Catchment Ecosystems and Downstream Water:

The Value of Water Resources in the Pangani Basin, Tanzania

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EXECUTIVE SUMMARY

As water resources become increasingly scarce in Africa, the need for the use of economics to aid in decision-making and management becomes apparent. Indeed, global experience shows that economic approaches may achieve the best results. Water is the basis of the economy as well as essential for human life and biodiversity. The Pangani River Basin in north-eastern Tanzania provides a good starting point for evaluating the economic issues around water resources and how economics can be used to improve their management to align with national goals.

This document presents the findings of in-depth research into the economic benefits of the various activities in the Pangani River Basin. Decisions about the management, allocation and use of water should ideally maximise economic outputs from basin water uses and water utilisation over the long term. It should also sustain the ecosystems that supply and depend on water resources.

Macroeconomic and sectoral policies in Tanzania have a major impact on how water resources are used and managed, and currently provide little incentive for landowners to conserve catchment areas important for water supply, for industries and households to curb pollution, or for anyone with access to water to use it sparingly. At the same time, landowners in important catchment areas are not rewarded for conserving forests and soil, which would usually carry a cost to the landowner.

A drastic improvement in the management of the basin's water resources will also require improved funding. As it is, the Pangani Basin Water Office cannot meet their obligations adequately with their existing funding. There is an enormous capacity to increase the revenues from user fees due to the large degree of non-payment, and due to the fact that most users are currently not charged for water use at all. At the same time the high value of water in various uses underlines the capacity to institute some form of "payment for environmental services" scheme, where downstream water users compensate upstream catchment managers for the provision of ecosystem water services.

The increasing scarcity of water resources in the Pangani River Basin calls for strategic water resources management that will ensure the sustainability of water supply and the goods and services supplied by aquatic environments, as well as the efficient and equitable use of these resources. Sustaining water supplies for the numerous users in the basin will depend on reducing losses due to catchment degradation and wastage due to inefficient practices. The former will need to be addressed by creating incentives for catchment managers to maintain catchment forest areas, preferably through a system of 'payments for ecosystem services' which involves payment by those that benefit from the service, via the PBWO, to catchment managers. The price increases required for this will also serve as a demand management tool that encourages more efficient use of the water that is allocated to various uses.

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BACKGROUND

The project "Integrating Wetland Economic Values into River Basin Management" has the overall goal of more equitable, efficient and sustainable wetland and river basin management resulting from the practical application of environmental economics techniques and measures. To help to achieve this goal, its immediate objectives are:

- To increase awareness and capacity among planners, policy-makers and managers to identify and use economic measures for wetland conservation.

- To generate and disseminate practical and policy-relevant tools and examples of the use of economic measures for wetland conservation.

- To assess environmental economic aspects of wetland and river basin management at key sites, including the identification of wetland values, economic causes of wetland loss, incentives and financing mechanisms for wetland conservation.

- To work with local communities, government and non-government agencies and the private sector to integrate wetland economic values into development and conservation decision-making and to pilot concrete economic measures for wetland management.

National, regional and global case studies, policy briefs and technical working papers are being carried out as part of this project. These deal with the practical application of environmental economics techniques and measures to ecosystem and river basin management in different regions of the world, including Africa, Asia and Latin America.

This study was carried out in 2003 as a joint initiative between IUCN Eastern Africa Regional Office and the Pangani Basin Water Office. Its objectives were to provide first-cut estimates of the value of water in different uses within the Pangani River Basin, as well as to review various issues and economic tools pertaining to water resource allocation and financing mechanisms for Integrated River Basin Management. As a precursor to more in-depth studies in this and other basins, it also aimed to increase awareness and capacity among economic planners, water managers and decision-makers in the application and use of environmental and resource economics tools in Tanzania.

The application of economic tools to water resource management issues in the Pangani River Basin is considered to be an important step towards resolving water user conflicts and improving water allocation and management processes. At present, water is shared among a wide range of users, ranging from domestic use, large scale irrigation agriculture and hydroelectric power generation to pastoralists and the environment itself. With increasing demands on the water of this basin, coupled with a decreasing catchment runoff due to climate change, water resources are becoming increasingly scarce, leading to conflicts among users. Moreover, the way in which water is allocated in Tanzania will change under the new National Water Policy, which recognises subsistence needs and environmental water requirements, as well as the needs of future generations. Under the WANI initiative, the relationship between environmental flows and ecosystem health will be investigated in a comprehensive Environmental Flows study. The allocation of water between different users, including the environment, will be determined on the basis of economic values, subject to specified minimum ecosystem health obligations and basic human needs.

Water allocation is only one aspect of Integrated River Basin Management, however. Maximising the benefits from water in the basin will require various innovative management interventions such as the use of incentives to conserve catchment areas and to use water efficiently, as well as improving the effectiveness of management through monitoring and enforcement. Effective management, in turn, will need financing. This study touches briefly on all of these issues.

INTRODUCTION:
Valuing ecosystem water services

Objectives of the study

The objectives of this study are to provide first-cut estimates of the value of water in different uses within the Pangani River Basin, as well as to review various issues and economic tools pertaining to water resource allocation and financing mechanisms for Integrated River Basin Management (IRBM). As a precursor to more in-depth studies in this and other basins, it also aims to increase awareness and capacity among economic planners, water managers and decision-makers in the application and use of environmental and resource economics tools in Tanzania.

The terms of reference for the study were (in brief):

1. To estimate the economic and financial returns to alternative land and water uses in upstream and downstream areas of the Pangani River Basin, especially for poorer farmers, including:
   a. irrigation,
   b. hydropower generation,
   c. rural/urban water supplies and
   d. the environment;
2. To document basin-level incentives and disincentives for sustainable water resources management, including:
   a. Identifying existing incentives and disincentives
   b. Flagging positive and negative incentives for case studies, and
   c. Identifying key areas of conflict between user groups, government etc.;
3. To assess potential IRBM financing mechanisms in the Pangani River Basin, including:
   a. Documenting current level of financing and sources of funds
   b. Describing trends in financing and its sustainability
   c. Reporting on additional financial requirements for sustainable water management, and
   d. Identifying potential mechanisms for setting in place catchment fees;
4. To assess the impacts of macro-economic and national policies on sustainable water resources management;
5. To comment on the integration of economic instruments into sectoral policies, and
6. To identify areas of economic policy conflict at the transboundary level and propose solutions.

Emphasis was to be placed on the first task. In addition, the study was arranged to coincide with a related training workshop in environmental economics held at Mweka Wildlife College, Moshi. Thus, part of task 1 included training participants in the collection of such data, with some of those participants continuing with the study as enumerators.

Study approach

The study began by collecting and collating information on the study area, to build up a reasonable picture of land use and natural resources within the Pangani River Basin. This was used as a basis for identifying study sites and key stakeholders within the broader study area, in conjunction with the IUCN and Pangani Basin Water Office. In other words, the study covers only selected areas and aspects of water use in the basin as a whole.

The biophysical characteristics of the basin were described on the basis of GIS data collated by Tanrec (2003), and based on site visits. The population was estimated using recent (2002) detailed census data. The situation was also reviewed with regard to water supply and demand in the basin, including the amounts of water allocated to different types of uses at present. Water supply has been studied in detail within the basin (e.g. several contributions in Ngana 2001, 2002). Current water allocation and use was ascertained on the basis of data for over 3000 water use rights, which were categorised with the help of the Pangani Basin Water Office.

The value of water in **large-scale commercial agriculture** was estimated on the basis of interviews with managers of estates. Interviews ascertained, as far as possible, total area under production, total annual production, value of production, input costs, irrigation methods and quantity of water used.

The value of water in **small-scale agriculture** (a mixture of commercial and subsistence) and the value of direct **use of aquatic resources** (e.g. fish, reeds), was estimated on the basis of key informant interviews, focus group discussions and detailed household surveys, held in a total of 14 villages in four parts of the study area:

1. the densely-populated highland areas on the slopes of Mt Meru and Kilimanjaro around Arusha and Moshi,
2. the upper basin areas above Nyumba ya Mungu Dam,
3. the Kirua Swamp area, a major wetland area in the lowlands, and
4. the Pangani estuary and mangrove forest area at the coast.

Key informant and focus group discussions were carried out opportunistically, usually with village governments and key user groups. These served to obtain a general understanding of household practices, agricultural production systems and reliance on water and aquatic resources. The household questionnaire sought to quantify the value of agricultural production and value of wetland resource use (including value added). It also sought to put these values in context by describing the household economy as a whole. Thus the questionnaire covered a variety of household activities, including business and the use of upland (non-wetland) natural resources (Box 1). A total of 203 household interviews were carried out by ten local enumerators over a period of two weeks.

The value of **domestic water use** was estimated based on a combination of household survey data (giving consumption and rural prices for water), as well as population and municipal data.

The value of water in **power production** was estimated on the basis of interviews with TANESCO staff and three years' worth of daily data provided on flows and power generation of all three hydro-power facilities in the Pangani River Basin.

Values are all reported in Tanzanian Shillings (Tsh). The exchange rate is roughly Tsh1000 = US$1.

Limitations of the study

The valuation study was conducted over a period of 35 days of which 12 days were in the field, plus an additional 20 days for reviewing policy, incentives and financing issues. The limited time frame, especially for the valuation work, meant that the study could only concentrate on certain selected areas, and the figures produced in this report include some rough, first-cut estimates. The time frame did not allow an adequate degree of training of enumerators. The study was conducted without any of the advance "legwork" that is usually required in order to encourage co-operation from government officials and village leaders, which meant that much valuable time was lost in making arrangements. Wherever possible, advance parties were sent to announce the team's arrival, but this was at most two days ahead. Nevertheless, in spite of this, the overall level of co-operation was reasonably good, though generally better in inland areas than towards the coast.

Box 1. General structure of the household surveys.

HOUSEHOLD SURVEYS

A. Household information.
Household size and composition

B. Relative value of household production
Respondents were asked to apportion a pile of beans among different sources of income (crops, livestock, fishing, wetland resources, upland resources, employment, business and remittances) to indicate their relative contribution to household income in an average year.

C. Natural resources
Respondents were asked about fishing, wood products (forest or mangrove), honey, hunting, reeds, papyrus, grasses, palms, food and medicinal plants, clay and salt production. For each resource they were asked about the following, as applicable:

- whether they harvest the resource, and in the case of fishing, household fishing effort and equipment
- amount harvested over the past year,
- amount sold and price per unit
- amount of products produced from natural resources
- amount sold and prices obtained,

D. Livestock
Questions were asked on the following:

- numbers of small and large stock
- production and sales over the past year, and prices obtained

E. Crops
Questions were asked on the following:

- total area cultivated, and which crops grown
- input costs
- amount produced in the last year for each crop
- amount sold or exchanged, and price obtained

F. Water consumption

- Amount of water used for irrigation
- Amount of water used for domestic consumption.

Tasks 2 to 6 involved interviews with key informants, as well as review of relevant literature. No new calculations were made.

The national economy and macro-economic reforms

Tanzania's GDP for 2002 was Tsh 8 618 071 million, with agriculture, forestry, fishing and hunting making up 44% of this. Agriculture alone contributes Tsh 3 310 977 million. Average per capita incomes are Tsh 256 608 (roughly $257) (National Accounts of Tanzania 1992-2002). The study area contributes about 16% of Tanzania's GDP, and average per capita incomes in the basin are close to the national average.

The country has ambitious goals for economic growth and development which are reflected in its policies for macro-economic reform (see Appendix 1 for an overview of Tanzania's macro-economic reforms). As outlined in the Tanzania Development Vision 2025, Tanzania plans to transform itself into a middle-income country by 2025, by changing from the current low productivity agricultural economy to a semi-industrialised economy. In its Poverty Reduction Strategy Paper (PRSP), Tanzania sets out the medium strategy for poverty reduction by 2010. None of this will be possible, however, without adequate water resources. Indeed, in both these initiatives, water is seen as a strategic resource for socio-economic development of Tanzania. The effective management of water resources is recognised as being a central development challenge impacting most sectors and a necessary pre-condition for poverty alleviation.

National issues affecting water resources management

One of the major challenges for achieving its economic transformation is the fact that Tanzania faces water scarcity, despite having apparently abundant water resources estimated at 2 700 m^3/capita/year (Table 1). To some extent, the degree to which this water is available is limited by limited supply infrastructure which can capture seasonal flows and mitigate inter-annual variability in natural supplies. However, other factors are probably far more important. These include growing water demands, environmental degradation which reduces natural supplies, and inefficiency in the allocation and use of available water supplies.

Table 1: Use of water in Tanzania

Total freshwater withdrawal (Mm^3/yr	Estimated per capita withdrawal m^3/p/yr	Domestic use (%)	Industrial Use (%)	Agriculture use (%)	Domestic use m^3/p/yr	Industrial Use m^3/p/yr	Agriculture use m^3/p/yr
1170	35	9	2	89	3	1	31

Source: www.worldwater.org/table2.html

As populations have grown and economic performance steadily improved, the demands for water for all social and economic sectors have also increased. The rapid population and economic growth have not been accompanied by an equal rate of development in services – water, sewerage, agricultural and energy supplies, and waste disposal – but on the contrary, in growing competition over water, increasing pollution, land degradation and other stresses on the water resources.

Some of the most important problems also include the inefficiency of water use and resultant wastage, such as low efficiencies of many irrigation schemes (estimated at 10 – 15%), and leakage from domestic water supplies, which are estimated to lose up to 52%. Management is also made difficult by inadequate water resources data, institutional overlaps or gaps in control, lack of sufficient skilled manpower and inadequate financial resources.

Policy and legal framework for water resources management in Tanzania

Policy framework

Tanzania has adopted a very progressive National Water Policy (URT 2002) that aims to develop a comprehensive framework for sustainable development and management of the nation's water resources. This includes:

- The introduction of cost sharing and beneficiary participation in planning, construction, operation and maintenance of community-based domestic water supply schemes; and
- A composition of 3 sub-sectors, one of which is Water Resources Management which would aim to provide a comprehensive framework for promoting optimal, sustainable and equitable development and use of water resources for the benefit of all.

For water resources management the policy envisages that:

- Water allocation shall be prioritised for human needs (adequate quantity and acceptable quality) and for environmental protection (environmental flows);
- A sound information and knowledge base including both data on surface and groundwater, social and economic data shall be established;
- Fees and government subvention will finance water resources management. The fee system include a fee for conservation; and
- Use of technical, economic, administrative and legal instruments will be enhanced. Proposed economic instruments include water pricing, charges and penalties

Legislation

The new National Water Policy has not yet been incorporated into legislation. Water resources management in Tanzania is governed by the Water Utilisation (Control and Regulation) Act No. 42 of 1974 as amended by Act No. 10 of 1981, Act No. 17 of 1989, Water Laws (Miscellaneous Amendments) Act No. 8 of 1997 and Water Laws (Miscellaneous Amendments) Act of 1999, which relates to the administration of granting of rights to water users. The regulations provide in detail for the granting of water rights (1975), and determine water use fees for various water uses (1994, 1996; Table 2).

All of this legislation is currently being revised, based on the provisions of the new policy. Among many important elements in the proposed legislation is the charging for water and financing of water management.

Table 2: Current water use fees in Tanzania

Item	Matter	Fees (Tsh)	Fees (US$)
1	Water rights application for domestic/livestock, small scale irrigation/fish farming	40,000	40
2	Water rights application for large-scale irrigation / power generation / industrial / commercial	150,000	150
3	All other applications	40,000	40
4	On every appeal to the Minister	70,000	70
5	Economic water user fees		
	a) Domestic/livestock/fish farming for every $100m^3$		

Item	Matter	Fees (Tsh)	Fees (US$)
	• All abstractions less than 37 litres/second, flat rate	35,000	35
	• All abstractions equal or above 37 litres/second for 100m3	35	0.035
	b) Irrigation:		
	Small scale		
	• All abstractions less than 3.7 litres/second, flat rate	35,000	35
	• All abstractions equal or above 3.7 litres/second for 1,000m^3	35	0.035
	Large scale for every		
	• All abstractions less than 18.5 litres/second, flat rate	*35,000*	35
	• All abstractions equal or above 18.5 litres/second for 1,000m3	*70*	0.07
	Business (e.g. flower export) for every 1,000 m3	*1,000*	1
6	TANESCO power Royalty Fees	165,500,000	165,500
7	Industrial for every	100	0.10
	• All abstractions less than 1.11 litres/second, flat rate	35,000	35
	• All abstractions equal or above 1.11 litres/second for 1,000m3	35	0.035
8	Institutional / Regional centres		
	• All abstractions less than 1.4 litres/second, flat rate	35,000	35
	• All abstractions equal or above 1.4 litres/second for 100m3		
	Urban Water and Sewerage Authorities		
	Category A for every 100m^3	120	0.12
	Category B for every 90 m^3	100	0.10
9	Commercial for every		
	• All abstractions less than 0.94 litres/second, flat rate	35,000	35
	• All abstractions equal or above 0.94 litres/second for 100m3	150	0.15
10	Mining for every 100m^3	170	0.17

Source: Water Utilisation Act, 1999. 1 US$ = 1,000 Tsh

Definition of the Pangani River Basin

The Pangani River Basin, situated in the north-east of Tanzania, covers a total area of some 43 000 km^2, or 4.3 million ha. About 5.4% of this area is in Kenya. Note that the "Pangani River Basin", which is the study area selected by the WANI initiative, is defined on the basis of drainage patterns, and is not the same as the "Pangani Basin" which is the jurisdiction of the Pangani Basin Water Office. The latter also incorporates three smaller basins adjacent to the Pangani River Basin (Figure 1), and covers a total area of about 56 000 km^2. The terms "Pangani River Basin" and "Pangani Basin" thus have two different meanings and are carefully applied as such in this report.

The Pangani River Basin covers parts of Kilimanjaro, Manyara, Arusha and Tanga regions (Manyara has recently been subdivided from Arusha Region). Within these, it covers part or all of fourteen districts and two municipalities (Arusha and Moshi; Figure 2).

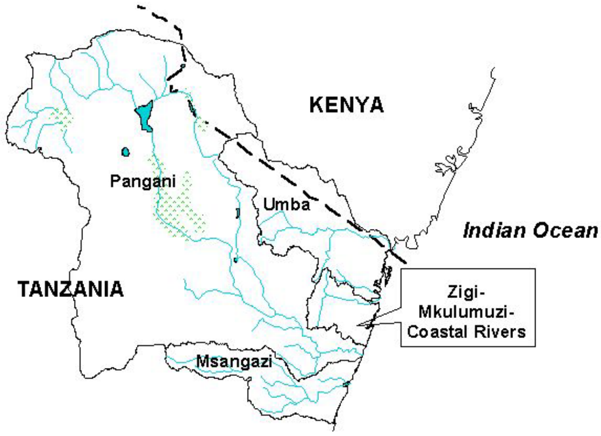

Figure 1: Map showing the river basins administered by the Pangani Basin Water Office, including the Pangani River Basin. Source: Pangani Basin Water Office

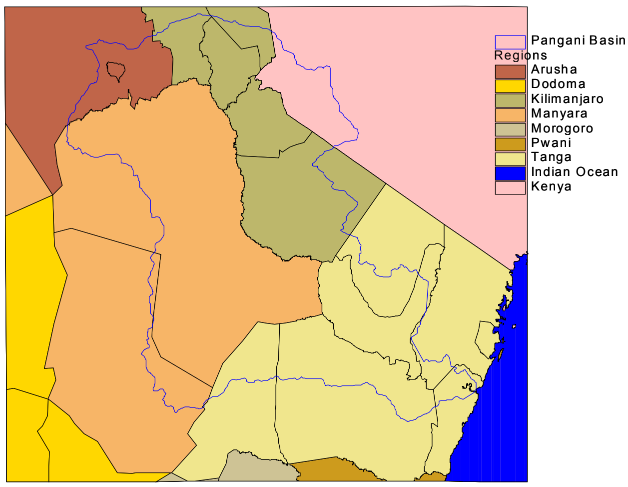

Figure 2: Map showing position of the Pangani River Basin (outlined in blue) in relation to Tanzanian regions and districts and Kenya, and showing major population centres

Table 3: Area of districts occurring within the Pangani River Basin, based on GIS data

Region	District	Area within Pangani R. Basin (km^2)	% contribution of each district to basin area
Arusha	Arusha	103.51	0.24
	Monduli/Arumeru	2 266.25	5.25
Manyara	Simanjiro	16 620.51	38.48
	Kiteto	1 290.84	2.99
Kilimanjaro	Hai	1 224.62	2.84
	Moshi urban, rural	1 527.53	3.54
	Mwanga	2 003.96	4.64
	Rombo	619.93	1.44
	Same	4 970.72	11.51
Tanga	Lushoto	1 387.88	3.21
	Korogwe	2 974.05	6.89

Region	District	Area within Pangani R. Basin (km^2)	% contribution of each district to basin area
	Muheza	410.74	0.95
	Pangani	462.86	1.07
	Handeni + Kilindi	4 987.64	11.55
Ocean		7.59	0.02
Kenya		2 333.90	5.40
	Total Area	**43 192.54**	**100.00**

Topography and rainfall

The Pangani River Basin is bordered by Mt Kilimanjaro (5895masl), Mt Meru and the Pare and Usambara Mountains to the north and north east, and encompasses the Simanjiro and Kitwei plains to the south west. Lowlands (up to 900masl) make up about 50% of the basin (Pamoja 2003).

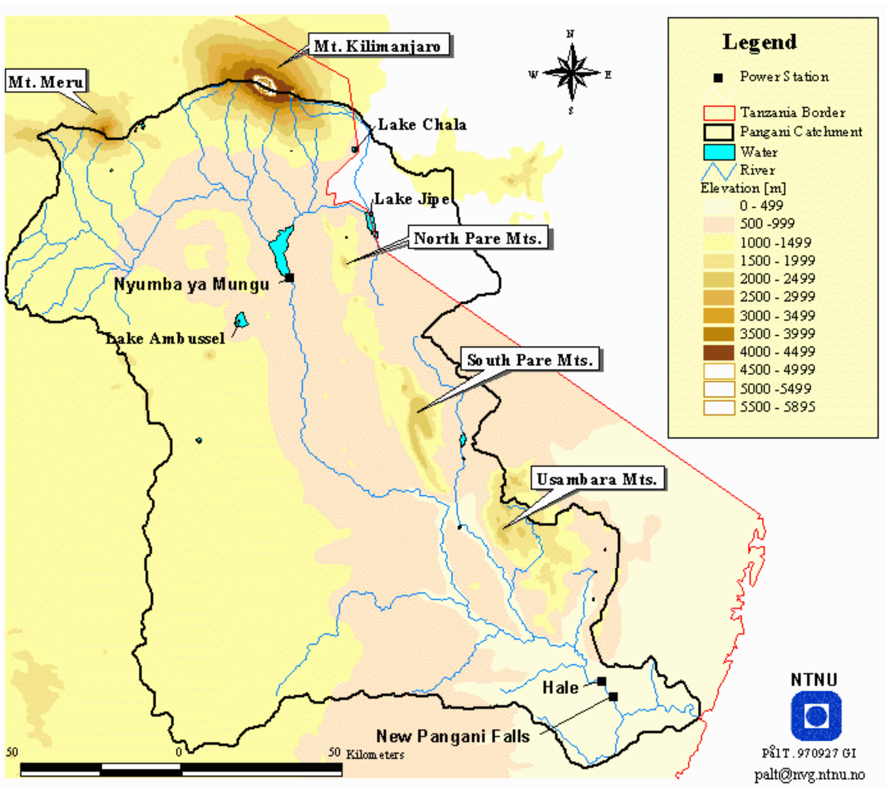

Figure 3: Topography of the Pangani River Basin. Source: Norwegian University of Science and Technology

Rainfall patterns are largely related to altitude, with the highlands receiving about 1-2000 mm annually, and the lowlands receiving 5-600 mm. Rainfall is bimodal, occurring mainly in March-June, with short rains in November-December.

Rivers and wetlands

The Pangani (or Ruvu) River rises on Mt Kilimanjaro, and flows over 500km before draining via the Pangani estuary into the Indian Ocean, just south of Tanga. The name Ruvu is more frequently used in the upper parts of the catchment, while Pangani is used more frequently as the river nears Pangani Town (after which the river was named, not *vice versa*), at the coast. In this study, the Ruvu/Pangani is termed Pangani from source to mouth to avoid confusion.

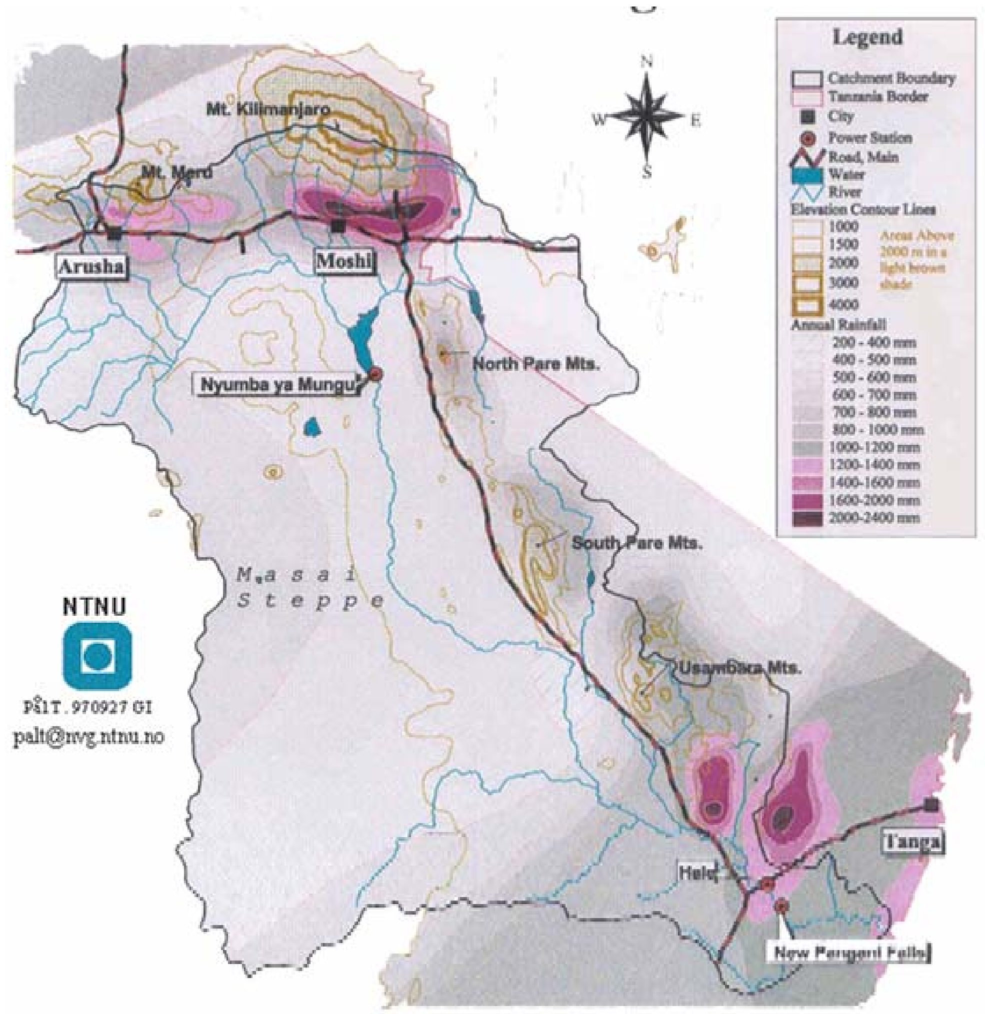

Figure 4: . Rainfall map of Pangani Basin. Source: Norwegian University of Science and Technology

The Pangani River has several major tributaries. The Kikuletwa River rises on Mt Meru, and joins the Pangani at Nyumba ya Mungu, now the site of a major dam. Above this confluence the Pangani is almost exclusively known as the Ruvu River. The Kikuletwa is fed by the Shambarai system, Upper Kikuletwa, Chemka, Kware Sanya, Karanga, Weruweru and Kikafu Rivers. The Pangani (Ruvu) above the confluence is fed by the Himo, Mue (joined by Miwaleni), and the Rau (joined by Njoro). Much of the water in these systems is from natural springs. Below the confluence with the Kikuletwa, the river is joined by the Mkomazi River, which is fed by the Muraini River, the latter having its source at Lake Jipe on the Kenya-Tanzania border, and by the Luengera River. Numerous smaller tributaries enter the river nearer the coast.

The Nyumba ya Mungu Dam, constructed in 1965 originally for water supply, irrigation and water control, but now used for power supply, constitutes the largest open water body in the study area. It covers an area of 14 000 ha (Røhr & Killingtveit 2002) to 18 000 ha (Bwathondi & Mwamsojo 1993), some 55% of the basin's surface water (Røhr & Killingtveit 2002). Natural lakes include Lake Jipe (1800-2800 ha) and Lake Chala (315ha) on the Kenyan border (Geheb 2003) and Lake Ambussel on the Lossogonoi Plateau, south of Nyumba ya Mungu.

