Comparison Assessment of Water Use and Damage between Modern and Traditional Rice Irrigation Schemes: Case of Usangu Basin, Tanzania

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Abstract: Water management and competition between users in water scarce river basins is a major challenge facing the human race. The inter dependence of users in such basins, necessitates a clear understanding of each user in relation to the location, the water demand, and the duration of water need. The understanding of these factors, together, is very important for the management of water resources in such basins without which, it is argued that, water is overused and wasted. As an example of this, the large modern and improved rice irrigation systems in Tanzania are believed to use water more efficient than the traditional irrigation systems. Yet, well-founded scientific analyses are a necessary part to quantify such beliefs as they can inform us whether the natural resource, in such systems, is properly utilized and managed or not. Likewise, such studies can allow us to quantify how much water is over used and thus the natural resource is unnecessarily degraded. This paper explores a study conducted in the Usangu basin, Tanzania, to investigate the gross and net needs for modern and traditional rice irrigation schemes, and the implications with regards to water resource management and damage. Problems relating to modernization of traditional smallholder irrigation systems and upstream - downstream water users are further discussed. The paper concludes from the study that modern irrigation schemes are inefficient compared to traditional irrigation schemes. Also modernization of traditional schemes in the study area have resulted into over abstraction and reduced productivity of water. Looking to the future, this study tells us that improvement or modernization of irrigation infrastructure should be balanced between negative impacts to available water resources albeit it's significant economic contribution to the community.

Keywords: Water, efficiency, irrigation, Traditional and Modern systems.

Introduction

The rapid world population growth have made the management of irrigation schemes vital, particularly in poorer countries, such as Tanzania where the greatest potential for increasing food production and rural incomes can be found in irrigated areas. Irrigation contributes about 40% to the world's food supply from only 18% of the total arable land in the world-approximately 237 million hectares [6, 16]. Of these irrigated areas, 71% are found in Least Developed Countries (61% in Asia alone). The production of food and fibers for irrigation makes up to 72% of the world water abstractions [3, 4]. Agriculture consumes more than 70% of the available world water resource. Both in Africa and Asia, irrigation water make up more than 80% of the continents abstractions.

High population growth coupled with increase in per capital water demand together with increasing demands of water for industries and cities will constrain available water resources worldwide. Because the value of water in industrial use is higher than in irrigated agriculture, it is anticipated that in future water will be diverted from less value irrigated agriculture to more productive use in industries and cities. Such phenomenon is partly being happening in some parts of China such as the Yangtze River [2]. In addition environmental water allocation is currently considered important and will claim its water share from irrigated agriculture. However, irrigated agriculture will remain to be important for providing food and livelihood security to the fast growing population expected to clinch 8 billion by 2025. Various projections on irrigation development to meet demand for food by 2025 have been produced using 1995

information as the base. IWMI [7] projects a 17 percent increase in diversion to supply a 29% of area that would be expanded for irrigation. It is estimated that 34% expansion in area under irrigation would need 12% addition increases in diversion to the current state [4]. On the other hand a projection of 28% percent increase in diversion has been anticipated [6]. A sustained gain in improved productivity and effective water use or business as usual [8] is the main assumption in these projections. The key question is what strategies will ensure such sustained effective and productive use. The only alternative to eliminate increase in diversion is the increase in production of cereals from the global level of 3.3 in 1995 to the level of 5.7 tons per hectare in 2025 [13]. Such leapfrog might make it difficult for African countries if pursued, where irrigation efficiencies are believed to be too low.

