AgWater Solutions Project Case Study

Impacts of Improving Traditional Irrigation Schemes in Mvomero District, Tanzania

Bernard Keraita
International Water Management Institute, Ghana

Meredith Giordano
International Water Management Institute, Sri Lanka

Henry Mahoo
Soil and Water Management Research Programme
Sokoine University of Agriculture, Tanzania

September, 2012

Acknowledgment
The authors and project partners wish to thank the Bill & Melinda Gates Foundation for the generous grant that made this project possible.

The AWM Project
The AgWater Solutions project was implemented in five countries in Africa and two states in India between 2008 and 2012. The objective of the project was to identify investment options and opportunities in agricultural water management with the greatest potential to improve incomes and food security for poor farmers, and to develop tools and recommendations for stakeholders in the sector including policymakers, investors, NGOs and small-scale farmers.

The leading implementing institutions were the International Water Management Institute (IWMI), the Stockholm Environment Institute (SEI), the Food and Agriculture Organization of the United Nations (FAO), the International Food Policy Research Institute (IFPRI), International Development Enterprises (iDE) and CH2MHill.

For more information on the project or detailed reports please visit the project website http://awm-solutions.iwmi.org/home-page.aspx.

Disclaimer

This report is based on research funded by the Bill & Melinda Gates Foundation. The findings and conclusions contained within are those of the authors and do not necessarily reflect positions or policies of the project, its partners or the Bill & Melinda Gates Foundation.

Copyright © 2012, by IWMI. All rights reserved. IWMI encourages the use of its material provided that the organization is acknowledged and kept informed in all such instances.

Contents

1. INTRODUCTION

Agriculture in Tanzania remains the most important economic sector. It contributes 45% of Tanzania´s GDP and nearly 30% of its export earnings, while employing over 80% of the nation´s work force (MoWI, 2009). A major constraint facing the agricultural sector is the falling labor and land productivity due to application of poor technology and dependence on unreliable and irregular weather conditions. Irrigation therefore holds one of the keys to stabilizing agricultural production, improving food security, increasing farmers' productivity and incomes and producing higher valued crops (MoWI, 2009). In Tanzania's national poverty reduction framework, irrigation has been identified as one of the key strategies for growth and poverty reduction (MoWI, 2009). The Kilimo Kwanza initiative (Pillar 2.2 Task 4) aims to increase irrigated area to 7 million ha and improve paddy yields from 1.8 tons/ha to 8 tons/ha by 2015 (TNBC, 2010).

Irrigated agriculture in Tanzania is dominated by smallholder irrigation, mainly under river diversion gravity-fed systems (Kaswamila & Masuruli, 2004). A survey conducted in 2002 showed that there were 1,189 irrigation schemes covering an area of about 192,000 ha, of which more than 90% were classified as traditional irrigation schemes (MoWI, 2002). Traditional irrigation schemes are initiated and managed by communities and constructed with local materials and skills. Water is diverted by structures made of rocks, branches and mud. Some aqueducts are made of logs. Canals are hand-dug and unlined, sometimes stretching for several kilometers (Mul *et al.,* 2011). Traditional schemes are found throughout the country (Figure 1).

Most traditional schemes are characterized by poor infrastructure, poor water management and low yields (MoWI, 2009). Water use efficiency estimates range from less than 15% to 30% (World Bank, 2004; IFAD, 2007; Turpie *et al*., 2003; Makuri *et al.,* 2007).[1] Because of the large water losses in the intake and conveyance canals, water allocations for farmers at the tail end are often uncertain. Poor on-field water management due to inadequate infrastructure reduces yields. Consequently, the area served under the traditional schemes and crop productivity can be substantially increased by improving infrastructure, water management and agricultural practices (World Bank, 2004).

External agencies and the government recently funded some large projects to improve traditional schemes by constructing intakes, lining canals and improving water management. Examples include the IFAD-funded Participatory Irrigation Development Project (PIDP) which rehabilitated some 5000 ha under traditional schemes in the central plateau regions during the period 2000-2007 (IFAD, 2007). From 1996-2002 the World Bank funded the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP) which, together with other projects rehabilitated some 15 traditional schemes covering 5,000 hectares in the Rufuji and Pangani basin. The project evaluation report

[1] Most authors do not define the term efficiency, so it is often unclear whether this is at field or at scheme level.

stated that in the improved schemes irrigation efficiency and yields had more than doubled while farmers' annual incomes increased by USD400-1,100 (World Bank, 2004).

