Southern Agricultural Growth Corridor of Tanzania

Appendix VII:

Irrigation and water in Usangu – A case study

Draft

Introduction

Private farms and smallholders in the Usangu plains produce over 200,000 tonnes of rice annually for the national market, placing Usangu number one among Tanzania's rice producing areas, followed by Shinyanga and the Kilombero Valley. Rice production in Usangu is a predominantly wet season activity where irrigation systems provide supplementary water to "kick-start" rice production. Scope exists to extend irrigated production through the dry season whilst respecting downstream environmental flow requirements if irrigation efficiencies improve and water storage is provided.

Crossed by the Great North Road and the Tanzam railway linking Mbeya with Iringa and Dar es Salaam, Usangu forms the headwater catchment of the Great Ruaha River (Figure 1). The catchment has a total area of 20,800 km^2. The catchment comprises the plains and the 'high catchment'. The plains are situated between 1,000 masl and 1,100 masl and cover about 4,800 km^2. The high catchment is situated between 1,100 masl and nearly 3,000 masl and covers the remainder of the area (Figure 2). The plains receive 600-800 mm rain annually; the high catchment between 900 mm and 1,500 mm. The high catchment is the source of perennial rivers which flow down the rift valley escarpment to the plains. The plains consist of alluvial fans which form a continuous band around seasonally flooded open grasslands and a perennial swamp, the *Ihefu*, which is situated in the Usangu Game Reserve, adjacent to the Ruaha National Park (RNP). The Great Ruaha River flows out of *Ihefu*, through the RNP for much of its course down to Mtera and Kidatu hydropower reservoirs where 330 MW or 51% of Tanzania's hydropower generating capacity is installed. The water resources of Usangu are exploited both within the Usangu catchment, for wet and some dry season irrigation, livestock watering, domestic supplies and the aquatic environment of the Usangu wetland, and downstream, for the aquatic environment, wildlife watering and aesthetic conditions for tourists along the river in the park and for hydropower generation at Mtera and Kidatu dams.

Irrigation takes place on the middle to lower parts of the alluvial fans on the southern margin of the wetland. Rainfall is supplemented by diverted river flows, the main source of irrigation water. A single rice crop and some maize and vegetables are cultivated. Rainfed agriculture exists on the upper parts of the fans where rainfall is slightly higher. There is currently no water storage infrastructure in Usangu, although the Lugoda dam on the Ndembera River is being studied for the provision of hydropower, irrigation supplies and environmental flows.

Current situation

Up to 42,000 ha of rice are irrigated by two large private farms, Mbarali and Kapunga, two large smallholder schemes, Madibira and Kimani, and individual smallholders who together cultivate approximately 67% of the total irrigated area (Table 1).

Table 1 Rice irrigation in the Usangu plains, 2008

		Irrigated area (ha)
Private rice farms		
	Kapunga	3,000
	Mbarali	3,200
	Sub-total	**6,200**
Smallholder rice production		
	Madibira (co-op)	6,000
	Kimani (co-op)	1,500
	Improved schemes	7,875
	Traditional schemes	19,950
	Unassigned	400
	Sub-total	**35,725**
Total irrigated area of rice, Usangu plains		**41,925**

Source: Zonal Irrigation Unit, Mbeya, Oct 2010

Studies in Usangu[1] have shown that the area of rice varies, depending on river flows, from a minimum of 22,000 ha in dry years to a maximum of 42,000 ha in an average year. An additional 2,500 ha of maize and vegetables is irrigated in the dry season for the local market. The maximum area irrigated now is approximately 44,500 ha, constant since 2001. About 120 intakes divert water from rivers. The estimated abstraction capacity in 2001 was 46 m^3/s[2]. The maximum irrigable area using natural river flows is considered to be 55,000 ha.

Usangu experiences a seasonal climate. The wet season in an average year lasts 162 days from the third decad of November to the end of April. The dry season lasts 203 days from 1 May to the end of the second decad of November.

