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A Profile of the Wami River Sub-Basin




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Prepared by the Tanzania Coastal Management Partnership for Sustainable Coastal Communities and Ecosystems in Tanzania

Coastal Resources Center
University of Rhode Island

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FOREWORD

This profile of the Wami river sub-basin is prepared by the Tanzania Coastal Management Partnership (TCMP) and its landscape-seascape initiative under the Sustainable Coastal Communities and Ecosystems project supported by the Tanzania mission of the United States Agency for International Development (USAID). The intention of the profile is to synthesize existing information on the Wami with the goal of promoting landscape-seascape scale planning and conservation.

The profile was started in April 2006. Since then it has catalyzed a number of Wami river assessments and sustainable development activities. These include a study of the interlinkages between Wami freshwater flows and Saadani National Park (February 2007), an ecological assessment of the Wami estuary (March 2007), and a new project supported by a partnership between The Coca-Cola Company and USAID's global water office. The Water and Development Alliance (WADA) project was initiated in February 2007. It has a 16 month timeframe and a focus on water sanitation and education, strengthening of community organizations, environmental flow assessment, and improved agro-industrial environmental practices.

ACKNOWLEDGMENTS

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We are grateful to all those who have contributed to this profile in one way or another, especially to Jeremiah Daffa, Brian Crawford, Michael McClain, Elizabeth Anderson, Cathy McNally, Doreen Sumerlin, Jason Gritzner, Donald Robadue, Eivy Monroy, Julius Shilungushela, and Vedast Makota.

Lastly, we would like to recognize the generosity with which so many people in the Wami river sub-basin and estuary shared with us their own observations about the Wami river, its condition, uses and fishing and farming practices in the region.

ACRONYMS

CRC	Coastal Resources Center
EFA	Environmental Flows Assessment
FIU	Florida International University
GIS	Geographic Information Systems
GLOWS	Global Water for Sustainable Program
GoT	Government of Tanzania
JF	January-February
JJAS	June-July-August-September
MAM	March-April-May
MOW	Ministry of Water
MSEL	Mtibwa Sugar Estates, Ltd.
NEMC	National Environmental Management Council
OND	October-November-December
SANAPA	Saadani National Park Authority
SUCCESS	Sustainable Coastal Communities and Ecosystems
TANAPA	Tanzanian National Parks Authority
TCMP	Tanzania Coastal Management Partnership
Tsh	Tanzania shillings
URI	University of Rhode Island
USAID	United States Agency for International Development
WAMACHA	Chalinze Water User Association
WRBWO	Wami Ruvu Basin Water Office
WUA	Water Users Associations

A PROFILE OF THE WAMI RIVER SUB-BASIN AND ESTUARY

1. Background

In an increasingly crowded world, competition for freshwater is becoming intense. Competition for freshwater for agriculture, industry and domestic uses is reducing, and in some cases eliminating, freshwater flows to estuaries. This is expressed not only in change to the volume of water but also the timing of freshwater inflows and the quality of that water. Too often, the allocation of freshwater among its human users ignores the impacts that such decisions have upon the goods and services generated by healthy estuaries. Those most negatively affected by such changes are often the poor who are dependent on natural systems for livelihoods.

The Tanzania Coastal Management Partnership for Sustainable Coastal Communities and Ecosystems is conducting a landscape to seascape environmental initiative for the Wami river sub-basin, with a focus on upstream impacts on the coastal and estuarine area. This initiative recognizes that any attempt to integrate watershed and estuary planning and management is a complex undertaking that requires addressing a number of management issues simultaneously, integrating across the needs of competing user groups, and integrating data and knowledge on how and why a large and complex ecosystem is changing.

This profile of the Wami river sub-basin draws together available technical information, interviews with a cross section of stakeholders, and two field assessments. In April 2006, a reconnaissance of the upper and lower river sub-basin was conducted and meetings were held with key users and stakeholders, including local leaders and key informants, the Wami Ruvu Basin Water Office, the Water Ministry, Saadani National Park Authority, Mtibwa Sugar Estates, Ltd., and the Chalinze-Wami water treatment plant and supply scheme. Two targeted rapid assessments were completed in February and March 2007 on the interlinkages of the Wami freshwater flows and Saadani National Park (Sumerlin and Gritzner, 2007), and the condition of the Wami estuary (Anderson and McNally, 2007).

The goal of this profile is to promote landscape-seascape scale planning and conservation in the Wami river sub-basin. The specific objectives are to:

- Describe the human uses of the river sub-basin and upstream user threats to downstream water flows and estuarine health
- Describe governance systems
- Define key stakeholder groups and their interests
- Identify major gaps in information as well as priorities for further analysis and management

2. The Defining Characteristics of the Wami River Sub-basin and Estuary

2.1 The River Sub-basin

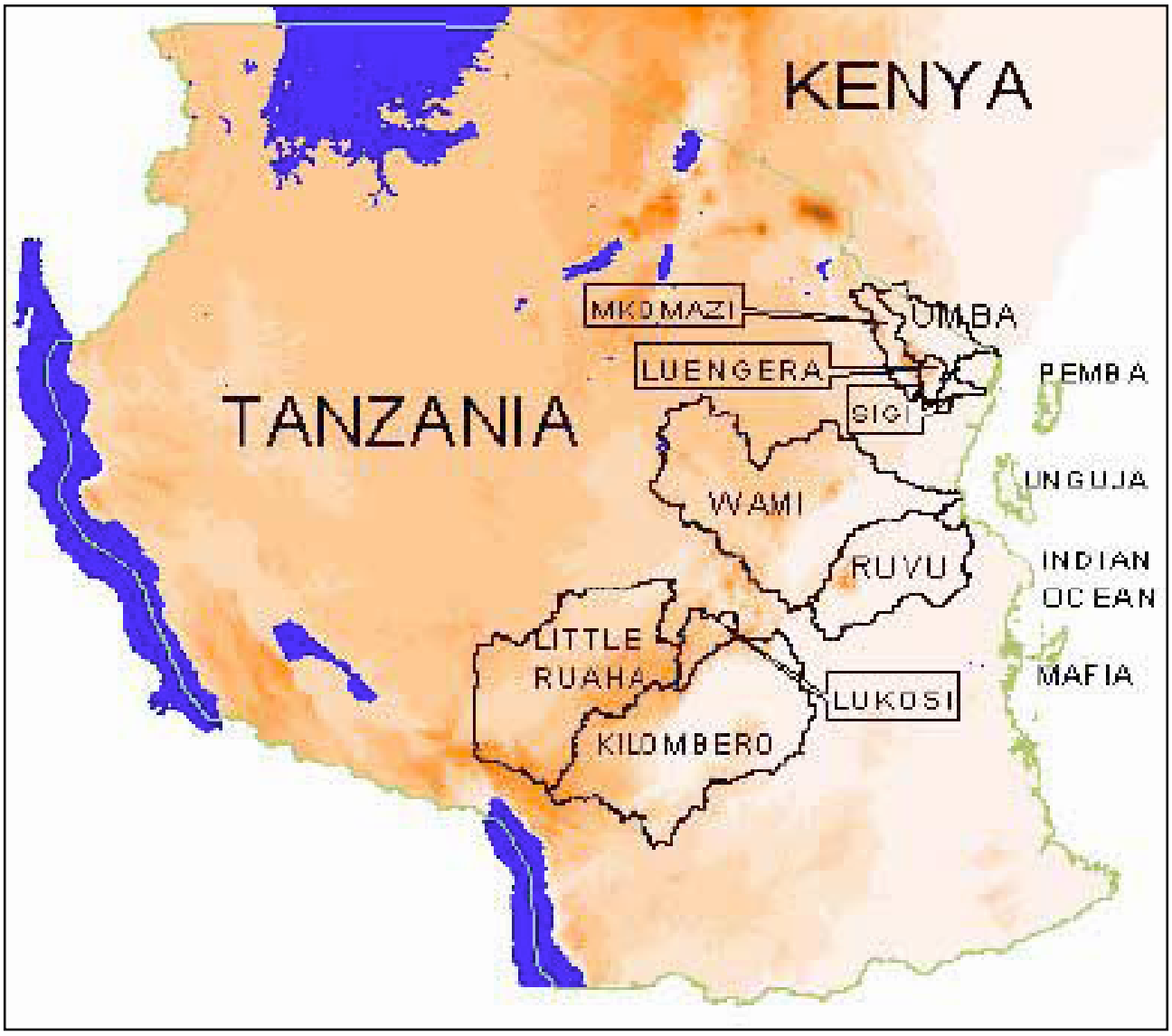
We use the term River Basin to mean the area drained by a river and its tributaries. It includes all the ecosystems within the basin, such as mountains, forests, woodlands, wetlands, pastures, agricultural areas and urban concentrations. The same geomorphological unit is often referred to as a drainage basin, a catchment or a watershed.

The main connection between the lower and upper reaches of a river basin and its component ecosystems is water. Those who live and work at the downstream end of a river basin depend upon the good conduct of those who use the upper reaches to ensure that adequate quantities and quality of water percolates from the upstream reaches to the downstream users.

The 1981 Water Act amendment introduced the concept of managing water use based on hydrological units called river basins and in 1989, the Minister responsible for Water Affairs gazetted nine river basins, including the Wami-Ruvu River Basin. The Wami-Ruvu basin is one of four basins that drain into the Indian Ocean. The total area of the Wami-Ruvu River basin is about 72,930 km^2. Of this total area, the Wami system encompasses

about 40,000 km^2 and crosses the political boundaries of four administrative Regions; namely Dodoma, Morogoro, Tanga and Coast Regions.