However, the effectiveness and sustainability of the improvements of traditional schemes is disputed. Lankford (2004) argues that improvement of traditional smallholder irrigation does not necessarily result in improved performance, greater equity and reduced conflict. His case studies in the Usanga Basin show that projects tend to focus on infrastructural improvements and ignore and hence disrupt existing arrangements for water management, resource sharing and conflict resolution (see Lecoutre, 2010). For example, the replacement of traditional intakes made of mud and sticks by cement weirs allows upstream schemes to take a larger share of the river water to the detriment of downstream users. Particularly in the dry season this may lead to increased conflicts. Water in traditional schemes flows from one field to another, thus providing water to tail-enders by recycling return flows from upstream users in the scheme.

In improved schemes, because of better infrastructure (lined canals), upstream users take more water leaving less for tail-enders. Newly constructed drains that lead the water back to the river instead of directing it to downstream users aggravate the problem. Water rotation and scheduling advocated by the improvement projects are largely ignored. Lastly, traditional irrigation schemes are not as inefficient as the appraisal reports of the World Bank and IFAD reports claim. In fact, Machibya and Mdemu (2005) found that modern and improved schemes in the Usanga Basin are less water efficient than traditional schemes where return flows from upstream users are recycled by tail-enders. On the other hand, while acknowledging the water allocation challenges in the same basin, Mwakalila (2006) shows in a rapid appraisal significantly higher socio-economic returns from irrigated paddy fields in improved schemes.

The aim of this paper is to explore whether improving traditional irrigation schemes are effective interventions for improving livelihoods. It compares three communal irrigation schemes in the Wami-Ruvu Basin: one unimproved traditional scheme, one improved traditional scheme and one newly constructed scheme, by quantifying the socio-economic impacts of irrigation on households in Mvomero District.

2. METHODOLOGY

2.1 Study area

This study was carried out in Mvomero District in Tanzania. Mvomero receives 1,146 mm of rainfall per annum in a bimodal pattern with a relatively short dry spell between June and September. Temperatures range from an average minimum of 19°C between June and September to an average maximum of 31°C from October to March. The dominating farming system in the district consists of irrigated rice, sugarcane, livestock and maize. The study was conducted in three communities (Mkindo, Hembeti and Dakawa), practicing irrigated paddy farming in Mvomero District in the Morogoro Region. The selection of communities was done to cover the three typical development levels of communal irrigation systems in Tanzania i.e. unimproved traditional (Hembeti), improved traditional (Mkindo) and modern (Dakawa).

Hembeti is an unimproved traditional irrigation scheme currently covering a command area of about 30 hectares. The intake consists of mud, sticks and stones and needs to be rebuilt every year. Canals are unlined and paddy fields are haphazard. There is no formal farmer's organization and little or no control of irrigation water. Hembeti illustrates a typical starting phase of traditional irrigation schemes in Tanzania.

The irrigation scheme in Mkindo uses a gravity-fed river diversion system which covers about 60 hectares. The community received external assistance to develop the intake and line about 200 meters of the main canal. Hence the scheme is classified as improved traditional. However, the other parts of the main canals and secondary distribution systems are earthen works leading to substantial water losses. Water control is poor due to lack of infrastructure in the scheme. The community has three distinct sub groupings of paddy farmers—those irrigating in the scheme on developed plots (scheme irrigators), those irrigating just outside the scheme in undeveloped areas (out-of-scheme irrigators) and those in the community without access to the scheme relying on rainfed paddy farming (rainfed farmers). Irrigation activities are managed by a well-established committee comprised of farmers from the community who are elected by fellow farmers every three years. Water and cropping scheduling in the scheme is done by the management committee of the scheme. Every year, two crops of irrigated paddy are and even though out-of-scheme irrigators and rainfed farmers are free to plant any crop, they also plant paddy due to market, biophysical and socio-cultural incentives.

In the Dakawa scheme, pumps lift water from the river to the main canal from where it is distributed to the fields by gravity. The developed area is about 2,000 hectares. It is a well-developed scheme, initially operated by a government agency, National Agriculture and Food Corporation (NAFCO), which has now been transferred to a farmers' cooperative. During the time of this study (2009-2010), paddy farming was done only once a year due to water distribution challenges, although there were plans to start the second season. The scheme is divided into 29 twelve-acre blocks. While all farmers in Mkindo are from the community, in Dakawa, most of the large landholders are not indigenes from the community. The local community is now battling to get a larger land allocation in the scheme.