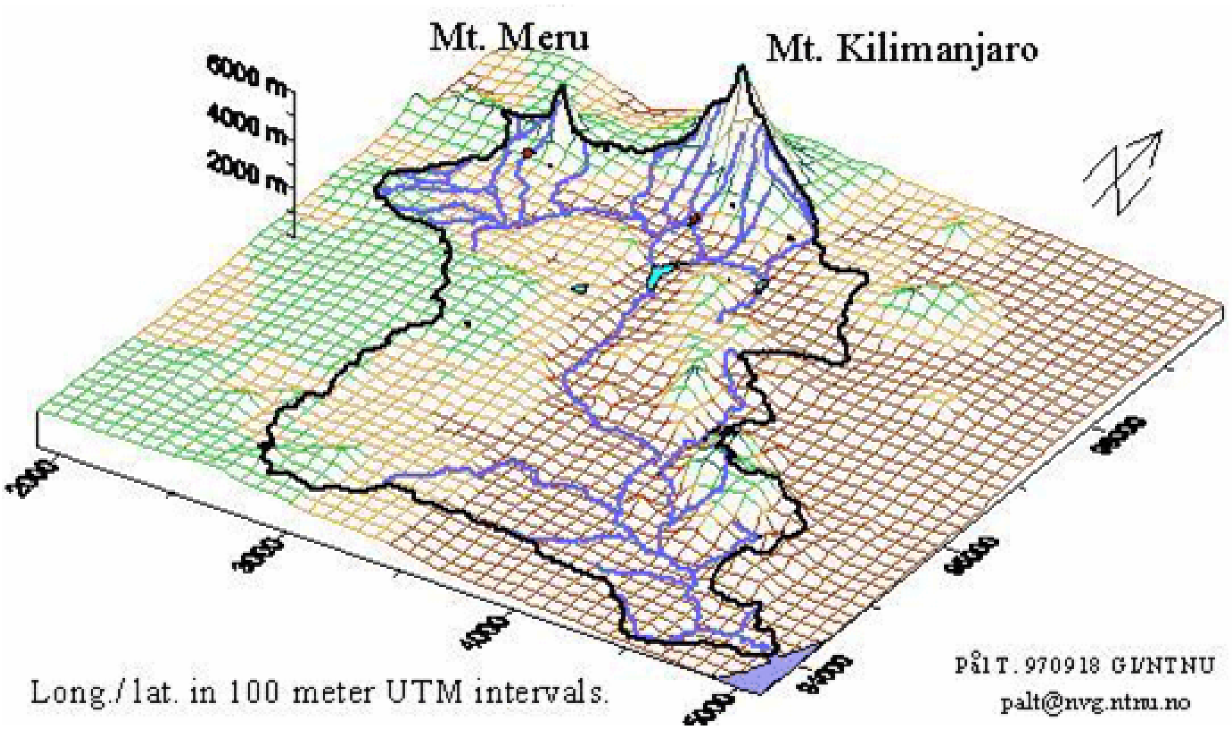

Figure 5: Digital terrain model showing topography and rivers in the study area. Source: Norwegian University of Science and Technology

Wetlands in the basin include the Ruvu swamps (3 500 ha) at Lake Jipe, the wetland at the Pangani-Kikuletwa confluence (4 000 ha), and the Kirua swamps (originally 90 000 ha) downstream of Nyumba ya Mungu (Geheb 2003, Baker & Baker 2001). Much of this wetland area has been lost since the construction of the Nyumba ya Mungu Dam, which inundates much of the original wetland area at the Pangani-Kikuletwa confluence (4000 ha remain), and has led to the drying up of a large portion of the Kirua Swamps. Recent mapping of the study area suggests that only 36 500 ha of swamps remain, suggesting that the Kirua swamps have been reduced by two-thirds to about 29 000 ha. In addition to the above mentioned wetlands, narrow floodplains supporting floodplain vegetation are found along major rivers throughout the basin, and major wetlands occur in the lower Mkomazi plains. The Pangani estuary also contains some 750 ha of mangroves (URT 1991).

Vegetation

Vegetation varies dramatically through the basin (Figure 6), ranging from forests on mountain slopes, to arid grasslands, and reflects differences in altitude and precipitation. Much of the basin area to the south of the Pangani River is arid. Apart from the more mesic floodplain vegetation, vegetation on the north bank is initially arid, becoming more mesic at higher altitudes and towards the coast. Mt Kilimanjaro and Mt Meru can be described as lush vegetation islands emerging from a very arid landscape.

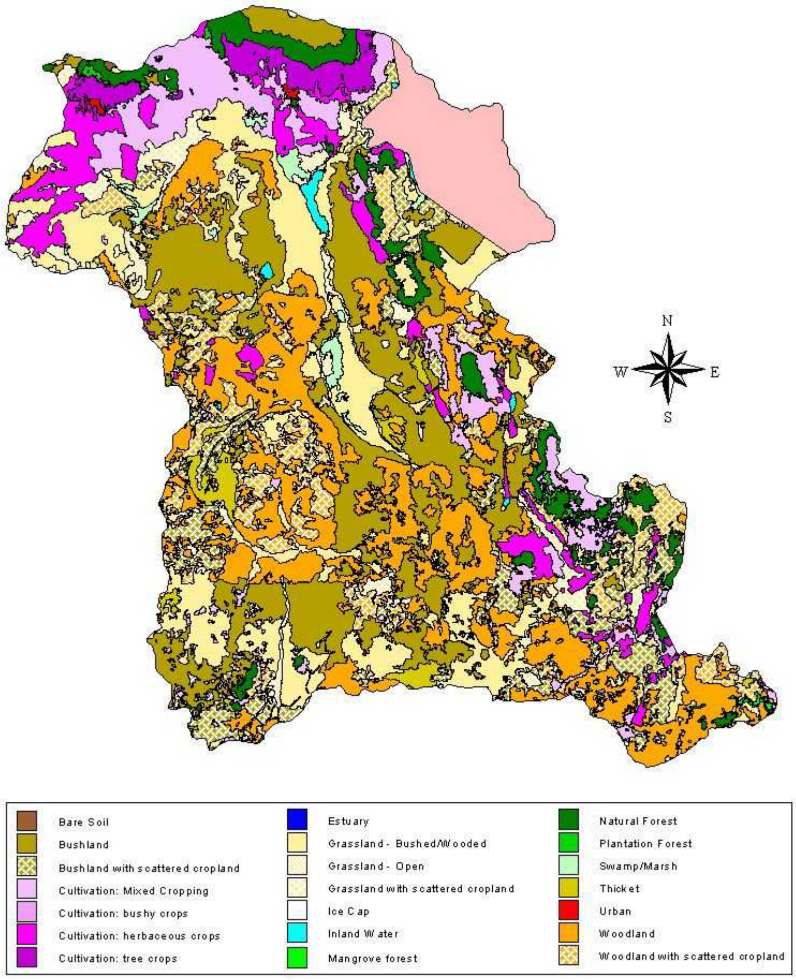

Figure 6: Map of the Pangani River Basin showing major natural features, vegetation types and land uses. Source: Tanrec GIS data, IUCN

Table 4: Land cover within the basin, as defined by Tanric / FRMP data of 1996. Areas are in km^2. Multiply by 100 to get ha

Land Cover Type	**Area in km^2**	**%**
Ice cap - snow	5.74	0.01
Bare Soil	9.23	0.02
Natural Forest	1 793.66	4.15
Closed Woodland	1 024.21	2.37
Open Woodland	7 147.65	16.55
Bushland with Emergent Trees	6 830.78	15.82
Dense Bushland	881.96	2.04
Open Bushalnd	563.45	1.30
Thicket with Emergent Trees	660.98	1.53
Thicket	7.11	0.02
Wooded Grassland	2 582.98	5.98
Wooded Grassland (Seasonally inundated)	67.92	0.16
Bushed Grassland	2 078.08	4.81
Bushland Grassland (Seasonally inundated)	1 581.95	3.66
Open Grassland	133.04	0.31

Land Cover Type	Area in km^2	%
Open Grassland (Seasonally inundated)	545.44	1.26
Inland Water	170.75	0.40
Swamp/Marsh (Permanent)	365.62	0.85
Mangrove Forest	30.00	0.07
Estuary	7.59	0.02
URBAN	69.88	0.16
Plantation Forest	119.61	0.28
Cultivation with Tree crops (with shade trees)	881.93	2.04
Cultivation with Bushy Crops (e.g. tea)	44.26	0.10
Cultivation with Herbaceous crops	2 318.93	5.37
Mixed Cropping	3 331.38	7.71
Grassland with Scattered cropland	1 193.77	2.76
Bushland with Scattered cropland	3 196.87	7.40
Woodland with Scattered Cropland	3 211.84	7.44
KENYA	2 333.90	5.40
Total Area	**43 190.51**	**100.00**

Land use in the Pangani River Basin

Cultivation patterns reflect the rainfall and vegetation patterns of the basin, with most cultivation being on the lower mountain slopes around Mt Kilimanjaro and Mt Meru, the foothills of the Pare and Usambara Mountains, and along narrow river floodplains. Based on GIS data (Table 4), plantation forests have replaced natural forests on about 12 000 ha of upper mountain slopes. Just below this, coffee is grown under shade trees or banana trees over an area of about 88 000 ha. Surrounding this, mainly on lower mountain slopes and foothills, about 333 000 ha are under mixed cropping, and a further 232 000 ha is under ‘herbaceous’ crops, which would include sugar, rice and vegetable crops. Further from the major urban centres, scattered croplands associated with smaller settlements are found over about 760 000 ha of grassland, bushland and woodland. These figures are for general areas and probably are much larger than the actual ploughed area, especially in the latter case.

Population

The total population of the districts falling wholly or largely within the Pangani River Basin is in the order of 4 million (2002 census data), having grown from about 2.85 million in 1988 (Pamoja 2003). However, a fairly large proportion of some of these districts falls outside the basin. Taking this into account, the total population of the Pangani River Basin was estimated to be about 2.6 million (Table 5). Based on average household size per district (2002 census data), the total number of households was estimated to be approximately 575 000. In comparison, the total population of the Pangani Basin was estimated to be 3.6 million, in roughly 800 000 households. These figures exclude the population in the Kenyan portion of the basin.

Table 5: Estimated population and number of households (Hh) within the Pangani River Basin and the whole Pangani Basin, based on 2002 census data

Region	District/town	Population	Pangani River Basin		Pangani Basin	
		2002	Population	Hh	Population	Hh
Arusha	Arusha urban	282,712	282,712	72,490	282,712	72,490
	Arumeru	516,814	516,814	112,351	516,814	112,351
Manyara	Simanjiro	141,676	127,508	29,653	127,508	29,653
	Kiteto	152,757	15,276	3,182	15,276	3,182
Kilimanjaro	Hai	259,958	129,979	28,884	129,979	28,884

Region	District/town	Population	Pangani River Basin		Pangani Basin	
	Moshi urban	144,336	144,336	35,204	144,336	35,204
	Moshi rural	402,431	402,431	85,624	402,431	85,624
	Mwanga	115,620	115,620	24,088	115,620	24,088
	Rombo	246,479	61,620	12,575	61,620	12,575
	Same	212,325	191,093	39,811	191,093	39,811
Tanga	Lushoto	419,970	167,988	35,742	419,970	89,355
	Korogwe	261,004	261,004	58,001	261,004	58,001
	Muheza	279,423	55,885	12,419	279,423	62,094
	Pangani	44,107	13,232	3,393	44,107	11,309
	Handeni	249,572	74,872	15,598	249,572	51,994
	Kilindi	144,359	28,872	5,892	144,359	29,461
	Tanga Urban	243,580	0	-	243,580	52,952
TOTAL			**2,589,240**	**574,907**	**3,629,403**	**799,029**

Population growth rates are currently estimated at 4.0% in Arusha Region, 3.8% in Manyara, 1.6% in Kilimanjaro and 1.8% in Tanga. It is widely held that there is much emigration within the basin from the overpopulated highland areas to the lowlands as people move in search of land (Mbonile 2002, Lein 2002). Nevertheless, the overall population increase over the past 14 years (since the 1988 census) has been greater in highland than lowland areas of the basin. Over this period, the population of Arusha town has increased over twofold (2.1 times), while that of surrounding Arumeru district and of Moshi town have increased 1.6 and 1.5 times, respectively. In comparison, all of the remaining areas have increased by factors of 1.17 to 1.25.

ISSUES AND CONCERNS:
Water supply, use and allocation

Water supply in Pangani Basin is largely from precipitation in the high altitude areas of the catchment, with precipitation on Mt Kilimanjaro providing some 55% of the basin's surface water (Røhr & Killingtveit 2002). Precipitation is highly seasonal, but year round water supplies are ensured by glacial melt of the ice cap and by infiltration of this and rainfall underground to emerge as spring-fed streams. Hundreds of streams merge to form perennial rivers in the upper catchment, which form the Kikuletwa and Pangani (Ruvu) Rivers. Streams in the lower basin tend to be more ephemeral, and make very little contribution to flow (Ngana 2001b).

Water supply is as least partly dependent on catchment forests, which facilitate infiltration and regulate flow so that water is released over a long time. Degradation of these forests leads to faster runoff with erosion, increased seasonality in stream flow, which leads to problems for domestic, power and irrigation users. Conservation of catchment forests would ensure permanent and good water supplies for all these uses.

The Pangani River Basin receives an average of 34 773 Mm^3 annually (Geheb 2003), of which flow into Nyumba ya Mungu is thought to be 43.37 m^3/s (~ 1 368 Mm^3 per year; TANESCO 1994), and discharge at the mouth is estimated as 850 Mm^3 per year (Van den Bossche & Beracsek 1990). Along the way, much of the water is lost to evaporation, evapotranspiration and infiltration, as well as consumption in various activities.

Water is abstracted for numerous purposes throughout the basin, but particularly in the highland and upper basin areas which are heavily populated and where most of the demand for agricultural, industrial, mining and domestic use of water occurs. Springs and rivers are tapped by about 2000 traditional irrigation furrows, mainly in the upper basin, but to some extent all the way down the main rivers. Many of these traditional furrows have been upgraded, increasing their efficiency of water delivery. In Kilimanjaro Region, water abstracted for irrigation amounts to about 80% of total water use, with only a limited amount being expected to return and contribute to river flow (Ngana 2001b). Abstraction is steadily increasing, and pollution is also a problem, especially in the Rau River, into which industries in Moshi Municipality discharge effluents, and Moshi Municipality discharges raw sewage (Ngana 2001b). Since 1994, it has been illegal to construct new furrows. Nevertheless, as more people settle in areas such as Kirua Swamps, they alter the existing furrows to take more water, by damming the river a little more.

There are three operational hydro-electric power (HEP) stations within Pangani Basin: Nyumba ya Mungu, Hale and New Pangani. All are managed by the Tanzania Electric Supply Company (TANESCO). Only Nyumba ya Mungu is associated with a major dam, but it should be noted that this reservoir regulates water for all three HEP stations. HEP is not a consumer of water, but requires sufficient flow through its turbines to meet electricity demands. In the case of Nyumba ya Mungu, this requires storage of water in the dam in periods of high flow, for release through the turbines during periods of low flow. This act of storage changes the availability of water to downstream users, including other downstream power stations (Hale and New Pangani). Since 1994, Nyumba ya Mungu has released less than 28Mm^3. As a direct result of this, the Kirua swamp has largely dried up (Sarmett, pers comm). The environment has only been recognised as a legitimate user of water since the new Water Policy was adopted in 2002, and water allocation (e.g. supply to Kirua swamp) has not yet been altered in this regard.

Since 1991, water supply has been managed by the Pangani Basin Board (representing different stakeholders), through the Pangani Basin Water Office. Water users apply for and are allocated rights to certain amounts of flow (given in m^3/s) by the office, based on a general understanding of supply and demand for water around the basin. Existing mechanisms for the allocation of water to different users (e.g. equity issues) are not clearly defined. The details of water rights holders and other users are kept in an electronic database of over 3000 lines. Analysis of these data suggests that agriculture is the biggest user in the basin, particularly in small-holder farms, although large scale irrigation also takes a major share (Figure 7). Among agricultural users (note that users can mean groups of users), there are reportedly about 850 authorised users and over 2000 users that do not have user rights, the latter being mainly small-scale traditional furrow farmers (FBD 2003). Domestic use is another major consumer of water, while industrial uses take a relatively small share. The small amount allocated to power reflects consumption by power companies rather than power station throughput, since hydropower is not a consumer of water.

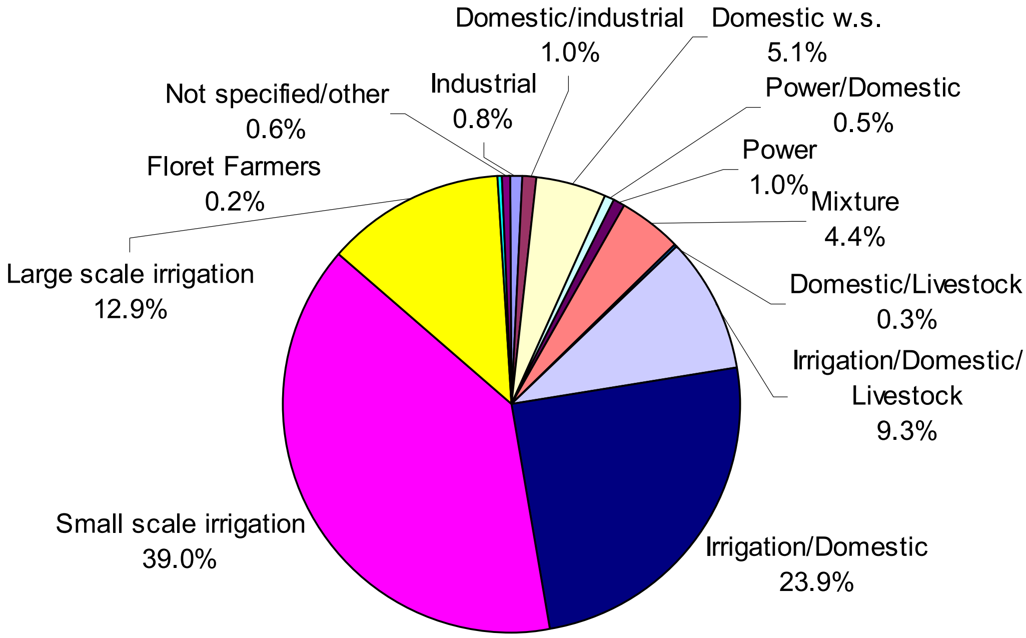

Figure 7: Proportion of total flows allocated to different categories of use. Based on raw data from Pangani Basin Water Office (October 2003)

Most water users generate return flows, which means that the above representation of water use is rather an abstract representation of water allocation, since some of the water allocated to agriculture in the upper basin may be reused in agriculture or other uses in the lower basin. The analysis of water use in different areas of the basin probably provides a better reflection of how water is used.

Most of the water allocated in the basin is to the high-lying districts of Moshi, Arumeru, Arusha and Hai (Figure 8), with all of the large-scale irrigated agriculture occurring in these areas. The total allocation accounted for amounts to some 1 881 Mm^3 per year, including estimated use without water rights. The PBWO has estimated that 1 800 Mm^3 is used in irrigation agriculture and about 80 Mm^3 is used for domestic, industrial and commercial purposes. The allocation may not reflect actual consumption of water, however, since the allocated flows do not always reach the rights holders in full, or may not always be demanded in full (e.g. during the rainy seasons), and does not take return flows into account. The actual consumption (net of return flows) per sector needs to be understood

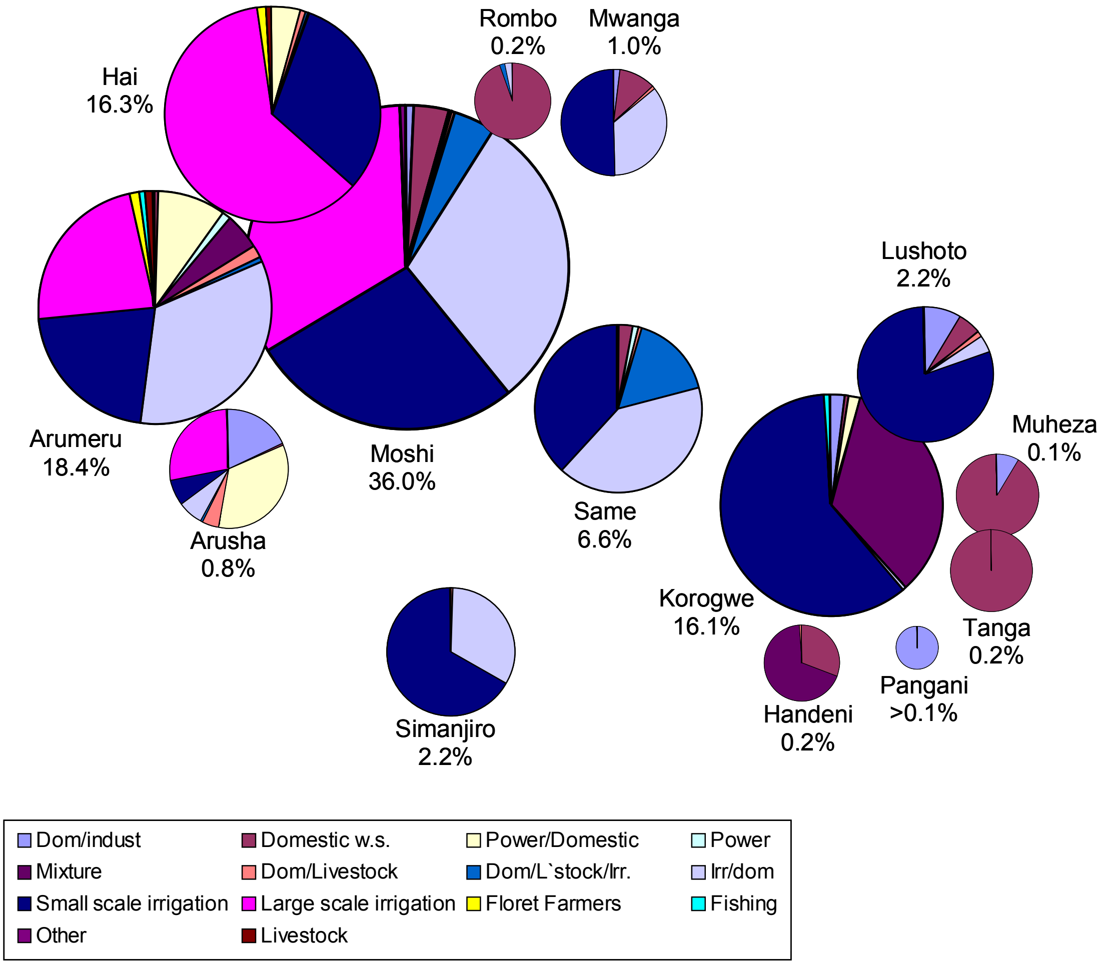

Figure 8: Allocation of water to different uses in each of the districts of the Pangani Basin. Sizes of the pie diagrams roughly represent relative amounts of water allocated. Based on data from Pangani Basin Water Office

Threats to water supply

The most alarming trend is the shrinking of the Mt Kilimanjaro's ice cap, which is the lifeline of water resources in Pangani Basin. This has been attributed to regional warming most likely linked to global climate change. Between 1912 and 2000, some 82% of the ice cap had been lost, with 55% having been lost between 1962 and 2000. Mount Kilimanjaro currently provides 60% of the inflow to Nyumba ya Mungu and 55% of the Pangani Basin's surface water.

In addition, there are serious threats to the catchment forests that protect water supplies and affect the timing of flows. Some 96% of the water flowing from the mountain comes from the forest belt. These forests are diminishing due to:

- Demand for land;
- Demand for timber and fuel wood;
- Demand for pasture;
- Weak enforcement of regulation; and
- Periodic fires.

The quality of water supply is also threatened by increasing pollution due to agricultural, industrial, mining, agricultural and urban runoff, a problem that has not been adequately addressed.

Increasing demand for water

Due to population growth and immigration, there is increasing water demand for irrigation, domestic and industrial water use. Some 80% of people in the Pangani Basin rely either directly or indirectly on agriculture for their livelihoods, with irrigation playing an important role. This places high demands on water, especially since irrigation efficiency is extremely low, estimated at less than 20%. The particularly high growth in urban populations in the basin, due in part to the tourism industry, places a growing burden on water resources.

Shortages for power generation

Water shortages and increasing settlement in the basin is also leading to serious problems for hydropower generation. The firm discharge (guaranteed supply) for the hydropower stations is about half of the discharge required to achieve maximum performance. During dry seasons, water shortage may cause power generation within the basin to drop to as low as 32% of capacity. These problems are exacerbated by the fact that, of the 24 tonnes/ha/year soil eroded from the Pangani Basin catchment, 13 tonnes/ha/year is deposited in Nyumba ya Mungu (58%), gradually reducing its water storage capacity and shortening the lifespan of the dam.

Environmental degradation due to water use

Abstraction, storage and evaporation of flows for consumptive uses and hydropower generation are depriving downstream ecosystems of flows required to maintain ecological functioning, thereby affecting users of the goods and services provided by these ecosystems.

Although hydropower does not consume water, the system claims certain inflow to the reservoirs thus "binding up" the water resources (857 million m^3/year of discharge), making it less available to other users (opportunity cost), plus losses through evaporation (250 million m^3/year (30%)). A worrying fact is that the capture of wet season flows by the Nyumba ya Mungu dam for use during dry season is perceived in a positive light as ‘preventing the waste of excess water during the rainy season‘, but without taking cognisance of downstream ecosystems that require these flows for their functioning (see below). The Kirua Swamp has not received any major floods since before 1991, and the wetland habitat is highly threatened. The wetland needs a flow of >24 m^3/sec from Nyumba ya Mungu in order to flood. The amount released by Nyumba ya Mungu varies seasonally, but only ranges from about 12 to 20 m^3/sec (Sarmett, PWBO, pers. comm.). Thus, the Kirua swamps have dried up as a result of the regulation of water flows issuing from Nyumba ya Mungu dam.

Decreased riverine inputs into the estuarine and marine environment affecting fisheries production, in that many inshore marine species are dependent on the nutrient input associated with freshwater inflows as well as the salinity gradients in the functional estuarine environment for the productivity. This has not previously been raised as an issue in the Pangani Basin, but is probably an issue here, as has been demonstrated for numerous other river basins. Indeed, fishery declines that are reported from Pangani estuary are likely to be related to decreases in water supply as well as management.

Decrease in river flow also allows salt water to penetrate further upstream in estuaries during the pushing tide. It is suspected that this has been the case at the Pangani river mouth. Concerns are that salt intrusion may cause damage to the 753 ha of mangroves and may affect the coconut and betelnut plantations around the estuary. This is a concern both to small-scale users and to large-scale commercial growers. There is no documented evidence of these effects, however.

Environmental degradation is also occurring due to polluted runoff. For example, the fishery at Lake Jipe is in jeopardy due to such extensive weed encroachment (*Typha* has colonised to about 200m into the lake along parts of the shore), that people can no longer fish. This is probably due to polluted runoff into the lake.

The Nyumba ya Mungu reservoir fisheries productivity has declined from 28,000 tonnes in 1968 to 1,800-5,000 tonnes in the 1980s to present day. This is popularly ascribed to overfishing and the 13 tonnes of soil per hectare of catchment flowing into the dam. However, it should be understood that fishery production booms shortly after dam construction (in this case 1964) before settling down to lower production levels. The changes in this fishery is thus unlikely to be a water supply or pollution issue.

Conflicts over water resources

Water shortages in Tanzania have been attributed to several factors ranging from a) increasing demand for water, energy and products whose production requires water for burgeoning populations; b) drought, and; c) poor coordination between sectoral planners and inadequate water resources management. By the year 2025, it has been projected that Tanzania on the whole will be water-stressed (Mutayoba, 2003). For instance water resources in Pangani and Rufiji river basins have become scarce and appear to be over-apportioned. These two basins contain most of the irrigated areas and all the existing hydropower production in Tanzania. Surface water in the Pangani Basin is over-apportioned even though a variety of current water demands, for example urban and rural water supplies, have not been met. This has led to a deficit in water available for the multiple uses in the basin as demonstrated by the water balance of inflows into and outflows from Nyumba ya Mungu showing a deficit of 2.2 m^3/sec (required inflow is 28.5 m^3/sec while observed inflow is 26.3 m^3/sec) (Mutayoba, 2003).

Uncoordinated planning in the past for water use, inadequate water resources data and inefficient water use has resulted in conflicts between sectoral users of water and interests that affect water use. These conflicts are bound to increase in future if management practices remain the same and demand for water rises.

Mutayoba (2003) and Geheb (2003) summarise the main conflicts as follows:

- Energy and irrigation sectors – irrigation systems are mostly located upstream of the hydropower plants. Tanzania Electricity Supply Company (TANESCO) is blaming the increased water abstractions by irrigation farmers upstream of the Nyumba ya Mungu dam on their water shortages. Farmers perceive basin management as a ploy by TANESCO to deprive them from exercising their historical (customary) rights to use water for irrigation;
- Irrigation and aquatic ecosystems;
- Hydropower and aquatic ecosystems;
- Pastoralists and farmers (though this is more of a land issue than a water issue);
- Upstream and downstream users, even within a sector. A good example of the latter is the 2 300 hectare Lower Moshi Irrigation Scheme (LMIS), which was developed in late 1980s. The scheme initially had sufficient water inflows. However, farmers upstream of Rau River began shifting to rice irrigation, which has now expanded to 3 000 hectares without proper water rights, and abstracting most of the water that was meant for the LMIS.

