KNOWLEDGE SHARING AND COMMUNICATION TOOLS FOR DIALOGUE ISSUES ON PRODUCTIVITY OF WATER IN AGRICULTURE: CASE STUDY OF MKOJI SUB CATCHMENT IN USANGU PLAINS, TANZANIA

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ABSTRACT

The concept of productivity of water in agriculture is new and understood differently by different stakeholders in Tanzania. Yet, to apply it all stakeholders require a common understanding. Currently there is a limited understanding of the concept to different stakeholders. This limits the potential for dialogue to enable concerns to be resolved. This study investigated knowledge sharing and communication tools suitable in facilitating dialogue among different stakeholders on the concept productivity of water in agriculture in Mkoji sub-catchment in the upper part of the Rufiji Basin, Tanzania. The study was based on a survey of multiple-stakeholders of water in the study area included direct water users in agriculture such as farmers, water resources and agricultural experts, and water managers of schemes. The survey covered 6 villages and involved 248 households selected randomly. The experts' category was formed by agricultural village extension officers, tutors from agricultural training institutes, Zonal irrigation officers, researchers from SHARDI Uyole, Rufiji basin water resources officers and local government leaders. A high proportion (87.5%) of the smallholder farmers indicated low awareness of the concept of productivity of water in agriculture as universally defined. Results indicated that options that farmers adopt in increasing PWA included minimum tillage, early planting, mixed cropping and planting drought resistant crops. The experts' category defined productivity of water as the ratio of total crop yield to the volume of water used. The main limitations were lack of technical know how and equipment's for measuring the volume of water used for crop production. Given the past experiences in the study area, knowledge sharing through farmers training, demonstration plots, field visits, radio and posters will assist in increasing the understanding by different stakeholders and thus improve dialogue. Communication and dialogue should be held among organization's that are operational in the Mkoji sub - catchment to influence productivity of water and water management.

Key words: Productivity of water in agriculture, Knowledge sharing, Dialogue, Communication tools, Stakeholders, Mkoji sub - catchment

INTRODUCTION

Productivity of water (PW) has been defined differently by different authors (Seckler *et al.*, 1998; Bastiaanssen *et al.*, 2003), but can simply be described as the ratio of benefits obtained to the amount of water that is quantitatively or qualitatively depleted during the process. The benefits may include biomass produced, the economic value of the produce or the value attached to the social benefit, e.g. good health resulting from sanitation made possible by the use of water (Dong *et al.*, 2001).

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The concept of productivity of water in agriculture is new and understood differently by different stakeholders. Yet, to apply it all stakeholders require a common understanding. Currently, there is a limited understanding of how the concept can be communicated to different stakeholders. This limits the potential for dialogue to enable concerns to be resolved (FAO, 2001). Dialogue is the interaction between people with different viewpoints, intent on learning from one another (Phillips, 1984). The purpose of this learning is to lay the foundation for creating new solutions. Dialogue differs from discussion, which focuses on each person presenting, advocating, or selling his or her point of view to others. The intent of discussion appears to be winning, or convincing others of your view. Each side tends to dig in deeper and hold more firmly to their view. Simultaneously, each side becomes more and more convinced that the other's position is untenable. Rigidity creeps in, polarization occurs and the distance between the viewpoints increases (Phillips, 1984). Taken to a logical extreme, discussion can escalate to litigation. Dialogue cannot occur when some people believe they have "the word" and that others do not (Phillips, 1984). Therefore, the purpose of this study was to investigate the knowledge sharing and communication tools for facilitating dialogue on issues of productivity of water in agriculture.

Objective of the study

The main objective of this study was to investigate the knowledge sharing and communication tools for facilitating dialogue on issues of productivity of water in agriculture. The specific objectives were as follows: To describe how different stakeholders conceive and understand the concept of productivity of water in agriculture. To identify the type and form of knowledge sharing tools suitable for each type of stakeholders. To evaluate knowledge sharing tools necessary for communication and dialogue on issues of productivity of water in agriculture at a catchment level.

RESEARCH METHODOLOGY

Study site

The Mkoji sub-catchment is drained by the Mkoji River and is located in the southwest of Tanzania, between latitudes 7°48' and 9°25' South, and longitudes 33°40' and 34°09' East (Figure 1). It is a sub-catchment of the Rufiji River Basin and covers an area of about 3,400 km². Most of the sub-catchment lies within Mbarali and Mbeya Rural Districts, while smaller portions of the sub-catchment lie within the Makete and Chunya Districts in Iringa and Mbeya Regions, respectively. According to the 2002 population census, Mkoji sub-catchment had a population of about 146,000 people with an average annual growth rate of 2.4%. The highest population density is found along the Tanzania-Zambia Highway and in the Southern highlands. Scattered villages are located in the plains.

The study area receives a unimodal type of rainfall starting from early November and ends in June. The annual rainfall is about 1500 mm in the highlands and ranges from 600 – 800 mm in the lowlands (SMUWC, 2001). There are five major perennial rivers and several seasonal streams, all of which drain in to the central plain. Over time, these surface flows have been used for both domestic and agricultural purposes in this area. According to Lankford (2000), the use of ground water is not commonly used in this area.

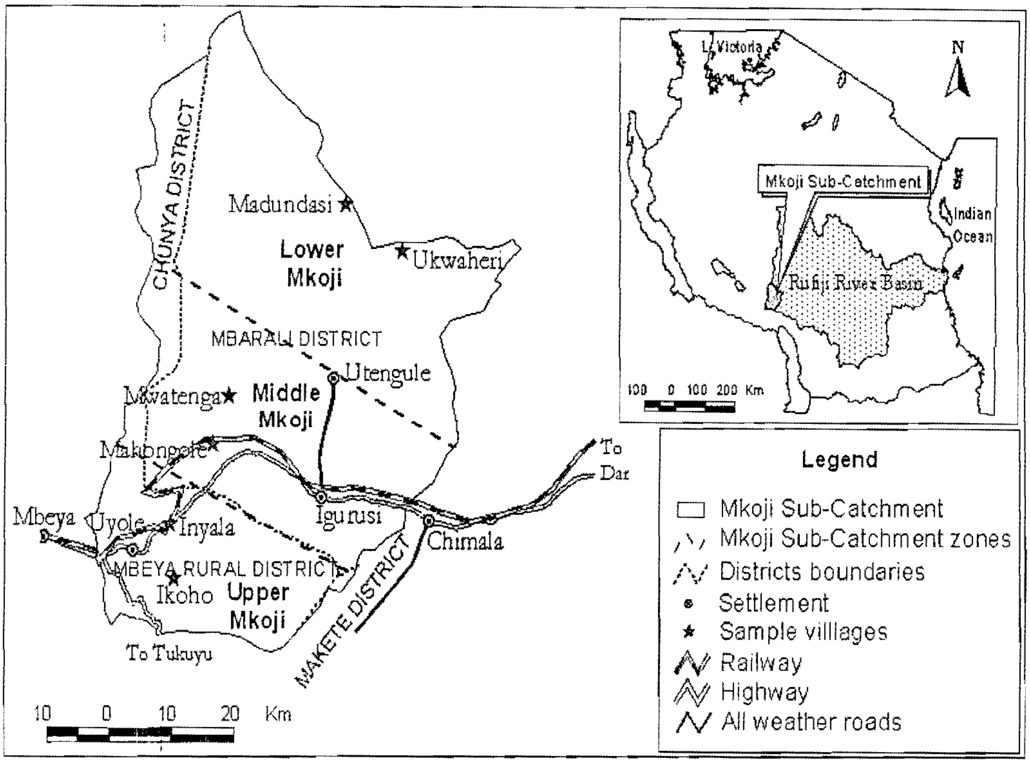

Figure 3: Map of the Mkoji sub-catchment and studied villages

Design and Sampling Procedures

The research involved sub catchment level households survey and employed a cross section research design in which data were collected at a single point in time without repetition from the target population using questionnaires and checklists. The design was used because it uses minimum time and resource (Bailey, 1978; Babbie, 1990).