The Wami river originates in the catchment of the Ukaguru, Rubeho, and Nguru mountain ranges, which are all part of the Eastern Arc chain of mountains in Kenya and Tanzania (see Figure 1). The Eastern Arc Mountains are recognized as one of 25 globally important "hot spots" for forest biodiversity in need of immediate conservation action. The Eastern Arc Mountains are directly linked to the Indian Ocean. Predominantly Easterly Trade Winds from the ocean are forced to rise, cool and are converted to precipitation on the mountains. The main source of water for the lowlands, which are the main population centers, is therefore the Eastern Arc Mountains.



(source: Forestry and Beekeeping Division, 2005)

The Wami drains into the Indian Ocean just to the South of Saadani village. Figure 2 shows some of the features of land cover and towns in the Wami sub-basin.

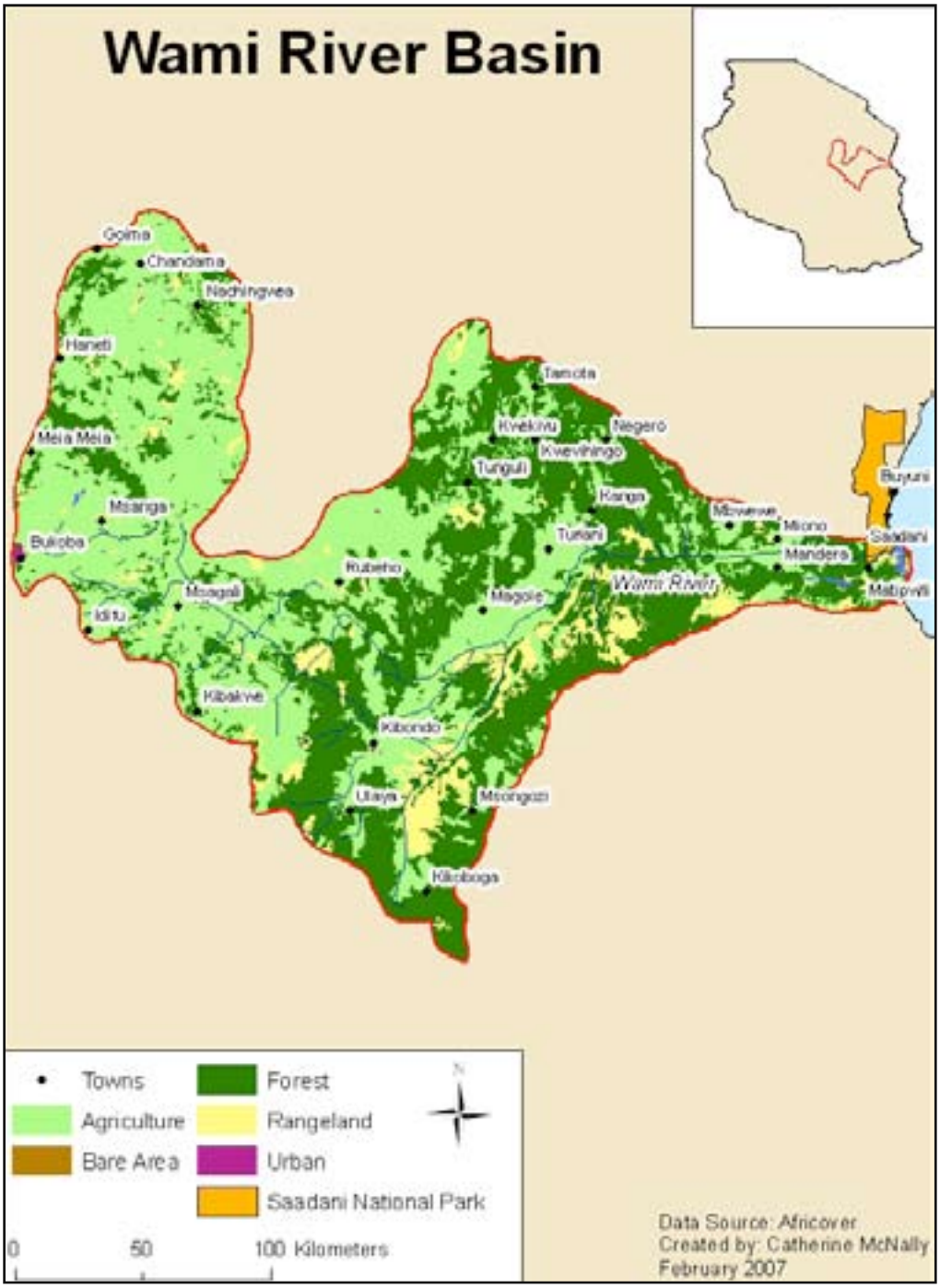


Figure 2. Wami river sub-basin

Rainfall analysis. A detailed historical analysis of seasonal rainfall patterns in the Wami river sub-basin indicates that the primary rainy season is March-May (MAM), dry season is June-September (JJAS), short rains in October-December (OND) and intermediate season from January-February (JF) (Forestry and Beekeeping Division, 2005). August is the driest month in the sub-basin while the highest rainfall amounts are mainly experienced March/April. Each of these seasons has a specific name in Kiswahili: long rains (Kusi), short rains (Maleleji), dry season (Parataza/Kusi) and intermediate season (Kaskazi).

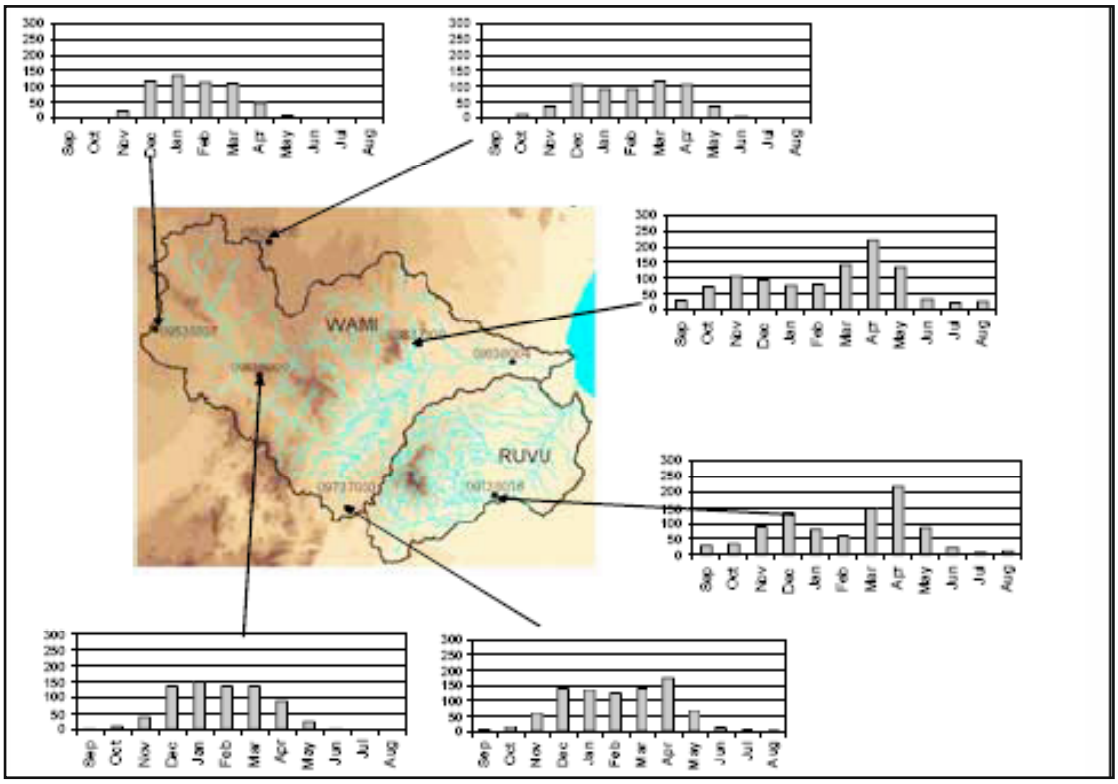


Figure 3 Typical seasonal rainfall patterns in the Wami-Ruvu river basin. The vertical maximum is 300 mm and the interval is 50 mm while the horizontal axis is from September (left) to August (right). Source: Forestry and Beekeeping Division, 2005, p. 31.

Decreasing average seasonal rainfall in the Wami sub-basin occurred from 1964 to 1993 for all seasons except the short rains between October and December (Forestry and Beekeeping Division, 2005, p. 31). In eastern Tanzania and the region of the Wami river sub-basin, there are anecdotal reports of drought conditions and decreased dry season base flows in the Wami over the past five years. Rainfall data through 2003 provided by the Wami-Ruvu Water Basin Office indicate a downward trend in precipitation (Sumerlin and Gritzner, 2007). During the lowest flow period, the lower Wami river is reduced to a series of residual pools connected by a shallow stream. Since the share of agriculture that is rain fed is high in Tanzania, this trend increases food insecurity. Predictions for climate change in the region also indicate that sub-Saharan Africa will be at risk for food security (Co-operative Program on Water and Climate, 2006).

Streamflow analysis. A system of 23 flow gaging stations was established in the Wami-Ruvu river basin in the 1950s and 1960s. Fourteen of the 23 were located on the Wami sub-basin. The gaging stations and available records are shown in Table 1.