2.2 Data collection

A combination of data collection methods and sources was used to enhance validity and reliability in this study. A review of the secondary information and data from the different project documents and other existing literature from previous studies was carried out. This was followed by a reconnaissance survey in the study area and a transect walk in the community and irrigation schemes which was guided by community members. Preliminary data on the irrigation systems, agricultural practices, farming systems, farm infrastructure living standards of farmers, geographical characteristics and the size (magnitude) of the study area was collected and this helped in further sampling for individual farmer surveys.

This was followed by farmer surveys in the three study communities using a detailed questionnaire. The questionnaire focused on six main areas: Bio-data of farmers, farming practices, decision making, productivity assessments, forward (i.e., inputs) and backward (i.e., market) linkages and assessment of scheme management. Respondents were farmers in the community, stratified according to their farming groups and gender. Hussain & Hanjra

(2004) classified approaches used to study the socio-economic impacts of irrigation in various studies into three: *before and after* comparisons; *with-and-without* comparisons; and *more and less* comparisons. In this study, we adapted the with-and-without comparisons within each community, where we compared irrigating farmers (*with*) and purely rainfed farmers planting same crops where possible (*without*). A total of 127 interviews were conducted comprising of 89 for irrigators and 38 for purely rainfed farmers (non-irrigators). Respondents were household heads actively involved in farming activities.

To obtain detailed and longitudinal data on irrigation practices, interviews were conducted within the study communities. Interviews were conducted with the leaders of farmers association (former and current), scheme managers and pioneer female and male farmers. In Mkindo, where there was a rural savings and credit cooperative organization (SACCO) and also a farmers' training college within the community, additional interviews were held with the leaders of the two institutions. A total of 12 such community level interviews (5 in Mkindo, 3 in Hembeti and four in Dakawa) were conducted. Additional information was obtained from key informant interviews with representatives from the irrigation sector, especially from organizations with a specific focus on communal irrigation systems. These included officials from the Ministry of Water and Irrigation, River Basin Authorities (Wami-Ruvu), District Agricultural (irrigation) officers, Regional Secretaries, and agricultural extension officers. Others interviewed were researchers from Sokoine University of Agriculture, University of Dar el Salaam and heads of institutions responsible for training small-scale farmers like Kilimanjaro Agricultural Training Centre. NGOs involved in agricultural development at community level such as World Vision International also provided useful information. In total, 9 key informants were interviewed.

3. Results

3.1 Characteristics of farmers and farming activities

Regardless of location and farming type, most respondents are married and educated to primary school level. Rainfed farmers in Mkindo have a significantly higher number of household members (7.2 compared to 5.5 for irrigators) though the average number of household members who contribute to farming activities is almost the same as that of irrigators. Likewise, gender was not a significant factor in contributions of household labor to farming activities. A typical farmer in smallholder communal irrigation schemes may be described as a married female or male with primary-level education, having five household members, of which three contribute to farming activities, a description which equally holds for rainfed farmers in the same communities.

In Mkindo and Hembeti, farmers irrigate on average only about one-third of their total land while in Dakawa irrigation is done on about three-quarters of total land owned by farmers (Table 1). The difference can be attributed to the extent of irrigated areas that are developed with Dakawa having more than 2,000 ha and Mkindo and Hembeti only 60 ha and 30 ha respectively. This is also reflected by the average irrigated farm holdings per farmer: in Dakawa these are 3-5 times bigger than those of Mkindo. However, rainfed farming sizes are similar. While access to land outside the scheme in Mkindo and Hembeti is not a limitation, the lower productivity of rainfed areas and irrigated fields outside the scheme discouraged farmers from investing in larger plots.