Selection of sub-catchments and villages

The GRRB is made up of eleven sub-catchments. Including all the ten sub-catchments in this study would clearly be the best option, but due to the practical reality much attention was given to the Mkoji sub-catchment. The villages included in this study were mainly selected from the Mkoji sub-catchment and only a few from Mbarali. The Mkoji sub-catchment alone had 70 intakes with a capacity of abstracting 12 cubic metres of water per second with 100 percent abstraction efficiency (SMUWC, 2001)

Selection of villages

The Mkoji sub-catchment is large (about 3,400 Km^2) and was studied through random sampling of the villages and then the households within the villages (Table 1 and 2). The sub-catchment was therefore purposefully divided into three zones – upper (27 villages), middle (19 villages), and lower (7 villages). Two villages were purposively selected from each zone, to capture the variability in livelihood and production systems among the water users in the catchment (Table 4). The most important criteria used for selecting the villages were: (i) Sub-zonal representation within the major zone; (ii) Inclusion of a wide range of production systems (including irrigated and rain- fed crop production), and (iii) Availability of secondary data (Table 1 and 2).

Table 2: Selected study villages

Name of village	1st criterion	2nd criterion	3rd Criterion
Ikhoho	Upper	**Rain-fed (maize, potatoes and Wheat)**	RIPARWIN database and SHARDI reports
Inyala	Upper	Dry-season irrigation (maize, Beans, potatoes, vegetables)	RIPARWIN database and SHARDI reports
Mahongole	Middle	Dry season irrigation (maize, Beans, vegetables) and wet Season irrigation (paddy)	SMUWC and RIPARWIN Databases
Mwatenga	Middle	Wet season irrigation (paddy)	RIPARWIN database
Ukwaheri	Lower	Rainfed (maize, sorghum/millet) And livestock	SMUWC and RIPARWIN Databases
Madundasi	Lower	Rainfed (maize, sorghum/millet) And livestock	SMUWC and RIPARWIN Databases

Source: SWMRG, 2001.

Household sampling

The sampled households were drawn from the registers of the study villages on the basis of vulnerability/poverty groups. For each village the sample included about ten percent of the total households as well as ten percent of each vulnerability/poverty groups. Vulnerability relates to the presence of factors that place people's livelihood at risk of becoming food-insecure or malnourished, including those factors that affect their ability to cope. Vulnerable groups living in the agro-ecological zones within the targeted agricultural production systems were identified and their conditions assessed (Table 3). There is a wide range of both internal and external factors that contribute to vulnerability of households to food insecurity. The internal factors are numerous, and relate to the socio-economic position of an individual or a group, physical constraints, culture or geo-political situations. The external factors may include changes in the social, physical, economic and/or natural environment. The study analysed a multiplicity of these factors in as much as they interact with the productivity of water in agriculture conditionality parameters. The selection was random within each category. The total sampled household was 248. Table 3 shows characteristics of the wealth categories that emerged from the exercise.

Table 3: Characteristics of wealth groups in the study area

Variables	Poor	Middle	Wealth
Total land irrigable (ha)	<0.4	0.3 –1.2	>1.2
Livestock owned	Cattle:0 Chicken 1-5	Cattle: 1-5 Shoats: variable Chicken: 8-24	Cattle: >8
Farm tools used	Hand hoe	Hand hoe	Hand hoe and ox-plough
Type of labour used	Family labor	Family and casual Labour	Family labour, casual labor

Source: Survey data, 2003.

Selection of sample households in the sampled villages

In order to map up water linkages with poverty among households, a participatory wealth ranking technique was used. The wealth ranking criteria included such variables like livestock holding, area under cultivation, access to irrigable land and access to water. The exercise allowed the researcher to stratify households and classified as poor, middle and well off. The stratification was based on the villagers' own criteria for wealth ranking obtained during the session. A sample of 248 households was randomly drawn from the list of stratified households in each village included in the study. The total sample contained 108 households from the poor wealth group, 124 households from the middle group and 16 households from the well-off group. The distribution of households by wealth rank in the catchment is shown in the Table 6 below.

Table 4: Distribution of households by wealth rank

Location	Poor	Middle	Well-off	Total
Upper zone villages	38	42	6	86
Mid-zone villages	32	36	4	72
Lower zone villages	38	46	6	90
Total	108	124	16	248

Source: Survey data, 2003.

Respondents characteristics

The study was based on a survey of multiple-stakeholders of water in the study area, including direct water users in agriculture namely farmers, water resources and agricultural experts, and water managers especially in irrigated systems. The survey of smallholder farmers covered 6 villages and 248 households selected randomly (Table 5)

Other stakeholders included village agriculture extension officers, MATI Igurusi tutors, southern highland zonal irrigation officers, SHARDI Uyole researchers, Rufiji basin water officers and local government leaders who were considered as indirect water users. Table 6 below shows indirect water users distribution (stakeholders) most of who were extension officers, trainers of extension officers, irrigation technician, researchers and water managers.

Table 6: Distribution of other stakeholders' and their institutions (N = 95)

Institution	Number	Percent
MATI Igurusi tutors	16	16.8
MATI Igurusi students	20	21.1
SHARDI Uyole	20	21.1
Zonal irrigation office	15	15.7
Agricultural village extension of Ficers	14	14.7
Water managers	10	10.6
Total	95	100

Source: Survey data, 2003.

Data collection

For the three specific objectives, Participatory Rural appraisal, Focus group discussions and household surveys were employed in data collection. The study employed qualitative approach through focus group discussions. The sub catchment was divided into three zones namely upper, middle and lower. Preliminary visits were done to the six sampled villages. Ikhoho and Inyala in the upper zone; Mahongole and Mwatenga in mid zone; and Ukwaheri and Madundasi in the lower zones. The purpose of the visits was to explain to the villagers and their leaders the purpose of the study and to ask them to join the focus group discussions. The criteria for the selection of the villagers' representatives was to have equal representation of village clusters, water users, wealth categories based on their ages and gender. Representatives, who were also key informants, were selected based on the fact that they were knowledgeable on issues of water management. The study also employed qualitative approach through focus group discussions with key informants and Districts Officials. Different FGD were held for MATI Igurusi tutors, SHARDI Uyole, water managers, RBWO officers and irrigation managers.

Establishing validity and reliability

The first draft of the questionnaires was pre- tested at Mahongole village, one of the villages in the project. Ten farmers and two agriculture extension officers participated in the pre-test. The pre-test group was completely different from the one used in the main study. After pre testing, the instruments were submitted to SUA experts, who read it and made necessary changes before producing the final draft of the questionnaires.

Data collection in the sampled households

Structured questionnaires were used to collect data from the sampled households, and the survey was conducted between November and December 2003. The questionnaire included both open and closed - end questions and the intended respondents were household heads in the selected villages.

Secondary data

Secondary data used included quantities of water, river flows, rainfall data and volumes of abstraction. Methods included reviewing reports of previous studies conducted in the study area. Major sources of secondary data were the Soil Water Management Research Group (SWRMG) offices in Morogoro and Igurusi in Mbeya, Sokoine National Agricultural library (SNAL) SUA, Morogoro, and Ministry of Water and Livestock Development (MWLD), the river basin offices (RBO) in Dar-es-salaam and Mbarali and Iringa

Data Analysis

Quantitative analysis

Data collected using questionnaires were reduced, summarised, coded and entered in the Statistical Package for Social Science (SPSS) computer software and later analysed. Descriptive statistics such as frequencies, means and cross-tabulations were used to display data and later in writing the study results.

Qualitative analysis

According to Kanbur (2001), there is a growing recognition that sensible combination of qualitative and quantitative methods can help solve problems that are associated with each type of method taken separately. Booth *et al.* (1998) urged that qualitative method in particular, are often more appropriate for capturing the social and institutional context of people's lives than the quantitative methods. In view of these considerations, the study employed the qualitative method and quantitative component to assess the stakeholders' understanding of PWA in the Mkoji sub-catchment. Structural analysis was employed in the analysis of documented information and qualitative data collected during the PRA session. Structural Analyses such as River Basin Game (RBG) contributed in the analysis as was used to attach meaning to the collected qualitative information. The information generated by interviews, focus group discussion and observational data was described and summarised. Further, the relationship was sought between information and specific objectives. Implications for policy or practice were derived from the data and interpretation.