Financing of water resources management

The Pangani Basin Water Office is mandated with management of water resources in the Pangani Basin. The PBWO faces many challenges ranging from difficulties in monitoring abstractions; inadequate funding; to weakness in dealing with defaulters (60% of annual water right bills fail to be settled). Further compounding the problem of management is the fact that there are twice as many illegal abstractions (2094) as legal water rights (1028). The current government budget allocation to PBWO covers staff salaries only. Indeed, Pangani Basin Water Office (PBWO) requires Tsh 400 million to meet their needs for recurrent budget per year compared to their current annual income of Tsh 75 million. This is discussed in more detail later in the report.

It is also important to note that funding for catchment management extends beyond the problems of the PBWO. Catchment management falls under the Forest and Bee-keeping Division but does not have adequate staffing levels and finances to be effective.

VALUES:
Water in alternative uses

This chapter provides a summary of current knowledge of the consumption and value of water in selected activities in four areas of the Pangani River Basin, based on existing data and raw data collected from key informants and households from selected sites. These sites are not necessarily representative of all such activities in the basin, nor do they provide exhaustive coverage of the use of water in the basin. Sampling areas were chosen with the assistance of the Pangani Basin Water Office, but the representativeness of the samples could not be determined statistically during this study due to the lack of comprehensive data on household activities in the basin. This preliminary exercise does, however, serve to provide a first-cut estimate of the magnitude of values associated with most of the main uses of water in the basin, thus helping to guide and focus future research efforts.

Irrigated agriculture

The total irrigated area in the basin is variously estimated as 29 000 ha (Geheb 2003), 31 000 ha (Ngula 2002), 40 000 ha (Mujwahuzi 2001) and 55 000 ha (Sarmett & Kamugisha 2002), though the latter probably refers to Pangani Basin rather than Pangani River Basin. The irrigated area comprises commercial estates, such as coffee, sugar and on a smaller scale, flowers, which are concentrated in the upper basin, and a much larger area of small-scale farms which grow mixed crops for both commercial and subsistence purposes. In highland areas, small-scale farmers have plot sizes of between 0.1 and 0.2 ha, whereas lower in the basin, they tend to be about 0.8 – 1.5 ha, and farmed less intensively (Mwamfupe 2001). The total areas under these different categories of farms and the numbers of households involved could not be ascertained. Some 80% of the total irrigated area relies on traditional furrows which have been in existence in the area for centuries (Mwamfupe 2001). There are an estimated total of 2 000 traditional furrows supplying small-scale farmers (Mujwahuzi 2001).

In this study we provide rough estimates of the average productivity of water in different activities. The fact that irrigation yields return flows is not taken into account at this stage, however, and water losses at the farm level are considered equivalent to losses at the basin scale. The economic value of agricultural production was estimated in terms of value added to national income (gross domestic product). This is the difference between gross farm income and external costs, i.e. most input costs except for labour and capital costs (Gittinger 1982). Thus, where possible, values were taken at highest level (beyond the ‘farm-gate’ level) to reflect total value added to the national economy, taking processing and exports into account as appropriate. Outputs, inputs and prices were obtained from interview data, but were based on small sample sizes and should be viewed with caution. Prices were assumed to reflect the true scarcity of inputs. For large-scale commercial operations such as coffee, sugar and flowers, insufficient data were collected on input costs, especially at the processing stage, and external costs were thus estimated within a range of 25 – 50% of gross income.

Coffee estates

Coffee is Tanzania’s largest export crop, contributing about Tsh 115 000 million to export earnings. A total of 235 000 ha are under coffee production in Tanzania. About 48 000 tons are produced, 95% of which is produced by some 400 000 smallholders (Baffes 2003), the remainder being grown on 12 200 ha of estates. At least 90 000 ha and some 32% of this production is estimated to come from Northern Tanzania (Baffes 2003), most of which probably falls within Pangani River Basin. There are at least ten coffee estates in the Moshi area, and probably about double this number in the study area. Two coffee estates were interviewed for this study, one near Moshi and the other near Arusha. The planted area was 280 and 100 ha respectively, all of which was irrigated. Data obtained from the two estates, together with information acquired from the literature, were used to make the following assessment.

The large-scale coffee estates derive their water from furrows from small rivers such as the Namwi R. (a tributary of the Kikafu R.), the Usa R. and the Ngarasero R., all of which eventually flow into the Kikuletwa and Pangani Rivers. Water is directed via furrows into reservoirs, and into gravity-fed irrigation systems including flood, overhead sprinkler or drip irrigation systems. Managers claimed that flood irrigation has an efficiency of about 45%, whereas drip irrigation is about 75% efficient.

Coffee plants are planted at a density of about 1700 trees per ha. With flood irrigation they are given about 40-60 litres every two weeks during the period Sep/Oct to Mar/Apr, though not always during the short rains (Nov-Dec). Total irrigation water use thus amounts to about 1000m^3 per ha per year. Other inputs include red copper 5kg/ha @Tsh3000/kg, and urea, about 40kg/ha @ Tsh300/kg. Labour ranged from 0.25 to 0.7 permanent labourers per ha, plus an additional 2.5 - 6 temporary labourers per ha during the approximately three-month picking season. Coffee production involves pulping the berries to get beans, which are then dried, and finally cured. Beans are sun-dried on racks. Pulping is mechanised and requires power and substantial quantities of water (not quantified). Some coffee estates supply their own hydropower using turbines (one produced 400kW).

Annual production ranges from about 1.5-2.5 tons of dry beans per ha, reportedly sometimes up to 5 tons. This is compared with reported top production of 1.2 tons per ha for small-scale dryland production. Production of both dryland and irrigated coffee is highly correlated with rainfall.

There are no subsidies and no price controls in the coffee industry. Large scale producers usually cure and export themselves. In the case of small producers, co-ops or private buyers buy and sell on auction. The dried beans (parchment coffee) are sold for about Tsh 4-600 Tsh/kg (KNC price) at the farm gate. After curing, which costs about Tsh 500 000 per ton, 'clean' coffee can be exported for US$1-2000 per ton. The price of coffee is relatively low at present. There has been a general decline in quality of coffee produced in Tanzania, associated with changes in ownership and controls. Coffee prices are highly volatile. For example, during the 1990s, Arabica prices ranged from $1.17/kg in 1992 to $5.89/kg in 1997, but then declined to $1.24/kg in 2001. The price collapse has been attributed to oversupply, due to increased outputs from other continents (Baffes 2003).

The annual value added in coffee production is thus estimated to be between Tsh 0.7 and 3.7 million per ha. This suggests that the average value of water in coffee production is between Tsh 700 and 3 700 per m^3. This could be increased with greater efficiency of water use (Table 6).

Table 6: Preliminary estimates of the average value of water used in large scale coffee production

Value of water in large-scale coffee production	Lower bound	Upper bound
Export price	Tsh 1 million	Tsh 2 million
Production	1.5 tons	2.5 tons
Gross (export) income /ha	Tsh 1.5 million	Tsh 5 million
Value added/ha (gross income less labour & capital costs)	Tsh 0.7 million	Tsh 3.7 million
Average value added per m3 water (at 45% efficiency)	Tsh 723/m^3	Tsh 3 723/m^3
Average value added per m3 water (at 75% efficiency)	Tsh 1 205/m^3	Tsh 6 205/m^3
Annual labour equivalents per m^3 (at 45% efficiency)	0.0009	0.0022
Annual labour equivalents per m^3 (at 75% efficiency)	0.0015	0.0037

Sugar estates

There is at least one large scale sugar estate in the study area, situated near Moshi. The estate has a total area of 14 000 ha, of which about 6 500 ha can potentially be planted and 6 200 ha are currently under cane. The rest of the area is too marginal to be cultivated. Ongoing expansion will result in another 1 200 ha being planted in the Kahe area.

For the area presently being exploited, the sugar estate derives its water via two irrigation canals from the Weruweru River and from ten (10) boreholes, the latter supplying about 20% of requirements. During droughts water is obtained from the Kikuletwa River. The new area at Kahe will obtain its water from the Miwaleni Springs (Kahe). The fields are irrigated using overhead sprinklers and surface furrows, throughout the dry season, but not during the long rainy season (*ca*. March-June). Irrigation boreholes supply about 1 700 litres/sec, Weruweru supplies 3 600 litres/sec, and Miwaleni spring supplies 1 700 litres/sec (presently only very little being used).

Sugar cane is irrigated with about 50 – 70 m^3/ha/day of water, amounting to an estimated total of about 12-17 000m^3/ha/year. The Pangani Basin Water Office receives Tsh 12.8 million per year for this water. Production without irrigation would not be viable. Other direct inputs include 300 kg of Urea/ha at roughly Tsh 250/kg (US$ 240-260/tonne), and herbicides, at a cost of about Tsh 80,000 per ha.

A total of about 1 200 permanent staff members are employed directly in the growing of sugar, and an additional 1 000 temporary labourers are employed mainly during harvesting, from July to March. However, the total number of permanent employees, in the field, garage and transport, factory, human resources and administration amounts to 3 500. Some activities are also contracted out equivalent to about 600 man days.

The farm reported an annual production of about 90 tons of cane per ha (compared to global average of 65 tons/ha), which produces about 9 tons of sugar per ha (sugar yield from cane is 8 – 14.5% of mass). About 92% of the sugar produced is sold in local markets, and the remainder is exported to European markets. The international price of raw sugar is currently about $120 - $180/ton, though it may fluctuate in the longer term between about $120 and $200/ton. Sugar production is thus worth some Tsh 1.08 – 1.65 million per ha in terms of gross income, and value added is roughly estimated to be in the region of Tsh 625 000 – 940 000 per ha. Net farm income is reportedly at least Tsh 323 000 per ha. The average value of water in sugar production, in terms of value added to the economy, is estimated to be about Tshs 52 – 55 per m^3 (Table 7). This is less than the amount paid for the water.

Table 7: Rough estimates of the average value of water used in large scale sugar production, based on interview data

Value of water in large-scale sugar production	Lower bound	Upper bound
Gross income /ha	Tsh 1.08 million	Tsh 1.65 million
Value added /ha	Tsh 540 000	Tsh 1 215 000
Average value added per m^3 water	Tsh 32	Tsh 101
Annual labour equivalents per m^3	0.00004	0.00005

Flowers

The flower industry in Tanzania started in 1987 with Tanzania Flowers Limited. Flowers are grown in Arusha and Kilimanjaro regions, where the climate is favourable and in proximity to major airports, and where a constant and reliable supply of water is assured. By 1998, there were 12 farms in northern Tanzania (Mbelwa & Bonaventura 2000), with a total area of 80ha under production (Table 8).

Table 8: Summary of Tanzanian flower production in 1998 showing types, area under production and yields (Semboja 2000)

Company	Flower type	Area (ha)	Yield (million stems)
Hortanzia	Lisanthus	5	2.4
Arusha Cutting	Chrysanthemums	4	
Multiflower	Chrysanthemums	1.2	63.0
Kiliflora	Roses	18	
Horticulture farms	Roses	6	
Tanzania Flowers	Roses	7.1	
Kombe Roses	Roses	5	
Le Fleur dÁfrique	Roses	8.5	
Others	Roses	26.4	256.4
Total		**80**	**321.8**

Grown in greenhouses, the flowers are usually irrigated by drip irrigation, but at least two farms use overhead sprinklers. Water is from boreholes, springs and rivers such as the Usa and Nduruma, and reservoirs are used to help ensure supply. One farm interviewed had a water right of 27.32 litres per second for 2 ha of chrysanthemums. Water was abstracted from the Weruweru River, some 5 km away, and stored in two reservoirs with a 3 000 m^3 capacity. Losses of water reportedly occurred due to illegal abstractions from the furrow, and through seepage. Increasing turbidity levels were also a problem. Thus piping was being considered as a future option. This farm used sprinkler irrigation throughout the year, consuming roughly 100 m^3/day, or 18 250 m^3 per ha per year. Although financial data were not divulged, it was remarked that 50% of the total costs involved are the thrice-weekly freights to Holland. Some 60 people were employed on the farm.

Approximately 2350 people are employed by the industry as a whole, with the majority (57%) being women (Semboja 2000). 86% of these are casual labour, involved in harvesting, planting and grading, with skilled labour and managers making up the balance. While most employees are local, they also come from other parts of Tanzania and abroad. Indeed, some coffee farmers in Arumeru district have sold or leased their farms to foreigners for cut-flower production (Semboja 2000). Foreign workers hold management posts and some are owners.

Although local markets exist in Arusha, Moshi and Dar es Salaam, most production is exported. The value of EU imports from Tanzania in 2000 was estimated to be 8.4 million Euros (74% to Netherlands; 26% Germany; remainder to Italy and UK; Mbelwa & Bonaventura 2000). Another estimate is that 90% of Tanzania's flowers go to Holland. Based on these data, the average gross income from flower production (2000) was estimated to be in the region of Tsh 128 million per ha, which is somewhat lower than the estimated net return from rose production alone of Tsh 202 million per ha per year (2000). Water used in flower production was valued at Tsh 3500 – 5300 per m3 (Table 9).

Table 9: Preliminary estimates of the average value of water used in flower production, based on literature and interview data. 2000 values

Value of water in flower production	Lower bound	Upper bound
Gross (export) income /ha	Tsh 128 million	Tsh 128 million
Estimated value added /ha	Tsh 64.2 million	Tsh 96.25 million
Average value added per m^3 water	Tsh 3 500	Tsh 5 300
Annual labour equivalents per m^3*	0.001	0.001

* assumes casual labourers are employed half-time or half the year.

Small-scale irrigation

Smallholder irrigation ranges from traditional furrows through 'improved' furrows to much more modernised irrigation schemes. A major concern in the basin has been that the traditional furrow irrigation schemes are highly inefficient in their delivery of water, with an overall efficiency of less than 15%, as well as having low productivity (Table 10). Thus development plans in the region contain much emphasis on the improvement of these systems in order to increase both their overall productivity and water efficiency, with the ultimate aim of raising the living standards of smallholders. With improved efficiency, production increases at the farm level, and overall, since greater availability of water may lead to expansion of planted area. The number of farmers may also increase, as farm size decreases, for example from 0.2 to 0.1 ha.

Table 10: Water use efficiency and crop yields under traditional furrow and improved irrigation (Source: Zonal Irrigation Office)

Crop	Traditional Furrow	Improved Irrigation
Efficiency	12-15%	>50%
Maize	<1 ton/ha	3 tons/ha
Rice	2-3 tons/ha	Up to 6 tons/ha

The development of irrigation schemes involves the upgrading or rehabilitation of traditional furrow systems to more efficient irrigation systems, e.g. by lining canals to reduce seepage, rather than the introduction of irrigation to formerly dryland production areas. Indeed there is relatively little new land that is available for irrigation farming. This is important to note from a water allocation point of view. Thus as more and more schemes become improved, so the overall use of water required for irrigation should theoretically be expected to decrease, and the marginal value of water in production should increase up to the point where further increases in efficiency of water delivery do not add production.

In an irrigation scheme, crop water requirements are carefully calculated, e.g. 1 litre/s/ha for maize, 2.3 litres/s/ha for rice. Both crops are irrigated once a week until the crop is matured, with water use diminishing as the crop matures. Two harvests are obtained per year, which means that irrigation is required for 3.5-4 months. The water right is constant, although irrigation does not take place during the rainy season. Thus calculations are probably not done optimally (S. Asenga, Zonal Irrigation Office, pers. comm.). Fertilisers are used for rice, otherwise the costs of irrigation are not worthwhile.

The Zonal Irrigation Office (Moshi), under the Ministry of Agriculture and Food Security's Irrigation Division, takes care of irrigation matters in Tanga, Kilimanjaro, Arusha and Manyara Regions. In collaboration with donors, it selects potential areas for funding the development of improved irrigation schemes, using a point system out of 100. 50% of the weighting is based on readiness (the social weighting), the other 50% apportioned to water resource availability, soil type and economic viability.

Within the Pangani Basin, such government-supervised, World Bank-funded schemes have been developed at Kivulini, Mombo, Mahenge, Lemkuna, Soko, Lekitatu, Kambi ya Tanga and Longoi. Schemes developed by NGOs such as TIP, include Ngoma and Kikafu Chini, and are sponsored by organisations such as UNDP and FAO (S. Asenga, Zonal Irrigation Office, pers. comm.). A host of other small schemes have also been developed in the basin. According to the National Irrigation Master Plan (2003), some 51 000 ha and 46 000 ha are already under improved irrigation schemes in Arusha and Kilimanjaro regions, respectively. Water use within the schemes is usually organised through co-operatives or water user associations. However, the co-operatives do not market their products co-operatively, and harvests are sold individually.

Given the trend for improvements in traditional irrigation schemes, it is important to distinguish the productivity of water in smallholder agriculture in terms of the state of the irrigation systems involved. It is also important to recognise the spatial differences, with different parts of the Pangani River Basin having different rainfall patterns and being suited to different crops.

In this study, key informants and households involved in small-scale agriculture were interviewed in a variety of areas above and below Nyumba ya Mungu (Table 11) to obtain data on household agricultural production and value. The household surveys also put the value of agricultural production in the context of household livelihoods. Not all households in villages with irrigation have access to irrigation. Thus interviews with these households, as well as households in villages without any irrigation, provided comparative data on agricultural productivity.

Table 11: Villages or schemes in which interviews were held, and the type of irrigation

District	Ward	Village	Type of irrigation	Scheme/Co-op/User Group	Main crops
Arumeru		Ambureni/Mwivaro	Traditional	Ambureni water user group	Coffee, banana, maize, vegetables,
Arumeru		Lekitatu	Improved	Lekitatu Scheme	Maize, rice, Vegetables
Moshi/Hai?		Kisangesangeni, Mwangaria, Ngasinyi, Mawala and Oria	Traditional	KIMWANGAMAO water user group	Rice, maize, vegetables
Moshi/Hai?		4 villages	Improved	Chawampu co-operative	Rice, maize
Simanjiro		Lemkuna	Improved	Lemkuna scheme	Rice, maize
Simanjiro		Ngage	Traditional	-	Maize
Same	Ruvu	Marua, Mferejini, Muungano, Jiungeni (Jitengeni, Mvungwe)	Traditional		Maize, mixed
Same	Hedaru	Mesrani, Kivukoni, Kumbamtoni, Lolokai	None	-	Maize, mixed
Pangani		Bweni, Mseko, Mkwajuni	None		Maize, Coconuts

Spatial variability in crop production

Maize is the most ubiquitous crop, grown by most small holder farmers throughout the Pangani River Basin, both in irrigated and non-irrigated conditions (Table 12). Other crops vary tremendously, however. Coffee is grown by most households within the highland forest belt. This is done in association with bananas, grown by almost 90% of households in this area, and maize. Bananas are also grown by about a third of households in the lowlands. Tomatoes are grown in all areas, but tend to be more frequent in irrigated areas, particularly in the highland area. Beans are very commonly grown in the upper basin and highlands, but not in the lowlands. While the highlands are too cool for rice production, it is a major crop of irrigated areas in the upper basin, and is planted to a small extent in the lowlands, in irrigation areas or in close proximity to flooding areas. Farmers in the highlands and upper basin that do not have access to irrigation concentrate their efforts on maize and beans, as well as a variety of fruits and vegetables. Sugar, grown commercially on a large scale, is a very minor crop on smallholder farms, but grown throughout the basin. Cassava is only grown in the lowlands, as are peri-peri, paprika and fiwi. Okra is more commonly grown in the lowlands.

In the irrigated areas of the Kirua swamp area, farmers grow maize and a wide variety of other crops. This probably reflects their distance from markets, and hence greater need for self-sufficiency, as well as a more variable climate, which requires risk-spreading agricultural strategies. This was the only area visited that produced *fiwi* (a type of legume). In the same zone, farmers that do not have irrigation grow fewer crops, but still concentrate to a similar extent on maize, bananas and *fiwi*.

At the Pangani estuary, apart from maize and bananas, the suite of crops grown is quite different. Over half of households have coconuts, and a fifth grow betelnuts, which is planted amongst coconuts. There is also more emphasis on cassava, sweet potato, pumpkin.

Table 12: Proportion of households growing different crops in different parts of the study area, separated into households with or without access to irrigation, based on household survey data

	High altitude basin traditional furrow	Upper basin traditional furrow	Upper basin irrigation scheme	Upper basin - no irrigation	Kirua swamp – traditional furrow	Kirua swamp – no irrigation	Pangani estuary - no irrigation
n	24	13	16	11	54	21	33
Coffee	80-100%						
Rice		69%	44%		9%	5%	6%
Maize	42%	85%	63%	91%	91%	52%	76%
Beans	54%	38%	44%	55%	15%		
Tomatoes	58%	15%	25%	9%	24%	10%	18%
Onions	4%	8%		9%	11%		
Cassava				18%	11%	5%	24%
Sweet potato	4%				7%		15%
Pumpkin	4%			9%	2%		21%
Okra			6%		4%	5%	6%
Watermelon		8%			24%		
Other Veg.	42%	8%	19%	9%	9%	5%	21%
Pilipili/Paprika					28%	10%	3%
Fiwi					24%	24%	
Sugar	4%			9%	7%		6%
Coconut					4%		52%
Popo							21%
Banana	88%				39%	33%	30%
Other Fruits	33%	8%	6%	27%	15%	10%	18%
Other	17%				4%	19%	6%

Highland traditional furrow irrigation

There is a high density of settlements within the highland forest belt of Mts Kilimanjaro and Meru, with a large number of traditional furrows that serve the smallholders. Interviews were conducted at **Ambureni/Mwivaro villages** on the slopes of Mt Meru, near Arusha. Their water supply is via Ambureni furrow, which is a traditional furrow system, although there is a gate control that was built by Pangani Basin Water Office. The gate is opened at 8am, water taking an hour to reach the farmers, and is closed at 4pm, so that water can be 'returned to the river' for downstream users. The water user group allocates water to different users on a roster. For example, up to 18 people receive water per day in the dry season, each getting about 2 hours of flow. According to the village elders, about 600 farmers are involved, each having a farm of 0.6-0.8 ha (1.5-2 acres). Indeed, average field size reported in the household survey was 0.7 ha.

Crops are irrigated once a week. Open flood irrigation is used, with water flooding depressions around the banana and coffee trees. The main crop is coffee, but increasingly also tomatoes and onions. Only a quarter of farmers use fertiliser inputs in growing coffee. The water supply is also important for their stall-fed cattle. In this relatively moist area, an excess of rain was said to bring disease and decrease production.

It was claimed by the water user group representatives that the average farmer produces about 500kg of coffee, which would equate to about 350kg/ha. However, household survey respondents claimed to produce an average of 275kg/ha.

Upper basin traditional furrow irrigation

The group of villages visited in the upper basin illustrates some of the complexity in water management. The villages Oria, Ngasinyi and Mawala together form the **ONGAMA** Water User Group (name derived from the three village names). However, Ongama and the Tanzanian Planting Company (TPC), a large-scale sugar estate, share water from the same source, and have formed the **Tujikomboe** Water Users Association. To add complexity, the Ongama villages also join with the villages of Kisangesangeni and Mwangaria to form the **Kimwangama** water user group, representing the 5 villages. Nevertheless it is said that most farmers from Kisangesangeni do not have irrigation due to physical difficulty of accessing water from the furrows. This cluster of users derives its water via a furrow from 17 springs, of which the Miwaleni Spring (named for the Miwale palm trees surrounding it) is the largest.

Some 1045 households have access to irrigation, with a total field area of 1215 ha (3000 acres), of which 502 ha (1241 acres) are under production (Lucy Tesha, Chairperson of Tujikomboe, pers. comm.). Average field size ascertained from the household survey was 1.18 ha, slightly bigger than in the highlands.

The water right issued to Tujikomboe: is 900 litres/sec, for which PBWO requires payment of Tsh900 000 per year. Farmers pay Tujikomboe, a charge of Tsh 5000 per acre per season (there are two seasons).

Irrigation areas are used for production of rice, maize and vegetables, and there is also dryland production. Fertilizers are used for rice, but not usually for maize. For rice, annual inputs include tilling, at Tsh 37-74 000 per ha (for machine hire), 220kg seed per ha per year for the local variety, and 250kg urea/ha at Tsh 300 per kg.
Of the households with access to irrigation, 50% grew a combination of irrigated rice and maize, and most of the remainder had dryland maize. All the other crops grown (e.g. beans, onions, tomatoes), were irrigated, except for beans in one case. Overall average production per ha comprised 4.9 tons rice, 1.5 tons of maize, 1.1 bags of beans, 13.9 bags of onions and 690kg tomatoes (n = 19 farms).

Upper basin improved irrigation schemes

The **Chawampyo** Rice Estate (meaning *Chama cha wakulima wa mpunga Yongama*) is an improved traditional furrow system, managed by a co-operative. It is the biggest rice estate in the basin, the next biggest being at Ndungu (Chawampyo). Rice was first introduced to the area with the Lower Moshi Irrigation Project that was constructed between 1984 – 87, in turn initiated by the Kilimanjaro Agricultural Development Centre (KADC) which was established in 1981 to train farmers in Moshi, Hai, Same and Mwanga districts on irrigation farming (Mr Kimichu, Chawampyo, pers. comm.). Before that, people from the mountains only came to farm beans. The estate was initially a government (KADC) project, but changed to Chawampyo farmers' co-operative in 1993. However, Chawampyo has not provided very effective management and the government has decided to take up the management for 2 years to embark on capacity enhancement for Chawampyo. This will begin from November 2003.

Chawampyo encompasses four villages, involving 3000 farmers (up from 2000 in 1987), and has a total irrigated area of 1100 ha. All the irrigation canals are lined with concrete except for the supply canals and the conveyance is very high. Water is drawn at 804 litres/second from the Mabogini – Njoro spring (average discharge of the spring is 1,000 – 1,200 litres/second), and at 100 litres/second from the Rau River (despite having a water right for 1,135 litres/second). The total project water right is 1,900 litres / second but the actual water abstracted is 1,000 litres / second. Part of the problem is that another irrigated rice scheme of 500 ha has subsequently been developed upstream, and has diverted water so that there is no longer sufficient water for the Chawampyo farms. On average Chawampyo pays Tsh 1 – 1.2 million to the Pangani Basin Water Office.

During the rainy season, the full 1100 ha are planted, and during the dry season, about 800 ha are planted. Irrigated plots are 0.3 ha, and farmers each have one to two plots. Irrigated rice is the main crop, although rainfed crops (maize and beans) are also grown. There are reportedly three seasons per year (which is unusual) – Jan-Jun, May-Oct and Sep-Feb. Average rice yields are reportedly 6.5 tons/ha, but the members of the co-operative also gave an estimate of 20 – 25 bags of about 130 kg (i.e. 2600 – 3250 kg) harvested per plot, which equates to 8.6 to 10.8 tons per ha. Production costs average Tsh 500 000/ha (Tsh 150 000 per plot). Milling is done by Chawampu (40%) and the Kilimanjaro National Coffee Union (60%), at a cost of Tsh 360/kg. Merchants purchase the rice directly from the farms at Tsh 150 per kg, and revenues generated are reportedly about Tsh 1 – 1.67 million/ha, which suggests a range of 6.7-11 tons/ha. There is no controlled price and CHAWAMPU does not market the produce on behalf of farmers, and 70% of the rice selling business is handled by women. In comparison, dryland maize production is about 2.5 – 3.7 tons per ha per year, yielding a gross income of Tsh 150 – 370 000 per ha.

Lekitatu Village's traditional furrow system was improved by a World Bank scheme. The village has a population of about 3000, though not all households have access to irrigation. About 464 ha of fields are irrigated, and 363 ha are not. Water rights suggest a total consumption of 394 000 m^3. While maize, rice and vegetables are the main crops in the irrigated fields, rain-fed crops are mainly maize and beans. Households with access to irrigation produced an average combination of 1.5 tons of rice, 1.4 tons of maize, 2.5 bags of beans, 600kg tomatoes and 76kg green vegetables per ha (n = 23 farms).

Lowland traditional furrow and improved irrigation schemes

Below Nyumba ya Mungu, the river enters arid lowlands and forms a green lifeline through these plains. Formerly the domain of Maasai cattle herders, these areas now contain a low density of scattered small villages populated with a mixture of Maasai, a few of whom have become agriculturalists, and other tribes.

Some 7 km south of Nyumba ya Mungu, on the west bank of the river, a relatively new irrigation scheme in **Lemkuna** village irrigates 87 ha for fields. The village has over 1000 inhabitants. The main crop is rice, with reported yields of 7.4 – 8.6 tons/ha. Other crops such as maize, onions and tomatoes are also grown. **Ngage** village, about 31 km south of NyM, also has irrigated fields, with the main crops being maize (reportedly 25 bags/acre), onions and tomatoes. No household surveys were conducted in these villages, however.

Kirua Swamp traditional furrow irrigation or no irrigation

Slightly further south, the Kirua Swamp was originally a massive floodplain system predominantly on the eastern bank of the river. The situation has changed dramatically, however, since the construction of the Nyumba ya Mungu Dam. According to village elders, before NyM there was moderate flooding, and the flood arrived gradually. Floods were annual. Since the dam was built, the flood releases have become far more sudden and cause more damage. Floods are no longer beneficial, but destroy farms. The beneficial lower-order floods no longer occur. There are also periods when the river gets too low, especially from Mar to Jul, when the dam is closed to allow it to fill up.

Within the original extent of the Kirua Swamp, several villages are found on the banks of the Pangani, or situated at the periphery of the floodplain. In Jiungeni village (Ruvu ward), **Mvungwe** subvillage is an example of one of the several villages with traditional furrow irrigation, whereas the nearby **Jitengeni** subvillage has none, and shows signs of poverty and decay. Mvungwe has one traditional furrow from the Pangani which gives rise to 6 smaller furrows that go to the farms. Another furrow is under construction. There is no agriculture relying on natural flooding, since floods are too unreliable. Nevertheless, after floods, farming does not depend on furrows.