Studies have shown that there are net and gross demands for irrigation water in Usangu. Net demand can be defined as a believable lower limit to real water use. Net demand arises from evapotranspiration and seepage at field level, minimum domestic demands (villages are supplied with domestic water by canal), minimum cultivation periods and an ideal crop season length. Gross demand, a believable upper limit to real water use, is defined as the maximum water demand occurring at the irrigation system level, arising from measurements and observations of the factors making up net demands plus commonly observed extended periods of cultivation and crop season lengths, extended field wetting practices and a small proportion of return flows. Table 2, distinguishing between wet and dry years and wet and dry seasons, presents available river flows, net and gross irrigation demands.

[1] SMUWC-Sustainable Management of the Usangu Wetland and its Catchment, a technical cooperation project, was implemented between 1998 and 2001 by the then Ministry of Water and co-funded by the UK Department for International Development. SMUWC formed a detailed input to RBMSIIP-River Basin Management and Smallholder Irrigation Improvement Project, also implemented by the then Ministry of Water and co-funded by the World Bank.

[2] Estimated by SMUWC in 2001.

Table 2 Net and gross irrigation demands and excess water used in Usangu

	Average year				Dry year[1]			
	Wet season		Dry season		Wet season		Dry season	
	Mm^3	%	Mm^3	%	Mm^3	%	Mm^3	%
Total available flow in rivers	2,134	*100*	495	*100*	924	*100*	261	*100*
Gross irrigation demand (A)	537	*25*	278	*56*	389	*42*	168	*64*
Net irrigation demand (B)	405	*19*	67	*13*	308	*33*	66.5	*25*
Excess water used (A-B)	132	*6*	211	*43*	81	*8*	101.5	*39*
Irrigation efficiency (B/A)		*75*		*24*		*79*		*39*
Additional irrigable area[2]			9,000 ha[3]				3,600 ha[4]	

[1] 5-year return period dry year. [2] Calculation made only for the dry season, assumes irrigation efficiencies are improved and a 1 l/s/ha gross water requirement for rice in Usangu. [3] Allows for 3 m^3/s environmental flow. [4] Allows for 2 m^3/s environmental flow.

Irrigation in Usangu has had and continues to have a number of impacts. Wet season inflows to Mtera hydropower reservoir may have decreased by 5% over the period 1980 (when Mtera was constructed) to 2000 as a result of diversion of wet season flows for irrigation, although detailed analysis of flow data recorded downstream of Usangu do not indicate such a trend. Flow in the Great Ruaha River downstream of Usangu, historically a perennial river, ceased in 1994 and almost each year subsequently. A number of dry season surveys of irrigation areas have observed the continued diversion of 95-100% of flows out of rivers, severely reducing flow into the *Ihefu* and resulting in the gross demand and low irrigation efficiency indicated for the dry season in Table 2. The Ruaha National Park, fearing reduced tourist revenue as a result of the dry river has recently been extended to cover the Usangu wetlands. Maintenance of the wetlands as a functioning ecosystem and source of dry season flow for the Great Ruaha River, through maintaining dry season inflows from upstream, remains an important objective of Tanzania National Parks, the park authority, and the national government to whose attention the plight of the Great Ruaha River was brought.

Future irrigation and water development

Irrigated agriculture in Usangu can be expanded; in the wet season by increasing abstraction capacity, and in the dry season by improving the efficiency of irrigation, providing domestic supplies from groundwater resources and by providing storage, while allowing for environmental flows downstream.

Although an excess of 132 Mm^3 is potentially available in an average wet season irrigation efficiency averages 75%, rising to 79% in a dry year, there is probably relatively limited scope for increasing the cropped area through improvements in efficiency in the wet season (Table 2). An increase in the area of wet season rice will require an increase in the available water resources. An additional 15 m^3/s abstracted from rivers in the wet season would be sufficient to expand the irrigated area from 44,500 ha to the maximum irrigable with natural river flows of 55,000 ha[3]. However, this would probably cause an additional 2-5% reduction in mean annual inflows to Mtera reservoir and a consequent decrease in the amount of hydropower that can be generated.

