Tanzanian country report

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FRP FORESTRY RESEARCH PROGRAMME

DFID Department for International Development

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Chapter 1: Introduction

1.1 Project overview

The Catchment Management and Poverty (CAMP) project involves collaborative research implemented by several Institutions. The leading institution is the Centre for Land Use and Water Resources Research (CLUWRR) at University of Newcastle upon Tyne, UK. Sokoine University of Agriculture (SUA) in Tanzania is among collaborators, which include Centre for Ecology and Hydrology (UK), CSIR–Environmentek (RSA), School of Bio–Resources Engineering and Environmental Hydrology at University of Kwazula Natal, RSA; University of Durham, UK and the Forestry Department in Grenada.

The project is premised on the belief that in water-stressed environments the livelihoods of poor people are affected by their access to water resources, but land and water management policies have not been evaluated against this impact. Particular concern exists over inadequate consideration given to the impact of forestry operations on water availability. National governments and international development agencies seek to achieve sustainable development of land and water resources through adopting strategies based on whole-catchment management approaches. However trade-offs exist between desires for economic use of resources, protection of ecological integrity and livelihoods improvements for poor people. The project aims to meet the need for comparative analysis of alternative policy instruments, which seek to deliver pro-poor whole catchment management.

Project activities are focussed mainly within a selected case study catchment in South Africa, but transferability of findings and methodologies is an important consideration, which is tested through additional fieldwork in Tanzania and Grenada. This report is an output from the Tanzania CAMP-component. The report provides introduction of the study, literature review, description of the identified catchment followed by a discussion on the findings of biophysical and socio-economic data of interest to CAMP.

1.2 Research problem

This study is based on the hypothesis that in water-stressed environments the livelihoods of poor people and performance of the agricultural sector on which the majority of them depend are affected by their access to water resources. The development theory asserts that the livelihoods of the poor depend much on natural resources such as water and land, which are vital resources for agricultural production. Ellis and Mdoe (2002) found that poverty in Tanzania is strongly associated with lack of assets such as land. As a result, the policy and legal frameworks enabling the poor to access water and land resources are critical aspects for a successful poverty reduction strategy. DFID (2002) also found that, although livelihood of rural poor people depend on agriculture, they face many challenges including access to land, finance and markets, and increasing competition for resources such as water leading to conflicts among users.

Existence of conflicts among competing users has been reported in previous studies conducted in the Usangu plains (SMUWC 2001; Baur *et al.,* 2000; and Kikula *et al.,* 1996). The study by SMUWC (2001) identified several constraints among which water competition and conflicts between upstream and downstream farmers were mentioned as the most important with regard to paddy production. Other constraints; including biological factors such as weeds, pests, diseases and socio-economic factors such as market unreliability; were also identified (SMUWC, 2001). The major policy and legal challenges facing water resource managers in the Great Ruaha, as in other river basins in Tanzania, are centered on how to balance different water demands and manage intersectoral water related disputes. The challenge is on how irrigated agriculture can produce more food and provide incomes to the poor while using less water. The idea is for the irrigated agriculture to use water resources efficiently and release saved water to other sectors. This will enable the poor, as other water users in the basin, to realize more or less equitable economic rent from water resources while maintaining the ecosystem integrity. This challenge calls for an empirical assessment of the existing water policies and regulations for highlighting areas requiring radical reforms.

Much of the past research on water management in the Tanzanian river basins, including the Great Ruaha river basin focused on hydrological engineering and agronomic practices (SMUWC, 2001;

Mwakalila 1996; Faraji and Masenza, 1992; Lankford, 2001; Maganga and Juma 2000; DFID, 1998; Mbonile et al., 1997; DANIDA/World Bank, 1995; UVIP, 1993). Much is also known about the typologies of farming systems, livestock, land, water, fisheries, game, and forestry resources (See for example, in SMUWC 2001). Common to these previous studies is the acknowledgement of the complexities and problems associated with irrigated agriculture and the potential that irrigation has in improving economic benefits and rural livelihoods. However, these studies have very little or inadequate information about the disaggregated household level impacts of water policy on rural livelihoods. Gaps still exist in our understanding, particularly of the values of water and their inter-linkages with other benefits. According to (Revenga *et al.,* 1998) water policies need to be fully informed of such aspect if multiple economic, social and environmental objectives are to be met in a sustainable fashion. It is for this reason that this study was carried out with the aim of narrowing this knowledge gap.

This study attempts to provide answers to policy-relevant questions like: What are the economic policy instruments that are currently being used in water management? What effects do they pose on the existing rural livelihoods? What is the economic value of water in different land and water use options? Answers to these questions are useful inputs in making and/or reforming pro-poor water policies and regulations in the country.

Chapter 2 Research context

2.1 Country water situation

Over the past fifteen years demand for water has intensified due to an increased population and current rapid growth of economic activities requiring water as an input, such as in hydropower generation, irrigated agriculture, industries, tourism, mining, livestock, domestic use, wildlife, fisheries and forestry activities (MWLD, 1998). The inadequacy of supply of the resource due to unreliable rainfall, multiplicity of competing uses, degradation of sources and catchments has threatened food security, energy production and environmental integrity (MWLD, 1998). In the Great Ruaha river basin there are conflicts of interest over the use of water resources, challenges of managing the multiple trans-boundary water resources, inadequate policy, legal and institutional framework (MWLD, 1999). Previous study in the basin by SMUWC also identified several constraints among which water competition and conflict between upstream and downstream farmers were mentioned as the most important (SMUWC, 2001). According to Lankford (2000), competition over natural resources is a critical concern because the severe drying up of the Ruaha river has potentially deleterious effects on biodiversity conservation in the *Ehefu* swamp, on hydro-electric power generation, on irrigated agriculture and on the wildlife tourism potential of the downstream Ruaha National Park. Other constraints such as biological factors like; weeds, pests and diseases and socio-economic such as market unreliability were also identified (SMUWC, 2000).

The inadequate regulations to monitor ground water resources development has led to under utilization of the resource and in some places over utilization and interference of existing water resource (MWLD, 2001). Poverty in Tanzania, complex as it is, has always been looked through as characterized by inadequate inputs, lack of productive land, lack of control over decisions affecting people’s lives, lack of access to credit and information. According to Narayan, (1997), low assets base, low farm-gate prices, high transaction and transport costs, seasonality of agriculture, lack of opportunity for off-farm income and discrimination against women are among causes of poverty. However, water related poverty has not been analyzed.

Previous studies in the Great Ruaha, showed that there exist water shortages and imbalances. Lankford (2000), Charnley (1996) and DANIDA (1995) reported that imbalances in water access are largely associated with human population growth and over-abstraction of water by upstream users. The problem has been exacerbated further by development of irrigated agriculture and increased human immigration. The area (particularly the Usangu basin plains) has attracted cultivators from highland regions and pastoralists from northern and central Tanzania (Mbonile *et al.,* 1997). The establishment of irrigation schemes, like the large-scale Mbarali Irrigation Scheme and smallholder schemes (e.g. the Kapunga, Majengo, Kimani and Motombaya) has attracted more immigrants. All these have resulted in a concomitant expansion of both rain-fed and irrigated agriculture as well as growing conflicts and competition for water resources. In view of the basin as complex scenery, it is interesting to note these previous findings tie the shortage to a single simple explanation. None has advocated on the revised water management policy environment, for sound policy instruments development to foster equitable and sustainable water management. According to SMUWC (2001) the growth of irrigated agriculture in this basin is thus, viewed in two stances:

- On the one hand, the growth is seen as having the potential to improve economic gains and enhance rural livelihoods. (SMUWC, 2001) reports that about 30,000 households in Usangu are benefiting from irrigated agriculture through cultivation of about 40,000 ha of paddy. Irrigated agriculture also supports the local people with food and cash from crop sales, which help them to pay school and medical costs and buy other goods and service to improve their lives.
- On the other hand, the sector is also seen as a major cause of troubles, which mainly arise from excessive use of water in irrigation systems leading to serious water shortages downstream (SMUWC, 2001). This is reported as a common problem, particularly during the dry season when people are experiencing deficit of water for domestic use and animal drinking, less grass for animals, less water for hydropower generation, less area for fish breeding and growth and less area suitable for wildlife. Tourism in Ruaha National Park also suffers as the Great Ruaha River dries up (SMUWC, 2001).

2.2 An overview of water management policies in Tanzania

In Tanzania, water conservation and management is steered to varying degrees by land policy, agriculture policy, water policy and environment policy. As noted in Hatibu *et al*, (1999), historical analysis of the trends and effects of these policies on water conservation and management showed that these policies have passed through three eras, namely: colonial and post-independence (1906-1967), post Arusha Declaration (1967-1985) and liberalisation (1985). It is further shown that there has been a gap between emphasis given on the macro-level policies, strategies and programs, and what is really practiced by farmers (Hatibu *et al.*, 1999). Previous studies also show that several changes took place during these periods but more dramatic changes were observed during Liberalization period (Planning Commission, 1996 .

In view of the reforms that are currently taking place in the country and elsewhere as a result of policy changes, and by considering that these policy changes have a bearing on the development and sustainability of natural resources, the impact of these macro and sectoral policies must be analysed (MNRT, 1998). Policies for sustainable land use are fragmented and incomplete, generally because of institutional barriers, conflicting mandates and the prioritisation of economic over social and environmental goals and of short-term development over long-term conservation goals (WRI, 1998; FAO, 1999).

Food security, poverty alleviation and sustainable development through a wise use of water and other natural resources are some of the fundamental goals highlighted in most policies, particularly in the developing world. In Tanzania, for example, the *Water Utilization (Control and Regulation) Act* of 1974 as amended in 1981 (Act no. 109) and 1997 (Act no. 370) and the 2002 *Water Policy* are the paramount legislations or policies, which deal with water management and utilization. Beside these, there are also many other legislations and policies, which directly or indirectly affect water management and utilization (e.g. those concerning agriculture, energy, fisheries, mining, wildlife and forestry). Forestry is particularly relevant in the overall context of this research project.
A key document is *Tanzania's Development Vision 2025,* which provides the guiding framework for all these and other policies. The vision is for Tanzania to move from a less developed country

(LDC) to a middle-income country by 2025, with a high level of human development. Specific targets include: a high quality livelihood, which is characterized by sustainable and shared growth (equality), and freedom from abject poverty; good governance and the rule of law; and a strong and competitive economy capable of producing sustainable growth and shared benefits (URT, 2001). A second key document is *Tanzania's Poverty Reduction Strategy*, which sets out a medium term strategy for poverty reduction and the indicators it will use for measuring progress. It views irrigation as an important strategy for increasing food security (URT, 2000). In addition the *National Poverty Eradication Strategy* sets out Tanzania's strategy and objectives for poverty eradication through to 2010. The key priority areas for achieving poverty reduction include: reducing income poverty through equitable economic growth; improving human capabilities, survival and social well being; and containing extreme vulnerability among the poor (URT, 2000). If these targets are to be met in a sustainable fashion, balancing the conflicting water demands is one of the key issues that need to be addressed.

2.3 An overview of forestry and forest policy in Tanzania

Forests and woodlands cover 33.5 million hectares, or 40% of the total area of mainland Tanzania, however, only 1.2 million hectares are classified as forest (including small areas of coastal mangrove and high altitude Alpine forests). Most is classified as woodland and in particular "miombo woodland" (Zambezian savannah) dominates. These are open , annually burnt, deciduous woodlands, rich in grasses and dominated by *Brachystegia* species (Luoga et al, 2002). Forest degradation is a long-standing concern and policy instruments that aim to conserve forest resources were first introduced in colonial times. Approximately 30% of the total is said to be "protected" with the remainder (approximately 24 million hectares) used for productive purposes (URT, 1998). Currently, six different categories of legal status exist, which vary in the level of protection given (Table 2.1). Pelkey et al (2000) found that national parks and game reserves with their heavy restrictions on resource extraction policed by on-site patrols offered effective protection, whereas forest reserves, which are explicitly designed for forest protection, did no better than lands under no legal protection. In addition, it should be noted that many small patches of natural forest are protected even in the absence of and legal designation because of their status as “sacred groves”. There is at present no inventory of their extent and condition, but recent research (Mgumia and Oba, 2003) indicates that they merit greater consideration.

Table 2.1: Summary of policy instruments offering legal protection

	National park	Ngorongoro conservation area	Game reserve	Forest reserve	Game controlled area	Open area
Funding status	Well funded	Well funded	Moderate funding	No funding	No funding	No funding
Ranger patrols	Yes	Yes	Yes	No	No	No
Restrictions on resource use	Heavy	Moderately heavy	Moderately heavy	Moderately heavy	Very light	Virtually none
Temporary settlements	No	Yes	No	No	Yes	Yes
Permanent settlements	No	Yes	No	No	No	Yes
Cattle grazing	No	Yes	No	No	Yes	Yes
Tourist hunting	No	No	Yes	No	Some	Some
Resident hunting	No	No	No	No	Yes	Yes
Mining	No	No	No	Some	Some	Some
Bee keeping	No	No	No	No	Yes	Yes
Hardwood extraction	No	No	No	Yes	Some	Some
Firewood extraction	No	Some	No	Some	Some	Yes

Modified from: Pelkey et al (2000)

Tanzania’s National Forest Policy (URT, 1998) defines four key objectives for the sector:

- Sustainable supply of forest products and services ensured by maintaining sufficient forest area under effective management;
- Employment and foreign exchange earnings increased through sustainable forest-based industrial development and trade;
- Ecosystem stability ensured through conservation of forest biodiversity, water catchments and soil fertility;
- National capacity to manage and develop the forest sector enhanced in collaboration with other stakeholders.

The roles and responsibilities defined under the new forest policy foresee the transfer of forest management, conservation and enforcement roles to local government and communities. This is consistent with the general thrust of recent policy initiatives on natural resources management, which are based on decentralization and community empowerment. The reform process in the forestry sector is on-going and in view of the discrepancy between the limited state capacity and the enormity of the task of managing the resource base is greatly pre-occupied with the transition to participatory management approaches (Peterson et al, 2001).

The policy makes no explicit reference to commercial forestry, which plays only a minor role in the sector within Tanzania. It acknowledges that where replanting initiatives have been pursued the emphasis on planting exotic species has overshadowed native species, but there is no mention of a problem with “alien invaders”. The role of forests in watershed protection receives explicit mention, but recognition of their true hydrological impact is lacking, as is evident from the statement that “deterioration of catchment forest areas is causing water shortages”. It appears that evidence from previous catchment-scale research in Tanzania is still not reflected in policy.

2.4 An overview of methodological approaches

2.4.1 Integrated water resource management

Integrated Water Resource Management is now generally accepted following the United Nations Conference on Environmental and Development (UNCED), which called for all countries to develop national strategies for sustainable development and the use of integrated approach to natural resource management (CAMP, 2002). Sustainable development encompasses the need to combine long-term economic growth with social and environmental objectives in order to meet human and natural resource need for future generations (World Bank 2002). It is however, noted that promoting economic growth to address poverty in a sustainable manner is difficult, and yet crucial. The sustainability of water; which is both an economic and social good is decreasing while the demand for the same is increasing at faster rate. While in different parts of the world, economic instruments are increasingly being developed and used to address water concerns, participatory and policy reforms that incorporate new techniques and institutional mechanisms are also needed for managing water in sustainable manner (Sharma *et al* 1996). Although several studies in water management have been conducted a gap still exist as many scientific and policy-oriented researches on watershed have focused more on biophysical links between upland farms and downstream water users (Dixon *et* al, 1986 cited by Shively, 2001). Researchers have emphasised more on physical characteristics of upstream externalities, and in some cases have made some progress in modelling the main hydrological processes with downstream damage (Shively, 2001).

However, few attempts to date have integrated economic, environment, stakeholders' livelihoods, policy and institutional analysis in natural resource management.

2.4.2 Sustainable Livelihoods (SL) approach

The word livelihood has been used in many different ways but for this study the definition adopted from Chambers and Conway (1992), is used to capture a broad view of livelihood understanding: A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Creswell, 1997, Hussein and Nelson 1998, Scoones 1998 and Carney 1998). Building on this definition, Ellis (2000) brought in a more explicit consideration of claims and access issues, and in particular the impact of social relations and institutions that mediate an individual or family's capacity to secure means of living.

Livelihoods thinking dates back to the work of Robert Chambers in mid 1980s and further developed by Chambers and Conway and others in the early 1990s (DFID, 2000). Since that time a number of development agencies have adopted livelihood concepts and made efforts to begin implementation. Several livelihood models have been put forward over the years. As noted by ODI (2000), the core of livelihoods model going back to Sen (1981), Chambers (1988), Swift (1989), Kabeer (1991), Scoones, (1998), Davies, (1996), Carney (1998 and others such as Barratt and Reardon (2000) has been the relationship between assets, activities and outcomes within a mediating environment. However, for DFID, the sustainable livelihood approach represents a new departure in policy and practice. The UK government's 1997 white paper on international development commits DFID to supporting: policies and actions which promote sustainable livelihoods; better education, health and opportunity to poor people; protection and better management of natural physical environment; thereby helping to create a supportive social, physical and institutional environment for poverty elimination (DFID, 2000). The focus of the basic livelihood model is the household as the appropriate social group for the investigation of livelihoods, although external measures to manage risk may be social or public in nature. It is also people centred as it puts people at the centre of development.

Chapter 3 Selection and overview of the case study area

3.1 Choice of Mkoji as the case study catchment

Two river basins within Tanzania have been selected as sites for a pilot programme on integrated water resources management: Pangani basin in the north and Rufiji basin in the south. The Rufiji river basin in made up of eleven sub-catchments as listed in Table 3.1. The Mkoji sub-catchment was selected as the case study site on the grounds that:

- it is a similar size to Luvuvhu catchment (the case study site in South Africa),
- it contains a range of environments and land uses,
- it is a water-stressed catchment.

Table 3.1: Sub-catchments within the Rufiji river basin

Sub-catchment	Max (ha) Irrigable	Wet year (ha)	Dry year (ha)	Dry season (ha)	Number of intakes on rivers	Total Abstraction (cumecs)	Abstraction efficiency (%)
Ndembera	7623	4502	3165	449	6	4.30	65
Kyoga	14646	5461	3075	164	11	7.00	100
Mbarali	8403	9367	3634	240	3	8.50	100
Mlomboji	0	20	0	0	1	0.10	50
Kimani	3666	2269	849	46	5	4.00	95
Ruaha	5432	4525	1964	28	1	5.00	85
Chimala	2115	2769	566	202	7	2.75	100
Mkoji	12600	12675	3316	1388	70	12.00	100
Mjenje	657	270	92	0	12	0.60	70
Kimbi	60	28	11	0	3	0.20	70
Northeast	0	0	0	0	0	0	0
Total	55202	41883	16670	2517	119	44.5	

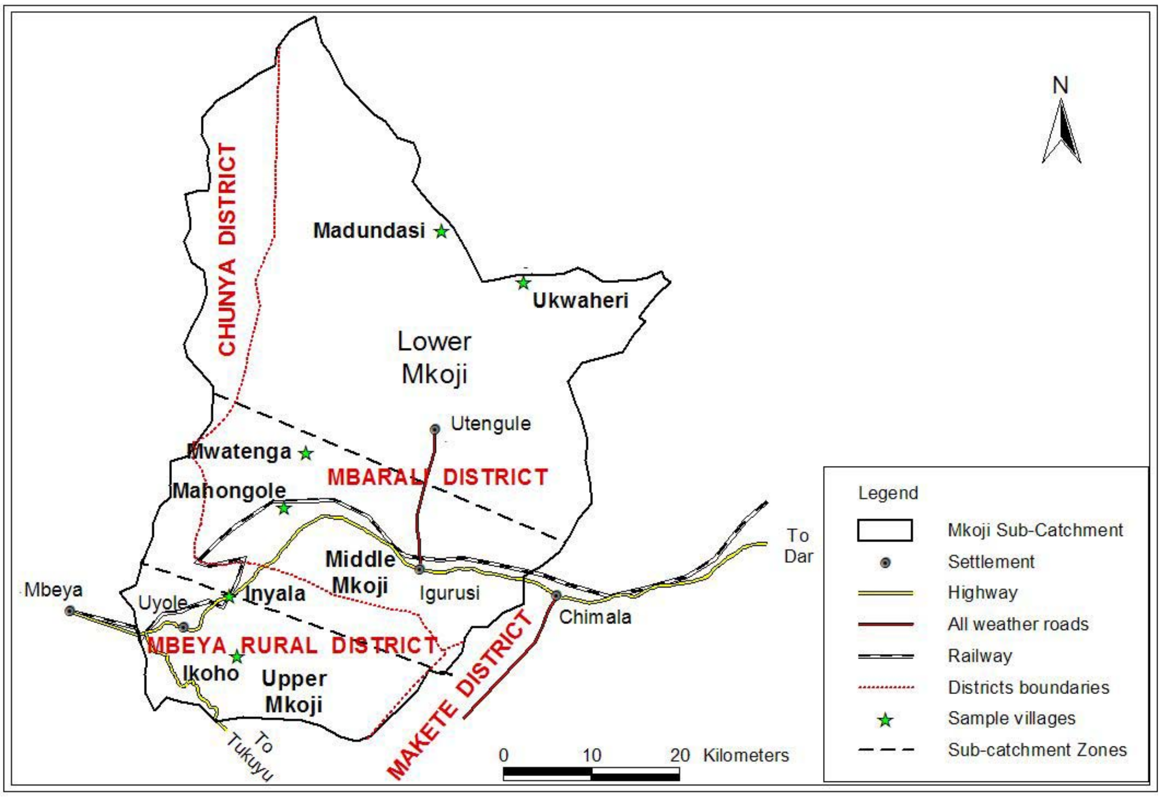
Source: SMUWC database 2001

3.2 Overview of Mkoji catchment

Location, size and population

The Mkoji catchment is drained by the Mkoji River and is located in the southwest of Tanzania, between latitudes $7^0$48’ and $9^0$25’ South, and longitudes $33^0$40’ and $34^0$09’ East (Figure 3.1). It is a sub-catchment of the Rufiji River Basin and covers an area of about 3400 km². Most of the catchment lies within Mbarali and Mbeya Rural districts, while smaller portions lie within the Makete and Chunya districts in Iringa and Mbeya Regions respectively (Figure 3.2). According to the 2002 population census, the catchment has 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.

Figure 3.1: Location of Mkoji Sub-catchment within the Rufiji Basin in Tanzania



Map Sources: 1. Modified SMUWC data; 2. RIPARWIN data (mainly GPS measurements); 3. East Africa (Tanzania) Topo sheets 1:50 000. Sheets 244/2, 244/4, 245/1, 245/2, 245/3, 245/4.

Figure 3.2: Administrative boundaries and the Mkoji Sub-catchment zones

Topography

The Mkoji catchment is characterised by two distinct landscapes:

- a central plain (the Usangu Plains), which is a natural sedimentation basin and part of the East African Rift Valley, surrounded by highlands with an average elevation of 1100 m above sea level.
- highlands (the Chunya escarpment to the West and the Kipengere range and Poroto Mountains to the South) which rise to over 2400 m above sea level.

Geology and soils

A basement complex of precambrian rocks dominated by gneiss and granite underlays the major part of the sub-catchment. Mudstones, siltstones, quartz sandstones and quartzitic sandstones are found outcropping around Igurusi. In the southwestern part of the catchment, in the Poroto mountains, the parent material is volcanic ash deposit originating from the Rungwe-Mbozi volcanic complex (Figure 3.3). The relief surrounding the plains and the rivers cutting across have generated quaternary alluvial, colluvial and terrestrial deposits in the western part of the catchment.

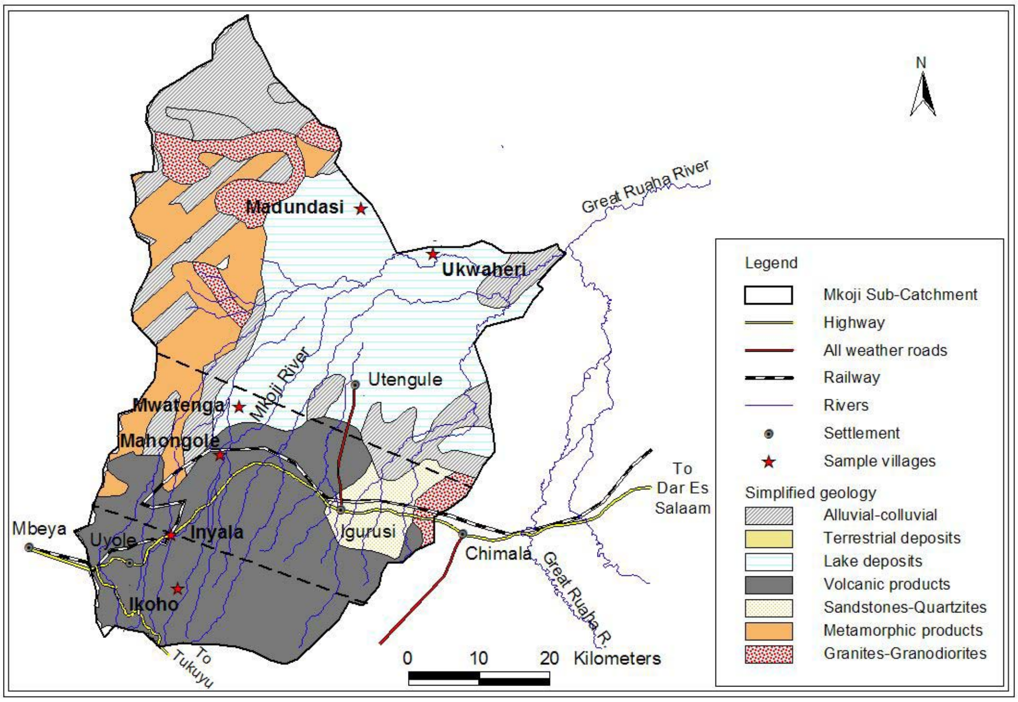
In the higher rainfall areas, most of the soils are deep weathered and highly leached red and yellow soils with high iron and aluminium concentrations (Ferrasols). In the highly dissected parts, the soils are however shallow and rocky. Most of the soils still have relatively high organic contents and good soil structures. Thus many of these soils are still relatively resistant to soil erosion. In the Usangu plains a variety of textural classes can be found according to the variation in sedimentation conditions prevailing when the deposition took place. Alluvial clay and clay loam soils occupy the greatest part of the existing paddy producing area. These soils are generally of high fertility, though poorly drained (Vertisols).

Land use

The distribution of the land use patterns in the catchment is shown in Figure 3.4. The middle Mkoji and the Chunya escarpment in the west are covered with Miombo woodlands. Acacia woodlands and bushlands cover the plains in the lower Mkoji with grasslands and wooded grasslands in the wetlands. The highlands in the South are covered with high altitude grasslands, mid altitude wooded grasslands and evergreen forests that have been partly replaced by woodlots of Eucalyptus. Cultivation is mostly found in the southern highlands and along the Tanzania-Zambia highway. Table 3.2 provides a list of the crops grown under the three different agricultural production domains in the catchment.