Further south along the Kirua Swamp area, villages in Hedaru ward are located close to the river and have easy access to water for crops. In some parts, such as around **Kumbamtoni**, there is very little evidence of any floodplain, with bush right up to the river banks, whereas in much of the Kirua Swamp area, the former floodplain area is largely dry and large areas are bare. Here, households have their fields right next to the river.

About half (48%) of all farms owned by household respondents in the Kirua Swamp area were irrigated (n = 105), although not all of these were irrigated by elaborate traditional furrow systems. Maize was grown on almost all irrigated farms, but in combination with a large variety of other crops. Irrigated farms had a combined average production of 250kg of rice, 560kg of maize, 0.4 bags of beans, 390kg watermelons, 107 kg tomatoes, 185kg periperi and 130 kg of fiwi per ha, as well as a few other minor crops (n = 50 farms). Fields without irrigation produced an average combination of 130kg rice, 275kg maize, 18kg tomatoes, 85kg periperi, 80kg of fiwi per ha (n = 55 farms). An average of 64 bunches of bananas was also produced per household.

Pangani estuary

There is no furrow irrigation in the area close to the coast, although there may be some flood-tide irrigation, where tidal water pushes upstream freshwater onto the floodplain during spring tides. Rice growing at the coast suggests this could be the case. In addition, 3 households (7% of 44 households that provided farming data) claimed to irrigate their vegetables, but this was presumably with borehole water. Average production per ha was 13kg of rice, 320kg maize, 140kg cassava, 13 pumpkins, 40kg tomatoes, 66 kg green vegetables, as well as minor production of other crops. In addition, households produced an average of 20 bunches of bananas, 3.6kg cashewnuts, 49 pawpaws, 7 bags citrus, 2000 coconuts and a substantial quantity of betelnuts from their trees.

Income from small scale agriculture

Average gross income per ha was estimated for the different areas based on field size and crop production reported by households. This included the portion of output consumed by the households. Income was typically in the range of Tsh350 000 – 600 000, but was far higher than this in the Upper Basin Traditional Furrow area (Oria and surrounding villages). Interestingly, the estimated income from this area – over Tsh1.5 million per ha, is within the range reported by Chawampyo, which would be classified as an upper basin scheme. Thus although the results from the household survey suggest that an irrigation scheme in the upper basin was less productive than a traditional furrow system, this is not necessarily always the case. The irrigated areas did, however, produce higher incomes per ha than fields without irrigation in the upper basin (Figure 9).

In the lowlands, there was no significant difference in crop income in areas with or without furrow irrigation. However, this may be to some extent because those without irrigation furrows were planted close to the river banks and were effectively well watered. The non-irrigated agriculture around Pangani estuary yielded similar incomes per ha to the rest of the lowland areas.

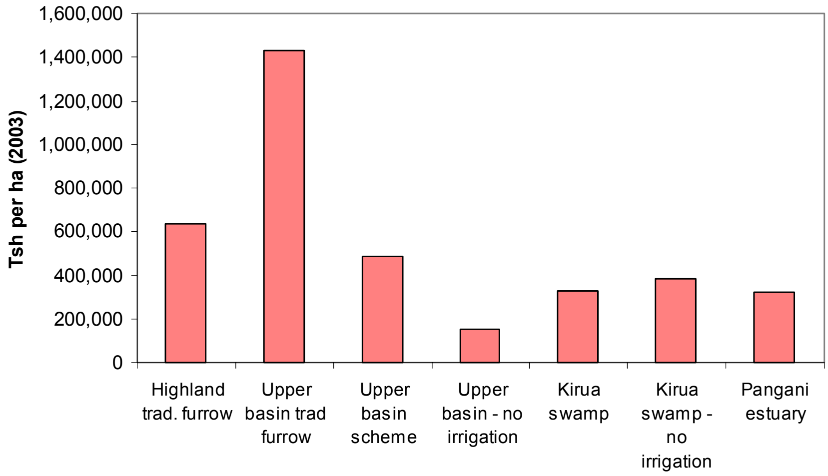

Figure 9: Estimated average gross income per ha from crops in different parts of the study area, based on household survey data

Note that the values reported for small-scale farming reflect gross income rather than value added, as data on external costs were not sufficiently reliable. In general, the sample sizes, when disaggregated by farming type, were small, and the results need to be verified with more sampling.

The most difficult information to collect was the actual quantity of water used in small scale agricultural production. The estimates of water use and value in Table 13 below are thus extremely rough and must be considered as preliminary estimates to be updated. Based on these estimates, water used in improved irrigation schemes is substantially more productive than in traditional furrow systems.

Table 13: Estimated water use and value added in irrigated agriculture in four areas of the Pangani River Basin. Water use estimates are based on actual data for the two schemes. For the rest*, it is assumed that three times as much water is used per ha irrigated, although only 15% reaches the crop

	Highland Traditional furrow	Upper basin traditional furrow	Upper basin scheme (Lekitatu)	Upper basin scheme (Chawampyo)	Kirua Swamp traditional furrow
Water consumption: m^3 per ha per year	3000*	3000*	850	1 195	3000*
Average value added per m^3	Tsh 211	Tsh 475	Tsh 574	Tsh840-1400	Tsh 109

Water for livestock

The types and numbers of livestock kept by households in the Pangani River Basin varies between different areas (Table 14). Most households keep a similar stock of chickens, and a few ducks, but pigs are rare. In the highland and upper basin areas, households keep small numbers of cattle and goats and a very few sheep. In the densely-populated highland and upper basin areas, most cattle are stall-fed ('zero-grazing') dairy cattle, but a few households in the upper basin have larger herds (up to 32), which are presumably grazed. In the lowlands, cattle and goat herds are much bigger, and almost all associated with the Maasai community, who are also the only community keeping donkeys. Other tribes in this area keep very few livestock, mainly goats. Livestock numbers in households around Pangani estuary are slightly higher than those of the upper basin, but the average number of cattle is misleading, as all the cattle belonged to a single household.

Table 14: Average numbers of livestock per household in four parts of the Pangani River Basin, based on household survey data

	Highlands	Upper basin	Kirua Swamp (Maasai)	Kirua Swamp (Other tribes)	Pangani estuary
N (households)	25	43	18	71	45
Chickens	7.6	10.7	6.0	12.8	9.2
Ducks		2.7		0.1	
Pigs		0.1			
Cattle	2.6	3.5	57.1	0.6	4.5
Donkeys			4.2		
Goats	1.2	3.1	49.8	2.8	1.6
Sheep	0.4	0.2	1.8	0.1	0.5

Water consumption by livestock is highly dependent on ambient temperature (and availability of shade), water quality, drought (animals require more water due to having to digest coarser feed), and pasture quality. It also depends on the age and condition of stock. Lactating animals have higher requirements, and dairy breeds have generally high water requirements, whereas cattle of the lowlands are more hardy. In Australia, hardy breeds of sheep and cattle consume abut 4 – 10 and 40 – 100 litres per day, respectively. There, sheep and cattle normally graze within a radius of 2.5 and 5 km from a watering point, respectively (Agfact 2002).

Stall-fed cattle in the highlands are watered directly from irrigation canals or rivers, or in 29% of cases, with water brought to the homestead, presumably from the same source (household survey). In the upper basin, 89% of households water their cattle at rivers or canals, the remainder using borehole or well water. In Kirua Swamp, 14% water livestock at wells, and another 14% claim to bring water to their livestock (source presumably boreholes), the remainder being from rivers/canals. In Pangani, only 9% of cattle are watered at rivers. Thus livestock consumption uses a mixture of surface and ground water.

In the lowlands, cattle are mostly tended by nomadic and semi-nomadic Maasai. Maasai herdsmen were interviewed in four localities in the lowlands: Lemkuna village and Ngage hamlet on the west banks of the Pangani, and at Mvungwe and Meserani on the eastern banks, within the Kirua Swamps area.

The movements of livestock are strongly linked to availability of grazing and water. During the dry season, both of these become scarce. There are a total of about 40 Maasai bomas in Lemkuna village area, who range with their livestock between the river and the small Lossogonoi hills that run parallel to the river in the wet season, bringing their livestock down to the river about twice per week. In the dry season, they move beyond the hills, when they range 20 – 25km in search of good grazing and water for their livestock at springs. However, both villages complained that water availability in the outer areas had decreased due to droughts. The herdsmen also claimed that cattle diseases are more prevalent when water levels are lower.

At Mvungwe, livestock were shifted upland to the Kombo area, where they are watered on the seasonal Terite River. During the drier months, from Jun-Oct, they are shifted closer to the Pangani, moving between nearby upland areas and the floodplain and drinking daily from the river. About half of their grazing time is spent on the floodplain during this period. In a normal dry season, goats and sheep follow a similar pattern to cattle, and require water once very 4 days, but during serious drought, sheep and goats cannot go long distances from water. It was the herdsmen’s opinion that there was no more capacity for herd expansion. The region had changed from one of only pastoral and fishing activities before the 1940s, to the arrival of the agricultural community after construction of the first furrow in 1976, which led to the loss of grazing land. There was concern that growing agriculture would necessitate a decrease in the numbers of livestock.

Some herd statistics for lowland livestock are summarised in Table 15.

Table 15: Herd statistics supplied by Maasai herdsmen in interviews

	Cattle	Goats	Sheep
Age at first breeding	3 years	2 years	
Birth rate (% breeding females)	45% (Sep-Oct)	70%, 2 – 3 times per year	
Suckling period	8 – 9 months, 10 m in drought		
Breeding males to 100 breeding females	20-30	20	
Survivorship	10-20% calf mortality, up to 66% if outbreak of *ndigana* (tick-borne)		
Treatment	Dipping (1litre @Tsh10 000 treats 70 cattle, once per year), Tromicine for calves to treat Ndigana: Tsh 2500 treats 30 calves; Berein: 1pkt per calf at Tsh 500 each.	Vaccination against lung disease	
Selling age	4 years	1 year	
Selling price (Tsh)	Bulls usually sold: 80 000 (drought) 140 000 (normal) 200 000 (when fat) Cows: 75 000 (normal)	10 000 to 40 000 (big ram)	8 – 12 000

The value of cattle production lies in the annual change in value of the stock (herd growth), some of which is sold for cash, and some of which is effectively 'reinvested' in the herd. Respondents were asked about herd size, production and sales. Results suggested relatively high rates of growth (Table 16) especially in the upper basin, as some respondents reported higher production than stock numbers, possibly due to under-reporting of herd size or misinterpretation of the question. The accurate estimation of herd growth requires more information than could be gathered in this study.

Table 16: Average productivity figures reported by households in the household surveys

		Highlands	Upper basin	Kirua Swamp	Pangani estuary
Cattle	% production	29%	74%	33%	-
	%sold	19%	19%	13%	-
Goats	%production	34%	48%	40%	30%
	%sold	3%	24%	10%	6%
Sheep	%production	33%	89%	58%	40%
	%sold	11%	11%	0%	0%

Prices reported in the household survey (Table 17) concur with focus-group data for the lowland areas, particularly considering that the past year had been relatively dry. Cattle prices in the highlands were high, mainly because the dairy breeds are more costly. Consistently low prices were reported in the upper basin area, however.

Table 17: Average prices (Tsh) for livestock in 2003 in different parts of the study area, from household survey data

	Highlands	Upper basin	Kirua Swamp	Pangani estuary
Cattle	203 214	70 462	117 765	No data
Goats	37 500	13 250	14 905	13 100
Sheep	20 000	8 000	10 750	10 000

Average income from livestock was dominated by income from cattle (Table 18). Milk production is particularly important in the highland areas, but is also important in the upper basin generally. In the lowlands, milk production makes a substantial contribution to households, but is minor compared to income from livestock sales. In the case of Maasai households in the lowlands, the income from livestock constitutes a major portion of overall household income, since there is little or no other agricultural activity or fishing by these households. Based on rough estimates of water consumption (dairy cattle 100 lt/d, lowland cattle 50 lt/d, mixed herd in upper catchment; 7 lt/d for goats and sheep), the income per m^3 of water consumed was calculated to be highest in the highlands. However this was not insubstantial for lowland cattle.

Table 18: Average income per household from livestock (cattle, sheep and goats only), calculated on the basis of livestock sales and the total value of milk produced, and the average income per m3 of water consumed by livestock (including donkeys), based on rough estimates of water consumption by livestock

Data	Highlands	Upper basin	Kirua Swamp	Kirua Swamp Maasai	Pangani estuary
n	25	44	71	18	44
Cattle income	90 400	39 818	5 915	881 111	?
Milk value	132 728	41 459	?	162 222	?
Goat income	2 000	7 841	2 866	71 167	750
Sheep income	800	182	0	0	0
Total income (Tsh)	225 953	89 344	8 853	1 114 518	794
Water consumption m^3	100	104	18	1 204	87
Income per m3	**2 263**	**860**	**479**	**926**	**?**

Domestic use of water – urban and rural

At least 4.6% of catchment runoff is allocated to domestic water supply, though a further 35.6% of runoff is allocated to a mixture of domestic and other uses (PBWO Data). Domestic water supply in the Pangani River Basin ranges from the supply of tap water in major urban areas and smaller towns to collection of water from rivers in remoter rural areas. The supply of water is gradually being improved to smaller population concentrations. The following findings from interviews with a range of water supply authorities and households provides a fairly good understanding of the situation.

Large towns

Moshi urban area has a population of about 145 000 (2002 census). It's urban water facility (established in 1998) supplies a total of about 50 000 people with 26 000 m^3 per day (including leakages; F. Kiula & J. Ndetiko, Moshi Urban Water Supply and Sewerage Authority, pers.

comm.). This includes commercial and industrial use, so it is not possible to work out average consumption for domestic purposes.

This water is supplied from three springs (Sere – 12.5 lt/sec, Shiri – 11.5 lt/sec and Njoro ya Dhobi – 3 lt/sec) and three boreholes (Mawenzi, KCMC and Msoro), the latter contributing 3000 m3/day (11.5%), and is stored in four large storage tanks (Kilimanjaro tank – 2000m^3, CCP(2) – 2 270 m^3, Petershaft – 1350 m^3 and Kiusa – 650m^3). The Moshi Urban Authority claim that the springs supply the equivalent of about 9 boreholes. Boreholes cost about Tsh15 million to sink and Tsh 54 million per year for operations and maintenance (F. Kiula & J. Ndetiko, pers. comm.).

This water supply service entails a water rights payment to the PBWO of Tsh 6,995,780 per year, as well as running costs (salaries, electricity, chemicals, O&M) = Tsh 1 172 million. It also involves protection of the springs that supply the water. Indeed, the Moshi Urban Authority has recently planted 7000 seedlings to this end, and cite a willingness to pay of Tsh 100 million per spring. Some Tsh 779 million of the costs are covered by revenues from water sales. Since the water tariff is Tsh 205/m^3 (F. Kiula & J. Ndetiko, pers. comm.), this suggests that payment is received for 40% of the water supplied. Nevertheless, with only a third of the population being supplied, the service needs expanding.

Small towns

Many of the small towns in the basin are supplied with gravity-fed piped water from rivers and from boreholes. For example, Same town, which has a population of 17 000 (2002 census), is supplied with 1 896m^3 per day, from the Same springs and 2 boreholes (Mr. Masawe Ezekiel, District Water Engineer, Same District, pers. comm.), and it is planned to increase this to 2 500 m3/day. This will increase water supply from the current supply of 47 to 53m^3/person/year. Actual domestic consumption is lower than this, since the supply is also for commercial and industrial use. Future expansion will be through groundwater wells, and possibly from the Shengena forest springs, for which feasibility studies are currently being conducted.

In Same District, water tarriffs are Tsh 500/m^3 for domestic use, Tsh 750/m^3 for commercial use (e.g. hotels) and institutions (e.g. schools), and Tsh 1000/m^3 for industrial use (e.g. Sisal plants), though flat monthly rates are also levied in some cases. Same town sells 63% of the water produced, generating Tsh 15 million per year (Mr Mwita, Same Urban Water Authority, pers. comm.). The rest is lost through leakages and illegal abstraction. The cost of this service includes water user rights of Tsh 730 000, and total costs (including electricity bills, salaries, administration, etc) amount to Tsh 144 million.

Rural water supplies

Rural areas obtain water from surface (springs and rivers) and groundwater sources.

In **Moshi Rural District**, there are a total of 67 water sources, of which a total of 53 springs supply 30 water schemes that provide gravity-fed piped water. These 53 springs, most of which are surrounded by forest, are protected by the District Council and the local communities. This includes tree-planting around the springs. The water is clean, and no chemicals are added. The existing schemes supply 58% of the rural population.

Water provided by the schemes is charged at Tsh 900 /month, paid directly to the PBWO. Costs of provision include salary and operational costs of Tsh 166 million. 70% of the annual revenue target of Tsh 26 million has been reached. Losses are incurred due to a history of free access to water (water was provided free after independence), a lack of metering, and also because the latter allows people to use the water for irrigation during the dry season. Many of these schemes are in need of rehabilitation.

The other 42% of the population that do not benefit from these supply schemes are mostly found in the lower plains. They rely on shallow wells for water, or they take water from traditional furrows. In addition, 17 boreholes have been provided in the lower areas in return for which the users contribute funds for their management.

In **Hai District**, water is tapped from springs and rivers and flows by gravity, with water descending in the order of 850 m. Most of the sources are located within forest reserves. Pumping from boreholes is considered very expensive and not sustainable.

A large water supply programme has benefitted 94 000 people, providing 3580m3/day (Engineer Mama Raphael, Hai District Water Engineer, pers. comm.). The programme, which commenced in 1990, comprises several projects which have been implemented in phases, involving both rehabilitation and new schemes. The first phase covered 8 villages and Hai District headquarters, involving 105 km of pipe network, and is now under Uroki Bomangombe water supply. The second phase rehabilitated Kilimanjaro International Airport water supply and Losaa-KIA water system covering 16 villages, involving 175 km of pipe network, as well as Magadini Water Supply (5 villages and institutions; 36 km of pipes) and Lawate / Fuka water supply (11 villages; 96 km of pipes). A third phase will rehabilitate Masam water supply, covering 5 villages (35 km of pipes), and a fourth phase will follow. In total the project has rehabilitated 16 reservoirs (1 621m^3) and constructed 11 new ones (total 716m^3). Overall the project has involved an investment of 10 million Deutsch Marks by foreign donors, 0.78 million DM by local government and 0.99 DM in terms of self-help contribution (M. Raphael, pers. comm.).

At present, 80 villages (60% of total) are supplied with water. By the end of Phase IV, 80% will be covered. The remainder are villages in the lower plains.

Water is charged at Tsh 300/m^3, paid to the PBWO. In Lozaki (near KIA), revenue collection compliance has been high (90-100%) due to commercial trading of water. Overall, there are unaccounted loss of 10-20%, and the District Water Engineer believes there are no illegal connections.

In **Same District**, there are 47 gravity water schemes and 11 boreholes (7 shallow wells and 4 deep areas) serving the rural areas (M. Ezekiel, pers. comm.), which have a population of 195 000. However, water resources are believed to have deteriorated due to deforestation, encroachment and grazing in the catchment, and available water is no longer sufficient to meet demands. More boreholes will be needed, at a construction cost of about Tsh 12 million for a 200 m deep borehole.

Thus in general, water supply in the rural areas is quite variable, and appears to be better supplied in the upper parts of the catchment and close to mountains and urban areas, than in the lowland plains. The results of the household survey show some of the variation in water sources for rural households in the basin (Figure 10). Rural households in the highlands are well positioned to obtain water from rivers and irrigation canals fed by rivers or springs. In the upper basin and at the coast, rural households had access to a number of water sources, including boreholes, but still relied heavily on rivers or canals. Wells are often privately owned, and water is purchased from the owners. Of the households surveyed in the lowlands (Kirua Swamp), all sourced their water from the river or irrigation canals, though some paid others to fetch the water. The survey covered villages in close proximity to the river, and boreholes are likely to be a more important source of water further away.

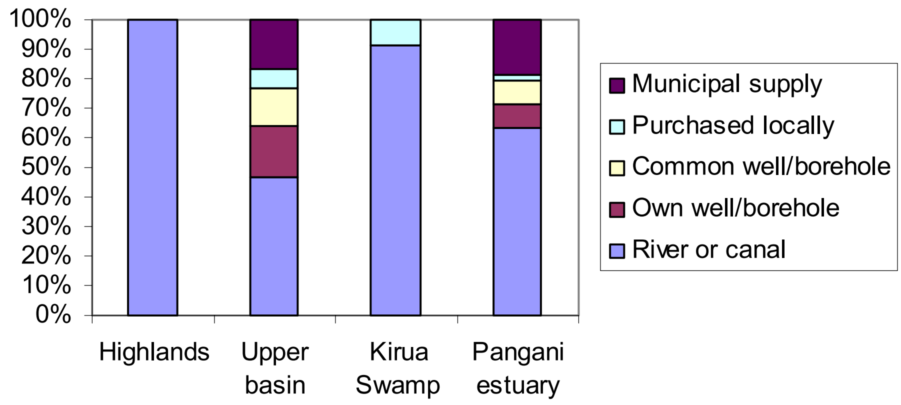

Figure 10: Percentage of rural households obtaining water from different sources in different parts of the Pangani River Basin

Domestic water consumption and value

Under Tanzania's new Water Policy, a water consumption of 70 litres per day in urban areas and 25 litres per day in rural areas should be allowed for. According to household survey data (Table 19), the rural allowance made in the new Water Policy is a reasonable one. Most household use was within or close to this limit, except in the highlands, where household water consumption was much higher. This might have something to do with the more urbanised lifestyles of people in the highlands, but is also possible that some livestock consumption was included in this domestic use, since livestock are kept at the homestead.

Table 19: Domestic consumption of water (litres per person per day) in four rural areas of the Pangani River Basin

	Highlands	Upper basin	Kirua Swamp	Pangani estuary
Consumption per person per day (litres)	36.9	22.0	17.9	27.6

Since data provided for urban areas could not be disaggregated by type of use, it has to be assumed that the urban provision of 70 litres per person per day corresponds to average urban use of water.

The valuation of water in domestic use has been approached in numerous different ways in the literature. One type of approach is to value it on the basis of replacement costs for supplying water if the sources were to be depleted, such as the cost of sinking boreholes (Sjaasted *et al.* 2003). According to their estimates, the total present value of construction and maintenance of boreholes is about Tsh 20 million, and these supply about 8400 litres per day. Other studies have taken a similar approach by using the costs of dam construction. However, the cost of supplying water is often much lower than the true market value of water. Indeed, water supplies to urban areas are often priced to recover supply costs, but these prices do not necessarily reflect the market value of water.

The value of water for domestic use is better reflected in the willingness to pay demonstrated through trade of water in rural areas. FBD (2003) found average prices of Tsh0.256/lt and Tsh 1.543/lt in villages in Kilimanjaro and Arusha Regions, and Tsh0.25/lt in villages in Tanga Region. In this study, average prices of water in villages were Tsh1.50/lt in the highlands, 1.25/lt in the Kirua Swamps area and Tsh1.20/lt at the coast. These prices, equivalent to Tsh 1500, Tsh 1250 and Tsh 1200 per m^3 respectively, are far higher than the prices charged by

PBWO. Since people in rural areas generally have a lower ability to pay than those in urban areas, it is reasonable to assume that urban willingness to pay would be at least this much, or in other words, that water for domestic use is just as valuable in urban areas.

Total willingness to pay for, or value of, domestic water supplies in Pangani River Basin is thus estimated to be in the order of Tsh 37 – 46 billion (Table 20). The value is higher if the total population of the Pangani Basin is considered. These values may not have any bearing on water allocation decisions, since all inhabitants should have access to basic water supplies, but are of interest in terms of the potential for revenue generation and water demand management.

Table 20: Estimated value of water in domestic use in the Pangani River Basin and the Pangani Basin

	Pangani River Basin	Pangani Basin
Total urban population	427048	670 628
Total rural population	2162 192	2 958 775
Total water consumption in domestic use (m^3/year)	30 641 078	44 133 367
Value per m^3	**Tsh 1200 - 1500**	**Tsh 1200 - 1500**
Total value (lower bound)	Tsh 36 769 million	Tsh 52 960 million
Total value (upper bound)	Tsh 45 962 million	Tsh 66 200 million

Value of water in the environment

Water supply in the Pangani River Basin is crucial to the functioning of the basin's aquatic ecosystems. Apart from the intrinsic value of these ecosystems, they provide goods and services that contribute to the economic wellbeing of inhabitants of the basin. These include aquatic plants, such as reeds, sedges, mangroves, food and medicinal plants, and aquatic animals, including fish, crocodiles, hippos and water birds that can be harvested for household consumption or sale. It also includes salt that can be extracted in coastal pans. In addition, aquatic ecosystems provide services such as water purification, regulation of water supply, flood amelioration, nutrient cycling, carbon sequestration and the provision of nursery areas for inshore marine fisheries, though the latter services were not investigated in this study. The supply of all of these goods and services is affected by the quantity and quality of runoff in the catchment. Their value is determined by the degree of use and the sustainability of that use. The direct use of aquatic resources was investigated in the household surveys. Note that the sample sizes of households interviewed were small and thus may not necessarily be entirely representative (total populations in these areas was not established during this study). They do, however, provide a first quantitative description of natural resource use by households in these areas and serve to provide first-cut estimates of the value of resource use.

Food and medicinal plants

Food and medicinal plants are harvested by at least a small proportion of households throughout the study area (Table 21). One of the main uses of medicinal plants in the upper basin was for domestic animals. Nevertheless, households in the Kirua Swamp area and at the coast had the highest reliance on medicinal plants, suggesting that, at least at the coast, some of this is for human consumption. This study supports the findings from elsewhere that food plants tend to be harvested more in areas where there is little access to markets or shops (Turpie 2000). It could not be ascertained how much of this harvest was from aquatic ecosystems, but the proportion of medicinal plants is likely to be negligible. There are many fruiting trees associated with the riparian zone, though experience in other areas would suggest that most wild fruits are probably from upland species. It would be reasonable to assume that about half of wild food plants are from wetland areas, but this needs to be verified with further research.

Table 21: Percentage of user households and average value of harvests of food and medicinal plants reported by respondents in the household survey. Overall income per household (including non-user households) is calculated based on estimated proportions derived from aquatic habitats

	Highlands	Upper basin	Kirua Swamp	Pangani estuary
n	25	44	89	45
Food plants				
% households that harvest	4.0%	6.8%	9.0%	0.0%
Average value of harvest per user hh	2 333	23 950	32 537	4 758
Wild fruits				
% households that harvest		4.5%	5.6%	6.7%
Average value of harvest per user hh		85	7 781	2 420
Medicinal plants				
% households that harvest	12.0%	6.8%	30.3%	28.9%
Average value of harvest per user hh	1 333	?	27 444	4 758
Estimated overall average income derived from aquatic plants	**63**	**815**	**2 383**	**170**

Reeds, sedges and grasses

Reeds (mainly *Phragmites* spp), are used in the study area for construction purposes, especially for the construction of temporary structures, but also in house construction and for making doors. Few households use reeds in the highlands, where they are probably not abundant. In the upper basin and lowland areas, reeds are extremely common in the rivers and canals, and harvests were reported by about 7% of households (Table 22).

Sedges, such as papyrus (*Cyperus papyrus*) and *ngage* tend to be found in more natural wetland areas, and were only harvested in the Kirua Swamp area, where they occur along the Pangani River. These are used as roofing material in this area.

Grasses were harvested for different purposes in the different parts of the basin. In the highlands, upland grasses are cut for feeding stall-fed cattle. In this area grass was more valued than in other areas, but is probably entirely from non-wetland habitats. This is probably also the case in the upper basin. In the Kirua Swamp area, grasses were reportedly harvested by over 12% of households, probably mostly for fencing. Most of this harvest is likely to have come from the floodplain. Thus only the latter grass value is considered to be associated with aquatic habitats.

Table 22: Percentage of user households and average harvests of reeds, sedges and grasses reported by respondents in the household survey

	Highlands	Upper basin	Kirua Swamp	Pangani estuary
n	25	44	89	45
Reeds				
% households that harvest	4.0%	6.8%	7.9%	0%
Average harvest per user household (bundles)	12.0	26.7	77.3	
Average amount sold (bundles)	0.0	30.5	0.8	
Average price per bundle (Tsh)	500	1233	233	
Value per user household	6 000	32 921	18 011	
Sedges				

	Highlands	**Upper basin**	**Kirua Swamp**	**Pangani estuary**
% households that harvest	0%	0%	9%	0%
Average harvest per user household (bundles)			21.0	
Average amount sold (bundles)			7.5	
Average price per bundle (Tsh)			300	
Value per user household			6 300	
Grass				
% households that harvest	8.0%	2.3%	12.4%	0%
Average harvest per user household (bundles)	47.0	28.0	26.7	
Average amount sold (bundles)	0.0		0.0	
Average price per bundle (Tsh)	500	300	263	
Value per user household	23 500	8 400	7 022	
Overall average income per hh from wetland plants*	**2 120**	**2 433**	**2 852**	**0**

* this excludes grass in the upper basin and highlands

Palms

Palms are largely associated with wetlands in the Pangani River Basin. There are no palms in the highlands. The most common palms are the Doum or Lala Palms *Hyphaene* spp., which are known as *mikoche* in the upper basin and *miaa*, *milaa*, or *minyaa* in the lowlands and coastal areas. These palms grow at sea level and inland along seasonal water courses, and are often found at the edge of springs and floodplains. Wild Date Palms *Phoenix reclinata* (locally known as *mikindu*) occur in the warm lowland and coastal areas, usually beside swamps and rivers.

