# IUCN WATER AND NATURE INITIATIVE

# PANGANI BASIN WATER BOARD[1]

## PANGANI RIVER BASIN FLOW ASSESSMENT


# Socio-economic Baseline Assessment: The Role of River Systems in Household Livelihoods Final report

*J. Turpie, B. Clark, A. Duffel-Graham, Eng. I.I. Nkuba, A. Hepelwa and S. Kamugisha*

**November 2007**

[1] As of 2010, Pangani Basin Water Office is known as Pangani Basin Water Board

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## CONTRIBUTORS

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# EXECUTIVE SUMMARY

**Introduction**

This study forms part of the Pangani River Basin Flow Assessment Initiative, which aims to develop an understanding of the hydrology of the Pangani River Basin, the nature and functioning of the river system and the links between the river and subsistence use of its resources, in order to provide the means to guide the allocation of water in the basin in future.

The aims of the socio-economic baseline assessment were:

- To provide an overview of the basin and its economy
- To provide a description of the livelihoods of people living in proximity to rivers in the basin, and
- To estimate the contribution that aquatic ecosystem resources make to people's livelihoods.

**Study area and zonation**

The Pangani River Basin is situated in the north-east of Tanzania and covers a total area of some 43 650 $km^2$, about 3 900 $km^2$ of which is in Kenya. Note that the area under the Pangani Basin Water Office (PBWO) jurisdiction is referred to as the Pangani Basin and also incorporates the Umba, Zigi-Mkulumuzi Coastal and Msangazi river catchments.

The Pangani River Basin is bordered by Mt Kilimanjaro (5895 masl), Mt Meru (4565 masl) and the Pare and Usambara Mountains to the north and north-east, respectively, and encompasses the Simanjiro and Kitwei plains to the south-west. Lowlands (up to 900 masl) make up about 50% of the basin.

Rainfall patterns are largely related to altitude, with the highlands receiving about 1000-2000 mm annually, and the lowlands receiving 500-600 mm. Rainfall is bimodal, occurring mainly in March-June, with short rains in November-December.

The Pangani River rises as a series of small streams on Mt Kilimanjaro and Mt Meru, and flows over 500 km before draining via the Pangani estuary into the Indian Ocean, just south of Tanga town. The two major rivers created by these streams are the Kikuletwa and the Ruvu Rivers. Other major tributaries include the Mkomazi and Luengera Rivers in the south-east.

The administrative Pangani Basin has an estimated population of about 3.4 million, with about 2.6 million within the Pangani River Basin. Population density is highest in the northern and eastern highlands, and is relatively sparse throughout most of the rest of the basin area.

Land use is governed primarily by rainfall, with agriculture being concentrated in the highlands and foothills. There is considerable large-scale/commercial cultivation of coffee, sugar and flowers, as well as small-scale agriculture, mostly irrigated. The latter concentrates on coffee, bananas and vegetables and dairy production in the higher areas, and a wide variety of crops, including rice, on the foothills. Lower areas include extensive commercial plantations, such as sisal, as well as small-scale agriculture. Towards the coastal lowlands, the latter includes coconut, sweet and Irish potatoes, pumpkins, cassava, okra, sisal and fruits. Although livestock are important throughout the basin, pastoralism is particularly important in the arid

regions of the basin, with herds of cattle and goats being relatively large in these areas.

The economy is typical of a developing country, with a low GDP per capita (Tshs 384 000 – 445 000 for the Regions in the basin). While agriculture contributes about 46% to national income, it is relatively more important for the basin regions, apart from Arusha, for which other sectors such as tourism make a substantial contribution. Most of the population is dependent on agriculture for subsistence and employment. Within the agricultural sector, forestry, wildlife and fisheries are relatively minor within the basin in terms of their economic contribution, but fisheries are an important source of income and food locally. Of the other sectors, mining and hydropower production are important outputs of the basin, but other sectors, such as industry make a relatively small, although growing, contribution.

Irrigated agriculture is the biggest user of surface water in the basin, but urban and industrial uses and hydropower are also major users. Water that remains in the environment generates aquatic ecosystem goods and services. Households living near aquatic ecosystems harvest a variety of resources, the most important being fish.

The basin was delineated into six relatively homogenous socio-economic zones on the basis of land use and relationships to aquatic ecosystems (Figure 2-1). The six zones are Northern Highlands, Eastern Highlands, Lakes, Pangani-Kirua, Mesic Lowlands and Coast.

**Methods**

This study builds on a preliminary study on the use and value of water and aquatic ecosystem resource use in selected areas of the basin conducted in 2003. While aquatic ecosystems generate various types of value, this study concentrated only on the value of water and aquatic natural resources to rural households in the basin. We examine this from a household perspective only.

The study commenced with an initial review of existing published and unpublished information and a two week-long visit to the basin in which information on the study area was collated, the study area was delineated into sampling areas and the sampling frame was designed. A total of 659 rural households were interviewed throughout the study area and various focus group discussions were held to inform different aspects of the study. Data were standardised and analysed to estimate the value of natural resource use as well as agricultural production by rural households. Values were related to the aquatic habitats of the study area as far as possible.

The study had a capacity building component and involved a Tanzanian resource economist working under the guidance of a South African mentor and in conjunction with staff of the Pangani Basin Water Office. Several others also benefited from the study in terms of experience gained, including senior staff at the Pangani Basin Water Office and eight graduates of the University of Dar es Salaam and Sokoine University of Agriculture who participated as enumerators in the study.

**Results**

Households in the Pangani River Basin are characterised by considerable ethnic diversity, with dominant groups changing throughout the basin. Households are typically large, with an average of over 6.5 people in most areas. Average income from employment and business not related to own agricultural or natural resource production is in the order of only Tshs 10 000 – 48 000 per month. Almost all

households are farmers, having both crops and livestock. The main exceptions are in the lakes zone and at the estuary, where only 71 – 74% are farmers, but where fishing is more important. A high proportion of households collect a variety of natural resources.

*Agriculture*
Small-scale farming is practiced throughout the basin, with much of the smallholder farming area being irrigated, particularly in the higher-lying areas of the basin. There is almost no crop rotation, reportedly due to acute shortages of arable land area. The dominant crops are maize, beans, bananas and vegetables. In addition, coffee is common in the northern highlands, rice in the eastern highlands, fiwi beans in the lowland areas and cassava and coconuts are common around the estuary. Some 40 – 60% of farmers in the highland areas irrigate their fields, compared with much lower proportions around the lakes and mesic lowland areas, and almost none in the Pangani-Kirua and estuary zones. However, a large proportion of irrigation farmers in the highlands felt that they did not have access to enough water. Income from dryland farming is about Tshs 200 000 – 300 000 per household apart from the northern highlands, where an average of over Tshs 600 000 was recorded. Irrigation more than doubles the gross income generated by farming per unit area and irrigation farmers tend to have slightly larger fields than others.

Most rural households in the Pangani Basin keep livestock, apart from in the estuary, where the sample included an urban area, and only 61% had livestock. The most common types of livestock are chickens, cattle, goats and sheep. Other animals include donkeys, pigs, ducks and guineafowl. Income from livestock is significant, ranging from about Tshs100 000 – 300 000 throughout most of the basin, apart from the highlands, where dairy in particularly contributes to a livestock income of over Tshs 500 000 on average, and in Pangani-Kirua, where livestock generate an average of over Tshs 700 000 per household.

*Water for domestic consumption*
Household consumption ranged from about 90 – 120 litres per household per day, apart from the northern highlands, where consumption was closer to 190 litres per day, partly due to consumption by zero-grazing cattle. Over half of rural households in the survey area had access to municipal water (taps), and 16% had access to wells or boreholes. However, there is still considerable reliance on natural and semi-natural (dams, canals) systems for water, with nearly half of households obtaining water from these sources. The degree of reliance on natural or semi-natural sources of water varies from 25% at the estuary to 92% in the Lakes zone.

*River systems for cultural, religious and recreational use*
Respondents indicated that river systems contributed significantly to religious and recreational activities as well as for washing clothes.

*Natural resources*
Food and medicinal plants are harvested by about a third of households throughout the basin, generating income of Tshs 12 000 – 52 000 per household. This is more important in the more remote areas. Grasses, sedges, bulrushes and reeds are used for thatching, fencing and making doors, with the use of different species varying across the basin according to their availability. About a third of households harvest these resources in any one year, generating income of Tshs 1500 at the estuary to 128 000 in the northern highlands. Palm leaves, mainly *Hyphaene* in the upper basin and *Phoenix* toward the coast, are also an important resource, used for producing a variety of goods such as baskets and mats. These resources generate up to Tshs 198 000 per year to user households.

Timber is only harvested by a few households, particularly in the uplands, and a few households engage in the production of wood products such as furniture. Those that do so earn substantial incomes. At least a third of households harvest poles in any one year, and firewood is harvested by the majority of households throughout the basin. Very little of this comes from aquatic ecosystems apart from at the estuary, where about 10% reportedly comes from mangroves. These resources only generate modest income, but are vital for construction and cooking. Charcoal production tends to be done by only a small proportion of households, but can generate substantial income.

Hunting is undertaken by a small proportion of households throughout the basin, but the information on the amount of hunting is considered to be underestimated due to the illegal nature of most activities. Waterbirds are reportedly an important component of hunting.

Fishing is carried out throughout the basin. Fishing effort is greatest in the lakes zone (at Nyumba ya Mungu Dam and Lake Jipe), with over half of the households involved, and at the estuary (25%), but is relatively minor in the highlands apart from the activity at Kalimawe Dam (eastern highlands). Freshwater catches are dominated by tilapia and catfish, whereas estuary catches are far more diverse and include crabs and prawns as an important component. Fish catches everywhere are correlated with flow or water level, apart from crabs which are caught in the low flow period.

On average, households derive incomes of between Tshs 140 000 and 630 000 from the use of natural resources. Income from aquatic ecosystem resources ranges from under Tshs 15 000 in the northern highlands, to Tshs 560 000 in the lakes area. Fisheries are the major source of income from aquatic resources, as can be seen from the relatively large contribution of aquatic resources in the lakes, estuary and eastern highland zones. 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 and waterfowl hunting is probably underestimated because of the legality of use.

Households generally perceived crops and livestock to be their most important sources of income. This was borne out to some extent in the estimation of income, but varied between areas. According to the estimated values, river systems (including fish) provide 0.5 - 6% of income in the highlands and 3 – 6% of income in the lowlands. They provide about 35% and 13% of income, in the lake and estuary zones, respectively. Households perceived the contribution of aquatic resources to be somewhat higher than these estimates, possibly due to the fact that the market value of natural resources does not always reflect their importance or their replacement cost.

A total of 75% of rural households in the basin are within 10 km of major rivers, and 47% are within 5 km. The total value of aquatic ecosystem resources harvested in the basin was estimated to be between Tshs 8.1 billion and 11.9 billion per year (US$ 6.5 – 9.5 million). Over 60% of this value (Tshs 5.0 billion – 7.3 billion) was attributed to fishing.

**Discussion and conclusions**

This study provides an estimate of the value of aquatic ecosystems to rural households living within a few kilometres of the Pangani River system. Sample sizes

are modest but considered adequate for input into a broadscale analysis of livelihood impacts. The study was limited to estimates of average gross incomes from different activities, and analysis of trade-offs will require estimation of marginal net incomes based on reasonable assumptions regarding costs and the impact of water availability and environmental quality on activities and outputs.

Rural households in the Pangani River Basin are highly dependent on agriculture. It is clear from this study that the irrigation water provided by the river system adds significant value to the agricultural income generated by small-scale farmers, with gross incomes from irrigated fields being more than double that of dryland fields.

Aquatic ecosystems in the Pangani River Basin are a valuable asset to households living in their proximity, and the more important fishery resources attract households from considerable distances. The contribution of these resources to household livelihoods is modest but significant. The relative gross income of these resources compared with other activities does not take into account their value as a safety net or in terms of spreading risk in poor households. Natural resources, particularly fisheries, act as a safety net by providing a means of survival for households that have suffered shocks such as loss of employment or death of a breadwinner. Thus these systems perform a service that the state might otherwise have to perform. Natural resources also help to spread risk for poor households that are vulnerable to crop failures due to rainfall variation, or other risks such as famine before the main harvests. It is interesting to note that the income provided by aquatic ecosystems exceeds the social welfare that is received in the form of pensions.

The total direct consumptive use value of the basin's aquatic ecosystem resources was estimated to be between Tshs 8.1 billion and 11.9 billion per year. However, it is evident that the value provided by aquatic resources has already been substantially eroded. Rivers in the highlands are no longer perennial, and fish have reportedly disappeared from these. The Kirua swamp has been reduced to a fraction of its former size due to cessation of flooding, and with it has been lost a valuable fishery, leaving households in the area even more vulnerable and poor than they were before. Fishers at the Pangani estuary report that catches there have declined, and some believe this is due to reduction in freshwater inputs. Even at Nyumba ya Mungu Dam, which largely replaced a natural wetland, fisheries have reportedly declined due to low water levels as well as over-fishing. At Lake Jipe, the fishery was all but exterminated by anthropogenically increased nutrient levels leading to encroachment of the lake by emergent vegetation. Thus the capacity of the aquatic systems in the basin to provide value to households has been compromised. It follows that restoration of these habitats would provide a significant social service to poor rural households in the basin.

Finally, it is important to note that this study concentrated entirely on the direct consumptive use value of the basin's aquatic ecosystems. Although direct consumptive use value is likely to be the most important component of value in this case, these systems also provide non-consumptive use value in the form of recreation and tourism, and indirect use value in the form of ecosystem services such as dilution of wastes, all of which contribute to economic production. The aquatic ecosystems also have option and existence value, which affect the present and future wellbeing of society generally.

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# ACKNOWLEDGEMENTS

We are grateful to the Pangani Basin Water Office for logistical support, the Project Management Unit; the Regional Administrative Secretary of Arusha, Manyara, Kilimanjaro, and Tanga; the District Executive Directors, the Ward Executive Officers, the Village Governments and the Extension Officers in all areas that the study was conducted.

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We are grateful to the numerous members of the public who willingly participated in our focus group discussions and household survey.

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# 1 INTRODUCTION

## 1.1 Background

The Pangani River Basin Flow Assessment Initiative (FA) is an IUCN-Pangani Basin Water Office (PBWO) initiative that brings together a Flow Assessment Group selected from within Tanzania, consisting of specialists in a range of river-related, water-allocation and policy-making disciplines, that will work together with flow-assessment advisors from Southern Waters and Anchor to develop an understanding of the hydrology of the Pangani River Basin, the nature and functioning of the river system and the links between the river and subsistence use of its resources.

The objectives of FA are to:

- generate baseline data of the condition of the Pangani River system against which the impact of water-related decision-making can be monitored in future;
- enhance the understanding among PBWO and Ministry of Water staff of the relationship between flow, river health and the people who use the river;
- create an awareness of the trade-offs to be made between water development and natural-resource protection;
- develop simple tools to help guide flow management and water allocations in the Pangani Basin;
- build capacity that will enable PBWO to act as a nucleus of expertise for FA-related work in other areas;
- support the National Water Policy (NAWAPO 2002) and the National Environmental Management Act (2004).

## 1.2 Objectives

The aims of the socio-economic baseline assessment were:

- To provide an overview of the basin and its economy
- To provide a description of the livelihoods of people living in proximity to rivers in the basin, and
- To estimate the contribution that aquatic ecosystem resources make to people's livelihoods.

# 2 STUDY AREA AND ZONATION

## 2.1 Definition of the Pangani River Basin

It is important to distinguish the "Pangani River Basin" from the "Pangani Basin". Tanzania has nine administrative river basins, of which the Pangani Basin, situated in the north-east of Tanzania, is the smallest (Figure 2.1). This area falls under the jurisdiction of the Pangani Basin Water Office (PBWO). The Pangani Basin covers a total area of about 56 000 km$^2$ and contains the Pangani River Basin, which has a total area of some 43 650 km$^2$, as well as three smaller basins (Figure 2.2). About 3 900 km$^2$ (5.4%) of the Pangani River Basin is in Kenya (IUCN 2003). The terms "Pangani River Basin" and "Pangani Basin" thus have two different meanings and are applied as such in this report.


Figure 2.1 The nine river basins in Tanzania.

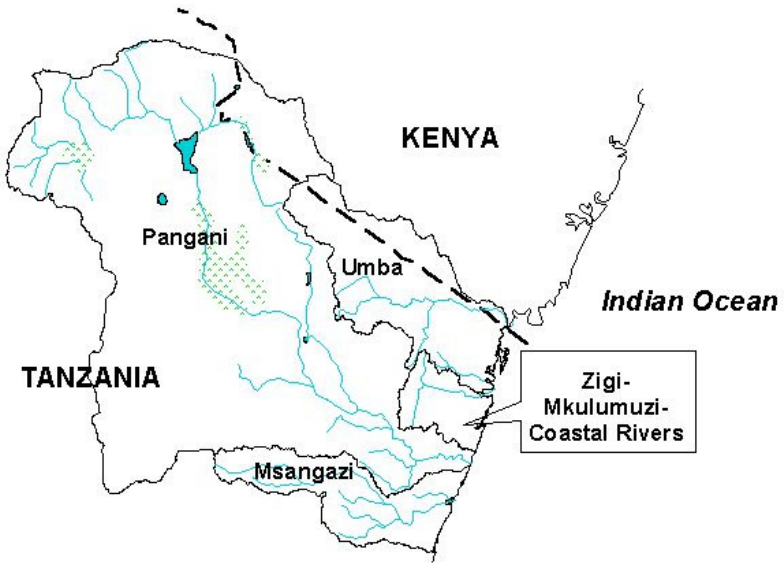


Figure 2.2 River basins administered by the PBWO, including the Pangani River Basin. Source: PBWO.

## 2.2 Location in relation to administrative divisions

The Tanzanian portion of the Pangani River Basin covers parts of Kilimanjaro, Manyara, Arusha and Tanga Regions. Within these, it covers part or all of fourteen districts and two municipalities (Arusha and Moshi; Figure 2.3).

## 2.3 Topography and rainfall

The Pangani River Basin is bordered by Mt Kilimanjaro (5895 masl), Mt Meru (4565 masl) and the Pare and Usambara Mountains to the north and north-east, and encompasses the Simanjiro and Kitwei plains to the south-west (Figure 2.4). Lowlands (up to 900 masl) make up about 50% of the basin (Pamoja 2003).

Rainfall patterns are largely related to altitude, with the highlands receiving about 1000-2000 mm annually, and the lowlands receiving 500-600 mm, but increasing towards the coast (Figure 2.4). Rainfall is bimodal, occurring mainly in March-June, with short rains in November-December.

## 2.4 Rivers, wetlands, lakes and dams

The Pangani River rises as a series of small streams on Mt Kilimanjaro and Mt Meru, and flows over 500 km before draining via the Pangani estuary into the Indian Ocean, just south of the town of Tanga. The two major rivers created by these streams are the Kikuletwa, from streams draining Mt Meru and the western slopes of Mt Kilimanjaro, and the Ruvu, from streams draining the central and eastern slopes of Kilimanjaro. The Muraini River, rising in the North Pare Mt and flowing north through Lake Jipe and surrounding swamps (3500 ha), becomes the Ruvu River at its exit from the lake, and further on is joined by the more well-watered streams of the Kilimanjaro complex.

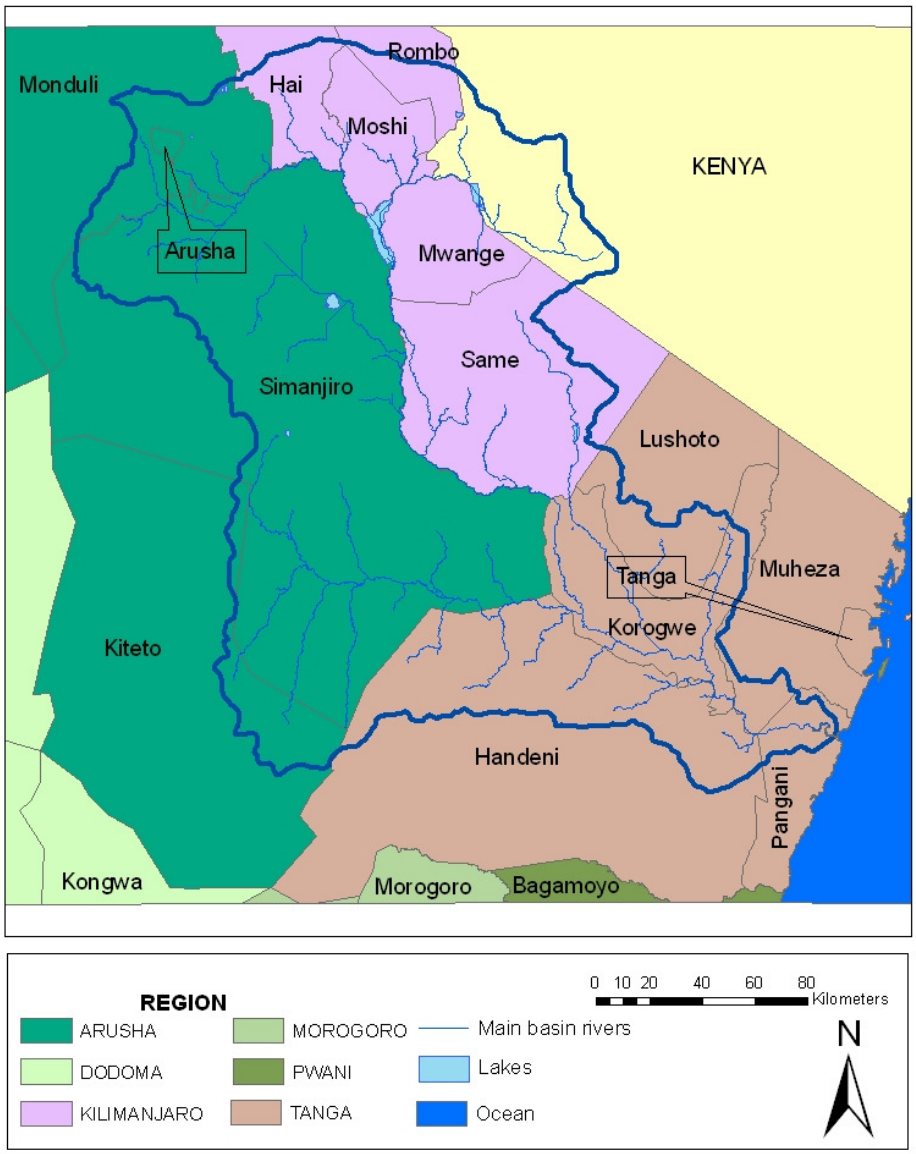


Figure 2.3 The Pangani River Basin in relation to administrative boundaries in north-eastern Tanzania.