One of the major reasons for large water consumption in irrigation has been largely attributed to low (20-50%) irrigation and water use efficiency especially in sub-Saharan Africa where surface irrigation is the mostly commonly used method of irrigation. Between 1950's and 1980's large irrigation development through the support of the International Development Assistance (IDA) took place in sub Saharan Africa by modernizing the irrigation infrastructure particularly intakes and canals. The aim of the modernization was to increase the amount of controlled water supply to meet the expansion of the irrigated area. This development plethora took place similarly in Tanzania. In Usangu Basin for example more than ten (these include among others the irrigation schemes of Mbarali, Chimala, Majengo, Kapunga, madibira, Ipatagwa, Moto mbaya, Langwira, Kapunga and Kimani) large and medium irrigation schemes were developed between 1960 and 1990 with assistance of grants from Canadian International Development Assistance (CIDA), Food and Agriculture Organization (FAO), World Bank (WB) and African Development Bank (AfDB) [11]. Apart from improving reliability of water supply, to expanded area, less was improved in terms of irrigation and water use efficiency in the schemes. The inefficiency of water use in these modern schemes was partly due to the high authority given to the schemes in terms of non binding terms to water abstraction because they were government agency led schemes that also depend on government financial allocation for the operation and maintenance and their staffs. The collapse in Nations economy impacted negatively on performance of schemes in terms of their operation and production falling far below standards. This had further consequences in water use efficiencies of the schemes as a result of poor water management for irrigation. Research finding on current improvement in smallholder irrigation schemes under the financial supported by the World Bank in Usangu Basin disproves the notion of increased efficiency from the infrastructure improvement [10]. The levels of efficiency improvement from 20% to 30% targeted by the program [14] are still very questionable. However, essence of improvement have further increased the ability of farmer to divert almost the whole rivers supported by intakes designs that can allow the diversion of entire river especially during low river flows in the dry seasons. The irrigation development in Usangu is now cited as the main reason for drying of the Great Ruaha River from 1990s [18, 19] that used to support different sectors due to its year round flow.

This paper reports the finding on water use efficiency between the Modern and traditional irrigation schemes in Usangu Basin in Tanzania. The level of inefficiency is refereed as water damage especially when such loss appears in evaporative losses or ground water flows that cannot be recovered and used again because of the nature of infrastructure and management failures. The Usangu Basin is a relevant study for this case because of the following:

- It is home to over 200 000 people, most of whom depend for their livelihoods on the natural resources (water) of the basin and 30,000 household directly depending on rice farming in the basin [19];
- It has extensive water abstraction for rice irrigation achieved through improved intakes in modernized irrigation schemes;
- Multiple water use sectors apart from irrigation exists including domestic, livestock, river line environment and wetlands, wild animals and ecological functions in the Ruaha National Park, fishery in the rivers and the wetlands and hydropower generation which contribute over 50% to National Electric Grid in the dry season.

The overall objective of this paper therefore is to demonstrate whether irrigation efficiency and productivity in Usangu can be achieved through infrastructure improvement or it is more of water management, policy and institutional arrangement.

Material and Methods

Description of the Study Area

The study was carried out in Kapunga water system in the Usangu Basin (USB) during the period 1999-2001. The Usangu basin is located in South West of Tanzania, between approximately latitudes $7^041´$ and $9^025´$ South and longitudes $33^040´$ and $35^040´$ East. The basin forms an important part of the upper catchments of the River Rufiji, Tanzania's largest river basin (Figure 1). Usangu covers an area of about $20,800km^2$ and consists of two distinct parts, a mountainous and well-wooded area with moderately high rainfall (1000-1600mm) in the south, falling to an extensive flat plain in the north. Within the flat plain there are large areas of alluvial fans, supporting the majority of the settlements in the catchments, as well as irrigated and dry land farming. The alluvial fans in turn give way to an extensive wetland, comprising seasonally flooded grassland and a much smaller area of permanent swamp. Average annual rainfall received in the flat plains is about 700mm which is moderately lower compared to the mountainous areas. The basin receives rainfall in the period between December and March, which is followed by a prolonged dry season of about seven months.