In addition, coconut palms *Cocos nucifera* (*minazi*) grown around Pangani estuary provide an important source of palm leaves. Whilst the indigenous palms harvested are largely associated with functional wetland habitats, such as floodplain areas, the value obtained from planted coconut palms cannot be said to be a value of aquatic ecosystems. It is of interest, however, in that coconut palms replace the services provided by indigenous vegetation associated with aquatic ecosystems, being a preferred material for roofing and other uses.

Palm leaves generate substantial incomes for user households, particularly at the coast. Averaged across all households, an average of Tsh 66 000 worth of indigenous palm leaves are harvested by households at the coast, and much smaller values are achieved elsewhere (Table 23).

Table 23: Percentage of user households and average harvests of palm leaves reported by respondents

	Highlands	Upper basin	Kirua Swamp	Pangani estuary
n	25.0	44.0	89.0	45.0
***Hyphaene* leaves (mikoche, miaa)**				
% households that harvest	0%	6.8%	1.1%	6.7%
Average harvest per user household (bundles)		60.0	5.0	166.7
Average amount sold (bundles)		32.0	0.0	0.0
Average price per bundle (Tsh)		1000.0	300	300.0
Value per user household		60 000	1 500	50 010
***Phoenix* leaves (ukindu)**				
% households that harvest	0%	0%	4.5%	24.4%
Average harvest per user household (bundles)			58.8	98.0
Average amount sold (bundles)			66.7	3.5

	Highlands	Upper basin	Kirua Swamp	Pangani estuary
Average price per bundle (Tsh)			1080.0	2365.4
			63 504	231 809
Coconut leaves				
% households that harvest	0%	0%	0%	20.0%
Average harvest per user household (makuti)				332.9
Average amount sold (makuti)				174.4
Average price per makuti (Tsh)				91.9
				30 627
Overall average income per hh from natural palms*	**0**	**4 091**	**2 869**	**66 115**

* excludes income from coconut palms.

While a large proportion of the palm leaves were harvested for sale, the amount sold was highly variable. Many households retain part or all of their harvest for making various products. The products made usually require a specific type of palm leaf, and thus the frequency is geographically variable, depending on the supply. Leaves of *Phoenix reclinata* are known as *ukindu*, and are the only type of palm leaf that can be dyed. It is only available in lowland areas, and becomes increasingly desired at the coast, where it is used to make decorative mats, food covers, and other products. Products that were not mentioned in the household surveys but which are possibly also made include *ukindu* hats, ornaments, sleeping bags and *Hyphaene* ropes. While much of this is for own use, there is some demand for these products among coastal communities that creates a small amount of trade. The overall income from making palm products, averaged across all households, is very small, but not insignificant at the coast (Table 24).

Table 24: Value added to palm leaves by making products, giving average income per producer household for each product, and overall average income from these activities to all households in each area

Type of palm	Product	Highlands	Upper basin	Kirua Swamp	Pangani estuary
n		25	44	89	45
Hyphaene	**Brooms**				
	% hh		6.8%		
	No. per producer hh		667		
	Average price		200		
Hyphaene	**Baskets**				
	% hh		4.5%	3.4%	4.4%
	No. per producer hh		120	21.0	3.5
	Average price		200	1100.0	150.0
Hyphaene	**Milala mats** (*vitanga*)				
	% hh	0.0%	2.3%	0.0%	4.4%
	No. per producer hh		3.0		3.5
	Average price				1500.0
Hyphaene	**Drying mats** (*majamvi*)				
	% hh				6.7%
	No. per producer hh				9.7
	Average price				2550.0
Phoenix	**Ukindu mats** (*mikeka*)				
	% hh			9.3	10.7
	No. per producer hh			8.7	8.9
	Average price			2500.0	5416.7
Phoenix	**Praying mats** (*miswala*)				

Type of palm	Product	Highlands	Upper basin	Kirua Swamp	Pangani estuary
	% hh				11.1%
	No. per producer hh				6.0
	Average price				9500.0
Phoenix	**Covers** (*kawa*)				
	% hh				8.9%
	No. per producer hh				12.0
	Average price				2250.0
Phoenix	**Fans** (*vipepeo*)				
	% hh				6.7%
	No. per producer hh				19.3
	Vipepeo price				733.3
Overall average income per household		**0**	**2 178**	**1 565**	**20 606**

Mangroves and salt

Coastal Tanzania is rich in mangrove resources, and at least 8 species are found in the study area. The total mangrove area in Pangani District is 1755.6 ha, containing 221 090 m^3, or 126m^3 per ha. Associated with this are 741 ha of bare, saline areas and 12 ha of salt pans. Together with open water creeks, the total reserve area is 3114.4 ha. About 753 ha of mangroves are situated around the Pangani River (URT 1991), although the estimate has not been updated in the past 12 years. According to the district natural resource officer, the area has about a third of the mangroves, but 95% of the district's harvest comes from this area. This estimate is probably exaggerated. Mangrove poles are exported to other areas where they are in high demand for construction purposes. Many are exported to Zanzibar.

Cutting mangroves involves obtaining permission from the local village authority and then applying to the district office for a licence. The licence fees were greatly increased in 2000, to Tsh2500 per score. Thus much use of mangroves remains uncontrolled, probably more so with the high licence fees which are almost as high as their market value (see below). According to official statistics, about 240 – 260 scores (*koreja*) are harvested per year (Table 25). In addition, it is estimated that some 8 – 25 m^3 of firewood are removed, and 70 – 90 boat ribs are obtained. In these records, the poles are valued at Tsh 2000/score, firewood at Tsh3000/m3 and ribs at Tsh2500 each.

Table 25: Data from the Pangani District Office on the quantity and value of mangrove harvests

		2000		2001	
Resource	**Unit**	**Quantity**	**Value (Tsh)**	**Quantity**	**Value (Tsh)**
Poles	Scores	237.7	475 450	289.75	579 500
Firewood	m^3	24.71	61 775	8.23	24 700
Boat ribs	Each	80	175 000	71	177 500
		2002		**2003 Jan-Sep**	
Resource	**Unit**	**Quantity**	**Value (Tsh)**	**Quantity**	**Value (Tsh)**
Poles	Scores	259.2	518 400	141.32	282 650
Firewood	m^3	16.3	49 000	1.56	4 700
Boat ribs	Each	87	217 500	60	150 500

Some 24% of households in the Pangani estuary area reported having harvested poles in the last year, and these households harvested an average of 41.5 scores (= 830 poles) with an average value of Tsh3100 per score. Although many respondents did not answer the question on what proportion of these poles were mangrove poles, the average that was reported was 22%. Thus a minimum estimate of 183 poles per user household were mangrove poles. Household surveys obviously do not include harvesting conducted by outside businesses, and the official estimates may thus be a better estimate of overall value. Unfortunately there was a discrepancy among district officials as to whether the official statistics included household use. If not, as is probably the case, then the two estimates need to be added.

91% of households in the Pangani estuary area collected firewood, at an average rate of 138 loads per year, each load being worth an average of Tsh300. Again, few respondents would divulge how much of this came from mangroves, with a resultant average of 3%. It is likely that the actual percentage is far greater.

According to respondents, none of the timber, withies or charcoal production came from mangroves. Thus although information on the production of wooden products was obtained from households, none of this pertained to mangroves.

In addition to harvesting mangroves themselves, the habitat also lends itself to salt making. Although salt making equipment was seen in operation in the mangrove area, and informal interviews confirmed substantial salt making activity, none of the households interviewed admitted to making it. Salt production of this nature is illegal (because of the quality of salt produced) and is no longer practiced openly.

Reptiles, mammals and birds

Although household surveys were not conducted in this area, the inhabitants of two villages immediately below NyM Dam claimed that crocodile hunting was an important revenue-generating activity. None of the households interviewed in this study admitted to hunting crocodiles, however.

Many households are engaged in hunting, however, and this includes other aquatic fauna such as hippopotamus and water birds. Hunting was reported by 7% of households in the Upper Basin, and by 2% of households in Kirua Swamp. These are relatively low proportions compared with other areas, and may be underestimates. Nevertheless, it is possible that hunting opportunities are relatively limited in the areas studied due to the level of development. About 1% of the hunting income in the Upper Basin was from aquatic fauna, whereas this proportion was about 43% in the Kirua Swamps.

Table 26: Estimated income (Tsh per year) from hunting among hunting households in the study area. Note that sample size is small and estimates therefore provisional

Data	Highlands	Upper basin	Kirua Swamp	Pangani estuary
N	25	41	87	45
% hunting households	0.0%	6.8%	2.2%	0.0%
Total income per hunting household		7883	875	
Income from aquatic fauna		83	375	
Average income per hh from wetlands		**6**	**8**	

Fish and crustaceans

Fisheries in the Pangani River Basin include fisheries in natural lake, riparian and estuarine systems, and fisheries in man-made aquatic systems. Natural lake fisheries include the fishery at Lake Jipe, which is currently dogged by water quality and weed encroachment problems. The value of this fishery has not been quantified. Natural riparian and estuarine fisheries are usually difficult to quantify and have been little-studied in the region (Turpie 2003). Among the man-made habitats, traditional furrows create little opportunity for fishing, but fish ponds have been created in association with some irrigation schemes. The yield from these ponds is unknown. The most notable man-made fishery in the area is associated with the Nyumba ya Mungu Dam. Annual fish production is highly variable, ranging between 1 800 tons and 5 000 tons in the 1980s (Bwathondi & Mwamsojo 2002), about 4000 tons in the 1990s, and about 1930 tons in the recent past (Sjaasted *et al.* 2003). Valued at Tsh 300/kg, the fishery is worth some Tsh 540 - 1500 million per year. While some authors have suggested that the fishery has become overexploited, the relationships between water inflow, effort and yield have not been explored.

Among households surveyed in this study (which were not in close proximity to any natural or man-made lakes), fishing was carried out in all areas except the highlands. About a third of the catches in the upper basin were derived from Nyumba ya Mungu Dam, and the remainder from rivers. However, reported catches in the upper basin were very small compared to catches elsewhere. Fishing effort increased significantly towards the coast, although the relatively high amount of gear in the Kirua Swamp perhaps indicates that effort used to be greater in this area. All fishing in the Kirua Swamps was in the river. At the coast, at least part of the fishing that was considered to come from the river may technically be classified as estuarine, depending on how the estuary was defined by the respondents. 11% of catch was from the inshore marine environment. However, since productivity in this zone is heavily dependent on riverine inputs, it can be considered a value of water in the basin. Moreover, the estimates provided here do not include the full extent of the inshore crustacean fisheries which are also utilized by fishers from elsewhere. Species targeted by households in the different areas are listed in Table 29.

Table 27: Proportion of households involved in fishing, amount of effort and gear per fishing household, and reported catches per fishing household, in kg per year

	Highlands	Upper basin	Kirua Swamp	Pangani estuary
n	25	44	89	45
% of households fishing	0%	14%	16%	36%
Average fishing days/hh/year		26.6	72.4	177.7
Gear per fishing household:				
Canoes/boats		-	0.3	0.8
Nets		0.5	3.3	1.3
Lines		0.5	4.6	2.4
Traditional gear		0.4	0.2	0.5
Catch per fishing household (kg):				
Fish		4	421	1,059
Shark				10
Rays				37
Crab				903
Prawns				114
Octopus				10
Average value of catch/year (income to fishing households)		2,800	211,769	1,925,034

Table 28: Percentage contribution of different habitats to fishing in villages surveyed in four part of the study area

Source	Upper basin	Kirua Swamp	Pangani estuary
Dam	33.3	-	-
River	66.7	100.0	60.3
Estuary	-	-	28.7
Sea	-	-	11.0

While the creation of the dam has led to the development of a major fishery in the basin, the change in water flow to downstream aquatic areas has probably led to a decrease in fishery yields in these habitats. Indeed, residents of Kirua Swamp describe a collapse of the fisheries in this area. Before the dam, communities in the Kirua Swamp area were dominated by fishers and pastoralists, whereas fishing is no longer prevalent in the area nowadays. Only 16% of households surveyed in villages close to the river were engaged in fishing, and average catch reported by these households was about 420kg per year, which is a moderately good catch, but not enough to sustain a household.

Table 29: Fish species mentioned by respondents in the household survey, and the number of times they were mentioned in each area

Fish species targetted	Upper basin	Kirua Swamp	Pangani estuary		Upper basin	Kirua Swamp	Pangani estuary
Hangwe/hongwe	0	0	12	Mkungu	0	1	0
Perege/Pelege	4	9	1	Gege	0	1	0
Kambale	1	6	3	Ndomondomo	0	1	0
Paramamba	0	0	7	Chafi	0	0	1
Kambare	0	4	2	Kerengwa	0	0	1
Ndedi/Ndadi	0	0	5	Chije	0	0	1
Dagaa	0	4	0	Mahogwe	0	0	1
Chewu	0	0	4	Mzia	0	0	1
Kuyu	2	1	0	Mikonge	0	0	1
Ngogogo	0	3	0	Tambanchi	0	0	1
Buju spp	0	3	0	Ngogo	0	0	1
Changu	0	0	3	Kao	0	0	1
Kolekole	0	0	3	Mafuni	0	0	1
Parata	0	0	3	Kenegwa	0	0	1
Ukamba	0	0	3	Dimbwara	0	0	1
Kaa	0	0	3	Makaji	0	0	1
Chazanda/Chezanda	0	0	2	Kamba Weupe	0	0	1
Clarias	1	0	0	Chafi	0	0	1
Dolmacl?	1	0	0	Kerengwa	0	0	1
Catfish	1	0	0	Chije	0	0	1
Tilapia	1	0	0	Mahogwe	0	0	1
Bunju	0	1	0	Mzia	0	0	1
Ningu	0	1	0				

Further downstream, the estuarine and coastal fisheries associated with the Pangani River were said to have collapsed by 1996 (Abdallah Abdi, District Executive Director, pers. comm.). A lively trading centre which mainly dealt in prawns and lobsters has all but disappeared from Pangani Town (A. Abdi, pers. comm.). Past over-fishing may have played a role in all cases, but water supply is likely to be the major causal factor in the natural fisheries.

Although no long-term fisheries data were available in Pangani District, the fisheries officer felt that there may be a correlation between flow and catch, citing the fact that last year's catch was bad due to drought (Mr Chomeka, District Fisheries Officer, pers. comm.). The artisinal prawn fisheries in the estuary (mainly white prawn, caught in gillnets) are productive during and after the rainy seasons, with peak catches in Feb – Apr, and November. In the past two years, recorded catches suggest an overall catch of 3 to 5 tons. These catches are small, and support the assertion that the fishery has suffered a major decline. However, it is unknown how the data were recorded. Mr Chomeka implied that data were obtained from a particular prawn buyer, in which case they could be underestimates. The number of fishers is unknown, but average catches reported by fishing households suggest at total of 30 – 40 fishers. The catch is bought by agents for a single company in Tanga, for about Tsh5-8000 per kg (Mr Chomoka, pers. comm.), though there is also some black marketing to Kenya. The average price reported by households was much lower – approximately Tsh2500, suggesting that the above price was that fetched by the traders. Export prices would probably be double this. Total recorded catches would thus be worth at least Tsh 15 – 40 000.

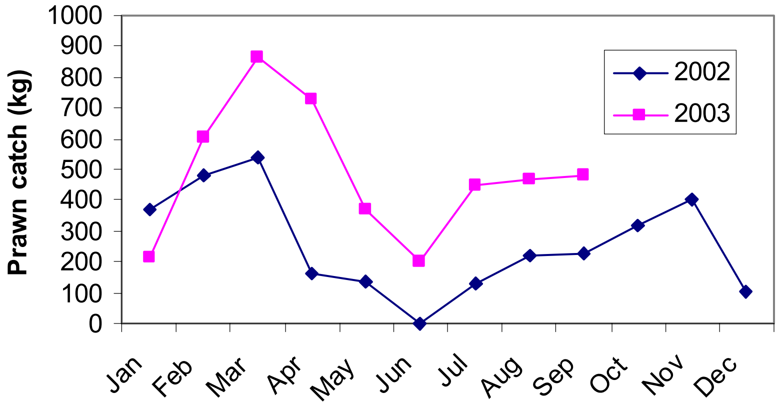

Figure 11: Prawn catch records in Pangani for 2002 and 2003. Source: Pangani District Office

Fish catches in Pangani estuary are reportedly about 150-200kg/month, year round (Mr Chomoka, pers. comm.), which equates to 1.8 – 2.4 tons per year, apparently by the same fishers These estimates are extremely small and conflict with the household survey results. Indeed the fish catches reported by households appeared to be overestimated, possibly due to better recall of good fishing days. Whereas prawns are weighed and sold by the kilogram (facilitating recall), fish catches are not weighed, and estimates would be much rougher.

Around Pangani estuary, these catches were also supplemented by catches of crustaceans, octopus, rays and sharks. Judging from interviews with key informants, the crab catches may have been overestimated and the prawn catches underestimated.

Estimates of income based on household survey data were moderate in the Kirua Swamp area, and fairly high at the coast. Overall, these estimates are still considered preliminary.

Overall value of aquatic resources

On average, households derive modest incomes from aquatic resources, increasing from a very small amount of income in the highlands to a fairly large amount in Pangani estuary (Table 30). Fisheries are the major source of income from aquatic resources, but palms also make a substantial contribution. The value of plants such as reeds and sedges are small, but this belies the degree to which they are used. Their low value is due to their relative abundance. The value of mangroves is probably underestimated.

Table 30: Overall average value per household derived from harvesting of aquatic resources (including value added in processing), averaged across user and non-user households

	Highlands	Upper basin	Kirua Swamp	Pangani estuary
Food & medicinal plants	63	815	2 383	170
Reeds, sedges and grasses	2 120	2 433	2 852	0
Palms	0	4 269	4 434	86 721

Mangroves				7 890
Reptiles, mammals & birds		6	8	
Fisheries		392	33 883	693 012
Average total income per household	**2 183**	**7 915**	**43 560**	**787 793**

Although income from aquatic resources is small, they are significant in the context of overall household income. The perception by households themselves was that aquatic resources contributed some 4 – 23% of household income (including subsistence values; Table 31). Although data were collected that will enable calculation of this proportion with actual data, sample sizes will need to be increased before reliable estimates can be made.

Table 31: Perceived relative value of different resources in terms of their percentage contribution to overall household income. Based on household survey data

Data	**Highlands**	**Upper basin**	**Kirua Swamp**	**Pangani estuary**
Crops	40.1	48.4	52.7	33.5
Livestock	32.4	17.2	14.4	5.3
Woodland resources	9.0	8.1	10.1	13.2
Fish	-	0.0	2.5	9.9
River/floodplain/estuary resources	8.1	4.0	7.3	13.1
Employment, Business	9.9	13.6	11.3	19.5
Pensions & remittances	0.6	8.7	1.7	5.4

Linking the values of aquatic ecosystem goods and services to flow is more problematic, however. Calculation of the average value per m^3 water would require relating the supply of these goods and services to the overall annual flows in different parts of the basin. This would be not be a particularly useful measure, however, since the relationships between flow and the production of ecosystem goods and services is complex, and yet to be studied in the Pangani River Basin. More importantly, as is true for all of the values reported in this study, the average values calculated are not as important as understanding the marginal value of water in different uses. For example, how will reed supply change if water allocation to the environment changes in a particular area. Such estimates can only be made in conjunction with a full environmental flows assessment.

Hydroelectric Power

Tanzania's power supply is mainly from hydropower (HEP), with HEP stations in Pangani River Basin supplying about 17% of the country's electricity via the national grid. Areas outside this grid rely on thermal generation. Most of the power production plants are under the Tanzania Electricity Supply Company (TANESCO), which currently state-owned, but is undergoing restructuring. There are currently three operational HEP stations in the basin: Nyumba ya Mungu, Hale and New Pangani Falls (Table 32), all under TANESCO.

Table 32: Specifications of the three power stations in Pangani River Basin. Rated discharge is the flow rate needed to produce the installed capacity, and firm discharge is the 'guaranteed' flow

	Nyumba ya Mungu	**Hale**	**New Pangani**
Operational since	1964	1968	1995
Installed capacity (MW)	8	21	68
Rated discharge (m^3/s)	42.5	45	45
Firm discharge (m^3/s)	24	24	24
Typical output (MW)	4	16	16

Energy equivalent:			
kWH/m^3	0.052	0.130	0.420
m^3/s per MW	5.3	0.46	0.6
MW per m^3/s	0.19	2.1	1.5
Reservoir	871Mm^3	-	0.8Mm^3

The installed capacity does not reflect actual output, however. Power production is a function of electricity demand and water supply. The plants can only operate at their maximum capacity when there is enough water, and almost never can. Each HEP station also only operates at above a minimum flow. For Pangani Falls, that is 9 m^3/s (M. Makunga, TANESCO, pers. comm.). Given enough water, users draw the power, and only that amount is produced. The amount of power drawn is obviously limited by both water supply and installed capacity. The whole grid acts as one entity, and shortages only occur when the instantaneous capacity (which varies with water supply) is exceeded at a national level.

When the HEP stations are unable to meet demand, the two alternatives are “load-shedding” (not supplying) and buying from independent suppliers, e.g. IPTL, Independent Power (thermal power station). Tanzania’s total installed capacity in mid 1993 was 333 MW of hydropower and 105MW of diesel plants, with a maximum available capacity of 310 MW, and the maximum demand in 1992 was about 308 MW.

Rainfall in the catchment, and thus natural river flow, is highly seasonal, whereas power demand is more constant. The dam at Nyumba ya Mungu serves to capture the high flows and releases water at a more regular rate through its turbines (Figure 12). Thus flows downstream of the dam are far more constant than would occur naturally, as suggested by levels in the much smaller Pangani reservoir Figure 12). Because of their lack of storage capacity, releases at Hale and Pangani, some 300km downstream of Nyumba ya Mungu, are almost entirely dependent on the flows released from that dam (Figure 13), although this is augmented to a small degree by flows from Mkomazi and Lwengera Rivers.

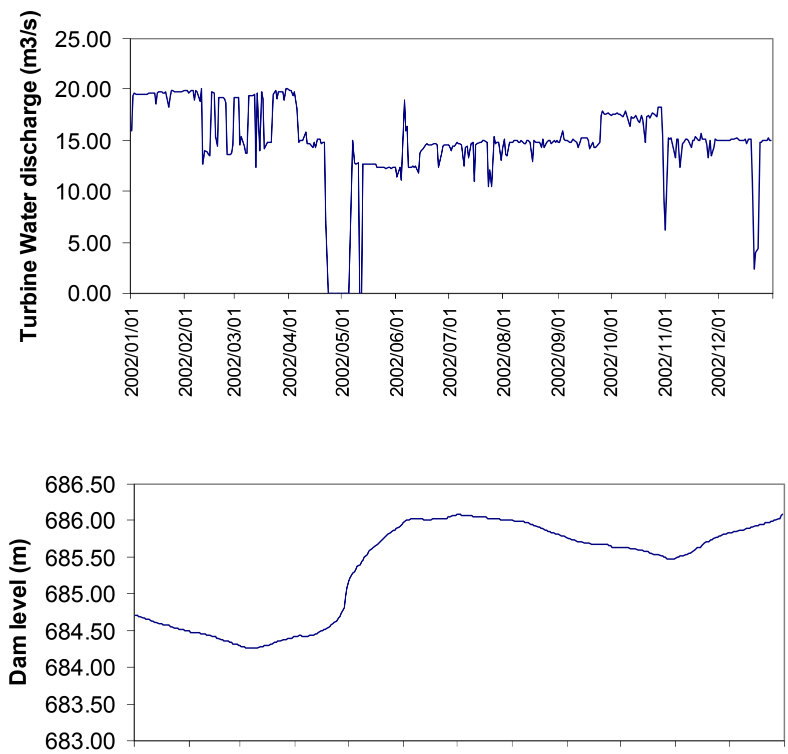

Figure 12: Seasonal patterns in dam levels and turbine water discharge (and power output) at Nyumba ya Mungu in 2002. Daily data provided by M. Makunga, TANESCO

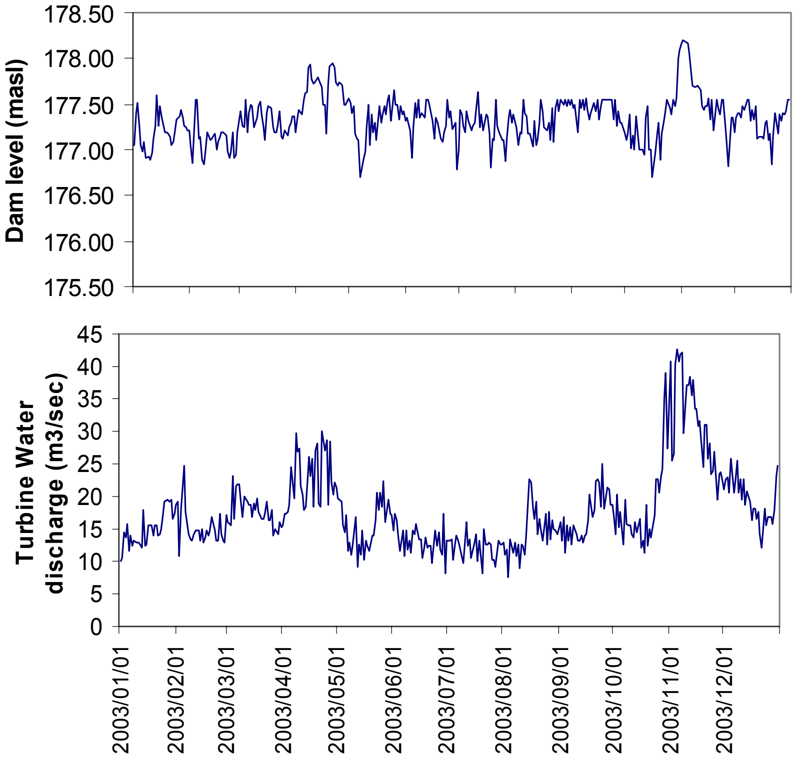

Figure 13: Seasonal patterns in dam levels and turbine water discharge (and power output) at New Pangani Falls in 2002. Daily data provided by M. Makunga, TANESCO

The relationship between power and water flow is described as:

$$Power = eQH/c,$$

where e = efficiency, Q = flow, and H = head (height of water above turbine). Head is relatively fixed for the lower 2 stations but variable for NyM, but does not have a very significant effect on power generation. Thus flow can easily be translated to power output.

The valuation of power output is not as simple. FBD (2003) valued power production as the price of power to domestic consumers in 2003 (= Tsh25.9/kWh), under the assumption that this price was equal to the price that would be attained in a competitive market, less the operational costs of power generation (=Tsh2.32/kWh). In fact, the price rises to Tsh 90/kWh after the first 100kWh, and average revenue from power generation from all users is Tsh 73/kWh (M. Makunga, TANESCO, pers. comm.).

During 2001, regarded as a normal year (FBD 2003), about 364 million kWh were produced by the three HEP stations, which should have generated some Tsh 26 543 million, based on average price. This is a minimum notion of the value of this power generation. Another possible approach to estimating the value of power production is to consider its contribution to the economy as a whole. For example, the output of Tanzania's manufacturing sector contributed some Tsh 638 663 million to GDP in 2002. If this sector was the main consumer of power and was assumed to be entirely reliant on hydropower (much of it is), then the average value of power generated could be estimated to be in the region of Tsh 300/kWh, with the Pangani River Basin contributing about Tsh 108 573 million. Nevertheless, the more relevant measure relating to water allocation is its marginal value, or how much value each extra unit of power generated would add to the economy.

What is particularly interesting is that Nyumba ya Mungu, which has the greatest impact in terms of effect on downstream water supplies, provided only 8% of the basin's power output, while Hale and New Pangani produced 25% and 67%, respectively. The more modern systems, such as that installed at New Pangani Falls, are far more efficient in converting flow to power. This is illustrated by the energy equivalents for the three power stations, in terms of kWh produced per m^3 of water passing through the turbines. Thus the value of water in power production differs depending on the HEP system used (Table 33), as well as the head. The value of water flow through Pangani is eight times that of water flowing through the turbines at Nyumba ya Mungu.

Table 33: Estimated average value per m^3 of water used in power generation

	Nyumba ya Mungu	Hale	New Pangani
kWh /m^3	0.052	0.130	0.420
Cash value/m^3 @ Tsh73/kWh	Tsh 3.8	Tsh 9.5	Tsh 30.7

Use of water in industry and mining

Most industry in the basin is associated with farming, such as sisal processing and sugar refineries (Geheb 2003). Sisal processing is a particularly water-dependent process and uses large quantities of water, in spite of the fact that the plant itself can be grown in fairly arid conditions. Mining also plays an important role in the basin. This includes tin mining in Korogwe, tanzanite and phosphate mines in Arusha Region (80% of the world's tanzanite reserves are within 100km of Arusha), and limestone mines in Tanga Region (Mkuula 1993, Geheb 2003). Ruby mining is carried out in the Kenyan part of the basin (Geheb 2003). These activities are important users of water in the Pangani Basin, and need to be investigated in terms of the value added by water use. However, due to time constraints, this was beyond the scope of the present study.