Table 1. Major crops and land sizes in study communities

	Mkindo			Hembeti		Dakawa	
	Scheme irrigators (n=30)	Out-of-scheme irrigators (n=12)	Non-irrigators (n=15)	Irrigators (n=21)	Non-irrigators (n=11)	Irrigators (n=26)	Non-irrigators (n=12)
Major crops	Paddy	Paddy	Paddy, Maize	Paddy	Paddy, Maize	Paddy	Maize, paddy
Total area (ha)	1.53 ±1.03[a]	0.95 ±0.44	1.10 ±0.54	1.49 ±1.39	1.20 ±0.10	2.83±2.58	1.98±0.82
Area under irrigation (ha)	0.52±0.21	0.41±0.23	n.a.	0.40 ±0.88	n.a	2.15±2.19	n.a
Rainfed area (ha)	1.01±0.76	0.54±0.47	1.10±0.54	0.91 ±1.21	1.20 ±0.10	0.65±0.78	1.98±0.82

[a] Standard deviations
n.a.- not applicable

3.2 Paddy yields

The data on yields obtained from farmer surveys in Table 2 show statistically significant differences ($P \leq 0.05$) in productivity between the improved schemes (Mkindo and Dakawa) and the unimproved scheme (Hembeti). Having no improved off-take and main canal, yields at Hembeti were about half of those produced in Mkindo and Dakawa. Within the schemes, there are statistically significant differences in yields between irrigated and rainfed plots. On average, irrigated plots produce twice as much paddy as rainfed plots. Based on data collected from interviews, the differences in yields in Mkindo are attributed to the reliability in access to irrigation water and improvements in farming practices. For example, irrigating farmers use power tillers for land preparation, transplanted seedlings instead of broadcasting as done in rainfed plots, and used fertilizers to boost yields.

Table 2. Paddy yields from various kinds of farmers in different seasons (n=126 farmers)

Community	Farming type	Irrigated Dry season *(tons/ha)*	Irrigated Wet season *(tons/ha)*	Rainfed *(tons/ha)*
Mkindo	Scheme Irrigators	5.77 ±1.69[a]	6.00±1.66	2.95±1.20
	Out-of-scheme irrigators	5.44 ±1.93	5.59 ±1.04	2.77 ±0.66
	Purely rainfed	n.a.	n.a.	3.00 ±1.09
Hembeti	Irrigators	3.09 ±1.29	2.46 ±1.60	1.95 ±0.91
	Purely rainfed	n.a.	n.a.	1.19 ±0.58
Dakawa	Irrigators	n.a	5.87±1.22	2.39±0.84
	Purely rainfed	n.a.	n.a.	2.50 ±0.75

[a] Figures in parenthesis are ranges
n.a. – not applicable/practiced

Further analysis reveals a large variation in yields among farmers who have access to the same irrigation facilities. For example, during the dry season of 2009 one farmer in Mkindo recorded yields as high as 12 tons/ha, when another farmer in the same scheme recorded only 3.21 tons/ha. The data show differences in yields of 2-6 times among the farmers within the same irrigation scheme. This can be attributed to individual farming practices related to water management, land preparation, use of farm inputs and farmers' knowledge. Farmers with the highest yields had obtained some training on rice cultivation (e.g., from the Mkindo Farmers' Agricultural Training Center), used power tillers for land preparation, planted seedlings and used fertilizers. The wide variations in yields provide evidence that there is scope to improve yields within the same farming system.

3.3 Revenues generated from farming activities

The data in Table 3 show the potential revenues, assuming all produce was sold, from paddy fields under different farming systems and in different seasons. In Hembeti and Mkindo where irrigation is done in two seasons, higher revenues are obtained in the dry season than in the wet season. In Hembeti, revenues during the wet season are more than three times lower than those during the dry season. This is because the scheme has no flow control infrastructure so water flooded the fields even during harvesting time, so yields were lower. Observations made during the wet season in Hembeti showed that water levels in some fields were as high as 0.5 m during harvesting time when paddy fields should actually be dry. In addition, costs of production during the wet season were generally higher and paddy prices lower due to increased supply of paddy in the market. In Mkindo, other than having too much water flowing into the fields, farmers recorded high operational costs during the wet season especially when they needed extra labor or had to hire power tillers for land preparation, which reduced revenues.

Table 3: Potential incomes generated by kinds of farmers in different seasons (N=126 farmers)

Community	Farming type	Irrigated dry season (US$/ha)		Irrigated wet season (US$/ha)		Rainfed (US$/ha)	
		Mean	Range	Mean	Range	Mean	Range
Mkindo	Scheme Irrigators	709	196-2155	634	(408)[a]-1887	329	(337)-1296
	Out of scheme irrigators	776	(233)-1848	553	175-1342	374	(97)-753
	Purely rainfed	n.a		n.a.		441	(63)-1068
Hembeti	Irrigators	283	(213)-1158	87	(154)-775	184	(185)-670
	Purely rainfed	n.a		n.a.		36	(156)-207
Dakawa	Irrigators	n.a.		732	(11)-(1730)	297	(172)-717
	Purely rainfed	n.a.		n.a.		312	(12)-732