The upper catchments in the basin are well drained by means of a number of perennial rivers falling sharply over an escarpment to the flat plains. The rivers flow
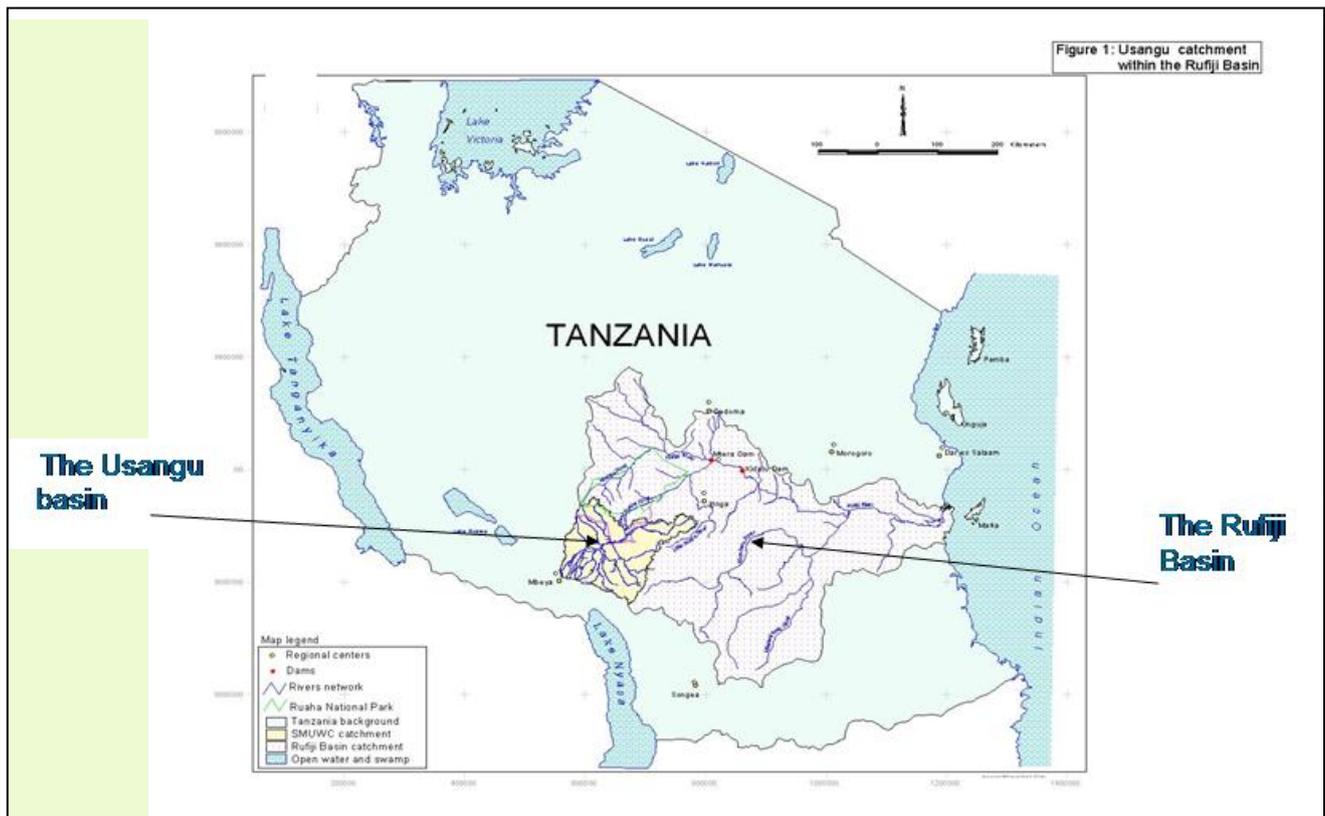
Figure 1: Map of Tanzania showing the Usangu Basin within the Rufiji River Basin

through the seasonal wetlands and into the Ihefu, permanent wetland, after abstraction for irrigation in the medium slopes of the plains. The outflow from the swamp is controlled through a weir in the form of a natural rock outcrop, from where all downstream flows from Usangu are channelled through the Great Ruaha River which flows through the Ruaha National Park and then to the Mtera/Kidatu hydropower reservoirs after being joined by little Ruaha upstream and river Lukosi downstream of Mtera Dam. Generally River flows are at their lowest in the months of October-December each year.