Discussion: water values and water-allocation decisions

The values presented here are preliminary estimates of the current average values of water in different uses, based on small sample sizes, and should be recognised as such. The types of uses considered are not exhaustive, as many more applications probably exist in the basin. There is also considerable variability within different types of uses, depending on the efficiency of water transport and the management, skills, and other inputs involved in production processes. Nevertheless, the values presented here (summarised in Table 34 below) give an idea of the orders of magnitude involved for some uses of water in certain parts of the Pangani River Basin.

Table 34: Summary of values of water in different uses

Type of use	Estimated water consumption	Estimated average value (Tsh per m^3)
Coffee estates	1000 m^3/ha	723 – 6205
Sugar estates	12 – 17 000 m^3/ha	32 - 101
Flower farms	18 250 m^3/ha	3500 - 5300
Small scale irrigation		
Highland traditional furrow	3000 m^3/ha	211
Upper basin traditional furrow	3000 m^3/ha	475 – 574
Upper basin improved schemes	850 – 1195 m^3/ha	574 – 1400
Lowland traditional furrow	3000 m^3/ha	109
Livestock		
Highlands (dairy cattle)	36 m^3/head	2263
Upper basin (dairy & beef cattle)	27 m^3/head	860

Type of use	Estimated water consumption	Estimated average value (Tsh per m^3)
Lowlands (beef cattle, goats)	18 m^3/head, 2.5 m^3/head	479 – 926
Domestic use	18 – 70 m^3/head	1200 – 1500
HEP	2.4 -19 m^3/kWh	73 – 300(?)
Aquatic ecosystems	?? m^3/ha wetland	Flow data unavailable

The most difficult aspect of the valuation of water in different uses is the quantification of water use in these activities. Although data will exist in some form for most uses, time allocated to this study did not permit a detailed analysis of flow data or exhaustive search for data on water consumption in different uses. This will be critical to developing a more accurate understanding of the value of water in different uses, and particularly in the environment. Similarly, data on efficiency of water use in agriculture need to be substantiated.

This study provides a brief description of the different types of water uses and aquatic system values in the study area, and gives a general idea of their relative values and a basis for focussing future work. It is important to note that the average values presented here are not values upon which water allocation decisions should be based. The measure that is actually required is the net marginal value of water in different uses. This is the added value gained by adding an extra unit of water to any particular use. As more water is allocated to any particular use, the added value will diminish. For example, increased water allocated to irrigated agriculture may allow expansion of better irrigated fields, but when land is in short supply, there will be a point where adding more water does not generate that much more income. Diminishing returns will be found in any activity, but depending on the level of water already supplied in relation to demand, the rate of decrease in marginal productivity will differ.

Moreover, the average value of water in different productive activities is a problematic concept in itself. Production is usually the result of multiple inputs, of which one is water. In this study, the benefit net of other production costs is ascribed to water. In reality, production would potentially fall to zero if any of the factors of production were to be lost. But it is impossible to ‘allocate’ the net benefit of production to among these factors in a static analysis. This further serves to illustrate the point that when it comes to water allocation, only marginal value can provide a suitable guide.

Previous studies have used the price of water as a proxy for marginal value in different uses. For example, FBD (2003) valued the use of water in agriculture at the current water user fee (Tsh 70 per 1000m^3) for licensed users, and at the average price of water in villages (Tsh 0.256 per litre) for farmers using traditional furrows. The former is set by the government, whereas the latter is set through a competitive bargaining process. Based on Mujwahuzi’s (2001) estimate of total abstraction in the basin of 48 m^3/s, which equates to 1 500 Mm^3 per year (slightly less than the 1800 Mm^3 currently estimated by PBWO), and the fact that large and small scale irrigation schemes are allocated about 400 Mm^3 of water annually, with traditional furrows using the rest, FBD (2003) arrived at an estimated total value of Tsh 25 million per year. However, these prices do not reflect the full economic impact of water use, since water contributes towards the residual value of production. A similar argument is provided for the value of water in power production. Thus allocation decisions should ideally be guided by the construction of data-intensive production functions in which the change of output can be predicted for a change in water input.

Estimating the marginal value of water in the environment is a particularly challenging task. This requires an understanding of the relationship between flows and resource productivity, in conjunction with an understanding of demand for these resources. This in turn requires multidisciplinary research, and is often dependent on the existence of long term data series on both the flow characteristics and biological aspects. For example, prawn fisheries are understood to be strongly correlated with freshwater flows into estuaries. To quantify the effects of a change in flow on prawn catches, one needs time series data on both flows and catches, which are not available over a long period. In Pangani River Basin, data such as this will be difficult to obtain in many cases, and inferences may need to be made from other areas. It is also important to note that while most uses can be valued simply in terms of output per quantity of water per year, environmental outputs depend not only on the quantity of flow but also the temporal way in which it is delivered. Environmental productivity is strongly linked to frequencies of low and high order floods. In short, there is much work to be done before sufficient understanding of the value of water in different uses is gained in order to optimise allocation of water in the basin for maximal economic value.

Impacts of macro-economic and national policies on water resource management

Macro-economic Policies

Governments aim at attaining goals and targets for development and economic growth by using economic, financial, legal and institutional instruments to encourage or discourage particular forms and types of economic activities at microeconomic and sectoral levels. Economic policies and their supportive instruments impact on water catchment status and on community involvement in sustainable resources management, because they shape economic activities. They affect the ways in which land and resources are allocated and used, investments are made, markets function and economic opportunities are presented. They set in place the economic conditions under which people conserve or degrade water resources. Table 35 summarises the negative impacts/influences of some selected macro-economic policies on sustainable water resource management, both in "environmental" and "productive" sectors of the economy.

Table 35: Negative impacts of some macro-economic policies on sustainable management of water resources

Macro-economic Policy	Influence on Sustainable Resource Management
1. Trade liberalisation	Increased tendency to procure goods and services out of the environment for trading; destruction of watersheds due to deforestation; putting more pressure on water resources partly due to increased crop production (especially irrigated agriculture) and consequently leading to increased pollution loads and water scarcity. It generally induces rapid depletion in export activities based on natural resources, e.g. mining, logging, fishing and agriculture.
2. Market liberalisation	More natural resources are marketed; destruction of watersheds due to deforestation resulting from exploitation of more wood-based products; putting more pressure on water resources partly due to increased crop production (especially irrigated agriculture) and consequently increased water pollution.
3.Privatisation and Private sector involvement	More people get involved in the exploitation of natural resources, leading to catchment degradation, and ultimately water scarcity and pollution. Tendency for private sector to concentrate on profit maximisation at the expense of the environment.
4. Reducing government expenditure	Reduced number of skilled technicians hampers the management of water resources, leading to increased pressure on the exploitation of catchment resources and water.
5. Deregulation of foreign exchange controls	This encourages export, and implicitly more exploitation of environmental products. This in turns increases pressure on water resources.
6. Financial sector reforms	When interest rates are favourable, capital investment increases, putting more pressure on water resources. Reduces the financial capacity of firms to undertake environmental expenditures in abatement procedures and capital stock conversion.

Macro-economic Policy	Influence on Sustainable Resource Management
7. Civil service and public administration reforms	Lack of capacity, reduced manpower and inappropriate institutional arrangement lead to poor water resources management. It also reduces scope for improvement of public servant remuneration and budget allocation in environmental management sector.
8. Fiscal Reforms	Reduces the scope of specific environmental fiscal instruments
9.Export promotion and globalisation strategy	Creates opportunity for trade in many products, some of which may be dangerous to environment including water resources.

Policies which have negative impacts are those which directly or indirectly promote natural resource exploitation (e.g. catchment deforestation) or weaken control of catchment resource use. Some of these same policies can also have positive impacts, however, depending on how they are translated into action (Table 36). For example, privatisation and trade-liberalisation can create opportunities for greater efficiency and environmental friendliness when they occur in conjunction with incentive measures such as marketing standards and tradable pollution permits.

Economic policy formulation and implementation has generally taken little cognisance of water and water catchments areas, which has resulted in devastating impacts on water resources in the country.

Table 36: Positive impacts of some macro-economic policies on sustainable management of water resources

Macro-economic Policy	Influence on Sustainable Resource Management
1. Privatisation	Creates opportunities to introduce efficiency, eliminate subsidies, and correct water resource liabilities in a privatised state owned economic activities (such as: provision of electricity, oil products, clean water, sanitation services, and solid waste collection)
2. Trade liberalisation	Encourages dynamic export-oriented industrial and commercial companies to comply with international standards in environmental management
. 3. Export promotion and globalisation strategy	Induces imports of capital goods with embodied clean technology
4. Fiscal Reforms	Creates opportunity for the introduction of environmental criteria into conventional taxation

National sectoral policies

National Water Policy

The Nation's freshwater is a basic natural resource, which sustains life and provides for various social and economic needs. In its natural state, water is an integral part of the environment whose quantity and quality determine how it can be used. Unfortunately water is poorly distributed, in time, space, quantity and quality.

The main objective of the reviewed National Water Policy (URT, 2002a) is to develop comprehensive framework for sustainable development and management of the Nation's Water resources, in which an effective legal and institutional framework for implementation will be put in place. The policy aims at ensuring that beneficiaries participate fully in planning construction, operation, maintenance and management of community based domestic water supply schemes. It seeks to address cross-sectoral interests in water, watershed management and integrated and participatory approaches for water resource planning, development and management. The policy also lays a foundation for sustainable development and management of water resources in the changing roles of the government from service provider to that of coordination, policy and guideline formulation, and regulation.

The water utilisation (control and regulation) Act. No. 42 of 1974 and its subsequent amendments govern the present water resources management systems. Amendment Act. No. 10 of 1981 introduced pollution aspects. However, the water utilisation Act and other sub-sector water related laws are inadequate to meet the growing water resources management challenges facing the country today. The water utilisation (control and regulation) and other water statutes are currently being revised.

Environmental Policy

This policy seeks to provide the framework for making fundamental changes that are needed to bring environmental considerations into the mainstream of decision making in Tanzania. Its overall objectives include the following (URT, 1997a):

(a) To ensure sustainability, security and equitable use of resources for meeting the basic needs of the present and future generations without degrading the environment or risking health or safety;

(b) To prevent and control degradation of land, water, vegetation, and air which constitute our life support systems;

(c) To conserve and enhance our natural and man-heritage including the biological diversity of the unique ecosystems of Tanzania;

(d) To improve the conditions and productivity of degraded areas including rural and urban settlements;

(e) To raise public awareness and understanding of the essential linkages between environment and development; and to promote individual and community participation in environmental action; and

(f) To promote international cooperation agenda and expand our participation and contribution to relevant bilateral, sub-regional, regional and global organisation and programmes, including implementation treaties.

Besides above objectives, the policy advocates on : planning and implementation of water resources and other development programme in an integrated manner and in ways that protect water catchment areas and their vegetation cover; improved management and conservation of wetlands; promotion of technology for efficient and safe water-use particularly for water and waste water treatment and recycling; institution of appropriate user-charges that reflect the full value of water resources; prevention, reduction and control of pollution of the marine and coastal waters. Therefore this policy encourages sustainable water resources management.

National Agricultural Policy

The main objective of the National Agriculture Policy is to ensure food security at both national and household levels (URT, 1997c).

The objective calls for irrigated agriculture since the agriculture which is mostly rain-fed remains susceptible to drought and the inadequate and eratic nature of rainfall. Eighty percent of the irrigated area is under traditional irrigation schemes with low level of water use efficiencies. Irrigation is a highly consumptive water user and makes greatest impact on net water resources. In the Pangani and Rufiji basins, for instance, irrigation systems are located, upstream of major hydropower plants, thus the two sectors are competing for the same sources. Agricultural activities also contribute to pollution from use of agrochemicals, which are washed by rainwater and find their way to water sources. Furthermore, some agricultural activities involve expansion of farmlands by clearfelling the forests. At times, may go to an extent of disturbing the watersheds. The policy therefore has considerable negative effects to sustainable water resource management.

Tanzania's National Forest Policy

The first policy was drafted in 1953 with subsequent review in 1963 to articulate the approaches through which forest resources would be managed sustainably to meet both national and local needs.

The current national Forest Policy (URT, 1998a) was prepared with the full involvement of stakeholders and this presupposes that their interests and priorities are considered. The primary policy instrument is the establishment of village forest reserves. The National Forest Policy is explicit on the strategies aimed at developing the necessary infrastructure for marketing of priority forest products.

As a deliberate intervention to enhance livelihood systems of the local communities, the government has decided to promote beekeeping for the benefits of the local communities.

Among other things, the policy:

- strives to prevent and control degradation of land, water, vegetation and air that constitute life support systems,
- strives to ensure ecosystem stability through conservation of forest biodiversity, water catchment and soil fertility. This involves establishment of some new catchment forest reserves for watersheds management and soil conservation in critical watershed areas,
- promotes research and information dissemination in order to improve watersheds management and soil conservation, and
- advocates the inclusion of watersheds management and soil conservation, in the management plans for all protection and production forests. Involvement of local communities and other stakeholders in watershed management and soil conservation has been encouraged through joint management agreements.

In the view of the above, it is explicit that the pertinent policy encourages sustainable water resource management

Wildlife Policy

The Wildlife conservation in Tanzania dates back in 1891 when laws controlling hunting were first enacted. The process of the enactment did not consult the affected stakeholders and thus, the communities' level of welfare was affected.

The current wildlife policy (URT, 1998b) has the involvement of all stakeholders in wildlife conservation and sustainable utilisation as well as in a fair and equitable sharing of benefits as one of its visions. The policy also aims at using wildlife resources to contribute to poverty alleviation and improve the life quality of Tanzanians.

The policy identified the following as some of the problems facing the wildlife sector:

- The existing land tenure system and the wildlife resource ownership by the state, hinders investment in, and development of wildlife industry by private sector.
- Inadequate wildlife use rights especially to the rural communities.

The policy prohibits human settlement and hence activities in the National Parks and Game Reserves. It therefore discourages the destruction of water catchment, thus promotes sustainable water resource management. The policy further stipulates explicitly that, water catchment and soil resources should be conserved. Another strategy of the policy is to enhance the use of indigenous knowledge in conservation and management of natural resources including water catchment areas.

National Beekeeping Policy

The Beekeeping sector in Tanzania has been managed without a policy since 1949 when it was officially formed as a department under agriculture. The existing beekeeping policy document was prepared in the initial stages as a part of the forest policy involving relevant stakeholders.

The Beekeeping Policy, whose main goal is to enhance sustainable contribution of the sector for socio-economic development and environmental conservation, covers both stinging and non-stinging (stingless) honey bees regardless of ownership or administration; it includes feral (wild) and domesticated (kept in hives) colonies and all other bees which are non-parasitic and collect nectar and or pollen for their food (URT, 1998c).

Six basic policy areas were identified:

- Establishment and sustainable management of bee reserves
- Apiary management
- Beekeeping-based industries and products;
- Beekeeping in cross-sectoral areas
- Beekeeping for ecosystem conservation and management; and
- Institutions and human resources

In each of the above policy areas, pertinent policy issues are discussed and brief policy statements; instruments and directives to be applied are stated. One of the policy's objectives is to prevent and control degradation of water resources and vegetation and in this view, it encourages sustainable management of water resources.

The Mineral Policy of Tanzania

The Ministry of Energy and Minerals is charged with the responsibility of formulating a mineral policy, overseeing administration and co-ordinating the development of the mineral sector in Tanzania. The vision for the next 25 to 30 years for the mineral sector is to have a strong, vibrant well–organised private sector lead, large and small-scale mining industry conducted in a safe and environmentally sound manner.

The current mineral sector policy is designed to address the following national challenges (URT, 1997b):

- to significantly raise the contribution of the mineral sector in the national economy and increase the Gross Domestic Product (GDP),
- to increase the country's foreign exchange earnings,
- to create gainful and secure employment in the mineral sector and provide alternative source of income particularly for the rural population, and
- to ensure environmental protection and management.

The policy has attracted number of private mining sectors artisans and small-scale mining, dominated by Tanzania citizens; and large-scale mining, conducted mostly by foreign investors. Most of these large and small-scale mining operations are not environmentally sound and large quantities of water is used during processes and discharged thereafter. In most cases this water is contaminated and thus pollutes water sources. Artisanal and small-scale mining activities are overwhelmed by technical, financial, marketing, social and environmental problems.

The policy stimulated exploration and mining development, thus attracting foreigner investors whose main objective is profit maximisation and often don't adhere to environmentally friendly guidelines; consequently destroy watersheds, and increase pollution problem. The mineral benefaction promoted by this policy leads to contamination of waterways and air pollution, thus impinging sustainable water resource management.

However, one of the policy's strategies is to establish a co-ordinated consultative mechanism within the government, especially with central ministries responsible for planning, health, water, finance, lands, works, environment, law and order; and regional authorities for effective development of the sector. This strategy attempts among other things, to manage water resources and avoid pollution. Another positive effect of the policy towards sustainable water resource management is that it encourages the mining companies to invest in power, water supply and social infrastructure. The policy also incorporates the provision of social infrastructure and hygiene enhancing facilities such as water supply and sewage systems in community development plans of highly concentrated mining areas. This supports sustainable water resources management. The 1998 Mining Act also has made provisions on environmental standards especially on water pollutants.

The National Fisheries Sector Policy and Strategy Statement

Tanzania is rich in marine and inland fishery resources. The fisheries sector has a significant economic and social impacts. It greatly contributes towards poverty alleviation and food security. It provides a source of employment and livelihood to a substantial number of people and recreation, and tourism. The main sector issue and concern is water availability and acceptable quality. The objective of the policy include (URT, 1997d):

- To efficiently utilised available resources in order to increase fish production,
- To enhance knowledge of the fisheries base,
- To establish national strategic research programmes that are responsive to the fisheries sector,
- Improving fisheries products utilisation and their marketability,
- To strengthen regional and international collaboration in the sustainable exploitation, management and conservation of resources shared water bodies,
- Develop and strengthen inter-sectoral co-operation in general fisheries development and minimize operational conflicts,
- Incorporate gender respective in the development of the fisheries sector,
- Encourage and support all initiatives development of the protection and sustainable use of fish stock and aquatic resources, and
- Protect productivity and biological diversity of coastal and aquatic ecosystems through prevention of habitat destruction, pollution and over exploitation.

This policy encourages private investment in the sector in order to stimulate fish production, processing and marketing; and other related socio-economic activities. Promotion of private sectors has increased fishing activities and violation of sustainable fishing guidelines and subsequent pollution of water bodies. On the other hands, the policy empowers the communities to participate in the management and conservation of the fisheries environment by ensuring responsible fishing principles by all communities. This is a positive signal towards sustainable water resource management. The policy insists on adherence to Environmental Impact Assessment (EIA) before launching any fisheries investment. It bans destructive fishing and processing methods thereby discouraging water pollution. It also encourages the establishment of multidisciplinary fisheries development advisory committee to advise the government on various fisheries related issues including control of water pollution.

Local-level incentives and disincentives affecting water use

Although macro-economic and sectoral policies have an important bearing on the way in which water is supplied, allocated and used, it is also important to understand the incentives and disincentives for sustainable use at the level of the user. In Pangani River Basin, the bulk of water consumption is by small holder farmers and domestic users. These are probably also the areas in which most wastage or excessive consumption takes place, yet there are few incentives that encourage the economical use of this water.

Most small-holder farmers rely on traditional furrow irrigation systems which are highly inefficient in terms of the percentage of water consumed that actually goes into crop production. Some of this inefficiency is due to physical problems such as seepage through the canals. However, much of the problem is probably due to inefficient management of water in these systems. Efficient management is time consuming and costly, and would be perceived as unnecessary because access to water is free and quantities used are virtually unregulated. There is even less incentive to fix problems such as leakages from canals, because of the very high costs involved. This is where many of the improvement projects and new irrigation schemes have made a difference. In return, users are theoretically charged for the water supplied. However, payment is not enforced, and only a fraction of users in schemes actually pay for their water. Thus, even with improved efficiency of water delivery, there is still considerable wastage, because water is free and thus is not considered a scarce resource by users. Moreover, many improved schemes have been built with a higher capacity for drawing off water from the river sources than the draw-off which is allowed by the water rights. Structures are fitted that reduce draw-off to the maximum allowed, but these structures are frequently removed to allow greater access to water. The latter occurs because there are no negative consequences. The Pangani Water Basin Office does not have sufficient capacity to physically prevent or reduce access to water in these systems should transgressions occur. Another important factor is that upstream users of water are under no obligation to downstream users, even within the same river system, which means that upstream users have no incentive to use water with due regard to downstream users, a problem which is exacerbated by the number of users involved. In all these smallholder irrigation systems, water is thus effectively a free resource in an open access system. The only areas in which there is an incentive to use water efficiently are those in which water is becoming more scarce, e.g. due to increased upstream abstraction.

In urban areas, the price of water is low and fixed, and payment is not always enforced. This, particularly the lack of enforcement, provides little incentive to use water economically or to prevent unnecessary losses. Another problem which affects downstream water supplies is the pollution of water by municipalities and industry. This occurs because the costs imposed on downstream users do not have to be compensated by the polluters.

Ultimately, the expansion of economic development possibilities within the basin relies on both maintenance of the supply of water (e.g. though catchment forest conservation and limiting pollution) and increase in the overall efficiency of water use. Possible incentive mechanisms to achieve this are discussed in the following chapter.

ECONOMIC INSTRUMENTS: promoting sustainable water resource management in the Pangani Basin

Water can be viewed both as a fundamental ingredient for ecosystem health and as a catalyst to economic development. As such it makes a critical contribution to human welfare. The degradation of water resources and increasing water scarcity are thus major threats to the welfare of Tanzanian society. Given the gravity of the situation, it is imperative that Tanzania embarks on a programme that facilitates sustainable water resources management. This is recognised in the revised water policy, but the details as to how this will be achieved are yet to be worked out. Other sectors have not yet recognised the importance of water, taking its availability for granted and not paying mind to the degradation of water resources and catchment areas. Water resources management thus needs to be integrated across all relevant sectors and needs to be applied at the basin level.

Integrated river basin management can potentially draw from a number of approaches, depending on its policies and goals. Nevertheless, there is a growing sentiment, worldwide, that economic instruments are likely to be the most effective tools for encouraging efficient and optimal use of water resources and for protecting catchment areas. While the implementation of these mechanisms is still in its infancy at a global scale, it is becoming increasingly urgent.

The Ministry of Water and Livestock Development (URT 2003) in the review of water resources legislation, recognises that currently there are no incentives mechanisms in place to promote efficient and sustainable use of water resources in Tanzania. The new water policy (URT 2002) proposes that all water uses, especially for economic purposes, will be charged for, and a catchment conservation charge will be introduced. However, these appear to be aimed primarily at raising revenues for water resource management, rather than as incentive mechanisms.

According to the water policy (URT 2002), incentive mechanisms should be developed that address the following problems in the Pangani Basin

1. *Catchment degradation*: The current water resources in the Pangani Basin have been dwindling as a result of catchment degradation;
2. *Wastage of water*: Inefficient use of water in Pangani Basin is attributed to the low water tariffs. It has been proposed that a water pricing mechanism is initiated (URT 2003);
3. *Water losses*: much water is lost through seepage and leakages;
4. *Non-payment of water user fees and other charges*: setting up water user rights that are not collected or paid will not address the current inadequate funding.

Potential mechanisms to encourage sustainable use of water resources

Any instrument that aims to induce a change in behaviour of economic agents by internalising environmental or depletion costs through a change in the incentive structure that these agents face (rather than mandating a standard or a technology) qualifies as an economic instrument. In other words, economic instruments are policy levers that operate through market mechanisms to alter prices and costs in order to induce firms and households to behave in an environmentally friendly way in the production and consumption of goods and services. For example, rather than proscribing pollution behaviour, economic instruments work through setting an incentive structure that makes polluting less attractive to individuals and firms.

Emerton (1999) defines an incentive, as a specific inducement designed and implemented to influence government bodies; business, NGOs or local people to conserve natural resources in a sustainable manner. She argues that many of goods and services associated with natural resources (including water resources), and the premium attached to conserving them –are undervalued by the market and tends to be under-priced, over-consumed and under-conserved because they are treated as free goods which can be mined, converted, depleted, or degraded at no cost. The provision of economic incentives and dismantling of perverse incentives, are necessary conditions for sustainable water resources management in the Pangani River Basin.

However, despite the importance of economic incentives for water resources management, there is little or no actual experience of their use in Tanzania. Even use of economic instruments for environmental management in Tanzania is not very common (Mkenda & Ngaga 2003a), despite being provided for in some policies such as National Water Policy, National Environment Policy and Mining Policy of Tanzania. User charges, fees, taxes, royalties and fines are widely used in Tanzania, but they are mostly used for revenue generation and not regulating behaviour with respect to environment.

With this limited use of incentives and economic instruments for natural resources management, the water resource managers in Pangani River Basin will be breaking new ground in this field. Fortunately, provision of use of economic instruments in the National Water Policy and the ongoing revision of Water Legislation affords an opportunity to develop practical incentive measures that will improve water resources management in Tanzania. The section below is written with the understanding that ongoing review of Water Act is at the stage of discussing and exploring viable incentives and economic instruments for the enhancement of water resources management in Tanzania and therefore would adopt some of the incentives proposed below.

The National Environment Management Authority – Uganda (NEMA) (2001) lists the three main objectives of using incentives and disincentives as follows:

1. To incorporate environmental costs in the decision of producers and consumers and to reverse the tendency to treat the environment as a “free good” and to pass these costs on other parts of society, other countries and future generations;
2. To move more fully towards integration of social and environmental costs into economic activities, so that prices will appropriately reflect the relative scarcity and total value of resources and contribute towards the prevention of environmental degradation; and
3. To include wherever appropriate, the use of market principles in the framing of economic instruments and policies to pursue sustainable development.

Economic instruments in water resources management come in many forms. In addition to water user charges, there are also other charges, taxes, transferable rights, liability fees, non-compliance fees, and performance bonds. Mkenda & Ngaga (2003c) and NEMA (2001) present a catalogue of economic instruments that could be employed as incentives that could be used to encourage, motivate or reward resource users for their good practices in environmental management or disincentives to discourage degradation of the environment. These are summarised in Table 37.

Table 37: Summary of the different types of economic instruments that can be used to influence the sustainability of resource use, and how they can be applied to water

Economic Instrument	Brief Description	Examples
Charge systems	Charges are payment for use pf resources, infrastructure and services and are akin to market prices for private goods.	Water user fees.

Economic Instrument	Brief Description	Examples
Liability systems	Liability systems are normally used to regulate activities, which involve a degree of risk. The use of the threat of legal action to recover damages is the economic instrument.	Penalties for damaging water quality, for instance, through mining.
Bonds and deposit refund systems	These are instruments aimed at shifting responsibility for controlling pollution, monitoring and enforcement to individual producers and consumers who are charged in advance for potential damage.	A bond or deposit refund could be designed for mining companies whose mining activities might affect water quality.
Property rights	Property rights refer to bundles of entitlements defining owners' rights and duties in the use of a particular natural resource.	Water rights.
Market creation	It is now recognised that the environment has a significant market price, and one of the economic approaches is to try and mimic the market, that is, create a market in environmental goods and services	Tradable water rights; payment for environmental services
Financial instruments	Financial instruments are extra-budgetary instruments financed from foreign aid, external borrowing and examples include grants, revolving funds, green/ecofunds etc.	Water trust fund
Fiscal instruments	Fiscal instruments either impose taxes (disincentives) or reduce them (incentives) for the sake of natural resources management	Water pollution taxes; subsidies for infrastructure improvement for example of the traditional furrows.
Information disclosure	This involves provision of information on environmental implications of production and consumption of goods and services.	Awareness creation; formation of local water management committees

Economic incentives can complement the use of institutional, regulatory, technical and other kinds of tools used in the water sector. Use of economic instruments involves the use of prices and other market based measures to provide incentives to consumers and all water users to use water carefully, efficiently and safely. Economic instruments may offer some advantages over other tools, such as providing incentives to change behaviour, raising revenue to help finance necessary adjustments, establishing user priorities and achieving overall IWRM management at the least overall cost to society (www.gwp.ihe.nl). Successful application of economic instruments need appropriate standards (e.g. for discharges or surface quality), effective administrative monitoring and enforcement capabilities, institutional coordination and economic stability.

UNEP 1995 and www.gwp.ihe.nl discuss some of the economic instruments that have proved to work and are practical in the promotion of integrated water resources management. Some of these economic instruments have been proposed for the management of water resources management in the Pangani River Basin by Kristiansen (2000). These are described below.

Water pricing

The current review of the Water legislation identifies water pricing as one of the areas that need to be worked on in Tanzania in order to improve water resources management. A major omission of water pricing is consideration of maintaining environmental services.

The purpose of water pricing is:

- Environmental protection: encouraging conservation and efficient use; recognising environmental benefits from leaving water in its natural state.
- Cost recovery: generation of funds for the operation of the sectors
- Cost reflectivity: signalling water users to the true scarcity value of water and the cost of providing the service; providing incentives for more efficient water use

This involves structuring a water tariff that should be affordable, acceptable to the public and administratively feasible. Volumetric tariffs, which charge according to the amount consumed, are more versatile than fixed charges and can provide incentives for careful use. This has been the experience in Hai district where all the water is metered and users pay based on the volumes consumed, and even the monies paid to PBWO are based on the consumption at the intake points. Further, in some places in Hai district, they are using increasing block rate tariff structures, which mean that as consumption increases, the consumer pays more per unit for additional consumption. A major concern for Pangani River Basin should be to avoid placing an additional cost burden on the poor, especially for a basic necessity of life such as water. Increasing block rate structure can do this by charging very little for the small amount of water needed to cover basic human needs. The tariff then increases per unit of water sold as consumption exceeds the basic consumption level and water is used for less vital purposes.