Table 1. Summary of available stream flow records in the Wami river sub-basin

Station	River	Location	Lat.	Long.	Area (km^2)	Available records
1G1	Wami	Dawawa	-6.4333	37.5333	28,488	1953-83
1G2	Wami	Mandera	-6.2333	38.4000	36,450	1954-84
1G5A	Tami	Msowero	-6.5172	37.2114		1964-83
1G6	Kisangata	Mvumi	-6.6167	37.1833	404	1955-69
1GA1A	Lukigura	Kimamba Rd. Br.	-6.8000	37.8000	1,060	1964-81
1GA2	Mziha	Mziha (Kimamba)	-6.9000	37.7833	178	1964-89
1GB1A	Diwale	Ngomeni	-6.1667	37.6167		1964-89
1GD2	Mkondoa	Kilosa	-6.8333	37.0000	17,560	1952-81
1GD14	Kinyasungwe	Gulwe	-6.4333	35.4167	11,103	1957-77
1GD16	Kinyasungwe	Kongwa/Dodoma	-6.2000	36.2833	9,570	1958-84
1GD29	Mkondoa	Mbarahwe	-6.5958	36.7833	475	1969-93
1GD30	Lumuma	Kilimalulu	-6.6833	36.6667	502	1969-75
1GD31	Mdukwe	Mdukwe	-6.8311	36.9333	460	1969-2002
1GD36	Mkata	Mkata	-6.7631	37.3686		1973-78

Source: Forestry and Beekeeping Divison, 2005.

In 2006, the WRBWO rehabilitated 12 stream flow gauge stations. The location of the stations is shown in Figure 4.

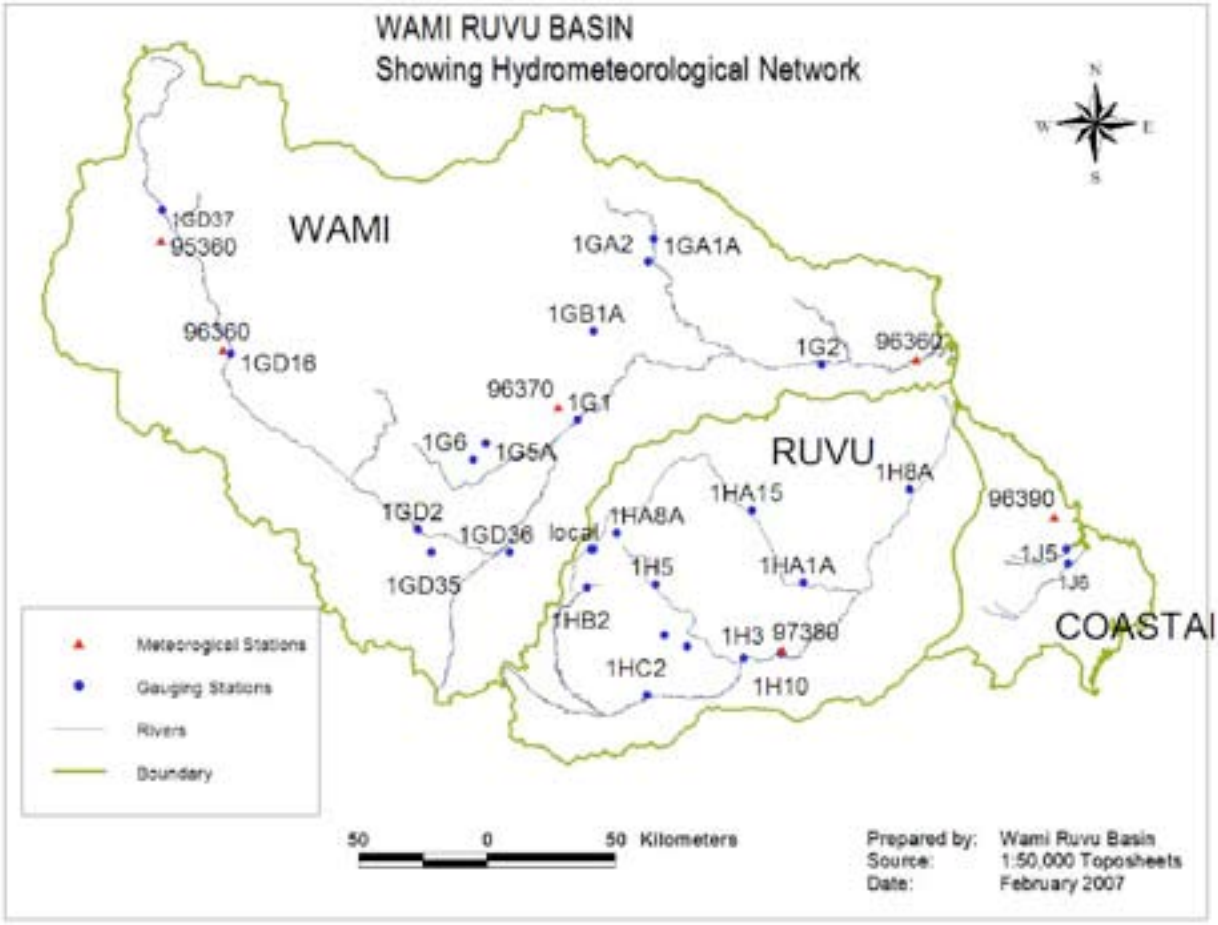


Figure 4. Wami-Ruvu river sub-basin gaging and meteorological stations

Runoff from the Dodoma region of the Wami and in the plains of the lower Wami is low due to high rates of evaporation in the river sub-basin and low precipitation. Most of the flow (about 60 to 70 percent) at Mandera station (1G2) originates from a small part of the catchment on the slopes of Nguru, Ukaguru and Rubeho mountains because these areas have much higher rainfall (Shilungushela, 2007).

Average daily flows (ADF) for selected gaging stations established from available records are shown in Table 2:

Table 2. Average daily flow at six gaging stations

Flow Gauge – tributary and location	ADF (m3 /s)	% zero flows
1G1 – Wami at Dakawa bridge	25.8	0.0
1G2 – Wami at Mandera	60.6	0.6
1GA1A – Lukigura at Kimamba road bridge	3.98	36.3
1GA2 – Mziha at Mziha (Kimamba)	1.28	17.1
1GD2 – Mkondoa at Kilosa	10.15	0.2
1GD31 – Mdukwe at Mdukwe	4.58	0.0

Source: Forestry and Beekeeping Division, 2005.

The small percentage of days with zero flows indicates that most of the rivers are perennial although some dry up during relatively dry years.

Figure 5 shows the seasonal flow pattern for Mandera station (1G2). It shows lowest flows in October and highest in April/May.

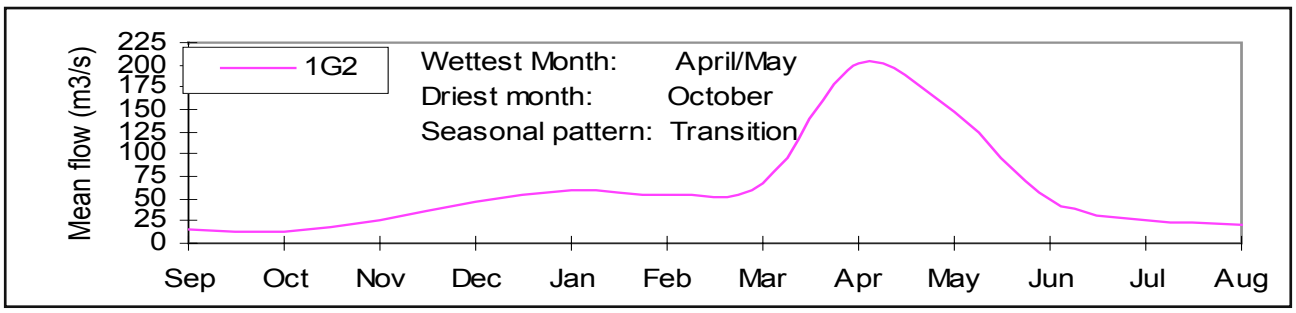


Figure 5. Seasonal flow pattern in the Wami (source: Forestry and Beekeeping Division, 2005)

Table 3 shows that about 45-60 percent of annual flow volumes in the Wami sub-basin flow during the long rains (MAM).

Table 3. Seasonal contribution to annual flow volumes at five gaging stations

Station	Seasonal contribution to annual flow volume (%)			
	Intermediate Season (JF)	Long rains (MAM)	Dry season (JJAS)	Short rains (OND)
1G1	19	55	19	7
1G2	16	60	16	8
1G5A	17	49	22	12
1GB1A	11	50	27	12
1GD31	17	45	26	12

Source: Forestry and Beekeeping, 2005

Trend analysis of annual flows in the Wami sub-basin shows a predominance of declining flows throughout the year in the Wami sub-basin, with a predominance of declining flows in each of the four seasons – long rains, dry season, short rains, and intermediate season (Forestry and Beekeeping, 2005). Seasonal flow decreases in long rains and dry season are most significant in the Wami (based on Mdukwe station 1GD31 data) since the early 1990's. The results of trend analysis are shown in Table 4 and Figures 6 and 7 below.