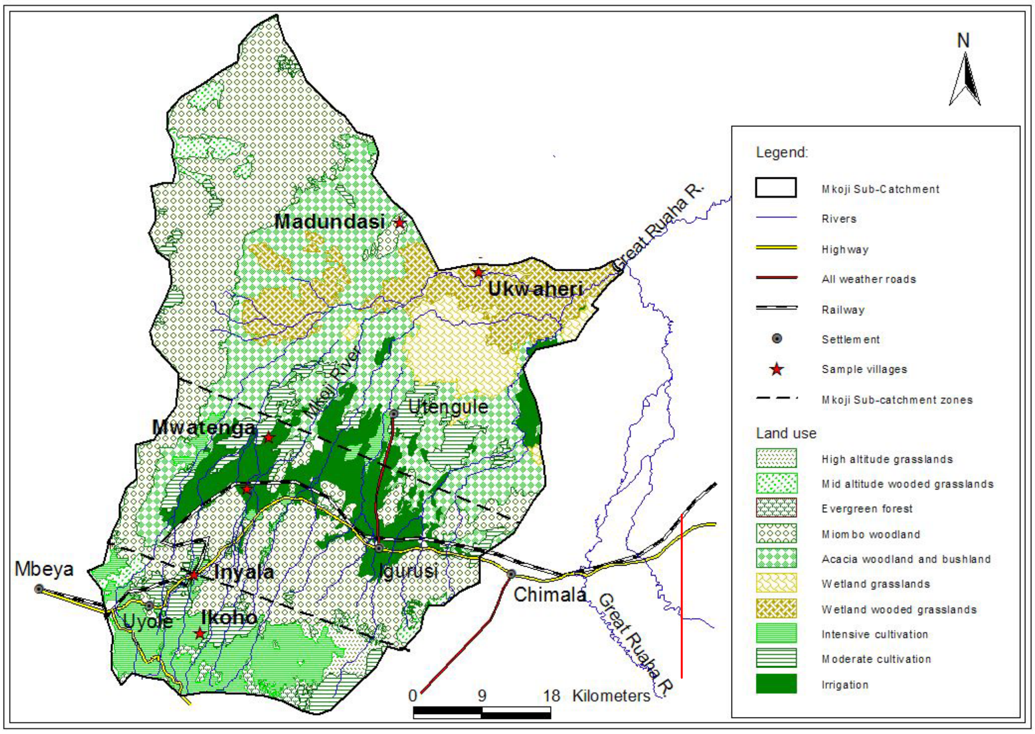
Table 3.2: Crops grown in the Mkoji catchment

Zone/agricultural domain	Irrigated	Intermediate (rainfall with supplementary irrigation)	Rainfed
Upper Mkoji	Maize, beans, tomatoes, Irish potatoes, onions	Vegetables, maize	Maize, millet, beans, round potatoes, tomatoes, spring wheat,
Middle Mkoji	Maize, beans, tomatoes, Irish potatoes, onions	Rice, maize	Maize, sorghum, beans, groundnuts, tomatoes, onions, sugarcane, cassava, sweet potatoes
Lower Mkoji		Rice	Maize, sorghum, beans, green beans, groundnuts, sweet potatoes



Map Sources: 1. Modified SMUWC data; 2. RIPARWIN data (mainly GPS points).

Figure 3.3: Mkoji Sub-catchment – Geology and Soils



Map Sources: 1. Modified SMUWC data; 2. RIPARWIN data (mainly GPS points)

Figure 3.4: Mkoji Sub-catchment – Land use patterns

3.3 Climate, hydrology and water resources

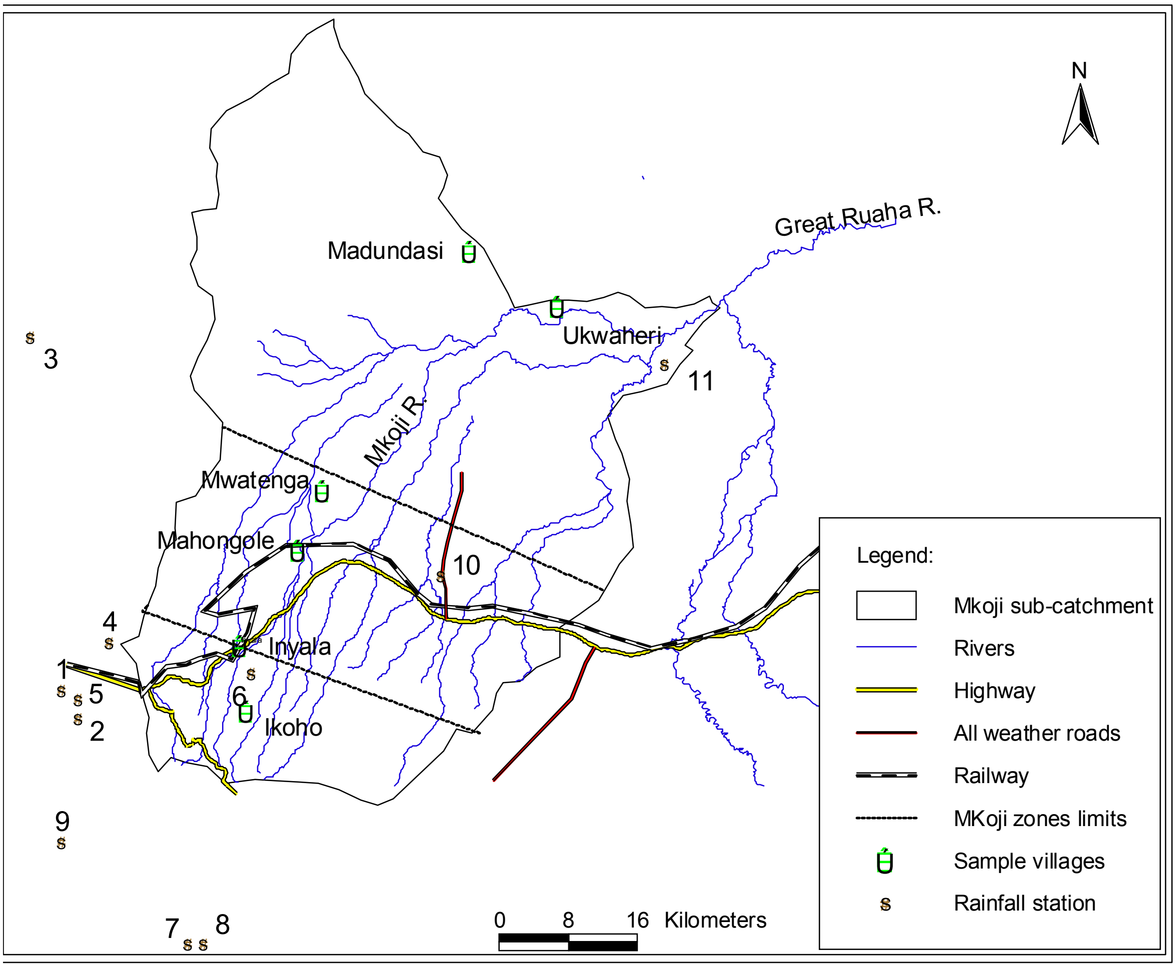
A summary analysis is presented here based on data collected from 11 rainfall stations and 3 climate stations (Table 3.3, Figure 3.5). The distribution of rainfall stations is uneven with most located in the upper catchment. The length and completeness of records is also variable. Only one full climate station occurs within the catchment (Igurusi), but others lying just outside provide representative data for the upper (Mbeya) and lower (Kapunga) catchment. Runoff data are collected at several points within the catchment, but reliability is generally poor and only three are suitable for analysis (Table 3.4)

Table 3.3: Rainfall stations

S/no	Station Code	Station name	Easting	Northing	Open date	No. of Years available	% Missing
1	09833000	Mbeya Boma	549475	9016173	01/01/1923	67	35.10
2	09833001	Mbeya Met	551340	9012854	01/01/1937	62	5.65
3	09833002	Chunya Agriculture	545892	9057084	01/01/1934	65	6.88
4	09833015	Kawetere Forestry	554980	9021694	01/01/1951	44	6.28
5	09833020	Mbeya Boma	551343	9015065	01/01/1961	38	12.53
6	09833025	Allsa Farm	571468	9018020	01/01/1970	29	3.74
7	09933004	Rungwe Tea Estate	564051	8986632	01/01/1934	65	17.94
8	09933013	Rungwe Secondary School	565919	8986629	01/01/1949	24	49.51
9	09933028	Igembe Primary School	549453	8998483	01/01/1961	39	52.43
10	09833031	MATI Igurusi	593485	9029364	01/01/1984	19	22.03
11	-	NAFCO Kapunga	619271	9053893	01/01/1991	12	30.01

Table 3.4: River flow gauging stations

Sno.	Station code	Station name	River Name	Physical location	Grid location		Duration of records
					Easting	Northing	
1	1KA51a	Umrobo	Mlowo	Great North Road	*574909*	*9025081*	1958-2003
2	1KA50a	Mswiswi	Mswiswi	Wilima	*584800*	*9025800*	1958-2003
3	1KA16a	Lunwa	Lunwa/Loisi	Igurusi	*593600*	*9019900*	1956-2003

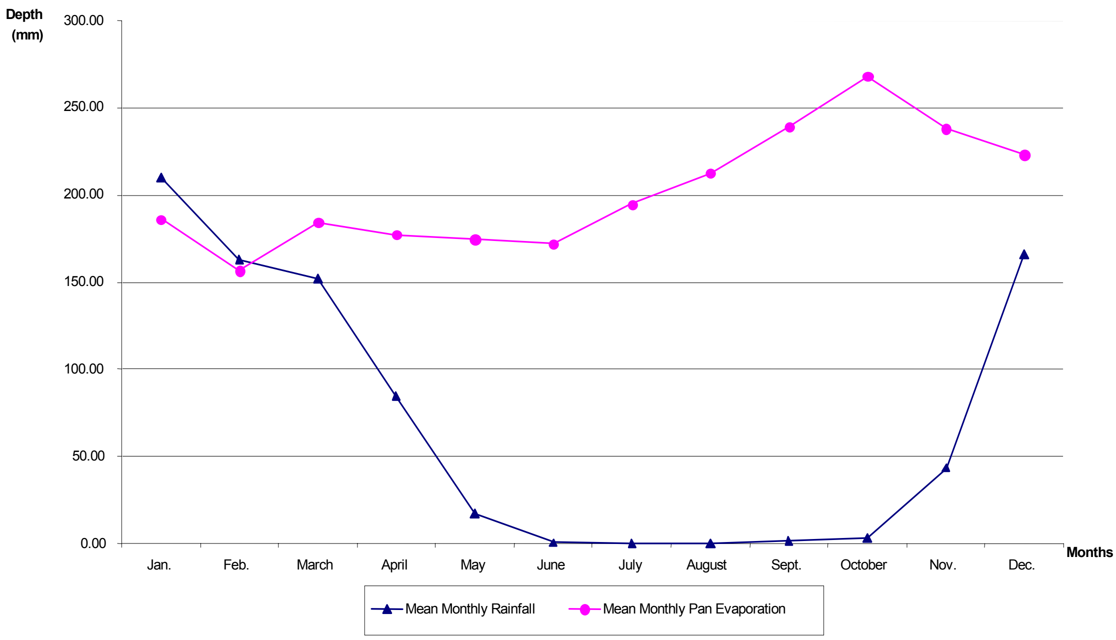


Map Sources: 1. Modified SMUWC data; 2. RIPARWIN data (mainly GPS measurements)

Figure 3.5: Locations of rainfall stations

The rainfall regime in the Mkoji catchment is unimodal with a single rainy season starting from the third dekad of November and ending in the first dekad of April in the plains and third dekad of April in the highlands. Hardly any rain falls during the rest of the year. In the high rainfall areas the dry season is shorter as the rainy season tends to continue up to May. The heaviest rainfall generally occurs in December-January and March-April. The driest months are June to October. The highlands receive the highest annual rainfall. For example the mean annual rainfall at Mbeya meteorological station (which represents the highland) is about 1070 mm. The annual rainfall decreases towards the plains to about 840 mm at Igurusi (in the middle of MSC) and 520 mm at Kapunga (representing the lower MSC area). The mean annual areal rainfall over the MSC is about 898 mm (3052 Mm^3 for the catchment). The rainfall amounts as well as the onset of the rainy season can vary considerably from year to year (annual coefficient of variation is over 20% at Igurusi), which often have a detrimental effect on crop production and other activities that depend on the availability of water, especially in the drier areas.

Potential evaporation varies considerably within the Mkoji catchment. There is a tendency for decreasing evaporation with increasing altitude. The pan evaporation is 2430 mm/year at Igurusi (middle zone) and decreases to 1890 mm/year in Mbeya (representing the upper zone). The lowest evaporation is experienced in February (during the wet season) and increases during the dry season (from August to December), reaching a maximum in October/November. The moisture deficits (rainfall minus evaporation) calculated using average evaporation and rainfall data (using Igurusi meteorological station) are presented in Figure 3.6. Significant moisture deficits are evident in the months of March to December. The annual total moisture deficit is of the order of 1585 mm. The annual mean temperature varies from about 18^{0}C at the higher altitudes to about 22^{0}C at Igurusi and Kapunga (representing the middle and lower zones of the catchment respectively). Most of the lower zone of the catchment, comprising the Usangu plains, is semi-arid, whereas the upper zone (in the highlands) is semi-humid to humid.

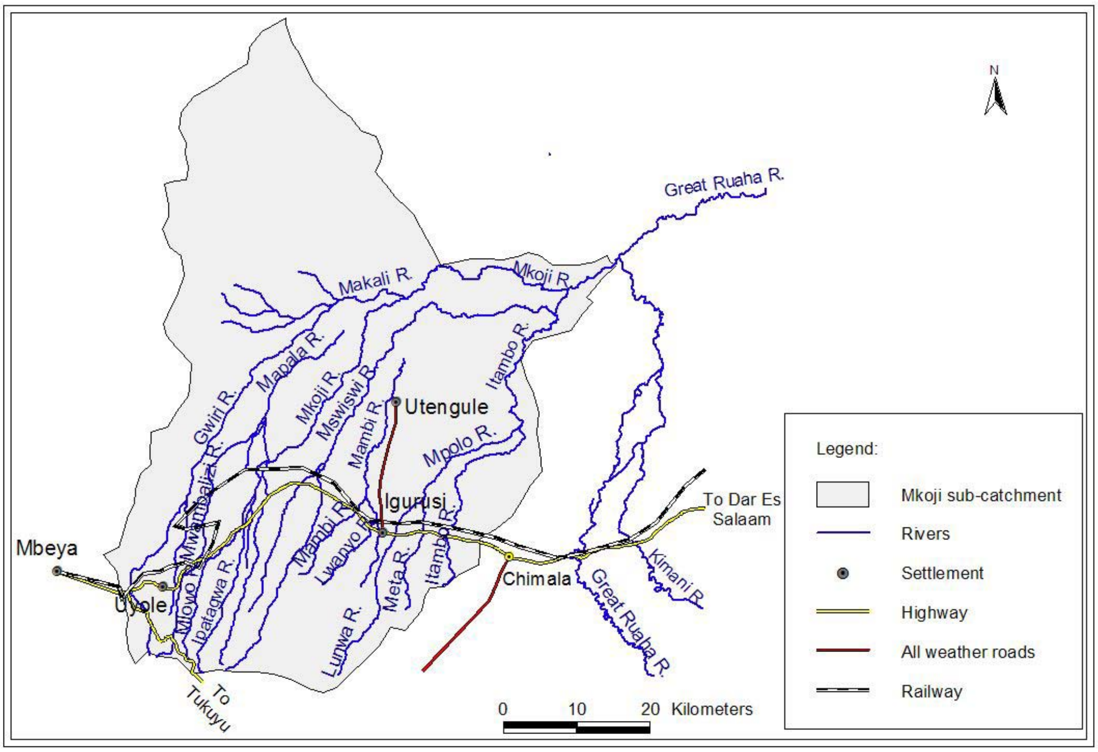


	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean monthly evaporation (mm)	**186**	**156**	**184**	**177**	**175**	**172**	**195**	**213**	**239**	**268**	**238**	**223**	**2427**
Mean monthly rainfall (mm)	**210**	**163**	**152**	**85**	**17**	**1**	**0**	**0**	**1**	**3**	**43**	**166**	**842**
Moisture deficit (mm)	**24**	**7**	**-32**	**-93**	**-157**	**-171**	**-195**	**-213**	**-238**	**-265**	**-195**	**-57**	**-1585**

Figure 3.6: Mean monthly rainfall and pan evaporation for Igurusi met station

The Mkoji River, which has given name to the catchment, is the main river draining through the whole catchment. It originates from the northern slopes of the Poroto Mountains from where it flows to the Usangu Plains, collecting en route water from the Makali and Itambo rivers before joining the Great Ruaha River. Other important rivers that drain the Mkoji catchment are Meta, Lunwa, Lwanyo, Mambi, Mswiswi, Ipatagwa, Mlowo, Mwambalizi and Gwiri (Figure 3.7). All the rivers draining the Mkoji catchment, including the Mkoji River itself, are perennial upstream of the Tanzania-Zambia Highway. However, a few kilometres downstream of this highway, all these rivers dry up and are perceived as seasonal. This is mainly due to dry season irrigated agriculture, which uses all the water that would have kept them flowing during the dry season. The distance from the highway to the points where the rivers dry up varies from river to river and is a function of the number, capacity and location of water abstraction canals in a particular river.

There are two springs located at Inyala and Idunda villages that provide water used for dry season irrigated agriculture. Average flows from these springs were 6 l/s for Inyala (when measured on 9/9, 13/10 and 04/11/03) and 16 l/s for Idunda (when measured on 9/9, 13/10 and 27/10/03). Ground water use is confined to domestic use only. There are a total of three pump-tested boreholes and nineteen wells in Luhanga, Muhwela, Mwatenga, Ukwaheri, Azimio and other villages.



Map Sources: 1. Modified SMUWC data; 2. RIPARWIN data (mainly GPS measurements

Figure 3.7: Mkoji sub-catchment – Water Resources

Chapter 4 Research method

4.1 Conceptual framework of the study

4.1.1 Study objectives

The main objective of this study is to investigate the effect of water management policy instruments on the livelihoods of the rural-poor in Tanzania, with particular reference to the the Mkoji subcatchment in the Great Ruaha River basin.

The following specific objectives were identified:

(i) Examine various water-based livelihoods in the Mkoji subcatchment;

(ii) Examine economic benefits of water in relation to the value of water use in agriculture and brick making;

(iii) Identify and assess the water and land policy instruments;

(iv) Assess how different policy instruments affect the rural poor access to land and water resources

These objectives were addressed through a combination of household-level survey and participatory research (PRA) amongst selected communities within the study area. The household survey was designed focused on the need to isolate water-poverty linkages using precipitation, relative location in the catchment (upstream, middle and downstream) farning systems and production domains (wet season irrigation, dry season irrigation and rain-fed agriculture.

4.1.2 Conceptual framework

The conceptual framework employed in this study (Figure 4.1) is modified from the DFID Sustainable Livelihoods Framework and also draws on a number of livelihood frameworks, models and approaches. These include: The CARE's Livelihood Model, the UNDP's approach to promoting Sustainable Livelihoods (SL), and the Oxfarm's SL framework. The detailed discussion of these frameworks is given in Carney *et al.*, (1999). The SL framework distinguishes those economic, political, environmental and social factors that influence the strategies that people employ and the possible set of outcomes that may be achieved. The framework considers the economic benefits and their consequential impacts on livelihoods as determined by an array of both endogenous and exogenous factors (including vulnerability factors, livelihood assets, and institutional frameworks) All these influence the strategies that people employ to shape their well-being.

The vulnerability context acknowledges the shocks and trends that may influence livelihood strategies and can have devastating impacts on the poorest members of a basin. In this study the vulnerability context refers to increased population in Usangu, which in turn resulted in increased water demands in the area, and then reduced water flow downstream. These shocks influence farmers' decision on their asset portfolio. The SL framework describes the asset portfolio of a livelihood as consisting of five "capitals". In this study, these assets include (Human (e.g. health, education; Financial (e.g. income (stored as cattle or money); Social (e.g. kin, associations); Physical (e.g. schools, roads and irrigation infrastructure); Natural (e.g. Rivers and Water).

These five livelihood capitals provide the matrix from which an individual has the means to make a living. The policy instruments such as water rights, pricing, allocation and land tenure arrangements, directly or indirectly influence farmers' decisions on the use of these assets. As evidence from Scoones, (1998); Uphoff and Wijayarathna (2000); Krishna and Uphoff (1999), farmers in the area can increase, decrease, maintain or even substitute within the assert portfolio as an attempt to break out of poverty. The policy environment, which is the focus of this study, is visualized as producing alternative policy instruments in water management across the basin. The policy instruments influence the water-based livelihood strategies in relation to water management. Sound policy instruments can thus be achieved through proper understanding of the livelihood outcome. It is from these premises that the current study takes off. The underlying assumption for the study is that from a thorough understanding of these benefits and livelihood outcomes it becomes possible to formulate effective interventions in water management and allocation. The livelihood outcomes are derived from these strategies and can be measured by criteria such as income level, increased value of water, reliable water supply, increased well-being and reduced vulnerability.

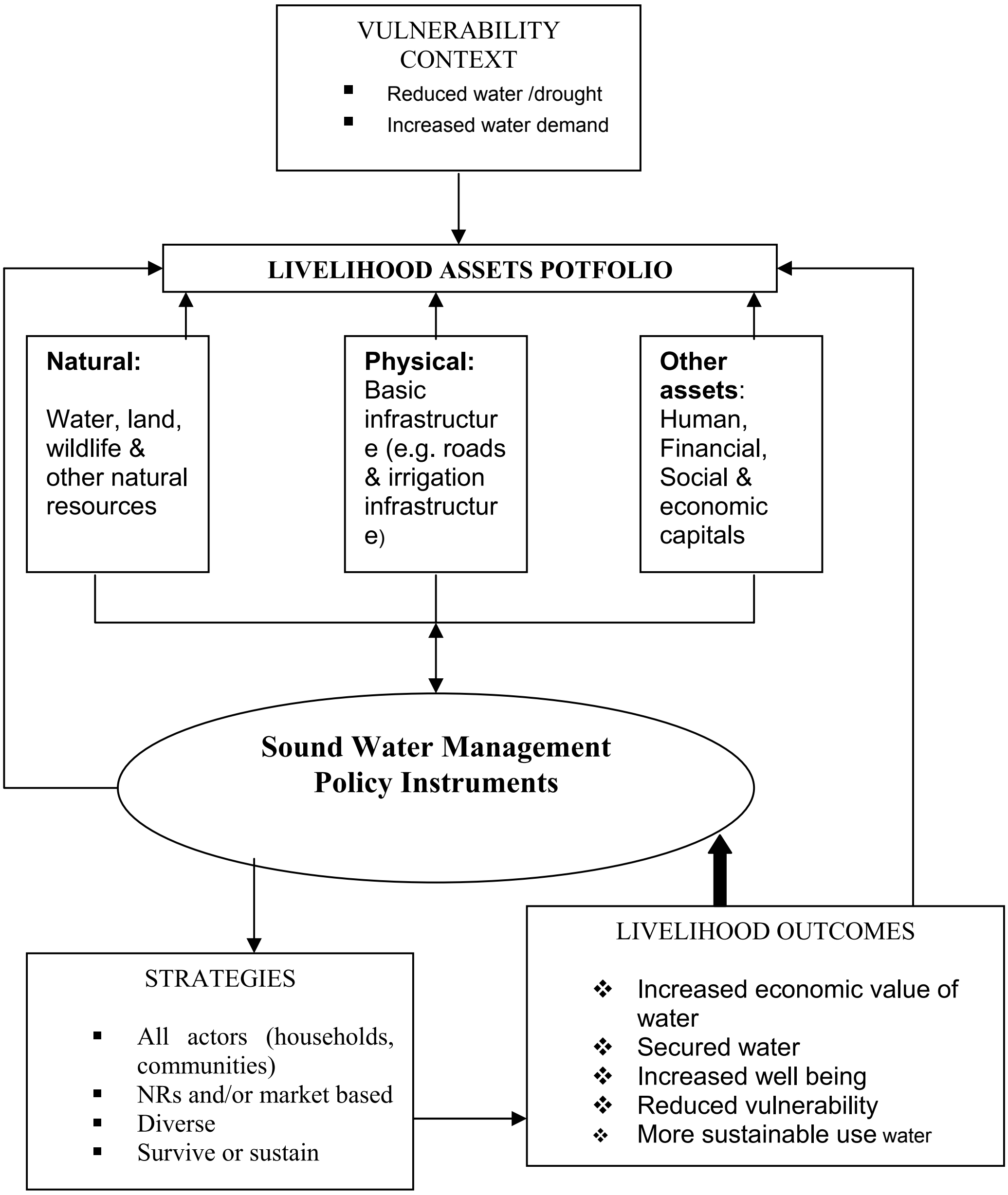


Figure 4.1: The Conceptual Framework of the study

4.2 Research design and strategy

4.2.1 Selection of sample villages and households

The Mkoji catchment is large (about 3400 km^2) and can only be studied through random sampling of the villages and then the households within the villages. The catchment was therefore purposefully divided into three zones – upper (27 villages), middle (19 villages), and lower (7 villages) as per Figure 3.2. Two villages were purposively selected from each zone, to capture the variability in livelihood and production systems among the water users in the catchment. The selected villages are described in Table 4.1.

Table 4.1: Selected study villages

Name	Location	Production system
Ikhoho	Upper	Rainfed (maize, potatoes and wheat)
Inyala	Upper	Dry-season irrigation (maize, beans, potatoes, vegetables)
Mahongole	Middle	Dry season irrigation (maize, beans, vegetables) and wet season irrigation (paddy)
Mwatenga	Middle	Wet season irrigation (paddy)
Ukwaheri	Lower	Rainfed (maize, sorghum/millet) and Livestock
Madundasi	Lower	Rainfed (maize, sorghum/millet) and Livestock

Households were selected with a view to vulnerable group assessment and gender analysis.

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. The key aspects addressed included: (i) who are the insecure and vulnerable? (ii) where are they located within the agricultural production system? (iii) why and how are they vulnerable to food insecurity? (iv) what strategies do they adopt to cope with the vulnerability? (v) how effective are these strategies?

4.2.2 Sources of data

The study used both secondary and primary data. The secondary information used included quantities of water and other hydrological data. Other secondary information used includes policy and institutional data. Both qualitative and quantitative methods of data collection were employed in the collection of data. The secondary information was collected through reviewing of various documentation of previous study conducted in the area. Major sources of secondary data were the Soil and Water Research Management Group (SWRMG) offices, SUA Agricultural library, Morogoro, Ministries and other relevant institutions. The study included the PRA, which was undertaken in November 2002, and a single visit household survey that was conducted between December 2002 and February 2003.