The streams feeding the Kikuletwa River are the Nduruma, Tengeru, Chemka, Kware, Sanya, Karanga, Weruweru and Kikafu Rivers. Those feeding the Ruvu River downstream of Lake Jipe are the Himo, Mue (joined by the Miwaleni), and the Rau (joined by the Njoro). Much of the water in the streams draining Mts Meru and Kilimanjaro is from an arc of natural springs located about half way down the steeper slopes.

As the two rivers converge, they flow through an area of steepened topography and then enter a swamp (4000 ha) that stretches across the northern end of Nyumba ya Mungu Dam before entering the dam itself.

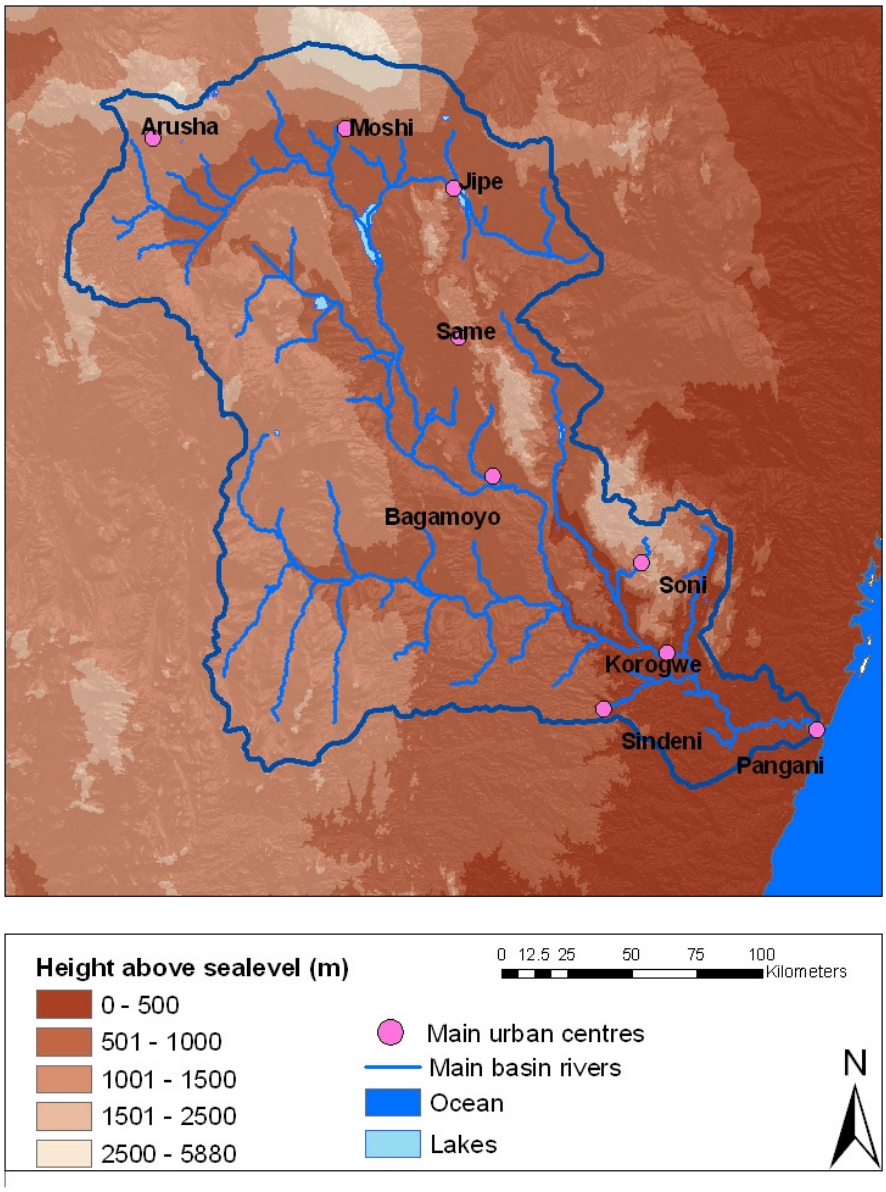


Figure 2.4 Topography of the Pangani River Basin.

The Nyumba ya Mungu Dam is the largest open water body in the study area. Constructed in 1965, originally for water supply, irrigation and water control, it is now used for power supply. It covers an area of 14 000 ha (Røhr and Killingtveit 2002) to 18 000 ha (Bwathondi and Mwamsojo 1993), and comprises some 55% of the basin's surface water (Røhr and Killingtveit 2002). The natural lakes in these upper reaches of the river are Lake Jipe (1800-2800 ha) and Lake Chala (315ha) on the slopes of Kilimanjaro and near the Kenyan border (IUCN 2003).

Downstream of Nyumba ya Mungu Dam, the Pangani River flows as a single channel that eventually floods the vast wetland of Kirua Swamps. With an original area of

90 000 ha, this swamp now covers about 36 500 ha since building of the upstream dam.

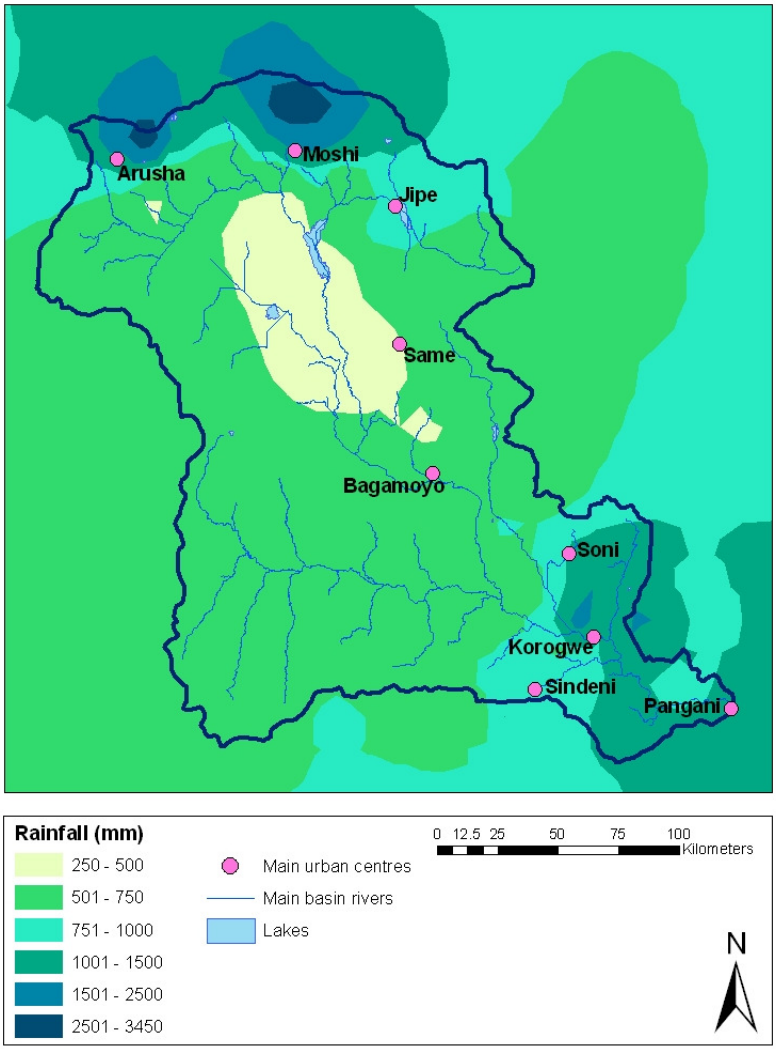


Figure 2.5 Rainfall of the Pangani River Basin.

Downstream of the Kirua Swamps, the Mkomazi River and Luengera River enter the Pangani River, draining the South Pare and Usambara Mountains, respectively. Numerous smaller tributaries enter the river nearer the coast.

In addition to the wetlands mentioned above, narrow floodplains supporting floodplain vegetation occur along major rivers throughout the basin, and major wetlands occur in the lower Mkomazi Plains and upstream of the estuary.

## 2.5 Vegetation

Vegetation changes across the basin (Figure 2.6), ranging from forests on mountain slopes to arid grasslands in the lowlands, and reflects differences in altitude and

precipitation. Much of the basin area to the south-west of the Pangani River is arid. Apart from the more mesic (wet) floodplain vegetation, vegetation on the north bank is generally arid, but becomes more mesic at higher altitudes and towards the coast. Mt Kilimanjaro and Mt Meru can be described as lush vegetation islands emerging from an arid landscape.

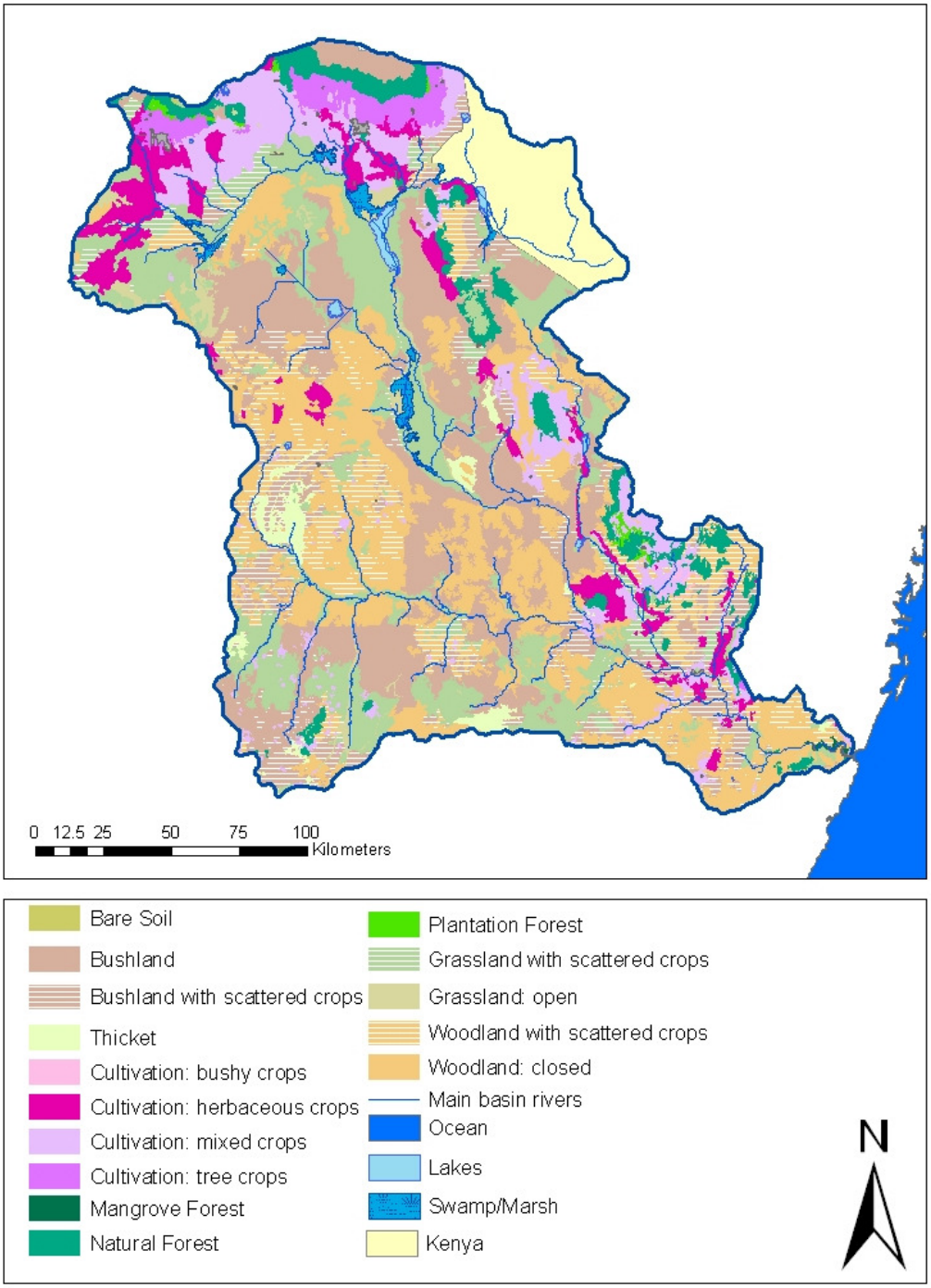


Figure 2.6 Map of the Pangani River Basin showing major natural features, vegetation types and land uses. Source: Tanrec GIS data.

## 2.6 Land use

Land use in the basin is governed primarily by rainfall but also by slope, soils and availability of surface water (Figure 2.7). The mountainous areas and coastal lowland areas have the highest rainfall. The highlands are particularly favoured for coffee and bananas, flowers and a host of vegetables. Dairy production (using a zero-grazing system, i.e., stall-fed animals) is also important here. The mountain foothills are used mainly for cultivation of crops such as rice, sugarcane, bananas, maize, tomatoes, beans, sugarcane, millet, sorghum, wheat, groundnuts and onions. Much of the agriculture in this area is irrigated, both from reservoirs and from traditional furrows, and there is considerable large-scale/commercial cultivation of coffee, sugar and flowers, as well as small-scale agriculture. However, the latter dominates the cultivated area.

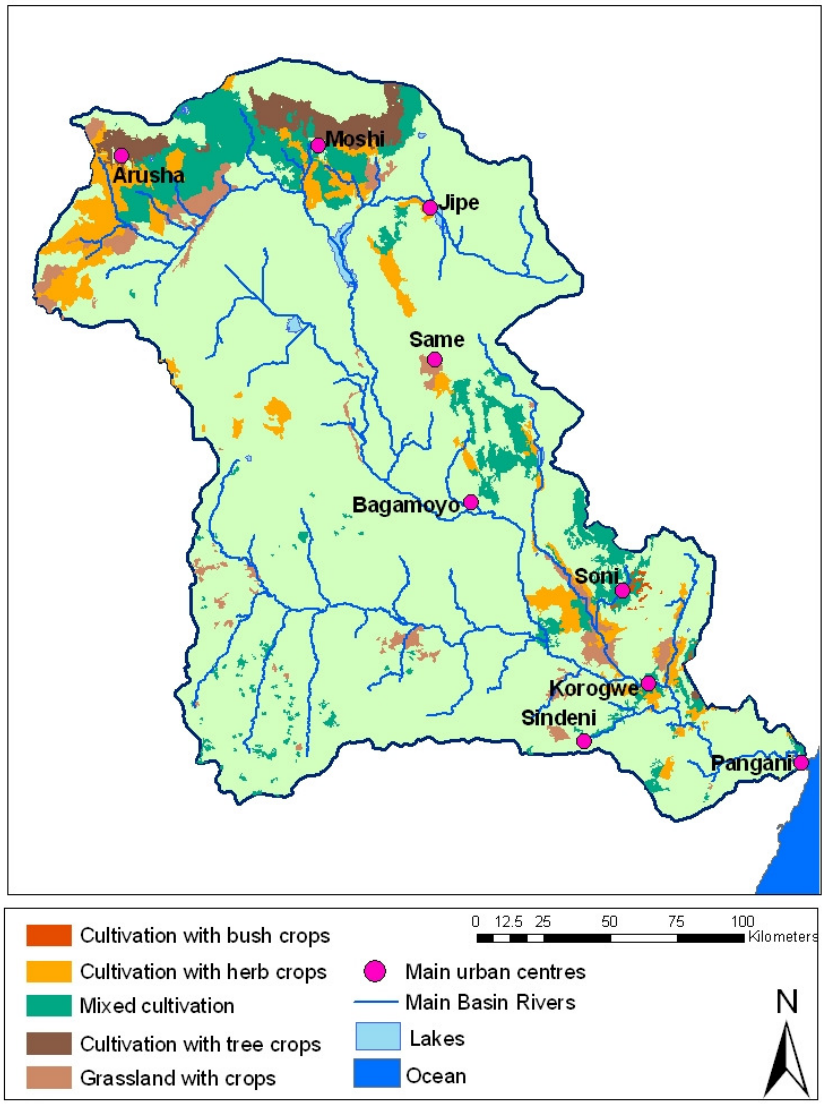


Figure 2.7 Distribution of cultivated areas within the Pangani River Basin, in relation to altitude, rivers and major dams and lakes.

In the dryer areas, mountain foothills are favoured for sisal production at a commercial scale. Lower lying floodplain areas in the basin are also cultivated extensively. Most crops that are grown in the highlands are also grown in these areas. Dryland cultivation takes place in the arid south-west. In the relatively mesic (higher rainfall) coastal lowlands near the estuary, important crops include coconut, sweet and Irish potatoes, pumpkins, cassava, okra, sisal and fruits.

Whereas relatively small numbers of cattle and sheep are kept in the higher parts of the basin, livestock grazing is the predominant agricultural activity in the arid regions of the basin, with herds of cattle and goats being relatively large in these areas (Turpie *et al.* 2003). Livestock outputs in the highland and upper basin areas are predominantly milk and beef, whereas in the arid rangelands, the output is the meat from cattle and goats. These activities are described in detail in the results section.

## 2.7 Population

The Pangani Basin has an estimated population of about 3.4 million (Mbonile 1999), with at least 2.6 million people in the Pangani River Basin (Turpie *et al.* 2005) more than 80% of whom depend on agriculture, directly or indirectly, for their livelihood (Mwamfupe 2002). The population density in the basin varies between highlands and lowland zones. The highland areas are characterized by urbanization and high density of population, whereas the lowland areas have scattered small settlements (Figure 2.8). Population growth rates are much higher in the highland areas than the lowland areas (about 4.0% versus 1.8%; Turpie *et al.* 2005), suggesting that there is emigration from the latter and immigration into the highland areas.

## 2.8 Overview of the economy

Tanzania is a developing country with a gross domestic product (GDP) of Tshs 13 063 317 million (US$ 10 900) in 2005. This translates to an average income per capita of Tshs 361 000 (US$ 300). Average income per capita in the Pangani Basin is slightly higher than the national average (Table 2.1), but is still very low.

Table 2.1 Average GDP per capita in 2005 (Tshs).

| **Region** | **GDP/capita 2005[p]** | |
|---|---|---|
| | **Tshs** | **US$** |
| Arusha | 414 764 | 346 |
| Kilimanjaro | 445 463 | 371 |
| Tanga | 439 576 | 366 |
| Manyara | 384 151 | 320 |
| **TANZANIA MAINLAND** | **360 892** | **301** |

Kilimanjaro, Arusha, Tanga and Manyara Regions, in which the basin is situated, contribute 4.9%, 4.5%, 5.8% and 3.4% of national GDP, respectively, collectively contributing 18.6% of GDP (Figure 2.9).

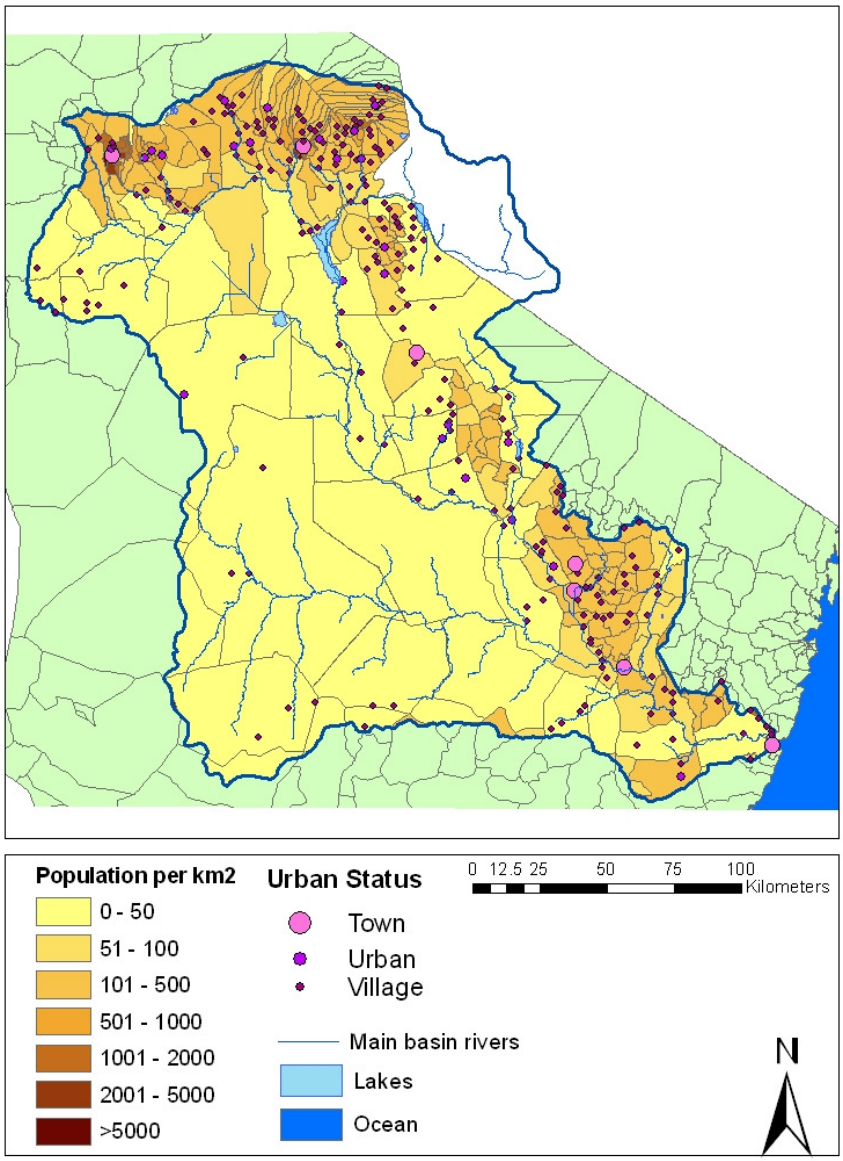


Figure 2.8 Variation in population density in the Pangani River Basin at a ward level. Based on 2002 census data.