Table 4. Trend in seasonal mean flows at selected gaging stations

Station	Useful records	Trend				
		Intermediate season (JF)	Long rains (MAM)	Dry season (JJAS)	Short rains (OND)	Annual
1G1	1954 - 1983	0.31	-1.47	-1.44	0.56	-0.62
1G2	1955 - 1981	-0.46	-1.42	-2.33	-0.14	-1.28
1G5A	1965 - 1983	-0.88	-2.16	-2.08	-2.08	-1.36
1GD31	1969 - 2002	-1.52	-1.05	-1.77	-1.07	-1.05

Source: Forestry and Beekeeping, 2005

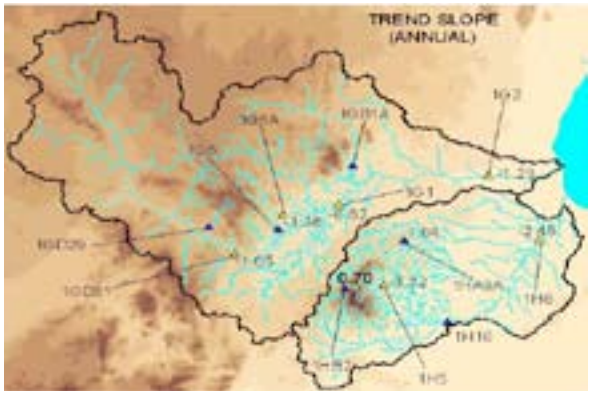


Figure 6. Spatial variation of the slope of a linear trend for annual flows in the Wami-Ruvu basin. Yellow triangles indicate decreasing trends (source: Forestry and Beekeeping, 2005)

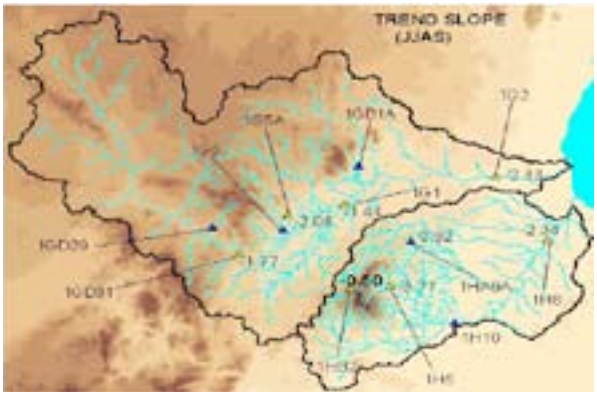


Figure 7 Spatial variation of the slope of a linear trend for short rains (OND) in the Wami-Ruvu basin. Yellow triangles indicate decreasing trends (source: Forestry and Beekeeping, 2005)

2.2 The Estuary[1]

The lower Wami river ecosystem and estuary supports abundant and diverse bird life, fish, hippos, crocodiles, and well preserved mangrove forests. The salty marsh estuaries close to the river are home for pelican and flamingo which come to feed on fish and crustaceans of the sea. The prevailing species of mangroves in the estuary are Avicennia marina (Verbenaceae) and three species of Rhizophoraceae (Rhizophora mucronata or mkoko, Bruguiera gymnorrhiza or msindi and Ceriops tasgal or mkandaa). The mangroves support an extensive intertidal fishery and provide nursery grounds for a nationally important prawn industry. Mangroves also protect the coastline against destructive waves, enhance water quality, retain sediments and nutrients, and provide habitat for fish, bird species, hippos, crocodiles, and monkeys.

The lives and livelihoods of people living in villages along and near the estuary are tightly linked to the environmental services that the estuary provides. The Wami river estuary and nearby coastal areas support one of the most important artisanal and commercial prawn fisheries in Tanzania. At the mouth of the Wami river lies a small fishing camp, home to about 100 people whose main source of food and income are fish that inhabit the estuary and nearby offshore areas. Just north of the Wami river along the Indian Ocean coastline is Saadani Village, one of Tanzania's oldest human settlements. Prawn fisheries drive the local economy of Saadani Village. Fishers working in groups of two use seine nets and fish at low tide standing in the water up to their chest. Nearly all men in the village are involved in the prawn fishery in some way and during peak times of the year, the population increases dramatically as fishermen from other parts of the coastline migrate to Saadani Village for the prawn season.

The peak season for prawn fishing occurs between March and May, and then there is another smaller peak that occurs between September and December. These seasons correspond with transitional and wet periods in the Wami river Sub-basin. During the peak fishing season, some zonation occurs in the distribution and abundance of prawns in coastal areas north of the mouth of the Wami river. According to local fishermen, near the start of the March-May peak season, the catch is best around Saadani Village (Anderson and McNally, 2007). As the season progresses, shifts occur in prawn distribution and abundance. Toward the end of the peak fishing season, catch is best in villages north of Saadani. Local fishermen claim that these shifts are driven by changes in winds, rather than being a response to prawn fishing pressures (Anderson and McNally, 2007).

Local fishermen acknowledge the importance of the Wami river estuary and of freshwater flows to the prawn fishery around Saadani Village. Freshwater flows to the estuary transport fresh organic materials; muddy deposits and mangrove forests near river mouths serve as important breeding ground for several species of prawns. The prawn fishery is said to be more productive during wetter years: low flows in the Wami river during the transition and wet seasons are linked to lower shrimp abundance. Four artisanal fishermen from Buyuni Village provided anecdotal information that in 1998, an El Nino year, there were higher catches due to higher levels of precipitation, whereas the drought conditions experienced from 2003 to 2006 resulted in lower than average catch levels (Anderson and McNally, 2007). Local fishermen believe that the estuary serves as a nursery ground for prawns and the deeper, middle areas of the Wami river Channel are viewed as particularly important. Juvenile shrimp are thought to inhabit the estuary during the short rains that occur annually in November and December, and migrate back out to the ocean during the longer rains that occur from March to May. Prawn fishing presently does not occur in the estuary, the main reason being fear of hippos and crocodiles rather than a desire to protect nursery areas.

Although the prawn fishery dominates the local economies of Saadani and surrounding smaller villages, estuarine fishes are also important source of food and income in the area, particularly to those people living along the banks of the Wami river.

Maintaining the integrity of the Wami river estuary in the future will depend on sustainable use and management of natural resources in areas within and adjacent to the estuary, as well as in areas in the greater Wami river sub-basin.

3. Human Uses of the Watershed

Outside of the major urban areas (Morogoro, Dodoma, and Kibaha), agriculture is the primary livelihood in the Wami river sub-basin. Sugar cane, sisal and cotton are produced as cash crops in large scale agriculture.

1 This section drawn from Anderson, E. and C. McNally (2007), "Rapid Ecological Assessment of Wami River Estuary," report prepared for the Tanzania Coastal Management Partnership, Dar es Salaam, Tanzania, March 2007, 38 pp.

Small holder agriculture includes maize, rice, sweet potatoes and beans. Surplus food crops in small-scale agriculture are typically sold in local markets. Other rural livelihood activities include livestock keeping, bee keeping, hunting and fishing. In general, the only source of livelihood available to many in the basin is primary, i.e. a livelihood based on the direct exploitation of the basin's natural resources. The success of these livelihoods is directly related to land and water availability.

Population growth, poverty and natural resource exploitation are interdependent. Agricultural expansion and harvesting of forest products for subsistence and local use has been increasing largely because of population growth and the increasing urban demand for charcoal, fuel wood, and timber. To a large extent, poverty and income generation are the major driving forces behind commercial harvesting of forest resources in the Wami sub-basin.

At the same time, agricultural practices are often not environmentally sustainable. Kajembe and Nzunda (2002) report that in the Nguru mountain chain, fallow periods are either skipped or are extremely shortened due to high demand of land. Similarly, shifting cultivation is diminishing. The continuous use of soil coupled with lack of supplementation of fertility with fertilizers has resulted in declines in yields. Soil conservation measures such as terracing, contour planting, strip cropping and/or use of fertilizer are rarely practiced even on the steepest of the slopes.

Table 5 shows the population and growth rates of villages in the Wami river sub-basin between 1988 and 2002 as observed from the 1988 and 2002 population censuses. The data demonstrate a population increase in most villages in the Wami sub-basin. As the population increases, more demands are made on natural resources (including water resources and river ecology).

The human population of Saadani Village near the Wami estuary has expanded rapidly over the past two decades, and recent trends suggest it will continue to grow in the near future. Between 1988 and 2002, national census statistics calculated a growth rate of 6.1%, compared to a rate of 1.0% in the ten years prior (Tobey et al., 2005). This increase in growth rate has been attributed to an influx of residents drawn by prawn fisheries or salt production, and the creation of Saadani National Park. Expanding human populations result in increased pressures on the resources of the Wami river estuary to support their lives and livelihoods.

Table 5. Population growth rates in selected villages in the Wami river sub-basin

District	Villages	Population		Growth rate
		1988	2002	
Bagamoyo	Pongwe Msungura	1972	879	-5.8
	Diozile	1870	2067	0.7
	Makombe	680	745	0.7
	Kinzagu	509	652	1.8
	Mindu Tulieni	984	1706	3.9
	Tukamisasa	2127	2910	2.2
	Kaloleni	2146	3000	2.4
	Visakazi	1441	3283	5.9
	Mwidu	1450	1413	-0.2
	Pongwe Kiona	2117	2808	2.0
	Kifuleta	2441	2922	1.3
	Kwaluhombo	1823	2058	0.9
	Kibindu	3002	4661	3.1
	Kwamsanja	659	933	2.5
Morogoro rural	Mkono wa Mara	765	730	-0.3
	Gwata Ujembe	1381	1790	1.8
Mvomero	Dihombo	1604	2536	3.3
	Kambala	885	2905	8.5
	Kunke	2033	4289	5.3
	Kidudwe	2033	5378	6.9
	Lukenge	792	1890	6.2
	Mziha	2704	4222	3.2
	Kanga	2241	2282	0.1
	Dihinda	2242	5320	6.2

Source: United Republic of Tanzania

Another problem associated with poverty and population growth is water pollution from sanitary facilities and washing in streams. Sanitary facilities are very poor. About 70 percent of the population use pit latrines

and the walls of the pits are not protected. Many are also ignorant of the pollution they cause to the river by daily life practices like washing clothes in the riverbed.