In an average dry season an excess of 211 Mm^3 is potentially available and irrigation efficiencies are low at around 24%, rising to 40% in a dry year. There is potential to increase the irrigated area by

[3] SMUWC (2001)

9,000 ha from 2,500 ha to 11,500 ha in the dry season in an average year from efficiency improvements using natural river flows and allowing for an environmental flow of 3 m^3/s, which is close to the historical dry season flow in the Great Ruaha River between *Ihefu* and Mtera. Larger areas may be able to be irrigated by introduction of shorter season rice varieties, strict adherence to a compact cropping calendar and more disciplined sharing of water abstracted for irrigation.

Considerable potential for storage exists in the high catchment, a runoff generating zone of relatively high rainfall and relatively low evaporation where natural grassland predominates with no large areas of forest. A regulating reservoir is designed to store surplus water in the river in the wet season and then release it during the dry season. In Usangu the shortage of natural flows during October-December and April-June is the main limitation on how much land may be irrigated from any particular river. Storage could enhance natural river flows during these periods of shortage and, if it were to occur, during a prolonged dry spell in the middle of the cropping season. Storage could also be used to develop dry season agricultural production and enhance downstream environmental flows.

The Mbeya Irrigation office has identified many sites for storage. Table 3 lists some of the potential regulating reservoir sites that, singly or in combination, could form part of a future irrigation development scenario. The sites are shown on Figure 2 together with other dam sites that have been identified recently by the Rufiji Basin Water Office, Iringa, and the Zonal Irrigation Unit, Mbeya. Alternative sites on the Ndembera River at Ngalenge and Lugoda are currently being studied for the supply of irrigation water, environmental flows and hydropower generation.

Table 3 Potential storage sites in the high catchment[1]

Site	River	Dam type	Height (m)	Crest length (m)	Design flood (m^3/s)	Storage capacity (Mm^3)	Average regulated flow over a year (m^3/s)	2020 Capital cost[2] (US$M)	Cost per unit storage (US$/$m^3$)
Great Ruaha	Great Ruaha	Rock / Earth	71	1,170	2,030	132	8.4	$59.9	$0.45
Kimani Alt 2	Kimani	Rock / Earth	48	2,310	1,540	160	4.5	$53.4	$0.33
Mbarali	Mbarali	Rock / Earth	55	770	2,620	141	11.5	$47.1	$0.33
Ipwani	Ipwani	Earth	-	-	1,345	74	2.7	$10.0	$0.14

[1] Source: FAO (1961) The Rufiji Basin, Tanganyika. FAO Report to the Government of Tanganyika on the preliminary reconnaissance survey of the Rufiji basin. ETAP Report No. 1269. Food and Agriculture Organisation of the United Nations, Rome. [2] FAO 1961 cost estimates in sterling escalated using the average of the US Engineering News Record and Bureau of Reclamation cost inflation indices and converted to US$ at $1.5.

Table 4 presents estimates of the areas that could be irrigated from the dams listed in Table 3 in a dry season of nine months (April-December) assuming that 10% of the yield is allocated to environmental flow to the wetland and downstream.

Table 4 Potential dry season irrigation areas with water storage

Site	River	Average regulated flow over a year (m^3/s)	Regulated flow over a 9-mth period (m^3/s)	Allocation to environmental flow (%)	Allocation to irrigation (m^3/s)	Irrigable area[1] (ha)	Cost of storage per unit irrigated area (US$/ha)
Great Ruaha	Great Ruaha	8.4	11.2	10	10.1	10,100	$6,000
Kimani Alt 2	Kimani	4.5	6.0	10	5.4	5,400	$10,000
Mbarali	Mbarali	11.5	15.3	10	13.8	13,800	$3,400
Ipwani	Ipwani	2.7	3.6	10	3.2	3,200	$3,100

[1] Assumes irrigation efficiencies improved and 1 l/s/ha gross water requirement for rice in Usangu.

Storage of wet season flows will reduce the seasonal flood inflow to Mtera and hydropower power production.

Only a full survey can outline the true potential of water storage and cost in the area. However it is plain that with careful planning and design the Usangu can be a more efficient, productive and environmentally sustainable agricultural area efficiently using water storage and irrigation to reliably produce crops all year round..