(i) Participatory Rural Appraisal

The PRA exercise was done especially to determine the principal constraints of the livelihood and stakeholders perception of the importance of water. This included meetings, transect walks, semi-structured interviews of key informants and focus group discussions. Group meetings were held in each of sample villages for wealth ranking. A list of between 10 – 30% of the village households randomly selected from the village register was used for this activity. Members of the group meetings in each village deliberated the criteria for wealth ranking (Table 4.2). Focus group discussions based on gender and wealth were used for livelihood analysis. The groups drew activity charts, time charts, labour profiles, livelihood scenarios, mobility maps, historical profiles and food calendars using locally available aids as decided by the participants. A checklist (Appendix 1) of the intended information to be gathered was used to guide the PRA sessions.

(ii) Household level sample survey

The household questionnaire survey (Appendix 2) included both open and closed end questions. Although the intended respondents were heads of household, for the purpose of clarity on some issues that required recall, other members of household also participated. This helped in cases where situations necessitated the respondents to recall some past events such as previous selling prices etc. The timings of interviews were another key consideration due to migratory nature of labour in the catchment and the fact that this was the cultivating season. According to Casley and Kumar (1988), sampling errors are likely to be reduced by a frequency of one community per strata. Non-sampling errors such as listing errors and omissions, interview non-response, measurement errors, interview recording errors and data entry, which are difficult to estimate but easy to predict were minimized, by in-depth training of assistants (enumerators), piloting and data cleaning up.

Table 4.2: Wealth groups for households in the study area

Variables	Poor	Middle	Better off
Access to irrigable land (ha)	< 0.25	0.2 - 0.75	> 1
Livestock holding	Cattle:0 Chicken 1-5	Cattle: 1-5 Shoats: 8-15 Chicken: 8-24	Cattle: >8 Shoats: >15
Mode of cultivation and labour force	Hand hoe, family labour	Hand hoe, casual labour and Mgowo*	Hand hoe, casual labour and ox-plough

Source: PRA session 2002 *Traditional way of sharing labour among households

Stratified random sampling was employed in the selection of households included in this study. The stratification was based on the villagers' own criteria for wealth ranking obtained during the PRA session (Table 4.2). The strata emanated from the stratification allowed the households to be classified as poor, middle and well-off. From these categories, household were then randomly selected such to make a total of 10% of all the categories. The working sample was thus 246 households distributed by wealth rank as shown in Table 4.3.

Table 4.3: Distribution of household by wealth rank (%)

Location	Poor	Middle	Well-off
Upstream villages	35	46	19
Mid-stream villages	36	40	24
Downstream villages	44	35	21

Source: PRA session 2002

4.2.3 Data analysis

(i) Qualitative analysis

The data collected were first summarized and a database template containing the collected information was made in Statistical Package for Social Science (SPSS) computer software. Descriptive statistics such as frequencies, means and cross-tabulations were used to decode the attached messages in the data collected. Content analysis was employed on qualitative data collected during the PRA sessions.

(ii) Quantitative 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 methods in particular, are often more appropriate for capturing the social and institutional context of people's lives than the quantitative methods. In this study the quantitative component of analysis assessed the assets and incomes among sample households where a multivariate regression analysis was employed to determine factors influencing vulnerability. Predictor variables fitted in the model included: the relative distances from the major markets, the value of household assets, farm size and household size.

(iii) Crop Water Productivity Modelling

Weather data from three weather stations [Mbeya Tanzania Meteorological Agency (TMA), Igurusi and NAFCO Kapunga] was collected for use in the Crop Water Productivity Modelling (CWPM). The three stations represent the upper, middle and lower locations of the catchment respectively. The weather data collected included the maximum and minimum temperatures (^{0}C), relative humidity (%), wind speed (Km/day), sunshine hours (hour) and rainfall (mm). The daily records of five years (1998 - 2002) were used to calculate the mean monthly values (for each of the five years), which were then used in modelling Crop Water Productivity.

The CROPWAT Model (8.0 Beta version) was used to model water productivity for the major crops grown in the catchment. Table 4.4 summarizes the crops modelled in the upper, middle and lower zones for the different agricultural production domains.

Table 4.4: Major crops used in water productivity modelling

Agricultural Production Domain	Crops		
	Upper Zone	Middle Zone	Lower Zone
Rainfed	Maize, Millet, Spring wheat, Dry Beans, Irish potato, Tomato	Maize, Sorghum, Dry Beans, Groundnuts, Tomatoes and Onions	Maize, Sorghum, Dry Beans, Groundnuts
Intermediate		Paddy rice	Paddy rice
Irrigated	Maize, Dry Beans, Tomatoes (early, mid and late), Irish potatoes and Onions	Maize, Dry Beans, Tomatoes (Early, mid and late) and onions	

The data from the weather stations for the upper, middle and lower zones was entered into the CROPWAT model and the reference crop evapotranspiration (ETo) calculated. The ETo together with rainfall, crop parameters (crop types, crop coefficients, crop growth stages, crop heights, depletion factors from total available soil moisture (TAM), and planting dates) were used in the simulation of crop water requirement (CWR). For crops under irrigation, soil information (soil types) and irrigation schedules (of fixed intervals) - to replace the soil moisture to field capacity was used in the simulation. Water productivity (kg/m^3) was calculated from respective CWRs and crops yields as recorded from the field survey.

5.1 Characteristics of sample households

5.1.1 Socio-economic characteristics of households

The average household size for the entire sample was found to be 6 people (Table 5.1). This is slightly above the national average of 4.9 (TNBS, 2002).[1] The higher average household size in the study area can largely be associated with polygamy, which was reported to be popular among agropastoralists in the lower plains. The mean age for the head of households was found to be 39 years and the average number of children with age of less than 15 years was 3. This means that on average, half of the household members are children, a reflection of high birth rates and population growth. Female-headed households constituted about 16% of the total households, somewhat lower than the national figure of 20%. About half of all members of the sample households were reported as having formal education.

Table 5.2: The socio-economic profile of sample households in the study area

Characteristics	Value
Male-headed households (%)	84
Female-headed households (%)	16
Percent attended formal education (%)	49.9
Average age for head of households (years)	39
Average household size (members)	6
Average number of children less than 15 years	3
Average adult members working fulltime on farm	2
Average number of children working full time on farm	1
Average number of children working part time on farm	1
Average adult labour equivalent	4
Average dependency ratio	0.40
Average net household income per annum (US $)	495

Source: Survey data, 2003 Sample size n = 246

[1] **Tanzania National Bureau of Statistics (TNBS), Household budget survey, 2002**

Agriculture (crop farming and livestock keeping) is the major economic activity. About 80% of all the members in the sample households reported as engaged in on-farm activities either as part time or full time workers. The average adult labour equivalent for the farming households was put at 4.[2] The involvement of children in farming activities is fairly low. The findings show that, children rarely work full time on-farm: only four percent were reported as working full time on-farm and only eight percent were working on part time basis. The possible explanation for this could be that most children spend much time in schooling and/or doing other domestic chores as the elderly go out to farm. The dependency ratio[3] was found to be 0.40, which is slightly lower than the national ratio (0.42). With regards to household incomes, a wide range of disparities was noted among households. The average net household income was put at US $ 495 per annum, which is more than twice the national average of about US $ 209.

5.1.2 Wealth Ranking

For the PRA wealth ranking exercise that was conducted in all the six sample villages, 10% of the total households were chosen in each village (from the village registers) in order to provide a logistically feasible sampling frame. The wealth ranking exercise eventually resulted in identification of five wealth groups that acted as the sampling frame for a stratified random sample. With a list of households in each wealth group, 10% of the households were then randomly chosen from each of the wealth category resulting in a sample size of 246 households (10 from the "very rich" category, 30 from the "rich" category, 96 from the "medium" category, 80 from the "poor" category and 30 from the "very poor" category). The purpose of the wealth ranking, apart from the perceptions about poverty and wealth gained from the exercise, was to ensure that the sample drawn represents the full range of livelihood circumstances to be found in the catchment, rather than being accidentally clustered around the mode of the range. The characteristics of wealth groups in the sample villages are shown in Table 5.2.

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[2] Different types of labour make different contributions to production, depending on the nature of the task performed, age and sex of the person performing it. In this study the family size variable was used to calculate a common denominator for all age and sex groups (the Adult Labour Equivalent) using the coefficients given in ILCA, 1990.

[3] Dependants are considered as the number of people younger than 15 and older than 65. The dependency ratio is the number of dependants over the remaining members of the household.

Land holding was considered as one of the most important determinants of wealth and various types of land ownership were noted. These included: inherited, Government given,[4] borrowed, hired or purchased. Those who are not able to cultivate their own land can hire it for money or in exchange of agricultural produce especially the crop that was grown on that particular farm for that particular period. In terms of land ownership the determining factors for wealth include the total area cultivated and that which is inherited (owned). In addition, the quantity of crops harvested is another important determinant. In the upper zone, the priority crops are maize, potatoes and vegetables. Rice is the priority crop in the middle zone and maize, millet and sorghum in the lower zone. Hence the measure for wealth is not only dependent on the number of hectares cultivated but also on the crop yield which is often expressed in number of bags.

Possession of paddy was considered as the most important factor determining the well being of a family, particularly in the middle zone. A person who harvests adequate rice has almost everything such as money, food, can build a good house, and has social status in the community. The poor category of farmers harvests little rice because they cultivate little land using mostly family labour. Again, because of low life standards, the poor is more likely to become sick and hence reduced time for working on-farm. The poor have therefore, problems in securing their food. Livestock (mainly cattle and shoats) was also considered as another important indicator of wealth, particularly in the lower zone, where the majority of the people are Sukuma agropastoralists. Other than cattle and shoats, the villagers, particularly in the upper and middle zone considered owning pigs as an important resource that can help promote a person to a wealthier rank.

The "very rich" and "rich" households cultivate between 4 and 20 hectares of land or more. They harvest 45 – 200 bags of paddy or more and they own 15 -200 heads of cattle or more. They have modern houses and can afford to pay for their children's education. Some own assets like milling machines and involve themselves in other income generating activities (may own shops, lodgings, bars, trading, etc).

[4] The government given land, refers to a land given to *bonafide* residents and can be passed over to children (son) as long as the initial recipient does not migrate out of the village.

Table 5.3: Local criteria and indicators derived from the wealth ranking exercise

Indicator	Wealth categories				
	Very rich	Rich	Medium	Poor	Very poor
Land owned	Up to 8 - 20 ha or more	4 - 8 ha	1.2 – 4 ha	0.4 – 1.2 ha	Less than 0.4 ha or do not own land at all
Land rent	Rent out land	Rent out land	May rent in/out land	Many rent in land	Do not rent in/out land
Paddy harvest (bags)[5]	70 – 200 bags or more	45 – 70 bags	10 – 45 bags	3 – 10 bags	1 – 3 bags
Maize harvest (bags)[6]	40 – 100 bags	10 – 50 bags	5 – 10 bags	1 – 3 bags	1 – 2 bags
Livestock	Cattle: 20 – 200 or more, shoats: 50 – 180, pigs: 10 – 20	Cattle: 15 – 20, shoats: 20 – 50, pigs: 5 – 10	Cattle: 2 – 15, shoats:3 – 20, pigs: 2 – 5	Less than 2 cattle or no cattle, shoats:1 – 2, pigs: 1 – 2, a few chickens	A few chickens only
House	Cement blocks/ burnt brick walls Cement floor Iron roof	Burnt brick walls Iron roof	Burnt or mud walls, iron roof or thatch	Mud walls, Thatch roof	Have houses with mud walls or no houses at all Thatch roof
Labour	Hire labour	Hire labour seasonally	May hire labour seasonally	May sell labour	Selling labour
Education	Primary level or above	Primary level	Primary level	Many have not been to school	Many have not been to school
Health services (Govt Hospitals, Dispensary, Clinics, traditional healers)	Can always pay for health services	Can pay for health service	Can afford to pay for services from Dispensaries and traditional healers	Can afford to pay for services from traditional healers /use traditional medicines	Can not afford paying for health service (use traditional medicines)
Other assets owned	Vehicles, Milling machine, Sewing machine, Refrigerator, Bicycles, TV, Radio, (ox-carts, oxen ploughs), private water point	Bicycle(s), Radio, Implements (ox-carts, oxen ploughs)	Bicycle(s), Radio	Few have radios	None
Other activities	Run different businesses (shops, lodgings, bars, milling machine)	May run few businesses (trading, beer brewing)	Handcraft and petty trading	Handcraft	None
Food security	Food secure all year round	Food secure all year round	Most are food secure all year	Seasonally food insecure	Food insecure most of the year

Source: PRA, 2003

[5] For paddy, 1 bag is 80kgs
[6] For Maize, 1 bag is 100 kgs

Households in the "Medium" category cultivate between 1.2 - 4 hectares and harvest 10 – 45 bags of paddy and they own between 2 and 15 heads of cattle. Their houses are normally made of burnt bricks or mud walls, iron roof or thatch. They have the means to own a bicycle and a radio. The "poor" and "very poor" households cultivate not more than 1.2 hectares and harvest at most 10 bags of paddy and they own less than 2 heads of cattle or none. They normally have grass-thatched houses with mud walls. They cannot afford paying their children's school fees. The very poor, sometimes manage only one meal a day or none.

Clothing was also used as one of the wealth indicators, but no difference was reported among the ranks. Essentially, those who are rich are expected to wear new clothes and not second hand clothes (mitumba) and those under rank number 5 (very poor) to have the poorest clothes because the income they earn does not allow them to buy expensive clothes. In general clothing was to a large extent, considered as a personal taste, interest and occasional. Some people who are considered poor dress better than the rich do. From the PRA, the general conclusion was that clothing was not an important indicator for wealth. Table 5.3 presents the summary of households falling under each wealth group as obtained from the wealth ranking exercises in the sample villages. Only 13% of the total households in the sample villages were grouped as "very rich" and "rich". The "Medium" category constituted 35%, the poor 32% and the remainder (the "very poor" households) constituted about 20%.

Table 5.4: Summary of wealth ranks in the sample villages

Village/ Wealth Rank	Very rich	Rich	Medium	Poor	Very poor	Unranked	Total
1. Ikhoho (hhs)	**8**	**24**	**104**	**90**	**44**	**0**	**270**
2. Inyala (hhs)	**2**	**5**	**287**	**138**	**51**	**1**	**484**
3. Mahongole (hhs)	**8**	**40**	**187**	**336**	**167**	**10**	**748**
4. Mwatenga (hhs)	**4**	**17**	**124**	**59**	**9**	**1**	**214**
5. Madundasi (hhs)	**36**	**67**	**192**	**197**	**204**	**8**	**704**
6.Ukwaheri (hhs)	**48**	**102**	**95**	**73**	**62**	**3**	**383**
Total (hhs)	**106**	**255**	**989**	**893**	**537**	**23**	**2803**
%	**4**	**9**	**35**	**32**	**19**	**1**	**100**

Source: PRA, 2003

5.2 Farming systems

Different authors have defined the term "farming systems" differently. FAO and World Bank, 2001, for example, define it as a population of individual farm systems that have broadly similar resource bases, enterprises patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate." A frequently quoted definition of a farming system is that it is "a unique and reasonably stable arrangement of farming enterprises that the household manages according to well-defined practices in response to physical, biological and socio-economic environments and in accordance with the household's goals, preferences and resources. These factors combine to influence output and production methods. More commonality is found within the system than between systems. The farming system is part of larger systems – e.g., the local community – and can be divided into subsystems – e.g., cropping systems." (Shaner et al., 1982, p 16).

However, although it may be more logical to consider only farming enterprises in a definition of farming systems, farming systems analysis usually casts its net wider. The authors quoted above recognize that non-agricultural commodities (e.g., handicrafts) and income earned off the farm also interact with the household's goals, preferences and resources (op cit., p 3). Hence an alternative definition: "A specific farming system arises from the decisions taken by a small farmer or farming family with respect to allocating different quantities and qualities of land, labour, capital, and management to crop, livestock, and off-farm enterprises in a manner which, given the knowledge the household possesses, will maximize the attainment of the family goal(s)" (Norman, 1980, p 2).

A further definition also includes consumption: "The total of production and consumption decisions of the farm-household including the choice of crop, livestock and off-farm enterprises and food consumed" (Byerlee and Collinson, 1980, p 70).

The analysis of farming systems in this study borrows from all the above definitions and the existing farming systems are considered to condition both the actual and potential crop water productivity of the agro-zones. They are either a driving force towards food security or a crucial limitation on it and the resultant vulnerable groups.

In general, the family incomes in Mkoji catchment are almost entirely dependent on natural resources. Other non-natural based activities (e.g., local merchandizing and trading) are indirectly dependent on natural resources in one way or another. Cultivation is the primary activity in the catchment, both in terms of numbers employed and total income generated. This, together with the adaptation to resource opportunities has in turn resulted in different farming systems, reflecting the spatial variation in resource availability and land uses. The major divisions in catchment and their associated major farming systems are categorized as:

The upper zone: has been divided into two major areas: the most upper (represented by Ikhoho village and dominated with rainfed agriculture and the lower upper (e.g., Inyala village) which is dominated by supplementary and dry season irrigation. Both areas benefits from access to the main road and railway. Human population in the Upper Mkoji is put at 59,234 people and the total number of households at 14,870 (2002 Census).

The middle zone: has been divided into two major areas: the upper middle (represented by Mahongole village and dominated by both wet and dry season irrigation and benefits from access to the main road and railway) and the lower middle (represented by Mwatenga village and dominated by rainfed maize and irrigated paddy), both making use of favourable land and water resources available in the area. The middle Mkoji has a population of 48,366 people and 12,695 households (2002 Census).

The lower zone: is an agro-pastoral area with both pastoralism and rainfed cultivation being important farming systems, responding to local variations in opportunity — lighter soils permitting cultivation, and grassy mbugas favouring livestock in the northern western wetland and the eastern wetland, and seasonal grasses on the northern fans. Human population in the lower Mkoji is 25,868 people and the total number of households is 4,352 (2002 Census).

(i) Upper Mkoji

In the most upper Mkoji, cultivation is primarily rainfed. Irrigation, while locally important, is trivial in the area and is largely confined to narrow valley bottoms. Cultivation strongly reflects climatic variables. As altitude and rainfall increase, the range of crops and the length of the cropping season also increase. However, at the highest altitudes crop choice again becomes more restricted. The cool conditions favour long maturing crops, which are facilitated by the favourable moisture conditions. Most areas of the highlands have standing crops most of the year, with staggered cropping calendars for the major crops. Crop choice is influenced by conditions of soil and topography and, to a lesser extent, accessibility to markets.

At high altitudes especially along watersheds and on the high altitude grasslands, potatoes and pyrethrum are grown (the potato farming system). Potatoes are primarily planted from May to August, and harvested from December to February. Rainfall is high and the area benefits from moisture (both rain and cloud) drifting over from the Lake Nyasa catchment to the south. Soils are often shallow, poor, and gravely, and the climate cool and sometimes with frosts from June to August. Despite this, the area has become one of the major potato producing areas in Tanzania, with most of the crop transported to Dar es Salaam.

At lower altitudes, maize is the dominant crop. The break with the potato farming system is quite marked and abrupt. This perhaps reflects the limit of influence of the Lake Nyasa weather systems. Three maize-dominated highland systems have been recognized. On the western part, maize is mixed with potato production, along with wheat and pulses (beans and peas). This is a maize-potato farming system. Tree fruits (e.g., peaches, papaya, bananas and citrus) and vegetables are also important crops. The farming system takes advantage of fertile and well-structured volcanic soils and favourable climate. Incorporation of stubble and crop rotation are the primary means of maintaining soil fertility and the use of agro-chemicals is limited. Where land availability allows, fallowing may also be used. Not only does this area receive high annual rainfall, but also has low evapotranspiration and occasional dry season rains.

Labour comes mainly from the family. Only a small number of families own cattle, which are used primarily for milk production. Animal traction is uncommon. Families generally have a small stock of animals, 23 (sheep, goats and pigs), and a few chickens. Grazing land is in short supply, especially during the dry season from July to November.

At still lower altitude, especially in areas close to Uyole, beans supplant potatoes as the second crop, followed by wheat, potatoes and vegetables (this is a maize-beans farming system). The cropping season is somewhat shorter than the maize-potato system, reflecting lower rainfall, little dry season rains, and higher temperatures. However, the areas are favoured by moderate slopes, and are intensively cultivated. Almost all the forests and shrubs have been entirely cleared to pave way for crop production and fertilizer use is relatively high.

(ii) Middle Mkoji

In the middle Mkoji, wet season paddy cultivation is an important activity. Amongst farmers, paddy plot sizes are typically between 0.5 and 2 hectares. The majority of farmers depend on family labour, which is normally provided by both men and women for maintaining their crop fields. Sometimes family labour becomes a constraint especially when the rainy season is delayed and the labour demands of the rainfed maize and paddy overlap. Farmers respond to these constraints by managing the available labour in several ways (e.g., stopping their children from going to school). Although hired labour could be a viable option it turns out to be expensive especially at peak times of labour demand. If the rains are delayed, many farmers may not be able to cultivate all their land and will hire out land to others.

While paddy is an important cash crop for most farmers, priority is given to maize, which is a staple food. Most of the former crop is sold to traders with only small amounts reserved for family use. In general, despite the importance of marketed rice as an income supplement, cultivation of both maize and rice is still essentially a low input-low output activity. Management is driven by the need to minimize risk rather than maximize opportunities (yields), and the emphasis is on provision for the family. As such, few inputs are used apart from hired labour in paddy production. There is almost no use of fertilizers, herbicides or pesticides. Varieties grown are generally local, and seed is typically carried over from one year's crop to the next year.

While taste is often cited for the choice of local varieties, other factors are also important. Improved seeds are expensive; they may not allow seed to be carried over from year to year, thus necessitating seed repurchase every year; and they are typically more demanding of both water and nutrients, require increased inputs (and associated cost) and are less adapted to the vagaries of climate.

(iii) Lower Mkoji

In the lower catchment, pastoralism and rainfed cultivation are the major farming systems. The area has the largest number of livestock which are owned mostly by immigrant pastoralists (e.g., the Sukuma people from northern Tanzania). The Sukuma are agropastoralists and cultivate much larger areas. Charnley (1994, p. 330) reports that on average they cultivate about 2.2 hectares of maize, 1.4 hectares of millet, and 1.76 hectares of rice. The use of draught animal power has enabled the majority of Sukumas to cultivate larger areas and on heavy clay soils.

Other cropping systems within the pastoral zone are primarily opportunistic. On the northern part, small, isolated and fenced fields may be found on mounded sandy patches. Rainfall is equivalent to or greater than that on the southern part, but soils are generally not favourable. However, within the pastoral zone there are also islands of extensive cropping. In the north-east of Ukwaheri village, extensive areas have recently been cropped by the Sukuma. The soils are heavy (vertisols) and the areas cleared are local mbugas, extending into the Acacia seyal woodland. The vegetation and soils indicate strongly that these areas have until recently been seasonally inundated. The conversion to cultivation suggests that, while these areas may still be relatively wet, inundation is no longer a constraint.

5.3 Livelihood strategies and outcomes

5.3.1 Assessment of vulnerable groups

A variety of techniques and indicators were used to distinguish between households of different levels of wealth and the processes of impoverishment and accumulation. The study defines the poor and vulnerable groups as those:

- Who lack assets and the capability to use them
- Who have limited access to livelihood platforms or capital (natural, physical, human, financial and social)
- Who are highly dependent on, and disadvantaged by, market relations
- Who rely on small and ineffective social networks
- Who are unable to cope (temporary make adjustments in the face of change) or adapt (make longer shifts in livelihood strategies)
- Who are food insecure or malnourished
- Households that fall under the bottom income quintile for different family types

Tables 5.4 and 5.5 show the number of households falling under each wealth class and the percentages of households categorized as poor and vulnerable in the three major agro-ecological zones using the PRA results (wealth ranking) and the 2002 census results. About half of all the households in these zones were classified as vulnerable (ranked as 'poor' or 'very poor'): 6,593 households (or 44.4%) in the upper zone; 5,005 (or 49.5%) in the middle zone, and 2,006 (or 46.4%) in the lower zone. As shown in Table 5.5 about 13,600 households (equivalent to 46% of the total households) can be classified as poor and vulnerable. Out of these, about 48% are found in the upper zone and the remainder (37% and 15%) are found in the middle and lower Mkoji respectively.

Table 5.4: Number of households under each wealth category

Location	Very rich	Rich	Medium	Poor	Very poor	Unranked	Total
Upper	251	738	7273	4598	1995	15	14870
Middle	149	672	4192	3664	1341	91	10108
Lower	384	787	1133	1024	983	42	4352
Total	784	2196	12598	9286	4319	148	29330

Source: 2002 Census results and PRAs, 2003

Table 5.5: Number and percentages of "poor" and "very poor" households

Location	Number of hhs	% in the zone	% in the whole catchment
Upper	6593	44.3	48
Middle	5005	49.5	37
Lower	2006	46.1	15
Total	13604	46.4	100

Source: 2002 Census results and PRAs, 2003

5.3.2 Production/livelihood systems in the upper zone

Table 5.6 is a summary of production/livelihood systems in the upper zone and the respective number of households involved and average income earned per year. All the households in the upper zone reported as engaged in rainfed maize cultivation and about 65% and 58% in irrigated maize and irrigated beans respectively (Table 5.6). In the quantitative livelihood analysis, about 3.6% and 25% of all the sample households in Ikhoho village (upper most) were categorised as "very poor" and "poor" respectively with their major sources of income shown in Tables 5.7 and 5.8. In Inyala village, about 11.5% and 17.3% of all the sample households were categorised as "very poor" and "poor" respectively. Their major sources of income are shown in Tables 5.9 and 5.10.

