Disparity of Attitudes and Practices on a Concept of Productivity of Water In Agriculture in the Great Ruaha River Sub-Basin

Zakaria J Mkoga[1], Nuhu Hatibu[2], Henry Mahoo[3], Bruce Lankford[4], Kumar P.C. Rao[5]

1. Research associate (PWAIS CA Project) and PhD Student, Department of Agricultural Engineering and Land Planning, Sokoine University of Agriculture, P.O. Box 3003, Morogoro, Tanzania.
2. Coordinator for Soil and Water Management Network of ASARECA, P.O. Box Nairobi, Kenya
3. Associate Professor, Sokoine University of Agriculture, Department of Agricultural Engineering and Land planning, P.O. Box 3003, Morogoro, Tanzania.
4. Lecturer, University of East Anglia,
5. Senior Scientist, ICRISAT,
6. Research Associate (PWAIS CA Project) and MSc Student, Department of Agricultural Education and Extension, P.O. Box Morogoro, Tanzania.

Emails: mkogazj@yahoo.co.uk,

ABSTRACT

A study was done in the Ruaha river sub-basin of the Rufiji basin to assess knowledge, attitudes and practices of measuring productivity among stakeholders. Amongst the major water uses, agriculture and specifically irrigated agriculture is avowed as an inefficiently user of water resources in the Rufiji basin. However, there is lack of realistic analyses of water requirements and water values in various water uses for cultivating and implementing strategies for rational water allocation. More important, there is no common understanding of the concepts of productivity of water and no consistent and complete monitoring, reporting and auditing of the productivity of water among stakeholders. Necessary components in the estimation of productivity of water are measured with spartial and temporal inconsistence. The different stakeholders approach the different records and measurements differently. There is very little awareness and understanding on the concept of productivity of water, because the water used in agricultural systems is seldom measured. However, on the basis of the data and records kept by some stakeholders it is possible to make estimates on the current levels of productivity of water and initiate dialogue to develop the practice further.

Introduction

The concept of productivity of water is quite 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 a lot of irrigation development in the upstream of 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 in allocating water among uses and users has more prominently emerged. However, there is a wide disparity in definitions and understanding the concept of productivity of water among stakeholders in the basin. Most of the stakeholders are not aware of the productivity of water concept. However, they keep some records, which could be used to piece together an assessment of productivity of water. This paper includes a review, which explores stakeholders understanding of the concept, the current practices, methodologies and data kept by the

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different stakeholders as a basis of dialogue for consensus of definition and methodological tools appropriate for the basin.

Stakeholders' Knowledge of the Concept of Productivity of Water

Kasele (2004) documents perceptions of stakeholders in Mkoji sub-catchment on the concept of productivity of water. 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 irrigation department (Kasele, 2004). It is reported that about 87.6% of farmers are not aware of the concept of productivity of water. The remaining few have been recently introduced to the concept in seminars organised by the irrigation department. This does not mean 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 conflicts due to struggle over water in the dry season among farmers is a clear indication of the value they put on water. As it will be shown later in this paper farmers conception and definitions are not so formal as expected by experts. They have their own proxies and jargons to explain and assess productivity and value of water.

The concept of productivity of water is new even to 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. There were two schools of the definitions of productivity of water among the experts in Mkoji. The first school hold that productivity is 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 described as the ratio of amount of water required for an intended purpose, divided by the total amount of water diverted.

Even globally, the general understanding and definitions of productivity of water differ. 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, Stanhill, 1986, 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 indeed measures of productivity of water in the *more crop per drop* paradigm. As Baker et al., (2003) that: 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.

Even for the agreed definition of productivity of water, the general understanding has not been uniform and is based on background of stakeholder. 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.

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

Table 1. Examples of definitions of Productivity of Water by different stakeholders

Stakeholder	Useful definition would be	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 productive water use (URT, 2002). It also recognises the need for water to be used in producing high value crops to increase productivity of irrigation water. This has been echoed in the Agricultural Sector Development Strategy (ASDS), which strived to enhance the efficiency of water utilization though the promotion of better management practices (URT, 2001). However the enforcing laws have not been able to motivate increased productivity of water. 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 1997are 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 are a good example of complementary apparatus to enhancement of productivity of water. The policy and law 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.

Little Consideration of Productivity of Water by Development Projects

In the few past years there has been a lot of development projects in Tanzania meant to improve 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 big budgets for irrigation improvement (Kamuzora, 2003; World Bank, 1996; JICA/MAFS, 2002; UNOPS, 2001). Under these programmes emphasis was give to increase water abstraction efficiency through improvement of intakes with little improvements in the infield water management. Consequently, hefty investments were made in the construction and improvement of intake structures and limited lining of main canals. Although the programmes recognised water as a limiting factor there was little provision of facilities and practice to monitor productivity of water. Performance of the programmes was measured based on improved abstraction and conveyance efficiency of the irrigation projects rather than increased productivity of water.

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. There is therefore no direct means by which farmers monitor and keep record of productivity of water in agriculture. However, there is an obvious and general understanding that water is an important input in agricultural production. For example, farmers relate production of rain-fed agriculture to frequency, intensity and duration of rainfall. These are held to have a direct influence to yield of crops. In a way they do 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'. Good year means high amount of total rainfall with no intense dry spells in sensitive growing stages of the crop and vice versa. While farmers have no practice of monitoring absolute quantities of rainfall, they skilfully monitor quantities of farm produce. There is little use of standard scales. But 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.