[a]Figures in parenthesis are negative values

Even though costs of farming activities are much lower for rainfed cultivation, higher revenues were recorded from irrigated plots. During the wet season when both rainfed and irrigated farming is practiced, farmers in Mkindo and Dakawa experienced 1.5 to 2.5 times higher revenues from irrigated plots than from their rainfed plots. Purely rainfed farmers obtained higher revenues from their fields than irrigating farmers from their rainfed plots but these revenues were significantly lower than those from irrigated plots. In Hembeti, due to the flooding of fields during the wet season, it would make more sense to avoid paddy farming in irrigated plots and instead focus on farming rainfed plots as revenues from wet season irrigated paddy plots were less than half of those in rainfed plots by the same farmers.

Actual incomes, based on what farmers actually sell, are much lower than potential incomes because farmers use substantial amounts of rice from rainfed plots for household consumption (Table 4). Also farmers engage in barter trade for their produce. For example, farmers exchange paddy for maize, sorghum or beans. These kinds of transactions could not be captured in income calculations as farmers do not perceive these as revenues.

Table 4: Actual incomes generated from various kinds of farmers in different seasons (n=127 farmers)

Community	Farming type	Irrigated dry season (US$/ha)		Irrigated wet season (US$/ha)		Rainfed (US$/ha)	
		Mean	Range	Mean	Range	Mean	Range
Mkindo	Scheme Irrigators	273	(792)-1207	214	(626)[b]-819	1	(779)-920
	Out of scheme irrigators	386	(333)-1690	175	(738)-736	(24)	(494)-551
	Purely rainfed	n.a		n.a.		112	(175)-516
Hembeti	Irrigators	(35)	(402)-734	(142)	(379)-354	(815)	(1616)-(229)
	Purely rainfed	n.a		n.a.		(670)	(933)-(346)
Dakawa	Irrigators	n.a.		438	(343)-1663	(29)	(414)-451
	Purely rainfed	n.a		n.a.		12	(234)-350

[a]Actual income is a factor of % yield sold. The more kept for household consumption, the less actual income.
[b]Figures in parenthesis are negative values

3.4 Impacts on household incomes

Many farmer households in the study area rely on communal irrigation systems for both food and income. In general, dependency on farming as a source of income is high (Table 5). Based on farmers' own estimates, this study estimates that more than 85% of household incomes are derived from farming. Some farmers prefer producing cash crops and use revenues to buy staple foods for their own consumption. For example, many farmers in Mkindo cultivate paddy even in rainfed plots, which typically are used for staple crops such as maize. Returns from paddy are much higher allowing for the purchase of maize when needed.

Table 5. Farmers' estimates on contributions of farming type to household income (n=127 farmers)

Community	Farming type	Irrigated farming (%)	Rainfed farming (%)	Other sources (%)
Mkindo	Irrigators	82.5	16.6	0.9
	Purely rainfed	n.a.	76.7	23.3
Hembeti	Irrigators	78.0	9.0	13.0
	Purely rainfed	n.a.	100.0	0.0
Dakawa	Irrigators	73.8	21.7	4.5
	Purely rainfed	n.a.	67.0	33.0

n.a. – not applicable/practiced

Other than household incomes, the figures reflect the extent of community welfare. From the observation-based wealth ranking criteria used in this study (combination of housing features, household assets and social amenities), Hembeti was ranked low (less than two in a scale of 1-5), while Dakawa was ranked high (more than 3.5 on the same scale 1-5). Rainfed farmers in Hembeti fully relied on rainfed paddy for household income as they had no other sources of income as their counterparts in the two other study communities. On average, rainfed farmers in Dakawa and Mkindo have more off-farm income sources than in

Hembeti. Interviews with community leaders attributed the diversification of sources of household incomes in Dakawa and Mkindo to benefits accrued from irrigated farming.