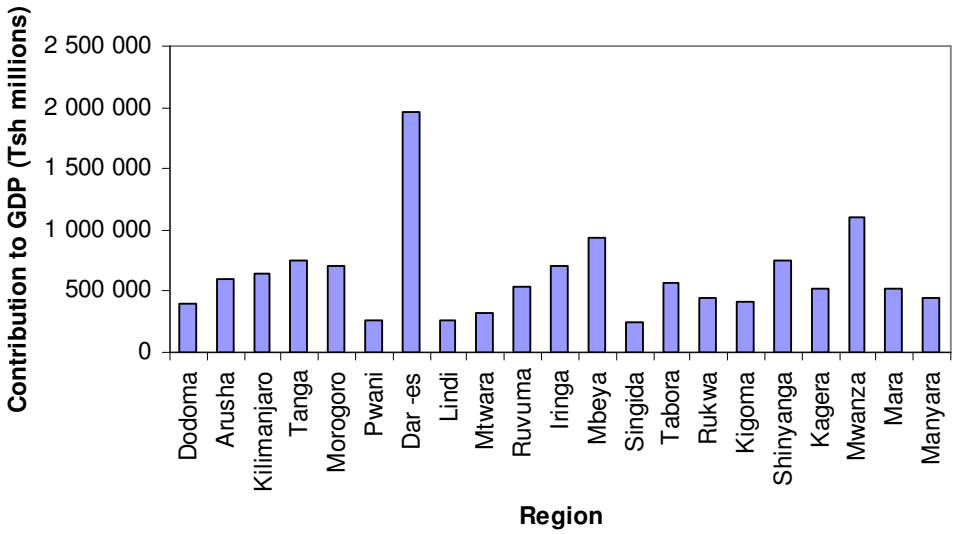


Figure 2.9 Contribution of each of Tanzania's Regions to national economic output (GDP)

Agriculture accounts for about 46% of the national income (GDP) of Tanzania, about 66% of the merchandized exports and 80% of employment, and is the main socio-economic and subsistence livelihood in Tanzania. The national picture includes Dar es Salaam, which is very different from the other regions of the country where agriculture more typically accounts for a much higher proportion of regional income.

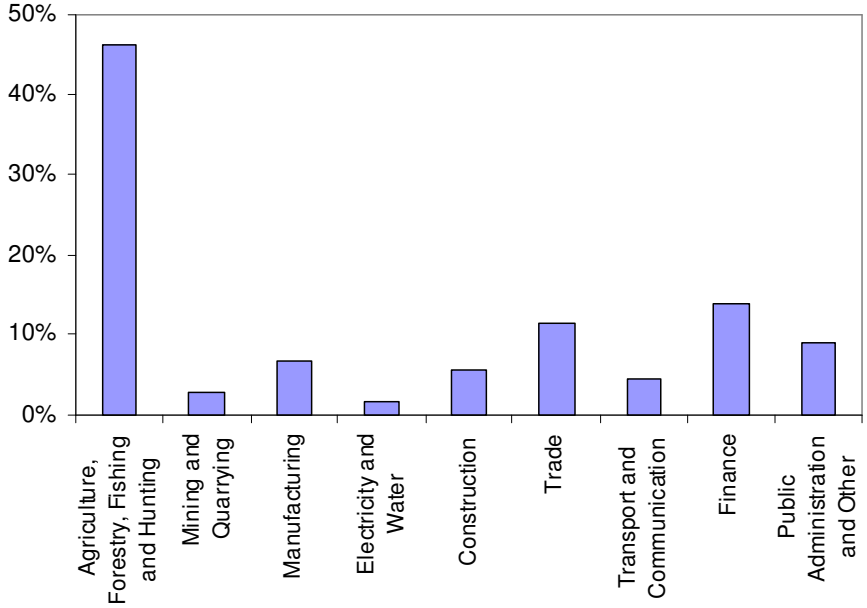


Figure 2.10 Contribution of different sectors to national income in 2005 at current prices.

In Kilimanjaro region, the agricultural sector contributes to about 69.2% of the region's GDP (URT 2002). In Arusha region, agriculture contributes about 40% to GDP and 75% of export earnings. Tourism accounts for much of the GDP in this region, and much of the latter is based on wildlife resources outside the Pangani Basin. Nevertheless the agriculture and livestock sectors employ more than 85% of the rural population in Arusha region. The economy of Tanga Region depends mainly on subsistence agriculture, livestock keeping and fishing. Food production to a large extent is undertaken by small holders, while cash crop production is carried out by both small holders and large scale farmers.

### *2.8.1 Agriculture, forestry and fisheries*

Pangani basin is an important area for commercial irrigation crops. Rice is mostly grown in Kilimanjaro and Tanga regions through irrigation, and provides a significant source of income to these regions and provides food to the majority of the population (Kulindwa 2005). Other irrigated crops include maize, sugarcane, coffee, flowers, bananas, vegetables and fruits. Estimates of the total irrigated area in the basin range from 31 000 ha to 50 000 ha (Mujwahuzi 2001, Ngula 2002, Kulindwa 2005) and that irrigation in the basin uses between 400 and 480$m^3$ of water annually (Mujwahuzi 2001). The results of the hydrological modelling conducted for the Pangani Basin Environmental Flows Initiative (this study) suggest a current total irrigated area of about 80 000 ha and water use of about 550 $Mm^3$ per annum.

The regions in which the Pangani basin is situated are well-known for pastoralist activities in Tanzania. The majority of pastoralists in the basin have migrated into the area in search of water. The Arusha, Kilimanjaro and Tanga regions together contain about 14% of the cattle in the country (URT 2005).

Forestry, both in the form of natural and plantation forests, is a relatively minor commercial activity in the basin.

Although not as important overall as agriculture and other activities, fishing is important in some areas of the basin. There are fishing activities at Nyumba ya Mungu Dam, Kilimawe, Mworoworo, Diondara and the small lakes of Jipe and Challa as well as the Kikuletwa and Ruvu Rivers (URT 1998, 2002) and the Pangani estuary. These fisheries are an important source of employment and food to the people in the basin, particularly in areas where protein food is scarce, and also contribute to the region and district revenues in terms of taxes levied to fishers.

Beekeeping is also a widespread practice throughout the basin.

### *2.8.2 Mining*

The Pangani Basin contains a variety of mineral deposits. There is tin mining in Korogwe, tanzanite and phosphate mining in Arusha Region, limestone mining in Tanga Region (Mkuula, 1993) and gold mining in the Usambaras. About 80% of the world's known tanzanite reserves are to be found at Merelani, 100 km northeast of Arusha. Sand mining for building purposes is common along riverbanks and salt making is carried out (illegally) in the estuary. Mining as an economic activity in the basin is still in its infancy and is currently undertaken mainly by small scale miners, using very poor tools and technology. However, this is changing with increasing foreign investments in technology and infrastructure.

### *2.8.3 Hydroelectric power supply*

Hydroelectric power, or hydropower, contributed about 82% of total electricity in the country for the period between 1987 and 2005. Of this, about 16% is from hydropower plants located in the Pangani River Basin, namely Nyumba ya Mungu, Hale and New Pangani (Table 2.2), with a total installed capacity of 97 MW. While the contribution of electricity to the GDP in terms of sales revenues stood at about 1.5%, the estimated contribution of hydropower alone to the GDP is 1.19%[2]. The Pangani Basin system contributes about 0.23% of GDP or 19.3% of the total hydropower revenue contribution to the GDP (Table 2.3). This is simply the direct contribution. If the backward and forward linkages were considered, Pangani Basin would register a much higher contribution to the GDP than is reported here. A much larger benefit is realised due to the multiplier effects in all production activities using hydropower as a factor input in the production process, such as sugar refineries and sisal processing located within the basin and other industries throughout the national grid.

Table 2.2 Percentage of Hydropower generation in Tanzania 1993 to 2005

| Year | Kidatu | Mtera | Kihansi | Rufiji Basin System | Hale | New Pangani | Nyumba ya Mungu | Pangani Basin System |
|---|---|---|---|---|---|---|---|---|
| 1993 | 65.2 | 24.8 | - | 90.1 | 4.8 | 4.1 | 1.1 | 9.9 |
| 1994 | 64.8 | 25.0 | - | 89.7 | 3.8 | 5.4 | 1.1 | 10.3 |
| 1995 | 55.6 | 15.1 | - | 70.8 | 6.6 | 20.2 | 2.4 | 29.2 |
| 1996 | 56.6 | 19.3 | - | 75.8 | 5.2 | 16.9 | 2.1 | 24.2 |
| 1997 | 53.1 | 14.1 | - | 67.1 | 7.9 | 23.0 | 1.9 | 32.9 |
| 1998 | 50.3 | 20.5 | - | 70.8 | 5.8 | 20.6 | 2.8 | 29.2 |
| 1999 | 53.2 | 19.4 | 0.7 | 73.2 | 5.8 | 18.8 | 2.2 | 26.8 |
| 2000 | 38.7 | 13.3 | 27.8 | 79.9 | 4.1 | 14.2 | 1.8 | 20.1 |
| 2001 | 43.5 | 17.1 | 26.4 | 87.1 | 2.4 | 9.4 | 1.1 | 12.9 |
| 2002 | 43.8 | 17.6 | 26.5 | 88.0 | 2.6 | 8.5 | 1.0 | 12.0 |
| 2003 | 45.1 | 20.9 | 21.3 | 87.2 | 2.6 | 8.7 | 1.4 | 12.8 |
| 2004 | 35.7 | 11.8 | 37.7 | 85.2 | 2.9 | 10.5 | 1.4 | 14.8 |
| 2005 | 38.4 | 13.1 | 34.7 | 86.2 | 2.9 | 9.6 | 1.3 | 13.8 |

Source: United Republic of Tanzania (1998 – 2005) The Economic survey. Published by the Planning Commission Tanzania.

Table 2.3 Electricity revenue and GDP in Tanzania for 1993 to 2005

| | % of GDP |
|---|---|
| Hydropower revenue | 1.19 |
| Rufiji Basin System | 0.96 |
| Pangani basin system | 0.23 |
| **Total energy revenue** | **1.45** |

### *2.8.4 Other sectors*

Of all the remaining sectors, tourism (part of the trade sector) and manufacturing are probably the most important in the basin. Tourism is prevalent in Arusha region, with

[2] The contribution from thermal is 0.13% and others sources (gas, coal, etc) contribute 0.13%.

Arusha town being the gateway to major wildlife attractions such as Serengeti. Moshi is also an important hub for tourism to Mt Kilimanjaro. There is limited tourism in the eastern highlands, which are known for being a centre of endemism, and to the coast, where beaches and the historic town of Pangani are the main attractions.

Industry is growing in the basin and is concentrated in the main towns. Some of the more important industries include sisal processing, tanneries, paper products, chemicals, textiles, timber and metal works, and bottled water production. At the coast, the most important industries are cement, fruit canning, and saw milling. Other industries include textiles, sisal ropes/twines, steel rolling, timber, plastic bags and soft drinks.

## 2.9 Use of water

Irrigated agriculture is the biggest user of surface water with an estimated total areas of some 80 000 ha in the Pangani River Basin. The major water users are urban water authorities (Moshi and Arusha) for the supply of water for domestic users, various estates (coffee, sugarcane, flowers, rice, sisal and banana), vegetables, sunflower and industries (sugar refineries and sisal processing plants).

Major crops under irrigation, which consume large amounts of water, include coffee (1 000 $m^3$/ha/a), sugarcane (12 000 – 17 000 $m^3$/ha/a), and flowers (18 250 $m^3$/ha/a) in large commercial estates and small- scale farms. Other crops under small-scale irrigation and amount of water consumed include traditional furrow (3 000 $m^3$/ha/a) and improved schemes (850 – 1 195 $m^3$/ha/a) in the highlands, upper basin and lowland areas (Turpie *et al.* 2003). In Kilimanjaro region, it is estimated that about 80% of water abstracted is for irrigation purposes (Ngana, 2001).

Other users of river waters in the basin are the pastoralists who migrate into the basin searching for water. Highland dairy cattle use about 36 $m^3$/head/a, upper basin dairy and beef cattle 27 $m^3$/head/a and lowlands cattle 18 $m^3$/head/a.

Pastoralists and dryland farmers who occupy the western portions of the basin do not place significant demands on surface water supplies, and probably rely largely on groundwater and seasonal springs.

## 2.10 Household use of aquatic resources

Households living near rivers and the estuary derive subsistence benefits and modest incomes from the use of natural resources. These include food and medicinal plants, reeds, sedges and floodplain grasses, palms, mangroves, fisheries and animals for hunting. The reliance on these resources is relatively low in the highlands, and increases downstream, with the highest benefits from aquatic resources being provided by those associated with the lower floodplain areas and estuary. The construction of the Nyumba ya Mungu Dam also resulted in the development of a fishery, which benefits the communities living around the dam. This has essentially replaced a fishery that was previously associated with the river and Kirua Swamp area below the dam (Turpie *et al.* 2003).

## 2.11 Delineation of the basin socio-economic zones

Using the above information as a guide, the basin was delineated into relatively homogenous zones on the basis of land use and relationships to aquatic ecosystems (Figure 2.11). This exercise was performed with the aid of local experts who had a

knowledge of the basin. The boundaries are approximate at this stage and will be refined during the description of the state of the basin. The areas are described in more detail below.

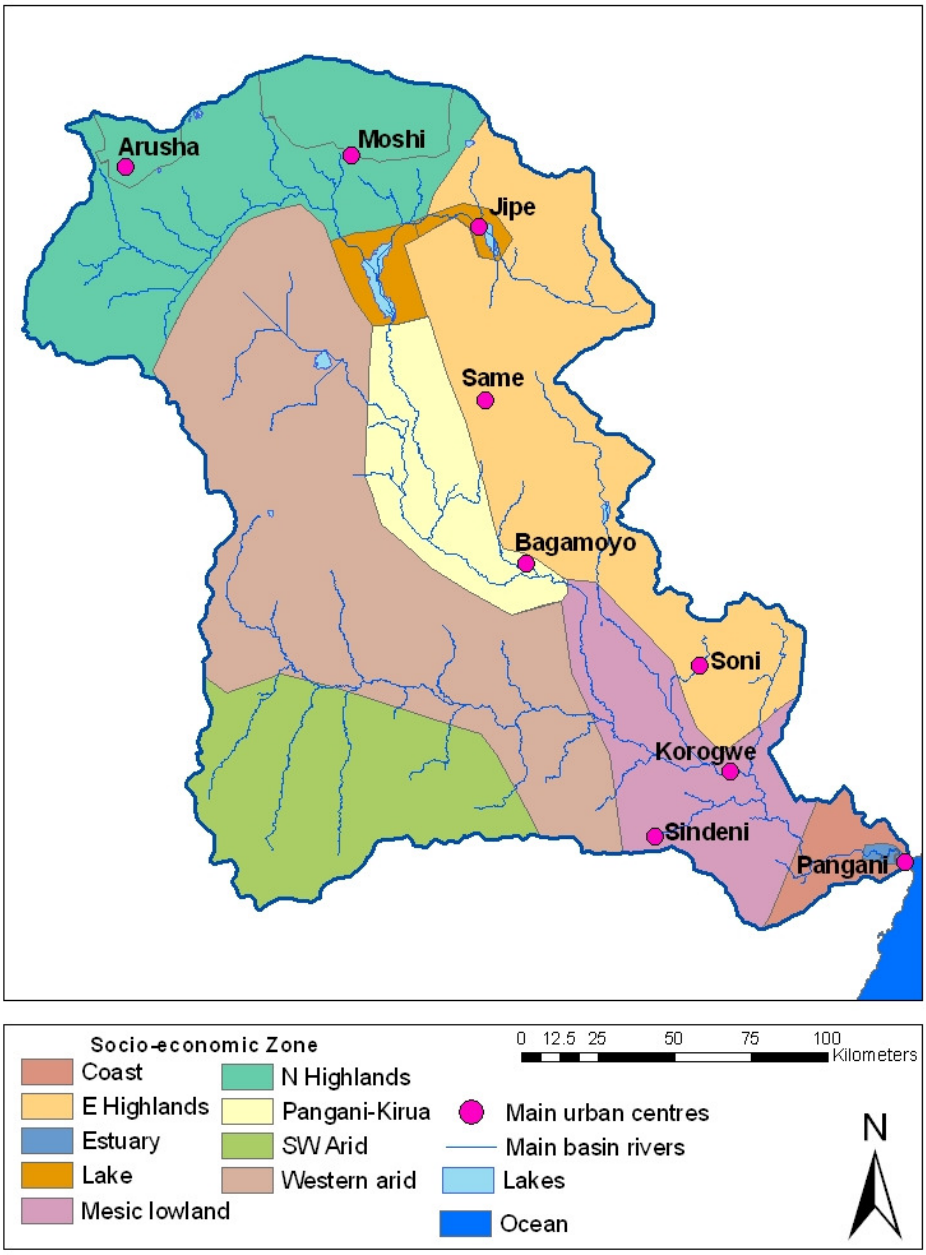


Figure 2.11 Delineation of socio-economic zones within the Pangani River Basin, in relation to rivers, major dams and lakes, and villages and towns.

### *2.11.1 Northern Highlands*

These are the foothills of Mt Meru and Mt Kilmanjaro, roughly corresponding to the catchments of the Kikuletwa and Ruvu Rivers above the Nyumba ya Mungu Dam. The area is characterised by dense populations and small-holder irrigated agriculture, with small-scale farmers relying on furrow irrigation. Coffee, bananas, paddy rice and maize are the dominant crops. There are several schemes that improve the efficiency of irrigated agriculture. In addition, this zone contains a commercial plantation of sugar. There is a very small amount of fishing, as well as harvesting of aquatic plants.

Within this zone, the upper mountain areas can be considered as a subzone. These are the areas above the 1200 m contour on the slopes of Mt Meru and Mt Kilimanjaro. These areas are characterised by dense populations and smallholder cultivation of coffee, bananas, dairy and vegetables, interspersed with large-scale commercial coffee plantations. Most of this is irrigated agriculture, both from furrows and from more sophisticated systems using reservoirs and boreholes. There is relatively little utilisation of riparian resources, with those used being mainly aquatic plants.

Although distinguishable in terms of agricultural activities, the upper mountain areas are considered together with the rest of the highland zone because many households have fields in both.

### *2.11.2 Eastern Highlands*

These are characterised by the relatively dense settlements and cultivated areas around the Pare and Usambara Mountains. In addition to small-holder cultivation, the lowland areas immediately below the foothills are used extensively for sisal production. There are also extensive populations living along the main road between Moshi and Tanga. We include these populations in this zone, as their connections are probably more with agricultural lands above the road than towards the river.

### *2.11.3 Lakes*

These are the communities associated with Nyumba ya Mungu Dam and Lake Jipe, and the associated wetland areas.

Fishing is important in both of these communities. The majority of fishers around Nyumba ya Mungu Dam are Ngoni and Luo who migrated to Nyumba ya Mungu Dam from Songea in southern Tanzania and from Kisumu in Kenya (URT 1996). Because the reservoir is within a former major wetland area, it is possible that households in this area also have a significant association with other wetland resources.

### *2.11.4 Middle Pangani River and Kirua Swamps*

Between Nyumba ya Mungu Dam and its confluence with the Mkomazi River, the Pangani River flows through an arid lowland area. There are a few small villages and temporary settlements associated with this stretch of river. These people depend on the river for watering cattle, fishing, aquatic plants, and irrigating floodplain fields. In the past, the community living in the northern part of this zone would have been more distinguishable from those living further south due to their

association with the Kirua Swamp. However, the difference would probably have diminished since the drying up of the swamp over the past 12 – 15 years. For the purposes of scenario analysis, it might be possible to distinguish these communities into two sub-zones.

### *2.11.5 Mesic lowlands*

Lowland areas in the south-east of the basin are cultivated, with smallholder cropping, probably due to the combination of extensive floodplain areas and high rainfall. In addition, the coastal areas contain large commercial-scale sisal plantations. This area also has a relatively dense population, with economic activity centred in Tanga.