Table 5.6: Production/livelihood systems in the upper zone: All wealth classes

Production domain	Output	No. of hhs	% of hhs	Avg. (ha)	Avg hh income (Tsh)	Average household income US $	% of total income
Irrigated agriculture	Maize	52	65	0.1825	61471.75	59.70	23.09
	Beans	46	57.5	0.235	11233.45	10.90	4.22
	Tomatoes	34	42.5	0.1365	12426.85	12.05	4.66
	Irish potatoes	1	1.3	0.025	NA	NA	NA
	Onions	27	33.8	0.2064	10165.10	9.85	3.81
Rainfed agriculture	Maize	80	100	0.31755	37391.75	36.30	14.04
	Beans	26	32.5	0.15125	25029.35	24.30	9.40
	Round potatoes	1	1.3	0.1	NA	NA	NA
	Tomatoes	19	23.8	NA	13740.00	13.35	5.16
	Spring wheat	27	33.8	NA	15577.50	15.10	5.84
Livestock	Live animals	10	12.5		1766.75	1.70	0.66
	Milk	2	2.5		31028.40	30.10	11.64
	Other livestock products	9	11.3		1396.85	1.35	0.52
Brick making	Bricks	26	32.5		3982.70	3.85	1.49
Other NR-based activities		25	31.3		16380.80	15.90	6.15
Selling out labour - Wet		19	23.8		6688.20	6.50	2.51
Selling out labour – Dry		14	17.5		1718.30	1.65	0.64
Selling out labour – Rainfed		13	16.3		963.65	0.95	0.37
Non-farm activities		23	28.8		14091.80	13.70	5.30
Remittance		7	8.8		1208.60	1.15	0.44
All households		80	100		266261.80	258.50	100.00

Table 5.7: Production/livelihood system of the "very poor" households in Ikhoho village

Production domain	Output	No. of sample hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Rainfed agriculture	Maize	1	0.1	NA	NA	NA
	Spring wheat	1	NA	16,472.40	16.00	52.98
Selling out labour –Wet				7,020.00	6.80	22.52
Selling out labour –Dry				3,861.00	3.70	12.25
Non-farm activities				3,744.00	3.60	11.92
All sources		1		31,097.40	30.20	100.00

Table 5.8: Production/livelihood system of the “poor” class in Ikhoho village

Production domain	Output	No. of sample hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Rainfed agriculture	Maize	13	0.245	5,658.10	5.50	11.70
	Round potato	1	0.25	NA	NA	NA
	Spring wheat	13	0.22	7,335.90	7.10	15.11
Livestock	Milk	1		15,444.00	15.00	31.91
	Other livestock products	4		1,842.80	1.80	3.83
Brick making	Bricks	5		6,205.70	6.00	12.77
Selling out labour - Wet		1		5,031.00	4.90	10.43
Selling out labour – Dry		2		2,808.00	2.70	5.74
Non-farm activities		1		2,340.00	2.30	4.89
Remittance		5		1,790.10	1.70	3.62
All sources		14		48,455.60	47.00	100.00

Table 5.9: Production/livelihood system of the “very poor” class in Inyala village

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Irrigated agriculture	Maize	6	0.18	12,191.40	11.80	6.52
	Beans	6	0.21	7,300.80	7.10	3.92
	Tomatoes	1	0.12	18,720.00	18.20	10.06
	Irish potatoes	1	0.2	NA	NA	NA
	Onions	1	0.18	19,492.20	18.90	10.44
Intermediate agriculture	Vegetables			NA	NA	NA
Rainfed agriculture	Maize	6	0.25	24,963.10	24.20	13.37
	Beans	6	0.25	26,910.00	26.10	14.42
	Tomatoes	4	0.112	57,213.00	55.50	30.66
Brick making	Bricks	5		10,483.20	10.20	5.64
Other NR-based activities		2		7,605.00	7.40	4.09
Selling out labour – Rainfed		3		1,544.40	1.50	0.83
All sources		6		186,423.10	181.00	100.00

Table 5.10: Production/livelihood system of the "poor" class in Inyala village

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Irrigated agriculture	Maize	36	0.5	17,076.30	16.60	4.65
	Beans	30	0.52	27,063.10	26.30	7.37
	Tomatoes	28	0.222	40,355.50	39.20	10.98
	Onions	18	0.2872	17,547.20	17.00	4.76
Rainfed agriculture	Maize	38	0.5	22,849.20	22.20	6.22
	Beans	15	0.28	46,901.00	45.50	12.75
	Tomatoes	12	0.25	37,981.60	36.90	10.34
Livestock	Live animals	7		5,618.70	5.50	1.54
	Other livestock products	1		433.8	0.40	0.11
Brick making	Bricks	10		9,061.60	8.80	2.47
Other NR-based activities		18		59,833.60	58.10	16.28
Selling out labour - Wet		10		6,482.90	6.30	1.77
Selling out labour – Dry		7		1,762.70	1.70	0.48
Selling out labour – Rainfed		9		3,033.90	2.90	0.81
Non-farm activities		14		71,573.60	69.50	19.47
All sources		36		367,574.70	356.90	100.00

5.3.4 Production/livelihood systems in the middle zone

About 62% and 66% of the total households in the middle zone reported as engaged in intermediate paddy and rainfed bean cultivation respectively. About 54.7% reported as earning income from selling livestock products other than live animals and milk. In addition, 8% reported as earning from selling live animals. Households earning from sale of labour (both during the wet and dry season) constituted about 7 – 13% of all the households and about 14% also earn from non-farm activities (Table 5.11).

Table 5.11 : Production/Livelihood systems in the middle zone: All wealth classes

Production domain	Output	No. of hhs	% of hhs	Avg. (ha)	Avg hh income (Tsh)	Average household income US $	% of total income
Irrigated agriculture	Maize	12	14	0.311	5673.00	5.51	1.74
	Beans	18	20.9	0.101	11045.53	10.72	3.38
	Onions	21	24.4	0.22	NA	NA	NA
Intermediate agriculture	Paddy	53.58	62.3	21.756	65000.83	63.11	19.89
Rainfed agriculture	Maize	36	41.9	1.0375	20801.94	20.20	6.37
	Millet	1	1.2	0.4	NA	NA	NA
	Beans	57	66.3	0.305	21094.01	20.48	6.45
	Round potato	4	4.7	0.2035	2552.55	2.48	0.78
	Tomatoes	3	3.5	0.075	12598.56	12.23	3.86
	Groundnuts	14	16.3	0.185	4593.23	4.46	1.41
Livestock	Live animals	7	8.1		38124.93	37.01	11.67
	Milk	14	16.3		57415.61	55.74	17.57
	Other livestock products	47	54.7		20668.04	20.07	6.32
Brick making	Bricks	22	25.6		5117.14	4.97	1.57
Other NR-based activities		12	14		15329.93	14.88	4.69
Selling out labour - Wet		11	12.8		3410.16	3.31	1.04
Selling out labour - Dry		6	7		1345.50	1.31	0.41
Non-farm activities		12	14		29014.54	28.17	8.88
All sources		86	100		326793.54	317.28	100.00

In Mahongole village (upper middle) about 10% and 50% of all the sample households were categorised as “very poor” and “poor” respectively. Their major sources of income are shown in Tables 5.12 and 5.13. In Mwatenga village (lower middle) about 6% and 20% of all the sample households were categorised as “very poor” and “poor” respectively. Their major sources of income are given in Tables 5.14 and 5.15.

Table 5.12: Production/livelihood system of the “very poor” class in Mahongole

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Irrigated agriculture	Beans	1	0.3	10530	10.22	2.61
Intermediate agriculture	Paddy	3	0.7	11932.596	11.59	2.96
Rainfed agriculture	Beans	5	0.2	8950.5	8.69	2.22
Livestock	Live animals	1		60837.66	59.07	15.09
	Milk	1		294840	286.25	73.12
	Other livestock products	4		16146	15.68	4.00
All sources		5		403236.756	391.49	100.00

Table 5.13: Production/livelihood system of the “poor” class in Mahongole village

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Irrigated agriculture	Beans	8	0.2	5463.9	5.30	1.82
	Onions	4	0.31	46074.6	44.73	15.33
Intermediate agriculture	Paddy	12	0.66	30073.446	29.20	10.01
Rainfed agriculture	Maize	1	0.25	6800.04	6.60	2.26
	Beans	8	0.2	56160	54.52	18.69
	Tomatoes	1	0.5	11325.6	11.00	3.77
Livestock	Live animals	1		121675.32	118.13	40.49
	Milk	2		5452.2	5.29	1.81
	Other livestock products	5		9063.599999	8.80	3.02
Brick making	Bricks	3		8424	8.18	2.80
All sources		12		300512.706	291.76	100.00

Table 5.14: Production/livelihood system of the "very poor" class in Mwatenga village

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Irrigated agriculture	Maize	1	1	11700	11.36	8.08
Intermediate agriculture	Paddy	1	1.2	91353.6	88.69	63.07
Rainfed agriculture	Maize	1	1.2	10717.2	10.41	7.40
	Beans	1	0.25	2106	2.04	1.45
	Round potato	1	0.2	NA	NA	NA
	Other livestock products	1		6739.2	6.54	4.65
Brick making	Bricks	1		12636	12.27	8.72
Selling out labour - Wet		1		2106	2.04	1.45
Non-farm activities		1		7488	7.27	5.17
All sources		2		144846	140.63	100.00

Table 5.15: Production/livelihood system of the "poor" class in Mwatenga village

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Irrigated agriculture	Maize	3	0.58	12175.722	11.82	5.30
	Onions	7	1.2	NA	NA	NA
Intermediate agriculture	Paddy	11	0.9	26519.922	25.75	11.54
Rainfed agriculture	Maize	14	1.2	11477.7	11.14	5.00
	Beans	7	0.8	15795	15.33	6.88
	Round potato	1	0.2	9477	9.20	4.13
	Groundnuts	8	0.2	1766.7	1.72	0.77
Livestock	Milk	2		12636	12.27	5.50
	Other livestock products	13		25821.432	25.07	11.24
Brick making	Bricks	3		9750.078	9.47	4.24
Other NR-based activities		4		55434.6	53.82	24.13

Selling out labour - Wet		**5**		**8629.92**	**8.38**	**3.76**
Selling out labour – Dry		**3**		**8424**	**8.18**	**3.67**
Non-farm activities		**8**		**31806.45**	**30.88**	**13.85**
All sources		**14**		**229714.524**	**223.02**	**100.00**

5.3.5 Production/livelihood systems in the lower zone

More than half of the households in the lower zone are involved in rainfed maize (91%); rainfed sorghum and millet (58%) and intermediate paddy farming (56%). About 34% also earn from selling live animals and about 78% from sales of livestock products (other than live animals and milk). About 5 – 10% of all the households earn from sale of labour during the wet and in the dry seasons (Table 5.16). Only a small number of households (3%) earn from remittances.

In Ukwaheri village the "very poor" and "poor" households constituted 25% of all the sample households each. Their major sources of income are shown in Tables 5.17 and 5.18. In Madundasi village about 20.5% and 31.8% of all the sample households were categorised as "very poor" and "poor" respectively. Their major sources of income are shown in Tables 5.19 and 5.20.

Table 5.16: Production/Livelihood systems in the lower zone: All wealth classes

Production domain	Output	No. of hhs	% of hhs	Avg. (ha)	Avg hh income (Tsh)	Average household income US $	% of total income
Intermediate agriculture	**Paddy**	**45**	**56.3**	**1.497**	**53691.44**	**52.13**	**5.70**
Rainfed agriculture	**Maize**	**73**	**91.3**	**2.5075**	**39271.36**	**38.13**	**4.17**
	Sorghum	**46**	**57.5**	**2.7415**	**45110.33**	**43.80**	**4.79**
	Beans	**3**	**3.8**	**NA**	**48.75**	**0.05**	**0.01**
	Round potatoes	**2**	**2.5**	**NA**	**234.00**	**0.23**	**0.02**
	Groundnuts	**28**	**35**	**1.0415**	**4930.44**	**4.79**	**0.52**
Livestock	**Live animals**	**27**	**33.8**		**529358.40**	**513.94**	**56.23**
	Milk	**19**	**23.8**		**124330.50**	**120.71**	**13.21**
	Other livestock products	**62**	**77.5**		**37979.87**	**36.87**	**4.03**
Brick making	**Bricks**	**17**	**21.3**		**3286.24**	**3.19**	**0.35**
Other NR-based activities		**13**	**16.3**		**17593.86**	**17.08**	**1.87**
Selling out labour - Wet		**8**	**10**		**3642.60**	**3.54**	**0.39**
Selling out labour – Dry		**4**	**5**		**721.50**	**0.70**	**0.08**
Non-farm activities		**8**	**10**		**81049.80**	**78.69**	**8.61**
Remittance		**2**	**2.5**		**117.00**	**0.11**	**0.01**
All sources		**80**	**100**		**941366.10**	**913.95**	**100.00**

Table 5.17: Production/livelihood system of the “very poor” class in Ukwaheri village

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Intermediate agriculture	Paddy	9	0.622	30595.5	29.70	10.48
Rainfed agriculture	Maize	9	0.7	14817.114	14.39	5.07
	Sorghum	2	0.4	936	0.91	0.32
Livestock	Live animals	2		146010.384	141.76	50.00
	Milk	2		18252	17.72	6.25
	Other livestock products	5		2457	2.39	0.84
Brick making	Bricks	1		14040	13.63	4.81
Other NR-based activities		3		55692	54.07	19.07
Selling out labour - Wet		2		7324.2	7.11	2.51
Non-farm activities		1		468	0.45	0.16
Remittance		2		1404	1.36	0.48
In-kind				0	0.00	0.00
All sources		9		291996.198	283.49	100.00

Table 5.18: Production/livelihood system of the “poor” class in Ukwaheri village

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Intermediate agriculture	Paddy	7	2.34	209258.244	203.16	38.99
Rainfed agriculture	Maize	8	1.01	46292.922	44.94	8.63
	Sorghum	1	2.4	NA	NA	NA
	Groundnuts	2	0.2	NA	NA	NA
Livestock	Live animals	5		128367.4626	124.63	23.92
	Milk	1		58968	57.25	10.99
	Other livestock products	10		76541.4	74.31	14.26
Brick making	Bricks	1		4680	4.54	0.87
Other NR-based activities		1		2207.322	2.14	0.41
Selling out labour - Wet		1		1404	1.36	0.26
Selling out labour – Dry		1		1404	1.36	0.26
Non-farm activities		1		7581.6	7.36	1.41
All sources		10		536704.9506	521.07	100.00

Table 5.19: Production/livelihood system of the "very poor" class in Madundasi village

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Intermediate agriculture	Paddy	3	1.8	13806	13.40	1.92
Rainfed agriculture	Maize	9	2.8	26482.95	25.71	3.68
	Sorghum	9	4.11	NA	NA	NA
	Beans	1	0.25	585	0.57	0.08
	Groundnuts	3	0.7	11251.422	10.92	1.56
	Live animals	3		616488.2802	598.53	85.65
Livestock	Milk	1		2106	2.04	0.29
	Other livestock products	9		43636.086	42.37	6.06
Brick making	Bricks	4		5382	5.23	0.75
All sources		9		719737.7382	698.77	100.00

Table 5.20: Production/livelihood system of the "poor" class in Madundasi village

Production domain	Output	No. of hhs	Avg. (ha)	Average household income (Tsh)	Average household income US $	% of total income
Intermediate agriculture	Paddy	1	1	63180	61.34	12.37
Rainfed agriculture	Maize	10	2.2	25658.1	24.91	5.03
	Sorghum	8	2.4	17082	16.58	3.35
	Beans	1	0.5	NA	NA	NA
	Round potato	1	0.4	2808	2.73	0.55
	Groundnuts	10	1.2	10647	10.34	2.09
	Live animals	2		282895.119	274.66	55.41
Livestock	Milk	1		93.6	0.09	0.02
	Other livestock products	8		102180	99.20	20.01
Brick making	Bricks	4		6014.502	5.84	1.18
All sources		11		510558.321	495.69	100.00

5.4 Poverty and dependency

Given the association between large families and poverty, it is worth exploring the structure of family life in the catchment. Large families are generally expected to be far more common among the poorest households of the bottom quintile and average family size to be smaller for households in the upper income quintiles. Small households, those with very young children and those dominated by older people are also more likely to be poor and vulnerable.

Tables 5.21 and 5.22 summarize a probability analysis, which was done so as to highlight the impact of family size and composition on vulnerability to poverty. Households made up of three or more adults and three to four children were more than twice as likely to be in the bottom quintile as households with a single adult and one to two children. The female–headed households were also more likely to be vulnerable than the male-headed households (compare probability of 27% versus that of 21%). A close analysis of the percentages shown in Tables 5.21 and 5.22 and Figure 5.1 suggests that vulnerability in the study catchment, as in most other rural communities, increases with the number of dependents. This is evidenced by the higher probability values for the households with 6 to 10 or more children.

Table 5.21: Probability analysis of low-income households in the catchment

Family type	Percent in the lowest quintile
Female headed household	27
Male headed households	21
Single adult 1-2 children	12
Single adult more than 2 children	32
2 adults 3 – 4 children	30
2 adults with 6 –10 children	35
Household with 11+ people	38

Table 5.22: Probability analysis of low-income households in the sample villages

Vulnerable groups	Ikhoho	Inyala	Mahongole	Mwatenga	Ukwaheri	Madundasi	Whole sample
FHH	31	19	16	27	22	34	27
MHH	25	20.9	14	29	17	28	22
1Adults 1-2c	11	6	7	15	18	21	13
1Adults 2c+	34	37	39	24	27	23	31
2 Adults 3-4c	33	36	37	23	25	22	29

2 Adults 6-10c	38	33	27	39	36	31	34
11+people	42	37	36	40	38	28	37

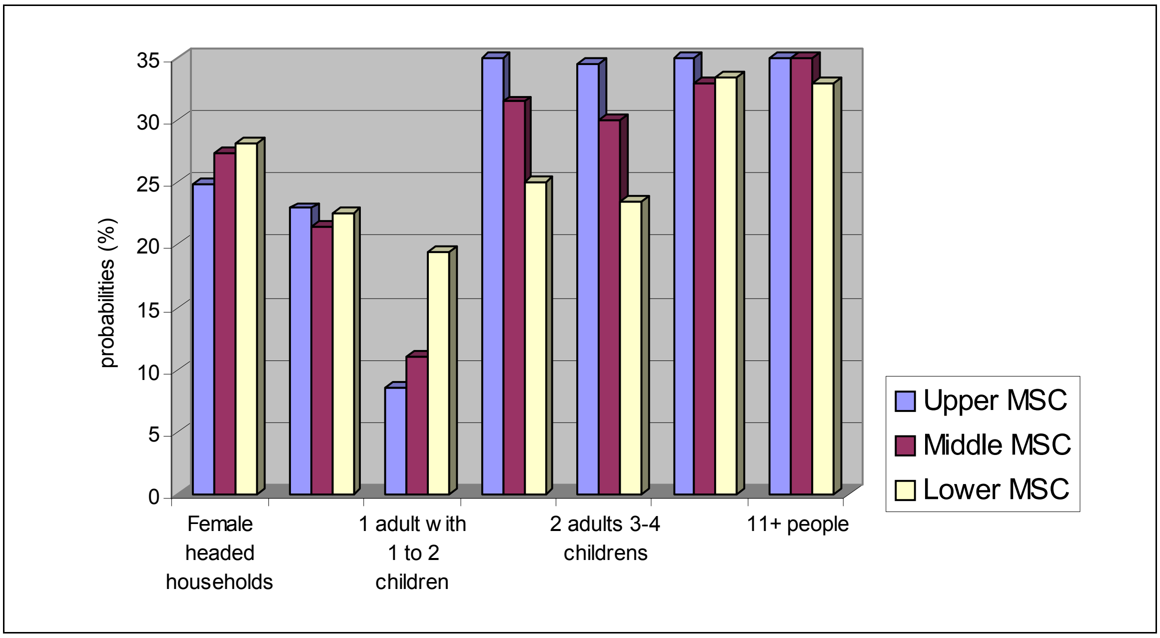

Figure 5.3: Probability that female-headed and large households fall in the bottom income quintiles

The analysis in this study has shown that the poor (low-income/vulnerable groups) in Mkoji are also characterised by low resource endowment (Table 5.23). The average land holdings for the poorest in the area is put at 1.9 ha, which is about three times lower than the average size of land owned by the "very rich" category (about 6 ha). With regards to other livelihood assets, the findings suggest that the poorest are also prone to vulnerability because they either lack or own assets of low values. When put differently, the lack of valuable assets among the poor makes them remain in the vicious cycle of poverty while the rich, who own valuable assets have good chances of climbing the ladder because they may mortgage their assets so as to get loans from credit institutions. As shown in the regression results in Table 5.24, the value of household assets is one of the important determinants of wealth (as measured by the value of annual household incomes).

Table 5.23: Resource ownership and income by wealth rank

Variable	Very poor	Poor	Medium	Rich	Very rich
Average land owned (ha)	1.9	3	2.1	4.5	5.7
Average value of household assets (US $)	70.5	91.3	155.7	450.3	481.2
Average household annual income (US $)	287.8	318.7	575.9	555.1	713.7

Source: Survey data, 2003

Table 5.24: Regression between household incomes and selected determinants of income

Predictor	Coefficients	Std. Error	T	P
(Constant)	-0.05	0.130	-0.409	0.683
Farm size (ha)	0.147	0.021	2.003	0.047
Household asset value (US $)	0.134	0.000	1.873	0.063
Household size	0.187	0.014	2.459	0.015
Relative distance from markets	0.158	0.061	2.040	0.043

ANOVA

	Sum of Squares	Df	Mean Square	F	P
Regression	11.164	4	2.791	7.604	0.000
Residual	63.503	173	0.367		
Total	74.667	177			
		$R^2 = 46.4\%$			

Source: Survey data, 2003

The average household income for the "very poor" was low (US $ 288): two times lower than that of the "very rich" category (Table 5.23), which implies limited consumption and/or expenditure for goods and services, including health. This has negative implication, particularly on their health status as it may lead to reduced labour force, deaths and increasing number of orphans, widows and families without able-bodied, working-age adults. This situation will increase their vulnerability.

Labour is one of the most limiting resources in the agricultural production systems in the catchment. Labour is an essential household resource in an agricultural production system. Its use can be related to the use of other household resources, such as land and capital. It influences management practices, enterprise combinations, labour hiring and sharing strategies, and overall levels of technical and economic performance of the farm households. Labour is very often reported as a limited resources in agrarian systems in the developing world and was also noted as common among households in the study catchment, where it is worse in the upper and middle zones (Table 5.25). This can be explained by the existing livelihood opportunities in the upper and middle zones. The two areas are closer to the Dar es Salaam – Mbeya main road and the Tanzania – Zambia railway with most of the areas with roads passable throughout the year and hence, easier access to markets. In addition, the establishment of smallholder schemes like the Ipatagwa and Motombaya (in the middle zone) might have accelerated the markets for labour.

With labour deficit the poor are affected most, whereas rich households may use hired labour and crop staggering to lessen the effects of labour deficit for farm work. In general, due to lack of livelihood capital, the poor are inclined to adopting production practices, which do not ensure sustainability of their resource bases. The lack of labour flexibility and other important inputs like irrigation water disproportionately affect their livelihoods and make them more vulnerable to poverty and hunger. The ability to diversify their production systems is also limited due to insufficient livelihood capital. They are also adversely affected by commercialisation of natural resources (such as water, firewood and thatching grass) because they lack adequate financial capital. When access to these resources is commercialised the poor may have to travel long distances to collect "free" supplies**.**

Limited social networks and a high degree of social isolation also characterize the poor and vulnerable households. They may have difficulty in accessing help from relatives, are unable to pay entry fees of contributions to clubs and associations and infrequently attend village government meetings. In the lower zone, associational activities (in the form of collective labour arrangements, traditional ceremonies and informal groups such as drinking circles) cross cut rich and poor households and resulted in higher levels of social capital. In the middle, co-operation and social interaction was primarily around income-generating clubs and livelihood associations, membership of which was dominated by middle income households.

Table 5.25: Labour availability in sample villages (by wealth classes)

Village	Wealth category	Average hh size	Adult Labour Equivalent	Average income from sale of labour (wet season) (Tsh/year)	Average income from sale of labour (dry season) (Tsh/year)	Average cost for hiring in labour (Tsh/year)
Ikhoho	Very rich	6	3.5	7254.0	3159.0	0
	Rich	4	2.4	2620.8	2047.5	100000
	Medium	4	3	3384.6	NA	32750
	Poor	5	2.9	5031.0	2808.0	0
	Very poor	4	2.7	7020.1	3861.0	0
	All	4.2	3.3	4947.4	2489.8	46200
Inyala	Very rich					
	Rich	8	5			
	Medium	5	3.3	27233.0	2024.4	45136
	Poor	5	3			58000
	Very poor	3	1.9	6482.9	1764.7	14000
	All	3.2	2.2	8428.0	946.8	45215
Mahongole	Very rich					
	Rich	5	3.4			149500
	Medium	9	3.5			111600
	Poor	4	2.5			86875
	Very poor	5	2			0
	All	5	3			102710
Mwatenga	Very rich	11	5			710000
	Rich	6	4	18954	3042	110600
	Medium	5	3.2	2808		90571
	Poor	6.5	3	8629.92	8424	59400
	Very poor	5	3.1	2106	7888	114000
	unranked	1			4680	
	All	6	3.5	5416.32	2691	121473
Madundasi	Very rich	8	2.6			322000
	Rich	13	4.8			115000
	Medium	9	4.5			57375
	Poor	6.7	3.9			42700
	Very poor	9	2.8			2400
	unranked	1		12636		
	All	8	3.9	1206		68472
Ukwaheri	Very rich	5	4.5	2808	4914	360000
	Rich	12	5.5			1800000
	Medium	7.7	4.1	2340	702	66500
	Poor	8	4.49	1404	1404	175500
	Very poor	5.5	3.4	7324.2		52666
	unranked	3		17199	1638	
	All	7	4.1	5179	1443	135115
TOTAL	All categories	6.1	3.8			86551.02

Chapter 6 Water use and productivity

6.1 Current water uses in wet season

6.1.1 Crop water use under rainfed and intermediate agriculture

Table 6.1 shows water utilization and the areas under different crops in Mkoji catchment during the wet season. The crop water use was determined from the crop water requirements within the crop growth period for each crop. The total crop water requirement for lower Mkoji is less when compared to middle and upper zones. This is mainly due to fewer alternative main crops grown under rainfed condition in the lower zone. The area under rainfed agriculture is distributed into 2680ha for the upper, 2867ha for the middle and 4407ha for the lower zones. Total crop water use for rainfed crop is 42.50Mm3. This amount is apportioned into 10.78Mm3 for upper, 12.33Mm3 for middle and 19.38Mm3 for the lower zone. The increase in crop water use in the lower part of the catchment corresponded to the increase in area and crop water requirements for the different crops grown under rainfed agriculture respectively.

Table 6.1: Crop water use under rainfed agriculture in the Mkoji catchment

Crop name	Upper			Middle			Lower		
	Area (ha)	CWR (m)	Volume of water (Mm^3)	Area (ha)	CWR (m)	Volume of water (Mm^3)	Area (ha)	CWR (m)	Volume of water (Mm^3)
Maize	575	0.46	2.64	665	0.46	3.03	1056	0.47	4.95
Wheat	362	0.37	1.34						
Millet	728	0.39	2.86						
Sorghum				1274	0.40	5.06	1995	0.41	1.67
Beans	468	0.32	1.51	231	0.34	0.78	484	0.35	8.18
Onions				47	0.45	0.21			
Tomatoes	311	0.48	1.48	207	0.48	0.98			
Potatoes	236	0.40	0.95						
Ground nuts				444	0.51	2.27	871	0.53	4.58
TOTAL	2680	2.42	10.78	2867	2.63	12.33	4407	1.75	19.38

Table 6.2 shows the crop water use for paddy in the middle and lower parts of Mkoji catchment. Paddy is cultivated under irrigation supplemented with rainfall in the middle zone. Return flows

from irrigation in the middle zone joins the rivers downstream, which together with rainfall flood the lowlands of lower zone. It is this flood, which is used to grow rice in the lower zone. Crop water use for the middle part of the catchment was 14.55Mm^3 while for the lower part was 20.52Mm^3 and the total water use for Mkoji catchment was estimated at 35.52Mm^3.

