Socioeconomic Conditions and links to Freshwater Ecosystem Services of the Ruvu River Basin, Tanzania

Tanzania Integrated Water, Sanitation and Hygiene (iWASH) Program

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Summary

The Ruvu River sub-Basin is one of the most important river systems in Tanzania, overlapping with areas of critical ecological significance (high level of biodiversity) and economic activities with national importance. The largest city of Tanzania, Dar-es-Salaam (DSM, with a population more than 3 million) and a number of smaller towns (Morogoro, Kibaha and Bagamoyo) rely on the Ruvu River system for water to meet domestic, industrial, and irrigation needs. The population (both rural and urban) within the Ruvu sub-Basin is projected to rise significantly in the next 2 to 3 decades and the demands for water will greatly increase to accommodate for this growth.

While there are substantial variations of available water resources and societal needs for water in each Sub-Catchment within this basin**,** a common concern about meeting the future demand for water and maintaining the water quality rises with the projected economic growth in the Basin. On the other hand, it is increasingly recognized through institutional changes, that allocating enough water to meet the environmental needs is critical for the provision of a wide range of ecosystem services (e.g. hydrological services, carbon-related services, timber and non-timber forest products, nature-based tourism services, fisheries, wildlife habitat and biodiversity). Valuation studies focusing on these ecosystem services can quantify their contributions to human wellbeing in order to take actions to sustain them (e.g. designing suitable payment for ecosystem services program).

Based on the preliminary achievements of the Equitable Payments for Watershed Services (EPWS) program, it is feasible that similar programs can be extended to other sub-catchments in the Ruvu Basin. Incentives for other potential ecosystem services that have increasing demands can be combined into the existing framework to develop a more stable institutional framework for ensuring continuation of these types of programs. Integrating multiple ecosystem services into a synergistic framework can potentially increase ecological connectivity among different watersheds and ecological boundaries to reduce soil erosion and increase net primary production (e.g. by reducing water deficiency and improve water quality for human, animal and plant consumption).

Given the competing demands for water in the Ruvu basin, which comprises a wide variety of human and environmental needs (e.g. domestic use, agriculture, industry, livestock, mining, water quality, flood control etc.), developing an Integrated Hydro-Economic Model for the basin will be quite useful. The objective of the Integrated Hydro-Economic Model is to capture and quantify the interactions between water and the economy to ensure optimal management of water resources. Diverse social and environmental needs for water use can be incorporated into this type of modeling framework to evaluate and compare diverse strategies for water resource management in the Basin. Output from these types of integrated hydro-economic models can also provide key information and basis to effectively engage stakeholders to prioritize water allocation across different groups and sectors in the Wami/Ruvu Basin.

This report has been created by Nadia Seetaram and Pollob Mozumdar.

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Chapter 1: Introduction and Background

1.1. Statement of Objectives

The Ruvu River sub-Basin is one of the most important river systems in Tanzania, overlapping with areas of critical ecological significance (high level of biodiversity) and economic activities with national importance. The largest city of Tanzania, Dar-es-Salaam (DSM, with a population more than 3 million) and a number of smaller towns (Morogoro, Kibaha and Bagamoyo) rely on the Ruvu River system for water to meet domestic, industrial, and irrigation needs. Against this backdrop, the objective of this study is to conduct a review of the socio-economic conditions of the Ruvu River sub-Basin and its linkages to the ecosystem services it provides to the local society and economy.

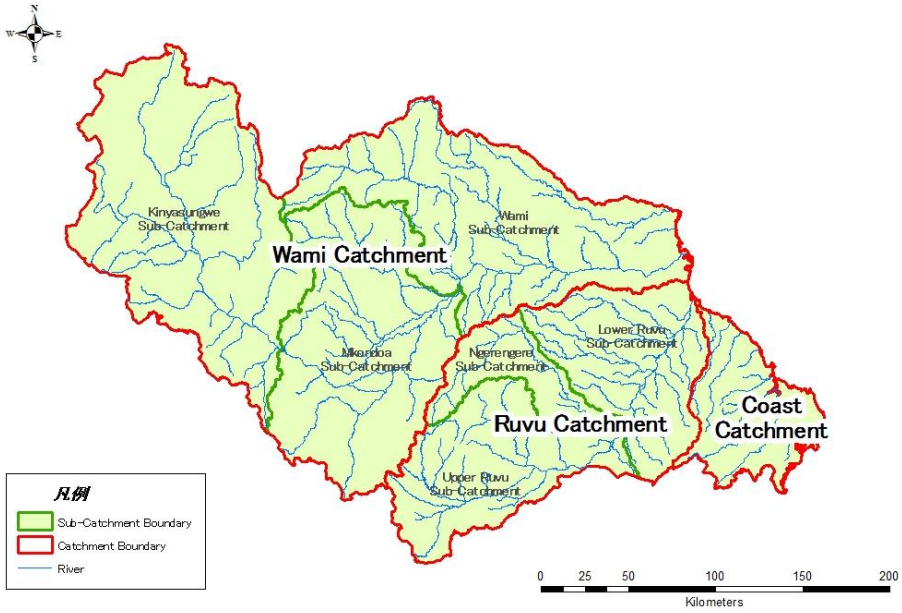
1.2. The Characteristics of Ruvu River Sub-Basin

The total landmass of Tanzania is divided into nine basins (see Figure1.1). The Wami/Ruvu basin which is located in the east-central part of the country comprises an area of 66,295km^2. The Wami/Ruvu basin is divided into three catchments of Wami, Ruvu and Coast. Both the Wami and Ruvu basin are divided into three Sub-Catchments. Kinyasungwe, Mkondoa and Wami from the upstream are the three Sub-Catchments of the Wami and Upper Ruvu, Ngerengere and Lower Ruvu are the three Sub-Catchments of Ruvu. The Coast catchment is also a Sub-Catchment in the Wami/Ruvu Basin. Altogether the Wami/Ruvu Basin is divided into seven (7) Sub-Catchments as shown in Figure 1.2.