Over 80% of the irrigation systems in the Rufiji basin are farmer managed under irrigation water committees and water user organizations (SMUWC, 2001). As for the case of other gravity irrigation systems; Water User Associations (WUA) seldom practice recording the amount of water used or abstracted. In most of the make shift 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 there is no regular monitoring of volume of abstraction for water user fee estimation, which would motivate WUA's to keep flow records.

In practice, water is allocated among farmers in terms of duration and frequencies of irrigation and not the specific volume of flow. 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). This set of data is essential for estimation of quota of 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 small holder Kapunga rice farm, the only data he could retrieve from farmers' records were yield and acreages and not the water used or diverted. In this case, smallholder farmers record productivity of land rather than water, which they refer as good or poor yield and further related to good or poor access to irrigation water (in the head or tail end of the scheme).
Hence for farmers, productivity of water is not necessarily an absolute number but a relative measure of water use, which is not most of the times quantified by measuring precise amount of water used.

It is only in micro irrigation systems in which most farmers have to carry and irrigate with buckets and other small containers, where the amount of water is measured in the process of use. In this case farmers can 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, there is no deliberate effort among smallholder farmers to monitor and record water use and water productivity but there are several implied means of assessment suitable for their own situation.

The Role of SMUWC and RIPARWIN Projects[2]

The practice of assessing productivity of the products of water in agriculture and interacting systems is new in the study areas. 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, the 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 (Mdemu *et al.*, 2004; 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). The system abstracts between 4.8 m^3/s and 6 m^3/s of water to irrigate about 3000 ha of the main Kapunga rice farm together with some 700 ha of smallholder farmers' scheme. Drain water from Kapunga rice farm irrigates about 700 ha of paddy fields down stream supporting livelihoods of people in Yala village (SWMRG-FAO, 2003). Brick making is also an important user of irrigation water. It is also estimated that the system supports about 50 fishermen activities producing around 59.8 tons of fish per year worth 27,504 USD (RIPARWIN, 2003). Such productivity values were not determined and recognized before. When Chemka (1996) assessed productivity of water for both smallholder and government managed Kapunga rice farm, productivity determinations neglected reuse and multiple uses of water in the system. Water accounting was not attempted, hence both actual water depleted and down stream reuse was not known.

Water Management Based on Distribution Regardless of its Productivity

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 (James, 1988).

As it will be explained in this section, it is in pumped irrigation water supply systems in which cost of pumping water is a high input in the farm cost. 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 not measured.

[2] *Sustainable Management of the Usangu Wetlands and Catchment (SMUWC) was a World Bank and DFID funded project designed to explore alternatives to water management in the Usangu plains. Raising Irrigation Productivity And Releasing Water for Intersectoral Needs (RIPARWIN) is a SMUWC follow up project.*

Influence of Type of Irrigation System on the Need to Monitor Productivity of Water

Type of irrigation system also 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, the estate collects and uses 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.

The Practice of Engineers and Designers

Application of the concept of productivity of water is new even to engineers and designers of the irrigation systems. In many cases, engineers do not consider concepts of productivity of water when designing irrigation systems. In practice irrigation efficiency rather than productivity is the major factor in the irrigation design (Halcrow et al. 1992, FAO, 2001, URT-FAO 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) (Bos, 1982; 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. This has been the practice for many other researchers in Usangu and elsewhere in Tanzania (e.g. Makongoro, 1997). Only recently that SMUWC (2001) and RIPARWIN projects have consistently used productivity concepts and indicators in assessing performance of Kapunga water system. However, this was a research context and not a design endevoir.

Potential and constraints of the Practice of Assessing Productivity of water

From the preceding sections it is evident that no consistent and complete monitoring and reporting of productivity of water is practiced along the continuum of stakeholders. Some pieces of methods are used and records are kept, which can be used as a basis of assessing productivity of water. However, much of the data that can be used to assess water are 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 hydrologist 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 (FAO, 1993)). Much 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 too remote for the farmers to 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 (Howel, 1996; Allen et al., 1998; Evett et al., 1993;

Khan et al., 1993). Use of GIS and remote sensing are considered expensive and technologically removed away from farmers.

In this situation probably it may be appropriate for farmers to continue monitor relative rainfall amounts instead of puling them towards measuring absolute amounts of rainfall and water use. As for them, most important issue is whether there has been adequate or inadequate rains to meet crop demand. Not the accuracy of rainfall measurement. In the irrigation scheme farmers care whether they will have access to irrigation water long enough to meet crop demand. That is why even in the opportunity where they measure buckets of irrigation water, the amount of water does not feature in the farmers, economics.

However, 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 although the existing regularly collected data is spatially and temporally inconsistent it makes a good basis 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	Temporal Consistency
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

Parameter	Normally Recorded or estimated by:	Spatial Consistency	Temporal Consistency
Crop production levels at district and national level	Administrators	Aggregates	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 this paper that the general understanding by different stakeholders, on productivity of water differs immersely 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. However, the different categories of stakeholders assess and keep recprds oof several aspects of the benefits and amount of water. On the basis of these records it is possible to make estimates on the current levels of productivity and thus initiate dialogue to develop the practice further. It is recommended that the basin dialogue on water be initiated to come up with acceptable tools for assessing productivity of water in agriculture. Eventually be able to device equitable water allocation procedures for basin uses and users.

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