Table 6.2: Paddy rice water use under intermediate agriculture for middle and lower zones

Location	Total area (ha)	CWR (m)	Mm^3
Middle	2194	0.66	14.55
Lower	3072	0.68	20.52
TOTAL	5265	1.35	35.52

Figures 6.1 and 6.2 show the area under different agricultural domains and the corresponding amount of water used for each production domain. The area under rainfed production was larger in lower zone followed by middle and upper zones respectively. The volume of water consumed by crops was also comparably higher in the lower part of the catchment. The area under dry season irrigation was higher in the upper zone than in the middle zone.

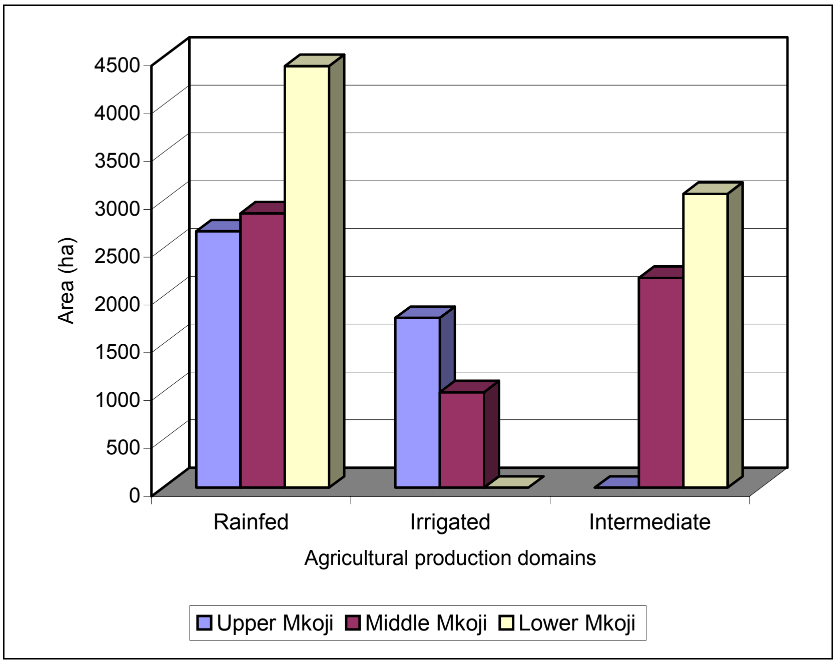

Figure 6.1: Area under different agricultural domains in Mkoji catchment

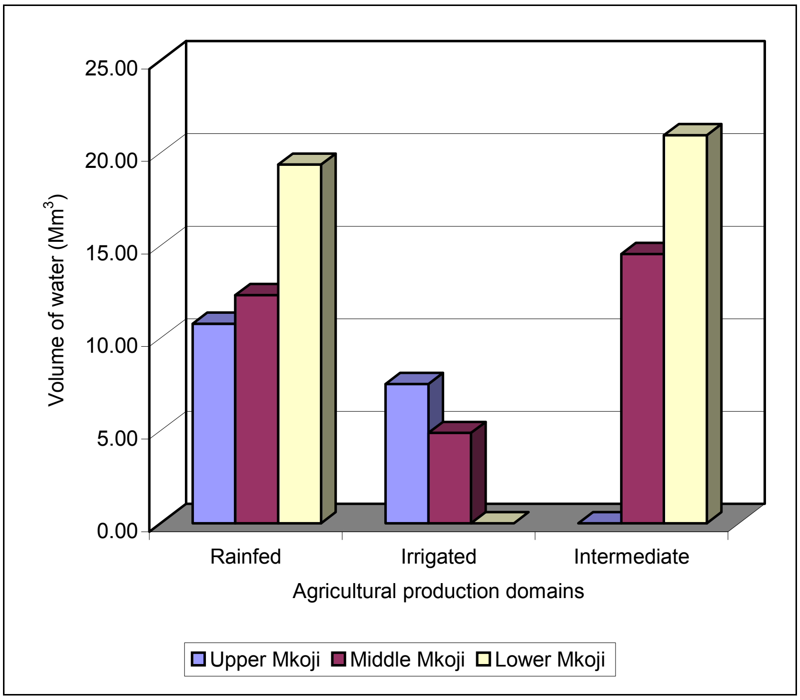

Figure 6.2: Crop water use under different agricultural domains in Mkoji catchment

6.1.2 Domestic water use

This part presents an analysis of the domestic water uses in Mkoji catchment using the average amount of water utilized by households as reported during the questionnaire survey. In addition, the 2002 census results were used to estimate the total water requirements at the ward and sub-catchment levels. During the wet season, domestic water uses were found to range from 0.12 to 0.41 million m^3 (Table 6.3). The total domestic water uses for the whole of Mkoji was estimated at 0.9 million m^3.

Table 6.3: Wet season domestic water uses

District	Mkoji zone	Household consumption (m^3/hh/day)	Ward	Household number (Census)	Domestic water uses ($10^5 m^3$)	Sub-Total ($10^5 m^3$)	Total (10^6 m^3)
Mbeya rural	Upper	0.151	Inyala	2780	0.76	4.09	0.9
			Tembela	3836	1.05		
			Ilembo	5173	1.42		
			Ulenje	3081	0.84		
Mbarali	Middle	0.143	Ruiwa	2587	0.67	3.30	
			Mahongole	3681	0.95		
			Igurusi	6427	1.67		
	Lower	0.153	Utengule	4352	1.21	1.21	

6.1.3 Livestock water uses

The average number of livestock owned per household was converted into Tropical Livestock Units by applying the Tropical Livestock Units (TLUs) conventionally used for Sub-Saharan Africa. According to ILCA (1990), Jahnke (1982) and Williamson and Payne (1978) the units are given as follows: an adult cow is equivalent to 0.7 TLU; a donkey to 0.5 TLU; a pig to 0.3 TLU; goats and sheep to 0.1 TLU; and poultry 0.01 TLU. The average numbers of livestock and their corresponding TLU for the sample villages are summarised in Table 6.4.

Table 6.4: Wet season average numbers of livestock and their corresponding TLU

Area	Average	Cattle	Shoats	Chicken	Pigs	Average TLU per household owning livestock
Upper MSC	Livestock number	154	337	1710	107	3.1
	Livestock per household owning livestock	2.5	5.4	27.6	1.7	
	TLU	107.8	33.7	17.1	32.1	
	TLU per household owning livestock	1.7	0.5	0.3	0.5	
Middle MSC	Livestock number	428.0	426.0	2491.0	289.0	6.7
	Livestock per household owning livestock	6.3	6.3	36.6	4.3	
	TLU	299.6	42.6	24.9	86.7	
	TLU per household owning livestock	4.4	0.6	0.4	1.3	
Lower MSC	Livestock number	4987.0	2010.0	4514.0	43.0	55.9
	Livestock per household owning livestock	74.4	29.6	66.4	0.6	
	TLU	3490.9	1407.0	3159.8	30.1	
	TLU per household owning livestock	52.1	3.0	0.7	0.2	

Source: Survey data, 2003 and 2002 census results

The average TLUs increase as one moves from the highlands to the plains. The average TLUs per household owning livestock for the upper, middle, and lower zones were estimated at 3.1; 6.7 and 55.9 respectively (Table 6.4). It is however, worth noting that livestock ownership in the study area is not uniformly distributed. Most of the households own none or few TLUs and few households own many. The largest average TLU was reported in the lower zone where only 4% of the total households own more than 250 cattle and the majority own none or less than 5 cattle.

Table 6.5: Wet season average numbers of TLU.

District	Area	TLU per hh owning livestock	Percentage of hh owning livestock	Ward	Total number of hhs	Number of hh owning livestock	Number of livestock	Total number of livestock in the zone
Mbeya rural	Upper	3.1	77	Inyala	2780	2155	6679	35725
				Tembela	3836	2973	9216	
				Ilembo	5173	4009	12428	
				Ulenje	3081	2388	7402	
Mbarali	Middle	6.7	78	Ruiwa	2587	2023	13554	66514
				Mahongole	3681	2879	19286	
				Igurusi	6427	5026	33674	
	Lower	55.9	85	Utengule	4352	3690	206299	206299

Source: Survey data, 2003 and 2002 census results

The calculation of water use by livestock was mainly based on estimates given by King (1983) and SMUWC (2000). King (1983) states that an African indigenous adult cattle with 350 kg liveweight in semi arid area consumes about 25 litres of water per day, but discussions with herders and owners revealed that water consumption by cattle (250 kg) is about 40 litres/day in the dry season when forage has low moisture content and 20 litres/day during the rainy season. These latter estimates are in line with the estimates given by SMUWC (2000). In the study area the wet season lasts about 165 days and the dry season 200 days.

The study extrapolated the 2002 census results for the number of households to get the estimated total number of TLUs in the catchment using the average number of TLUs obtained during the sample survey. The total number of TLUs in the catchment was estimated at about 300 000 with 36, 000; 67, 000; and more than 200, 000 in the upper, middle and lower zones respectively (Table 6.5). Using these estimates, the volumes of water consumed by livestock were therefore estimated at about 0.2 million m^3 for the upper zone; 0.3 million m^3 for the middle zone and 1 million m^3 for the lower zone. The total amount of water for the whole Mkoji catchment was put at 1.5 million m^3 (Table 6.6).

Table 6.6: 2002/2003 Wet season livestock water uses in Mkoji catchment

District	Area	Ward	Number of TLU	TLU water uses (m^3)	Total for each area ($10^6 m^3$)	Total for Mkoji ($10^6 m^3$)
Mbeya rural	Upper	Inyala	6679	31959	0.17	1.5
		Tembela	9216	44099		
		Ilembo	12428	59469		
		Ulenje	7402	35419		
Mbarali	Middle	Ruiwa	13554	64857	0.32	
		Mahongole	19286	92285		
		Igurusi	33674	161128		
	Lower	Utengule	206720	1109053	0.99	

Source: Survey data, 2003 and 2002 census results

6.1.4 Brick making

According to the respondents interviewed in this study, no brick making is done during the wet season. This is because the practice requires a dry weather to dry the bricks before being burnt**.**

6.1.5 Fishery

Although all of the interviewed households reported as not been engaged in fishing activities, discussions with key informants during the PRA exercises indicated that there are small-scale fishing activities going on. This is particularly done in irrigation canals or in-streams mainly in the middle and lower zones. A few fishing ponds were also observed which are mostly constructed next to irrigation canals and filled once a year by diverting water from the irrigation canals. The study could not capture the actual catches from this activity because none of the respondents reported as being involved in fishing activities. This implies that the activity, while important in other parts of the Usangu area, appears to be insignificant in Mkoji catchment.

6.2 Current water uses in dry season

6.2.1 Crop water use (irrigation)

Table 6.7 shows the crop water use during the dry season for the upper and middle zones. There is no dry season irrigation in the lower zone (Ukwaheri and Madundasi) because all the available water from the rivers is completely used by upstream users, including irrigators in the middle zone (e.g., in Mahongole, Mhwela, Mwatenga and Utengule villages). The total area under dry season irrigation in Mkoji catchment is 2772ha. This is distributed into 1775ha for the upper and 997ha for the middle . The total water use for dry season irrigation in the catchment is estimated at 12.40Mm^3.

Table 6.7: Crop water use under irrigation in the upper and middle Mkoji

Crop	Upper			Middle		
	Total area (ha)	CWR (m)	Mm^3	Total area (ha)	CWR (m)	Mm^3
Maize	902	0.43	3.92	402	0.52	2.09
Onions	214	0.52	1.11	47	0.56	0.26
Beans	413	0.33	1.35	313	0.38	1.19
Tomatoes	245	0.46	1.14	235	0.57	1.34
Total	1775	1.75	7.52	997	2.03	4.88

6.2.2 Domestic water use

The analysis of domestic water uses during the dry season was done using the same approach as for the wet season. As shown in Table 6.8, the average water uses were estimated at 0.36; 0.4; and 0.11 million m^3 for the upper, middle and lower zones respectively. The total volume of domestic water use for the whole of Mkoji was estimated at 0.87 million m^3.

Table 6.8: 2002 Dry season domestic water uses in Mkoji

District	Mkoji area	Household consumption (m^3/hh/day)	Ward	Number of households (Census)	Domestic water uses (10^5m^3)	Sub-total for each area (10^5m^3)	Total for Mkoji (10^5m^3)
Mbeya rural	Upper	0.131	Inyala	2780	0.66	3.55	8.7
			Tembela	3836	0.91		
			Ilembo	5173	1.23		
			Ulenje	3081	0.74		
Mbarali	Middle	0.175	Ruiwa	2587	0.82	4.02	
			Mahongole	3681	1.17		
			Igurusi	6427	2.04		
	Lower	0.143	Utengule	4352	1.13	1.13	

Source: Survey data, 2003 and 2002 census results

6.2.3 Livestock water use

During the dry season there is shortage of pasture and water resources to support big herds of livestock. Consequently, livestock keepers with huge number of cattle are forced to migrate to the Usangu wetlands. The Ihefu wetland was the main dry season grazing area but since it was gazetted in 1998, it is now part of the Usangu Game Reserve where livestock is prohibited to enter and graze. Discussions with cattle keepers revealed that only livestock keepers with less than 40 herds of cattle could stay with their herds within the catchment. Those with large cattle herds are forced to migrate and they do so with their shoats (sheep and goats). Thus, the number of livestock found in the catchment is normally very low during the dry season particularly in the lower zone where the average TLUs per households were found to decline from 55.9 in the wet season to only 8.7 during the dry season (Table 6.9). This is a decline of about 75%. The total number of TLU present in the Mkoji declines from 300 000 to 99 000 (Table 6.10).

Table 6.9: Dry season average numbers of livestock and their corresponding TLU

Zone	Average	Cattle	Shoats	Chicken	Pigs	Average TLU per hh owning TLU
Upper	Livestock number	94	207	1710	107	2.2
	Livestock per hh owning livestock	1.5	3.3	27.6	1.7	
	TLU	65.8	20.7	17.1	32.1	
	TLU per hh owning livestock	1.1	0.3	0.3	0.5	
Middle	Livestock number	207	305	2491	289	4.2
	Livestock per hh owning livestock	3.0	4.5	36.6	4.3	
	TLU	144.9	30.5	24.9	86.7	
	TLU per hh owning livestock	2.1	0.4	0.4	1.3	
Lower	Livestock number	697	382	4514	43	8.7
	Livestock per hh owning livestock	10.4	5.7	67.4	0.6	
	TLU	487.9	38.2	45.1	12.9	
	TLU per hh owning livestock	7.3	0.6	0.7	0.2	

Source: Survey data, 2003 and 2002 census result

Table 6.10: TLU for the Mkoji during the dry season

District	Zone	TLU per household owning livestock	Percentage of households owning livestock	Ward	Total number of households	Number of households owning livestock	Number of livestock	Total number of Livestock
Mbeya rural	Upper	2.2	77.5	Inyala	2780	2155	4740	25353
				Tembela	3836	2973	6540	
				Ilembo	5173	4009	8820	
				Ulenje	3081	2388	5253	
Mbarali	Middle	4.2	78.2	Ruiwa	2587	2023	8497	41695
				Mahongole	3681	2879	12090	
				Igurusi	6427	5026	21109	
	Lower	8.7	84.8	Utengule	4352	3690	32107	32107

Source: Survey data, 2003 and 2002 census results

The quantities of water consumed by livestock during the dry season were estimated at 0.3 million m^3 for the upper zone; 0.5 million m^3 for the middle zone; and 0.4 million m^3 for the lower zone. The total amount of water used for livestock in the whole of Mkoji was estimated at 1.1 million m^3 (Table 6.11).

Table 6.11: 2003 Dry season livestock water uses in Mkoji

District	Mkoji area	Ward	Number of livestock	Livestock water uses (m^3)	Total for each area (10^6m^3)	Total for Mkoji (10^6m^3)
Mbeya rural	Upper	Inyala	4726	54035	0.29	1.13
		Tembela	6521	74560		
		Ilembo	8794	100548		
		Ulenje	5238	59885		
Mbarali	Middle	Ruiwa	8537	96863	0.48	
		Mahongole	12147	137825		
		Igurusi	21209	240641		
	Lower	Utengule	32205	366023	0.37	

Source: Survey data, 2003 and 2002 census results

When livestock are grazing outside the Mkoji catchment, they are using water resources from other catchments (in Usangu basin). In other words, this water can be accounted for in the livestock water balance equation as “imported virtual water” and was proportioned as 0.12 million m^3 for the upper zone; 0.28 million m^3 for the middle zone; and 1.99 million m^3 for the lower zone. The total livestock “virtual water” imports in Mkoji was estimated at 2.39 million m^3 (Table 6.12), which is twice as much as the amount of water consumed by livestock staying within the Mkoji catchment during the dry season.

Table 6.12: 2003 Dry season livestock “virtual water imports” in Mkoji

District	Zone	Number of TLU out of Mkoji	Total Number of TLU grazing out of Mkoji	Total for Mkoji	“virtual water imports” (m^3)	TLU “virtual water imports” (10^6m^3)	Total TLU “virtual water” imports (10^6m^3)
Mbeya rural	Upper	1939	10372	209382	22105	0.12	2.39
		2676			30502		
		3608			41133		
		2149			24499		
Mbarali	Middle	5058	24819		57656	0.28	
		7196			82038		
		12565			143239		
	Lower	174191	174191		1985782	1.99	

Source: Survey data, 2003 and 2002 census results

As stated above, the grazing pattern in Mkoji is seasonal and can be classified into two categories:

(i) Wet season grazing (5 months): which spans from late January to late June. During this period, all livestock graze in Mkoji, with the majority of them using the temporal wetlands in the north and the fanslope rangeland in the south and west of the catchment, and

(ii) Dry season grazing (7 months): which starts from early July to late January and the majority of livestock are moved outside the catchment in search of grazing land either within the Ihefu grasslands, or fallow and/or post-harvested crop areas.

According to the study done by SMUWC (2000), the Ecological Carrying Capacity[7] (ECC) for livestock in Usangu plains was estimated at 934, 622 TLU (during the dry season), with the Ihefu wetland having an ECC of 834, 513 TLU and the fallow land and post harvested areas having 100, 109 TLU. During the wet season, the total ECC for Usangu plains was estimated at 526, 337 TLU with the Western wetland and fanslope rangelands having 191, 721 and 334, 616 TLUs respectively. These figures show that by restricting cattle keepers to graze in the Usangu Game Reserve (during the dry season), the ECC of the Usangu plains will be reduced by up to 90%. Quantifying the total amount of water needed to maintain the ECC of the area is a very difficult endeavour, so to say, because of the methodological complexities associated with it, but one would logically argue that the amount might be significantly huge and may add much to the total amount of water supporting the livestock sector in the study area.[8]

6.2.4 Brick making

Brick making is normally a dry season activity. The study has revealed that about 32.5% of the total households in the upper, 25.6% in the middle and 21.3% the lower zones are involved in brick making. The average number of bricks made per these household were 2531; 2137; and 2031 for the upper; middle; and lower zones respectively. According to the questionnaire results, the amount of water used to produce 400 bricks was put at about 1 m^3. Using this figure, water used for brick making was therefore, estimated at 0.16 million m^3 with most of it being used in the upper and middle zones (Table 6.13).

Table 6.13: Water used for brick making in Mkoji

Location	Average number of bricks produced per hh involved	Number of hh	Percentage of Hh making bricks	Total number of bricks produced	Quantity of water needed (m^3)
Upper	2531	31917	32.5	26254126	65635
Middle	2137	61054	25.6	33400934	83502
Lower	2031	4352	21.3	1882688	4707
Total	2233	97323	26.4	57422548	153844

Source: Survey data, 2003 and 2002 census results

[7] **The term *Ecological Carrying Capacity (ECC)*, as used here, refers to the carrying capacity of an area when the number of animals is limited by the available forage plus other ecological factors, and there is no attempts to maximise the growth/productivity of individual animals.**

[8] **The estimates of water uses by livestock (as given in this report) do not capture other components of water utilization than water used by livestock as drinking water (e.g., the amount of water embedded in the pasture grazed by livestock).**

6.3 Cropping calendars, sequences and patterns

6.3.1 Upper Mkoji

As already explained in the preceding chapters, the upper zone was divided into two major areas represented by Ikhoho village (characterized as dominated by rainfed agriculture) and Inyala village (characterized as dominated by supplemental irrigated agriculture and dry season irrigation).

Cropping calendar

In the upper zone, farming activities are carried out throughout the year. The main crops grown are maize, sorghum, beans, Irish potatoes and other vegetables such as cabbages and peas. The cropping calendar (as shown in Table 6.13), indicates that the main growing season extends from November, during which period all major crops are planted, to July when the longest crop, maize, is harvested. Sorghum, which is grown in the lower parts of the upper zone, is harvested in June. Short duration crops (i.e. beans and Irish potatoes) planted in November are harvested in March and April. Thereafter, a sequential cropping of similar short duration crops begins to make use of end of season rains and residual moisture. While residual moisture is very useful in the upper part of the zone, supplementary irrigation is common in the lower part.

Cropping sequences

(i) Intercropping of maize and beans followed by monocrop maize or beans.

Beans are intercropped with maize during the main rainfed-farming season. Beans are harvested in February and March while maize is harvested in July. Soon after harvesting maize, another crop of maize or beans is planted under irrigation farming system. Almost each household in the lower part of the upper zone practices this, except very few households, which cannot afford to own land close to the irrigation canals. The vulnerable group which include most of the female headed household and poor households do not practice dry season farming because it needs enough money for purchasing agricultural inputs. Irrigated maize is normally harvested green and fetches more market prices in January.

(ii) Beans followed by beans or Irish potatoes

The first bean is planted in November and December and harvested in February and March. The second crop is planted in March and April under both rainfed and irrigated conditions and harvested in June or July. The third crop of either beans or Irish potato is planted in July or August under irrigated conditions. This is practiced by about 90 percent of the total households in the lower part of the upper zone .

(iii) Vegetables (tomatoes and leafy vegetables)

Vegetables, such as tomatoes, cabbages, spinach, and lettuce contribute substantially to household income. Tomato and cabbages are normally planted in November and December (during the beginning of rainy season) and harvested in February and March to fetch high prices, after which tomatoes or leafy vegetables are replanted. This kind of farming system is carried out by about 10 percent of the total households in the upper zone because it demands money for purchase of fertilizer, fungicide and insecticide.

Cropping patterns

The cropping patterns found in the upper MSC include monocrop, intercrop and mixed cropping. Wheat, sorghum, tomatoes, Irish potatoes and vegetables are normally grown as monocrop. Maize is usually intercropped with either beans or groundnuts. Irrigated crops are seldom mixed or intercropped and hence grown as monocrop.

6.3.2 Middle Mkoji

The middle zone has been divided into two major areas represented by Mahongole village, which is dominated by both wet and dry season irrigation, and by Mwatenga village, which is dominated by rainfed maize and irrigated paddy. In the middle Mkoji catchment wet season paddy cultivation is an important activity. Almost every household practices paddy production, while paddy is an important cash crop for most farmers, priority is given to maize, which is the staple food. Most of the paddy crop is sold to traders with only small amount reserved for family use. During the Focus Group Discussions, it was reported that in bad years with little rainfall (like 2002/03) and poor yields, households have little produce to sell and they suffer much financially.

Cropping calendar

The cropping calendar for the middle zone is shown in Table 6.14. The main growing season begins in November and ends in May. In irrigated fields, maize harvested in May is immediately followed by another crop of maize, which is harvested in October and November. Other crops grown include paddy and sorghum, which are planted in late November or early December and harvested in June. Most farmers also practice rainfed agriculture with runoff harvested in paddy basins. Onions and tomatoes are grown under rainfed and irrigated conditions. Supplementary irrigation is practiced for paddy except sorghum, which rely entirely on rainfall.

Cropping sequences

(i) Intercrop of maize and beans followed by monocrop maize or beans

In this sequence either beans or maize normally follows maize-beans intercrop, which is planted in December and January and harvested in March and April. This is purely rainfed ad normally done by almost every household. The latter crops are grown under irrigated conditions. More than 50 percent of the households practice dry season irrigation in the upper middle zone.

(ii) Vegetables (tomatoes and leafy vegetables)

This cropping sequence is normally practiced in irrigated plots whereby tomatoes, onions and sometimes beans are planted in November or December and harvested in March. This production system is carried out in wet season, hence limited to few households, which can afford purchase of fertilizer, fungicide and insecticide. Basically, less than 20 percent of the households carry out vegetable production in wet season but the percentage increases in dry seasons.

(iii) Beans cultivation followed by vegetables

This cropping sequence is more or less similar to the vegetable sequence. Beans are planted as monocrop at the onset of the rainy season in November and followed either by beans or tomatoes and leafy vegetables. In total, there can be at least three cropping cycles. This cropping sequence is practiced by more than 50 percent of the total households because beans normally fetch high prices.

Cropping patterns

For the middle Mkoji there is only one major cropping pattern, which is the maize–beans intercrop grown at least by each household. Other crops are normally grown as monocrop.

6.3.3 Lower Mkoji

Crop production in the lower zone relies entirely on rainfall, therefore farming activities are concentrated only in five months of the year. This follows the annual rainfall distribution resulting into a single cropping season. Major crops grown are maize, millet, paddy and groundnuts.

Cropping calendar

Table 6.15 shows the cropping calendar for the lower zone. Since farming is purely rainfed, all major crops, namely maize, millet, paddy and groundnuts are harvested in April while other crops are harvested in June. There is a potential for growing sesame and sunflower in the area, however, these crops are not grown due to lack of knowledge and reliable markets.

Cropping sequence

In the lower zone there is only one cropping sequence which is basically paddy followed by chickpeas. Basically, this cropping sequence is carried out by Sukuma farmers. The latter crop is planted soon after harvesting paddy and utilizes the residual soil moisture. Paddy production is done by many households as cash crop while maize and sorghum are used as staple food.

Cropping patterns

The main cropping patterns in the lower zone include the maize and groundnuts intercrop and the paddy, sorghum and chickpeas monocrops.