Data Collection and Analysis

Three rice irrigation farms in NAFCO, National Agriculture and Food Corporation, a government parastatal organization with the mandate of running large National Farms in Tanzania, Kapunga modern and Mwashikamile traditional irrigation schemes (in Tanzania Morden irrigation schemes are defined by concrete built diversion structures with adjustable inlet gates (open and close) and designed field layout. Presently two types of modern irrigation schemes exist in Tanzania: Large and smallholder irrigation schemes. Traditional irrigation schemes are those which use traditional diversion structures to divert water to the irrigation plots. The traditional diversion structures include water blocking logs, stone intakes, sand, and earth bags. These are temporary structures that can be washed away by the flowing river from one season to

another) were sampled for field water use monitoring depending on location in the farms, reliability to inflow and outflow measurement of water, accessibility during rain season and farmers willingness to allow experiments to be conducted in their rice fields. The field plot experimentation was conducted in two crop seasons of 1999/2000 and 2000/01. The sample farm plots were monitored for irrigation inflow and outflow from the plots, paddy transpiration, evaporation from standing water in the fields, and lateral and deep percolation. Inflow and outflow were measured using portable rectangular and trapezoidal flumes for the traditional farms. The flumes were calibrated each season by using equation for small rectangular and trapezoidal weirs [1]. For the Modern irrigation scheme inbuilt structures for inflow and drainage outflow were calibrated for each season and used to measure water flows. On all sampled plot in modern and traditional schemes lysimeters (900mm x 350mm-height x diameter) were installed 400mm deep below the soil surface to measure evaporation, rice transpiration and deep percolation losses. Three lysimeters were installed for each farm plot (Figure 2). Six rain gauges, one for each farm plot were also installed to measure the rainfall contributed into the farm plot during each rainfall events for the entire crop growth season. Water levels maintained in the rice farms were measured by using graduated water depth meters. The farm water inflow and drainage measurement were taken whenever the event of irrigation or drainage occurred. Other measurements were measured and recorded every day at 0900 GMT.
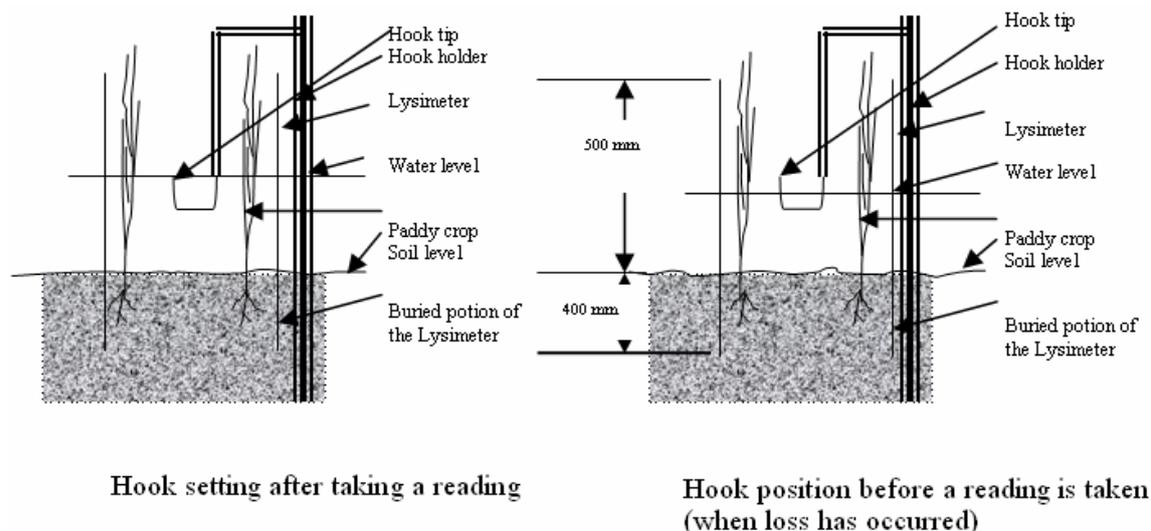
Figure 2: Cross sectional view of a lysimeter installed in a field