The Wami sub-basin does not have any major dams or hydroelectric plants that in other river systems typically have important impacts on freshwater flows and estuary condition.

Some of the important land use features in the Wami are described in more detail below:

Mtibwa Sugar Estate Ltd. (MSEL).[2] The Mtibwa Sugar Factory in the village of Turiani and in the eastern foothills of the Nguru mountain range was established in the early 1960s and was owned by the Government of the United Republic of Tanzania until it was purchased by Tanzania Sugar Industries (TSI) in August, 1998. The change of ownership followed the Government's Economic Reform Program which includes, among other things, the privatization of most of its Corporations and Parastatal Organizations. Sugar cane in Tanzania is primarily grown in four estates, of which MSEL is one of them.

MSEL produces about 47,000 tons of sugar per year, which is sold both domestically and exported to other countries in Africa and Southeast Asia. It has a workforce of 1,300 permanent employees and some 1,500 additional seasonal employees during the harvesting season (June-February).

MSEL occupies an area of more than 6,000 hectares of land of which 5,400 ha are currently under cane cultivation. About 33 percent of the cultivated area is under irrigation (1,800 acres) while the remainder is rain fed. The company also purchases sugar cane from about 900 local farmers through an out growers program. In 2002 it was estimated that sugarcane out grower farms covered over 12,000 hectares owned or cultivated by 3,500 farmers (Madulu, 2005). Local sugar cane farms are not irrigated, they are rain-fed. About half of the cane processed at the factory comes from the factory and half from out growers. The sugar cane is harvested once per year, when the sugar content is optimal, and this usually occurs from June to December, January, or February.

In an effort to increase production, the company is expanding its operation to Dakawa Estate, which has an area of 30,000 ha. Of this area, 10,000 ha have been set aside for livestock development while 20,000 hectares have been earmarked for sugar cane cultivation.

MSEL extracts 1.5 m3 /s of water for irrigation and for factory boiler uses from the Diwale River, which is a tributary to the Wami river. During the rainy season, less irrigation water is needed and the extraction levels fall to 0.5-0.75 m3 /s. The factory has plans to expand irrigated area, but the flow at Diwali is not sufficient and will either need to construct a dam and reservoir or extract from another tributary.

About five years ago the production capacity of MSEL increased and the methods of controlling effluents also changed. Six stabilization ponds, each at 11,000 m2 were constructed. All water from the factory is discharged into the ponds and water is allowed to settle for 3-4 months. Most of the discharge from the stabilization ponds is reused in Mtibwa's own irrigation canals. A small amount is discharged into the Wami, at a location approximately 16 km downstream from the intake point (estimated to be less than 0.1 m3 /s). Mtibwa tests the water at the intake and discharge points for electrical conductivity, fluoride, sodium, calcium, pH, and dissolved oxygen.

There have been fish kills reported (e.g. near Lukenge village) as a result of sugar processing and dumping of excess molasses from the sugar production into the Wami. In response to the problems associated with releasing molasses into the river, the company established a cattle-fattening program in December 2004. The cattle are fattened by feeding them with a mixture of molasses, crushed maize, and rice. All excess molasses is now used in the cattle-fattening program and the cattle provide another source of income for the Sugar Company during the off-season of sugar can production. MSEL is also hoping to use the cow manure in the future as fertilizer instead of the 25 lbs of N25 (25% urea) fertilizer they are applying to each hectare of sugar cane. They also have a long-term plan to build an ethanol plant so that they can covert the molasses into ethanol and export the ethanol to local distilleries. Finally, they also want to compress the bagasse, which is a by-product of sugar production, into fiberboard and sell it.

2 Unless otherwise noted, all information comes from personal communication with Mr. Edward Adul, Irrigation Engineer with Mtibwa Sugar Factory, during two site visits, the first on April 24, 2006 and the second on March 6, 2007; and, a site visit and consultation on Environmental Management Systems on March 20, 2007 conducted by Tanzania Health and Environmental Sanitation Association (THESA).

Chalinze-Wami water treatment plant and supply scheme. The Chalinze water project was initiated in 2001 and has the purpose of providing water treatment and delivery to the Chalinze township and surrounding villages. It was constructed by the People's Republic of China at a cost so far of 23 billion Tsh in collaboration with the Government of Tanzania. Villages in this area are semi-arid and suffer from water shortage. They rely on wells, but the groundwater is not potable and during the dry season the water table is too low. The length of the main pipe line from Chalinze to the target area is 126 km and the distribution pipe line is 34 km.

The design capacity of the treatment plant is 7,200 m^3 /day. As of April 2006 the plant was providing 800 m^3 /day. The barrier to delivering more water is not plant capacity, it is the need to install the pipe distribution network. In this first phase of the project 20 villages are targeted. The villages covered in phase one are: Chalinze, Pingo, Msoga, Mboga, Lugoba, Saleni, Mazizi, Msata and Kihangaiko in the south direction. In the north direction the following villages were covered, Mandera, Hondogo, Kilemela, Miono, Kikaro, Rupungwi, Kimange and Mbwewe. The communities involved have been mobilized to form the association called Chalinze Water User Association (WAMACHA).

The second phase of the project to be completed in 2015 has another 22 villages targeted. Over 100,000 residents will benefit from the project when finished. During the second phase, direct connections from standpipes to home are also anticipated. A three stage water treatment process is used: sedimentation, flocculation and sand filtration. The plant has a stage gauge and a rainfall gauge. The plant also monitors water before and after intake for turbidity, Ph, conductivity, and ecoli.

The Chalinze water supply project receives a subsidy from the government of Tanzania, but it is designed to eventually be self financing through user fees. All the water is metered at the standpipe, with the number of standpipes determined by the population in the village. Each standpipe is monitored by a village member and every liter is paid for. Collection rate is 95 percent so far. The fee for the water is low (1 Tsh/liter) and less than other means of providing outside water. Before the project, water brought in by truck was selling for as much as 20 Tsh/liter. The project estimates that at 25 percent capacity, water use payments of 1 Tsh/liter will cover costs of operation.

Wami-Mbiki Wildlife Management Area. The Wami-Mbiki is a conservation area that covers 3,000 km of core area, approximately 1,200 km of buffer area, and 22 surrounding villages. Most of the villages lie within the Wami river sub-basin.[3] The area is situated to the north of the main road between Dar es Salaam and Morogoro in both Bagamoyo District and Morogoro Rural District. The Danish Hunters Association has since 1997 been supporting the 22 villages around Wami Mbiki to establish the area as a Wildlife Management Area for community based wildlife management. The Wami-Mbiki project has an office in Morogoro. The project has formed the Wami-Mbiki Society, a management group representing the 22 villages around Wami-Mbiki. The goal is to reduce poverty through sustainable wildlife management by local communities and socio-economic development. Many of the poorer villages have a high dependence on charcoal making for livelihood. The government restricted charcoal permits in 2005.

The project faces many challenges such as, the size of the WMA, which makes it difficult to patrol, and high poverty levels, which makes the population dependent on unsustainable natural resource exploitation for survival. The average annual cash household income in the Wami river sub-basin is low. In predominately rural areas, it is estimated that it is about 75,000 Tsh (about US$70) per year (Wami Ruvu Basin Water Office, 2005).

Saadani National Park. The mouth of the Wami to about 20 kilometers upstream is fully within the southern end of the Saadani National Park (SANAPA). Tanzania's legislative body approved the law establishing the Park in October 2004 and it was gazetted in November 2005. The combined area of the Park is 1,137 km2. This Park is unique because it not only consists of a mosaic of savanna, woodland, forest, and mangrove, but it also contains 66 km2 of ocean with offshore coral reefs and one of two breeding sites in the world for the endangered green turtle (Chelonia midas) (TANAPA, 2003). No other park in the Tanzania national park system contains both terrestrial and marine ecosystems. The terrestrial portion of the park consists of coastal plain and low hills generally below 100 meters elevation with somewhat higher ground to the southwest (TANAPA, 2003). Figure 8 shows the boundaries of SANAPA, location of the Wami river, surrounding villages, and two Collaborative Fisheries Management Areas.

3 Wami-Mbiki villages include: Tukamisasa, Visakazi, Kololeni, Mwidu, Mindutulieni, Kinzagu, Diozile, Makombe, Pongwe Msungura, Pongwe Kiona, Kufuleta, Kwaruhombo, Kwamsanja, Kihinda, Kanga, Mziha, Kunke, Kidudwe, Lulenge, Maseyu, Gwata-Ujembe and Mkono wa Mara.