Table 73: Cropping sequences for the upper zone

Month/Crops	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Farming system	Rainfed	Rainfed	Rainfed	Supplementary Irrigation			Pure irrigation farming				Rainfed & Irrigation								Pure irrigation farming & Bottom valley farming				Rainfed & rrigation	
Maize	Harvest & Weeding					Harvest & Planting				Plowing		Harvest & weeding							Harvest & Planting					
Sorghum		Weeding				Harvest					Plowing and Planting											Plowing & sowing		
Beans			Harvest & Planting				Harvest & Planting				Harvest & Planting				Harvest & Planting				Harvest & Planting				Harvest & Sowing	
Irish Potato			Harvest / Planting				Harvest				Plowing and planting				Harvest / Planting				Harvest				Plowing & Sowing	
Groundnuts		Weeding			Harvest						Plowing and Planting				Weeding		Weeding						Plowing & Sowing	
Tomato		Harvest & planting			Harvest & planting				Harvest & planting				Harvest & Planting								Harvest & planting			

Table 6.14: Cropping sequences for the middle zone

Month/Crops	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Farming system	Rainfed	Rainfed	Rainfed	Supplementary Irrigation			Pure irrigation farming				Rainfed & Irrigation								Pure irrigation farming & Bottom valley farming				Rainfed &irrigation	
Maize	Weeding			Harvest & Plowing & Planting						Plowing & Planting				Harvest & Plowing & Planting						Plowing & Planting			Plowing & harvest	
Beans		Harvest		Plowing & Planting			Harvest/Planting				Plowing and planting								Plowing and Planting				Plowing & harvest	
Paddy	Transplanting		Weeding			Harvest					Plowing & paddling			Transplanting			Harvest						Plowing &Paddling	
Sorghum			Weeding			Harvest					Plowing and Planting												Plowing &Sowing	
Onions			Plowing & Planting			Harvest & Planting					Harvest				Plowing &Planting				Harvest &Planting				Harvest	

Table 6.15: Cropping sequences for the lower zone

Month/Crops	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Farming system	Rainfed	Rainfed	Rainfed	Rainfed	Rainfed						Rainfed	Rainfed	Rainfed										Rainfed	Rainfed
Maize		Weeding		Harvest							Plowing & Planting			Weeding		Harvest							Plow & Sowing	
Sorghum		Weeding				Harvest					Plowing & Planting				Weeding			Harvest					Plow & Sowing	
Paddy	Transplanting		Weeding			Harvest					Plowing & paddling				Transplanting			Harvest					Plow & Sowing	
Groundnuts		Weeding		Harvest							Plowing & Planting					Harvest							Plow & Sowing	

6.4 Dynamics of paddy cultivation in the Mkoji catchment

6.4.1 Areas under paddy cultivation

Although small isolated fields can be seen in the upper part of Mambi River, in the Mkoji catchment paddy is grown mostly in the middle and lower zones. This is mainly due to availability of favourable soils (alluvial clay and clay loam soils - Vertisols) and water for supplementary irrigation. The area under paddy cultivation is highly variable and is a function of river flows and rainfall in each zone. The maximum area is cultivated during a normal-to-wet year when statistically average weather conditions are found, and when irrigation is essentially supplemental to the water provided by rainfall.

6.4.2 Paddy growing season

Paddy growing season coincides with rainfall season and as such farmers use rainfall to supplement irrigation. In general, the main paddy-growing season extends from November to July, with the actual duration depending on the on set and duration of the rains.

Paddy is grown in small bunded basins, locally known as vijaruba. For the mid Mkoji sub-catchment, farmers use available water abstracted from rivers to prepare their nurseries. However, in the lower zone, where there are no river flows during the dry season, farmers prepare their nurseries a bit late as compared to the mid zone. This is because they have to wait until sufficient rains fall or when river flows from high catchment reach their respective areas before they can establish paddy nurseries. Consequently, the paddy growing season starts earlier in the middle zone as compared to the lower zone.

During October to December, which is the highly stressed period the farmers so desperately need water to begin their rice nurseries and field preparation that they will try very hard to obtain water using any means at their disposal. For the farmers in the middle zone to begin their nurseries and to wet their fields for transplanting, they abstract almost all river flows available during this period.

6.4.3 Effects of market prices on the planting dates for paddy

A market-oriented situation has created a preference for early transplanting amongst farmers in Mkoji. For example, in 2002/2003 season, it was observed that early harvested paddy (April/May) fetched a very good price in the market of up to Tsh 25,000/= per 90 kg bag as compared to a price of Tsh 14,000/= in July, when most farmers sold their paddy so as to get money to foot the costs of fees, shoes, uniform, transport and up-keep for their schooling children. As such most farmers prefer to transplant early crop of paddy as it fetches higher prices in the markets. However, this cannot be realized in the lower zone, not only due to delayed water release from the middle zone and delayed onset of the rains to begin their nurseries, but also because early-planted paddy (say in mid December) is harvested in May when most fields are wet and the roads impassable. Consequently neither the farmers nor the traders can manage to transport paddy to nearby markets to fetch the higher prices.

6.4.4 Paddy irrigation methods

In the middle zone (Mahongole, Mhwela, Igurusi, Mwatenga and other villages) water is abstracted from the rivers using both traditional intakes (made of wooden sticks, clay soil, trashes, sand bags and stones) and improved intakes made of masonry cement. There are more than 70 water off takes, of which 16 have been improved. Water is abstracted from the rivers and conveyed by the main canals to different parts of the field. Secondary canals are used to distribute water to various plots. The water then mainly trickles from plot to plot, though some tertiary canals are also used to distribute water. However, when heavy rains fall, the off takes are normally partially closed and available rains then mostly meet the paddy water requirement. This usually happens during the peak of the wet season in March and April.

For the lower zone, preparation of nurseries usually begins around January when there are adequate rains and the river flows are sufficient enough to reach their respective areas. However, because the land is relatively flat and the rivers are shallow, traditional intakes utilizing locally available materials are used in the lower zone. Farmers construct small canals to direct water from the rivers to their paddy fields or sometimes, since the water spreads everywhere due to flatness of the land, farmers use small canals to direct flood water to irrigate paddy transplanted in excavated bunded basin. This is especially common in Utengule, Luhanga, Ukwaheri, Itambo/Mpolo and other villages in the lower zone. During the peak of the rainy season, these local off-takes are sometimes closed, as floodwater and rainwater become sufficient to meet the water requirement of transplanted paddy.

6.5 Water productivity

6.5.1 Crop Water Productivity

Rainfed crops

Tables 6.16, 6.17 and 6.18 show the crop water productivity for rainfed crops in the upper, middle and lower zones, respectively. The major crops grown under rainfed conditions include maize, millet, dry beans, Irish potatoes, tomatoes, wheat, sorghum and onions. Wheat and Irish potatoes are mostly grown in the upper zone while groundnuts and sorghum are important crops in the middle and lower zone. Onions and tomatoes are the key high value crops grown in the middle and upper zone under rainfed conditions. The CWP results are presented in terms of total rainfall (RF) received during the respective crop growth periods, its effective rainfall (ERF) and the actual water consumed by the crop (ETa) within the growth period.

Based on rainfall received, effective rainfall and actual crop water use respectively, the CWP values for Irish potato were generally high (0.62, 1.03, 1.04 kg/m^3) followed by tomato (0.50, 1.02, 1.08kg/m^3) and spring wheat (0.36, 0.83, 0.56kg/m^3). The CWP values for dry beans (0.13, 0.26, 0.28kg/m^3) were the least followed by millet (0.22, 0.48, 0.52kg/m^3) and maize crop (0.27, 0.52, 0.55kg/m^3). The low CWP values for dry beans, millet and maize can be described better by the low crop yields (914, 2032 and 2540kg/ha respectively) despite the fact that the actual crop water uses were generally low, with the exception of maize crop which recordered higher ETa compared with all the rainfed crops in the upper zone. Spring wheat, recorded the second lowest crop yield (1706.9kg/ha) after dry beans (914.4kg/ha). Its CWP was the third in the list after Irish potato and Tomato. The high value of CWP for wheat can be attributed to reduced actual water use by almost 17% of its crop water requirements (CWR). The crop is normally planted towards the end of January up to February and harvested in June and it experiences a moisture deficit of about 163mm in total (occurring in May and June) as a result of reduced amount of rainfall. The deficit contributes to crop yield reduction of about 17%. With the exception of spring wheat, CWP values under ERF and ETa doubled the CWP under RF for all the crops in the upper zone.

Table 6.16: Crop Water Productivity for rainfed crops in upper zone

Crop	CWR (mm)	ETa (mm)	RF (mm)	ERF (mm)	TRL (mm)	RE (%)	MD (mm)	CY (kg/ha)	PW_{RF} (kg/m3)	PW_{ERF} (kg/m3)	PW_{ETa} (kg/m3)
Maize	458.1	458.1	954.9	488.3	466.6	51.1	4.4	2540.0	0.27	0.52	0.55
Millet	393.5	393.5	928.6	421.1	507.5	45.3	1.3	2032.0	0.22	0.48	0.52
Dry Beans	322.3	322.3	717.0	347.7	369.4	48.5	3.4	914.4	0.13	0.26	0.28
Irish Potato	477.2	462.9	781.4	467.6	313.9	59.8	12.6	4826.0	0.62	1.03	1.04
Tomato	403.7	403.6	881.7	428.7	452.8	48.6	3.7	4366.0	0.50	1.02	1.08
Wheat	369.6	306.7	478.6	205.3	273.4	42.9	136	1706.9	0.36	0.83	0.56

The CWP values for tomato (0.61, 0.96, 0.92kg/m3) in the middle zone were higher compared with onions (0.46, 0.75, 0.64kg/m3) and groundnuts (0.23, 0.33, 0.32kg/m3). The CWP values for sorghum were the lowest (0.13, 0.23, 0.23kg/m3) preceded by dry beans (0.14, 0.23, 0.22kg/m3) and maize crop (0.19, 0.29, 0.28kg/m3). The variation of CWP between RF, ERF and ETa showed a unique pattern for all the crops in the mid of zone. Whereas the CWPs based on ERF were about 50% higher than the CWPs calculated based on RF, with the exception of tomato (38%) and onions (36%), the CWPs estimated based on ETa were less by almost three percent in most crops except for sorghum. Based on ERF, the increase in CWP can largely be attributed to reduced availability of water in crop root zone received from the total amount of rainfall. The decrease in CWP, in terms of Eta, is difficult to explain because CWRs were almost similar or less to ETa and no yield reduction was noted due to moisture deficits at the late crop growth except for onions (5.2%) which is grown in mid January and utilizes residual moisture in late April and early May (when the rainfall has already stopped**).**

Table 6.17: Crop Water Productivity for rainfed crops in middle zone

Crop	CWR (mm)	ETa (mm)	RF (mm)	ERF (mm)	TRL (mm)	RE (%)	MD (mm)	CY (kg/ha)	PW_{RF} (kg/m^3)	PW_{ERF} (kg/m^3)	PW_{ETa} (kg/m^3)
Maize	455.9	455.9	666.9	439.7	227.2	65.9	21.4	1274.7	0.19	0.29	0.28
Sorghum	396.9	396.9	66.9	391.7	275.2	58.7	5.2	894.4	0.13	0.23	0.23
Dry Beans	338.9	338.9	545.2	336.8	208.4	61.8	7.3	762.0	0.14	0.23	0.22
Groundnut	511.2	509.8	711.0	497.6	213.4	70.0	17.4	1625.6	0.23	0.33	0.32
Tomato	476.4	476.4	710.4	455.0	255.4	64.1	21.4	4366.0	0.61	0.96	0.92
Onion	447.5	427.2	589.3	363.8	255.5	61.7	63.3	2734.1	0.46	0.75	0.64

Comparing the CWPs between the upper and middle zones, those in the former area were generally higher than the ones in the latter area for all the crops. This can be attributed to factors like decreasing crop yields accompanied with increase in CWRs and hence increasing ETa (except for maize). However, the rainfall water use efficiency (RE) in the middle zone was much higher than the figures recorded in the upper zone. This is probably because of increased evaporative demand, such that much rainfall infiltrates into the soil to replenish the lost soil moisture and therefore less rainfall is lost as surface runoff. This is clearly indicated by the differences in the amount of rainfall losses between the upper and middle zone. Moisture deficit was also experienced in the middle Mkoji despite the fact that its effects to crop yield were very minimal for most crops.

The CWPs in the lower zone were higher for sorghum (0.79, 1.11, 0.89kg/m^3) followed by maize (0.66, 0.88, 0.66kg/m^3), groundnuts (0.53, 0.67, 0.55kg/m^3) and lastly dry beans (0.14, 1.17, 1.17kg/m3). The PW_{ERF}(s) were higher than the PW_{RF}(s) and the PW_{ETa}(s) were lower than the PWE_{RF}(s) except for dry beans whose PW_{ERF} and PW_{ETa} were the same (0.17kg/m^3). The CWPs for grains (maize and sorghum) and groundnuts in the lower zone were far higher than those in the middle and upper zone. These crops appear to perform better in terms of yields in the lower zone than in the rest of the catchment. Nevertheless, the moisture deficit problem appeared to have less effect on crop yield despite the high CWR and ETa because of increased RE (above 70%) and favourable growth temperatures resulting into early crop maturity. Table 6.18 presents Crop Water Productivity for rainfed crops in the lower zone.

Table 6.18: Crop Water Productivity for rainfed crops in lower zone

Crop	CWR (mm)	ETa (mm)	RF (mm)	ERF (mm)	TRL (mm)	RE (%)	MD (mm)	CY (kg/ha)	PW_{RF} (kg/m^3)	PW_{ERF} (kg/m^3)	PW_{ETa} (kg/m^3)
Maize	468.6	459.3	461.2	345.3	115.9	74.9	114.1	3048.0	0.66	0.88	0.66
Sorghum	409.8	409.8	461.2	329.7	131.5	71.5	80.1	3657.6	0.79	1.11	0.89
Dry bean	345.7	345.7	413.8	338.4	75.4	81.8	7.5	584.5	0.14	0.17	0.17
Groundnuts	526.0	441.8	463.4	364.3	99.1	78.6	77.5	2438.4	0.53	0.67	0.55

As a summary, the CWP results under rainfed condition show that:

- The CWR and ETa are higher in the middle and lower zones than in the upper zone,
- The RE increases as one moves from the middle to the lower zone due to increased infiltration rates of the rain water replenishing soil water to field capacity and therefore reduced runoff losses,

- The CWPs for maize, sorghum and groundnuts are higher in the lower than in the middle and upper zone,
- The CWPs for tomatoes are higher in the upper than in the middle zone,
- There is no significant difference in CWPs for dry beans in the three zones,
- The CWP values for the middle MSC are generally the lowest in all the three zones under rainfed crop production compared to those in the other crop production domains, and
- The CWPs for high value crops (e.g., tomatoes and onions) and Irish potato are higher than those of cereals (cf. maize, wheat and millet) ; beans and groundnuts.

Irrigated crops

Tables 6.19 and 6.20 show the CWP values for irrigated crops in the upper and middle zones, respectively. As a result of water abstraction for irrigation by the upper and middle villages, the streams at the lower zone are always drying up during the dry season. So no irrigated agriculture is normally practiced in this part of the catchment. Major crops grown under irrigation include maize, dry beans, tomatoes and onions. Irish potatoes are grown under irrigation only at the upper part of the catchment. Tomatoes are grown in two zones (the upper and middle zones) throughout the dry season, which spans from early May to first decad of November. The early dry season planting normally occurs in May, while the late season planting is done in September.

A fixed irrigation interval of 7-days is practiced for all the crops grown under irrigation in the two zones. The timing is increased to 10 days at the late season when the crop is close to maturity. The depth of water applied is normally not measured, but fields are flooded such that the soil moisture content is restored to field capacity. The irrigation efficiency assumed in CWP modelling for all irrigated crops was 65%.

Based on the gross (RF + TGI) and actual (ETa) water uses, the CWPs for irrigated crops in the upper MSC (Table 67) were higher for early planted tomatoes (1.26, 1.95kg/m^3) followed by irish potatoes (1.09, 1.75kg/m^3), middle planted tomatoes (1.02, 1.60kg/m^3), onions (0.99, 1.51kg/m^3), late tomatoes (0.87, 1.57kg/m^3) and lastly by maize (0.54, 0.85kg/m^3) and beans (0.27, 0.45kg/m^3). The total net irrigation requirements (TNIs) for all crops were higher than the actual irrigation requirements (AIRs) indicating decreases in moisture deficit occurring during the crop growth period. The maize, early tomato and onions experienced some slight moisture deficits of 21.4mm, 23.2mm and 19.9mm during their growth periods. However, these deficits had no much effects on crop yields for maize and early tomato but might have reduced the yields for onions (approximately by three percent). In addition to irrigation water, the late planted tomatoes received effective rainfall of about 118.2mm that occurred from the second decade of November in the upper MSC until when the crop was harvested in December. Irish potatoes and onions received effective rainfalls of 41.5mm and 18.5mm respectively.

Table 6.19: Crop water productivity for irrigated crops in upper zone

Crop	CWR (mm)	ETa (mm)	RF (mm)	ERF (mm)	TGI (mm)	TNI (mm)	AIR (mm)	MD (mm)	CY (kg/ha)	PW_W (kg/m^3)	PW_{Eta} (kg/m^3)
Maize	434.7	434.7	2.8	2.3	685.6	445.6	432.5	21.4	3703.3	0.54	0.85
Dry Beans	327.4	327.4	8.8	8.7	525.1	341.3	318.7	6.2	1460.6	0.27	0.45
Tomato (E)	403.0	403.0	9.2	9.2	614.7	399.5	393.9	23.2	7863.8	1.26	1.95
Tomato (M)	493.6	492.5	14.9	14.7	752.5	489.2	479.0	17.5	7863.8	1.02	1.60
Tomato (L)	501.6	499.7	282.8	118.2	622.2	404.4	383.4	5.9	7863.8	0.87	1.57
Irish potato	473.7	465.2	81.2	41.5	667.0	433.6	432.2	7.4	8128.0	1.09	1.75
Onions	518.8	504.7	27.7	18.5	743.8	483.5	500.3	19.9	7620.0	0.99	1.51

The CWPs for irrigated crops in the middle zone (Table 6.20) were higher for onions (1.03, 1.50kg/m^3) followed by early tomatoes (0.76, 1.10kg/m^3), middle tomatoes (0.52, 0.76kg/m^3) and late tomatoes (0.39, 0.57kg/m^3) respectively. As in upper zone, CWPs for beans (0.18, 0.27kg/m^3) were the least, followed by maize (0.23, 0.34kg/m^3). The AIRs for all the crops were higher than the TNIs, implying that the moisture deficits (MDs) had an effect in crop yields. Late planted tomatoes received an effective rainfall of about 108.3mm and had less MD (7.8mm), slightly higher than the MD for dry beans (7.3mm). Apart from increased irrigation requirements, crop yields for the middle MSC were lower than those in the upper zone. As a result, the CWPs for irrigated crops in the upper zone were higher than those in the middle zone with the exception of onions, which recorded higher figures of water productivity than in the upper Mkoji.

The CWPs for irrigated tomatoes, onions and potatoes were generally higher than those of irrigated grains. With the exception of irrigated onions, CWPs for irrigated crops in the upper zone were higher than those in the middle zone. The CWPs for rainfed grains were higher in the lower zone than those of the same crops grown under rainfed and irrigated conditions in the middle and upper zones of the catchment.

Table 6.20: Crop water productivity for irrigated crops in middle zone.

Crop	CWR (mm)	ETa (mm)	RF (mm)	ERF (mm)	TGI (mm)	TNI (mm)	AIR (mm)	MD (mm)	CY (kg/ha)	PW_W (kg/m^3)	PW_{ETa} (kg/m3)
Maize	521.1	521.1	0.9	0.9	760.8	494.5	520.2	25.7	1778.0	0.23	0.34
Dry Beans	379.2	379.2	14.0	10.0	556.7	361.9	369.2	7.3	1016.0	0.18	0.27
Tomato (E)	481.8	481.8	5.0	4.9	690.2	448.6	476.9	28.2	5303.5	0.76	1.10
Tomato (M)	592.4	591.8	6.2	6.1	856.9	556.9	586.3	28.7	4472.4	0.52	0.76
Tomato (L)	638.3	638.3	142.0	108.3	803.5	522.3	530.0	7.8	3641.3	0.39	0.57
Onions	556.2	543.6	1.4	1.0	787.5	511.9	555.2	30.7	8128.0	1.03	1.50

Intermediate

In the study area, intermediate agricultural production is mainly practiced for rice crop in the middle and lower zones. Rice cultivation is largely done downstream of the Dar-es-salaam - Mbeya highway although there are small portions of rice fields in the upper part of the highway. A large area covered with rice fields in the lower part of the highway is under smallholder irrigation systems (improved and traditional). The improved schemes consist of concrete intakes and most of them are close to river networks with good access to irrigation water from rivers. Therefore, irrigation water constitutes a large percent of the water used to meet rice water requirement and supplemented with rainfall in the middle zone. The drain water from most irrigation schemes in the middle zone flows downstream and joins the river system down of the irrigation schemes. The river flows combined with rainfall runoff normally flood the plains in the lower zone. These floods are used for rice cultivation using small canals to divert the flood from the rivers into rice fields. Therefore, rice production may be termed as “irrigated, but supplemented with rainfall” in middle zone and “flood or runoff irrigated” in the lower zone.

Table 6.21 shows the CWPs for rice under intermediate agricultural production in the middle and lower zones. The sum of CWR, Perc and Lprep has been refered at RiceRq or total water requirements for the rice crop. Based both on rice crop requirement (RiceRq) and crop water requirement (CWR), the CWPs were higher in the lower (0.36, 0.70kg/m3) than in the middle (0.21, 0.43kg/m3). The differences in total rice water requirement can be attributed to increased crop water requirements in the lower zone, because the amount of water used for land preparation (Lprep) and water lost through percolation (Perc) were found to be the same (270 and 375mm) in both the middle and upper zones respectively. Percolation losses of 2.5mm/day for 150 rice growth days were recorded in the two zones. The irrigation water requirement (IrReq) was higher by 26% in the lower MSC due to reduced effective rainfall (ERF) during the crop growth period. The higher CWP in the lower was a result of high crop yield, which almost doubled the crop yields for middle Mkoji. It is also believed that the soils in lower zone are more fertile than in the middle part of the catchment.

Table 6.21: Crop water productivity for rice

Location	CWR (mm)	Perc (mm)	Lprep (mm)	RiceRq (mm)	ERF (mm)	IrReq (mm)	Yield (kg/ha)	PW_W (kg/m^3)	PW_{ET} (kg/m^3)
Middle	628.5	375	270	1273.5	457.4	816.1	2722.9	0.21	0.43
Lower	694.4	375	270	1339.4	241.6	1097.8	4876.8	0.36	0.70

The estimated total area grown with rice crop in the wet season for MSC is above 12,000ha (SMUWC, 2001) for both improved and traditional smallholder irrigation systems. The crop is grown during the rainy season but land preparation starts earlier in November for middle zone because of easier accessibility to water from irrigation canals. Paddy transplanting (in the lower zone) starts in late January because water (from the upper zone) delays to reach the area. Transplanting therefore has to start in lower zone when water (in the rivers) is flowing from upper to lower zone and after it has increased substantially from rains that fall in the upper catchment. In general, the values of water productivity in rice for Mkoji (0.21 and 0.36kg/m^3) were relatively higher than the average CWP for rice recorded for the whole of Usangu plains (0.18kg/m^3) (SMUWC, 2001).

<u>Equivalent Crop Water Productivity in monetary terms</u>

Table 6.22 shows the equivalent Crop Water Productivity in Tsh/m^3 and US \$/m^3. The unit prices (Tsh/kg of crop) used in determining the economic water productivity are the farm gate prices as reported during the questionnaire surveys. Therefore, the value of water may not be an accurate representative of the true value of water in crop production, particularly when one considers the

prices that could be offered under perfect or competitive market conditions. It is also important to note that the economic crop water productivities presented under this section are in essence based on actual crop water use (ETa), which is assumed as used or consumed in producing the crop and the equivalent harvestable crop yield that can be marketed. In calculating the economic crop water productivity, the current exchange rate of US \$ 1 = Tsh 1030 was used to convert the values in Tanzanian Shilling into their equivalent US Dollar.

For rainfed crops in the upper zone, dry beans and Irish potatoes had the highest value per unit drop (US \$ 0.10/m^3) followed by maize and tomatoes (both recording a value of US \$ 0.08/m^3), spring wheat (US \$ 0.06/m^3) and last by millet (US \$ 0.05/m^3). The variations in the equivalent values are attributed to changes in crop yields and unit prices for the respective crops. Whereas crop yields for dry beans were found to be less (by 80%) compared to that of irish potatoes the economic water values for the two crops were found to be equal because of high farm gate prices for dry bean (Tsh 350/kg), which had raised the economic values of water for the crop. For irrigated crops (in the upper zone) the values were higher than those of the crops grown under rainfed conditions. The similar effects (of increased farmgate prices and crop yields) had influenced the resultant value of water in irrigated crops (in the upper zone). Tomatoes grown under different periods during the dry season, for example, had resulted into the same average yield (7863.8kg/ha) but different values of water because of the variations in farmgate prices for the crop. The prices were reported to be higher for the early and late planted tomatoes but lower for the mid planted tomatoes causing a difference of about 55% in the value of water between the same crop grown in different periods.

Although the value of water for crops in the middle and lower zone showed a similar pattern of variations in the upper zone, the value of water in the middle zone was lower than that in the upper zone, both under rainfed and irrigated conditions. Conversely, the value of water for maize, sorghum, dry beans and groundnuts in the lower zone were higher than those of similar crops in the middle and upper Mkoji. Since, the farmgate prices under rainfed condition in the three zones were almost the same, the differences in the value of water was largely associated with the differences in crop yields. For rice (unpolished), which is grown under intermediate condition, the value of water was higher (US \$ 0.09/m^3) in the lower Mkoji than in the middle Mkoji (US \$ 0.06/m^3).

Table 6.22: Economic water productivity in Mkoji

Upper MSC	Rainfed							Irrigated							Intermediate						
Crops	**Kg/ha**	**Tsh/kg**	**Tsh**	**Eta**	**m^3**	**Tsh/m^3**	**US$/$m^3$**	**kg/ha**	**Tsh/kg**	**Tshs**	**ETa**	**m^3**	**Tsh/m^3**	**US$/$m^3$**	**kg/ha**	**Tsh/kg**	**Tsh**	**Eta**	**m3**	**Tsh/m^3**	**US$/$m^3$**
Maize	2540	150	381000	458.1	4581	83.17	0.08	3703.3	165	611045	434.7	4347	140.57	0.14							
Millet	2032	100	203200	393.5	3935	51.64	0.05														
Dry Beans	914.4	350	320040	322.3	3223	99.30	0.10	1460.6	350	511210	327.4	3274	156.14	0.15							
Irish Potato	4826	100	482600	462.9	4629	104.26	0.10	8128	100	812800	465.2	4652	174.72	0.17							
Tomato	4366	80	349280	403.6	4036	86.54	0.08														
Spring Wheat	1706.9	120	204828	306.7	3067	66.78	0.06														
Tomato (E)								7863.8	140	1100932	403	4030	273.18	0.27							
Tomato (M)								7863.8	80	629104	492.5	4925	127.74	0.12							
Tomato (L)								7863.8	170	1336846	499.7	4997	267.53	0.26							
Onions								7620	120	914400	504.7	5047	181.18	0.18							
Middle MSC																					
Maize	1274.7	150	191205	455.9	4559	41.94	0.04	3703.3	150	555495	521.1	5211	106.60	0.10							
Sorghum	894.4	100	89440	396.9	3969	22.53	0.02														
Dry Beans	762	350	266700	338.9	3389	78.70	0.08	1460.6	350	511210	379.2	3792	134.81	0.13							
Groundnuts	1625.6	400	650240	509.8	5098	127.55	0.12														
Tomato	4366	80	349280	476.4	4764	73.32	0.07														
Tomato (E)								7863.8	165	1297527	481.8	4818	269.31	0.26							
Tomato (M)								7863.8	80	629104	591.8	5918	106.30	0.10							
Tomato (L)								7863.8	170	1336846	638.3	6383	209.44	0.20							
Onion	2734.1	120	328092	427.2	4272	76.80	0.07	7620	120	914400	543.6	5436	168.21	0.16							
Rice															2722.9	134	364869	628.5	6285	58.05	0.06
Lower MSC																					
Maize	3048	150	457200	459.3	4593	99.54	0.10														
Sorghum	3657.6	100	365760	409.8	4098	89.25	0.09														
Dry bean	584.5	350	204575	345.7	3457	59.18	0.06														
Groundnuts	2438.4	400	975360	441.8	4418	220.77	0.21														
Rice															4876.8	134	653491	694.4	6944	94.11	0.09

6.5.2 Value of domestic water

The value of water in the domestic sector was estimated using two methods, the first one entailed the use of market prices for water and the second one used the Contingent Valuation (CV) approach. The first method had used the current market prices as charged by local sellers, who carry water from sources to the villages (as at Uyole, which represents the upper MSC), at Tsh 20 per bucket of 20 litres (equivalent to Tsh 1000 per m^3). The same price is also charged to cover the maintenance and operation costs for the two wells drilled by the SMUWC project in Ukwaheri village and Lutheran Church in Madundasi respectively (both in the lower catchment).