Lateral and subsurface water flows in the experimented farm plot were determined using model equation (1).

$$\pm (L_{p+s}) = (E_{vt} + T_r + D_p + R_o) - (I + R) \qquad (1)$$

where:

R = Seasonal rainfall (mm) received during crop growth period,

I = Seasonal irrigation water (mm) applied during the crop growth period

E_{vt} = Seasonal evaporation (mm), occurred in the farm plots

T_r = Seasonal rice crop transpiration (mm),

D_p = Seasonal deep percolation losses (mm),

R_o = Seasonal runoff (mm) from the plots,

(L_{p+s}) = Seasonal lateral percolation and subsurface movement (mm) of water in the plots.

Water flows into the irrigation systems were measured by installed water level gauges in the primary canals and main drainage outflows from the systems. Current meter measurements were used to calibrate the flows and then the rating curves for different canals and furrows were developed. Measurements of flows and canal water levels were taken and recorded twice per day at 0900 and 1700GMTs.

At the end of crop season during harvesting, rice yield samples were collected from three square quadrants having an area of not less than 15m^2 [20] in each experimented farm and rice yield was measured using weighing balance (0.001g accuracy). The average yield was then determined per season for the modern and traditional irrigation schemes. The measurements obtained from the monitored farms were used to calculate the gross and net seasonal water used (GAWU&NAWU) for rice growing in the two types of scheme based on calculated field water balances. Field or farm water use efficiency was then calculated using model equation (2).

$$Efficiency\ (\%) = \frac{Gross\ annual\ water\ use\ (GAWU)}{Net\ annual\ water\ use\ (NAWU)} X100 \qquad (2)$$

The level of inefficiency between the two systems (farms) was used to source out the reasons for the difference. Several factors were related to inefficiency of modern irrigation systems which includes: excessive standing water layers in the rice farms that evaporates unproductively, ability to divert and apply large quantities of water for wetting the field, even at low river flows, which most of it eventually evaporate and percolate into the ground and prolongs water delays in the upstream to downstream users rendering it unproductive to downstream users due to late transplanting that does not match with best rice crop transplanting window.

Results and Discussions

Field Water Balance Analysis

The results for the net annual water use (NAWU) for rice for the two years of study are presented in Table 1. The results show that there were no significant differences in net water requirement between the rice planted in different irrigation systems within the different period in the year and as well as between the two years.

Table 1: Net annual water use (NAWU) by rice plant in different irrigation types

Site Name	Seasons		Mean net annual water use (mm)
	1999/2000	*2000/2001*	
Modern	985	1063	1024
Modern	989	986	988
Traditional	1151	1095	1123
Traditional	999	976	988
Mean			1031

However the gross annual water depleted in modern and traditional irrigated schemes, differed significantly. Tables 2 and 3 show the separate water uses in a dry year (1999/2000) and a wet year (2000/2001) and the respective efficiency for each irrigation type.

Table 2: Summary of water use 1999/2000 season (dry year)

Site Name	GAWU (mm)	NAWU (mm)	Efficiency (%)
Modern	2038	985	48%
Modern	1993	989	50%
Traditional	1668	1151	69%
Traditional	1789	999	56%

Table 3: Summary of water use 2000/2001 season (wet year)

Site Name	GAWU (mm)	NAWU (mm)	Efficiency (%)
Modern	3010	1063	35%
Modern	2327	986	42%
Traditional	1722	1095	64%
Traditional	1730	976	56%

In the dry year (Table 2) modern systems depleted a maximum annual gross of 2038 mm, whereas the net water requirement averages at 987 mm, which calculates an efficiency of about 48%. In the wet year (Table 3) however, the period when water is available in excess and the competition for water was less, modern system applied a maximum of 3010 mm and the efficiency was 35%.

Table 3 shows a maximum recorded gross annual water use (GAWU) for the traditional systems during the wet season of about 1730 mm. At a net water requirement of 976 mm, the efficiency is calculated to be 56%. During the dry year, more or less to the same amount of water was applied. The same efficiency of 56% was obtained from a gross water use of 1789 mm and a net paddy water requirement of 999 mm. It is worth noting however that the efficiency in traditional system can go up to nearly 70% in some fields particularly during the dry year (Table 2).