Increased revenues from agriculture have important implications on poverty reduction (Irz et al. 2001). Table 6 shows the contributions of farming to household incomes taking into consideration the average size of irrigated plots. Comparing across the three irrigation schemes, incomes from farming of irrigating households was USD 5.63, USD 3.62 and USD 1.43 per day for Dakawa, Mkindo and Hembeti, respectively. Based on estimates for contributions from other sources (Table 6), total daily household income was USD 5.88, USD 3.65 and USD 1.64 for Dakawa, Mkindo and Hembeti, respectively. The value for Dakawa would even be higher (USD 10.15 per day) if calculated on a seasonal instead of a yearly basis as Dakawa farmers are limited to one cropping season per year due to water distribution challenges. Comparing among farmers within the systems, the incomes of purely rainfed farmers are much lower than those of irrigating farmers: USD 5.16, 1.61, and 0.20 per day for Dakawa, Mkindo and Hembeti respectively. These household incomes could be one of the factors contributing to the observations made on household assets and general community development which clearly showed Dakawa community to be comparatively wealthier than the other two communities.

Table 6: Average contributions to household incomes

	Irrigating farmers		Rainfed farmers
	Irrigated plots	*Rainfed Plots*	*Rainfed plots*
Mkindo			
Average Area (ha)	0.5	0.9	1.0
Total monthly income per ha (USD)[a]	111.33	58.58	36.75
Total monthly income per farm holding (USD)	55.67	52.73	36.75
Average daily income per farm holding (USD)	1.86	1.76	1.23
Hembeti			
Average Area (ha)	0.4	1.0	1.0
Total monthly income per ha (USD)	31.08	30.67	6.00
Total monthly income per farm holding (USD)	12.43	30.67	6.00
Average daily income per farm holding (USD)	0.41	1.02	0.20
Dakawa			
Average Area (ha)	2.2	0.7	2.0
Total monthly income per ha (USD)	61.00	49.50	52.00
Total monthly income per farm holding (USD)	134.20	34.65	104.00
Average daily income per farm holding (USD)	4.47	1.16	3.46

[a]Based on mean potential revenues generated from Table 3

These findings are confirmed by other studies conducted in Tanzania. A socio-economic impact assessment of similar smallholder paddy producers in five villages in Mbarali District shows returns to labor in irrigated rice production of about USD 2.5/day which is above the poverty line of USD 1.0/day (Mwakalila, 2006). The same study shows that the lowest return to labor (USD 0.85/day) occurs in smallholder rainfed paddy cultivation using hand hoe and family labor. The World Bank showed that the increased crop yields from improving irrigation schemes under the RBMSIIP resulted in farmers having enough food to feed their families and sell excess for cash income. After improvement of the schemes, average family incomes increased from USD 425 to USD 1,500 in the Pangani Basin, and from USD 340 to USD 1,100 in the Rufiji Basin respectively (World Bank, 2004)

3.5 Farmers' demand for AWM interventions

Given the positive impact of irrigation on farmers' income, it is hardly surprising that farmers rank the improvement and expansion of irrigation schemes highest among agricultural water management (AWM) interventions. Surveys conducted as part of this study show that those farmers near Mkindo and Hembeti sites without access to irrigation ranked expansion of the irrigated area highest (Table 7). In the newly constructed scheme of Dakawa area, expansion was a lesser concern (the scheme already covers 2,000 hectares).

Table 7. Priority ranking of irrigation expansion and infrastructural improvements by farmers as key intervention measures (n= 127 farmers)

Intervention measure	Mkindo		Hembeti		Dakawa	
	Irrigators (%)a	Non-irrigators (%)	Irrigators (%)	Non-irrigators (%)	Irrigators (%)	Non-irrigators (%)
Improve irrigation infrastructure mainly canals	15 (3)b	n.m.(7)	23 (2)	n.m. (7)	28 (2)	n.m.(7)
Increase developed area of the scheme	9 (5)	55 (1)	11 (5)	43 (1)	6 (5)	13 (4)

[a]Relative importance in relation to other measures mentioned by same sample population
[b]Figures in parenthesis shows the rank out of 7 most highly rated measures
n.m. – not mentioned

For those with access to irrigated land in the three study schemes, improving irrigation infrastructure was the highest priority. This enables farmers to better manage and control water on-field and to expand their irrigated plots. In the unimproved traditional scheme of Hembeti, paddy yields suffered from too much water in the fields. It was observed that the standing water was knee-high during harvesting for lack of structures at canal and field level to control the water. Hembeti is typical of many unimproved traditional river diversion systems visited in the country. While the intake and main canals in Mkindo scheme were improved it has no control structures at secondary and tertiary canals. This leads to too much water in the fields at the head-end and water shortage at the tail end. At Dakawa, the challenge relates to the leveling of irrigated plots. In some sections of the expansive scheme, especially at the tail end, water does not reach and some farmers failed to produce a harvest. In all three schemes farmers, key informants and scheme managers were consistent in their ranking perceived problems.