Note that this area will also include coastal populations who derive income from inshore fishing. We need to include this part of the population in the Coast and estuary zone.

### *2.11.6 Coast and estuary*

At Pangani Falls, the elevation of the catchment drops sharply. The climatic conditions in the coastal zone differ somewhat from further inland, and the area is more conducive to cultivation of crops such as coconut palms.

Within this zone, the estuary sub-zone is defined on the basis of a relatively limited population that derives significant benefits from estuarine resources. The area is also characterised by coconut palm and betelnut plantations.

### *2.11.7 Western and south-western arid zones*

These zones are characterised by a very low population density and are dominated by nomadic pastoralists. The south-western region also has small-scale dryland agriculture. Since there is little direct relationship with the surface water resources in the basin in these areas, they will not be described in detail in the State of the Basin assessment.

### *2.11.8 Population per zone*

The estimated populations of these zones are summarised in Table 2.4.

Table 2.4 Estimated total population in each zone, based on 2002 census data.

| Zone | Population | % |
|---|---|---|
| N Highlands | 1 839 259 | 61.0 |
| E Highlands | 745 340 | 24.7 |
| Lakes | 10 969 | 0.4 |
| Pangani-Kirua | 36 546 | 1.2 |
| Mesic Lowlands | 84 859 | 2.8 |
| Coast | 292 312 | 9.7 |
| Estuary | 8 019 | 0.3 |

Source: National Bureau of Statistics (2002)

# 3 METHODS

## 3.1 Overall approach

The study builds on work that has been carried out in the study area, as well as primary data collection using surveys, and expands on a preliminary study on the use and value of water and aquatic ecosystem resource use in selected areas of the basin (Turpie *et al.* 2003).

The study commenced with an initial review of existing published and unpublished information and a two week-long visit to the basin in which information on the study area was collated, the study area was delineated into sampling areas and the sampling frame was designed. This also included a stakeholder workshop during which the study design was explained, and future issues which need to be addressed in future phases of the study were discussed.

This was followed by detailed methodological design. An interview survey was conducted of households throughout the study area and various focus group discussions were held to inform different aspects of the study. Data were standardised and analysed to estimate the value of natural resource use as well as agricultural production by rural households. Values were related to the aquatic habitats of the study area as far as possible.

The study had a capacity building component and involved a Tanzanian resource economist working under the guidance of a South African mentor and in conjunction with staff of the Pangani Basin Water Office. Several others also benefited from the study in terms of experience gained, including senior staff at the Pangani Basin Water Office and eight graduates of the University of Dar es Salaam who participated as enumerators in the study.

## 3.2 Valuation frameworks and scope of this study

Within the framework of Total Economic Value, the value of ecosystems comprises several types of value, as follows (Figure 3.1):

**Direct use values** result from the consumptive or non-consumptive use of ecosystem resources. Direct use values of aquatic ecosystems may be derived from fishing, wild plant use and hunting. They are also generated through consumptive (hunting) and non-consumptive (wildlife viewing) tourism.

**Indirect use values** are values generated by ecosystems that form inputs into production by other sectors of the economy, or that contribute to net economic outputs elsewhere in the economy by saving on costs. These outputs are derived from ecosystem functions, such as water filtration, flood attenuation, and carbon sequestration. They also include benefits (or costs) arising from the provision of source areas for wild animal populations.

**Non-use values** include the value of having the option to use the resources and generate use values from ecosystems in the future (option value), as well as the value of simply knowing that certain resources are protected (existence value including specific elements such as cultural, aesthetic, biodiversity and bequest values). Although far less tangible than the use values, non-use values are reflected in society's willingness to pay to conserve these resources, and with appropriate market mechanisms, can be captured through transfers and converted to income.

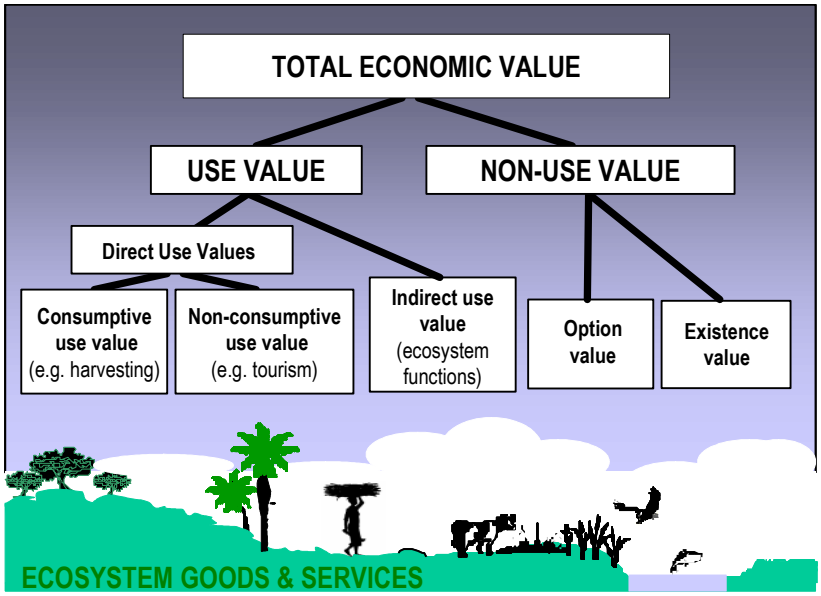


Figure 3.1 The classification of ecosystem values that make up Total Economic Value (Turpie *et al.* 1999).

Direct and indirect use values are of particular importance in a developing country context, since the economic growth and employment is a critical national objective. These values are manifested directly or indirectly in tangible income and employment. Existence values inherently are not manifested in income and employment, and they are often highest in foreign countries. Nevertheless, global existence values can be high and the resultant willingness-to-pay can be captured globally and converted to income within Tanzania, for example through grants.

Because the Pangani River Basin Flow Assessment Initiative is largely concerned with how water allocation affects the livelihoods of people in the basin, this study concentrates on the **direct consumptive use value of aquatic ecosystems to rural households** in the Pangani River Basin only. This is certainly one of the more important values associated with these systems. Tourism in the area tends to be concentrated in the mountainous areas and is not associated with river systems, although it should be noted that there is a small amount of tourism at the Pangani estuary, where coastal scenery and the historical town also contribute to the experience. While some indirect values are likely to be small, others, such as water purification, could be significant.

Any of the above types of value can be considered at various levels or from various perspectives. The benefits gained from the use of natural resources, including water, can be seen from a **private** or household perspective, in terms of how they benefit households that use these resources directly. This can be analysed in terms of a **livelihood framework**, by estimating the contribution of these resources to the overall livelihoods of people living in the basin.

Alternatively, the benefits of aquatic ecosystems can be analysed from a **social** or economic perspective, in terms of their **contribution to the outputs of the**

**economy** at a local, regional or national scale. Of course, the overall outputs of the economy are of interest in that they affect a much wider population than the people that are in direct contact with the resources. As economic output increases, so do overall levels of employment and the government's ability to provide services. Sectoral outputs are generally analysed in terms of a **national accounting framework**, whereby standard measures are used to estimate the contribution to national income and employment.

Both of these perspectives will be important in analysing the tradeoffs involved in water allocation in the Pangani River Basin. This study is mainly concerned with the benefits that river systems of the basin provide in terms of their contribution to people's livelihoods, updating information presented in Turpie *et al.* 2003. Other values discussed in Turpie *et al.* 2003, such as use of water for hydropower generation or in commercial-scale agriculture are not investigated further in this study. The macroeconomic impacts of water allocation will be analysed at a later stage.

## 3.3 Valuation methods

Direct use values were estimated using social survey methods in conjunction with existing information in the published and unpublished literature, and in existing economic models. Information on household activities and use of natural resources was collected during October 2003 and October 2006 by means of focus group discussions, key informant interviews and household surveys. The interviews were carried out with the help of a team of eight enumerators who were trained for two days in Moshi.

### *3.3.1 Focus group discussions and key informant interviews*

Focus group discussions were held to collect information of a generally applicable nature, e.g. on seasonality, markets and prices, as well as to collect sufficient information to be able to make a preliminary quantitative estimates of natural resources harvesting and processing and associated economic values. Focus group discussions were held in each of the villages visited, and broached the following topics

- Agricultural practices, with emphasis on the use of water
- Fishing
- Use of wood products, hunting and honey
- Use of medicinal and wild food plants and fuelwood.
- Use of reeds, sedges, grasses, palms, clay and associated production

Each group consisted of up to about 20 people. Discussions were unstructured, but followed the general topics outlined in Box 1.

**Box 1. General structure of Focus Group discussions**

**FOCUS GROUP DISCUSSIONS**

**A. Introductions**
The purpose of the discussion is explained, and members of the group are encouraged to be as open as possible about the issues to be discussed.

**B. Resource description**
The species of natural resources used are named and described as far as possible, giving where they occur or are grown. Their treatment and uses are also described.

**C. Rules of access**
The group is asked to describe how households gain access to resources, and any limitations on use.

**D. Who is involved**
People are asked about the role of men, women and children in the production or harvest of the resource.

**E. Equipment**
The group is asked about the type of equipment used, prices, durability, and sharing or hiring arrangements.

**F. Seasonality**
The group is asked to describe seasonality in the availability and harvesting of certain resources. Some groups are also asked about seasonality of different agricultural activities (e.g. cultivating, harvesting).

**G. Returns to effort**
The group is asked how much could be harvested in a day or week during different times of year.

**H. Prices and inputs**
Selling prices are obtained for each resource and for products made from these resources. Natural resource inputs into crafts and other products are also quantified.

**I. Changes in availability**
Members of the group are asked to describe and explain changes in availability over time.

### *3.3.2 Household questionnaires*

Quantitative data on natural resource use were obtained by means of an intensive household survey during October 2006 to augment similar data collected in October 2003. Household surveys were carried out in five zones. The household questionnaire served to quantify the use of natural resources, and get quantitative information on agriculture, value added through processing, and other income generation. The main topics covered in the questionnaire are described in Box 2 below. The most difficult questions were posed early in the questionnaire, with agricultural production at the end, to counter the effects of survey fatigue. Questionnaires took just under an hour to complete.

**Box 2. General structure of the household surveys**

**HOUSEHOLD SURVEYS**

**A. Household information**.
Household location
Household size and composition, education, occupations

**B. Relative value of household production**
Respondents asked to apportion a pile of beans among eight different sources of income (crops, livestock, woodland resources, floodplain grassland resources, fish, other wetland resources, other cash income from jobs, trade etc., and pensions) to indicate their relative contribution to household income in an average year.
Cash income: from wages, pensions, and absent family members

**C. Use of natural resources**
Respondents were asked about fishing, wood products, honey, hunting, salt, reeds, papyrus, grasses, palms, food and medicinal plants. For each resource they are 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. Crops**
- total area planted, area irrigated, and which crops grown
- amount produced in the last year for each crop

**D. Livestock**
- numbers of small and large stock
- production over the past year

**F. Water use**
- Payments for irrigation water
- Household use of water
- Importance of aquatic ecosystems for leisure and spiritual activities

### *3.3.3 Sample size*

A total of 456 interviews were conducted in 2006. This was added to the 203 interviews conducted in 2003, bringing the overall total to 659 households. Between 75 and 165 households were interviewed in each zone (Table 3.1). All households interviewed were in villages within 5 km of rivers, wetlands, lakes or dams.

Table 3.1 Number of households interviewed in each village in each zone.

| Zone | Village | Year | Total |
|---|---|---|---|
| N Highlands | Ambureni | 2003 | 25 |
| | Ghona | 2006 | 23 |
| | Kimangaro | 2003 | 27 |
| | Kisangesangeni/Ngasenyi | 2003 | 9 |
| | Lekitatu | 2003 | 24 |
| | Mbuguni/Ngumbaru | 2006 | 46 |
| | Oria | 2003 | 11 |
| | | | **165** |
| E Highlands | Kisiwani | 2006 | 31 |
| | Kwakoa | 2006 | 28 |
| | Makaranga | 2006 | 33 |
| | Ndungu | 2006 | 34 |
| | | | **126** |
| Lakes | Jipe | 2006 | 24 |
| | Magadini | 2006 | 51 |
| | | | **75** |
| Pangani Kirua | Jitengeni | 2003 | 7 |
| | Kombo (Kumbamtoni) | 2003 | 8 |
| | Lolokai | 2003 | 13 |
| | Mabilioni | 2006 | 16 |
| | Mesrani | 2003 | 7 |
| | Mvungwe | 2003 | 17 |
| | Ruvu Kivukoni | 2003 | 17 |
| | Ruvu Muungano | 2003 | 10 |
| | Ruvu-Marwa | 2003 | 10 |
| | | | **105** |
| Mesic Lowlands | Mazinde/Mheza | 2006 | 24 |
| | Mkalamo | 2006 | 31 |
| | Segera | 2006 | 24 |
| | | | **79** |
| Estuary | Bweni | 2003 | 14 |
| | Kigulusimba | 2006 | 34 |
| | Mkwajuni | 2003 | 15 |
| | Mseko | 2003 | 16 |
| | Pangani | 2006 | 30 |
| | | | **109** |
| **Overall Total** | | | **659** |

## 3.4 Aggregation of values

Average income from aquatic ecosystem resources in each zone was aggregated to estimate the total value of these resources to rural households in the basin. This required estimating the affected population that was represented by the sample. Based on the traveling time involved, it was assumed that the majority of the user population lay within 5 to 10 km of the main rivers and lakes in the basin. This population was estimated by creating 5 and 10 km buffers around the main rivers in GIS, and then using spatial data on the location of villages to estimate the proportion of villages within these buffers in each zone (Figure 3.2). These proportions were then applied to the rural population calculated for each zone, based on ward-level data. An exchange rate of US$ = Tsh. 1200 was used.

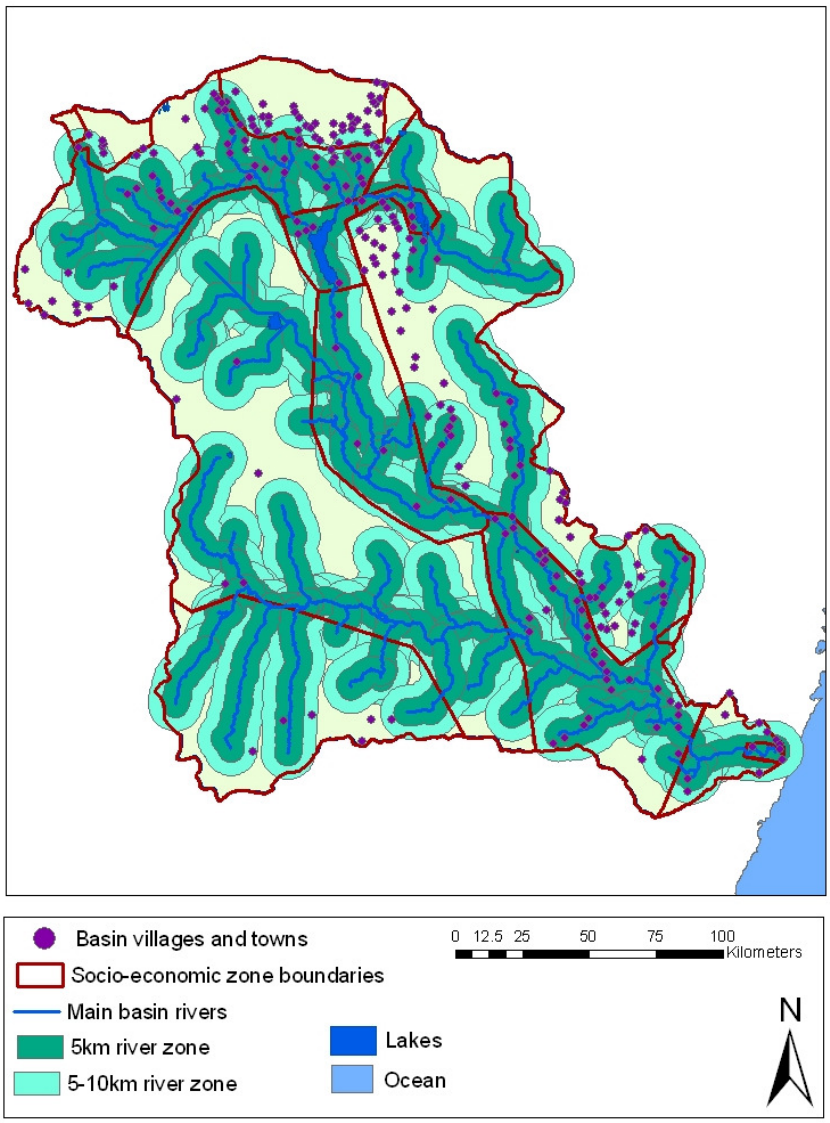


Figure 3.2 Map of the Pangani River Basin showing the main rivers surrounded by buffers of 5 km and 10km on either side of the rivers. Socio-economic zones are outlined in red and the main villages are shown. Dams and lakes are shown in brown.

# 4 RESULTS

## 4.1 Household characteristics and livelihoods

There is considerable variation in the ethnic composition of the zones of the study area (Table 4.1). The most populous northern highland areas are dominated by the Chagga and Meru, while the highland areas to the east are dominated by the Pare and Sambaa. The Pare also extend west to dominate the Pangani-Kirua zone, which also has a large proportion of Maasai. The mesic lowlands are dominated by the Zigua and the Sambaa, and at the estuary, these groups are outnumbered by the Bena. The lakes zone is ethnically the most diverse, due to the influx of fishers from all over, but they are dominated by the Sambaa and Nyamwezi.

Table 4.1 Percentage of each ethnic group in each zone for ethnic groups that made up 1% or more of the overall sample, and total number of ethnic groups recorded in each zone.

| | **N Highlands** | **E Highlands** | **Lakes** | **Pangani Kirua** | **Mesic Lowlands** | **Estuary** | **Overall** |
|---|---|---|---|---|---|---|---|
| *N* | *165* | *75* | *126* | *102* | *78* | *109* | |
| Pare | 16 | 37 | 28 | 46 | 5 | | 22 |
| Sambaa | 4 | 41 | 5 | 3 | 17 | 8 | 13 |
| Zigua | 1 | 3 | 1 | 6 | 64 | 21 | 13 |
| Chagga | 36 | 2 | 4 | 3 | | | 10 |
| Meru | 30 | | | | | | 8 |
| Bena | 1 | | 1 | | | 17 | 3 |
| Maasai | 1 | | 1 | 16 | 1 | | 3 |
| Arusha | 1 | | 15 | 1 | | | 2 |
| Nyamwezi | | 2 | 4 | | | 7 | 2 |
| Fipa | | | 7 | 5 | | | 2 |
| Hehe | | | 4 | 1 | | 6 | 2 |
| Sangu | | | | 1 | | 7 | 1 |
| Ngoni | | 2 | 7 | | | | 1 |
| Sandawe | 1 | | 1 | 5 | | | 1 |
| Bondei | | 2 | | | 1 | 3 | 1 |
| Digo | | 0 | | | 3 | 4 | 1 |
| Kinga | | 0 | | | | 6 | 1 |
| Sukuma | 1 | 3 | 1 | | | | 1 |
| Yao | | 1 | 1 | 2 | | 2 | 1 |
| Nyiramba | 2 | | 3 | | | | 1 |
| Ha | 1 | 1 | 1 | | 1 | | 1 |
| Kahe | 2 | | | | | | 1 |
| Makonde | | 1 | | | | 3 | 1 |
| Rangi | | 1 | 3 | 1 | | | 1 |
| Tot ethnic groups recorded | 19 | 25 | 17 | 21 | 13 | 26 | |

Households are typically large, with an average of over 6.5 people per household, apart from at the estuary (Table 4.2).

Table 4.2 Average household size of respondents

| | N.High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| Adults resident | 3.58 | 3.56 | 3.80 | 3.34 | 3.67 | 2.97 |
| Adults living elsewhere | 1.13 | 1.75 | 1.07 | 1.43 | 1.34 | 0.94 |
| Children 5-15 | 0.87 | 1.19 | 0.92 | 1.55 | 0.94 | 0.76 |
| Children under 5 | 1.76 | 1.88 | 1.88 | 1.80 | 1.96 | 1.23 |
| **Average household size** | **6.21** | **6.63** | **6.60** | **6.70** | **6.57** | **4.96** |

Average income per household from jobs and business other than related to own agricultural production or natural resource use is extremely low (Table 4.3), with average income ranging from Tshs 10 000 - 17 000 per month in the lowlands to Tshs 26 000 – 36 000 in the upper basin areas and Tshs 48 000 at the estuary, though this excludes one household that earned Tshs 2 million per month. Note that the relatively high income reported from the estuary zone is probably also related to the fact that this sample included respondents from Pangani town, whereas all other zones only included rural villages.

Table 4.3 Average income per household per month from business or employment sources other than related to own agricultural or resource-based production, and from pensions (Tshs per month)

| Income per month Tshs | N.High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| Business income | 35 815 | 28 394 | 26 149 | 16 633 | 10 395 | 47 817 |
| Pensions | 9 931 | 7 056 | 3 716 | 10 829 | 3 608 | 6 938 |

Most households engage in a variety of activities as a risk-spreading strategy. Most of these activities are vulnerable to environmental variability, and the income from each is likely to be variable both seasonally and interannually. Thus while jobs and small business provide a relatively stable source of income, income from the main household activities is likely to be far more variable.