Competition for Water and Water Damage

The water resources of the USB therefore have a multiplicity of uses, covering domestic supply, agriculture, livestock, fishing, environmental maintenance, wildlife, recreation and hydroelectric power generation. Of these, water for irrigation is the key use, since it is the largest human consumptive use, and the most obvious user at which management actions can have significant impact.

On many counts, irrigation development in Usangu has been extremely successful. Irrigation has been practised in the basin on a traditional and small scale over a century or more. Expansion of irrigation in

Usangu, increased steadily from 1930s to 1999 [10] starting with traditional system and later modern system. These two systems (*large "modern" scale owned by state and small "traditional"-scale for smallholders*) which have continued to develop side by side, are at present estimated to have 45 000 ha of rice irrigation in a wet year [16]. It is important to emphasize that this is a very dynamic figure, varying from year to year in relation to water availability and seasons. The smallholders, in particular, are very flexible in their response to changing conditions and take up or abandon plots because of the perception that the season is likely to turn out [5].

Considerably these two systems which have been constantly expanding, competing and changing from "traditional" to "modern", over a constant supply of water, has resulted in over abstracting water from the river systems. The "modern" systems which are equipped with large concrete intakes with ability to divert almost the whole river, uses this opportunity to win the competition over other water users. However, the low flows in the dry season, are not quite useful for the irrigation sector since the crop productivity during this period becomes quite low.

As the result of over abstraction by large "modern" systems, the following phenomenon happens in Usangu

(i)   Over-irrigation does occur in the field, with intakes which can abstract water from the river, indefinitely. But contrary this reduces the productivity of water since too much water results on low yield but also too much gross water use results in low rice productivity (expressed in yield per gross annual water use)

(ii) Since each crop type has a defined water requirement in a particular environment, the excess water abstracted is seldom useful for the crop and thus it is lost through natural processes such as evaporation, deep percolation and in this way losses of water resources occurs

(iii) Also, as less water is left for the traditional systems which are often located downstream of the modern systems, the cropped area is reduced and again either the yield per year is reduced or the crops attain their wilting point before maturity. This creates feelings to traditional farmers that upgrading of traditional intakes is the way to enable sufficient abstraction of water (the way to win water competition) – But indeed it has caused more competition in the basin and the traditional farmers they still manage the little water they get.

(iv) The competition does not end by the two users only (modern and traditional). As it was mentioned earlier that all the users in the USB get water from common sources, the effect of competition reaches other users like hydropower, livestock keepers and domestic in the downstream of the systems.

Strategies for Water Resources Management

Water Management in Irrigation

There are four key characteristics of irrigation that influence the amount of water abstracted from the river systems, thereby reducing downstream supply for the

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Usangu wetland. The first is the timing of cropping and the arrival of rains. There is evidence to indicate that, by necessity, most of the traditional farms wait until the onset of rains before planting their rice fields. Use of rainfall for preparation of traditional farms reduces the demand for river water abstraction as the main source. Therefore, at certain flow rates, a higher proportion of river water is likely to reach the wetland.

The dependence on rains is not found on the large modern farms. The intense use of perennial rivers throughout the dry season (from September) to prepare land and germinate unwanted weeds constrains the ability of the river system to supply water to both rice, hydro plant, National park and wetland in the downstream. Measurements and discussions "with farm managers indicate that up to maximum intake capacity (approximately 8,000 1/sec) the state farms take 70 percent to 90 percent of available river water. The design of the off-takes is important in aggravating this abstraction as evidenced by intake capacity of 6cumes for the Kapunga modern scheme whose water rights is only 4.8cumes.