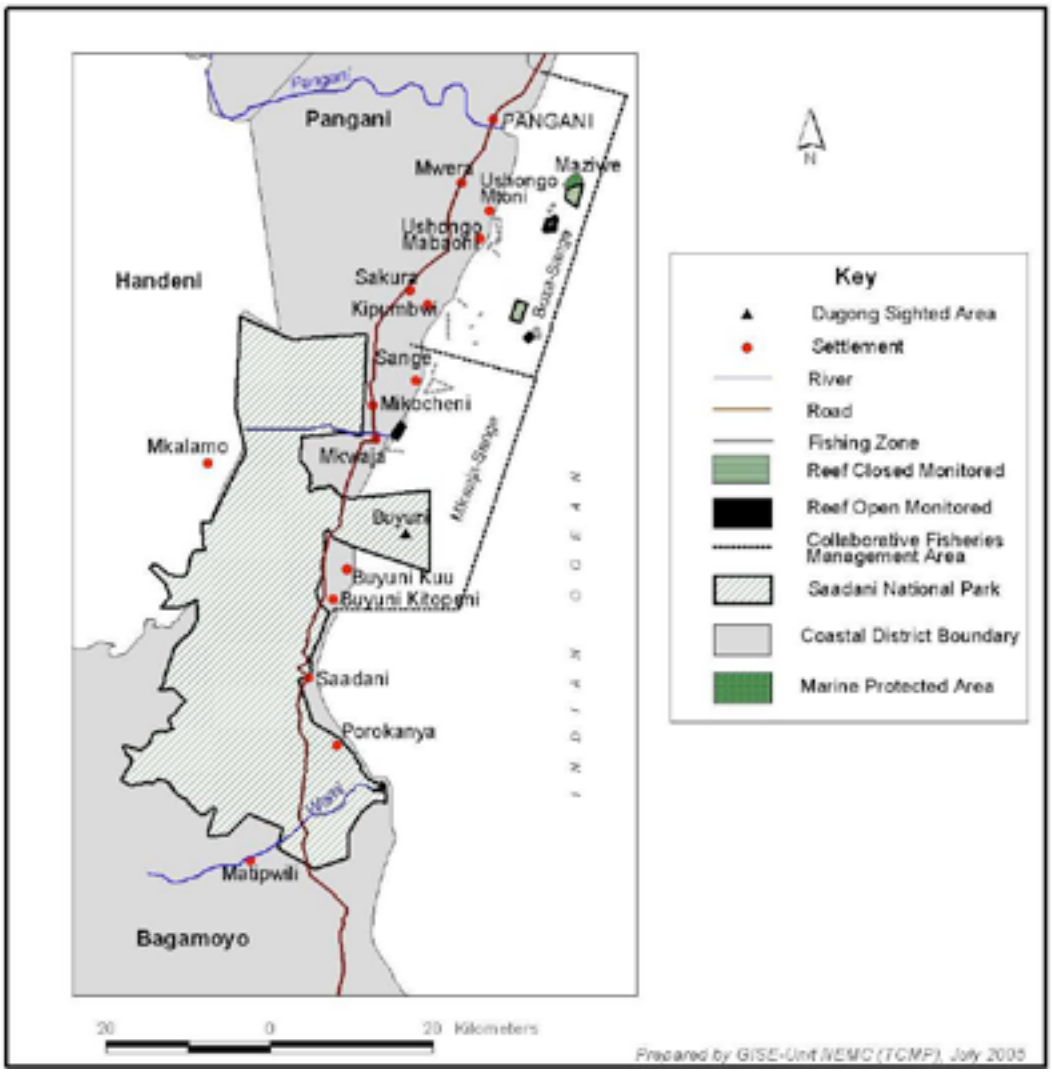


Figure 8. Saadani National Park

The Wami is a significant aspect of ecosystem function for the park. Its riparian areas support riverine forests that are extremely biodiverse both in floral and faunal species (TANAPA 2003). The Wami river is also the only perennial river in the park and thus a primary water source for the diverse wildlife of the park in the dry season.

To the west of Wami river in Saadani National Park lies the most important biological asset of the whole area: the Zaraninge Forest, which encompasses 200 square kilometers (50,000 acres) of closed canopy tropical forest, one of the larger coastal forests in Tanzania. The Zaraninge hosts several internationally scarce species including 8 mammals, 10 birds, a new species of reptile (dwarf gecko), one amphibian (Hyperolius parkeri), an endemic snail and many other species of invertebrates. The Zaraninge has been identified as one of the 25 global biodiversity hotspots in most urgent need of immediate conservation action.

Two multi-species groups of animals depend on the Wami river and adjacent creeks and wetlands for fresh drinking water and high quality forage during the dry season (Sumerlin and Gritzner, 2007). The largest of these two groups (population 1: giraffe, kongoni, lions, wildebeest, zebra) moves south toward the Kiyonga wetland and the Wami river at the onset of the dry season. The smallest of these two groups (population 3: buffalo, kongoni, reedbuck, waterbuck, wildebeest, warthogs) moves south, at the onset of the dry season, to the Mabumo wetland, continuing on to the wetlands of the Zaraninge Forest, and follow several different routes to the Wami river in the vicinity of Matipwili village

The Wami river and Saadani National Park also play a critical role in larger scale elephant movement corridors. Park Rangers, village elders, and USAID staff provided information on these corridors as they wind through Tanzania (Figure 9).

Figure 9. Elephant corridors dependent on the Wami river sub-basin

One corridor of movement is between the Wami in the Saadani National Park and the Arusha area to the north. Other corridors are between the Wami and Mikumi National Park (passing through the Wami-Mbiki Wildlife Management Area) and between the Wami and the Selous Game Reserve, continuing down to the Rufiji river basin. All informants feel that these are ancestral migration routes that may require several years for elephant groups to complete (Sumerlin and Gritzner, 2007). More information on the exact location of finite, limited dry season habitats and the migration corridors that animals travel to get to them is needed for a holistic approach to their protection.

Informal discussion with TANAPA planning staff and review of the Saadani National Park Management Zone Plan (TANAPA, 2003) reveal numerous park infrastructure development projects to accommodate an anticipated rapid increase in tourism (Sumerlin and Gritzner, 2007). Potential planned infrastructure includes a group campsite development at Mabumo wetland and re-construction and upgrade of the old Tanga Road that has not been used since dereliction of the ferry to cross the Wami in 1998. On the north side of the Wami river, this route parallels the river within the immediate riparian area and floodplain (including wetlands). Hippopotamus and elephant tracks are abundant in this area (Sumerlin and Gritzner, 2007).

SANAPA is now the closest park to the largest urban area in Tanzania. TANAPA officials anticipate that visitors will grow as much as 100 times in the near future. Such growth is indicative of the potential opportunities for economic return to the country. As Saadani National Park grows in popularity and more people visit the area, increasing demand for freshwater goods and services may place stress on the Wami river estuary. For example, during the dry season there may be additional demand for freshwater from the river caused by an increase in the number of tourists visiting SANAPA. More tourists could also mean more boat trips on the river and it is uncertain whether this increased river usage would compromise habitat for hippos and other channel-dwelling species. These considerations are important for future tourist investment and lodge construction within the Saadani National Park and surrounding areas.

Wildlife conservation and management of unique ecosystems like those found in Saadani National Park are in line with Tanzanian national interests, as is the generation of revenue from tourism. The location of Saadani National Park along a relatively undeveloped coastline and adjacent to terrestrial habitat still supporting large wildlife species makes it a very unique holiday destination. The Wami river is a keystone of the Saadani National Park ecosystem and one of the biggest attractions for international tourists. Economic return will depend greatly on natural resource condition in this area. Therefore, there is a clear need for conservation and careful planning in the Wami river watershed and Saadani National Park to support viable freshwater flows in the river, biodiversity, and livelihood strategies.

4. The Impacts of Human Activities on the Estuary, River Basin, and Freshwater Flows

It is difficult to know precisely what impact human activities have had on freshwater flows, water quality and the condition of the estuary. There is no continuous monitoring program of water quality parameters and condition of the river basin and estuary.

It is known, however, that the environment in the basin is being degraded and polluted. Agriculture has expanded as a function of population increase leading to deforestation, and water is being extracted from the basin for agricultural irrigation, industry, and household use. In areas with intensive agricultural activities, people cultivate up to the river bank. It is known that this accelerates erosion and sedimentation. The potential consequences of these threats are reduced river flow, changes in seasonal flows (pulsing), nutrient loading and water contamination from agro-chemicals, and water contamination from washing and sewage.

Deforestation

All reports on the Wami river sub-basin note that deforestation is one the primary environmental threats. The driving forces for forest cover loss are population growth, agriculture, charcoal making, and cutting of trees for poles and home construction.

Trees and other vegetation serve to hold moisture and regulate the release of water into the basin. They reduce the runoff velocity during the rainy season and increase runoff during the dry season by recharging groundwater during the rainy season. Cutting trees and clearing vegetation also exposes water and increases stream temperature, which in turn disrupts aquatic life cycles.

Depletion of forest cover in the catchment area of the Eastern Arc Mountains has been analyzed. It is estimated that about 2000 years ago the forest cover on the Eastern Arc Mountains was 23,000 km2, which was reduced to around 15,000 km2 by 1900 and to 5,340 km2, in the mid 1990s (Newmark, 1998). In the Nguru mountain chain the decline in woodland cover was more than 50 percent over a span of 20 years between 1970 and 1990 (Forestry and Beekeeping Division, 2005).

Another study of land use and land cover change in the area surrounding Saadani National Park using remote sensing found similar dramatic changes in land use (Tobey et al., 2005; Torell et al., 2006). The data also showed that the amount of agricultural land outside the park has increased by 76 percent. At the same time, there has been a large decrease in the area of open and closed woodlands outside the park (Tobey et al., 2005; Torell et al., 2006).

To accurately quantify the impacts of forest changes in the Wami sub-basin on river flows would require the installation of new gauges at suitable sites close to understand the interactions between the forest cover, surface and subsurface water (Forestry and Beekeeping Division, 2005).

Mangrove Cutting

The 1990s saw a decline in the overall abundance of mangroves located along the coast between Saadani

Village and the mouth of the Wami estuary, as well as the areas located adjacent to the southern banks of the Wami river and estuary (Figure 10). This trend was largely due to illegal cutting of mangroves by villagers and people from outside the region for building materials, firewood, and charcoal, as well as mangrove removal for salt making.