Nearly all rural households consider themselves to be farmers (Table 4.4), although the proportion of households engaged in crop farming is somewhat lower at the lakes and estuary, where fishing is more prevalent. Fishing is relatively unimportant in other parts of the basin. Hunting is undertaken by only a small fraction of households. At least a third of households harvest timber of poles from surrounding woodlands, riparian areas or mangroves in a given year, and about two-thirds of households are dependent on these areas for firewood (Table 4.4). A significant proportion of households also harvest raw materials such as reeds, grasses and papyrus from river systems. About a third of households harvest wild food and medicinal plants.

Table 4.4 Percentage households engaging in different types of activities in different parts of the basin

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| Crop farming | 96 | 97 | 71 | 87 | 96 | 74 |
| Livestock | 99 | 87 | 89 | 88 | 86 | 61 |
| Fishing | 4 | 6 | 53 | 17 | 14 | 25 |
| Hunting | 2 | 2 | 1 | 2 | 3 | 1 |
| Timber or poles | 33 | 33 | 43 | 46 | 44 | 27 |
| Firewood | 61 | 71 | 68 | 69 | 95 | 80 |
| Reeds, papyrus, palms, grass | 22 | 32 | 35 | 48 | 61 | 50 |
| Food and medicinal plants | 26 | 40 | 24 | 31 | 48 | 30 |

## 4.2 Small-scale agriculture

### *4.2.1 Crops*

Small scale farming is practiced throughout the basin, with much of the smallholder farming area being irrigated, particularly in the higher-lying areas of the basin. There is almost no crop rotation, reportedly due to acute shortages of arable land area. Most farmers grow one of the staples in conjunction with some other food and cash crops. Numerous crops are grown in the different areas of the basin (Table 4.5), varying across the basin depending on soil and rainfall conditions as well as the availability of irrigation water. The dominant crops are maize, beans, bananas and vegetables. In addition, coffee is common in the northern highlands, rice in the eastern highlands, fiwi beans in the lowland areas and cassava and coconuts are common around the estuary.

Small scale farmers tend to rely on manure more than chemical fertilizers (60 – 70% of farmers in Mabilioni depended on manure). This is because of the high cost of chemical fertilisers compared with manure (Table 4.6). Cultivation mainly involves hand hoes, but ploughing is also done to some extent using cattle or hired tractors at a cost of Tshs 10 000 and Tshs 20 000 per acre, respectively. Some farmers rent farm land. For example in Magoma village, rental costs about Tshs 40 000 per acre per year.

Smallholder irrigation is largely via traditional furrows, many of which have been improved to become more modernised irrigation schemes. However, a very small proportion of households with small fields reportedly use buckets to irrigate their crops (e.g. as described in Segere, Kisiwani and Mkalamo).

Some 40 – 60% of farmers in the highland areas irrigate their fields, compared with much lower proportions around the lakes and mesic lowland areas, and almost none in the Pangani-Kirua and estuary zones (
Figure 4.1). However, a large proportion of irrigation farmers in the highlands felt that they did not have access to enough water (
Figure 4.1). Many irrigation farmers complained of reduced flows due to increased population, increased water abstractions and a reduction in rainfall. These shortages can have significant impact on crop outputs. For example, farmers in Mabilioni claimed that delays of up to three weeks in receiving irrigation water during the dry season had affected productivity.

Table 4.5 Percentage of households growing different crops in different parts of the basin.

| Crop | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| Maize | 79 | 82 | 96 | 84 | 95 | 75 |
| Beans | 59 | 51 | 62 | 11 | 29 | 1 |
| Banana | 34 | 16 | 19 | 31 | 25 | 20 |
| Vegetables | 25 | 29 | 40 | 10 | 22 | 23 |
| Tomatoes | 20 | 14 | 8 | 16 | 17 | 10 |
| Fruits | 18 | 13 | 6 | 11 | 25 | 11 |
| Rice | 11 | 36 | 4 | 7 | 9 | 11 |
| Cassava | 11 | 11 | 4 | 8 | 5 | 27 |
| Fiwi beans | | 3 | 2 | 35 | 21 | |
| Coffee | 25 | | | | | |
| Okra | 4 | 10 | | 3 | 8 | 6 |
| Coconut | | 5 | | 2 | 1 | 27 |
| Watermelon | 3 | 2 | 9 | 14 | 3 | |
| Sweet potato | 3 | 6 | 2 | 4 | 4 | 9 |
| Pumpkin | 2 | 8 | 4 | 1 | 3 | 9 |
| Sugar | 1 | 10 | 4 | 4 | 4 | 2 |
| Pilipili/Paprika | | | | 19 | | 1 |
| Onions | 2 | | 2 | 7 | 1 | |
| Betelnuts | | | | | | 9 |
| Other | 13 | 3 | | 3 | 3 | 1 |

Table 4.6 Costs of fertilizer

| Type of fertilizer | Price Tshs |
|---|---|
| Urea | 22 000 – 25 000 per 50kg |
| NPK | 20 000 – 25 000 per 50kg |
| Manure | 1 000 – 2 2000 per 15m3 |

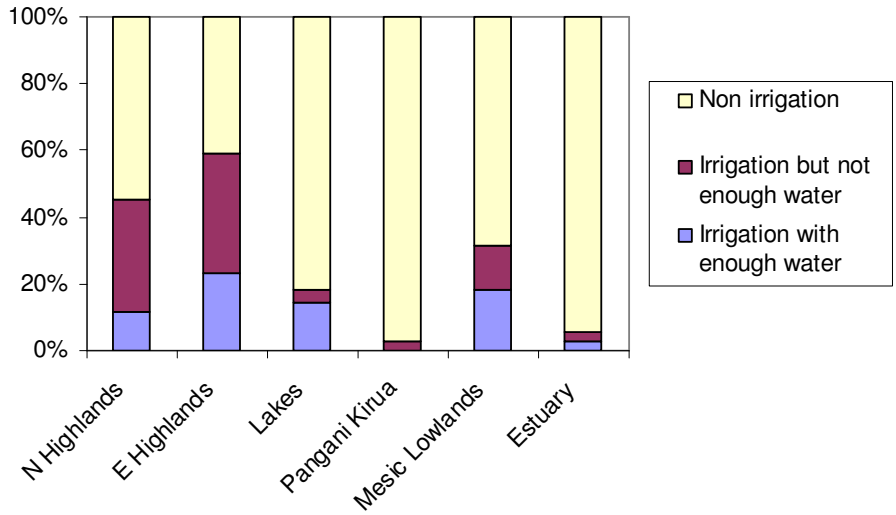


Figure 4.1. Proportion of crop farmers that irrigate their lands, showing the proportion of irrigation farmers that consider their water supply to be sufficient.

Field size is fairly constant across the basin, with irrigation farmers planting a slightly larger area. The average planted area is between two and four acres (Table 4.7). For farmers that do irrigate, usually only a portion of the planted area is irrigated, apart from the northern highlands, where irrigation farmer tend to irrigate their entire plot. Income from dryland farming is about Tshs 200 000 – 300 000 per household apart from the northern highlands, where an average of over Tshs 600 000 was recorded. Income from irrigation farming is usually more than double that from dryland farming (Table 4.7). The difference will be slightly less when costs are taken into account, as input costs are higher for irrigation agriculture, but will nevertheless be substantial.

Table 4.7 Estimated average gross annual income (Tshs) per farming household, based on survey data.

| | N.High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| **Non irrigation farmers** | 36% | 41% | 75% | 40% | 68% | 89% |
| n | 57 | 50 | 40 | 36 | 52 | 72 |
| Area planted (acres) | 2.0 | 2.2 | 2.2 | 3.8 | 3.5 | 2.6 |
| Total income/hh | 623,530 | 207,810 | 375,800 | 259,450 | 374,640 | 301,170 |
| Income per acre | 319,760 | 95,330 | 167,490 | 68,550 | 107,630 | 114,040 |
| **Irrigation farmers** | 64% | 59% | 25% | 60% | 32% | 11% |
| n | 100 | 72 | 13 | 55 | 24 | 9 |
| Area planted (acres) | 3.2 | 2.5 | 3.2 | 3.3 | 4.2 | 2.5 |
| Area irrigated (acres) | 3.2 | 1.5 | 1.9 | 1.0 | 1.2 | 0.8 |
| Total income/hh | 2,074,580 | 636,870 | 947,400 | 559,380 | 374,100 | 553,980 |
| Income per acre | 642,780 | 258,210 | 295,000 | 168,990 | 89,560 | 224,080 |
| **Income per acre** | | | | | | |
| Non-irrigated | 319 760 | 95 330 | 167 490 | 68 550 | 111 353 | 114 040 |
| Irrigated | 648 306 | 361 027 | 384 033 | 401 715 | 399 229 | 450 140 |

Most agricultural produce is sold directly to middlemen who come to the farmers from the towns. It is the traders that set the prices rather than the farmers, and there is no cooperative amongst the farmers that could play a price setting role. Thus farmers receive low prices that affect the gross income to households whose livelihoods depend on farming.

### *4.2.2 Livestock*

Most rural households in the Pangani Basin keep livestock, apart from in the estuary area, where the sample included an urban area, and only 61% had livestock. The most common types of livestock are chickens, cattle, goats and sheep. Other animals include donkeys, pigs, ducks and guineafowl.

Cattle rearing comprises both dairy cattle and local cattle for meat, milk and manure. A large proportion of household kept local cattle in most of the surveyed villages with the exception of the Kigulusimba village, where there were no livestock at all. Dairy cattle tend to be kept in the highlands (Table 4.8).

Households keep an average of 8 – 12 chickens and other fowl, as well as small herds of cattle, goats and sheep (Table 4.9). Average numbers of cattle and goats are far higher in the Pangani-Kirua area than elsewhere in the basin, because this

area includes a significant proportion of Maasai households which tend to keep large herds. Non-Maasai households have similar livestock keeping habits to those elsewhere in the basin.

Table 4.8 Proportion of local and dairy cattle in different villages, according to focus group discussions

| Zone | Village | Local cattle | Dairy cattle |
|---|---|---|---|
| | Segera | almost 100% | |
| | Mkalamo | almost 100% | |
| | Ngumbulu | 97% | 3% |
| | Mabilioni | 75% | 25% |
| | Ndungu | 70% | 30% |
| | Pangani | 15% | 85% |
| | Kisiwani | | almost 100% |

Income from livestock is significant, ranging from about Tshs 100 000 – 300 000 throughout most of the basin, apart from the highlands, where dairy in particularly contributes to a livestock in come of over Tshs 500 000 on average, and in Pangani-Kirua, where livestock generate an average of over Tshs 700 000 per household (Table 4.9).

Table 4.9. Average number of stock per livestock-keeping household, and the average annual gross value of production in different parts of the basin, based on market prices.

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| **Average number per hh** | | | | | | |
| Chickens | 10.7 | 9.4 | 11.5 | 10.2 | 8.6 | 7.7 |
| Ducks | 0.9 | 1.2 | 2.5 | 0.1 | 1.4 | 0.3 |
| Guineafowl | - | - | 0.1 | 0.4 | - | - |
| Goats | 5.2 | 3.3 | 4.2 | 12.8 | 2.5 | 1.4 |
| Sheep | 0.8 | 0.5 | 0.8 | 0.7 | 0.1 | 0.3 |
| Cattle | 2.9 | 2.0 | 2.6 | 12.2 | 1.3 | 2.1 |
| Pigs | 0.1 | 0.4 | - | - | - | - |
| Donkeys | - | - | - | 1.0 | - | - |
| **Value of production** | | | | | | |
| Chickens | 36 560 | 30 607 | 53 370 | 16 227 | 27 360 | 23 041 |
| Ducks | 722 | 4 303 | 14 864 | - | 2 765 | 6 080 |
| Guineafowl | - | - | 4 154 | 1 795 | - | - |
| Eggs | 10 492 | 6 555 | 7 682 | 1 318 | 3 701 | 1 122 |
| Goats | 42 981 | 30 717 | 38 324 | 88 888 | 18 111 | 6 430 |
| Sheep | 7 691 | 5 25 0 | 4 315 | 4 410 | 4 478 | 882 |
| Cattle | 128 476 | 69 052 | 97 808 | 561 415 | 25 336 | 237 313 |
| Milk | 286 339 | 53 993 | 29 481 | 44 760 | 20 697 | 16 103 |
| Pigs | 4 632 | 33 594 | 2 654 | - | - | - |
| Donkeys | - | - | - | 7 511 | - | - |
| **Total annual value of production** | **517 893** | **234 070** | **252 652** | **726 322** | **102 446** | **290 971** |

## 4.3 Use of natural resources

### *4.3.1 Water for domestic consumption*

Households in the basin were relatively consistent in terms of the reported consumption of water for domestic purposes (including water provided to livestock). Household consumption ranged from about 90 – 120 litres per household per day, apart from the northern highlands, where consumption was closer to 190 litres per day (Table 4.10). This difference is largely attributable to the practice of keeping zero-grazing cattle in this zone, to which water has to be provided.

Table 4.10 Average domestic water consumption per household.

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| Litres per household per day | 188 | 118 | 98 | 91 | 106 | 114 |

Over half of rural households in the survey area had access to municipal water (taps), and 16% had access to wells or boreholes. However, there is still considerable reliance on natural and semi-natural (dams, canals) systems for water, with nearly half of households obtaining water from these sources (Table 4.11). This is particularly true in the lowlands, especially in the more remote areas of Pangani-Kirua, and in the Lakes zone.

Table 4.11 Percentage households obtaining their water from different sources

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary | Overall |
|---|---|---|---|---|---|---|---|
| Municipal supply | 44 | 54 | 1 | 19 | 66 | 39 | 51 |
| Well/borehole | 30 | 2 | 21 | 0 | 1 | 64 | 16 |
| Purchased | 7 | 1 | 1 | 0 | 3 | 0 | 4 |
| Spring/River/canal | 41 | 54 | 37 | 81 | 49 | 25 | 47 |
| Dam/Lake | 0 | 1 | 55 | 0 | 0 | 0 | 1 |

The level of dependence on natural and semi-natural surface water sources was bimodal (Figure 4.2). This is probably best interpreted as households are mostly either not dependent or completely dependent on the river systems for water, depending on whether they have access to alternative water sources. This was true of all zones. A small percentage of households claim to be dependent on river systems for only part of the year, usually when wells were dry.

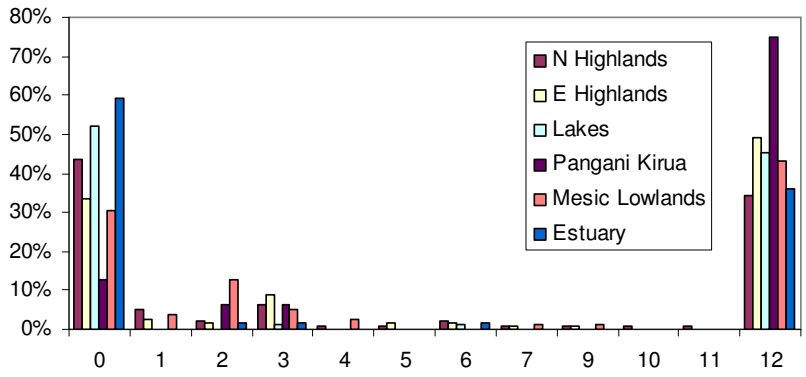


Figure 4.2 Frequency of responses to the number of months that households are dependent on rivers, lakes, dams or canals for water.

### *4.3.2 Cultural, religious and recreational use of river systems*

A large proportion of households throughout all the zones depend on river systems for washing their clothes. This is particularly high in Pangani-Kirua zone, where all households interviewed used the river for washing, with most being entirely dependent on the river for this activity. In other areas over 60% of households used the river system for this purpose apart from at the estuary, presumably because the estuary is only sufficiently fresh at certain parts of the monthly tidal cycle (e.g. spring low tide).

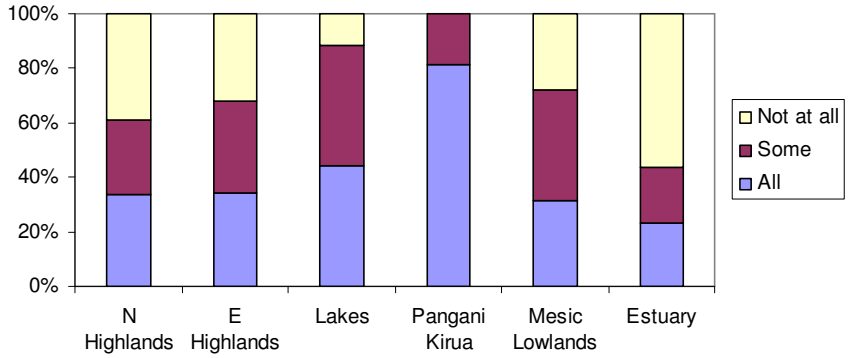


Figure 4.3 Percentage of households relying entirely, partially or not at all on the river system for washing clothes.

River systems were also significantly important for recreational activities such as swimming, resting and socialising, with over 20% of households stating that they were very important in all areas (
Figure 4.4). Overall, they were considered most important in the lakes and Pangani-Kirua areas.

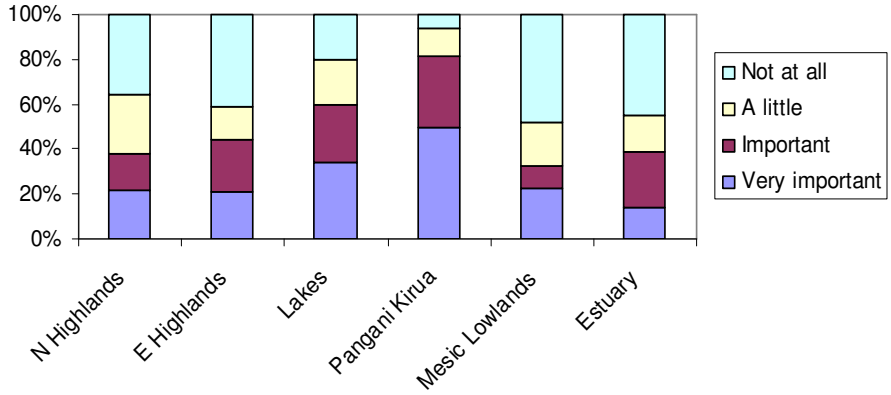


Figure 4.4 Household opinion on the importance of river systems for their household recreational activities.

Households were fairly evenly divided on the matter of the importance of river systems to their religious or spiritual wellbeing, with most stating they were either not at all important or very important. This division is largely along religious lines, in that Muslim households stated that rivers or lakes were essential for washing before attending mosque. Thus water quality would be expected to be of particular significance to these households.

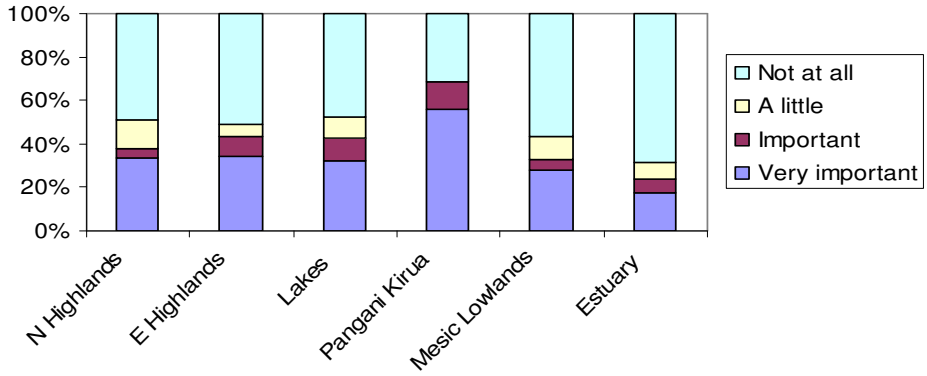


Figure 4.5 Household opinion on the importance of river systems for their household religious or spiritual wellbeing.

### *4.3.3 Food and medicinal plants*

Food and medicinal plants are harvested by households throughout the study area. Medicinal plants are harvested for treatment of domestic animals as well as humans. Several diseases are treated using wild plants found in the basin. These include anaemia, malaria, body swelling, wounds and all sorts of pains. The importance of these plants remains high because of low household income and the high transport costs to health centers. Many of the species that are used come from aquatic ecosystems or near river courses (Table 4.12). However, it is generally perceived

that the availability of these medicinal plants has declined as a result of increased land clearing for cultivation and reduced river flow.

The basin is also rich in various wild fruits and vegetables that are used by many households for food (see Table 4.12 for some examples). These include fruits and vegetables which grow near the river banks and floating aquatic plants. Wild vegetables are mainly used during the dry season, and the wetter areas of the basin are able to supply these foods. Food plants tend to be harvested more in areas where there is little access to markets or shops. However, the availability of food plants is also threatened by increased cultivation and over harvesting from the increased population in the basin.