The major challenge in these three schemes is not the shortage of water but rather the poor infrastructure to adequately manage it. This was typical of many other river diversion schemes visited in the country. Expanding and improving of traditional irrigation schemes responds to a genuinely felt demand by farmers throughout the country.

4. DISCUSSION AND CONCLUSION

Findings from this study support the initiatives of increasing irrigated areas and enhancing agricultural productivity in smallholder irrigation schemes that are currently ongoing in Tanzania. The Government of Tanzania‘s target of increasing irrigated areas to 7 million hectares and increasing paddy yields from 1.8 tons per hectare to 8 tons per hectare per season within the next 5 years (MoWI, 2009) may be overoptimistic, but not technically impossible: already a number of farmers in the communities of this study reported paddy yields well in excess of 8 tons/ha. Further, expanding areas under irrigation within and around the existing traditional schemes hold great potential. For example, in the Wami-Ruvu Basin, there are more than 26,000 ha of potential irrigation area around Mkindo and Dakawa where expansion is possible (MPEE, 2007). This could potentially accommodate more than 20,000 farmers who are currently depending on rainfed paddy farming.

This study reveals wide gaps (more than a factor 2) in agricultural productivity between irrigated and rainfed plots as well as between improved and non-improved schemes. It also shows large differences (2-6 times) in productivity among farmers within the same scheme. Revenues of irrigated plots in improved schemes are 1.5 - 2.5 times higher than in rainfed and unimproved schemes. Earlier assessments confirm these trends and order of magnitudes in other parts of the country. Dependency on paddy farming as a source of household income in the study area is high. Off-farm sources typically account for less than 15% of the total household income. Consequently, interventions to improve and expand smallholder irrigation in such communities will potentially have substantial impacts on livelihoods and poverty reduction at the household level.

The lack or poor state of infrastructure in traditional schemes hampers the ability to properly control and manage water. This leads to too much water in some schemes or fields and too little water in others. High losses in canal conveyance cause water shortages at tail end farms and limits possible expansion of irrigated areas. The Mkindo and Hembeti schemes, for example, suffer from too much water in the fields. In such cases irrigation interventions should focus on upgrading basic infrastructure such as improved intakes and canal infrastructure. Typically the upgrading of the intake consists of constructing a cement weir across the stream and valves at the entrance of the main canal. Improvements of canals include lining, small division structures and field off-takes (IFAD, 2007; World Bank, 2004).

However, in water scarce basins such as the Pangani and Usanga, cement weirs and valves may allow some schemes to augment their water intake during the dry season at the expense of others, aggravating conflicts over water between upstream and downstream users. There is evidence that this is already occurring in the Usanga Basin (Lankford, 2004; Mwakalila, 2006; Kadigi *et al.,* 2003). Therefore, any infrastructural changes and expansion should be based on sound technological designs and take into account potential effects on downstream users. Risks of conflicts and resource overexploitation should be evaluated on a case-by-case basis and indeed, sometimes improving intakes may not be the best course of action, even if it is a strong desire from the scheme users.

Further, the differences in yields and incomes between farmers in the same scheme point to the scope for improvement in on-farm water management, farming practices and marketing. Interventions in traditional irrigation schemes that exclusively address infrastructural concerns may not lead to the desired poverty alleviation impacts. For example, the surveys in this study revealed that most farmers in the study area were generally dissatisfied with the frequency and quality of visits by extension workers. Innovative approaches such as practiced by Kilimanjaro Agricultural Training Centre (KATC) under the TANRICE project show that improved information to farmers can lead to yield increases of 30-75% (KATC, 2008). Farmers who participated at farmer schools in rice cultivation conducted by the Mkindo Farmers' Agricultural Training Centre consistently achieve higher yields (by 30-200%) than their colleague farmers (Kaihura *et al*., 2008).

Finally, of particular interest is the marketing of crops. Access to markets is generally not the limiting factor for paddy farmers but smallholders tend to sell at the end of the cropping season when prices are low. A micro-credit organization in Mkindo is experimenting with delayed bulk selling. The micro-credit organization gives a credit at the beginning of the season equivalent to an agreed number of bags of paddy. At the end of the season the farmer pays his debt in bags of paddy. The micro-finance organization stores the paddy in their warehouse and sells later in the season when prices are high.