As a result of increasing pressures on mangroves throughout the country, the Forest and Beekeeping Departments in Tanzania issued a legal mandate in 2003 to protect remaining mangrove forests. In the Wami river estuary, Saadani National Park personnel patrol mangrove areas within the park's boundaries to reduce the amount of illegal harvesting and littering. Although the threat of mangrove cutting has decreased in recent years, it is essential for Saadani National Park staff to continue their enforcement efforts to ensure that the demand for charcoal in various areas of Tanzania does not result in the removal of mangroves within and around the Wami river estuary.

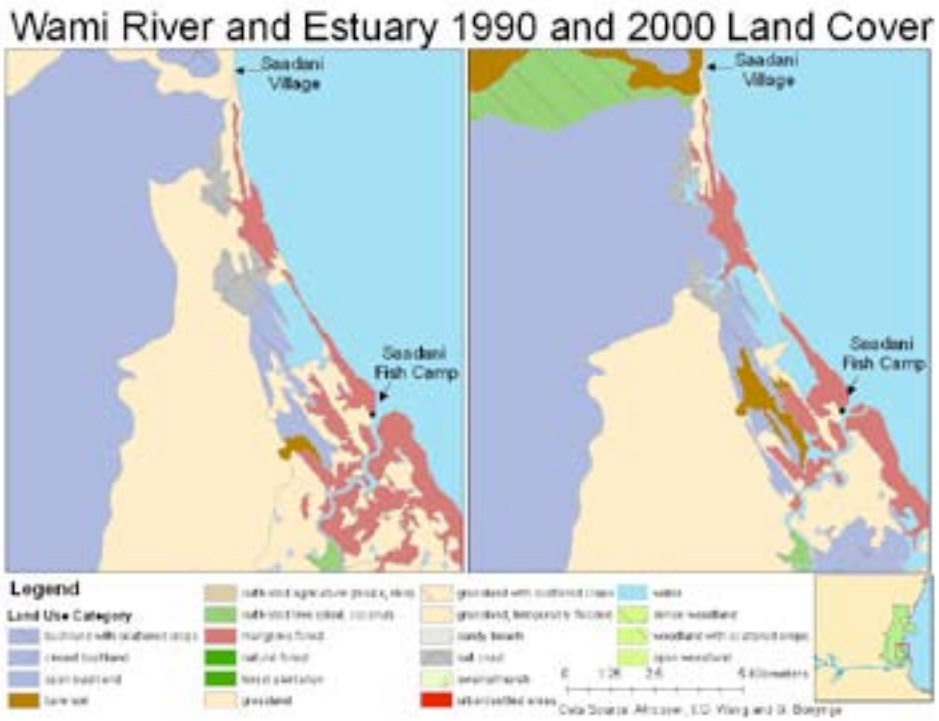


Figure 10. Changes in land cover along the Wami river estuary during the period 1990-2000

Overfishing and Fishing Conflicts

Overfishing by commercial trawlers and artisanal fishermen, as well as conflicts between these two user groups, are emerging concerns along the coast near the mouth of the Wami river. According to local fishermen, in the 1970s, a fisherman could catch over 100 kilograms per day in one meter deep water, but in recent years that number has dropped to less than 10 kilograms per day and working in deeper waters is now necessary to capture prawns (Tobey et al., 2005).

Several reasons have been given for the noted decrease in shrimp catch. Primary among these are the increase of artisanal fishermen in the area, the smaller mesh size of the beach seine nets, lower amounts of rainfall, and the presence of commercial shrimp trawlers that work in the area during the high season (Anderson and McNally, 2007). According to local fishermen, commercial prawn trawling boats disturb the ocean floor, catch large quantities of bycatch, and impact artisanal fishermen by interfering with their set gill nets and lowering the quantities of available catch in nearshore waters (Tobey, et al., 2005). Artisanal fishermen claim that when the trawlers are absent, some fishermen catch as much as 40 to 50 kilograms in a day, although 10-15 kg/day is more likely (Anderson and McNally, 2007). Some of the other reasons given for the decrease in shrimp harvest are the cutting of mangroves and the use of poisonous herbs/roots (utupa) for fishing. Clear cutting of mangroves removes important breeding habitat for shrimp and allows water temperatures to increase, which prompts migration out into the ocean. Since the creation of Saadani National Park, mangrove cutting and the use of poisonous herbs/roots for fishing have decreased because there are extension officials that inform the

fishermen of the laws and the penalties for breaking them (Anderson and McNally, 2007).

Changes in the quantity and quality of freshwater delivered to the estuary could also affect shrimp abundance and catch by artisanal fishermen. Survival and growth of juvenile shrimp in the estuary is influenced by salinity and temperature, both of which are parameters strongly related to freshwater flow from upstream areas. Shrimp abundance may fluctuate over time on the basis of inter-annual variability in these conditions. Maintenance of the estuary and river channel in the most natural state possible will create conditions that favor long-term survival and health of shrimp populations.

Freshwater fishing also occurs throughout the Wami river and its tributaries. There is anecdotal evidence of overexploitation of fishing activity in Matipwili village, located on the lower Wami river (Tobey et al., 2005). Fishing is historically an important livelihood for people in Matipwili. The Wami river and surrounding ponds are fished year round using canoes, line and hook, and fish traps. In recent years, both the size of fish caught and the total catch have declined. There has been talk of introducing a closed season, but some fishers are totally dependent on the Wami river fish for their livelihood.

Small net size is now being used because of the increasingly small size of fish. Fishing also occurs in the breeding areas, which further exacerbates the worsening condition of the fishery. Nets used by Matipwili fishers have doubled in length from 25 to 50 meters over the years, and the mesh has become so fine that no fish escape (Sumerlin and Gritzner, 2007). The Executive Officer from Matipwili referred to 'unsustainable' fishing practices as all of the fish are now caught and no small fish escape to provide fish for the future (Sumerlin and Gritzner, 2007). Furthermore, it was found that fishermen from Matipwili, and as far as 50 kilometers upstream, describe fishing all day and catching very few fish (Sumerlin and Gritzner, 2007). Declining fish stocks in the Wami river are forcing communities to find other sources of food. Matipwili, for example, has recently begun expanded agricultural development within the Wami river floodplain to augment their diet. Such agricultural development along the river banks, and loss of native riparian vegetation, is contributing to erosion of river banks and changes in river morphology (Sumerlin and Gritzner, 2007).

Other evidence of declining fish population in the Wami is a decrease in the populations of catfish and tilapia in the river and an increase in crocodile attacks along the river at Matipwili as people collect water. These attacks suggest that crocodiles no longer have enough to eat. Finally, raptors capable of exploiting fish as prey are nearly absent in the lower Wami, indicating fish populations are not adequate to support the expected abundance and diversity of raptor and wading bird species (Sumerlin and Gritzner, 2007).

5. Potential Future Threats to Freshwater Inflows and Estuary Health

This initial synthesis of readily available information suggests that the pressures on the Wami estuary have all been increasing and that trends are likely to continue in the same direction. The expected trends are summarized in Table 6 below.

Table 6. Trends in river basin and estuary threats

Pressure	Likely projection	Comments
Freshwater inflows	Diminished flows during all seasons	Diminished flows are due to both diminished rainfall trends and human pressures, especially deforestation and poor agricultural practices. The amount of water withdrawn from the Wami for irrigated agriculture is likely to increase, leading to a decrease in the amount of freshwater delivered to the estuary.
Freshwater quality	Further declines	Water quality is poorly documented, but further declines are projected from expansion of agricultural areas and agrochemicals, poor sanitation practices, industry, and untreated urban wastes
Agriculture	Increasing	There are plans for major agricultural expansion in the Wami river sub-basin and surrounding areas near Morogoro. Poor agricultural practices and encroachment on wetlands, river valleys, forests, and important catchment forests cause water contamination, erosion, diminished freshwater flows and changes in river morphology

Fishing in the lower Wami and estuary	Increasing	Fishing in the lower Wami is characterized by increasing net size and smaller mesh and overfishing of shrimp by commercial trawlers and artisanal fishers
Charcoal and timber production	Increasing	The economic importance of charcoal and fuel wood businesses and lack of alternative income generating activities makes charcoal making and timber cutting difficult to halt. However, without a deliberate effort to stop the degradation trend, the situation of forest cover loss is likely to deteriorate further.
Sugar cane cultivation and processing	Increasing	MSEL is expanding its operation to Dakawa Estate with potential for a four fold increase in land under sugar cultivation
Human population density and development	Increasing	The data demonstrate a population increase in most villages in the Wami sub-basin. As the population increases, more demands are made on natural resources (including water resources) and deforestation pressure increases. Development is a threat to large-scale animal corridors. The elephant migration corridor from the Wami to Mikumi is under intense developmental pressure
Tourism in the lower Wami at Saadani National Park	Increasing	If the old Tanga road and bridge are constructed from Bagamoyo to SANAPA, the growth in local tourism is predicted to grow rapidly. Infrastructure development and campsites within the immediate riparian area and flood plan may cause degradation of water quality or water quantity, and alterations in wildlife migration patterns

6. Major Stakeholders and their Interests

The table below lists key stakeholders and their interests.

