Few diversions are gauged. Only allowed water as per water user permit is known	Sometimes done only once per annum
Drainage from irrigation schemes	Researchers	Done for the research only	Only done when there is research demand
Actual amount of water used in a given field	Researchers	Done for the research only	Only done when there is research demand
Yields per unit area – at farm level	Farmers, managers and researchers	Always done in every farm	It is done for all seasons
Crop production levels at district and national level	Administrators	Aggregate data	Annual records
Supplementary benefits	Researchers	Done for the research only	Only done when there is research demand
Distribution schedules	Farmers and irrigation managers	Every scheme has a water distribution schedule	Every scheme has a water distribution schedule
Water user fees	Water office	Amount of water user fee is always communicated to respective schemes	Amount of water user fee is always communicated to respective schemes

Conclusion and Recommendations

It is evident from the above discussion that the understanding and practices by different stakeholders; of the concept of the productivity of water differ considerably and to some extent the understanding is non-existent. The attempt to link benefits and the amount of water used to produce them is rarely monitored, evaluated or reported upon. The different categories of stakeholders such as farmers, basin water officers, engineers, agronomists and others; work on different objectives and hence keep different types of records of several aspects of the benefits and amount of water. However, these different stakeholders compete and use the same water resources in the basin. It is important therefore that consensus and mutual understanding of the concepts of productivity of water is established so that rational and efficient allocation of water in the basin. This requires basin dialogue to piece together and harmonize productivity of water definitions, attitudes and practices. Such a dialogue need to be initiated from farmers at grass root level (WUA's) at sub-basin level and involve all stakeholders and organised by river basin water office. On the basis of such situation it is difficult to initiate dialogue on consensus of the practices. Such dialogue will come up with acceptable tools for assessing productivity of water in agriculture, agree on water allocation criteria and procedures for water uses and users.

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