Revising the water pricing in the Pangani River Basin should go hand in hand with improving the efficiency of water allocation, which could be enhanced through re-doubled efforts in formation of rural agricultural water users associations.

Kristiansen (2000) concludes that the current levels of water user fees are far too low to have any significant effect on water allocation and recommends that an urgent review, and proposes a substantial increase for irrigation to effective incentives for water saving efforts.

Pollution/Effluent charges

Pollution charges have not been provided for in the current water legislation in Tanzania. Pollution charges are designed to reflect the financial and economic costs of discharging wastes into the environment. By levying a charge, polluters are encouraged to reduce their polluting discharges, and in effect are paying for the reduction of the ambient water quality. Charges can be levied on specified pollutant load and/or concentration, and can reflect environmental damages imposed by the pollutants.

Tradable pollution permits

Individual polluters can be allowed the right to buy or sell quotas of emissions subject to an overall total quota of emissions. Nutrient trading is a potentially useful instrument to improve water quality. For this system to be effective, the demand for the permits must be greater than supply and there must be a number of firms, including some who can reduce pollution at less cost than what other firms will pay for effluent discharge permits. This provides a better incentive than effluent charges, and reduces pollution at the least cost to society.

Water markets and transferable water rights

The Basin offices cannot manage to solve the problems of efficient water allocation administratively. The most plausible alternative to achieve real efficiency in production is to create a water market, where in the long run prices and productivity decides the water allocation. Transferable water rights also encourage the development of water saving technology.

These tools allow sales of water allocations from one group to another. The markets can apply either to surface or ground water, and transfer may be seasonal or permanent. Such markets can:

- Enable water to be transferred from lower – to higher-value users;
- Overcome the resistance of the entrenched property rights of existing holders;
- Be a cheaper way for communities or farmers to obtain their water than alternatives, which may include creating a new source of supply; and
- Be used by environmental champions, to buy out existing users and preserve the water for habitat and natural amenity.

For transferable water rights to succeed the rights must be clearly defined, the demand for water must be greater than the supply as is clearly the case in Pangani, and it must be politically and socially acceptable that rights to water can be held privately. The idea of establishing “open water markets” in the Pangani River Basin was mooted in 1995 (NORPLAN), where it was to be run by the PBWO. The water prices would occur in the market making a basis for the water allocation where the water had the highest market value.

Subsidies

Given the massive water losses due to old furrows and reticulation systems, some degree of subsidisation of furrow rehabilitation and farming methods might be an efficient option for the basin. This could lead to a greater overall productivity of water as well as higher revenues accruing to the management body. NORPLAN (1995) made extensive studies in the Pangani River Basin and concluded that improvement of traditional furrows would increase the efficiency of schemes from some 25% to 40%, increasing water availability by about 0.3 cumecs annually which corresponds to the estimated annual increases in the water abstractions in the Basin. The irrigators could be educated to use more-efficient irrigation methods. An additional approach to address the water problem challenges in the Pangani River Basin is to revive the installation of control gates, which would save close to 100 Mm^3 in a normal year. There should be concerted efforts to modernise the traditional irrigation schemes which would cost Tsh 29 million/year against anticipated social benefits estimated at Tsh 150 million/year through increased farmers’ benefits from irrigation improvement and increased hydropower generation (NORPLAN, 1995).

Watershed Conservation Fees

The dwindling water resources in Pangani River Basin are partly attributed to catchment degradation. Protection of forests around catchment areas is a necessity, because the costs of providing alternative sources of water are very high. The case of water provision for New York City demonstrates this. New York City obtains much of its water from Catskill/Delaware watersheds. A recent evaluation showed it would cost US$ 7 billion to build a water treatment plant, against a US$ 1 billion bill for actively managing the forest catchment area by raising water taxes and in turn paying farmers to use less fertiliser and reduce grazing. In Quito, Ecuador, water consumers may soon be required to pay a small surcharge on their monthly water bills to maintain the forest cover of the watershed that supplies the city with drinking water (Spergel, 2002). In Costa Rica, the National Government and Energia Global, a private hydroelectric company compensates private landowners when they maintain or increase forest cover in watershed areas (Shilling & Osha, 2002).

Though the Water Act does not provide for catchment protection fees, the new water policy proposes that such a fee should be put in place. The Forest Act (Third Schedule of 1998 part C (4d)) requires that all commercial users obtaining water from the forest must pay an annual forest management fee of Tsh 100,000.00 (equivalent of US$ 100). Commercial farmers especially in Kilimanjaro have been reluctant to pay this, and the Kilimanjaro Regional Forests Officer has written (September 2003) to 12 farms requesting for the prompt payment. However the system is not equitable, because all users of water in the basin benefit from the conservation of the catchment areas, not just those obtaining their water directly from the forests. NORPLAN (1995) proposed that PBWO should contribute some Tsh 10 million per year to forest management in the Basin, which should come from the collected water user fees.

Rather than a flat fee, a payment in return for actual water supplied (taking quality and base flows into account), would provide a better incentive to forest managers to improve catchment forest conservation. Note that it is important that the PBWO would pay the appropriate parties out of revenues generated from selling water in the basin, but that the water users should simply pay for their water.

In concluding, it is worth noting that currently there is a water deficit in the Pangani River Basin. This deficit is a result of dwindling water resources from the sources as a result of land use changes in the catchment coupled by effects of climate change; wastage of water resources through inefficient uses especially small-scale irrigation schemes; and lack of adequate funds to sustainably manage water resources in the Basin due to low water tariffs and non-payment of the same. This places the Pangani Basin Water Office in a precarious situation as it has to address increasing water demand against decreasing available water resources; against a background of inadequate funding levels hampering its operations; to increasing degradation of the catchment to ever-increasing conflicts on water use. Overcoming all these drawbacks will require re-focusing how water in the Basin is priced; collection of the levied fees; and innovativeness in identifying new and innovative financing mechanisms. This will include introduction of some of the incentives described above, after wide consultations with water users and other sectors that contribute to or impact on water resources management in the Basin.

Economic instruments and sectoral policies

Generally the use of economic instruments for environment and water resource management is not common in Tanzania although there are efforts to introduce them in different sectors of the economy, and policy-makers are increasingly accepting such instruments in principle (Mkenda & Ngaga 2003a). A range of economic instruments could be integrated into the sectoral policies that have significant impact on water resources to reduce degradation of the resource.

The National Environmental Policy

The National Environmental Policy recognises the need to employ economic instruments in managing the environment (URT 1997a). Already the Vice-President’s office, Division of Environment has commissioned a study to identify economic instruments that can be used to support the implementation of the Environmental Policy in Tanzania. Also the Environmental Act is in the process and will incorporate economic instruments as one of the tools for policy implementation. The Act will address all sectoral issues including management of water resources.

The National Water Policy

The National Water Policy also identifies economic instruments as one of the tools that can be used to implement the policy (URT 2002a).

Taxes and charges: Economic instruments are envisaged in the National Water Policy include “water pricing, charges, penalties and incentives to be used to stimulate marketing mechanism, and serve as an incentive to conserve water and reduce pollution of water sources”. The Water Utilisation (Control and Regulations) Act of 1974 makes extensive provisions for environmental matters. There are wide provisions in the act in relation to water uses, pollution of rivers, streams and other public water bodies. The Act stipulates specific standards for production of certain water products, discharge of effluents/water back to receiving waters, treatment of effluents and maximum permissible concentrations for different chemicals and compositions. Already the MoWLD is reviewing the Water utilisation (Amendment) regulations of 2002 to properly institute economic instruments.

Property rights: Use of community based management (Joint Management) of water resources for example through Water User Associations.

Market creation: Tradable water shares can be used to address all the equity concerns of policy makers and at the same time improve the efficiency of water use by directing it to its higher value use. Also, tradable discharge permits/quotas allowable discharge can be set for each watershed and allocated among polluters either according to the level of output or current level of emotions

Subsidies and subsidy removal: Tax allowance, tax relief in form of fee or charge exemptions and rebates to encourage compliance or help firms meet compliance costs could be used. Subsidies for technology research and development of water sources especially for industries which have the potential to exploit ground water.

Financial Instruments: Instruments such as revolving funds, green funds, relocation incentives and subsidized interest or soft loans may be justified as instruments for mobilising additional financial resources for conservation, water protection and sustainable development

Information programmes: Education and Awareness creation campaigns to sensitise people on sustainable use of water.

Mineral Policy

Taxes and charges: Likewise, the Mineral Policy of Tanzania (URT 1997b) mentions "pollution taxes, fines and other penalties based on the "polluter pays principle" as one of the environmental control measures in the mining sector. The 1998 Mining Act has an impressive catalogue of environmental standards that investors are supposed to observe. The Act for example makes extensive provisions for environmental matters in relation to mining activities particularly with regard to limits of discharge of pollutants (liquid, solid, gaseous or particulate matter), noise or vibrations into the environment, reclamation requirement standards for land, waste dumps, water courses and pit walls,), waste treatments. In addition, the Act provides schedules for environmental standards for water (effluents and receiving waters) and air quality.

Liability Instruments: The Mining Act also has provision for performance bond for environmental damages and could be extended to water resources. The bond is also applied to oil companies transporting oil as could cause damage due to oil spills in waterways.

Forest policy

The forest sector is responsible for managing about 1.6 million hectares of water catchment forest reserves. However, most of these forests are being degraded due to harvesting of timber and other human activities.

Taxes and charges: The Forest Ordinance, Cap 389 (URT 2001) indicates that there are different types of fees payable for different classes of forest products, fees paid to conduct certain activities inside the forest and fees for license to graze, cultivate or to reside in the forest reserve. Also there are penalties/fines for culprits. However, activities inside critical watershed area are restricted.

Property rights: Use of Joint Forest Management in watershed areas, most of which are degraded by local communities due to activities such as agriculture. Also, there could be changes in property rights particularly from open access to private and or community based or local government ownership.

Subsidies: Use of subsidies for tree seedling to encourage planting in riparian land and destroyed watershed areas.

Fisheries policy

Taxes/charges: The Fisheries Regulations (1989) have prescribed fishing fees related to fishing. The regulations also make provisions for export tax for fish and fishery products. Fishing fees for artisanal fishermen are nominal, and not meant to regulate fishing effort. It is also important to notice that the fees and charges are not targeted to, say, reduce the catch, but for revenue generation.

Market creation: There is potential to use of Individual Transferable Quotas to limit resource over-use

Subsidies and subsidy removal: Removal of subsidies which increase fishing efforts

Land policy

There is also potential to use economic instruments in land policy to influence management of water resources.

Taxes and charges: Introduction of different taxes for various land use categories

Property rights: Secure property rights can encourage investment in soil improvement, reduce soil erosion and pressure on riparian land due to expansion in crop production.

Market creation: Tradable development quotas: relevant authorities can set a maximum allowable development (or construction) quotas for each year in areas close to water sources.

It can be pointed out that there is a wide array of economic instruments which can be integrated into economic sectoral policies and contribute to sustainable management of water resources. Some of the sectoral policies have already recognised the need to include these instruments in their Acts while other are still contemplating. The survey and consultations with stakeholders conducted by Mkenda and Ngaga (2003b) showed that there are good prospects for introducing economic instruments for environmental management in Tanzania.

The use of user charges, fees, taxes, royalties and fines is widespread in the country, even if they were not necessarily put in place for regulating behaviour with respect to the environment and water resources, but for revenue generation. The fact that such instruments are in place makes it easier to adapt them in various policies as economic instruments for sustainable water resources.

Transboundary issues

The Pangani River Basin straddles the border between Tanzania and Kenya, with a small portion of the basin in the north-west falling within Kenya. Management of the part of the catchment in Kenya thus affects water supplies in the Tanzanian part of the Pangani River Basin or vice versa. It is no good setting good policies and instruments in place in one country if they are not implemented in both of the riparian states in the basin. Thus it is important to identify whether there are any major policy conflicts that might hamper the success of implementation of water conservation measures in the basin. While there are no obvious conflicts at present, it would appear that both countries are in a similar situation regarding their overall policy climate in relation to the environment, both are in need of a reform in water resource management, and thus they should work co-operatively in developing appropriate and compatible policies and economic instruments.

According to the Tanzania water policy (URT 2002a), in order to attain equitable, efficient and sustainable water resources management, transboundary waters is one of the most important principles to guide water resources management in Tanzania. The policy emphasises that:

- Principles of equitable and reasonable use shall guide the forms of cooperation in the management of shared water resources;
- A cooperative approach to management of shared water will be fostered; and
- Technical cooperation especially in research, data collection and information dissemination will be promoted. It will ensure participation of legitimate representative of stakeholders so that the system to be established is highly responsive.

Transboundary water resources posses a number of challenges to be addresses which include the following (URT 2002a):

i. Environmental management challenges on issues of water pollution, biodiversity conservation, wetlands and catchment degradation, fisheries management, and water hyacinth control;
ii. River basin development for hydropower production, domestic rural and urban water supply, and irrigation;
iii. River control and regulation, and international border stabilisation, and
iv. Inter-basin water transfer.

In order to address the above principles and challenges, areas of economic policy conflict and ways of co-ordinating economic policy instruments need to be identified for appropriate strategies and actions for management of the water resources.

Areas of economic policy conflict

Areas of economic policy conflict relate to uses of transboundary water resources by each of the riparian states. All water management is multi-objective and is therefore based on conflict of interests which include agriculture, recreation, transportation, fishing, hydroelectric power generation, waste sink of pollutants, environment, domestic and livestock use.

The economic policy of one riparian state may give emphasis to irrigated agriculture especially in arid and semi-arid areas to increase production for economic growth. However, the same water may be needed by another riparian state to expand hydropower generation for industrial development.

Moreover, a riparian state may view water as playing a significant role in creating jobs for example through fishing and traditional agriculture using less capital intensive but demanding more water per unit production. Other riparian state may want to use water for industries and create more jobs. The level of disparities in wealth and in economy and social development may influence direction of economic policy on transboundary water inside a given country. Those who are better off will often demand more water and the wealthier have more advanced structures. These factors have to be considered when formulating water policies in respective countries and will influence discussion on the allocation of water resources.

Protection of transboundary water against non-point source pollution is also an issue. This threatens available water resources and activities dependent on these resources like agriculture, tourism, landscape and fishing.

Water allocation and reallocation can play a big role in domestic politics and could impact on national security particularly where water demand outstrip supplies by wide margins. Transboundary water can bring regional politics and destroy or build good relations between riparian parties and can easily be used by rival political parties domestically or regionally or both.

Disparities in economic development, infrastructural capacity and political orientation between riparian states may influence economic policies in riparian states and complicates transboundary water resources management.

Framework for setting in place incentives for conservation of transboundary waters

One successful approach to hand transboundary waters has been to help riparian shift focus away from allocating quantities of water, to the overall gain of allocating benefits of co-operative water resources management, and use agreements to build relationships and trust between riparian states.

Establishment of institution e.g. regional bodies conducive to conflict resolutions which can facilitate formulation of treaties and protocol to deal with issues such as availability of water and its access to utilisation, reviewing the provisions of national development plans relating to the water course system, and environmental aspects. Regional bodies could help harmonisation of sectoral economic policies in traditionally water resources, and development of regional convention and strategic action programs to facilitate development of shared goals and approaches, collecting, analysing, storing, retrieving, dissemination, exchange and utilisation of data, design and conducting research among others. Other considerations include the following:

- Broad based partnership in regional bodies,
- Use of integrated approach provides a framework of linking sector policy framework, policy dialogue, legislation, structural reforms, uses of economic instrument, technical interventions and environmental management,
- Strengthening of legal and institutional framework and development of human resources at regional, national and local levels, and
- Public-private partnership may be needed that requires broader participation and agreement by everyone in the basin to reduce risk.

FINANCIAL INSRUMENTS: Funding integrated river basin management in the Pangani Basin

Water resources require planning and development, and have to be assessed in terms of quantity and quality, monitored and protected. Management of water resources thus involves a number of technical, administrative, legal and regulatory activities, as well as provision of infrastructure, all of which place significant demands on sources of funding. The current level of funding for water resources management is not sufficient to perform all of these functions adequately.

The Tanzania water policy has emphasised that in order to realise the objectives of water resources management, all water uses, especially water use for economic purposes, will be charged for (URT 2002a). It is therefore important to understand the current level of financing water resources management in the Pangani River Basin (PRB), the shortfall, and the potential for improving the financing of water resources management.

Current level of financing and shortfall

Trends in funding Pangani River Basin Management

The current trend in financing for water resources management in the Pangani River Basin (PRB) and sources of funds for five financial years are indicated in Table 1 and Figure 1. It is apparent from the table that there are four main sources of funds; water user fee, royalty from Tanzania Electricity Supply Company (TANESCO), normal government budget and others (mainly support from other stakeholders to address specific issues). Pangani Basin Water Office (PBWO) has for the past four years received funds from the River Basin Management Project (RBM) to strengthen water management activities but this source is unsustainable as the project comes to an end in 2003. Funds from RBM for three years contributed on average about 12% of the total money the basin received annually. Also, PBWO received funds from the central government (i.e. from the Ministry of Water and Livestock Development (MoWLD)) as development funds not for recurrent expenditure. For the past three years the government has contributed on average about 29% of the money the basin received annually (Table 38). However to get development funds, the PBWO has to put a case to the Ministry every year and depending on the commitments and priorities of the Ministry there is no guarantee that the money will be available every time a request is submitted. For example for three consecutive years up to 1999/2000 the Basin did not get any government funding except for personal emoluments.

The main source of funds has been the Water User Fee (WUF) which for the past five years has contributed on average about 43% of the total funds the PBWO received annually. The second main source of funds has been the royalty paid by TANESCO which for the past five years has contributed on average about 30% of the total funds the PBWO received annually. It should be pointed out here that royalty is paid direct to the Ministry (i.e. MoWLD) and then the Ministry decides how much money should go to each basin. That means the Basin cannot be sure how much money it will get as opposed to the WUF which is collected by the Basin office.

Table 38: Trend in financing water resources management in PRB for five years (1998/99 – 2002/03), TSh

F/ year	1998/99 %		1999/2000 %		2000/2001 %	
Water user fee	44,523,000	52	51,060,000	55	52,603,422	42
Application fee	2,010,000	2	1,350,000	2	2,170,000	2
Royalty	39,900,000	46	39,900,000	43	23,250,000	19
RBM Fund					16,106,500	13
P's – MoWLD					30,000,000	24
Others						
Total Tshs	**86,433,000**		**92,310,000**		**124,129,922**	
F/ year	**2001/2002 %**		**2002/2003 %**			
Water user fee	60,192,609	40	74,995,472	27		
Application fee	2,920,000	2	3,395,000	1		
Royalty	22,000,000	14	77,650,000	28		
RBM Fund	20,462,600	13	24,597,500	9		
P's – MoWLD	45,000,000	30	95,000,000	34		
Others	1,415,000	.01	1,390,000	1		
Total Tshs	**151,990,209**		**277,027,972.00**			

Source: PBWO 2003

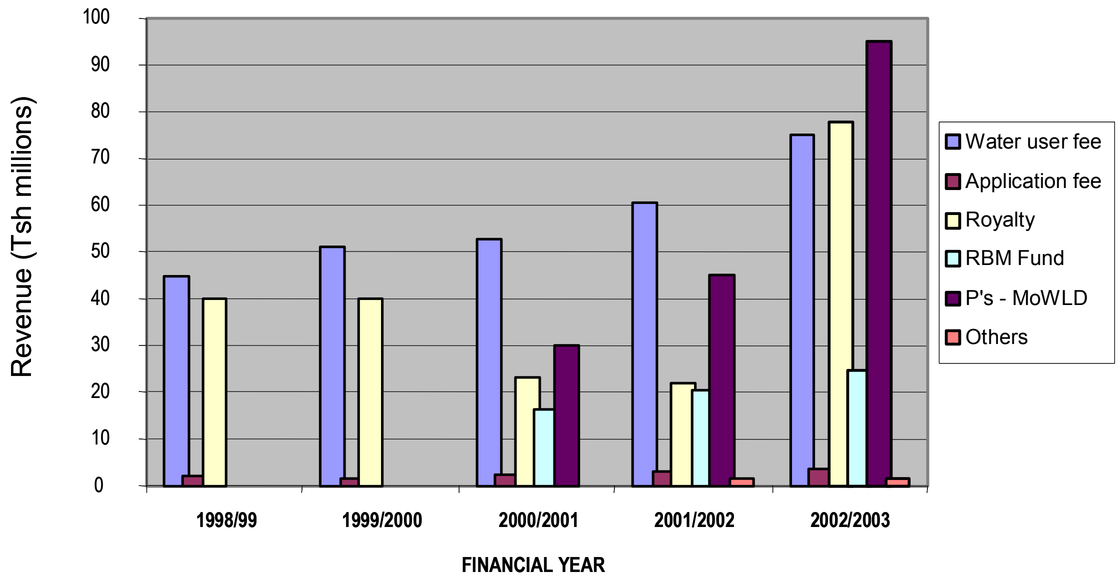

Figure 14: Trends in revenues accrued to PBWO over the past five years (1998/99 – 2002/03)

Main activities funded for management of water resources and the existing gap

The expenditure shows that the money is used to finance various activities as shown in Table 39. The main activities include control and utilisation of water, development and updating of databases, models and GIS (Data management system), water quality monitoring and control, development of Pangani Basin Water Office, estate and dam maintenance, rehabilitation of traditional furrows, attending conferences and meetings, and general administration.

Table 39: Main activities and expenditure for three financial years (2000/01 - 2002/03)

Main activities	2000/2001	2001/2002	2002/2003
Control and utilization of water	9,776,560	20,206,380	32,574,625
Information management system.	5,138,200	10,450,280	15,859,685
Water quality monitoring & control	0	4,602,045	11,201,000
Development of PBWO	2,848,720	25,957,568	46,305,200
Research/Study.	0	2,439,356	4,332,250
Baseline information collection	0	5,379,197	1,695,000
Estate and Dam maintenance	0	21,465,460	64,730,040
Conference and meetings	0	5,749,900	6,499,000
Administration general	37,016,837	53,802,322	77,346,768
P.E.	11,084,160	11,927,800	12,834,000
Total Tshs	**65,864,477.00**	**161,980,308.00**	**273,377,568.00**

Source: PWBO 2003.

The normal recurrent budget required to maintain sustainable water resources management in the Basin for the current financial year (2003/2004) is Tsh. 380 722 000 as estimated expenditure. As pointed out earlier, the actual revenue collected as user fee and royalty can only meet about 43% and 30% of the total budget respectively creating a gap of about 27-30%. Due to inadequate funding, a number of problems/obstacles have affected management of the PRB resources. Some of these problems include the following:

- Water users abstracting more water than allocated in their water permits,
- Use of water without formal water permit especially traditional furrows,
- Inadequate monitoring of inefficient use of water by abstractors,
- Inability to formulate integrated planning, development and management of water resources.
- Inadequate plans and implementation of participatory approaches in water resources management.
- Inadequate human resources, and
- Inadequate enforcement mechanism of regulations and bylaws.

Water user fee and royalty as main sources of funds

It is apparent that WUF and royalty are the two main principle sources of funds which should be focused on to improve the basin finances because these are funds which the government has allowed to be collected and retained by the Ministry/Basin offices. Retaining WUF by the Basin offices is an incentive to collect more revenue from fees and that explains why there has been an improvement in granting water rights and collection of WUF. This is the direction towards greater decentralisation and financial autonomy for management of water resources within a common national framework. On the other hand, the fact that the Basin office is allowed to retain WUF partly explains why the government may not give priority in allocating sufficient funds to the management of water resources of the basin. In principle, WUF/royalty should be the most important source of revenue since it is the user of water who should pay for the cost of using the resource. And those using more water should pay more and in this case it is Tanesco and Irrigation (small and large) who are using more than 90% of the water (Kristiansen 2000). There are also other users of relatively small scale such as industries, and domestic and livestock use.

The category of small scale farmers particularly those using traditional furrows who are estimated at around 2000 in PRB may need a special consideration because most of them have very low economic returns and/or are living in relatively poor conditions. Most of them have no water rights and cannot afford to pay high WUF although they use large amount of water inefficiently (10 – 20% efficiency). Of course a low price (fee) does not give them much incentive to use water efficiently. Also, low price does not reflect the true value of a scarce resource like water and one will not care about it. Notwithstanding these observations, social considerations to these farmers are important. A mechanism could be established for example through Water user Associations (WUAs) for farmers to pay a certain amount to make them feel and appreciate that water has a value. Some of these farmers still consider water as a free resource (or gift from God) and therefore education and awareness creation has to be intensified. Education will help to make them be more aware of the loss or consequences they inflict on others and the need to use water efficiently. Appropriate approach to these farmers and villagers is important because success in collection of WUF by the basin office will highly depend on cooperation from them and positive attitude towards management of water resources.

Potential for improving financing mechanisms

The Ministry of Water and Livestock Development (MWLD 2003) has proposed that funds should be raised by charging a number of different fees. Noting that the funding by the government to the Basin Water Boards has been inadequate and erratic it has been proposed that there should be a provision for the BWBs to be autonomous and have authority to levy, collect and use fees for purposes provide for in the Water Act. The proposed fees (MWLD, 2003) are not very different from the current ones being levied and rely more on various fees, and include:

1. Application fees
2. Permit fees for drilling, plugging and sealing of wells
3. Abstraction / extraction fees
4. Transfer fee and trading of water right fees
5. Inspection and verification fee
6. Monitoring and pollution fee
7. Sewage discharge permit
8. Easement fee
9. Appeal to Minister fee
10. Inland transport fee
11. Various penalties

In addition to raising user fees, strategies to improve the financing and sustainable management of water resources would include improved billing and fee collection, creation of awareness to water users about importance of participatory water resources management to promote their willingness to pay, provision of incentives and disincentives for the user fee, promotion of partnership, enforcing existing bylaws/legislation on user fee, looking for external support and contributions from indirect beneficiaries e.g. national parks. Overall, increasing the enforcement and collection of water fees is considered to be the most effective way of increasing income.

Improved billing and WUF collection

The PWBO has so far managed to bill about 700 water abstractions for the financial year 2002/2003 amounting to about Tsh. 199 million although not all of them pays for various reasons including difficulty in tracing them, lack of water rights, dead abstractions and willingness to pay by some of the abstractors. The Basin office has every year increased the number of water rights and there is every likelihood the enforcement will continue even if there are many problems to be addressed. There are more than 3400 known water abstractions for domestic, industrial and irrigation uses although some abstractions might be dead. Most of them have no water rights making it difficult to force them to pay WUF. The current billing (700) therefore represents only about 20% of the potential abstractions supposed to pay fees but not yet untapped.

Substantial investment is therefore needed to improve billing and fee collection in terms manpower and resources to enable the basin office identify all live water abstractions, facilitate them to get water rights and bill them, strengthen fee collection mechanism, and monitoring to ensure compliance. It has been revealed that there are water users who pay their bill in time and others who either pays late or don't pay at all or pay irregularly (Sarmett, pers. communication 2003). There is therefore a need to create incentives and disincentives for early and late paying customers respectively. There are several ways of handle this, one is to institute appropriate penalty in the law for late payers. Second approach is to use some kind of performance bond which is an economic instrument for environmental and natural resource management that makes non-compliance with the agreement costly to water users. This type of instrument involves water users or those who apply for water rights posting a mandatory bond upon getting the water right, and the bond is forfeited should it be established that the user has contravened what is prescribed in the water right or he/she has destroyed control water gates as it has happened in some places. Thirdly, the law could make provision for partial rebates or discount where a water user has proved consistent payment of WUF in time or one who pays in lumpsum for a given period of time say six months or a year.

Review of water user fee rates

The need to review and increase WUF was pointed out and justified in a detailed study by Kristiansen (2000). The study was commissioned by the River Basin Management Project (RBMP). Some of the issues discussed here are based on the report by Kristiansen. Also, as pointed out earlier, if WUF is the most important source of revenue then it is appropriate that the fee is correctly set. The current fees were reviewed in June 2002 but the increase from the 1994 fees was very small as shown in Table 40.

Table 40: Examples of fees schedule of 1994 and 2002

Matter	Fees (Tsh.)	
	1994	2002
Water Right Application for Domestic/ Livestock/Small Scale Irrigation/Fish farming	35,000/-	40,000/-
Economic Water User Fee		
Domestic/Livestock/Fish farming/District centres/rural: for every 100 m^3	30/-	35/-
Small scale irrigation: for every 1000 m^3	30/-	35/-
Large scale irrigation: for every 1000 m^3	60/-	70/-
Business (flower export): for every 1000 m^3	1,000/-	1,000/-
Industrial: for every 100 m^3	100/-	120/-
Institutional/Regional centres: for every 100 m^3	80/-	90/-
Commercial: for every 100 m^3	120/-	150/-
TANESCO power royalty fees	105 Mill.	165.5 Mill.

Source: URT (1974 & 2002b).