Table 4.12 Local names of medicinal and food plants harvested from aquatic habitats in the Pangani Basin, based on focus group discussions.

| | | Food Plants | |
|---|---|---|---|
| **Zone** | **Medicinal Plant** | **Fruits** | **Vegetables** |
| E. Highlands | *Mbwawa*<br>*Mtango*<br>*Mkuyu*<br>*Mtundutwa*<br>*Msosokwe*<br>*Mvule*<br>*Ndulele*<br>*Mayungingi* | *Mzambarau*<br>*Mpera*<br>*Mikukuma*<br>*Mavungo*<br>*Matuberi*<br>*Mkuyu* | *Mnavu*<br>*Mgagani*<br>*Mbuluja*<br>*Bondela* |
| Pangani Kirua | *Bwakabwaka*<br>*Mdudu*<br>*Mzera*<br>*Mjarato*<br>*Usigisi*<br>*Kongo*<br>*Mkuvukuvu* | *Makoche*<br>*Makwaju*<br>*Msala*<br><br>*Maungoungo*<br>*Matonga*<br>*Mshihwe* | *Magimbi*<br>*Horojo*<br>*Kisegeyu*<br>*Mnavu*<br>*Bwebwe*<br>*Mkochwe* |
| Mesic Lowlands | *Mvugunya*<br>*Ziya*<br>*Mshasha*<br>*Chatendee*<br>*Rumbizi*<br>*Kilemela kuka* | *Msambia*<br>*Kwingwina*<br>*Kungwina*<br>*Sambia* | *Mchunga*<br>*Mkoswe*<br>*Mngaa*<br>*Mnavu*<br>*Tarata*<br>*Sangale*<br>*Mkochwe*<br>*Zinge*<br>*Mkochwe*<br>*Bwebwe* |
| Estuary | *Makoka*<br>*Mtorilo*<br>*Mtula*<br>*Mnyonyo*<br>*Mswaki*<br>*Mhunga*<br>*Kivumbasi*<br>*Mdaha* | *Mtorilo*<br>*Mkuyu*<br>*Sambia*<br>*Kindu*<br>*Matufaa*<br>*Makoma*<br>*Kunazi*<br>*Mikungu* | *Mchunga*<br>*Mnavu* |

Households harvested wild foods in the form of fruits or vegetables, and wild medicines in the form of bark, roots, leaves or fruits. These are collected and sold in

a variety of ways, such as handfuls, bundles and bags. Based on the value of these different units, the overall gross value of these was estimated to be in the order of Tshs 12 000 to 22 000 in most areas, but was as high as Tshs 52 000 in the Kirua area, which is one of the more remote areas where people are likely to be more dependent on wild resources.

It could not be ascertained how much of this value 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 4.13 Value of wild foods and medicines collected by user households in different parts of the basin (Tshs per year)

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| Wild foods | 11 787 | 15 473 | 17 582 | 27 705 | 10 384 | 7 233 |
| Wild medicines | 4 977 | 6 478 | 2 733 | 24 403 | 6 961 | 4 511 |
| Total | 16 764 | 21 951 | 20 315 | 52 108 | 17 344 | 11 744 |

### *4.3.4 Reeds, sedges, grasses and palms*

Reeds (mainly *Phragmites* spp), are used mainly for the construction of temporary structures, but also in house construction and for making doors. Reed harvesting is most prevalent in the Lakes and Pangani-Kirua zones, where they are extremely common in the wetlands as well as along the rivers and canals (Table 4.14).

Bulrushes (*Typha* sp.), papyrus (*Cyperus papyrus*) and grasses are used mainly for thatching. The main material used for thatching in most of the basin areas is a grass (*ngage*, priced at Tshs 500 per bundle throughout the basin), but bulrush leaves (*makuruwila*), *ndulu, mainde* and *nguji* (species unknown) were also named as thatching materials. In the estuary zone, thatching is mainly made from coconut palm leaves. A normal house of two rooms requires about 20 – 50 bundles of *ngage* or about 70 bundles of *makuruwila*. The latter is an inferior thatching material which has to be replaced every six months or so.

*Makuruwila* is almost exclusively harvested in the lake zone (Table 4.14). Papyrus tends to be found in more permanently flooded wetland areas, and was only harvested in the Kirua Swamp area, where it occurs along the Pangani River (Table 4.14).

Very few of the reeds, papyrus and bulrushes harvested are sold (Table 4.14).

Table 4.14 Value of reeds, papyrus and bulrushes collected by user households in different parts of the basin

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| % households | 5% | 7% | 17% | 17% | 9% | 0% |
| **Reeds (*matete*)** | | | | | | |
| Harvested (bundles) | 27 | 8 | 39 | 30 | 10 | - |
| Sold (bundles) | 7 | - | - | - | - | - |
| Gross value | 28 350 | 5 678 | 27 085 | 7 078 | 6 700 | - |
| **Papyrus** | | | | | | |
| Harvested (bundles) | - | - | - | 9 | - | - |
| Sold (bundles) | - | - | - | 3 | - | - |
| Gross value | - | - | - | 2 800 | - | - |
| **Bulrushes *(makuruwila)*** | | | | | | |
| Harvested (bundles) | - | 6 | 32 | 2 | - | - |
| Sold (bundles) | - | - | - | - | - | - |
| Gross value | - | 2 778 | 15 846 | 1 167 | - | - |
| **Total gross value (Tshs per user hh)** | **28 350** | **8 456** | **42 931** | **11 044** | **6 700** | - |

Grasses were harvested throughout the basin, but mainly in the highland areas (Table 4.15). The harvest is almost entirely for home use. In addition to thatching, they were also harvested for other 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. In the Pangani-Kirua area, grasses were also used for fencing. In general, most grasses are harvested from upland habitats, except in the Kirua area, where most of the grass is likely to have come from the floodplain.

Table 4.15 Value of grass collected by user households in different parts of the basin

| Grass | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| % households | 14% | 20% | 19% | 16% | 44% | 1% |
| Harvested (bundles) | 296 | 224 | 59 | 26 | 34 | 5 |
| Sold (bundles) | - | - | 4 | - | - | - |
| **Total gross value (Tshs per user hh)** | **128 172** | **22 408** | **16 323** | **6 871** | **10 277** | **1 500** |

Palms are largely associated with wetlands or floodplains in the Pangani River Basin. There are no palms in the higher altitude parts of 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, where they form an important harvest (Table 4.16).

Table 4.16 Value of palm leaves (wild species only) collected by user households in different parts of the basin

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| % households | | | | | | |
| ***Phoenix* leaves (ukindu)** | | | | | | |
| Harvested (bundles) | 0.2 | 6.2 | 0.04 | 5 | 13 | 30 |
| Sold (bundles) | - | - | - | 4 | 3 | 1 |
| Gross value | 575 | 18 180 | 114 | 5 443 | 7 156 | 127 327 |
| ***Hyphaene* leaves (mikoche, milala, miaa)** | | | | | | |
| Harvested (bundles) | 7 | 3 | - | - | 10 | 17 |
| Sold (bundles) | 4 | - | - | - | 1 | - |
| Gross value | 4 541 | 2 474 | 37 | 30 | 38 594 | 4 967 |
| **Total gross value (Tshs per user hh)** | **120 312** | **36 211** | **33 574** | **11 147** | **46 727** | **132 294** |

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.

As for the other plant resources described above, most of the palm leaves are harvested mainly for home consumption, with a very small proportion being sold (Table 4.16). However, these resources are also used as inputs into the production of crafts and other household items. According to focus groups, the main types of plants used for handcrafts in the basin include *milala* (*mikoche*), *malulul*, *malumba*, *mikindu*, *majila* and *makumbi*. Reeds are used to make doors and mats, but these are relatively rare. Most mats, baskets and ropes are made with palm leaves. Each type of product requires 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. While *ukindu* mats sell for about Tshs 2 000 – 5 000 in the village markets, they fetch about Tsh15 000 – 20 000 in urban market centers.

Products that were not mentioned in the household surveys but which are possibly also made include *ukindu* hats, ornaments and sleeping bags. 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 modest, but not insignificant at the coast (Table 4.17).

Users in the focus group discussions generally felt that the availability of palms was declining. This was a particular concern since they are important for supporting women's livelihoods throughout the basin.

Table 4.17 Value added to palm leaves by making products, giving average number of products made per producer household, and overall average income from these activities to producer households in each area.

| Made from | Product | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Low-lands | Estuary |
|---|---|---|---|---|---|---|---|
| % households making products | | 8% | 6% | 8% | 11% | 34% | 31% |
| Reeds | Doors | - | - | - | 5 | - | - |
| *Hyphaene* | Baskets | 37 | - | - | - | 2 | - |
| *Phoenix* | Baskets | - | 1 | - | 47 | 0 | 2 |
| *Hyphaene* | Mats (*vitanga*) | 1 | 1 | - | - | 0 | 0 |
| *Phoenix* | Mats (*mikeka*) | 0 | 10 | 1 | 3 | 1 | 3 |
| *Phoenix* | Praying mats (*miswala*) | - | - | - | - | - | 2 |
| *Hyphaene* | Brooms | 334 | 11 | 12 | 10 | 163 | 30 |
| *Phoenix* | Covers | - | - | - | - | 0 | 3 |
| *Hyphaene* | Drying mats (*majamvi*) | 0 | - | - | 1 | 2 | 3 |
| *Phoenix* | Fans | - | - | - | - | 0 | 15 |
| *Hyphaene* | Ropes | - | - | - | - | 2 | - |
| **Total gross value (Tshs per user hh)** | | **19 935** | **7 342** | **3 149** | **45 917** | **21 354** | **66 070** |
| Total cash income | | **18 625** | **3 375** | **-** | **15 100** | **17 068** | **44 599** |

### *4.3.5 Woody resources: timber, poles, firewood and charcoal*

Households make use of various upland and wetland habitats for sourcing timber, poles and firewood, and for charcoal production. Throughout the basin, however, households maintained that access to these types of resources was limited, mainly because of the fact that areas in and around villages are largely cultivated, and natural habitats are generally a distance away.

In general, the use of woody resources, apart from timber, is relatively consistent across the basin. River systems do not make a very significant contribution to household use of these resources, and environmental conservation measures limit households from using riparian woodlands. Nevertheless, the riparian zones are often corridors of natural vegetation among developed lands, and can be important source areas for these resources. According to focus groups in this study, some of the utilised species found along rivers include *nyasati, mvie* and *mgunga maji* in the highlands, and *msaiti*, *makongodeka*, *mkole*, *mkungwine*, *mkuyu*, *mgunga*, *mwerera*, *mkongoi* and *mtunda* in the lowlands.

#### *4.3.5.1 Timber*

Only a small proportion of households harvest timber throughout most of the basin apart from the northern highlands, where 18% of households engaged in this activity. Average production by producer households was also highest in this zone, which has the most access to forest resources. None of the timber production is from mangroves.

A small proportion of households produce wooden products, this activity being most important in the northern highlands, and also at the estuary. These products are mainly a variety of items of furniture.

Table 4.18 Percentage households engaged in timber production, and the production and income per producer household

| Timber | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| % households | 18% | 2% | 0% | 2% | 0% | 2% |
| Production per user hh (pieces) | 127 | 75 | - | 44 | - | 4 |
| **Gross value per user hh (Tshs)** | **177 000** | **90 000** | | **120 100** | | **14 000** |

Table 4.19 Percentage households engaged in production of wood products, and the production and income per producer household

| Wood products | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| % households | 5% | 1% | 0% | 4% | 0% | 3% |
| Production per user hh (pieces) | 119 | 20 | | 9 | | 154 |
| **Gross value per user hh (Tshs)** | **1 831 000** | **240 042** | | **91 100** | | **1 063 333** |

*4.3.5.2 Poles*

About a third of households harvest poles in any one year, mostly for use in construction of their own houses. Similar proportions of households are engaged in collecting thin poles (*fito*), since these go hand in hand with poles in the construction of houses. Poles generate substantial value to households of up to Tshs 2 million per household. Whereas no timber is harvested from mangroves, about 8% of pole harvesting in the estuary area was from mangroves, although a previous study suggested this figure is over 20% (Turpie *et al.* 2003).

Table 4.20 Percentage households engaged in pole harvesting, and the production and income per user household

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| **Poles** | | | | | | |
| % households | 16% | 24% | 31% | 38% | 32% | 24% |
| Production per user hh (poles) | 243 | 101 | 46 | 580 | 67 | 433 |
| **Gross value per user hh (Tshs)** | **79 243** | **20 637** | **9 341** | **109 478** | **10 888** | **70 954** |
| % mangroves | 0 | 0 | 0 | 0 | 0 | 8 |
| **Thin poles (*fito*)** | | | | | | |
| % households | 20% | 24% | 39% | 36% | 29% | 18% |
| Production per user hh (bundles) | 72 | 27 | 42 | 43 | 16 | 21 |
| **Gross value per user hh (Tshs)** | **21 667** | **13 681** | **20 850** | **32 526** | **11 875** | **25 992** |
| % mangroves | 0 | 0 | 0 | 0 | 0 | 9 |

*4.3.5.3 Firewood and charcoal*

A large proportion of households harvest firewood, since this is the main source of fuel for rural households. A headload of firewood lasts 2 to 3 days. Households harvest about 100 – 165 headloads of firewood per year, most of which is used for home consumption. Indeed, the market value of firewood is very low and it is seldom traded. Charcoal production is a relatively specialised activity, carried out by only a small proportion of households. Those households can generate substantial revenues, however. In particular some fishers in the lake areas claimed that charcoal production was an important secondary activity when fishing was poor.

Table 4.21 Percentage households engaged in firewood harvesting and charcoal production, and the production and income per user/producer household

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| **Firewood** | | | | | | |
| % households | 61% | 71% | 68% | 69% | 95% | 80% |
| Production per user hh (loads) | 165 | 154 | 102 | 156 | 97 | 113 |
| **Gross value per user hh (Tshs)** | **73 011** | **62 070** | **41 031** | **48 609** | **96 587** | **42 759** |
| % mangroves | 0 | 0 | 0 | 0 | 0 | 9 |
| **Charcoal** | | | | | | |
| % households | 3% | 2% | 3% | 3% | 1% | 4% |
| Production per user hh (bags) | 94 | 20 | 451 | 19 | 4 | 9 |
| **Gross value per user hh (Tshs)** | **139 613** | **39 000** | **902 000** | **19 250** | **12 000** | **11 917** |
| % mangroves | 0 | 0 | 0 | 0 | 0 | 0 |

In addition to household use of mangroves, there is considerable commercial use which is worth mentioning. Coastal Tanzania is rich in mangrove resources, and at least eight species are found in the study area. The total mangrove area in Pangani District is 1755.6 ha, containing 221 090 $m^3$, or 126 $m^3$ 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 (Turpie *et al.* 2003). About 95% of the district's harvest reportedly comes from the Pangani estuary. 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 Tshs 2500 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 4.22). 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 Tshs 2000/score, firewood at Tshs 3000/$m^3$ and ribs at Tshs 2500 each.

Table 4.22 Data from the Pangani District Office on the quantity and value of mangrove harvests (Turpie *et al.* 2003).

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

### *4.3.6 Honey*

A small proportion of households throughout the basin is engaged in honey production, with much of this production coming from hives, but a substantial proportion being harvested from the wild (Table 4.20). Honey production was most important in the highlands and in the Pangani-Kirua zone.

Table 4.23 Percentage households engaged in honey production, and the production and income per user/producer household

| Honey | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| % households | 4% | 1% | 1% | 9% | 3% | 1% |
| Production from hives (litres) | 63 | - | 4 | 52 | 1 | - |
| Amount harvested from wild (litres) | 3 | 60 | - | 7 | 1 | 40 |
| Gross value per user hh (Tshs) | 139 800 | 103 283 | 6 886 | 108 658 | 1 700 | 16 000 |

### *4.3.7 Salt*

In addition to harvesting mangroves themselves, the mangrove habitat also lends itself to salt making. Although salt making equipment was seen in operation in the mangrove area, and informal interviews conduced by Turpie *et al.* (2003) 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.

### *4.3.8 Reptiles, mammals and birds*

There is very little hunting activity by households in the basin, except in the lake zone where water birds are reportedly hunted on a reasonably large scale. Water birds hunted include various ducks, egrets and spoonbills. Wild animals are protected under the reserves and parks regulations, and can only be hunted under license. Most hunting activities are illegal and households are reluctant to divulge information. Furthermore, the culture of some households does not permit eating wild meat. Nevertheless, it was commonly remarked that the availability of wildlife for hunting was being negatively affected by changes in land use. For example, in Eastern

Highlands, people claimed that most animals had been forced to take refuge in the Mkomazi game reserve. A few small animals are hunted in the lowlands, especially during the dry season when they come to riparian areas for water.

Hunting was reported by fewer than 3% of households anywhere in the basin (Table 4.24). These are relatively low proportions compared with other regions, and are likely to be underestimates. A very small proportion of the hunting income was from aquatic fauna. However, a previous study estimated about 43% was from aquatic fauna in the Kirua Swamps (Turpie *et al.* 2003).

Table 4.24 Estimated income (Tshs per year) from hunting among hunting households in the study area.

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| **Hunting** | | | | | | |
| % households | 2% | 2% | 1% | 2% | 3% | 1% |
| **Gross value per hunting hh (Tshs)** | **245 667** | **157 000** | **2 000** | **2 000** | **10 500** | **312 000** |
| % from river system (waterbirds) | 0.1% | - | 100% | - | - | - |

### *4.3.9 Fish and crustaceans*

#### *4.3.9.1 Overview of the fisheries*

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 hitherto been quantified. Natural river 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. In 1970, this fishery supported 3 161 fishers, who landed 28 509 tonnes of fish between them. By 1983, there were 1 342 fishers, who managed to land just 2 430 tonnes of fish (Van den Bossche and Bernacsek, 1999). 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 Tshs 300/kg, the fishery has been estimated to be worth some Tshs 540 - 1500 million per year (Turpie *et al.* 2003). While some authors have suggested that the fishery has become overexploited, the relationships between water inflow, effort and yield have not been explored.

The fishery at Nyumba ya Mungu Dam is primarily a gillnet fishery, though lines are also important, including long-lines with multiple hooks. Gillnetting in the dam requires a license which costs Tshs 4000 per year. Anyone in possession of identification can obtain a license, and fishers come from all over the country. The only other regulation of the fishery is that there are closed areas, for example the wetland area where the river enters the dam. Women participate in the fishery not as

fishers but as processors, and also may own or co-own fishing gear that is used by men. People who own fishing gear allow others to use it in return for a half share of the value of the catch. The main fish caught in the NyM gillnet and line fisheries are tilapia (*perege*) and catfish (*kambale*). Three types of tilapia are caught – *pangani*, *zili* and *jipe*. The fishery is seasonal (Figure 4.6) and the number of fishers present at any time is reportedly proportional to the abundance of fish. Catches are highest from March to June.

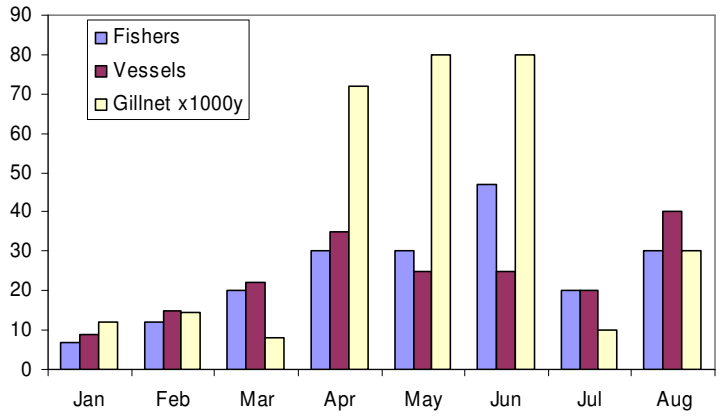


Figure 4.6 Fishing effort at Magadini, on Nyumba ya Mungu Dam during 2006. Supplied by Matthew Mapunda, village fishery officer. Magadini is one of 11 fishing centres around the lake.

Fishers based around Nyumba ya Mungu Dam also make use of the rivers that flow into the dam. Here, fishing takes place with traps, especially in the wet season (April to October), when the rivers are flowing more. Different designs of traps (e.g. made from lala palm leaf spines or larger traps made from branches) target different fish species. The most important species caught are catfish and *dagaa*, and the catfish are reportedly larger than those caught in the dam. Traditional fishing does not require a license.

Fish are sold to traders both fresh and dried. They are sold individually, based on size, rather than by weight. Tilapia are typically around 8cm and sell for Tshs 40. Catfish are typically about 15-40cm and priced at Tshs 1000 for 3.

At Nyumba ya Mungu, fishers claimed that there were many more fish 20 years ago, because there was more water in the dam, and also because the numbers of fishers then was less.

In the **eastern highlands**, there is a fishery associated with the Kalemawe dam in Ndungu village which supplies water for rice irrigation. The most common types of fish in this dam are *Dindila*, *Kambale* and *Dagaa*. According to focus groups, the dam provides about 60% of all fish catches in the village, the remaining 40% is obtained from the Yongoma river which drains into the Kalemawe dam. The fishery mainly involves local households and the main fishing methods are lines, nets and baskets.

**Lake Jipe** is a natural lake that supports an important fishery, attracting many fishers from all parts of the country. According to focus groups, the fishery is based mainly on *Perege, Kambale* and *Dagaa,* with *Perege* making up an estimated 95% of the total catch. During November to February and during April to July, catches are dominated by *Kambale* whereas they are dominated by *Perege* during August to October. *Dagaa* is caught throughout the year. The main types of fishing gear used are gillnets, lines and baskets. Fishing is done by men, while women handle the business side. While fishing contributes to food availability, it also serves as source of income to many households in the area. Some individuals rent fishing gear in order to generate income. For example, a canoe is rented to about Tshs15 000 per month or Tshs 500 per day. Alternatively, the user may pay a third of the cash received from the sale of fish. A large proportion of fishers (reportedly about 80%) use rented canoes. Fish catches, particularly of Kambale and Perege, have reportedly declined. Until recently, fishing activities on the Tanzanian side of the lake were halted due to low water and excessive growth of reeds (*Typha*) and papyrus which covered almost half of Lake Jipe's surface (Sarmett and Kamugisha 2002). This water situation has improved and fishing has resumed, but reeds remain a problem.