Conceptual Framework of the Study

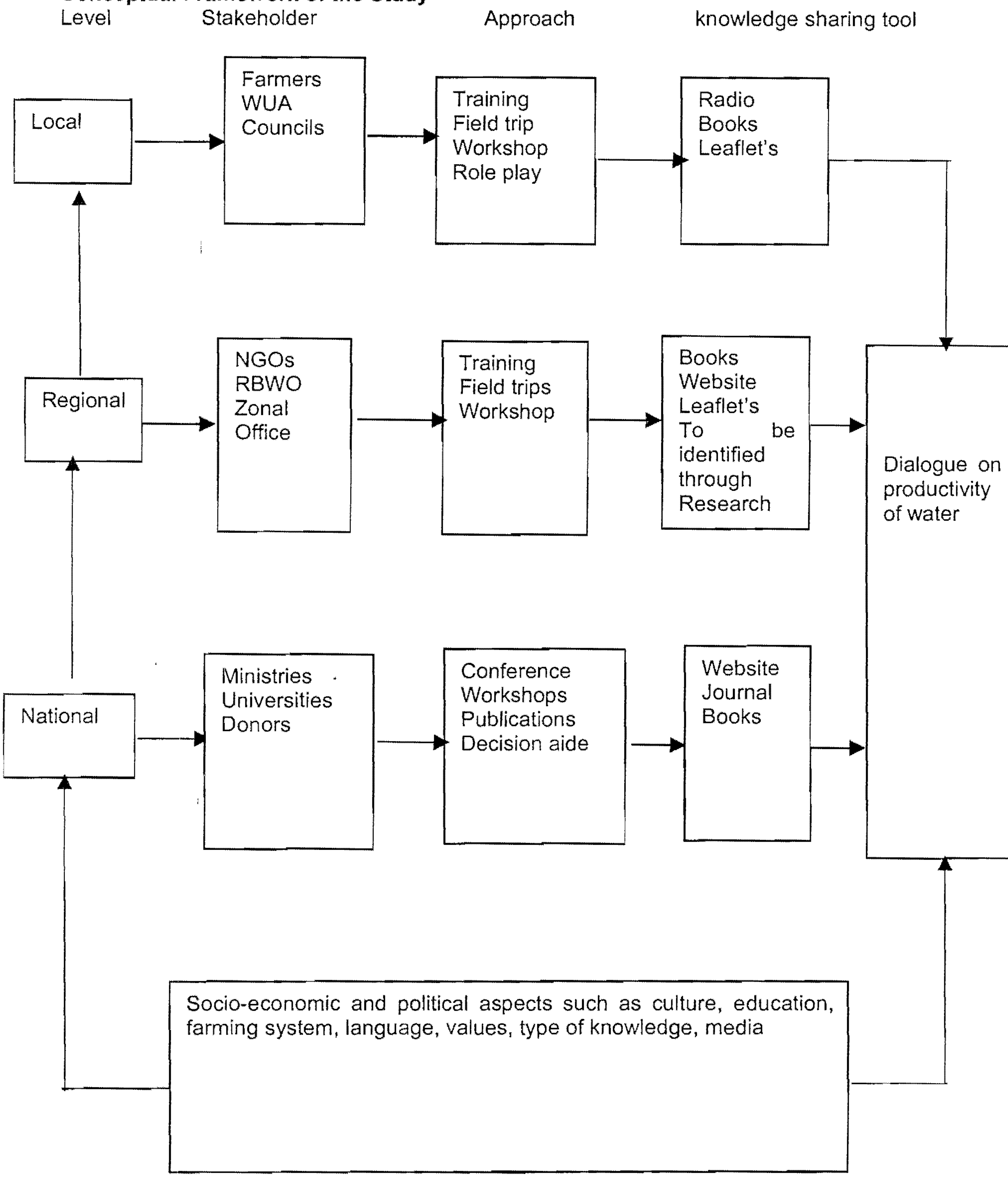

Figure 2:Conceptual framework of the study

The framework considers the importance of knowledge sharing and communication among stakeholders. It shows the process of sharing or conveying information and knowledge from the local level to national level. Further, it shows best knowledge sharing and communication tools for different stakeholders for facilitating dialogue on issues of productivity of water in agriculture.

RESULTS AND DISCUSSIONS

Respondents' Understanding of PWA

Focus group discussions were held for the selected villages. Participants described the concept of PWA as new and not measuring the volume of water used to produce crops. However, it was revealed that farmers had their own way of describing PWA by referring to good or bad rainfall year. Box 1 abstract views of the water users in Mwatenga village (mid-zone of Mkoji sub-catchment) during the FGD session on how they understood the productivity of water in agriculture.

Box 1: Mwatenga village focus group discussion views on perception of PWA

The concept of PWA is new in the village. Normally, farmers ask themselves whether there is progress forward or backward. Productivity of water is explained by referring to good rainfall years. The Sangu ethnic describe PWA as 'Mwagka ughu matile deni' or 'ikienye ikhi ngavile fijo' (there was few harvests this season) while description by the Sangu ethinic participants, "mwaka gwanu mwaka mnofu a malenga enonya ninji" meaning that year there was good rainfall and plenty of water.

Education of respondent by their description of PWA

The results in Table 7 show the responses on education level by smallholder farmers' understanding of productivity of water in agriculture in percentage. Out of the 248 respondents, 242 (97.6%) gave their responses, and 212(87.6%) indicated that they did not understand the concept of PWA. Of the 212 respondents, 72 (29.8%), 32 (13.2%), 128 (52.9%), 5 (2.1%), 4 (1.7%), 1(0.4%) indicated that they had non formal education, had attained standard four, standard seven, standard eight, form four, and higher education level, respectively. There were no significance differences between group means of education levels and the perception of PWA at $p<0.05$. However, the study found that those who had attained standard seven level of education were in the majority and too did not understand PWA.

Table 7: Education level by smallholders farmers understanding of PWA%(N= 242)

	Knowledge on Water productivity in agriculture				
Education of respondents	Yes	No	Total	X^2	p value
No formal education	6(2.5)	66(27.3)	72(29.8)	5.422	0.367
Standard four	4(1.7)	28(11.6)	32(13.2)		
Standard seven	17(7.0)	111(45.9)	128(52.9)		
Standard eight	2(0.8)	3(1.2)	5(2.1)		
Form four	1(0.4)	3(1.2)	4(1.7)		
Higher education	0(0.0)	1(0.4)	1(0.4)		
Total	30(12.4)	212(87.6)	242(100.0)		

Source: Survey data, 2003; Figures in parentheses are percentages and those out of parentheses are frequencies; not significant at $p< 0.05$.

The reason for low knowledge on PWA might be twofold. First, the few who were aware of PWA might had attended farmers training courses conducted by the MAFS, and this further implied that most respondents were not aware of the scientific knowledge of PWA. Second, there was lack of agriculture extension officers in the study areas, which was seen in the low level of PWA among smallholder farmers.
Figure 4 shows the study results and that there was little understanding of PWA except those with standard seven educations.

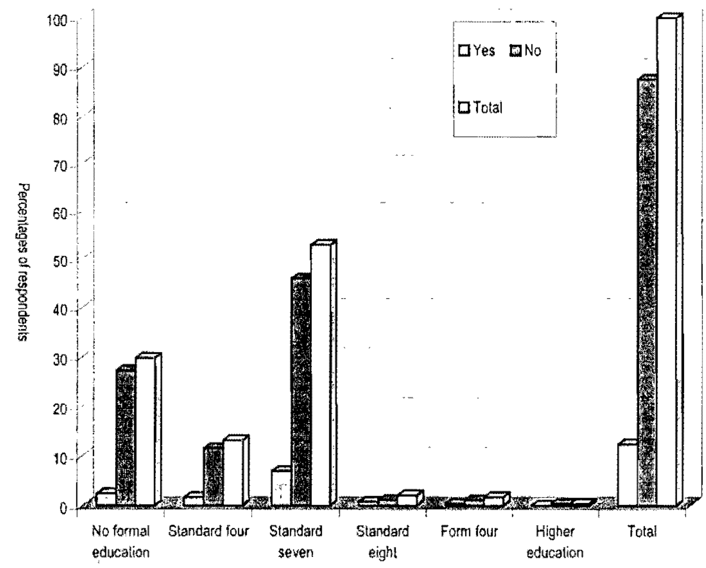

Figure 4: Percentages of respondents by educational level

Box 2 abstract views of the water users in Mahongole village (mid- zone of Mkoji sub-catchment) during the FGD session on the meaning of PWA. FGD participants said that in the past there was no need to consider productivity of water because there was sufficient rainfall and soils were fertile. They said that water use for agriculture differed by spatial and temporal, and the crop stages some villages could harvest more and others little crop yields as there were good and bad years. Participants also said that because there was enough water some farmers allowed water to flow to their neighbours crop fields, which lowered field temperatures and paddy yields.