The royalty paid by Tanesco could also be increased without significantly affecting their costing due to the fact that it is a very small fraction of their costs. The report by Kristiansen (2000) indicated that in 1997 the Tanesco royalty made only about 0.1% of their electric power sales and some 0.14% of their cost of sales. In 2002, royalty fee paid by TANESCO made about 11% of the generation costs and about 2% of the total cost of sales.

While fees for some categories e.g. business (flower farmers) could remain because they are relatively high, for other categories like irrigation, industrial, Institutional and commercial could be increased slightly without seriously affecting their economic returns. Fees for small and large scale irrigation categories could be increased to give effective incentives for water saving efforts or efficient use. Normally farmers who are typically poor are not those with small scale irrigation. Nevertheless, it should be studied further to see which levels are needed to make a significant impact on their water use. Both small and large scale irrigation farmers are competing in the same market for the agricultural produce and therefore they could pay the same fee rate. For most farmers this increase would possibly not be sufficient to initiate water saving measures, but some farmers might react on it. Moreover, the WUF is a disputed issue among the farmers, and too high fee increases at a time may destroy any good relationship built up between the basin offices and the farmers. Nevertheless, in the long run it is likely to encourage efficient use of water and trading of water rights. Once a water right is issued to a particular farmer or village then that farmer or village may decide to sell its water right to another farmer/company through mutual agreement. A farmer/company which buys increase its amount of water accordingly. The possibility of trading water rights is useful because it mimics the market and property rights, with the resultant benefit in terms of increased efficiency. This will be possible only if the fees paid by different categories create incentives for efficient use of water.

Raising fees will definitely meet some resistance from water users especially now when some of them e.g. TANESCO and industries are already complaining about not getting enough water while large scale farmers complain about excessive taxation. Therefore most of the fees collected must be re-invested in the management of water to justify the increase and for users to appreciate the efforts made. That means the basin office must spend a considerable amount of time in monitoring, conducting random inspections, control of abstractions and discharges, and advice on water allocation and management. If these activities increased, large water users like TANESCO are likely to benefit because of improved water management and the water situation in the basin.

The MoWLD is currently reviewing fees for different categories taking into considerations increased pollution, increased demand for water and inflation. The current levels of WUF are too low to have a “significant” effect on the water allocation, at least for irrigation. For WUF to become an effective water allocation instrument, the rates must be relatively high especially for large-scale and small-scale irrigation. The purpose is that it should be high enough to give incentives for water saving measures and lead to the economic efficient water allocation structure that the WRM authority is aiming at.

Pollution charges

Another potential area which could improve finances of the Basin Offices is that of pollution charges. The essence of a charge system is that a fee is charged for each unit of a specified pollutant or product that is released or produced in order to make pollution costly to producers and hence reduce the level of pollution. Any pollutant discharged into the water must be charged. The unit price for different pollutants should vary according to their toxicity or environmental effect. The implication of this is that if the pollutant discharged is more harmful, the polluter pays more.

At the moment polluters of water are charged a fixed fee of 150,000 Tsh. for a discharge permit regardless of the level of pollution. This system does not give enough incentives for polluters to reduce the quantities discharged and implement pollution abatement technology and/or management practices to reduce pollution. Normally, the government sets a price on each unit of pollutant discharged and the polluter pays to the government an amount equal to the quantity of pollutant times the unit price. The government can set a range of target improvements in ambient water quality parameters adopted as water quality standards. Then for either type of target, the government can use a range of policy options open to it to achieve the desired target. These options could be such as (1) quantitative and qualitative limits on discharges, (2) charges on polluting inputs, (3) charges on emissions or effluents, (4) product charges (5) different combinations of the above options. Some of the criteria, which the government may use in choosing amongst these options, include the following:

i. Efficiency of the instrument in terms of the desire to minimise the total control costs associated with achieving a given target.
ii. Fairness of the instrument is another important factor. That is, how the costs and transfer of payments incurred is spread across dischargers, and between dischargers and the public.
iii. The degree of uncertainty attached to the achievement of the environmental target using any policy option, and
iv. The political acceptability of the policy instrument.

One of the requirements for pollution or discharge system include establishment of regulations defining methods of monitoring or estimating emissions for the purpose of levying charges. The MoWLD is currently revising the Water Act to incorporate discharge fees for different levels of pollution.

It must be emphasised that much as revenue from charge fees may be used to manage water resources, most of it must be used to improve water quality. Acceptability of pollution charges may depend on the public perception that the revenue is used to improve the water quality and not simply for raising revenue to run Basin offices.

Cost and benefit sharing with stakeholders

Water scarcity and pollution due to high rates of watershed degradation and pollutant loading has been on the rise in Tanzania. This has partly been due to inadequate measures to conserve source catchment and other riparian ecosystems. The effects of Catchment Forest Reserves (CFRs) destruction for water flow stabilisation are potentially disastrous. Local communities surrounding the CFRs depend on these reserves for up to 15 percent of their incomes, and the poorest are particularly dependent on these resources (FBD 2003). On the other hand local communities can play a big role in conservation of watershed areas. Therefore, there is need to plan and implement various participatory approaches with local communities in water resources management as an important common strategy, including sharing some of the costs and benefits from water harvesting. The main constraint here is that at the moment the same water users do not have water rights and do not see the need to apply. Nonetheless, the potential for participatory management of water resources should be tapped and harnessed for example by using WUAs. The Basin office could give a share of the revenue collected from WUF to WUAs under special agreements, and in the long-run they could even be used in collection of WUFs.

Establishment of water funds

Another innovation which is becoming common in other places is the establishment of water funds raised through contributions from various sources such stakeholders, fees, grants, donations, general government budget to finance certain expenditures. Such funds could best be viewed as transitional mechanism to mobilise financing to address backlog of water management problems. Also such funds can play a useful role where capital for investment in water resource cannot be raised through government or established financial institutions. These funds could be used for various purposes including exploration and development of water sources, research, training, purchase of expensive equipment and other conservation measures.

Nevertheless, the weakness of setting aside some money in a separate fund for specific use is that it insulates those funds from competition among alternative uses. Also, setting aside such funds might set a precedent for other type of expenditures. A proper institutional mechanism should be in place to address these shortcomings and for such funds to deliver the intended output. Transparency in use of funds is an important factor in water fund system because acceptability of contributors depends on the perception and trust that the money is being reinvested to improve management of water resources. The fear of many people is that such funds are quite often mismanaged and in some places have done very little to improve access to timely and adequate funds.

Mechanism for raising catchment fees

Catchment Forest Reserves (CFRs) in Tanzania supply a vast number of goods and environmental services such as stabilisation of waterways. If Tanzania is to make a permanent and expanded commitment to management of catchment areas with local communities, permanent financing is necessary. Yet one of the most obvious aspects of an analysis of Tanzania's CFRs is the absence of clear involvement on the part of water and energy authorities in the protection of these resources (FBD 2003). As suggested in the previous chapter, one of the ways to finance management of catchment areas is by the payment of a catchment fee by PBWO to the Forestry and Beekeeping Division. This payment would vary with the delivery of base flows of adequate quantity and quality from the catchments forests, and would thus create the incentive for FBD to protect and manage these forest areas accordingly. In addition, it would effectively fund catchment management, an area which is currently sorely under-funded. PBWO would have to relinquish part of the water user fee in order to make this payment. It is thus important that the WUF generates sufficiently high revenues to allow for this payment. It is important to note that the catchment fee should not be an explicit component of the WUF, since the payment from PBWO to FBD would be variable.

Conclusion

The PBWO need about 400 million Tsh. annually to implement various activities related to management of water resources. There are substantial water users who could pay fees and raise more than the amount required by the Basin office but most of them do not have water rights, and do not apply and therefore do not pay WUF. Currently WUF is paid by only about 20% of water users. Efforts must continue and more investment may be needed to have all water abstractions with water rights and pay WUF. There is also a high potential to increase fees especially for TANESCO and irrigation who are using more than 90% of the water and still pay relatively low fees. Small and large scale irrigation could pay the same fee to give incentives for water saving measures and lead to the economic efficient water allocation. Small scale irrigation farmers need strong incentives to encourage efficient water use. Other potential financing mechanisms include pollution charges and establishment of water funds. Alternatively, fees could remain the same but the government budget increased to meet the basin needs, but given government priorities and pressure from other pressing needs, and even priorities within the MoWLD, improved collection of WUF remains the most feasible approach.

RECOMMENDATIONS: Economic and financial ways forward for sustainable water resources management

This study provides a broad overview of water supply and allocation in the basin, the magnitudes of economic values associated with different uses, incentives and disincentives for sustainable use of water and mechanisms for financing water resource management in the basin. As a rapid overview, none of these areas has been researched in great detail, but the overview provides an idea of where future research efforts should focus.

Integrated River Basin Management in the Pangani Basin will ultimately need to strive towards the optimal allocation of water among different types of uses in different parts of the basin, with the environment being seen as a legitimate user. Indeed, maintaining aquatic ecosystem functioning maintains the supply of ecosystem goods and services that contribute to peoples' livelihoods and to economic productivity of the region. It will also require the application of sound catchment management practices to ensure an ongoing supply of water resources and ecosystem services.

With respect to sustainable water resource management in the Pangani Basin, future activities should therefore concentrate on:

1. *Protecting water supplies* (e.g. forest and soil conservation, control of pollution)
2. *Maximising the efficiency of water use* in order to expand opportunities (e.g. using incentive measures)
3. *Maximising efficiency, equity and sustainability of water allocation*. This requires understanding basic human needs, environmental flows and economic trade-offs, and having a framework to guide decision-making.
4. *Generating revenues for effective management.*

Achievement of the above will be reliant on the following activities:

1. More in-depth research into the uses and productivity of water.

This study only covered four small areas of the basin, and found major differences between these areas. Future studies should cover the whole basin, develop a better handle on user populations in different areas of the basin in order to devise a statistically defensible sampling strategy that will allow extrapolation to these populations. One way of simplifying this potentially onerous task would be to identify 'ecozones' which are relatively homogenous in terms of ecological resources and economic activities.

2. Estimation of the marginal value of water in different consumptive uses

A more data-intensive approach needs to be taken in the above step in order to develop production functions from which the marginal value of water can be estimated. A modelling approach will be essential to understanding the implications of increasing or decreasing the allocation of water to different sectors. Part of this study should include the substantiation of claims about the efficiency of water use.

3. Estimation of the marginal value of water in the environment

A similar modelling approach is needed to estimate the marginal value of water in the environment. This is more complex, however, as it requires a detailed understanding of environmental flows, and hence has to be carried out in conjunction with environmental flow assessments, as well as understanding household demand for aquatic resources.

Thus future studies need to investigate the relationship between instream flows and the stocks and productivity of aquatic resources such as wetland plant, fishes and inshore prawn fisheries, controlling for the effects of harvesting. Both expert opinion (as in IFR assessments) and modelling approaches could be used, depending on data availaibility. Where data are scarce (e.g. flow data, fisheries effort and catch data), monitoring programmes should be initiated. This study has only considered harvesting of aquatic resources. Future studies also need to include assessments of the value of other ecosystem services provided by aquatic systems.

4. **Analysis of the trade-offs between conflicting uses**

   Any water management and allocation decisions in the basin will involve tradeoffs, because demand for the water resources is greater than the supply. The most pertinent trade-offs need to be studied in detail in order to guide water management policy at a broad scale. The subutilisation of the large investments in hydropower plants and consequences on downstream wetlands would provide a good cost-benefit analysis. Related to this is the need for a study on optimal dam operation that would internalising downstream costs. There are also trade-offs between forest conservation and use/degradation/loss that need to be analysed

5. **Estimation of the marginal costs of forest degradation**

   It is widely accepted that forest degradation is playing a significant role in the quantity and quality of water flows in the basin, particularly in its impact on the availability of runoff to potential users. However, the relationships between forest cover and water runoff have not been quantified, which seriously hampers economic analysis. It is also vitally important that these relationships are understood if economic instruments such as payments for ecosystem services are to be implemented in the basin. Monitoring of flows and forest cover are urgently required in order to facilitate this research.

6. **Assessment of the costs of pollution**

   Urban, industrial and agricultural pollution of water resources is known to be widespread in the basin, but the environmental impacts have not been quantified, nor the economic costs of these impacts. In order to justify and facilitate the implementation of pollution chargers or tradable pollution permits, it will be important to establish the external costs associated with polluting activities. This will require collection of information on the quantities of pollutants entering various points in the basin, and their effects. Potential case studies should include the pollution of Lake Jipe and its effect on weed encroachment and fisheries.

7. **Setting water user fees**

   Once the marginal value of water is better understood, the urgent priority of water pricing can be addressed. This pricing would need to take the incentive effects into account, as well as cost recovery, and would also need to be equitable and sensible.

8. **Setting up systems of tradable water use and pollution rights**

   Initiatives will be needed to establish systems of tradable water user rights and tradable pollution permits. This will require establishing areas within which rights can be traded, and the ceilings on quantities that can be traded in those areas. It would be a good idea to begin implementation in a single area, in order to test the system. There would be great value in setting up a demonstration project in Pangani Basin to pilot the implementation of these incentive measures in Tanzania.

9. **Piloting payment for environmental services schemes**

   The Water Policy allows for the development of catchment conservation fees; it also advocates financing management through user fees, as well as permitting the use of a range of other financial and economic instruments. A payments for environmental service scheme, whereby upstream land managers (including farmers, as well as the government agencies who manage the basin and upstream ecosystems) are rewarded for their conservation efforts through financial transfers from downstream water users, has the potential to operationalise this concept of catchment conservation fees. Such a system, if piloted in the Pangani Basin, could provide a mechanism both for reflecting the role and economic value of catchment ecosystems for downstream water supplies, as well as compensating upland managers for the environmental services they provide.

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ANNEX: Overview of Tanzania's macro economic reforms

Genesis of Macro-Economic Reforms

The Arusha Declaration passed in February 1967 had an aim of developing a locally – based economy which would bring structural changes, foster equity and hasten rural development.

Tanzania's development record during the first decade of independence indicate that the country was fairly successful in terms of meeting basic human needs and performed reasonably well in terms of achieving economic growth.

However, in 1970s economic performance weakened and by the early 1980s the country had plunged into an economic crisis of unprecedented proportions. Some of the manifestations of the crisis were reflected in:

(i) the decline in real GDP growth ,

(ii) the decline in real per capital income by more than 15 percent,

(iii) the soaring of inflation from an annual average rate of less than 5 percent in the 1966 – 70 period, to 30 percent after 1979,

(iv) the deepening external imbalance,

(v) The growing overall deficit in public finance.

A variety of external and internal factors led to this situation of crisis. Some of these factors are cited as:

- Underproduction in most economic areas (food crops and industrial – based goods),
- Heavy international borrowing,
- Dependence on foreign aid to support social welfare programmes,
- Nationalisation of major means of production,
- Establishment of a state – directed economy,
- Attempt to rely on central planning,
- High import prices and low export earnings,
- Increase in world petroleum prices experienced in 1973 – 4 and further price doubling in 1979-80, and
- Decision to emphasise industry over agriculture in making the country more self-reliant.

Due to the economic crisis described above, some reforms were introduced, in an attempt to alleviate the situation.

Macro Economic Reforms Undertaken in Tanzania

It is important to appreciate that a number of macroeconomic reforms have been undertaken in Tanzania since its independence in 1961. for the sake of convenience, the reforms may be categorised into two groups namely pre-economic crisis reforms and post-economic crisis-reforms.

Pre-Economic Crisis Reforms

(i) Tanzania's Economic Development Policy (1962)
This was put in place to implement the three-year development plan. The World Bank based it on an economic survey made. It emphasised on the livestock industry, the improvement and development of communications and the development of secondary and technical education, as the engine of economic growth and development.

(ii) Village Settlement Policy (1963)
This policy was put forward to adopt the transformation approach in fostering economic development. The implementation of this policy was on learning by trial-and-error process (experimental). It involved/entailed the establishment of new farms and recruitment of willing peasants. The policy makers felt that by moving people from their traditional environment they would be more open to changes. The settlements were supervised and controlled by government appoint managers. People were encouraged to increase cash crops production rather than depending solely on subsistence agriculture.

The basic hypothesis was that economic development was hindered by traditional methods of cultivation and peasant lifestyle. Therefore to address this handicap, settlers were recruited mainly from area with land shortages such as Kilimanjaro, and Usambara Mountains and were provided by the government, mechanised equipment and food.
This policy had a negative effect on the environment (and therefore water resources) because it accelerated deforestation, impoverishment of the soil through repeated use without fertilization and hampering efforts towards communal Afforestation (Lenin, 2003).

(iii) Industrialisation Strategy (1964)
The village settlement policy proved a dismissal failure and the five-year development plan (1964-1969) was then drawn by French economists to assess the possibilities of development in industry, agriculture, and commerce and in all other public and social services. The overall goal was to work out the quickest means of transforming the economy in order to get rid of poverty.
The National Development Cooperation (NDC) was then formed in January 1965 as a national institution to overseas industrial development in the country both for public and private sectors.

(iv) Ujamaa Policy (1967 – 1985)
This policy was formulated to express a single approach towards economic development. The policy aimed at raising the domestic resources necessary for financing economic development. Two documents titled "Education for self-reliance" and "Socialism and rural Developments" were issued, with the following main focuses: to counteract the temptations for intellectual arrogance, and to reject capitalism.

Post-Economic Crisis Reforms

(i) National Economic Survival Programme (NESP)
The first major attempt by the government to deal with the unprecedented economic difficulties facing the country, was the formulation of the National Economic Survival Programme (NESP) in 1981. The main elements of NESP, whose main objective was to mobilize domestic resources to the maximum level possible, included:

- An aggressive export drive in order to increase substantially foreign exchange earnings,
- Judicious use of available foreign exchange so as to enhance future earnings capacity as well as save on imports,
- The elimination of food shortage through in-expensive small-scale village irrigation projects as well as the cultivation of drought resistant food crops,
- Strict control of public spending in both government and parastatal

- Development plans should emphasize consolidation in contrast to expansion of new activities, and
- Expansion of the scope and capacity for self-reliance in all sectors of the economy and raising the productivity of the workers and farmers through appropriate incentive schemes.

(ii) Structural Adjustment Programme (SAP), 1983 - 1985

Adoption of the Structural Adjustment Programme (SAP) in 1982 was the government's second major attempt to address the deteriorating economy. The programme was to cover three years (1983 – 85) period, and aimed at improving both external and internal balances, restructuring economic activities through a system of incentives to producers, rationalising government spending, introducing measures to improve capacity utilisation and labour productivity, and strengthening a planning system. SAPs policy packages negotiated with IMF and World Bank included the following categories of reform:

(a) External sector reform: This was intended to induce international competitiveness, to promote exports, to liberalise imports, to enhance the availability of foreign exchange (forex) and liberalise its allocation (e.g. by the introduction of such schemes as own funds imports, open general licence, foreign exchange auctions, private forex bureau), currency devaluation, elimination of tariff barriers and tariff reform. These measures aimed at bringing domestic prices into line with World prices.

(b) Demand Management Reform: The reform Package included control of the growth of money supply (e.g. by credit rationing and squeeze, cuts in government spending, cost sharing measures, elimination of subsidies). These policies aimed at bringing expenditures into line with reality (i.e.revenue collected).

(c) Liberalisation of Internal Trade and Markets: This included the removal of price controls, deconfinement of industrial products and interest-rate liberalisation.

(d) Public sector restructuring: This involved the removal of protection, subsides and support for parastatals including commercialising public sector enterprises, privatisation, closure of certain parastatals, and civil service reform.

(e) Sectors reforms: This included agricultural reform, and industrial rehabilitation. The anticipated success of SAP reforms hinged on the assumption that foreign capital inflow would be forthcoming in sufficient amount. Since this was not the case, the effectiveness of these reforms was seriously undermined by the very low level of import capacity. Certainly, the SAP measures recorded some limited success particularly in reducing costs and increasing the efficiency in government operations and hence constituted a good foundation for future growth. Unfortunately, SAP measures did not halt the declining growth in the productive sectors of agriculture and industry. Inflation continued to run at 30% per annum and shortage of both consumer and food stuffs were rampant.

Much as measuring the impact of SAPs on environment and resource (including water) is not easy, it is asserted that the SAPs has increased pollution and resource degradation problems by ignoring the environmental concerns. This assertion is primarily based on the following assumptions:

- The need for short-term increase in export earnings can only be satisfied by increased exploitation of natural resources.
- The severe cuts in government spending called for by SAPs, reduced possibilities for enforcing regulations aimed at conserving water resources.
- Return of redundant urban workers increase pressure on natural resources and watershed areas were cleared.

- SAPs affected the environment by altering patterns of energy use e.g. by making imported commercial fuels more expensive accelerated the use of woodfuel.
- SAPs policies affected the environment through their influence on farming practices e.g. soil-erosive farming practices.
- A credit squeeze resulted in reduction in agricultural investment, thereby exacerbating rural poverty, and consequently environmental degradation.
- Trade and industrial policy reforms that encouraged foreign investments or low-cost domestic manufacturing, can result in increased industrial pollution especially water pollution by effluents where there are inadequate pollution control measures and work safety regulations.
- Reforms to restructure public enterprises and promote privatisation and foreign investment have encouraged the maximisation of private profits and evasion of environmental regulations.

(iii) Economic Recovery Programme (ERP) (1986 – 1989)
The Economic Recovery Programme was adopted in July 1986. It represents an organic extension of the Structural Adjustment Programme implemented during the years 1983 – 85. The objective of this programme (ERP) was gradual attainment of sustained growth in real income and output. It also aimed at correcting the external imbalance, reducing budget deficit, cutting down inflation and providing incentives to all types of producers.

The ERP measures included: regular monthly adjustment in the exchange rate and; consolidation of the partial import liberalisation measures; measures to improve agricultural marketing structures; further relaxation of controls; and a more active role of increased producer incentives to stimulate agricultural output. Other reforms focused in the fiscal, monetary and interest rate structures in order to cut down inflation and to instil discipline and improve efficiency in the allocation of domestic resources. The salient packages of ERP included but not limited to exchange rate policy, partial liberalisation of trade, streamlining crop marketing and distribution, reducing budget deficits, and money and credit.

The performance of the programme was generally promising. The GDP had risen by 3.9% from 1986 to 1987. Government borrowing from banking systems declined from Tshs. 5.6 billion in 1985 – 86 to 1.7 billion in 1986 – 87. The growth of economy ranged from 1.8 percent per year in 1986 to 7 percent per year in 1987, with an average growth rate of 4.4 percent per year over the period. The rate of inflation continued to fall from 33.3% to 32.4 percent in 1986 and 29.9 per cent in 1987, but is still well above the target figure of 25 percent in the economic recovery programme.

Nonetheless, since ERP was specifically addressing the problems in the agricultural sector, it led to extensification of agricultural activities in an attempt to increase output and reap the increase price incentive. Ironically, this has led to more environmental degradation.

(iv) Economic Recovery Programme II (Economic and Social Action Plan)
This programme was implemented in 1989 – 90 to 1991-92 as the successor to the ERP. Market liberalisation measures were gradually extended to achieve the same macro-economic goals as set under the ERP, but greater emphasis was placed on alleviating the social costs of the adjustment. Generally speaking, the major objectives of ERP II were as follows:

- to increase domestic production of food and exports,
- to restore efficiency in the mobilization and utilisation of domestic resources,
- to rehabilitate the physical infrastructure, in particular transport and communications in support to directly productive activities,
- to restore internal and external balance by pursing appropriate fiscal, monetary and trade policies,
- to reduce the rate of domestic inflation from about 28 percent in 1988/89 to below 10 percent in 1991/92,

- to revamp the industrial sector, and
- to rehabilitate the social services by identifying and designing appropriate strategies and programmes that would enhance people participation in the operation and management of these services .

(v) External Debt Strategy (EDS) (1993)
The government adopted the EDS for Tanzania in order to:

- Restore orderly relations with all creditors. This involved discussion with creditors whose debts were in arrears, for the purpose of settling them, or repayment and preventing the increase in outstanding debt resulting from accumulation of penalty and interest charges.
- Reduce contractual debt service due in three years time (1993 – 96). to a manageable level of about 20% of debt service ratio.
- Prevent the build-up of unsustainable level of debt and debt service obligations in the future.

(Vi) Tanzanian's Poverty Reduction Strategy paper (PRSP)
The PRSP sets out the medium term strategy for poverty reduction and indicators for measuring progress. It defines objectives for poverty eradication by 2010, with the following key priority areas for achieving its goal:

(i) Reducing poverty through equitable economic growth
(ii) Improving human capabilities, survival and social well being, and
(iii) Containing extreme vulnerability among the poor

The PRSP recognises the heavy dependence of the poor on the environment (Soil, water and forests), in particular, household's reliance on environmental resources for income generation. Water is considered a key factor in the socio-economic development and the fight against poverty. Deliberate efforts are therefore needed on the management of the resources in order to sustain the desired pattern of growth and consumption and to ensure that all the socio-economic activities maximize their capacities, as articulated in the vision 2025.

This entails integrated planning, development and river basin management in support of food security and poverty reduction as well as environmental safeguards.

(vii) The Tanzania 2025 Development Vision
The vision aims at achieving a high quality livelihood for people and attain good governance through the rule of law and develop a strong and competitive economy. Its specific targets include:

(a) A high freedom from object poverty by sustainable and shared growth (equity), and freedom from object poverty in a democratic environment. Specifically, the vision aims at:

- food self-sufficiency and security,
- universal primary education and extension of tertiary education,
- gender equality,
- universal access to primary health care,
- 75% reduction in infant and maternal mortality rates,
- universal access to safe water,
- increased life expectancy,
- absence of object poverty, and
- a well educated and learning society.

(b) Good governance and the rule of law:

- Moral and cultural uprightness,

- Adherence to the rule of law, and
- Elimination of corruption.

(c) A strong and competitive economy capable of producing sustainable growth and shared benefits:

- a diversified and semi-industrialised economy,
- macro-economic stability,
- a growth rate of 8% per annum,
- adequate level of physical infrastructure, and
- an active and competitive player in regional and global markets.

In order for Tanzania to achieve its development vision (both social and economic), eradicate poverty, attain water and food security, sustain biodiversity and sensitive ecosystems; then water is one of the most important agents to achieve these objectives.

(viii) International Economic Cooperation

(a) East Africa Community (EAC)

In 2002, the East Africa Community (EAC) continued with the implementation of its development strategy aiming at strengthening cooperation among member states. The protocol on the establishment of customs union was signed in November 2003. Main elements in this cooperation include elimination of internal tariffs, common external tariff and rules of origin. Others include efforts, to increase business and investment in EAC, environmental management, agricultural sector development strategy, and preparations for the phase II East Africa Road Network project.

(b) Southern African Development Community (SADC)

Tanzania hosted the SADC council of Ministers meeting held in Zanzibar in February 2002 and another SADC meeting in September 2003. Issues deliberated during the meeting include: investment opportunities in southern Africa, and Regional Indicative strategic plan for enhancing co-operation in the next 15 years, issues entailed in the plan are socio-economic problems facing the members states, particularly poverty eradication, equitable participation in economic development, globalisation, environmental problems, sustainable development and gender issues. The SADC body has also established a protocol on shared water- course systems ratified by member countries in August 1995.

(c) New Partnership for Africa's Development (NEPAD)

In July 2002, African Union (AU) was inaugurated with an objective of encouraging partnership among African countries in socio-economic and political spheres. NEPAD areas of priority include, promoting peace and security; good governance; trade development; debt cancellation; investment promotion; education; health; water; environment; fighting HIV/AIDS and Agriculture

(d) African Growth and Opportunity Act (AGOA)

AGOA is a programme approved by USA government to grant Sub-Sahara African countries an opportunity to access the USA market on duty and quota free basis for all products, so long as rules and procedures are observed.

Tanzania fulfilled the required procedures and thus qualified for the AGOA market in February, 2002. Through this opportunity, Tanzania Exported various products valued at USD 1.642 millions in 2002.

(e) World Trade Organisation (WTO)

In implementing the agreements reached in the fourth WTO ministerial conference in Doha, Qatar, in November 2001, Tanzania continued to cooperate with other developing countries in order to have common position that will benefit them from WTO agreed negotiations. The issues agreed for negotiations include:

- Agreement on tariff elimination,
- Trade barriers for goods from poor countries,
- Agricultural issues particularly removal of subsidies in developed countries,
- Relaxing investment conditionalities among member countries,
- Trade competition policies,
- Intellectual property right, and
- Quality of the products.

(f) Globalisation

The World is now is the era of globalisation. Information, money, goods and services produced in one part of the world are quickly and increasingly becoming available in all other parts of the world, international communication is common place, business do operate as if natural borders are noon-existent. Globalisation has impacts on employment, poverty reduction, economic growth, sustainable development and management of natural resources (including water resources).

About IUCN

IUCN -The World Conservation Union brings together States, government agencies, and a diverse range of non-governmental organizations in a unique partnership. As a Union of members, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.

http: //www.iucn.org

About the IUCN Water & Nature Initiative

The IUCN Water and Nature Initiative is a 5-year action programme to demonstrate that ecosystem-based management and stakeholder participation will help to solve the water dilemma of today - bringing rivers back to life and maintaining the resource base for many.

http: //www.waterandnature.org

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This project aims to develop, apply and demonstrate environmental economics techniques and measures for wetland, water resources and river basin management which will contribute to a more equitable, efficient and sustainable distribution of their economic benefits at the global level and in Africa, Asia and Latin America, especially for poorer and more vulnerable groups.

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