Table 7. Major stakeholders and their interests

Stakeholder	Interests
Ministry of Water, Dar es Salaam	Strengthened water resources management frameworks and sector coordination. Development and review of national water policy, guidelines and legislation. Oversight of basin water offices and effective operations of Water Boards. Implementing water law and the resolution of conflict between various national sectors.
Wami Ruvu Basin Water Office, Morogoro	Water resource planning and management; issuing water rights, monitoring their use, and collection of fees; monitoring hydrology in the basin and database management; building awareness; assisting water user associations.
Wami Ruvu Basin Water Board	Water allocation, the determination and modification of water rights, the measures to be taken in case of drought, and priorities to be given to different uses of water in the basin
Artisanal coastal fishers	Abundance of fish; good environmental condition of seas, marine habitat, and estuaries; control of commercial fishery and control of illegal fishing; and reduction of outside fishers in local waters
District and local government	Planning and development of water resources in accordance with basin plans, protection and conservation of natural resources, establishment of water management bylaws and conflict resolution. Assessment of District water demands and participation in the preparation of basin plans.
Local communities and Water User Associations	Conservation of water sources and catchment areas, mediation of disputes, data collection, participation in the preparation of water utilization plans, using water efficiently and ensuring return flows, law enforcement, and pollution control
Agricultural and agro-industrial sectors	Adequate allocation of water for irrigation and operations. Increased agricultural and livestock productivity. Development of irrigation infrastructure

Chalinze water treatment and supply	Abundant and clean supply of year round water.
NGOs and community groups	Effective participation of different stakeholders in integrated water resource management. Good governance and transparency. Protection and conservation of water resources
Wami-Mbiki Society	Reduced poverty through sustainable wildlife and natural resource management by local communities and socio-economic development
Saadani National Park Authority, lower Wami	Sustainable management of wildlife. Increased number of park visitors and park revenues. Sustained freshwater flows to the lower Wami to support wildlife populations and riparian habitat
Tourism industry, lower Wami	Sustainable development environmental and cultural attractions, improved infrastructure for tourism (roads, bridges, electricity and communications), and increased number of local and international tourists

7. The Governance System for the Wami River Sub-basin and Estuary

The importance of water resources for human uses, development and environmental services is proclaimed in various national policies. The Government of Tanzania (GoT) has endorsed the UN Millennium Development Goals, including the pledge to reduce by half by the year 2015 the proportion of people who do not have sustainable access to safe drinking water. The GoT's national strategy documents have included more ambitious targets. The Development Vision 2025 and the Poverty Reduction Strategy both identify improved water supply as one of the top priority areas for poverty reduction. The Poverty Reduction Strategy has the goal of universal access to safe drinking water and the Development Vision has a target of increasing access to safe water from 50% to 90% by 2025. Other objectives of the Development Vision include enhancement of equity of access to water, the use of environmentally sound technologies, and effective water tariffs, billing and revenue collection systems for all water users.

Closely allied to Tanzania's Development Vision and Poverty Reduction Strategy is its program in Public Service and Local Government Reform. At the heart of both reform programs is decentralization and a change in central-local government relations.

Water supply, management and policy are based on the National Water Policy adopted in 2002, and the Water Utilization Act No. 42 of 1974 and its amendments of 1981, 1989, 1997, and 1999. The amendment in 1981 introduced the concept of managing water use based on hydrological units called river basins. It devolved the responsibility for water management to the basin level. In 1989, the Minister responsible for Water Affairs gazetted the nine river basins, including the Wami Ruvu River Basin. It was later proposed that each basin have a semi-autonomous Water Office and advisory Board. The nine basins are Pangani, Wami-Ruvu, Rufiji, Ruvuma and the Southern Coast, Lake Nyasa, Internal Drainage, Lake Rukwa, Lake Tanganyika and Lake Victoria.

The National Water Policy (2002) and the Water Sector Development Program 2006-2025 define the future direction for the water sector in achieving sustainable development and utilisation of the Nation's water resources and in increasing the availability of water supply and sanitation services. Because water resources management is a multi-sectoral activity, the policy argues, it requires an effective collaboration and coordination mechanism among various sectors. The policy emphasizes integrated and inter-sectoral water resource planning based on River Basins as a planning unit. It also promotes participatory processes and puts more emphasis on community involvement in the management of water schemes.

Five levels of basin management are identified in the Policy: the nation, the basin, the catchment, the district and the community / water association level. At the national level, the ministry responsible for water is charged with policy development and review, implementing water law and planning and the resolution of conflict between various national sectors. At the basin level the primary responsible agencies are the Wami Ruvu Basin Water Office and the Wami Ruvu Basin Water Board. At the catchment level the Policy recommends establishing Catchment Water Committees or Sub-catchment Water Committees comprising representatives from the public and private sectors, and from the Water User Associations within the basin. The role of the Catchment Water Board includes the preparation and implementation of catchment plans, and resolution of conflicts within the catchment.

District councils, the Policy says, shall participate fully in basin boards and catchment committees. Districts will be responsible for the planning and development of water resources in accordance with basin plans, protection

and conservation of natural resources, establishment of water management bylaws and conflict resolution. In addition, district councils are to assess the water demands of their respective districts and participate in the preparation of basin plans.

The final level comprises community level and Water Users' Associations (WUAs). These associations are responsible for local-level management of allocated water resources, which comprises, among other things, the mediation of disputes, data collection, participation in the preparation of water utilization plans, conservation of water sources and catchment areas, using water efficiently and ensuring return flows, law enforcement, and pollution control. WUAs are to send representatives to water boards and catchment committees. To date, there are no operational Water User Associations in the Wami sub-basin.

The Wami-Ruvu Basin Water Office and the Wami Ruvu Basin Water Board were established in July 2002. The Basin Water Office has its headquarters in Morogoro and has two sub-offices in Dar es Salaam and Dodoma. The Water Office has the following main responsibilities:

- Monitoring water availability (including water levels, river flow, rainfall and climatological data) and use throughout the basin
- Issuing water rights
- Billing and collection of water fees
- Assisting in the formation of water user associations in the basin
- Building awareness of water users regarding water resources management
- Monitoring and control of water pollution in water bodies in the basin
- Participation in water related projects in the basin

The Office is mandated to assist users in defining their water requirements, instructing them on the proper way to prepare and submit their applications to the Office, and overseeing the proper utilization of water rights. The Office also ensures that those holding legal rights to water are protected, and are not deprived of that right by those who do not possess that right. The 5-Year Plan of the Wami Ruvu River Basin Office (2005) notes that once the Water User Associations (WUA) and the Sub-catchment and Catchment Committees are formed, the direct relationship with individual water users will diminish. At that time, the Basin Office will build the capacities of these institutions to assume many of these roles.

A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of the WRBWO highlighted a number of critical weaknesses of the Office: inadequate monitoring and enforcement of water users[4], inadequate billing and fee collection mechanisms, inadequate staff and office conditions, poor water resource monitoring networks, and lack of motivation to professional staff in the Office. Although the Office is responsible for monitoring water availability, the stations in the network until recently were not operational. Thus, the existence of adequate data on the basin is a persistent concern. While the total number of licensed abstractions are known, accumulated illegal abstractions are unknown. Also, the amount of water required to maintain the basin's environmental systems is unknown.

The principal Water Officer at the WRBWO is the Executive Officer and Secretary to the Basin Water Board. The Water Board has 10 members appointed by the Minister responsible for water affairs. The Minister responsible for water also appoints the Chairman of the Board. The Board reports to the Minister and is responsible for providing advice on all matters concerning: water allocation, the determination and modification of water rights, the measures to be taken in case of drought, and priorities to be given to different uses of water in the basin. The Board meets twice a year, or more often as needed.

In terms of the control and regulation of water pollution, the Basin Water Board is empowered to carry out research and investigations into the causes of pollution and ways for the efficient prevention or control of water pollution subject to the provisions of the water Act of Tanzania. It also has the power to regulate the discharge of effluent by industries and other water users.

The Ministry of Water released a National Water Sector Development Strategy in 2004 to support implementation of The National Water Policy. Some of the more important issues addressed in the strategy include community ownership and management of water and sanitation facilities, private sector participation in development, integration of water supply and sanitation initiatives, and decentralization of service delivery to the district council level.

4 The Wami Ruvu Basin Water Office has a database with a list of 700 water rights for a total of 11 m^3 /s. In terms of water extraction, most of the water rights are for irrigation for rice and sugar. According to the WRBWO, most of the water rights are not functional and the number of unlicensed water extractions is not known. Some of the water rights in the Basin Water Office's books go back to the 1950s.

8. Recommendations and Opportunities

Based on interviews, recommendations in other reports and information synthesized in this profile, the following actions are identified as priorities. Some of the recommendations have been incorporated in the Water and Development Alliance project in Tanzania and are part of the WRBWO business plan.

- Complete an Environmental Flows Assessment (EFA) of the Wami sub-basin to understand flow requirements for maintaining environmental services and downstream ecosystems. This information should then be used in the development of a basin water use plan. The WRBWO is participating in the EFA of the Pangani Basin to learn from this experience and is leading an EFA for the Wami sub-basin in collaboration with the Water and Development Alliance (WADA) project. The Wami sub-basin EFA will be completed in June 2008.

- Strengthen the capacity of the WRBWO in database management and geographic information systems for water resources management

- Provide agroforestry extension and establish demonstrations to agriculturists in the Wami river floodplain, including establishment of riparian buffer zones

- Facilitate the formation of Water User Associations and community water use and sanitation groups

- Promote sustainable fishing practices in the Wami river and estuary

- Conduct environmental management system assessments and make recommendations to reduce water use and wastewater discharges in the agro-industrial sector. The WADA project has completed one such assessment in the Wami sub-basin: Mtibwa Sugar Estates, Ltd.

- Begin long-term monitoring of key ecosystem indicators in the lower Wami, including:

    - Vegetation monitoring for riparian areas, wetlands, and Kinyonga wetland
    - Monitoring of channel morphology and bank erosion
    - Water quality sampling and monitoring of salinity along the Wami river estuary
    - Create a baseline map of residual pools used by hippos and crocodiles in the dry season, and monitor for number, location, and quality

- Improve community access to safe water and sanitation, especially in schools and public areas

- Strengthen sanitation awareness in communities

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