Table 4 shows different field operations for the Modern and Traditional rice irrigation systems in Usngu basin. The amount of water used to saturate the soil in Modern system is 4 times the amount used by Traditional systems. Both the amount (large quantity) and the duration that takes to saturate the soil in modern systems contribute to about 12 percent of water lost through ground water by seepage and percolation. While the traditional systems use only 4 to 6 days to saturate the soil, modern systems takes 19 days which is almost 5 times the period utilized in the traditional farms. The prolonged duration for pre-saturation in modern systems, the ability to abstract low flows, and their upstream location results into delay of up to two months for traditional systems to receive sufficient water to abstract from the river system. This is contrary to a delay of less than a week which could be caused by the traditional systems which uses only 4 days to pre-saturate.

Table 4: Field operation and water use for the different systems

| Site | Field Operations | | | |
| | Pre-saturation | | Water depth (mm) | Duration of water in field to maturity (days) |
	Amount (mm)	Duration in days		
Modern	665	19	121	200
Traditional	156	4	116	165

Source: [12]

Although water depths maintained in the fields and the duration of water does not show large differences between the systems, it plays key contributory role for water lost through the ground and by evaporation in modern systems because of a large contiguous area that stay with water for a considerable length of time.

With this kind of management difference between the two systems above it is clear that the two systems largely differ in management. Based on these observations the fact that GAWU in modern systems is about 600 mm more than the traditional systems could be explained.

Technology and Policy

Back to 1990s the Government of Tanzania with the Support of the World Bank, African Development Bank, CIDA and FAO embarked on modernization of large and smallholder Irrigation schemes in Usangu basin. The aim was to replace traditional intakes with concrete intakes and also to develop new schemes [8]. In 1996 the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP) again with the support from the World Bank was initiated with the target of improving smallholder irrigation schemes. The program covered two basins in the country the Rufiji basin, which includes the USB, and the Pangani Basins. The main reason behind the improvement program was to increase or improve the irrigation efficiency and crop production through improved access to water by the intakes. However evidence from Usangu indicates that the improvements of traditional schemes do not necessarily result in improved water control, equity, reduced conflict and higher performance [10]. The analyses of the problems of upgrading some traditional schemes in the USB with regard to water resources management are further elaborated in the proceeding paragraphs.

Structural or Hydraulic Effects of Improved Intakes

Traditional intakes are 'scooped' water from the river [8], allowing water to pass without necessarily raising river water levels. This means traditional systems could only manage to divert sufficient amount of water when the levels of water in the river rose. This is normally in the months of December to January for the case of USB after the rain season has already started. The by-pass in the river under traditional intakes was sufficient to sustain downstream water needs. The combination of the higher-level concrete weir and the lower level of the base of the intake orifice effectively raised the level of water behind the intake in modern intakes. With these arrangements all the water can be taken regardless to the level of flow and inevitably commanding land became possible even during low flow periods. In the advent of improved intakes, also upstream farmers take the advantage of opening fully the release gates and therefore denying downstream users during periods of low flows.

Operation and Maintenance (O&M)

The provision of improved intakes was equated by farmers with reduced maintenance and labour requirements for the operating the intakes. Although farmers consider this as a positive impact it has had some deleterious effects on water resources management of the basin because of reduced cooperation between

farmers to ensure the long-term sustainability of the system. The improvement in some of the schemes that did not evolved from participatory approaches, farmers feels that the responsibility of maintenance rest with those who were involved in the improvement. The farmers have further been reluctant to contribute for the money to cover the cost of maintenance or other activities related to proper operation of the schemes.

Further more, lack of cooperation has encouraged weak systems of management institutions. This is because the tasks undertaken by the management committees are based on individual or small group decisions resulting into much resistance from the farmers on tasks to be carried such as water scheduling, collection of water fees contribution and cleaning of irrigation canals. In most cases therefore water scheduling are not followed and farmers are happy to see water flowing through their fields.

Patterns of Rice Production

Because of easily control of water from the improved intakes, farmers have started capitalizing on late season rice irrigation and dry season cropping. Preparation of fields for rice nurseries and transplanting have even brought forward. This has outstripped the water demand for rice cultivation that initially was within January to May to within October to June window. The change in pattern of rice production has encouraged a year round abstraction of water from rivers. Farmers in the upstream start the rice activities as early as September while tail ender's may continue to transplant until end of April or first of May. This has an impact in water productivity and resources management in the fact that while water may be delivered in the field, farmers may be absent to utilize this water effectively encouraging losses through evaporation and seepage during this prolonged period of transplanting. This is what is refereed to as mosaic of planted and unplanted fields [9].