Figure 1 Location map

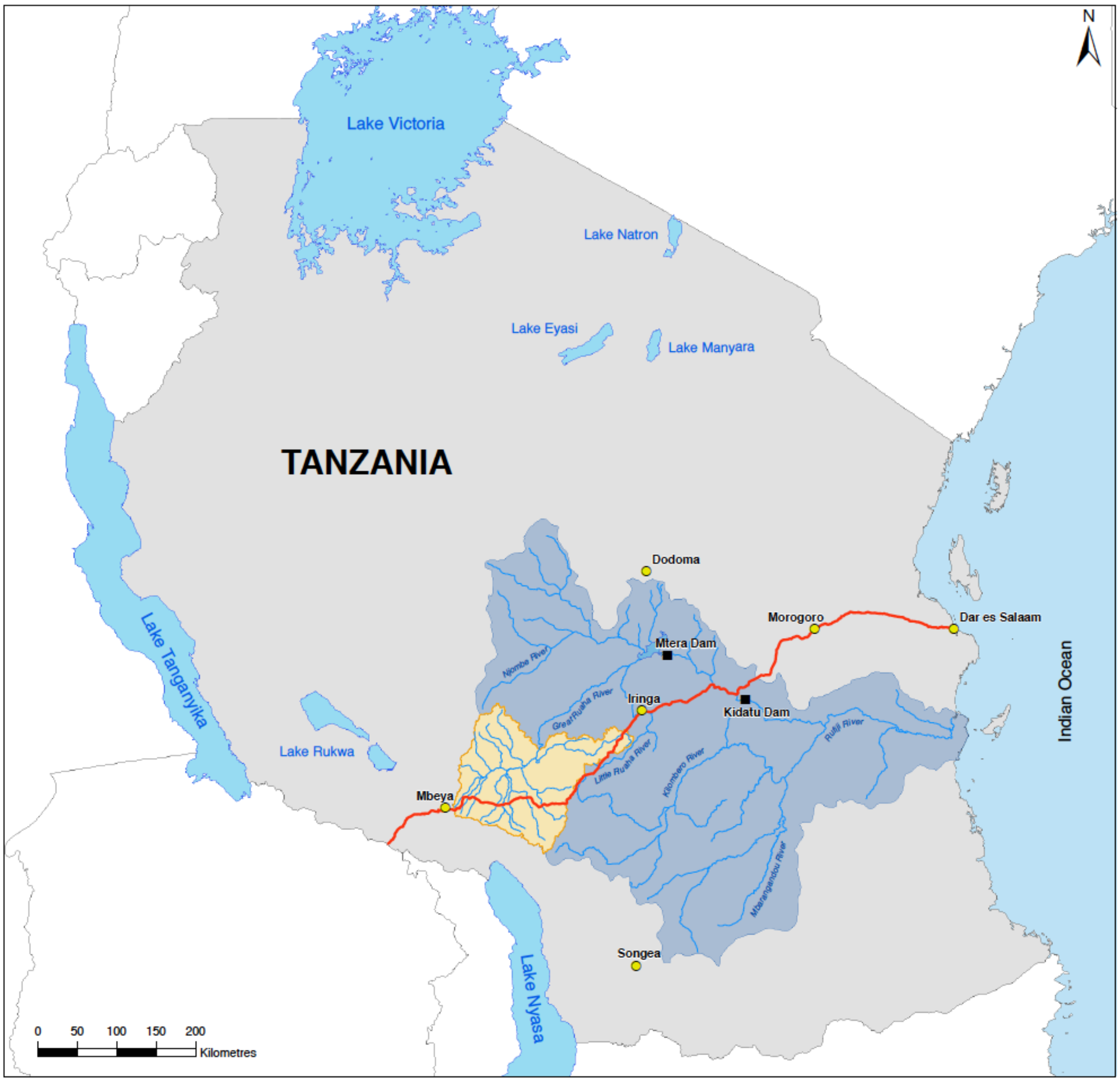

Figure 2: The Usangu Catchment