Box 2: Mahongole villagers' views on the perception of the knowledge of PWA

The concept of PWA is new and we hear it from you for the first time. It might be related to application of less water for more paddy yield. But, soils have been depleted of fertility and one need to put more water to suppress weeds. Because of weeds, we are compelled to allow water for some days in the paddy bunds. This increases the amounts of water used in paddy production, and hence reducing productivity of water in agriculture.

Most farmers' fields in the village were not well leveled and not square like those of Kapunga state rice farm. It was difficult to measure the volume of water used in this cascading pattern of fields whereby the paddy fields for individual smallholder farmers are linked with small water canals. It was difficult to measure the volume of water used in paddy production. The PWA concept is good but the government should construct water reservoir and have agriculture extension officers in the village to advise smallholder farmers, Mr Juma Mwakanyamale the chairman of Mahongole village commented.

Another focus group discussions were conducted at Ipatagwa irrigation scheme. Three hundreds and thirty (330) members formed the association in 1997. In May 2004, female members were ninety one (91), whereas male members are two hundreds and twenty nine (229). According to the chairman, the reasons for forming the WUA were to modern intakes instead of *dindilo* (traditional intake), repair of irrigation canals to direct water into the field. Farmers joined so that they could get government assistance, get more water and loans. Regarding the perception of PWA, some members had an idea following a farmer' training course conducted by MAFS in 2003. In the dry season, members of this association practice bottom valley farming in which they grow maize during the dry season, plants on plot get bucket twenty litres of water and thirty (30) buckets of water per day for 30 days are irrigated. The maize harvest is usually one bag of 100 kgs per plot. Participants in the FGD described PWA as the crop yield obtained after proper use of water. However, farmers were not practicing due to lack of skill. The little knowledge was obtained from farmers training. Box 3 shows the abstracts of views of the Ipatagwa farmers who participated in the FGD on their understanding of PWA

Box 3: Ipatagwa farmers' association views on the perceptions of PWA

This concept of PWA is not new for members of Ipatagwa farmers association. Productivity of water in agriculture is understood as the crop yield obtained after proper use of water. In this farmers association proper use of water is critical in crop production as water is for poverty alleviation and food security. However, farmers do not measure the volume of water used for crop production.

Gender of respondents by their understanding of PWA

Cross tabulation was done between gender and the respondents' understanding of PWA. The study results in Table 12 show that of the 248 respondents, 217 (87.5%) indicated that they did not understand PWA. Of the 31 (12.5%) respondents who indicated that they understood PWA, 28 (11.3%) and 3 (1.2%) were males and females, respectively. Furthermore, of the 217 (87.5%) who did not understand PWA, 184 (74.2%) and 33 (13.3%) were males and females respectively. There was no significance difference between means of the groups at $p < 0.05$ while the statistical value was very low implying that no relationship existed between gender and their understanding of PWA (Table 11).

Table 8: Gender of respondents by understanding of PWA in % (N= 248)

Gender	Knowledge on Water productivity in agriculture				
	Yes	No	Total	X^2	p value
Male	28(11.3)	184(74.2)	212(85.5)	0.587	0.306
Female	3(1.2)	33(13.3)	36(14.5)		
Total	31(12.5)	217(87.5))	248(100.0)(		

Source: Survey data, 2003; Figures in parentheses are percentages and those out of parentheses are frequencies; not significant at $p < 0.05$.

Furthermore, the study found that few females, 3 (1.2%) understood the concept of PWA, implying that most females were not aware of the concept of PWA, which might have been due to lack of agriculture extension officers to teach them. Though it was possible that most females measured the crop harvested but not the volume of water used to produce it. It also implied that probably female respondents did not access some of the interventions sent to the villages. However, respondents and other informants agreed that they had indigenous knowledge related to PWA. Box 4 shows the abstract of the key informants' views in Ukwaheri village in the lower Mkoji sub - catchment, which shows that they used indigenous knowledge to improve the productivity of water during water scarcity periods. For example adoption of minimum tillage, early planting, mixed cropping and planting drought resistant crops indicated that they were aware of PWA.

Box 4: Ukwaheri villagers' views on their perception of PWA

The concept of PWA is new in the village, but the soils in the lower zone are fertile because we have been harvesting 10 to 15 bags of maize per acre without use of fertilizers. Due to unreliable rainfall, we have some coping strategies like planting mixed crop (sorghum, groundnuts and green grams). We plant drought resistant crops like sorghum and cassava, and practice flat cultivation in order to increase crop yields. We are still growing local crop varieties because of high yielding, early maturing and are drought resistant. Recently, the Sukuma ethnic people have introduced new technology of planting a leguminous plant known as chick peas (*Cicer arietinum*) '*dengu*' immediately after paddy h arvest to exploit the available moisture content. Apart from food, the crop produce is sold at high price (Tshs 13, 000/= per 20 kg) during the dry season, other ethnic groups have started adapting it.

Understanding of PWA by other stakeholders

Different FGD sessions were held to capture the understanding of PWA by other stakeholders, and these include MATI Igurusi tutors, village agriculture extension officers, water managers from RBWO, and local village government leaders. Sixteen (16) agricultural tutors from MATI Igurusi were involved in the FGD session. The institute trained irrigation technicians and smallholder farmers in good water management. Of the 16 tutors, 4 (25%) indicated that they understood PWA and 12 (75%) said that it was new knowledge to them. MATI tutors described PWA as the amount of crop harvest per volume of water used, but indicated that it was difficult to quantify the volume of water used in the crop production, especially in the rain-fed agriculture. Furthermore, there was lack of technical know how and equipment's for measuring the volume of water used for crop production. For those who said that the concept of productivity of water in agriculture was new to them as it was not included in the syllabi for both irrigation and land use planning diploma courses at the institute.

Furthermore, some tutors from MATI Igurusi related the concept of PWA with irrigation efficiency, which was described as the ratio of the amount of water required for an intended purpose, divided by the total amount of water diverted. Such description was similar to that given by Wolters and Bos (1989) and Jensen (1980). Other defined PWA as the amount of crop harvested per unit volume of water used. FGD participants agreed that definition of PWA, a similar description given by Viets (1962), Tabbal *et al.* (1992), Molden (1997) that productivity of water in agriculture was the amount of food produced per unit volume of water used. This implied that water used in crop production had various components (evaporation, transpiration, gross inflow, and net inflow) hence it was important to specify which component was included when calculating the productivity of water (Tuong and Bhiyan, 1997, Molden, 1997). Hence, water efficiency and productivity concepts should be used in conjunction to assess water management strategies and practices to produce more food with less water.

Mkoji sub - catchment had few agriculture village extension officers. Of the six sampled villages, only two villages had village agriculture extension officers, which included Inyala and Mahongole of the upper and middle zones, respectively. Of the two VEO's none of them had knowledge of PWA. This idea was considered new for them. The farmers as well are not aware because of lack of know how. Box 5 shows the abstracts of the VEOs views describing their understanding of PWA.

Box 5:Inyala village extension officer views on perception of PWA

We are not measuring the volume of water used in crop production, but traditionally the cultivated area is measured and every one can tell how much is harvested per acre. Crop harvests per unit land have been improved because new agronomical practices had been adopted by farmers, these include early planting, use of improved seeds, application of fertilizers timely weeding, proper spacing, use of insecticide and fungicide, and adoption of dry season farming. Agriculture extension officers taught these practices.