In the second method the study adopted the use of the Willingness To Pay (WTP) approach. Households were asked individually how much they are willing to pay for an improved water supply. This involved the use of a direct, open-ended question such as: "What is the maximum amount of money they would be willing to pay (for improved domestic water supply)?" In addition, the respondents were given specific choices requiring a yes or no answer. The questionnaire was designed in the form of a bidding game with several options of combining open-ended and yes or no questions. This approach was specifically used in the lower zone where water resources are scarce especially during the dry season and where villagers often walk long distances in search of water for their domestic needs. Fortunately, the average amount that respondents were willing to pay per bucket was found to be Tsh 20.3 (Table 6.24), which is almost the same as for the first method. The price of Tsh 1000 per m^3 was therefore adopted in the calculation of the value of water in the domestic sector. The value was estimated at Tsh 1.7 billion per year, equivalent to Tsh 12000 per person per year for the whole of Mkoji (Table 6.23).

Table 6.23: Values of water used for domestic purposes

Mkoji zones	hh consumption (m3/hh/day)	Domestic water (Mm3/year)	Value of water (Mm^3/year)	Value of water (Tsh/m3)	Value of water (billion Tsh/year)	Value of water (TSh/person/year)
Upper	0.131	0.76				
Middle	0.175	0.73				
Lower	0.143	0.23	1.7	1000	1.7	12 000

Table 6.24: WTP and proportion of income spent on water for domestic uses in lower Mkoji

	Very rich	Rich	Medium	Poor	Very Poor	Unranked	Total
Total sample household	3	9	21	25	17	5	80
Average household size	7	13	9	7	5	9	8
Average household water consumption (litres/day)	178	152	134	118	107	167	143
Average household water consumption (litres/yr)	64,970	55,480	48,910	43,070	39,055	60,955	52,073
Average WTP per 20 litres of water (Tsh)	29.1	28.7	17.1	15.8	14.8	16.1	20.3
Average WTP per litre of water (Tsh)	1.5	1.4	0.9	0.8	0.7	0.8	1.0
Average WTP (Tsh/year)	94,531	79,614	41,818	34,025	28,901	49,069	52,768
Average household income (Tsh/year)	169,785	172,861	265,206	89,780	51,172	272,486	170,215
Average WTP as % of household income	55.7	46.1	15.8	37.9	56.5	18.0	31.0

Source: Survey, 2003

The WTP results showed a positive correlation between wealth and WTP for their essential water needs (during the dry season) with the correlation coefficient of 0.715 ($P < 0.05$). The correlation between wealth and WTP was strongest in both villages (Ukwaheri and Madundasi). As expected, the respondents from wealthier households were willing to pay more than those from poorer households, making a link between WTP and ability to pay (ATP). However, some respondents indicated that although they could not afford paying much in monetary terms, they would be able to contribute in other ways (e.g., providing family labour for O&M of the water borehole pump). In other words, this illustrates how their desire for improved water service is not only expressed in their stated financial WTP as they were even willing to draw on their only most valuable capital (family labour). On average, the poor ('very poor' and 'poor' households) spend about 47% of their income on water for domestic use whereas the rich ('very rich' and 'rich' households) spend about 51%.

During the dry season, the households in distant subvillages (e.g., Msisi – in Ukwaheri and Mwashota in Madundasi) spend about 6.5 hours on average walking from their homestead to the water source (mainly the borehole pumps). One would logically expect that households walking long distances for water collection (in the dry season) would be willing to pay more for an improved water supply than those with an immediate supply of water source irrespective of their wealth, the WTP results indicated that this was not the case. In Ukwaheri subvillage, where the borehole water pump is located, the average WTP for improved water supply was relatively higher in almost all wealth classes than in Msisi subvillage (which is located about 10 km from the water pump). Households in Ukwaheri subvillage are willing to pay almost twice as much as the households in Msisi subvillage with values of Tsh 24.5 and Tsh 13.8 respectively. During the PRA exercise the participants in the later subvillage (Ukwaheri) remarked that they would be willing to pay even more in order to get additional boreholes.

6.5.3 Productivity of water in the livestock sector

The productivity of water in the livestock sector was calculated using the shadow price of Tsh 1 per litre as deduced from the domestic sector. The Profit Margin Approach was then used to estimate the productivity of water in this sector. Livestock production in the study area can generally be defined as that of low input category involving family labour for herding as the major input, normally provided by young members of the family. Labour for herding was valued at Tsh 5000 per month, which is the average wage paid to herdsmen in other parts of Usangu plains. Livestock is both an asset and income earner. It represents future income generating capacity and household saving. The stock of animals allows the households to cope better with shocks and crises or overcome slack/difficult. Recognizing this, the results presented (Tables 6.25 to 6.27) and discussed in this section are based on the two types of WP (for livestock as both an income earner and asset).

Using the value of livestock assets the WP figures were Tsh 5,276 ; 5,831; and 6,295 per m^3 equivalent to Tsh 1,702; 870; and 113 per TLU per m^3 for the upper, middle and lower zones respectively. When the turnovers from the livestock enterprise were used, the resulting WPs were: Tsh –2097 ; -561; and -309 per m^3, equivalent to Tsh -677; -84; and -5 per TLU per m^3, all negative for the upper, middle and lower zones respectively.

Table6.25: Water productivity per annum in the livestock sector in upper zone

variable	Units	Price (Tsh/Unit)	Values for Assets (Tsh)	Values for Income (Tsh)
REVENUE:				
TLU	3.1		391,769.35	34,192.00
Total revenue			391,769.35	34,192.00
VARIABLE COSTS:				
Herding	12	5,000.00	60,000.00	60,000.00
Water consumed	48	1,000.00	48,492.86	48,492.86
Variable	3.1	8,840.77	27,406.39	27,406.39
Total variable costs (Tsh/year)			135,899.24	135,899.24
Margin (Tsh/year)			255,870.11	-101,707.24
Water productivity (Tsh/m3)			5,276.45	-2,097.37
Water productivity (Tsh/TLU/m3)			1,702.08	-676.57

Source: Survey data, 2003

Table 6.26: Water productivity per annum in the livestock sector in the middle zone

variable	Units	Price (Tsh/Unit)	Values for Assets (Tsh)	Values for Income (Tsh)
REVENUE:				
TLU	6.7		788,458.82	116,208.50
Total revenue			788,458.82	116,208.50
VARIABLE COSTS:				
Herding	12	5,000.00	60,000.00	60,000.00
Water consumed	105	1,000.00	105,156.50	105,156.50
Variable	6.7	1,504.13	10,077.67	10,077.67
Total variable costs (Tsh/year)			175,234.17	175,234.17
Margin (Tsh/year)			613,224.65	-59,025.67
Water productivity (Tsh/m3)			5,831.54	-561.31
Water productivity (Tsh/TLU/m3)			870.38	-83.78

Source: Survey data, 2003

Table 6.27: Water productivity per annum in the livestock sector in the lower zone

variable	Units	Price (Tsh/Unit)	Values for Assets (Tsh)	Values for Income (Tsh)
REVENUE:				
TLU	55.9		6,507,239.25	713,398.50
Total revenue			6,507,239.25	713,398.50
VARIABLE COSTS:				
Herding	12	5,000.00	60,000.00	60,000.00
Water consumed	877	1,000.00	877,350.50	877,350.50
Variable	55.9	842.87	47,116.43	47,116.43
Total variable costs (Tsh/year)			984,466.93	984,466.93
Margin (Tsh/year)			5,522,772.32	-271,068.43
Water productivity (Tsh/m3)			6,294.83	-308.96
Water productivity (Tsh/TLU/m3)			112.61	-5.53

Source: Survey data, 2003

Changes in livestock assets and the income earned from livestock enterprise are presented in Table 6.28. The average value of livestock assets for the whole of Mkoji has declined by 27% for the period from 2001/2 to 2002/3. While the middle and lower zones had their stock declining by 75% and 14% respectively, the upper zone had its stock increasing by 9%. This can be associated with the differences in the number of livestock holdings, carrying capacity and resource endowment (including weather conditions).

Table 6.28: Livestock assets, off-takes and average income by wealth category

Zone		Variable	Very rich	Rich	Medium	Poor	Very poor	Unranked	Total
Upper	**Total**	**% change in TLU assets current versus last year**	**11.0**	**5.5**	**31.6**	**-7.8**	**4.7**		**9.0**
		Income earned (Tsh)	**29,000**	**775,475**	**624,851**	**21,725**	**15,000**		**293,210**
	Ikhoho	**% change in TLU assets current versus last year**	**11.0**	**-4.4**	**57.0**	**-0.2**	**0.0**		**12.7**
		Income earned	**29,000**	**0**	**7,875**	**20,500**	**0**		**11,475**
	Inyala	**% change in TLU assets current versus last year**		**15.5**	**6.1**	**-15.4**	**9.3**		**3.9**
		Income (Tsh)		**1,550,950**	**1,241,827**	**22,950**	**30,000**		**711,432**
Middle	**Total**	**% change in TLU assets current versus last year**	**8.8**	**-79.9**	**1.6**	**-133.8**	**-234.4**	**-11.7**	**-74.9**
		Income earned (Tsh)	**0**	**366,408**	**333,169**	**266,059**	**178,395**	**120,998**	**210,838**
	Mahongole	**% change in TLU assets current versus last year**		**-170.5**	**37.5**	**33.0**	**-412.7**	**-34.5**	**-109.5**
		Income earned (Tsh)		**636,895**	**558,713**	**512,617**	**327,990**	**120,000**	**431,243**
	Mwatenga	**% change in TLU assets current versus last year**	**8.8**	**10.7**	**-34.3**	**-300.5**	**-56.0**	**11.2**	**-60.0**
		Income earned	**0**	**95,921**	**107,625**	**19,500**	**28,800**	**121,996**	**62,307**
Lower	**Total**	**% change in TLU assets current versus last year**	**-41.8**	**-12.2**	**-16.4**	**32.2**	**-6.1**	**-40.2**	**-14.1**
		Income earned		**2,063,360**	**1,063,950**	**2,545,357**	**1,685,508**	**4,162,919**	**2,304,219**
	Ukwaheri	**% change in TLU assets current versus last year**	**-10.4**	**0.1**	**-19.9**	**-15.5**	**-15.1**	**-24.3**	**-14.2**
		Income earned	**23,098,416**	**3,871,856**	**850,279**	**4,309,240**	**632,976**	**8,301,438**	**6,844,034**
	Madundasi	**% change in TLU assets current versus last year**	**-73.2**	**-24.6**	**-12.9**	**79.8**	**2.8**	**-56.0**	**-14.0**
		Income earned	**2,216,915**	**254,865**	**1,277,620**	**781,474**	**2,738,040**	**24,400**	**1,215,552**
Total MSC		**% change in TLU assets current versus last year**	**-7.3**	**-28.9**	**5.6**	**-36.5**	**-78.6**	**-25.9**	**-28.6**
		Income earned	**9,667**	**1,068,415**	**673,990**	**944,380**	**626,301**	**2,141,959**	**910,785**

Source: Survey data, 2003

6.5.4 Productivity of water in brick making

The Profit Margin Approach was used to calculate water productivity in brick making. The market price was reported to average Tsh 20 per brick during the dry season. Although the price can go up to Tsh 35 per brick particularly during the wet season when brick supply is limited to the quantity carried forward from the last dry season, most of the bricks are normally sold during the dry season when weather allows construction of houses. Therefore the dry season prices were used to value productivity of water. According to the estimates done, water productivity for brick making was estimated at Tsh 1.08, 0.94 and 0.93 per m^3 for the upper, middle and lower zones (Tables 6.29 – 6.30) respectively. The differences in WP were due to variations in the magnitude of variable costs such as wages paid for labourers, fuel (fire wood or rice husks), increased cost of water (in terms distances to water sources and hence labour costs). The average variable costs were estimated at Tsh 10.66, 12.46 and 12.75 per brick for upper, middle and lower MSC.

Table 6.29: Productivity of water for brick making in the upper zone

	Units	Price (Ths/Unit)	Value (Ths)
REVENUE:			
Brick	2531	20.00	50,625.00
Total revenue			50,625.00
VARIABLE COSTS:			
Water consumed	6	1,000.00	6,328.13
Man days and other variable costs	2531	10.66	26,983.42
Total variable costs (Shs/year)			33,311.55
Margin (Shs/year)			17,313.45
Productivty of water (TSh/m3)			2,735.95
Productivity of water (TSh/brick/m3)			1.08

Source: Survey data, 2003

Table 6.30: Productivity of water for brick making in the middle zone

Variable	Units	Price (Ths/Unit)	Value (Ths)
REVENUE:			
Brick	2137	20.00	42,739.29
Total revenue			42,739.29
VARIABLE COSTS:			
Water consumed	5	1,000.00	5,342.41
Man days and other variable costs	2137	12.46	26,621.11
Total variable costs (Shs/year)			31,963.52
Margin (TSh/year)			10,775.77
Productivty of water (TSh/m3)			2,017.02
Productivity of water (TSh/brick/m3)			0.94

Source: Survey data, 2003

Table 6.31: Productivity of water for brick making in the lower zone

	Units	Price (Ths/Unit)	Value (Ths)
REVENUE:			
Brick	2031	20.00	40,622.67
Total revenue			40,622.67
VARIABLE COSTS:			
Water consumed	5	1,000.00	5,077.83
Man days and other variable costs	2031	12.75	25,893.23
Total variable costs (Shs/year)			30,971.06
Margin (Shs/year)			9,651.60
Productivty of water (TSh/m3)			1,900.73
Productivity of water (TSh/brick/m3)			0.93

Source: Survey data, 2003

The average household percentage involved in brick making and values of WP were estimated for each wealth category in the study area in order to get an overall picture of the types of household involved in the activity. In addition the average income generated from the enterprise for each wealth class was also calculated. The results are given in Table 6.32.

Table 6.32: Relationship between wealth ranks and productivity of water for brick making

	Wealth Rank	Sample size	Household involved in brick making (%)	Bricks produced per household	Income generated (Tsh)	Volume of water used (m3)	Man days and other variable costs (Tsh)	Productivity of water (TSh/m^3)	Productivity of water (TSh/brick/m^3)
Upper Mkoji	1	3	33.3	500	10000	1.25	7521.67	983.00	2.46
	2	4	16.7	225	4500	0.56	6403.00	2109.00	5.27
	3	49	34.5	3171	63418	7.93	15341.42	20266.96	10.32
	4	16	21.4	492	9833	1.23	15540.00	-121.00	-0.30
	5	7	41.7	2240	44800	5.60	22862.00	3918.00	4.90
	6								
Middle Mkoji	1	1	0.0	0	0.00	0.00	0.00	0.00	0.00
	2	17	34.7	1725	34500	4.31	23916.25	2287.53	5.72
	3	26	23.2	2250	45000	5.63	25192.50	1380.60	3.45
	4	33	17.3	1722	34444	4.31	20435.00	2654.00	6.63
	5	7	25.0	3000	60000	7.50	40980.00	736.00	1.84
	6	3	0.0	0	0.00	0	0.00	0.00	0.00
Lower Mkoji	1	4	0.0	0	0.00	0	0.00	0.00	0.00
	2	9	0.0	0	0.00	0	0.00	0.00	0.00
	3	20	25.0	1357	27135	3.39	18131.09	583.79	1.46
	4	23	27.0	1067	21333	2.67	14030.56	1370.50	3.43
	5	18	27.8	2075	41500	5.19	27100.42	1646.99	4.12
	6	5	25.0	4500	90000	11.25	50055.00	2551.00	6.38

Source: Survey data, 2003

The correlation between wealth and involvement in brick-making was non significant for the upper (0.069) and middle zones (-0.097), while the same was significant for the lower zone (0.621, $P<0.10$). The correlation coefficient for the pooled sample was also not significant (-0.192). Brick making is practiced by almost all wealth categories with WP ranging from –0.30 for poor households to 10.32 for the medium category households, both extremes being in upper zone. The high variability in the WP is again mainly attributed to the differences in the costs of inputs. The negative values for WP in brick making can be associated with the fact that most households in the study area consider family labour and water as “free” inputs and most of them (about 80%) produce bricks for their own needs and not for sale. When the family labour and shadow price of water were added in the calculation, the values of WP were low and some were even negative.

Chapter 7 Conclusions and key policy implications

7.1 Conclusions

During the dry season, the water resources in the Mkoji catchment are inadequate to meet the domestic, livestock and crop production requirements. In the wet season, the highlands receive more rainfall, which is also more reliable and is adequate to meet crop water requirements under rainfed conditions in the upper zone. There is much less rainfall in the lower zone coupled with high variability, uncertainty and short rainfall duration. There is no irrigation or intermediate agriculture in the lower zone because all rivers flowing to that part dry up in the dry season. During that time even domestic and livestock water demand is not reliably met causing stiff water problems. The potential for using ground water exists but it has not been adequately studied and exploited.

The average households size (6) is higher than the national average (4.9). Female-headed households constitute about 16% of the total households, somewhat lower than the national figure of 20%. The adult labour equivalent for an average farming household is 4 and the dependency ratio is 0.40 (close to the national ratio of 0.42). There is wide income disparity among households. The average net mean income was US $ 495 per annum, which is more than twice as much as the national average (US $ 209). However, 46% of households (evenly spread across all zones) were categorised as poor and vulnerable. In general, the family incomes in Mkoji are almost entirely dependent on natural resources and cultivation is the primary activity, both in terms of numbers employed and total income generated. Together with the adaptation to resource opportunities this determines the types of farming systems and livelihood outcomes.

The farming systems in the catchment are diverse and vary with altitude and availability of water resources. There are a total of five farming systems. In the far South (in the highlands) there is potato based farming system followed by maize-potato and maize-beans farming systems (in the relatively lower altitudes) towards the North of Mkoji. These farming systems are accompanied by high altitude, high rainfall, long growing season and cool climate. Further North farming systems are dominated by paddy and pastoralism. Paddy is produced in supplementary irrigation systems in the middle zone and pure rainfed in the lower zone.

Livelihood strategies and coping mechanisms are diverse. Livelihood strategies relate to farming practices, business market, social and cultural relations. Agriculture is the main livelihood platform. Other livelihood platforms include land hiring, brick making and labour hiring. In the lower zone both pastoralism and crop production dominates as livelihood platforms. Coping strategies evolve mainly around sale of assets, sale of labour and support from clubs and credit arrangements.

There is little strict gender differentiation between livelihood activities. Gender specializations in certain tasks are common and women have variable degrees of command over household resources and livelihood decision-making and independent command over resources. However, others are severely constrained by marriage and cultural norms.

The vulnerable groups are those who lack assets and the capability to use them; have limited access to livelihood platforms or capital (natural, physical, human, financial and social); are unable to cope (temporary make adjustments in the face of change) or adapt (make longer shifts in livelihood strategies); are food insecure or malnourished; households that fall under the bottom income quintile for different family types.

The cropping calendars, patterns and sequences are quite diverse. More intensive farming activities are found in the upper and middle parts of the subcatchment. This is made possible by use of residual soil moisture and irrigation. Both maize and beans are grown extensively in the catchment. Paddy is mostly grown in the middle and lower zones.

Crop production is the dominant water user in the catchment with rainfed cropping during the wet season using almost 50% of the total. However, previous research in a nearby catchment has shown that runoff yield is greater under annual cropping than under the natural forest cover. Therefore clearance of land in this upper part of the catchment can be seen as having yielded net hydrological gain. Irrigated cropping (combining wet and dry seasons) uses slightly more water than rainfed cropping. Although the dry season use is only 25% of the total, its impact on dry season streamflows is profound and results in severe competition for water.

Other water users include livestock, brick-making and domestic. Collectively, they represent 3% of the wet season total and 15% of the dry season total. However, domestic use and brick-making have the highest values (estimated at US$1/ m^3 for domestic and >US$2 / m^3 for brick-making).

Under irrigation conditions, the estimated crop water productivity (US$ 0.10-0.25/ m^3) was higher than under rainfed conditions (US$ 0.05-0.10/ m^3). The estimated crop water productivity under rain-fed crop production is higher in the lower zone for most cereals compared to the middle and upper zones. However, vegetables (high value crops) had higher crop water productivity than cereal crops (e.g. maize).

7.2 Key Policy Implications

Interim findings of research in Mkoji catchment together with a review of CAMP project work in South Africa were presented in a stakeholders workshop involving key policy makers. A short report on these discussions is attached as Annex 1. These discussions have informed the process of identifying key policy implications and comparing findings from Mkoji catchment with those from Luvuvhu catchment in South Africa.

(a) Transferability of the project outputs to Tanzania

Generally all participants in the stakeholders workshops agreed that the CAMP methodology is useful for Tanzania. The linkage between land use and water use is important especially in strategy formulation of how to plan water and land use in the basin. Currently the national campaign on tree planting can particularly benefit from this kind of research as it requires cross sectoral planning especially on land use choices (eg. how much afforestation should made and what type of tree species should be adopted?). However, several issues pertaining to the research methodology and output were raised during the stakeholder consultation:

(i) Stakeholders commented that, the CAMP project methodology and outputs are very useful, but the transferability may be hindered by the fact that the current situation allows for many smallholders to make their own land decisions.

(ii) There may be some difficulties in handling the stream flow reduction activities such as RWH. The SFRA is strongly emphasised in the RSA context, the CAMP findings. The question in Tanzania context will revolve around on how are these activities going to be handled what tax, incentives and compensations will be necessary.

(iii) Due to lack of knowledge on environmental hydrology, in most watersheds, reserve for ecology has not been worked out. At the moment the modelling aspects has not worked and been able to put valuation on the ecological and human reserves. The difficulties in determining ecological reserve will be intensified by that fact that most of the basins (including Pangani basin) are already stressed. Currently many of the downstream water rights allocations are not met.

(iv) The current Tanzania water policy is very much influenced by the South African NWA. Like the RSA policy the first priority is on the basic human needs and the environment will attain the second priority. The policy is to allocate quantitatively to human and environmental flow and then to allocate to the remaining amount on the basis of social and economic values. The stakeholders commented that the analysis has remained silent on storage. The question was what will be the impact of storage on hydrology and livelihoods? This was seen as a limitation in the methodology.

(b) Conclusion and policy recommendations

It is now generally acknowledged that water is the most important agent that will enable the country to achieve its development vision objectives. It is also clear that the social and economic circumstance prevailing today have made particular demands upon the country's water resource base and the environment. From the study findings it is noted that the reliance and dependence of water in its various categories is vivid among water dependent livelihoods in the country. This livelihoods activities in connection to land use has different influence on hydrological cycle. The current water management instruments focus on water allocation by means of water user rights. While the socio-economic circumstances for water users in the Republic of South Africa allows for most farmers to pay for water, due to pensions arrangements, the situation in Tanzania can be difficult particularly for resource poor farmers. The increased demand for water resulting from increased sectors which require water as an input necessitate formulation of policy instruments based on strong analytical tools such as that produced by the CAMP project.

(c) Recommendations

Being similar to the RSA water policy, the current water policy emphasises the use of economic policy instruments such as pricing, charges and penalties in water management. The policy however has remained silent to mention the stream flow reduction activity element. This study therefore strongly recommends purposive efforts be made to ensure that all land uses that are SFRA be identified and incorporated in the legislation. Use of CAMP conceptualisation on blue and green water flows will be useful in quantification of water uses among competing uses, and can be used for improving dry land agriculture.

Lastly the study recommend stakeholders dialogue as a critical approach in increasing the degree of co-ordination among water management policies. Due to the high opportunity costs of participation, people are more likely to prefer institutional arrangements for resource management, that economize on transaction costs. In designing such arrangements it should be noted that the people making public decisions about regulations (mostly adult male household heads) are not necessarily those actually using the resource (children, hired labourers, women). Gender role flexibility suggests a scope for greater women's involvement in public decision-making about natural resource management. However, women are currently unlikely to substantially contribute above hamlet level, possibly because the decision-making fora at village level and above are not perceived by them as "women-friendly."

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CATCHMENT MANAGEMENT AND POVERTY ALLEVIATION
CAMP PROJECT

TANZANIA COMPONENT

POLICY INSTRUMENTS IN INTEGRATED WATER RESOURCES MANAGEMENT AND SUSTAINABLE LIVELIHOODS

ANNEX A

STAKEHOLDERS ANALYSIS OF CAMP METHODOLOGIES – OUTPUTS AND POLICY RECOMMENDATIONS

1.0 Background

1.1 Project overview

The CAMP research project aims to identify policy instruments that both improve the livelihoods of poor people and protect the resource base, through: macro-scale hydrological and economic modelling; combined with household level sustainable livelihoods assessment to examine the effect of alternative policy instruments relating to forestry and water allocation. The Tanzania component of CAMP project was to assess the transferability and wider applicability of the project's outputs. This report presents an analysis of the stakeholders' opinion for the projects outputs, their relevance to Tanzania and the compatibility of CAMP methodology and alternative policy instruments in Tanzania, using the case of Mkoji subcatchment.

1.2 Introduction

The country's development planners and policy makers generally accept the generalisation of the importance of water (both blue and green) role in the livelihoods of all Tanzanians. This is clearly shown in all National development objectives, the Vision 2025, the poverty reduction strategy paper PRSP, and the rural development strategy RDS and the corresponding policies, the National Water policy (NWP), National Forestry policy NFP and the National Land policy NLP. The V2025 is to have a strong resilient economy that can effectively withstands global competition. The second development objective (PRSP) is to improve quality of life and social well-being for the majority: reduce income and food poverty; reduce vulnerability. The RDS on the other hand targets on broad-based social and economic growth in the rural area.