Reduced Land and Crop Water Productivity

Rice production does not appear to have increased in most of improved schemes. In middle and tail-end reaches, yields remained at 1.5 t/ha to 3 t/ha, and have not increased to 4 to 5 t/ha as anticipated for in the RBMSIIP project plans. Top-end yields are higher to about 2.5 to 4.5 tonnes/ha because of earlier planting and optimal water conditions. Therefore the projections of yields of 4 to 5 tonnes/ha appears were unrealistic, even though it was used to justify the undertaken interventions. Greater use of water over an extended season results in relatively low productivity of water. Calculations indicate that this is in the region of 0.14 kg of rice per m^3 of water [10]. In many rice schemes in Asia, figures of 0.5 kg per m^3 are obtainable, indicating significant potential for improvement [14].

Equity of Water Supply within Systems

Because the upstream farmers takes the advantage of fully opening the offtake gates to their farms, downstream farmers remain inaccessible to irrigation water until when levels of water in are high to allow sufficient water flow in the canals. More worse in modern and improved schemes the drainage water that once in the past was easily recapturable downstream is now difficult because of deep drain canals which are often not managed and maintained. This could not have been a problem if water scheduling could have been functioning properly as it was planned before improving the systems.

The Upstream/Downstream Effects

The effects of the improvement programme though it has some positive benefits, some remarkable negative consequences have been observed. Firstly it has plaid a contributing role behind the general expansion of dry season rice irrigation, secondly it has facilitated into high value vegetable irrigation in the dry season and lastly the prolonged rice-growing season because of the ability to abstract water whenever needed which collectively has caused low or no flows to the downstream users during some critical period of the season. It should be noted that the extended cultivation accounts for the large proportion of water loss from the system especially during April through to September when the percentage of area under rice is quite small yet the fields are still being used to transfer water through to tail-end areas (who transplant late in the due to delays caused by upstream users). In addition, the rice that is grown yields poorly and therefore economically, contributing to water damage. The period April through to September is when recession flows from the highlands would normally have supplied and maintained the Usangu Wetlands and Ruaha National Park.

Conclusions and Recommendations

Irrigation efficiency and productivity in Tanzania could probably not be improved through improvement of irrigation infrastructure. This is demonstrated by these research findings whereby the modern systems in Usangu deplete more water than the traditional systems. Modern systems in Usangu deplete an extra amount of water of about 600 mm annually as compared to the water depleted by traditional systems. The current interventions on improvement of traditional rice irrigation systems in Tanzania might end up creating more chances for depleting water resource if scientific research findings are not taken on board. The way forward to improve the efficiency of traditional irrigation system and changing the management of modern farm need to be based on scientific research findings.

The River Basin Smallholder Irrigation Improvement Projects (RBMSIIP) being undertaken in the Usangu basin needs to be based on appropriate concepts and well founded results of irrigation efficiency and productivity. Research findings like these, undertaken in the area, for example, have shown traditional systems to have high irrigation efficiencies compared to improved or modern irrigation schemes. This differences lies in the approaches of managing and controlling water in the field between the two systems. It is further argued that measures to increase upstream control as envisaged by

improving the intakes may not result in any increase in system efficiency at this time, but may conversely lead to increases in conflicts and inequity between top-enders and tail-enders.

The paper further concludes that modern irrigation schemes are inefficient compared to traditional irrigation schemes in the water scarce river basin like the USB and in competing environment. Improvements of traditional schemes have resulted into over abstraction and reduced productivity of water, a common natural resource, which is very important for the poor in the Usangu basin. Looking to the future, this study tells us that developments in irrigation infrastructure should be proactive by considering the negative impacts to available water resources albeit its significant economic contribution to the community.

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