Participants from the Southern Highland Agriculture Research Development Institute (SHARDI) at Uyole described PWA as the ratio of total crop harvested to the volume of water used. Other SHARDI Uyole participants in the FGD said that productivity of water in agriculture could be increase yield per unit land, by using better varieties or agronomic practices, or by growing crops during the most suitable periods. The implications of such explanations were that productivity of water could be determined by factors other those within the water management. This implied that productivity of water alone would not be particularly useful in identifying saving opportunities of the system under consideration. Basically, researchers conceptualized the knowledge of PWA as all benefits of using water. The benefits include biomass and are classified as food grain, fodder and crop residues. The purpose is to meet household food security and sustainable maintenance of soil fertility.

Further, participants said that researchers have attitudes that assessed PWA using two main components of productivity of water: the physical mass of production or the economic value of produce and the unit volume of water used. Researchers acknowledged the multiple use of water in irrigated water system, but most of these uses are not accounted for in many irrigated water systems even though the users claim a large amount of water. The simple reason being that some of these uses are not easy to quantify. Box 6 shows the abstracts of the researcher's views on their understanding of PWA.

Box 6: Researchers views on their perception of PWA

Productivity of water in agriculture is the ratio of crop benefit to the volume of water used, one participant explained. Researchers record irrigation flow diverted for crop production, weather data, evaporation pan data, soil hydrologic properties and crop water requirement to determine the denominator of productivity of water. Direct measurement of water used/depletion from irrigated field and productivity of water can be done on the field by quantifying water accounting components such as transpiration or evapotranspiration, runoff and drainage from the crop field.

RBWO was responsible for water management, granting water rights, and allocation and collection of water user fees and co-ordination of stakeholders towards better water management. The RBWO has established a sub office in the Mbarali district, which among other things, monitors river water levels, collects water use fees, and arbitrates conflicts that arise from water uses. With regard to their understanding of productivity of water in agriculture few of the RBWO officers understood it. The areas and amounts of water under different agricultural domains in Mkoji sub-catchment were provided.

Figures 5 and 6 shows the area under different agricultural domains and the corresponding amount of water used for each production domain in Mkoji sub -catchment. The area under rainfed production was lager in lower Mkoji sub-catchment followed by middle and upper Mkoji sub-catchment, respectively. The volume of water consumed by crops was also comparably higher in the lower part of the sub-catchment. The area under dry season irrigation was higher in the upper Mkoji sub-catchment than in the middle Mkoji sub-catchment (FNPP, 2003). For example, paddy was cultivated under irrigation supplemented with rainfall in the middle Mkoji sub-catchment. In 2002, crop water use for the middle part of the sub-catchment was 14.55Mm^3 while for the lower part were 20.52Mm^3 and the total water use for Mkoji sub-catchment was estimated at 35.52Mm^3 (FNPP, 2003). The total area for paddy rice production in mid zone was 2,194 ha and for lower zone was 3,072 ha (FNPP, 2003).

Both formal and informal institutions in the Mkoji sub-catchment regulate water use. Informal arrangements were negotiations and agreements on who should get water, when, how. Water users themselves without influence from outside regulated water use, which was based on cultural and traditional values. For example, in the upper zone, people trust their chiefs- called *mwene*. In the past, a *mwene was* used to oversee conservation of water sources by banning tree cutting and perform rituals to rainfall and extended drought periods. A Mwene was also a chairperson for the environment sub committee of the village government. The implication of this was that people might have some knowledge on the productivity of water but not able to quantify the volume used. Both formal and informal institutions in the Mkoji sub-catchment were reported to regulate water use from the catchment to farm level. These institutions negotiated and agreed on who should get water, at what time, and how.

The study also found that village water committees and irrigation committees carried out the formal arrangements. The village water committees were responsible for domestic water use while the irrigation committees supervised water use oversees irrigation water. In places where there were improved irrigation schemes like in the Ipatagwa, Motombaya, Luanda majenje and Majengo the irrigation committees were more active and responsible for allocation and management of irrigation water use. The irrigation committees were referred to as Water User Associations (WUAs) although they do not operate as WUAs. Most existing irrigation schemes were in the process of forming WUAs. The water policy of 2002 recognizes WUAs as the lowest level of water management organization and promotes their formation (MWALD, 2002). The basin water offices were expected to coordinate the process of the WUAs formation in collaboration with local water users and stakeholders. This meant that there were possibilities of measuring the volume of water, which would improve the productivity of water in agriculture.

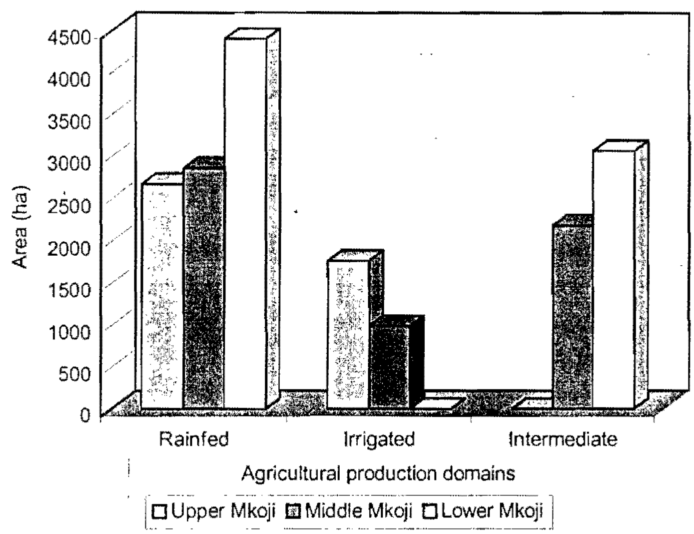

Figure 5: Area under different agricultural domains in Mkoji sub-catchment

Figures 6 and 7 shows the area under different agricultural domains and the corresponding amount of water used for each production domain in Mkoji sub - catchment. The area under rainfed production was lager in lower Mkoji sub-catchment followed by middle and upper Mkoji sub-catchment respectively. The volume of water consumed by crops was also comparably higher in the lower part of the sub-catchment. The area under dry season irrigation was higher in the upper than in the middle Mkoji sub-catchment. This implied that farmers in the sub catchment inevitably required the knowledge of PWA to reduce the volume of water used.

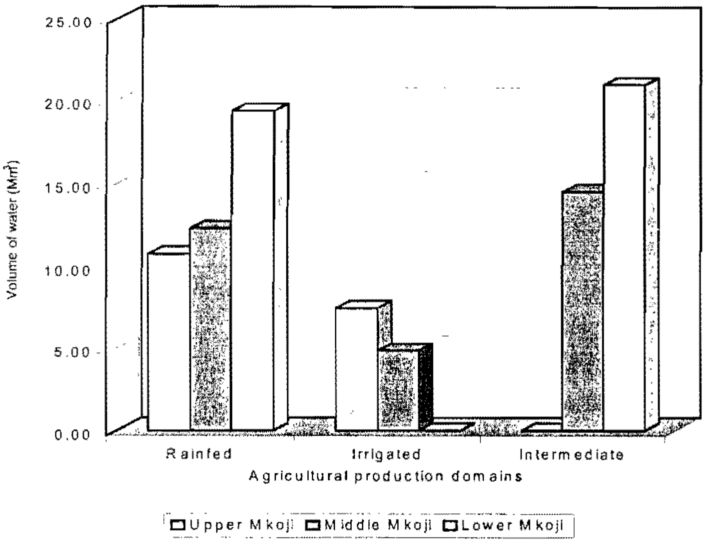

Figure 6: Crop water use under different agricultural domains in Mkoji sub-catchment

Knowledge Sharing Tools Suitable for Each Type of Stakeholder

Sharing knowledge is a social activity and so social implications of knowledge sharing systems need to be considered and used to help design processes and tools that are actually useful. In a complete knowledge sharing system tools to support finding the right person or group of people are required. Once connected people need to be able to share what they know. The information space in which knowledge is shared needs to be effective in supporting the knowledge sharing tasks. Relevant information (documents, data, etc) should be readily available and delivered in a form appropriate to the participant. Other tools to support the participant's understanding of the relationships between all participants may help. Understanding the dynamics of those relationships between participants and the knowledge or information they are sharing increases awareness and understanding. Communication practices and processes need to be designed to encourage the sharing of knowledge whether through synchronous or asynchronous communication (http://radio.weblogs.com). Evaluations of knowledge sharing systems in real environments are invaluable in determining what is useful, what works and what does not. Such evaluations help technologists determine what to improve.