The key identifiable policies in catchment management and poverty are Agriculture Sector Development strategy (ASDS), which has a focus on increasing incomes for those involved in the agriculture sector, through: productivity and profitability. The National Water Policy that focus on to improve health and alleviate poverty of rural populations. The National Forest policy (NFP) that focuses on the sustainable supply of forest products increased employment and earnings ensured ecosystem stability (biodiversity, water and soils) and the land policy (NLP), with a focus on clear land tenure system as an important factor ensuring both optimal and sustainable use.

In the country today, it has become increasingly clear that water is a complex and fragile resource that requires sound intersectoral management, derived from active stakeholder involvement and participation. This increasing awareness and the shift from a conventionally thinking in water management brings about awareness of involvement of other stakeholders in managing water resources however, can suffer from the exist methodology gap, which could lead on to development of sound policy instruments relating to sustainable livelihoods without jeopardizing the resource base. The integrated methodologies like that of the CAMP can provide for such alternatives. This report provides an assessment of the usefulness of the research; evaluates the transferability of the project methodology and outputs from RSA to Tanzania and highlight on policy guidelines demanded by stakeholders using the case study of Mkoji subcatchment.

2.0 Research Approach

The research involved institutional survey, participatory research, household survey and stakeholder's workshop. The institutional survey was done to comprehensively enlist the target organizations, institutions and individuals with direct or indirect connections with water use and management. While participatory survey was mainly conducted to assess livelihood platforms in the area, the household survey aimed at quantifying household level data. The stakeholder's workshop was mainly used to demonstrate findings from RSA methodology and findings and thus assess the relevance and suitability of the CAMP major outputs to Tanzania, using the case study of Mkoji subcatchment. Both primary and secondary data were used in this study

2.1 Description of the catchment

The Mkoji Sub-catchment, is drained by the Mkoji River and is located in the southwest of Tanzania, between latitudes $7^0$48' and $9^0$25' South, and longitudes $33^0$40' and $34^0$09' East (Figure 1). It is a sub-catchment of the Rufiji River Basin and covers an area of about 3400 km². Most of the sub-catchment lies within Mbarali and Mbeya Rural districts, while smaller portions of the sub-catchment lie within Makete and Chunya districts in Iringa and Mbeya Regions respectively.

According to the 2002 population census, Mkoji Sub-catchment has 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.

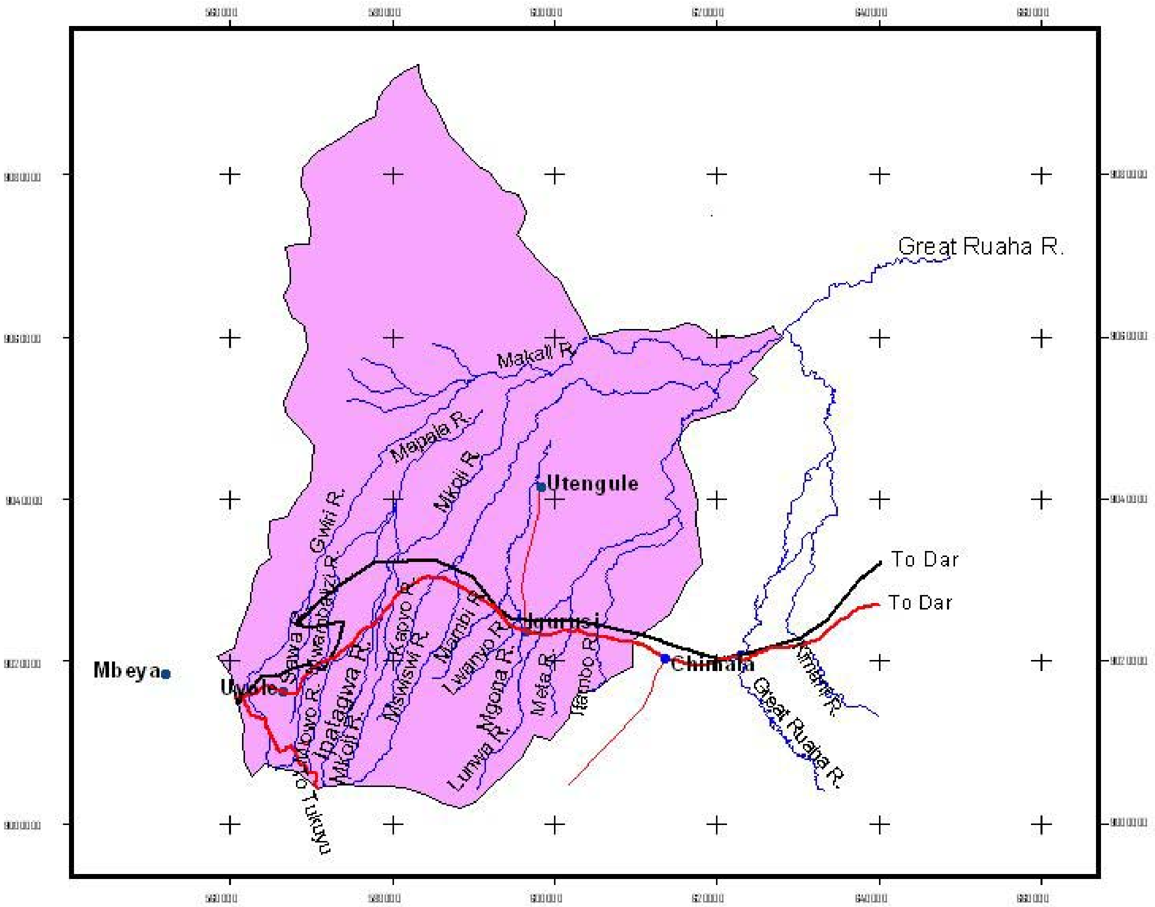
2.2. Land uses of the catchment

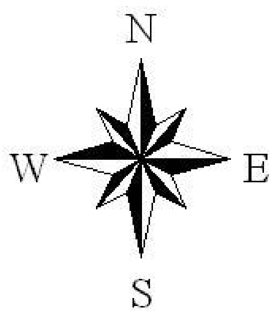
The prominent feature with regards to land use is the domination of Miombo woodland (Table 1). The evergreen forestland accounts only for 1% of the total land. Cultivated land ranks the second dominant land use in the area.

Table 1: Distribution of land use in Mkoji catchment

Land cover	Area (km^2)	%
Miombo woodland	1164.40	34.40
Acacia woodland and bushland	797.79	23.57
Evergreen forest	43.38	1.28
Cultivated land	847.16	24.43
High altitude grasslands	37.79	1.12
Mid altitude wooded grasslands	58.86	1.74
Wetland grasslands	161.82	4.78
Wetland woodlands	283.81	8.38
Other	10.24	0.30
Total	3385.30	100

MKOJI SUB-CATCHMENT MAP





3.0 Discussion of the findings

3.1 Hydrology

Analysis of the hydrological data collected from Mbeya catchment was done to illustrate hydrological responses on different land uses. Two land use scenarios were used. The first scenario was the forested catchment and the second was the cultivated catchment. The analysis showed that 1381mm (72%) of the total precipitation 1924mm that is the basic water resource was taken up as green water and 541mm (28%) was the blue water flow. On the other hand, the cultivated catchment showed that of the incoming precipitation 1658mm, 972mm (57%) was taken up as green water while 666mm (40%) flow as blue water. This analysis was done for the purpose of illustration and the study require more integration analysis to assess and explaining the hydrological changes impact on livelihood of poor people and the country's economy at macro level. The project findings on hydrological changes impacts on livelihoods of the people from South Africa case study were thus used to broaden the understanding of the stakeholders during the workshop. Figures 1a and 1b below illustrate the hydrological changes in Tanzania case study.

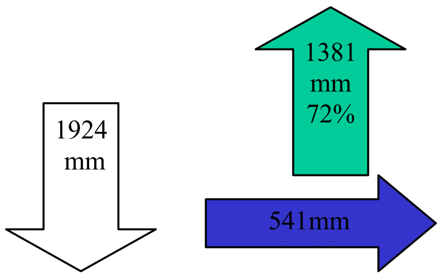


Figure 1a: Forested catchment

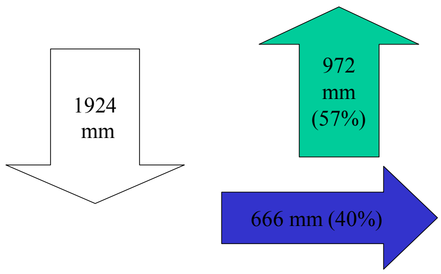


Figure 1b: Cultivated catchment

3.2 Livelihood analysis

Table 2. PRA wealth rank distribution

Village	Very rich	Rich	Average	Poor	Very poor	Unranked	Total
1. Ikoho (hhs)	8	24	104	90	44	0	270
2. Inyala (hhs)	2	5	287	138	51	1	484
3. Mahongole (hhs)	8	40	187	336	167	10	748
4. Mwatenga (hhs)	4	17	124	59	9	1	214
5. Madundasi (hhs)	36	67	192	197	204	8	704
6. Ukwaheri (hhs)	48	102	95	73	62	3	383
Total (hhs)	106	255	989	893	537	23	2803
%	4	9	35	32	19	1	100

Source: PRA data

Only 13% of the total households in the sample villages were grouped as "very rich" and "rich". The "average" category constitutes about 35% and the remainder (about 20%) were grouped either "poor" or "very poor". The "very rich" and "rich" households cultivate between 4 and 10 acres of land or more. They harvest 45 – 200 bags of paddy or more and they own 20 -200 heads of cattle or more. They have modern houses and can afford to pay for their children's education. Some own assets like milling machines and involve themselves in other income generating activities (may own shops, lodgings, bars, trading, etc). Households in the "middle" or "average" category cultivate 1.2 - 4 acres and harvest 10 – 45 bags of paddy and they own between 2 and 15 heads of cattle. Their houses are normally made of red or burned brick or mud walls, iron roof or thatch. They have the means to own a bicycle and a radio.

The poor ("poor" and "very poor" households) cultivate between 0 and 1.2 acres and harvest between 1 (or less) and 10 bags of paddy and they own less than 2 heads of cattle or no cattle at all. They normally have grass-thatched houses with mud walls. They cannot afford paying their children's school fees. The poorest of the poor, normally can only manage one meal a day and for some days they can go without meals.

3.3 Livelihood assessment in Mkoji subcatchment

Table 3: Socio- economic profiles of sample households

Variable	Upper MSC	Middle MSC	Lower MSC
a) Average number of household members	4.9	5	7.8
b) Average land owned (ha)	0.86	2.5	4.9
c) Average Livestock Units (LUs)	190.7	453.8	3749.9
d) Sources of income			
Paddy ($)	NA	461.34	228.79
Non-paddy crops ($)	157.59	35.90	110.00
Livestock ($)	453.16	768.91	19324.69
Remittance ($)	29.15	32.46	23.80
Fishing ($)	0	0	0
Brick making ($)	221.33	140.62	165.58
Other NR-based ($)	164.72	16.45	654.49
Non-farm ($)	9.59	16.45	23.80
Labouring ($)	NA	461.34	228.79

Source: survey data 2003

3.4. Livelihood Platforms

There exist major differences in the types of livelihood platforms among the three major areas in MSC. The prominent feature in the upper middle Mkoji, for example, is that livelihoods for the majority of people in the area is derived primarily from agriculture (both rainfed and irrigated). The economy of the areas is relatively more monetised, land is relatively scarcer and there is vibrant markets in land renting (Table 4), prevalence of labour hiring, income generating clubs and associations and little collective action or traditional forms of co-operation.

Table 4: Land renting and purchasing prices in the Mkoji Subcatchment

Item	Average Cost (US $ per ha)			
	Upper MSC	Middle MSC	Lower MSC	MSC
Renting for an irrigable land	28.5	47.6	0	43.8
Renting for a rainfed land	24.0	46.7	43.6	37.47

Source: Survey data, 2003

The prominent features in the lower Mkoji include: mixed crop production and pastoralism, seasonal access to markets, land availability, co-operative forms of labour arrangement, few income generating clubs or associations and higher levels of collective action in managing natural resources.

3.5. Livelihood Strategies

As for the livelihood platforms, livelihood strategies are diverse and can generally be categorized into the following three groups:
Those relating to farming practices,
Those relating to business and market relations and
Those relating to social and cultural relations.

As often expected, richer people in Mkoji combine a diverse of income generating activities, draw on a variety of social relationships, collective labour arrangements, lending and borrowing mechanisms to spread risks. On the contrary, however the poor people have little scope for risk management and the poorest are normally confined to growing drought resistant crops and selling their labour.

In general, the poor people have the most ineffective coping strategies, which erode their asset base. The most prominent of these are distress sales of household goods and sale of labour. Richer people on the other hand are more likely to be able to sell stored assets (grain, livestock) to cope with disasters without substantially eroding their asset base.

In the middle Mkoji, for example, coping strategies revolve around sale of assets, sale of labour and support from clubs and credit arrangements. In the lower Mkoji, sale of stored crops and livestock is important but the value of collective arrangements and drawing on social networks is also strongly stressed.

In the lower-upper and upper-middle Mkoji, diversification into small businesses, and strategies involving storage and sale of produce at high prices were prominent while in the lower zone collective action, good social relationships and traditional ceremonies as well as expanding cultivated plots are the common livelihood coping strategies. High seasonal stress (defined as high demands on household resources) was experienced by all households at the peak of the rainy season, due to labour shortages, food shortages, disease prevalence and cash demands. Poor households feel such seasonal stress most acutely and are more likely to have to meet basic needs by selling their labour and by taking children out of school, so reinforcing a vicious cycle of low productivity on their own fields.

In all the sample villages, many households experience some degree of labour shortage throughout the year. In the lower- upper and upper-middle Mkoji, households which combine dry season and rainy season crop growing experience few “slack periods” in the year whereas in lower Mkoji, dry season demands are increased by labour needs for herding and for collecting scarce water.

Little strict gender differentiation between livelihood activities of men and women was found although gender specializations in certain tasks were commonly noted. Women have variable degrees of command over household resources and livelihood decision-making, some having a considerable degree of freedom and independent command of resources, while others are severely constrained by marriage and cultural norms.

3.6. Poverty and the limits of social capital

Very limited social networks and a high degree of social isolation also characterize the poor/vulnerable households in Mkoji. They may have difficulty accessing help from relatives, are unable to pay entry fees of contributions to clubs and associations, and infrequently attend village government meetings.

In the lower Mkoji, associational activities (in the form of collective labour arrangements, traditional ceremonies and informal groups such as drinking circles) cross cut rich and poor households and resulted in higher levels of social capital in these villages. In the middle Mkoji, co-operation and social interaction was primarily around income generating clubs and livelihood associations, membership of which was dominated by-middle income households.

3.7 Assessment of Vulnerable Groups

A variety of techniques and indicators were used to distinguish between households of different levels of wealth and to understand the processes of impoverishment and accumulation. The study defines the vulnerable groups as those:

Who are poor (including the poor women)

Who get an income of less than US $ 1 per day per person[9]

Who lack assets and the capability to use them

Who have limited access to livelihood platforms or capitals (natural, physical, human, financial and social)

Who are located distant from the major centres and main roads

Who are highly dependent on, and disadvantaged by, market relations

Who rely on small and ineffectual social networks

Unable to respond effectively to change

Who are at risk of food insecurity or malnourishment

Households falling under the bottom income quintile for different family types

Key issues, which arose from the assessment of the vulnerable group include the need to recognize different values and preferences for investment and expenditure between ethnic groups, people's own preference for identifying capabilities rather than assets as significant in determining wealth and poverty, the importance of tracking changes to household status over life-courses, and the difficulty of reconciling household wealth with intra-household allocation of resources.

3.8. Natural resources/livelihood assets and poverty

The analysis in this study has shown that the poor (low-income/vulnerable groups) in Mkoji are also characterised by low resource endowment (Table 5). The average land holdings for the poorest in the area is put at 1.9 ha, which is about three times lower than the average size of land owned by the "very rich" category (about 6 ha).

- [9]The poverty line for Tanzania is US $ 1 per day per person or 46,173 Tsh equivalent (1991 prices - the Cornell-ERB study) or Tsh 73,877 (the WB study in 1996 using the 1993 prices); or Tsh 31,000 (1991 prices – equivalent to 63,240 in 1994 – earlier ILO study); or Tsh 71,426 (REPOA, 1998) per adult equivalent.

Table 5: Resource ownership and income by wealth rank

Variable	Very poor	Poor	Medium	Rich	Very rich
Average land owned (ha)	1.9	3	2.1	4.5	5.7
Average value of household assets ($)	70.53	91.27	155.66	450.27	481.21
Average household annual income ($)	370	450	468	607	1002

Source: Survey data, 2003

With regards to other livelihood assets, the findings in this study suggest that the poorest are also prone to vulnerability because they either lack or own assets of low values. Put it differently, the lack of valuable assets among the poor makes them remain in the vicious cycle of poverty while the rich, who own valuable assets have good chances of climbing the ladder because they may mortgage their assets so as to get loans from credit institutions. As shown in the regression results in Table 6, the value of household assets is one of the important determinants of wealth (as measured by the value of annual household incomes).

Table 6: Regression results between household incomes ($) versus selected determinants of income

Predictor	Coefficients	Std. Error	T	P
(Constant)	-0.05	0.130	-0.409	0.683
Farm size (ha)	0.147	0.021	2.003	0.047
Household asset value ($)	0.134	0.000	1.873	0.063
Household size	0.187	0.014	2.459	0.015
Relative distance from markets	0.158	0.061	2.040	0.043

ANOVA

	Sum of Squares	Df	Mean Square	F	P
Regression	11.164	4	2.791	7.604	0.000
Residual	63.503	173	0.367		
Total	74.667	177			
		R^2 = 46.4%			

Source: Survey data, 2003

The average household income for the "very poor" households was low ($370): three times lower than that of the "very rich" category, which implies limited consumption and/or expenditure for goods and services, including health services. This has negative implication, particularly on their health status as it may lead to reduced labour force, deaths and increasing number of orphans, widows and families without able-bodied, working-age adults. This situation will increase their vulnerability.

Due to lack of adequate livelihood capital the poor people are also inclined to adopting production practices, which do not ensure sustainability of their resource bases. The lack of labour flexibility and other important inputs like irrigation water disproportionately affect their livelihoods and make them more vulnerable to poverty and hunger. The ability to diversify their production systems is also limited, again because of livelihood capital. They are also adversely affected by commercialization of natural resources (such as water, firewood, thatching grass) because they lack adequate financial capital. When access to these resources is commercialized the poor may have to travel further so as to collect "free" supplies or purchase only smaller amounts than what they actually need.

3.9. Policy findings

3.9.1. Policy and instruments enhancing water resource management

Institutionally water management in Tanzania follows nine river basin divisions, the fact which then allows management water resources to be done at four levels; National level, basin level, district level and community or water user associations level which is the lowest level and integrate users of the same source. The three major national policies that have a direct link to water resources management include National water policy, National Land policy and forest policy. The section presents findings derived from the content analysis in relation to context of water and land policies, and the descriptive analysis of the information obtained through informal and formal interview with for both farmers and water institutions in the area is included.

3.9.2. Water management policy instruments relating to land, water and forest

The IWRM criterion in resource management depends very much on a well-defined property right or tenure arrangement. In this study, two land policy instruments relating to land that are necessary in water management were identified. These two identified instruments include the (1999) *Land Act*[10] and the *Village Land Act*[11]. Integral to it is a new system for settlement of land disputes.[12] These instruments are envisaged to allow for current socio-economic change, and provide a new set of rules for administering land and judge disputes arising from land ownership. Looking from IWRM view, the analysis showed that although provide for or give a legal force to the *National Land Policy* of 1995 the new instruments deprive the farmers (primary stakeholders in IWRM) a true sense of ownership to land. This is evident as the policy still upholds the declaration that all land in Tanzania shall continue to be public land and remain vested in the President as trustee for and on behalf of all citizens of Tanzania (Act. No. 4, 1999). The present system in land administration in this country is thus inefficient and incompatible with the aims of IWRM. Shivji (1994); and Isinika *et al.*, (1998) reported similar arguments that the system of administration in the country is inefficient, corrupt, and unable to resolve land disputes and marginalizing small holders particularly pastoralists. customary right of occupancy is the reserve of the village council which also the authority to issue a "certificate of customary right of occupancy" under section 25(1) of the Act. In view of this simple analysis, farmers as key stakeholders in IWRM are deprived of the sense of ownership of land, which is very crucial variable in IWRM mission. As also reported by Feder, (1985) the sense of ownership or good tenure arrangements has is necessary stimulus in resource conservation. Depth analysis to the current policy instruments, expose doubts on the desirability of farmers to use land as collateral for credit. This would be necessary especially for irrigation agriculture being a capital-intensive exercise.

With regards to water policy, *Water Utilization (Control and Regulation) Act*, is the major instrument that deals with water resources management. Other specific instruments in the study basin can further be divided two broad categories. The first category of instruments includes those, which are institutional in nature: these include village water bylaws and norms that have a role in the intra and inter canal water allocation. The second group is economic instruments. These include water right, pricing and taxation on water services. In the current situation emphasis is

[10] Act No.4 of 1999

[11] Act No.5 of 1999

[12] *The Courts (Land Disputes Settlements) Act*, 2002

made more on the use water user rights. This may hinder access to water by disadvantaged groups of poor farmers. The findings of the study showed that the conditions for which one is required to meet before water right is entitled are difficult to follow especially for poor groups of farmers who have low stock of social capital.

Table 7: Conditions for getting water rights

Conditions	Count	Percent
Payment should be done in advance and in every year	56	48.69
Must have a bank a/c with a minimum amount	21	18.26
Must be member of the Rufiji River Basin	19	16.21
Modern intakes (weir) for water abstraction is prior to water use right	12	10.43
Village is responsible for water right	7	6.08
Total	115	100.00

Source: Survey data 2002

Responses obtained from farmers (Table 7) showed that about 50% of farmers raised concern on payment condition, this implies that most of farmers and poor farmers in particular will not be able to easily obtain their water user rights. In the other hand there attached conditions after obtaining the water use rights, which were dissent as being difficult for most of farmers. As indicated in (Table 7), farmers for example are not allowed to abstract volumes exceeding the weir-calibrated volume, nornally calibrated during rain season when water flow was high. Contrary to this is that irrigation takes place during the dry season with low flow levels. Since farmers are not required to adjust the weir, the implication is that farmers are compelled to pay more than what they are actually abstracting. As reported by Dixon, (2000), designing of water structures much dominated by engineering aspects to be constraint of interest in water management.

Table 8: Conditions attached to water rights

Attached conditions	Count	%
Abstraction is limited to the volume in the certificate (modern intakes)	41	53.9
Water use is limited to intended activity only (irrigation)	9	11.8
Water user has to ensure environmental control	5	6.57
Those on the upper stream should consider those on lower stream users	4	5.3
You have to pay for water every year	13	17.1
Water use is limited to specified period of in the year	4	5.3
Total	76	100.0

Source: Survey data 2002

The findings (Table 8) show that majority of farmers were (54 %) are more felt with the attached condition associated with the volume of abstraction. Only a few farmers in the entire catchments (5.3 %) complained on the limited freedom to use water for unintended business.

With regards to forest policy, no specific instrument more concerns has been on deterioration or degradation of catchment forest with emphasis on creation of community based forest reserves (consistent with decentralization agenda under village Act, 1999). No reference is made to expansion of commercial forest. Explicit reference is made to value of forest products in watershed management viz "deterioration of catchment forest causing water shortages". Again no reference is made to "Alien invaders" but it is however acknowledged that tree planting campaigns have resulted in a widespread planting of exotic tree species.

3.10. Stakeholders responses

(a) Transferability of the project outputs to Tanzania

This section presents the findings as obtained after presentation to stakeholders the findings from all CAMP projects sites and methodology. Generally all participants in the stakeholders workshops agreed that the CAMP methodology is useful for Tanzania. The linkage between land use and water use is important especially in strategy formulation of how to plan water and land use in the basin. Currently the national campaign on tree planting can particularly benefit from this kind of research as it requires a cross sectoral planning especially on land use choices, example how much afforestation should made and what type of tree species should be adopted. However, several issues pertaining the research methodology and output were raised during the stakeholder consultation:

Stakeholders commented that, the CAMP project methodology and outputs are very useful, but the transferability may be hindered by the fact that the current situation allows for many smallholders to make own land decisions.

There may be some difficulties in handling the stream flow reduction activities as such as RWH. The SFRA is strongly emphasised in the RSA context, the CAMP findings. The question in Tanzania context will revolve around on how are these activities going to be handled what tax, incentives and compensations will be necessary.

Due to lack of knowledge on environmental hydrology, in most watersheds, reserve for ecology has not worked out. At the moment the modelling aspects has not worked and been able to put valuation on the ecological and human reserves. The difficulties in determining ecological reserve will be intensified by that fact that most of the basins (including Pangani basin) are already stressed. Currently many of the downstream water rights allocations are not met.

The current Tanzania water policy is very much influenced by the RSA water Law. Like the RSA policy the first priority is on the basic human needs and the environment will attain the second priority. The policy is to allocate quantitatively to human and environmental flow and then to allocate to the remaining amount on the basis of social and economic values.

The stakeholders commented that the analysis has remained silent on storage. The question was what will be the impact of storage on Hydrology and livelihoods? This was seen as a limitation in the methodology.

(b). Conclusion and policy recommendation

It is now generally acknowledged that water is the most important agent that will enable the country to achieve its development vision objectives. It is also clear that the social and economic circumstance prevailing today have made particular demands upon the country's water resource base and the environment. From the study findings it is noted that the reliance and dependence of water in its various categories is vivid among water dependent livelihoods in the country. This livelihoods activities in connection to land use has different influence on hydrological cycle. The current water management instruments focus on water allocation by means of water user rights. While the socio-economic circumstances for water user in the Republic of South Africa allows for most farmers to pay for water, due to pensions arrangements, the situation in Tanzania can be difficulty particularly for resource poor farmers. The increased demand for water resulting from increased sectors which require water as an input necessitate formulation of policy instruments based on strong analytical tools such as that produced by the CAMP project.

(c) Recommendations

Being similar to the RSA water policy, the current water policy emphasises the use of economic policy instruments such as pricing, charges and penalties in water management. The policy however has remained silent to mention the stream flow reduction activity element. This study therefore strongly recommends purposive efforts be made to ensure that all land uses that are SFRA be identified and incorporated in the legislation.

For appropriate water management strategies land use maps be produced that will provide baseline for comparisons in water management strategies.

Use of CAMP conceptualisation on blue and green water flows will be useful in quantification of water uses among competing uses, and can be used for improving dry land agriculture.

Lastly the study recommend stakeholders dialogue as a critical approach in increasing the degree of co-ordination among water management policies.

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