There is very little in the way of fishing in the **rivers in the highland areas**. While residents report that there may be a minor amount of fishing, there is almost none that takes place commercially. These rivers are also highly seasonal and probably support a low biomass of fish. Fishers based in the highland areas were usually found to be travelling to dams or lakes to fish.

Rivers appear to be moderately important for fishing in the lowland areas. the change in water flow to downstream aquatic areas has probably led to a decrease in fishery yields in these habitats. Indeed, residents of the **Kirua Swamp** area described a collapse of the fisheries in this area (Turpie *et al.* 2003). 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. All fishing in the Kirua Swamps now takes place in the river because the floodplain is dry.

In the **mesic lowlands** zone, fishing activity in the villages surveyed (Segera, Mazinde-Mhenza and Mkalamo) takes place in the Pangani river. The main species caught are *Perege*, *Kambale* and *Dagaa*. The fishing areas are not suitable for use of nets as they are destroyed by crocodiles, thus fishing is mainly by means of baskets and lines. Baskets are made locally using resources available to most of them. The availability of fish in this zone is seasonal, with better fishing during the wet season.

At, the **Pangani estuary** fishing is one of the major activities. Here catches are dominated by marine and estuarine species. Fish catches are highest in the high flow period. In addition to fish, fishers also concentrate prawns in the high flow season. During the low flow season the fishery is concentrated on crabs. Catches also include sharks, rays, octopus and squid, mainly from the marine environment. Fishing in the estuary takes place mainly from canoes, using gill nets, hand lines and traps. Crabs are caught using traps and kept in holding cages near the mouth before they are purchased by buyers. The estuary also serves as a harbour for sea-going fishing vessels (dhows).

The fisheries associated with the Pangani estuary were said to have virtually collapsed by 1996 (Turpie *et al.* 2003). A lively trading centre that mainly dealt in prawns and lobsters all but disappeared from Pangani Town. Past over-fishing may

have played a role in all cases, but water supply or quality could have been a major causal factor (PBWO/IUCN 2007).

However, fish business in the estuary has reportedly increased in recent years. There are currently ten small-scale fish traders, seven large scale traders and seven prawn traders. Average prices are shown in Table 4.25.

Table 4.25 Prices of prawns and fish in 2006 (Source: Pangani District, Fishery Office)

| Type | Price range (Tshs per kg) |
|---|---|
| King Prawns | 5,000 – 8,000 |
| Tiger Prawns | 2,000 – 3,000 |
| White Prawns | 1,500 – 2,000 |
| Other fishes | 1,000 - 1,200 |

Fish catches in Pangani district (which includes marine fisheries) have been in the order of 42 – 58 tonnes over the period 2002-5 (Table 4.26), worth about Tshs 11 million – 30 million. In 2005, there were a total of 552 fishers with a variety of gear, most of which is for marine fishing (Table 4.27). The number of fishers using the estuary, most of whom use gillnets, scoop nets, and handlines, is unknown.

Table 4.26 Fish catch in Pangani District for the Year 2002 to 2005

| Year | Total Catch (Kgs) | Catch Value (Tshs) |
|---|---|---|
| 2002 | 41 871 | 16 335 635/- |
| 2003 | 40 127 | 11 236 668/- |
| 2004 | 57 786 | 29 843 289/- |
| 2005 | 53 254 | 26 895 936/- |

**Source: Pangani District Fisheries Office**

Table 4.27 Fishing Gear in Pangani District in 2005

| Fishing gear | number | Fishing gear | number |
|---|---|---|---|
| Ringnets | 2 | Gillnets | 58 |
| Sharknet | 227 | Castnet | 7 |
| Traps | 556 | Scoopnet | 10 |
| Longlines | 42 | Sinia | 87 |
| H/lines | 390 | **Total** | **1,354** |

**Source: Fisheries office, Pangani District**

Although no long-term fisheries data are available in Pangani District, the fisheries officer felt that there may be a correlation between flow and catch, citing the fact that catches are bad in drought years (Turpie *et al.* 2003). The artisanal 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 (Figure 4.7). During 2002-3 recorded catches suggest an overall catch of 3 to 5 tons (Figure 4.7). These catches are small, and support the assertion that the fishery has suffered a major decline. However, these data were obtained by the fisheries department 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 (Turpie *et al.* 2003). The catch is bought by agents for a single company in Tanga, for about Tshs 5 000 – 8 000 per kg (Turpie *et al.* 2003), though there is also some black marketing to Kenya. The average price reported by households was much lower – approximately Tshs 2500, 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 Tshs 15 000 – 40 000 (Turpie *et al.* 2003).

Fish catches in Pangani estuary are reportedly about 150-200kg/month, year round (Turpie *et al.* 2003, based on fisheries data), which equates to 1.8 – 2.4 tonnes per year, apparently by the same fishers. These estimates are extremely small and conflict with the household survey results.

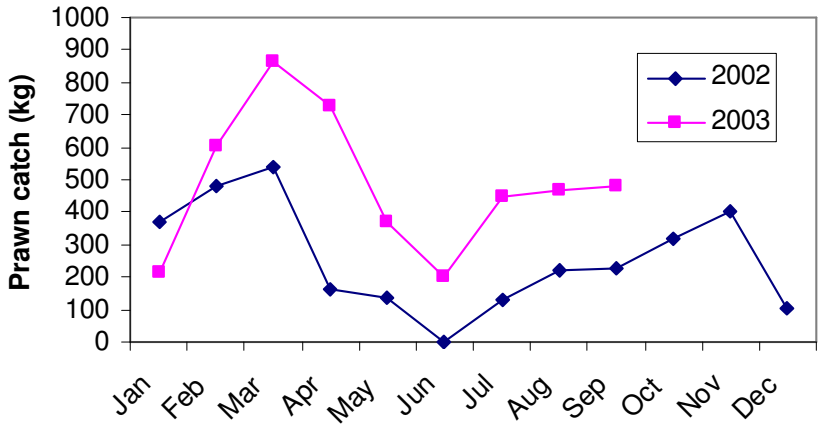


Figure 4.7 Prawn catch records in Pangani for 2002 and 2003. Source: Pangani District Office.

#### *4.3.9.2 Estimated fishing effort and catches*

Fishing is carried out by households throughout the basin, though it varies in importance among the different zones (Table 4.28). The proportion of households involved in fishing was highest at the lakes (48%) and estuary (24%), and 14-17% fished in the Pangani-Kirua and Lowland areas. However, only 4 – 6% of households fished in the highland areas. Fishing effort per fishing household was also highest at the lakes and estuary (Table 4.28). Fishers fishing in the lakes own considerable numbers of nets. Usually about ten 50-yard nets are sewn together to make a single gillnet. Ownership of canoes and traditional gear was also highest among the households at the lakes. Fishers were more likely to have boats at the Pangani estuary.

Table 4.28 Proportion of households involved in fishing, amount of effort and gear per fishing household.

| | N High-lands | E High-lands | Lakes | Pangani-Kirua | Low-lands | Pangani estuary |
|---|---|---|---|---|---|---|
| n | 165 | 126 | 75 | 105 | 79 | 109 |
| % of households | 4 | 6 | **53** | 17 | 14 | **25** |
| Average fishing days per fishing hh per year | 26.6 | 142.9 | 219.6 | 93.9 | 69.8 | 147.4 |
| Gear per fishing household: | | | | | | |
| Boats | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.4 |
| Canoes | 0.0 | 0.6 | 0.6 | 0.2 | 0.2 | 0.3 |
| Nets | 0.5 | 3.6 | 26.5 | 2.9 | 1.5 | 1.3 |
| Lines | 0.5 | 75.0* | 30.6 | 19.0 | 13.2 | 5.7 |
| Traditional gear | 0.3 | 1.0 | 43.1 | 1.6 | 0.8 | 1.7 |

About a third of the catches in the northern highlands and half of catches in the eastern highlands were derived from dams or lakes, and the remainder from rivers (Table 4.29). Around the lakes themselves, fishers claimed to obtain about 6% of their catches from rivers in the household survey. However, reported catches in the upper basin were very small compared to catches elsewhere. Almost all fishing in the Pangani-Kirua and Mesic Lowland areas took place in rivers, while at the estuary, about 10% of catches were reported to be from the sea (Table 4.29).

Table 4.29 Percentage contribution of different habitats to fishing in villages surveyed in four part of the study area.

| Data | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Lowlands | Estuary |
|---|---|---|---|---|---|---|
| Dam/lake | 33 | 50 | 94 | 6 | 0 | 0 |
| River/estuary | 67 | 50 | 6 | 94 | 100 | 90 |
| Sea | 0 | 0 | 0 | 0 | 0 | 10 |

Fish species targeted by households in the different areas are listed in Table 4.30, and their estimated percentage contribution to fish catches in the different areas are shown in Figure 4.8. Fish were identified as far as possible from the local names supplied by households and focus groups using Eccles (1992) and Bianchi (1985).

Catfish dominate catches in the rivers of the highlands and Pangani-Kirua, while tilapia (bream) are the dominant species caught in lakes (Figure 4.8). In the lowlands, catfish, *ngogogo* and labeos dominate catches. At the estuary, catches are dominated by crabs, as well as by paramamba and sea catfishes, and prawns (Figure 4.8). Since the survey was done in the low flow season, when crabs are caught, rather than the high flow season when prawns are caught, it is possible that the proportion of prawns in the annual catch is larger than was estimated here.

Fishing households caught an estimated average of almost 4 tonnes per annum in the Lakes area, and over 1 tonne per annum in the E Highlands, where fishers made use of a large dam. Catches were at a subsistence level in the Kirua and lowland areas and somewhat higher at the estuary. Catches were negligible in the Northern Highlands (Table 4.31).

Table 4.30 Fish species named by respondents in the household survey and focus groups.

| Local name | Scientific name | English name | Size | Hab |
|---|---|---|---|---|
| Perege | *Oreochromis pangani, O. jipe* | Bream/tilapia | | Freshwater |
| Polandi | *?* | ? Bream? | | Freshwater |
| Kuyu | *Barbus sp.** | | | Freshwater |
| Ningu | *Labeo sp.* | Labeos | Ca. 30cm | Freshwater |
| Mkunga | *Anguilla spp.* | Eels | 80 – 120 cm | Freshwater |
| Ngege | *Oreochromis esculentis* | | 37cm | Freshwater |
| Parata | *?* | | | Freshwater |
| Dindira | *?* | | | Freshwater |
| Shaba | *?* | | | Freshwater |
| Ngogogo | *?* | a barbed catfish | | Freshwater |
| Ndomondo | *?* | | | Freshwater |
| Buju spp | *?* | | | Freshwater |
| Bunju | *?* | | | Freshwater |
| Ndomondomo | *?* | | | Freshwater |
| Kambale | *Clarias gariepinus* | Catfish | | Freshwater/brack |
| Ngogo | *Plotosus lineatus* | Striped eel catfish | 30cm | Freshwater/brack |
| Hongwe | *Arius spp.* | Sea catfishes | | Marine/estuary |
| Paramamba | *?* | | | Marine/estuary |
| Ndedi/Ndadi | *?* | | | Marine/estuary |
| Dagaa | *Rhabdalestes leleupi* | | 8cm | |
| Chewa (Ng'ombe) | *Epinephelus spp.* | | 65-100cm | Marine/estuary |
| Changu | *Lutjanus spp.* | Snappers | Common to 35-35cm | Marine/estuary |
| Kolekole | *Alectis spp. & Carangoides spp.* | Pompano, trevally spp. | | Marine/estuary |
| Parata | *?* | | | Marine/estuary |
| Ukamba | *?* | | | Marine/estuary |
| Kaa | - | Crabs | | Marine/estuary |
| Chazanda | *Lutjanus argentimaculatus* | Mangrove red snapper | Max 120, common to 80cm | Marine/estuary |
| Chafi | *Siganus canaliculatus or S. luridus* | Spinefoots | Max 30, common to 20cm | Marine/estuary |
| Kerengwa | *?* | | | Marine/estuary |
| Chije | *Terapon puta* | Smallscaled terapon | Max 15cm, common to 12cm | Marine/estuary |
| Mahogwe | *?* | | | Marine/estuary |
| Mzia | *Sphyraena spp.* | barracudas | Max 45 – 180 | Marine/estuary |
| Mikonge | *Chirocentrus spp.* | Wolf-herrings | Max 100, common to 60 | Marine/estuary |
| Tambanji | *Sillago spp.* | Sillagos | Max 20 – 36, common 12-20 | Marine/estuary |
| Koe (recorded as Kao) | *Muraenesox yamaguchiensis* | Common pike conger | Max 180, common to 150 | Marine/estuary |
| Mafuni | *?* | | | Marine/estuary |
| Kenegwa | *?* | | | Marine/estuary |
| Dimbwara | *?* | | | Marine/estuary |
| Makaji | *?* | | | Marine/estuary |
| Kamba weupe | *?* | | | Marine/estuary |

* should be *B. altianalis* but this is only found in L. Victoria basin, but likely the name is being applied to another Barbus.

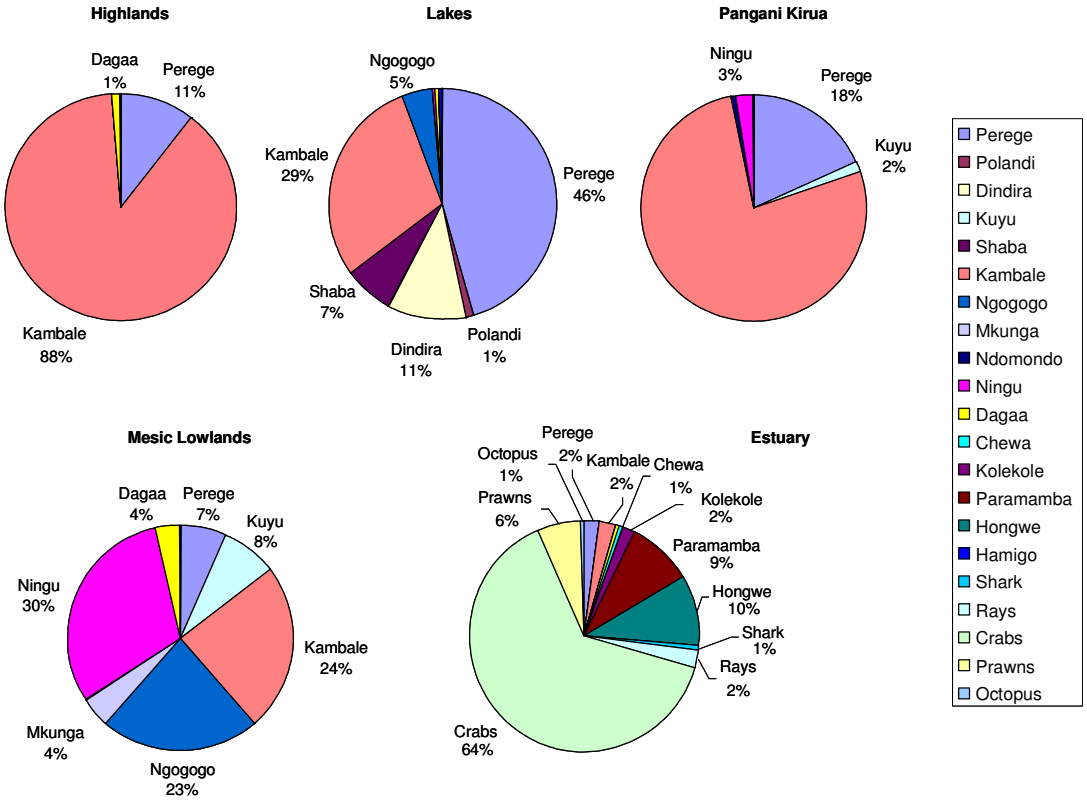


Figure 4.8 Estimated composition of catches by weight in different parts of the basin, based on household survey data.

Table 4.31 Reported catches (in kg per year) and average income per fishing household.

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic Low-lands | Estuary |
|---|---|---|---|---|---|---|
| % fishing hh | 4 | 6 | **53** | 17 | 14 | **25** |
| Catch per fishing household (kg): | | | | | | |
| Fish | 1.3 | 1254.6 | 3984.2 | 480.0 | 256.1 | 565.7 |
| Shark | | | | | | 5.8 |
| Rays | | | | | | 20.8 |
| Crab | | | | | | 548.1 |
| Prawns | | | | | | 50.8 |
| Octopus | | | | | | 5.8 |
| **Gross value** | **933** | **1 029 369** | **1 040 349** | **165 995** | **125 738** | **772 427** |
| **Cash income** | **-** | **951 095** | **810 804** | **53 198** | **102 660** | **685 033** |

* two hh each had up to 500 lines, likely that they travel elsewhere to fish, probably NyM.

## 4.4 Summary of natural resource use value

On average, households derive incomes of between Tshs 140 000 and Tshs 630 000 from the use of natural resources (Table 4.32). Income from aquatic ecosystem resources ranges from under Tshs 20 000 in the northern highlands, to Tshs 560 000 in the lakes area. Fisheries are the major source of income from aquatic resources, as can be seen from the relatively large contribution of aquatic resources in the lakes, estuary and eastern highland zones. The value of plants such as reeds and sedges is small, but this belies the degree to which they are used. Their low value is due to their relative abundance. The value of mangroves and waterfowl hunting is probably underestimated because of the legality of use.

Table 4.32 Overall average value per household derived from harvesting of natural resources (including value added in processing), averaged across user and non-user households, and the proportion of this value that is attributed to the river systems

| | **N High-lands** | **E High-lands** | **Lakes** | **Pangani Kirua** | **Mesic Lowlands** | **Estuary** |
|---|---|---|---|---|---|---|
| Fishing | 37 | 65 357 | 554 853 | 28 456 | 17 508 | 191 335 |
| Timber & wood products | 130 986 | 3 334 | - | 5 758 | - | 29 523 |
| Poles & withies | 16 820 | 8 171 | 10 927 | 53 477 | 6 903 | 21 694 |
| Firewood & charcoal | 48 922 | 44 955 | 51 955 | 33 882 | 91 848 | 34 566 |
| Grasses | 17 866 | 4 446 | 3 047 | 1 113 | 4 553 | 14 |
| Reeds, sedges | 1 546 | 604 | 7 441 | 1 893 | 594 | - |
| Palms & products | 2 714 | 2 343 | 279 | 7 854 | 35 095 | 34 554 |
| Food and medicinal plants | 4 395 | 8 711 | 4 942 | 16 377 | 8 343 | 3 556 |
| Honey and hunting | 10 398 | 3 312 | 118 | 9 352 | 309 | 3 009 |
| **TOTAL** | **233 685** | **141 231** | **633 561** | **158 161** | **165 152** | **318 250** |
| **Total from uplands** | 219 044 | 70 747 | 69 594 | 114 577 | 118 843 | 84 677 |
| **Total from river systems** | **14 642** | **70 485** | **563 966** | **43 584** | **46 309** | **233 574** |
| **% from river systems** | 6% | 50% | 89% | 28% | 28% | 73% |

## 4.5 Contribution of river system resources to household livelihoods

The contribution of aquatic ecosystem resources to household livelihoods was considered in two ways. Firstly, households were asked to estimate the relative contribution of different sources of income to their overall income, taking both home consumption and production for sale into account. Secondly, the relative contribution was estimated using empirical data collected in the household surveys. Thus perceived income is compared with estimated income, below.

Households generally perceived crops and livestock to be the most important sources of income to households, when both subsistence and cash income values were considered (Figure 4.9). Livestock were also considered to be highly important in all areas apart from the estuary, where most households only have domestic fowl. It is interesting that even in the lakes and estuary zones, crops were perceived to be more important than fish as a source of income. Natural systems were perceived to provide about 16 – 20% of income in the highland areas and 21 – 25% of income in the lowland areas. This proportion is 37% in the lakes area because of the high perceived value of fishing, and 28% at the estuary (Figure 4.9).

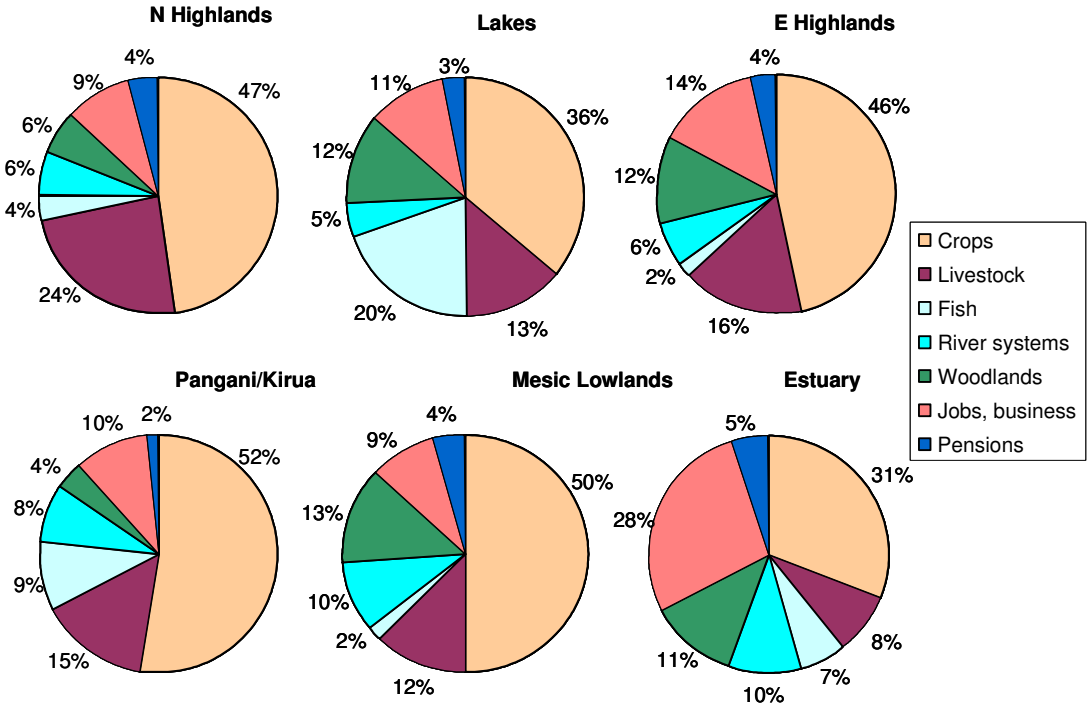


Figure 4.9 Perceived relative contribution of different sources of subsistence and cash income to household livelihoods, based on survey data (n = 659)

The estimated proportional contribution of different sources of income to household livelihoods, based on empirical data generated in this study, is shown in Figure 4.10. The proportion of household income from jobs is congruent with the average incomes reported above, with this proportion being perceived to be highest in the estuary zone. The main difference between the perceived and estimated proportions was that crops were consistently estimated to be a higher proportion of income, and natural resources a lower proportion than that perceived by households. According to the estimated values, river systems (including fish) provide 0.5 - 6% of income in the highlands and 3 – 6% of income in the lowlands. They provide about 35% and 13% of income, in the lake and estuary zones, respectively.