Knowledge sharing tools for smallholder farmers

A questionnaire survey was conducted in Mkoji sub - catchment to identify types and forms of the knowledge sharing tools suitable for each stakeholder for improving PWA. Focus group discussions sessions were held with stakeholders to identify the suitable knowledge sharing tools. Furthermore, key informant interviews were conducted to capture the same information. The subsequent section discusses the results of the study findings.

Table 12: Knowledge sharing tools by respondents' village in % (N = 245)

Knowledge sharing tools	Location of the village on the toposequence				X^2	p value
	Upper	Middle	Lower	Total		
Flip chart	35(14.1)	49(1.6)	43(17.3)	82(33.1)	174.368	0.000
Blackboard	3(1.2)	1(0.4)	15(6.0)	19(7.7)		
Demonstration plot	21(8.5)	5(2.0)	7(2.8)	33(13.3)		
Pamphlets	3(1.2)	61(24.6)	11(4.4)	75(30.2)		
Flip charts and demo plots	22(8.9)	0(0.0)	15(6.0)	37(14.9)		
Posters	2(0.8)	0(0.0)	0(0.0)	2(0.8)		
Total	86(34.7)	71(28.6)	91(36.70	248(100.0)		

Source: Survey data, 2003; Figures in parentheses are percentages and those out of parentheses are frequencies; not significant at p< 0.001.

Table 12 above shows the relationship between the most used knowledge sharing tools and geographical location of respondents. Results show that there was a significance difference at p< 0.001 between the means of the group between the most used knowledge sharing tools and the geographical location of respondents. That meant there was strong relationship between the most used knowledge sharing tools and the geographical location of the respondents. The study findings showed that the most used knowledge-sharing tool was flip chart 82 (33.1%) followed by pamphlets 75 (30.2%), and demonstration plots 33 (13.3 %). The implication of the findings was that facilitators used much theory methods rather that practical method, which meant participants might not have understood the intended intervention. Furthermore, probably there was lack of appropriate communication skills by agriculture extension officers.

Table 13 shows the relationship between location of respondents and the best knowledge-sharing tool for farmers training. The study found that 56.3 percentage of respondents chose demonstration method as the best method for farmers training. The second most suitable method was farm visits ((18.8%) followed by radio (12.5%). The data shows that there were significance differences between the best knowledge-sharing tool and the location of the of the respondents at p<0.01. This implied that there was relationship between location of the village of respondents and the best knowledge sharing tools for training farmers on the productivity of water.

Table 13: Location of respondents and best knowledge sharing tool (N =16)

Knowledge sharing tool	Location of the respondents			Total	X^2	P value
	Upper	Middle	Lower			
Farm visits	6.3	12.5	0.0	18.8	20.571	0.008
Booklets	0.0	0.0	6.3	6.3		
Demonstration	37.5	18.8	0.0	56.3		
Pamphlets	0.0	6.3	0.0	6.3		
Radio	0.0	12.5	0.0	12.5		
Total	43.8	50.0	6.3	100.0		

Source: Survey data, 200; Figures in parentheses are percentages and those out of parentheses are frequencies; significant at p< 0.01.

Similar results were obtained from focus group discussion sessions. Pair wise ranking for the knowledge sharing tools was conducted during focus group discussion sessions. The result in Table 14 shows the best knowledge-sharing tool for farmers training in Mahongole village mid Mkoji sub-catchment. High score was recorded for demonstration methods (53.4%), meaning that smallholder farmers possibly wanted to learn by doing rather than hearing and observation. Other village results for pair wise ranking had similar results. However, other participants requested books for further references in the absence of the facilitator.

Table 14: Pair wise ranking scores for best knowledge sharing tool by FGD participants at Mahongole village (N=15)

Method	Vote	Percentage	Remarks
Demonstration	8	53.4	Best bet method
Field visit	3	20.0	
Booklets	2	13.3	
Posters	0	0.0	
Pamphlets	2	13.3	
Total	15	100.0	

Source: Field survey, 2003.

Participants in the focus group discussions described exchange of idea as the best knowledge sharing tools as the exchange of ideas between individual farmers and scientist. Traditionally, farmers have their own ways of exchanging information as was explained by the Sangu ethinic *'tipelana mawazo uluhala numiayangu'* meaning that we exchange ideas with a friend.

For example, smallholders exchanged ideas of changing from cultivating one crop to another for improving crop yields and this was believed to preserve soil fertility and water. These findings implied that probably smallholder farmers had a wealth of knowledge that needed to be integrated by the scientific knowledge paradigm to improve productivity of water in agriculture. But, suitable knowledge sharing tools were needed to communicate this knowledge. Participant at Mwatenga FGD described knowledge sharing as exchange of idea and common for farmers. Box 7 shows the abstracts of the Mahongole village views on knowledge sharing tools.

Box 7: Mahongole villagers' views on perception of knowledge sharing

Knowledge sharing means telling a farmer friend about profitable operation in crop production or farmer to farmer extension or advice another farmer. The kyusa ethnic describe it as kupelania unogono (give another person a farming technique), while the Sangu ethnic describe as tipelanila luhala (give a fellow farmer a farming technique, the Safwa ethnic describe as tipelana injele ((give another a technique to solve a problem). The importance is to educate each other, improve production and share idea. For example, I was told by a friend to plant TMV 1 maize variety in dry season because are resistant to maize streak.

Knowledge sharing tools for communication and dialogue used by other stakeholders

The in-depth interviews with trainers, researchers, agriculture extension workers and water managers from Mbarali and Mbeya rural Districts indicated that agricultural shows, campaigns, study tours, video cassettes, method and results demonstrations were useful when imparting knowledge to farmers. These group methods motivated agriculture village extension officers to increase the awareness of the productivity of water in agriculture. Stakeholders further insisted that experts should use combinations of methods, and most agreed that demonstration plots were the suitable knowledge-sharing tools.

Furthermore, since productivity of water in agriculture was a new idea, stakeholders said that reference books, leaflets, newsletters, scientific journals, and web based knowledge-sharing tools be available. However, it was difficult to secure reference books and in most cases their prices were not affordable. The cost and availability of the knowledge sharing tools was another limiting factor. Most stakeholders showed interest on the web - based knowledge sharing tools, as it was accessible to most of them, cheaper, with current information and the language was well understood.

MATI Igurusi tutors expressed their concern about lack of knowledge sharing tools among stakeholders. The institute has obsolete books, teaching aids and equipments, that are necessary for knowledge sharing, and lacked of knowledge on using knowledge sharing tools like web sites. In the institute, only two tutors were able to access the internet services because of lack of knowledge. In the past, knowledge was mostly acquired through formal training and lasted a lifetime but not now. Box 8 shows the abstracts of the MATI Igurusi participant views on knowledge sharing tools.

Box 8: MATI Igurusi participants' views on perception to knowledge sharing

Knowledge sharing means reading books, attending workshop or any training and visiting World Wide Web for information. Further, story telling or advice by a friend implies sharing knowledge. However, the institute has obsolete books and lack internet facilities. Most of the tutors are computer illiterate. This is a bottleneck to knowledge sharing.

At Mbarali District, participants in a focus group discussion said that SMWUC project developed a communications programme as it involved stakeholders in planning for Usangu's future. Participants need to get opportunities to discuss and debate issues together. To do this SMUWC developed a targeted communication programme, using a variety of approaches from the written word, to video, theatre, displays, workshops and talks. This approach had introduced a kind of knowledge sharing in the District. SMUWC had developed the following materials to build on people's knowledge sharing issues in Usangu: talking about Usangu, bilingual booklet and video: basic information on issues in Usangu, in a non-technical and visual way. The booklet contains a reply card for people to send back their views on Usangu. Talking about Usangu leaflet, a quick introduction to Usangu and its issues, and invites people to ask for more information; understanding Usangu. A series of fact sheets that explain in more depth some of the issues introduced in 'Talking about Usangu', again in a non-technical and visual way; Quarterly newsletters, which help keep people up to date on what is happening in Usangu. Recognizing the diversity of readership, separate newsletters have been prepared for communities (in Kiswahili) and for higher-level stakeholders (in English).