This study demonstrates the potential of smallholder irrigation schemes in improving rural livelihoods in Tanzania. Improved schemes are more productive and profitable and justifies investments in existing unimproved schemes. Expanding developed areas, infrastructural improvements coupled with a watershed management approach and innovative farmer training and marketing offers significant opportunities to increase yields, improve household incomes, and contribute to Tanzania's poverty alleviation and development goals.

References

Hussain, I. & Hanjra, M.A. (2004). Irrigation and Poverty Alleviation: Review of the Empirical Evidence, *Irrigation and Drainage,* 53 (1), 1–15.

IFAD (2007). *Participatory Irrigation Development Program (PIDP): Completion Evaluation Report,* Report Nº 1831-TZ - Rev. 1, International Fund for Agricultural Development, Rome.

Irz, X., Lin, L., Thirtle, C., & Wiggins, S. (2001). Agricultural Productivity Growth and Poverty Alleviation, *Development Policy Review,* 19 (4), 449–66.

Kadigi, R.M.J, Kashaigili, J.J. & Ntegua, S.M. (2003). The economics of Irrigated Paddy in Usangu Basin in Tanzania: Water Utilization, Productivity, Income and Livelihood Implications, *4th Waternet/Warfa Symposium*, 15-17 October 2003.

Kaihura, F.B., Temi, M. & Julianus, T. (2008). Farmer Field School experiences in improved land, water and agro-ecosystem management in Tanzania. In: *Farmer Field Schools on land and water management in Africa proceedings of an international workshop* in Jinja, Uganda, 24-29 April 2008.

Kaswamila, A. & Masuruli, B.M. (2004). *The Role of Traditional Irrigation Systems in Poverty Alleviation in Semi-Arid Areas: The Case of Chamazi in Lushoto District, Tanzania.* Research

Report No. 04.3. REPOA. Dar es Salaam, Tanzania.

KATC (2008). *TANRICE Training course*. Kilimanjaro Agricultural Training College, Moshi.

Lankford, B.A. (2004). Irrigation improvement projects in Tanzania; scale impacts and policy implications, *Water Policy* 6 (2), 89–102.

Lecoutere, E. (2010). *Institutions under construction: Resolving resource conflicts in Tanzanian irrigation schemes,* MICROCON Research Working Paper 23, Brighton: MICROCON

Machibya, M. & Mdemu M. (2005). Comparison Assessment of Water Use and Damage between Modern and Traditional Rice Irrigation Schemes: Case of Usangu Basin, Tanzania*, International Journal of Environmental Research and Public Health* 2005, *2(2)*, 335-342

Makurira, H., Mul, M.L., Vyagusa, N.F., Uhlenbrook, S., & Savenije, H.H.G. (2007). Evaluation of community-driven smallholder irrigation in dryland South Pare Mountains, Tanzania: a case study of Manoo micro dam, *Physics and Chemistry of the Earth*, 32 (15–18), 1090–1097.

MoWI (2009). *National Irrigation Water Policy*, Ministry of Water and Irrigation, United Republic of Tanzania.

MoWI (2002). *National Irrigation Master Plan,* Ministry of Water and Irrigation, United Republic of Tanzania.

MPEE (2007). *Socio-economic status report for Morogoro Region*, Ministry of Planning, Economy and Empowerment, United Republic of Tanzania.

Mul, M.L, Kemerink, J.S., Vyagusa, N.F., Mshana, M.G., van der Zaag P., & Makurira, H (2011). Water allocation practices among smallholder farmers in the South Pare Mountains, Tanzania: The issue of scale, *Agricultural Water Management*, 98(11), 1752-1760.

Mwakalila, S. (2006). Socio-economic Impacts of Irrigated Agriculture in Mbarali District of South-West Tanzania, *Physics and Chemistry of the Earth,* 31 (15–16), 876–84.

TNBC (2010). Tanzania National Business Council website. http://www.tnbctz.com/index.php/KILIMO-KWANZA/View-category.html. Last accessed 2010.

Turpie, J., Ngaga, Y.& Karanja, F. (2003). *A Preliminary Economic Assessment of Water Resources of the Pangani River Basin, Tanzania: Economic Value, Incentives for Sustainable Use and Mechanisms for Financing Management.* Report to IUCN EARO, 96 pp.

World Bank (2004). *Tanzania RBMSIIP implementation completion report.* Washington DC: World Bank-IDA report No: 30929