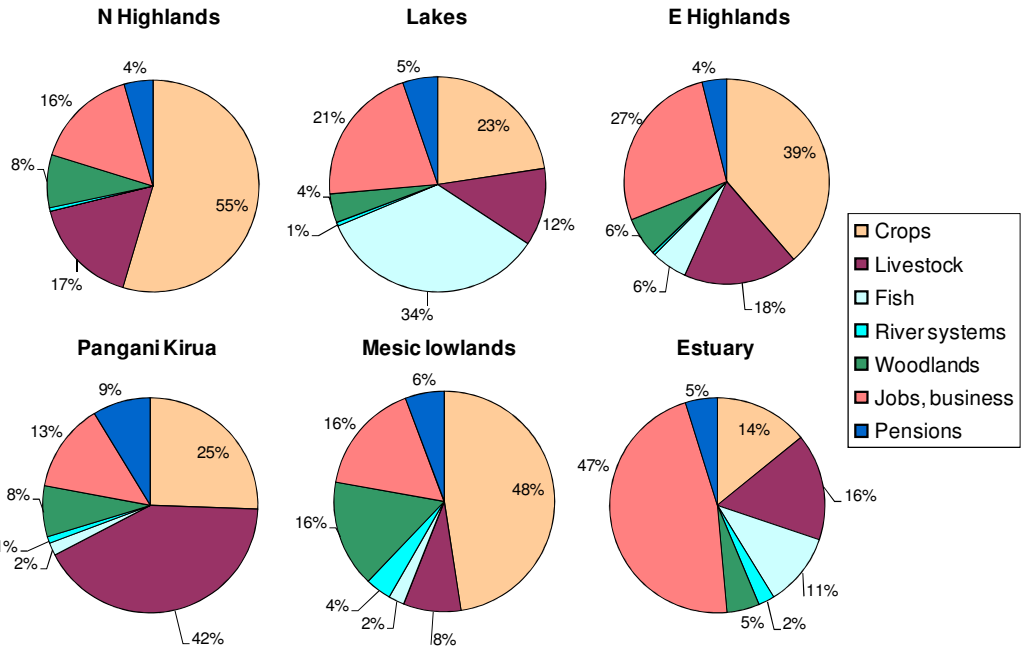


Figure 4.10 Estimated relative contribution of different sources of subsistence and cash income to household livelihoods, based on household data on production (n = 659)

The fact that river resources were perceived to be more important than is evident from the empirical data could be for three possible reasons. Firstly, it could be due to lack of accuracy, both in terms of recall of production and in terms of the quantification of perception of value. Secondly, it could be due to the fact that people are mindful of the risk-spreading function of natural resources and that they are more important in some years than others. Thirdly, it could be because the market value of these resources (upon which the estimates are made) does not reflect their value in terms of their replacement cost if those resources were not available. For example, thatching materials may be abundant and thus have low market value, but the next alternative (e.g. tin) may be far more expensive.

## 4.6 Aggregate value of river system resources

In total, some 75% of the basin's population is estimated to reside within 10 km of the main rivers. About 47% reside within 5 km (Table 4.33). Thus a high proportion of the population is within reasonably close proximity to rivers in the basin. The estimated number of households within 5 and 10 km of rivers was used to extrapolate the household level results in order to estimate the total value of aquatic resources in the basin (Table 4.34).

The total value of aquatic ecosystem resources harvested in the basin was estimated to be between Tshs 8.1 billion and Tshs 11.9 billion per year (US$6.5 million – 9.5 million). Just over 60% of this value (Tshs 5.0 billion – 7.3 billion) was attributed to fishing.

Table 4.33 Rural population of the different zones in the Pangani River basin and the estimated proportion of those populations living within 5 km and 10 km of major rivers.

| Rural population | N High-lands | E High-lands | Lakes | Pang-ani Kirua | Mesic Low-lands + coast | Est-uary | South-west arid | W arid |
|---|---|---|---|---|---|---|---|---|
| People '000s | 1 467 | 745 | 11 | 37 | 377 | 8 | 90 | 179 |
| Households | 236 431 | 112 336 | 1 662 | 5 459 | 57 411 | 1 616 | 14 364 | 28 586 |
| % within 5 km | 39% | 38% | 100% | 100% | 83% | 100% | 25% | 75% |
| % within 10 km | 71% | 68% | 100% | 100% | 96% | 100% | 100% | 75% |
| Hh within 5 km | 91 450 | 43 206 | 1 662 | 5 459 | 47 427 | 1 616 | 3 591 | 21 440 |
| Hh within 10 km | 167 286 | 76 331 | 1 662 | 5 459 | 54 915 | 1 616 | 14 364 | 21 440 |

Table 4.34 Lower and upper bound estimates of the value of aquatic ecosystem resources to households in different parts of the Pangani River Basin in Tshs millions

| | N High-lands | E High-lands | Lakes | Pangani Kirua | Mesic low-lands +coast | Estuary | TOTAL Tshs | TOTAL US$ |
|---|---|---|---|---|---|---|---|---|
| Fishing | 3.4 | 2 823.8 | 922.1 | 155.3 | 830.3 | 309.1 | 5 044.2 | 4.04 |
| | 6.2 | 4 988.7 | 922.1 | 155.3 | 961.4 | 309.1 | 7 343.0 | 5.87 |
| Timber & wood products | 598.9 | 7.2 | - | 1.6 | - | 7.2 | 614.9 | 0.49 |
| | 1 095.6 | 12.7 | - | 1.6 | - | 7.2 | 1 117.1 | 0.89 |
| Poles & withies | 76.9 | 17.7 | 0.9 | 14.6 | 16.4 | 8.8 | 135.2 | 0.11 |
| | 140.7 | 31.2 | 0.9 | 14.6 | 19.0 | 8.8 | 215.1 | 0.17 |
| Firewood & charcoal | - | - | - | - | - | 8.4 | 8.4 | 0.01 |
| Grasses | 81.7 | 9.6 | 0.3 | 0.3 | 10.8 | 0.0 | 102.7 | 0.08 |
| | 149.4 | 17.0 | 0.3 | 0.3 | 12.5 | 0.0 | 179.5 | 0.14 |
| Reeds, sedges | 141.4 | 26.1 | 12.4 | 10.3 | 28.2 | - | 218.4 | 0.17 |
| | 258.7 | 46.1 | 12.4 | 10.3 | 32.6 | - | 360.1 | 0.29 |
| Palms & products | 186.1 | 75.9 | 0.3 | 32.2 | 1 248.3 | 41.9 | 1 584.8 | 1.27 |
| | 340.5 | 134.1 | 0.3 | 32.2 | 1 445.5 | 41.9 | 1 994.5 | 1.60 |
| Food and medicinal plants | 60.3 | 56.5 | 1.2 | 13.4 | 59.4 | 0.9 | 191.6 | 0.15 |
| | 110.3 | 99.7 | 1.2 | 13.4 | 68.7 | 0.9 | 294.3 | 0.24 |
| Honey and hunting | 190.2 | 28.6 | 0.0 | 10.2 | 2.9 | 1.2 | 233.2 | 0.19 |
| | 347.9 | 50.6 | 0.0 | 10.2 | 3.4 | 1.2 | 413.3 | 0.33 |
| TOTAL | 1 862.2 | 3 045.4 | 937.3 | 237.9 | 2 196.3 | 377.4 | 8 133.2 | 6.51 |
| | 3 406.4 | 5 380.1 | 937.3 | 237.9 | 2 543.1 | 377.4 | 11 925.1 | 9.54 |
| **Total US$ (millions)** | **1.07** | **2.44** | **0.75** | **0.19** | **1.76** | **0.30** | | |
| | **1.96** | **4.30** | **0.75** | **0.19** | **2.03** | **0.30** | | |

# 5 DISCUSSION

## 5.1 Quality and reliability of the survey data

This study relied mainly on data collected in household surveys throughout the basin. Although the overall sample size was high, when disaggregated by region, the sample sizes were only modest. However, this was considered adequate because of the relatively similar lifestyle of the respondents in most cases. The enumerators underwent substantial training, and many were highly-trained professionals. However, there is always some error in obtaining this sort of quantitative data in a once-off survey, mainly because of the difficulties of recalling the details of an activity over a long period. In cases where few households engage in an activity, the results are likely to be less reliable than in cases where an activity is common. Nevertheless, there are no comparative estimates of resource use or agricultural activities for the whole basin area, and thus the estimates produced in this study can be seen as first estimates which can be refined over time.

This study was limited to the estimation of average gross incomes from different activities. These figures will need to be converted to marginal net incomes for the analysis of trade-offs (discussed below), based on assumptions about costs and changes in output in relation to changes in water availability or environmental quality.

It is important to note that the surveyed population comprised only those people living in rural areas close to rivers, lakes, wetlands or the estuary. Data have only been extrapolated to this subset of the population. It does not include consideration of urban residents that may also use rivers for extracting resources or for recreational or other purposes, or other users of water.

## 5.2 Degree of dependence on water and aquatic ecosystem resources

The majority of households in the basin have a strong relationship with aquatic ecosystems, both for water supply and the supply of natural resources. Rural households in the basin rely heavily on small-scale agriculture for subsistence and income, and this study has shown that the availability of irrigation water can more than double the gross income earned per unit area. The extra output due to irrigation is particularly high in the highland areas where agricultural income per unit area is already much higher than elsewhere in the basin. However, as far as subsistence livelihoods go, the extra production is more important to households in the lowlands, where productivity and hence agricultural income is somewhat lower. Land for small scale agriculture is clearly in short supply, since there is very little crop rotation in the basin, but this study suggests that irrigation could substantially raise the productivity of the existing land, increasing both food and cash crop production. Since crop production forms a large part of household income, it follows that water supply is a crucial issue to households. Livestock production is also an extremely important activity throughout the basin. Water is a limiting resource for this activity, and maintaining instream water supplies or alternative sources is clearly also a high priority for rural households.

In addition to agricultural production, a large proportion of households make use of a variety of resources from both upland and aquatic ecosystems in any one year. Many of these resources are harvested for subsistence use, such as building poles and wild foods, but some are also harvested over and above household needs in order to generate cash incomes. The same is true of the various products that are

made from these resources. In particular, fishing is an important source of cash income to households. Very few households specialize entirely in the collection of one resource or another, however. These activities serve to spread risks. Since the majority of income is derived from agriculture and natural resource use, households are extremely vulnerable to catastrophes such as drought and livestock diseases. For very poor households, natural resources may become the key to survival in years when crops fail, for example. Alternatively, they may provide cash income or sustenance during famine periods, for example, before harvesting. In addition to performing a risk spreading function, natural resources also provide a safety-net function. For example, fisheries commonly provide a fall-back option for families that have suffered shocks such as loss of employment or death of a bread-winner. This function is far more difficult to demonstrate in a study such as this, but is a significant function that would otherwise have to be performed with social-welfare hand-outs. It is interesting to note that the gross value of aquatic ecosystem resource use alone generally exceeds the value of pensions received by households.

## 5.3 The effect of changes in ecosystem quality on household income

It is evident that the value provided by aquatic resources has already been substantially eroded. Rivers in the highlands are no longer perennial, and fish have reportedly disappeared from these. The Kirua swamp has been reduced to a fraction of its former size due to cessation of flooding, and with it has been lost a valuable fishery, leaving households in the area even more vulnerable and poor than they were before. Fishers at the Pangani estuary report that catches there have declined, and some believe this is due to reduction in freshwater inputs. Even at Nyumba ya Mungu Dam, which largely replaced a natural wetland, fisheries have reportedly declined due to low water levels as well as over-fishing. At Lake Jipe, the fishery was all but exterminated by anthropogenically increased nutrient levels leading to encroachment of the lake by emergent vegetation. Thus the capacity of the aquatic systems in the basin to provide value to households has been compromised. It follows that restoration of these habitats could provide a significant social service to poor rural households in the basin, but this would have to be evaluated against the impacts of removing that water from other productive uses.

## 5.4 The way forward: analysing the trade-offs in water allocation

The Pangani Basin is a water-stressed system in which conflict is rife over the allocation and use of water and aquatic ecosystem resources. Under the new water policy, water in the basin will have to be allocated taking economic efficiency, ecological sustainability and social equity into account. While there is enormous demand for the water resources of the basin, the ecological and social impacts of its allocation need to be considered very seriously. Water which is allocated to extractive uses such as agriculture and industry generates substantial returns in terms of value added to the regional and national economy. However, these allocations take water from the ecosystem which has an effect on its functioning and quality, and hence on its ability to supply ecosystem goods such as fish, and ecosystem services such as the dilution of wastes. One of the social impacts that has to be considered is the impact on the livelihoods of people that live in proximity to the affected rivers.

It should be noted that while there is a trade-off between the values generated by water use and the availability of aquatic ecosystem resources, this trade-off can be analysed from the perspective of local livelihoods or the economy. It is not a case of

water is good for the economy and resources for local livelihoods. Both water and resources contribute value at both of these scales (Figure 5.1).

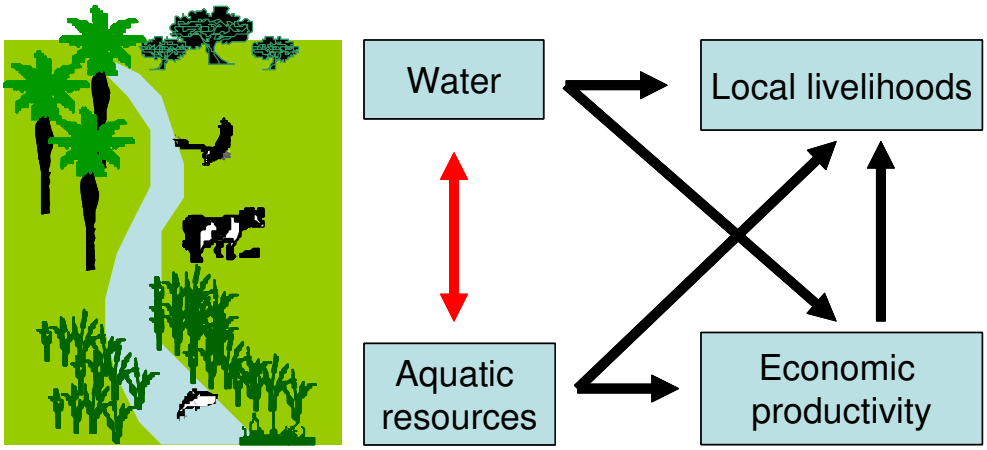


Figure 5.1 Diagram illustrating the trade-off between water extraction and the supply of aquatic resources, and the fact that both sides of the trade-off have implications for both local livelihoods and the economy.

The findings of this study will be used in the development of a flow assessment tool that will be used to estimate the impacts of different water allocation scenarios on rural livelihoods and the economy. However, the limitations of this and preceding studies will mean that the analysis of trade-offs will be limited in some respects. Future research that should be considered to fill important data gaps includes:

1. Estimation of the elasticity of demand for irrigation water. The way in which farmers respond to a change in the availability and price of water is crucial in understanding the implications of a change in water allocation.

2. Estimation of the value of ecosystem services provided by the aquatic ecosystems of the basin in relation to flow. Apart from the ecosystem goods considered in this study, 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 have not been investigated in this or the broader study. The supply of all of these goods and services is affected by the quantity and quality of runoff in the catchment.

# 6 REFERENCES


Bianchi, G (1985) ' FAO species identification sheets for fishery purposes. Field guide to the commercial marine and brackish – water species of Pakistan.

Bwathondi, P.O.J. and Mwamsojo, G.U.J. 1993. The status of the fishery resources in the wetlands of Tanzania. Kamukala, and Crafter, S.A (eds) Wetlands of Tanzania: proceedings of a seminar on the wetlands of Tanzania, Morogoro, 27 – 29 November, 1991. IUCN, Gland, Switzerland: 49 – 60.

Eccles, D. H. 1992. Field guide to the freshwater fishes of Tanzania. UNDP project United Republic of Tanzania (URT)/87/016. FAO, Rome.

IUCN Eastern Africa Programme. 2003. The Pangani River Basin: A Situation Analysis. IUCN Eastern Africa Region Office, Nairobi. Unpublished report to IUCN. Scan house press limited. xvi + 104 pp.

Kulindwa, K (2005) 'A Feasibility Study to Design Payment for Environmental Services Mechanism for Pangani River Basin' A report submitted to IUCN East Africa Regional

Mbonile, M.J. 1999. Population dynamics n Pangani Basin, Tanzania: workshop proceedings on Eater management in Pangani River Basin. University of Dar es Salaam and Technical University of Norway, Bahari Beach Hotel. Dar es Salaam, July 1999.

Ministry of Water (MoW) 2002. National Water Policy 2002. The United Republic of Tanzania (URT), 88 pp.

Mkuula, S. 1993. Pollution of wetlands in Tanzania. In: Kamukala, G. L. and Crafter, S. A. (eds.) Wetlands of Tanzania: proceedings of a seminar on the wetlands of Tanzania, Morogoro, 27 – 29 November, 1991. IUCN, Gland, Switzerland: 85 – 93.

Mujwahuzi, M. R. 2001. Water use conflicts in the Pangani Basin. In Ngana, J. O. (ed.). Water resources management in the Pangani River Basin: challenges and opportunities. Dar es Salaam, Dar es Salaam University Press: 128 – 137.

Mwamfupe, D.G. 2002. The role of non-farm activities in household economies: a case study of Pangani Basin, Tanzania.

Ngana, J.O. 2001 (ed). *Water resources management in the Pangani River Basin: challenges and opportunities.* Dar es Salaam, Dar es Salaam University Press.

Ngula, D. E. P. 2002. Pangani River Basin: power generation and the environment. In: The Pangani River Basin: options for management. Report of a Workshop held at the Kilimanjaro Crane Hotel, Moshi, Tanzania, 8-10 May 2002. December 2002. Nairobi, IUCN – EARO: 67 – 71.

Pamoja 2003. Dialogue on water: A concept paper on water resource use and management of conflicts in the Pangani River Basin: the possible role of PAMOJA. Moshi, PAMOJA.

PBWO/IUCN 2007. Pangani River Basin Flow Assessment: Estuary study. Unpublished report.

Røhr, P. C. and Killingtveit, A. 2002. Study of two catchments on the hillside of Mt Kilimanjaro. In Ngana, J.O. (ed.) Water resources management: the case of Pangani River Basin. Issues and approaches. Dar es Salaam, Dar es Salaam University Press: 211-231.

Sarmett, J. D. and Kamugisha, S. M. 2002 Control of water utilisation in the Pangani Basin: the role of PBWO and PBWB. In: The Pangani River Basin: options for management. Report of a Workshop held at the Kilimanjaro Crane Hotel,

Moshi, Tanzania, 8-10 May 2002. December 2002. Nairobi, IUCN – EARO: 19 – 24.

Turpie, J.K. 2003. The valuation of riparian fisheries in southern and eastern Africa. Report to ICLARM. 36pp

Turpie, J.K., Smith, B.S., Emerton. L.E., & Barnes, J. 1999. Economic value of the Zambezi Basin wetlands. Report to IUCN-ROSA, Harare. 205pp.

Turpie, J.K., Ngaga, Y. and Karanja, F. 2003. A preliminary economic assessment of water resources of the Pangani River Basin, Tanzania: economic value, incentives for sustainable use and mechanisms for financing management. Unpublished report to IUCN Eastern Africa Regional Office, Nairobi.

Turpie, J.K., Ngaga, Y. and Karanja, F. 2005. Maximising the economic value of water resources. Policy Brief no. 1. Policy briefs for water management, Pangani River Basin – Tanzania. IUCN Eastern Africa Regional Office, Nairobi.

United Republic of Tanzania (URT). 1991. Management plan for the mangrove ecosystem of mainland Tanzania. Ministry of Tourism, Natural Resources and Environment, United Republic of Tanzania.

URT 1998. Regional Socio-economic profile: Arusha region

URT 2002 Regional Socio-economic profile: Kilimanjaro region

URT 2005, Basic Data for Agricultural Sector Tanzania Mainland

Vanden Bossche, J.P & Bernacsek,G.M (1990) 'Sourcebook for the inland fishery resources of Africa. Vol 1 & 2.Rome, FAO.