The Rufiji Basin Water Board (RBWB) was established in 1993/4. It meets at least twice per year as mandated under the legislation, the main business of the meetings being to advise on the various activities of the Rufiji Basin Water Office (RBWO). The RBWO is authorized to grant water rights. The RBWO has established a sub office in the Mbarali district, which among other things, effects monitoring of river water levels, collection of water use fees and arbitrating in conflicts that arise from water uses.

Best Knowledge Sharing Tools for Communication and Dialogue on PWA.

Respondents and other stakeholders were interviewed on their best-bet knowledge sharing tools. Each respondent had different views regarding which should be the best tool for communication and dialogue for improving productivity of water in agriculture.

Best knowledge sharing tools by trainers and researchers

Farmers were asked to evaluate the existing knowledge sharing tools currently used in Mkoji sub - catchment. Table 15 below show that out of the 220 respondents, 85 (38.6 %), 9 (4.1%), 8 (3.6%), 65 (29.5%), 12 ((5.5%), 36 (16.4%), 2 (0.9%), 3 (1.4%) indicated radio, television, leaflets, reference books, cinema, video cassettes, news papers and poster as the best s knowledge sharing tools, respectively. There was significance difference between group means ($p < 0.01$) and high statistical value meaning that there was a strong relationship between a location of village and the best knowledge sharing tool when training farmers on PWA training. About one third of the respondents 85 (38.6%) showed that radio was the best knowledge sharing tool because farmers afforded it. Newspapers and posters had 0.9% and 1.4% least scores. The implication of the study findings was that because agriculture extension officers could not reach most respondents, the radio was the best method. In addition, the radio as a mass communication method reaches many farmers within a short time compared to other knowledge sharing tools. But some participants in the focus group discussions objected saying that the radio programmes were inappropriate due to the broadcasting time.

Table 15: Location of respondents by the best tools for training on PWA (N = 220)

Best knowledge sharing tool for training PWA	Upper	Middle	Lower	Total	X^2	p value
Radio	18(8.2)	23(10.5)	44(20.0)	85(38.6)	38.775	0.000
Television	7(3.2)	1 (0.5)	1(0.5)	9(4.1)		
Leaflets	5(2.3)	2(0.9)	1(0.5)	8(3.6)		
Books	19(8.6)	25(11.4)	21(9.5)	65(29.5)		
Cinema	5(2.3)	5(2.3)	2(0.9)	12(5.5)		
Videos	7(3.2	11(5.0	18(8.2	36(16.4		
Newspaper	2(0.9)	0(0.0)	0(0.0)	2(0.9)		
Posters	3(1.4)	0(0.0)	0(0.0)	3(1.4)		
Total	66(30.0)	67(30.5)	87(39.5)	220(100)		

Source: Survey data, 2003; Figures in parentheses are percentages and those out of parentheses are frequencies; Significant at p< 0.001.

Story telling as a communication tool was mentioned as the most common tool in the six villages. Participants for each focus group discussion said that it was a most effective communication tool and most used by farmers. In each village, participants described story telling as a common communication tool, which is used for knowledge sharing. All participants asserted that was the most effective and mostly used in the community. For example, participants narrated a story-related improvement of PWA. For example, participants narrated a story-related PWA that has been communicated from generation to generation. Box 9 shows the abstracts of the Ukwaheri village views on story telling.

Box 9: Ukwaheri village FGD participants' views on story telling

Good rainfall year (mwaka mnofu) is characterised by rainfall, which rains for sometimes, say three days and stops, the crops planted sprout earlier and do not wither. The implication will be more harvest realised. Also certain tree species was not allowed to cut down because it was believed that are sources of water e.g. mipogoro, mihango, mangwalizi traditional leaders restricted.

The finding which are similar to Ashley (2003), when used effectively, storytelling offers numerous advantages over more traditional organisational communication techniques: Hence productivity of water in agriculture might be communicated using story telling among farmers.

In Tanzania, mass media campaigns have been used in farmer training (Institute of Adult Education, 1973; Kauzeni; 1979). Some of the campaigns are designed to reach more farmers who are in remote areas, and are geared not only towards information but also toward changing individual and community behaviour (Kauzeni, 1979). The radio could be a good tool, but timing of programme was the issue.Table 16 shows the relationship between location of respondents and the reasons for the choice of radio as best knowledge sharing tool. Of the 212 respondents, 46(21.7%), 36(17%) that they choose the knowledge sharing tools because they were easily available, everybody could see and understand respectively

Table16: Respondents reason for the choice of the best knowledge sharing tool (N= 212)

Reasons for the choice	Upper	Middle	Lower	Total	X^2	P value
Knowledge is permanently kept	2(0.9)	1(0.5)	17(8.0)	20(9.4)	47.907	0.000
Can be revised later	12(5.7)	7(3.3)	5(2.4)	24(11.3)		
Teaching like a teacher	5(2.4)	0(0.0)	11(5.2)	16(7.5)		
Everyone can see and understand	8(3.8)	14(6.6)	14(6.6)	36(17.0)		
Easily available	16(7.5)	21(9.9)	9(4.2)	46(21.7)		
Can explain briefly and understand	3(1.4)	8(3.8)	4(1.9)	15(7.1)		
Cheap price and everyone can own	5(2.4)	4(1.9)	4(1.9)	13(6.1)		
Total	59(27.8)	67(31.6)	86(40.6)	212(100)		

Source of data: Field Survey, 2003; Figures in parentheses are percentages and those out of parentheses are frequencies; significant at $p< 0.001$.

There was significance difference between means of the groups between location of respondents and reasons for the choice of the radio as the best knowledge sharing tools. The findings meant strong relationships between the two variables. The study found that the radio was the best – bet (21.7%) knowledge sharing tools because it was available, everybody could listen and understand the messages broadcast.. In addition, the radio was cheaper, and most farmers could buy and own them. Farmers' willingness to learn innovations through the radio compared to other tools might have been due to lack of agriculture extension officers in the villages. During the focus group discussions, participants agreed that it was possible to learn new ideas through radio programmes. For example, they said that HIV programmes were broadcast through the radio and many people understood the messages.

Focus group discussion sessions indicated that formal knowledge sharing tools used for training farmers in the villages or at the agricultural institute included demonstration, field visits, meetings, seminar, study tours, farmer's field days, campaigns, and agricultural shows. Furthermore, participants mentioned that informal knowledge sharing tools included story telling by elders, exchange of ideas by fellow farmers, usually in local brew drinking places, and during funeral ceremonies. Participants' comments were that the informal methods were commonly used rather than the formal knowledge sharing tools.

Table17: Pair wise ranking of the knowledge sharing tools at Mwatenga village

Tools	Radio	Television	Books	Posters	Pamphlets
Radio	XX	1	1	1	1
Television	V	XX	3	2	5
Books	V	V	XX	3	3
Posters	V	V	V	XX	5
Pamphlets	V	V	V	V	XX

Source: Survey data, 2003; XX meant tallied tool where as V meant below the tallied tool score hence not selected

The results in Table 17 above show a pair wise ranking of the knowledge sharing tools conducted during the focus group discussion sessions and the radio scored highest. Four out of ten participants selected radio as a suitable knowledge-sharing tool for creating awareness about the knowledge of PWA. The reasons given were that radio messages were in a language that was easily understood and that most farmers had radios in the villages. Similar results were obtained in Inyala, Mahongole, Ikhoho, and Ukwaheri villages. Such findings were similar to Sadamate and Sinha (1978), and Mattee (1988) who found that the radio played an important role in imparting farm messages to the farmers in India and Tanzania, respectively.

Table 19 shows the relationship between location of respondents' villages and the best knowledge sharing tool used for teaching farmers about the productivity of water in agriculture. The study revealed that out of 217 respondents, 89 (41.0%) and 47 (21.7%) indicated that face to face and field visits were the best knowledge sharing tools when training farmers about PWA in the villages. Yet, 47 (21.7%) and 33 (15.2%) indicated that village sessions and farmer field schools were important knowledge sharing tools, especially in the lower and mid Mkoji sub - catchment, respectively. However, there were statistical differences between groups at $p< 0.075$ for farmers training. The study finding showed that face to face (41.0%) training of farmers was the best knowledge-sharing tool for improving the productivity of water in agriculture. This implied that the contacts between farmers and agricultural experts during the training sessions and demonstration plots were important for teaching PWA.

Table 18: Respondents village by best methods for teaching PWA (N= 217)

Best training Method for PWA	Upper	Middle	Lower	Total	X^2	P value
Face to face	19(8.8)	29(13.4)	41(18.9)	89(41.0)	14.263	.075
Field visits	19(8.8)	12(5.5)	16(7.4)	47(21.7)		
Village sessions	13(6.0)	11(5.1)	23(10.6)	47(21.7)		
Farmer field schools	10(4.6)	15(6.9)	8(3.7)	33(15.2)		
Agriculture shows	1(0.5)	0(0.0)	0(0.0)	1(0.5)		
Total	62(28.6)	67(30.9)	88(40.6)	217(100.0)		

Source: Survey data, 2003; Figures in parentheses are percentages and those out of parentheses are frequencies; not significant at $p< 0.05$.

Another aspect interviewed was whether smallholder farmers experienced constraints to measure PWA in the crop fields. Table 19 below shows that out of the 226 respondents, 148 (65.5%) agreed that there were constraints in measuring PWA in the fields. However, there was no significance difference between the means of the groups ($P<0.46$). The study findings implied that location of villages had no influence on constraints in measuring the PWA in the fields. The lower zone indicated more 88 (40.6%) constraints in measuring PWA compared to the others, which might be due uncertainties of getting water for irrigation. Also smallholder farmers possibly in the lower zone were reluctant to measure PWA because much water was abstracted in the upper and mid zones.

Best knowledge sharing tools by trainers and researchers

Focus group discussions were conducted in both agricultural training institute and research institute. The purpose was to evaluate the knowledge sharing tools suitable for communication. Participants were asked to discuss the existing communication tools and evaluate them. The evaluated knowledge sharing tools were books, newspaper, posters, journals, leaflets, recorded video, and slides.

Participants from MATI Igurusi indicated that books on the subjects should be up dated. They said that there was no up to date books in the institutes that could be used to teach knowledge sharing tools. It was further agreed that Internet services were important for getting up to date information. However, in a focus group discussion there was no one knowledgeable with World Wide Web. The Word Wide Web is being used as a direct teaching tool that allows virtual classrooms of interacting students and faculty to be created through 'asynchronous learning networks'. Because the web allows a course taught at one site to be taken by students anywhere in the world, it increases enormously the ability to build scientific and technical capacity in developing nations (CGIAR, 1998).

Moreover, participants discussed how the knowledge on PWA could be shared. Most said that there was a need for capacity building. Everyone recognizes the critical role played by agricultural professionals in linking technology sources to technology users. Professionals help in assessing and articulating farmers' technology needs technology development, and transfer and technology evaluation. But there is growing concern that today's agricultural professionals do not have the knowledge and skills to be effective in the current situation (Reeves, 2000). It is therefore essential that those who work with farmers to develop sustainable systems are knowledgeable about the systems with which they work (Reeves, 2000). Therefore capacity building and professional development are fundamental prerequisites for achieving the widespread adoption of sustainable agriculture practices.

Participants from the SHARDI Uyole indicated that World Wide Web was the best knowledge-sharing tool. The pair-wise ranking was employed to evaluate of the tool. Eighty percent voted the World Wide Web and 60 percent indicated had knowledge for the internet and visited the web sites. Sustainable agriculture presents a deeper and more fundamental challenge than many researchers, extensionists and policy previously assumed (Pretty, 1995). Sustainable agriculture needs more than new technologies and practices. It needs agricultural professionals willing and able to learn from farmers; it needs supportive external institutions; it needs local groups and institution capable of managing resources effectively; and above all it needs agricultural policies that support these features (Pretty, 1995).

Best knowledge sharing tools by water managers

Participants in a focus group discussion indicated face to face discussion through seminars and workshops as best knowledge sharing tool. Communication and dialogue should be held among organizations that are operational in the Mkoji sub - catchment to influence productivity of water and .water management. The other stakeholders which need to be involved in a dialogue issues of PWA included, the River Basin Management and Smallholder Irrigation Project (RBMSIIP) which is a joint World Bank funded project that brings together the MWLD and the MAFS in enhancing river basin water management and improving smallholder irrigation. The RBM component is in the MWLD, while the SIIP component is within the MAFS. RBMSIIP is undertaking a number of relevant activities to improve river basin management. These include:

1. Improving stakeholder participation and voice in the allocation and management of water resources by broadening stakeholder representation in the Basin Water Boards;
2. Establishing democratic methods for stakeholder selection, and strengthening the administrative power of the Basin Water Boards – including giving them the responsibility for the final approval of water right allocations (or modifications), as proposed by the Basin Water Officer;
3. Strengthening the Basin Water Office by enabling the Water Office to enforce and follow-up on existing legislation, regulations and operating rules governing water use;
4. Establishing the Basin Water Board as a preliminary centre for conflict resolution in water allocation and separating water use management from regulatory activities, following agreement on standard operating rules.

The Rufiji Basin Water Board (RBWB) was established in 1993/4. It meets at least twice per year as mandated under the legislation, the main business of the meetings being to advise on the various activities of the Rufiji Basin Water Office (RBWO). The RBWO is authorized to grant water rights. The RBWO has established a sub office in the Mbarali District, which among other things, effects monitoring of river water levels, collection of water use fees and arbitrating conflicts that arise from water uses.

CONCLUSIONAND RECOMMENDATIONS

Conclusion

Based on the findings from this study the following conclusions are made.

1. There was little understanding by stakeholders about the knowledge of PWA. Most smallholder farmers related PWA with scarcity of water but showed lack of awareness regarding this new science. Furthermore, water users described this knowledge by relating it to practices of planting short time varieties, high value crops, early planting, application of farmyard manure and use of industrial fertilizers for the purpose of increasing crop yield both in rainfed and irrigated agriculture.
2. The study found that smallholder farmers used different agronomic practices and tillage practices to improve their crop yields. For example, farmers practiced minimum tillage rather than conventional tillage that increased costs. Furthermore, they planted local crop varieties that were drought resistant in the lower zone of Mkoji sub-catchment where high water stress was a common phenomenon. With regard to tillage practices, flat cultivation was highly encouraged in the lower zone while in the upper zone bottom valley farming was common for soil and water conservation that increased crop yields
3. Farmers had positive attitude toward the knowledge of PWA and indicated that it had an added value to government initiatives for agricultural training programmes to make emphasis on good methodologies of quantifying crop harvests and the volume of water used. Furthermore, farmers suggested that improvement of agricultural extension services in rural areas. The findings showed that inadequate extension services and sometimes completely lack of them, as was the case in the lower zone of Mkoji sub-catchment, that farmers were ready to learn new idea from agricultural experts, but denied of the service.
4. Farmers training, demonstration plots, radio and field visit received high score for suitable forms of knowledge sharing tools. This implied that there was stakeholders' willingness to learn scientific methods through practical sessions rather than classroom sessions. Integration of indigenous and scientific knowledge needed to be underscored to common understanding and description of the productivity of water in agriculture in Mkoji sub – catchment and elsewhere.

Recommendations

Based on the conclusions drawn from the findings, the following recommendations are made.

1. Farmers training, demonstration plots, radio and field visits should be employed as knowledge sharing tools for creating awareness of PWA.
2. Communication and dialogue should be held among organizations that are operational in the Mkoji sub-catchment to influence productivity of water and water management.
3. Dialogue issues on productivity of water in agriculture should be held between stakeholders from village to national levels to get common understanding of the description of PWA.
4. Formal and informal knowledge sharing tools for ways of improving productivity of water should be integrated to raise the level of PWA in Mkoji sub-catchment.
5. Majority of smallholder farmers showed that radio was the best knowledge sharing tool because farmers afforded it and agriculture extension officers were few to reach most of farmers. Hence, radio programmes should be used to create awareness of productivity of water. However caution should be taken for inappropriate broadcasting time.
6. Professional help in assessing and articulating farmers' technology needs technology development, transfer and technology evaluation is vital. Therefore, capacity building and professional development are fundamental prerequisites for achieving the widespread adoption of PWA

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