Source: JICA 2013

Figure 1.1 River Basin in Tanzania

Figure 1.2. Catchment Boundaries of Wami/Ruvu Basin



Source: JICA (2013)

The land use and land cover types in the Wami/Ruvu Basin are presented shown in Figure 1.3. As seen from Table 1.1, bush land (30.06 %) and wood land (29.88 %) comprise the leading portion of the Basin followed by agricultural land use (16.29 %) and forest cover (11.28 %). The other environmental attributes (e.g. meteorology, hydrology, geology, geography) are quite diverse in the basin and so is the distribution of rainfall within the basin. As seen in Figure 1.4, the annual rainfall in the Wami/Ruvu Basin is 961mm. However the annual rainfall in the Coast area is around 800-1000mm, but it is less than 600mm inland. There is only one rainfall season inland (in December) but the rest of the Basin typically has two rainfall seasons (in April and December) and there is very little rain in the dry season (June to September).

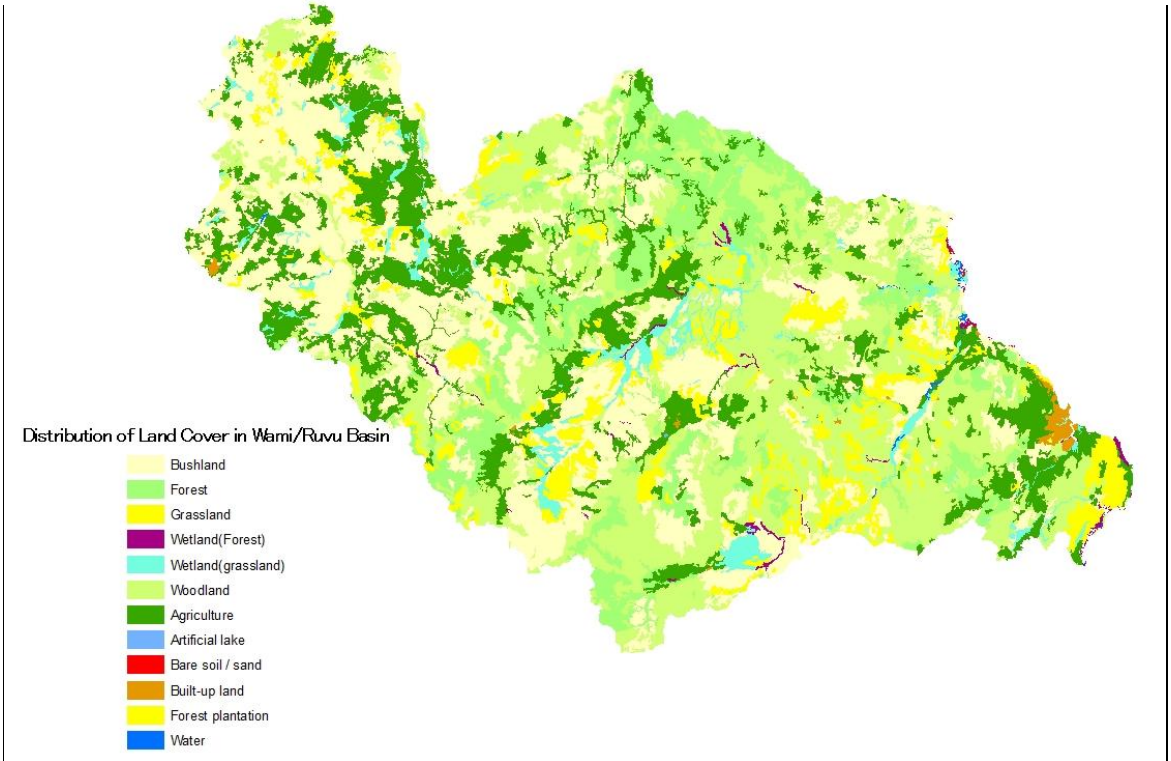
Table 1.1 Land Cover Type and Area Size in Wami/Ruvu Basin (2002)

Cover type	Area (km^2)	Area in Percent (%)
Land Cover	Area	%
Bushland	15798.35	23.84
Agriculture	7490.578	11.30
Grassland	12153.53	18.34
Mangrove	50.82	0.08
Forest	2389.63	3.61
Swamp	113.67	0.17
Plantation	93.08	0.140
Urban	190.22	0.29
Water	31.92	0.05
Woodland	27957.20	42.19
	66269	100
Total	15798.35	23.84

(Based on the 2005 Classification for the WR basin from FAO-AFRICOVER dataset)

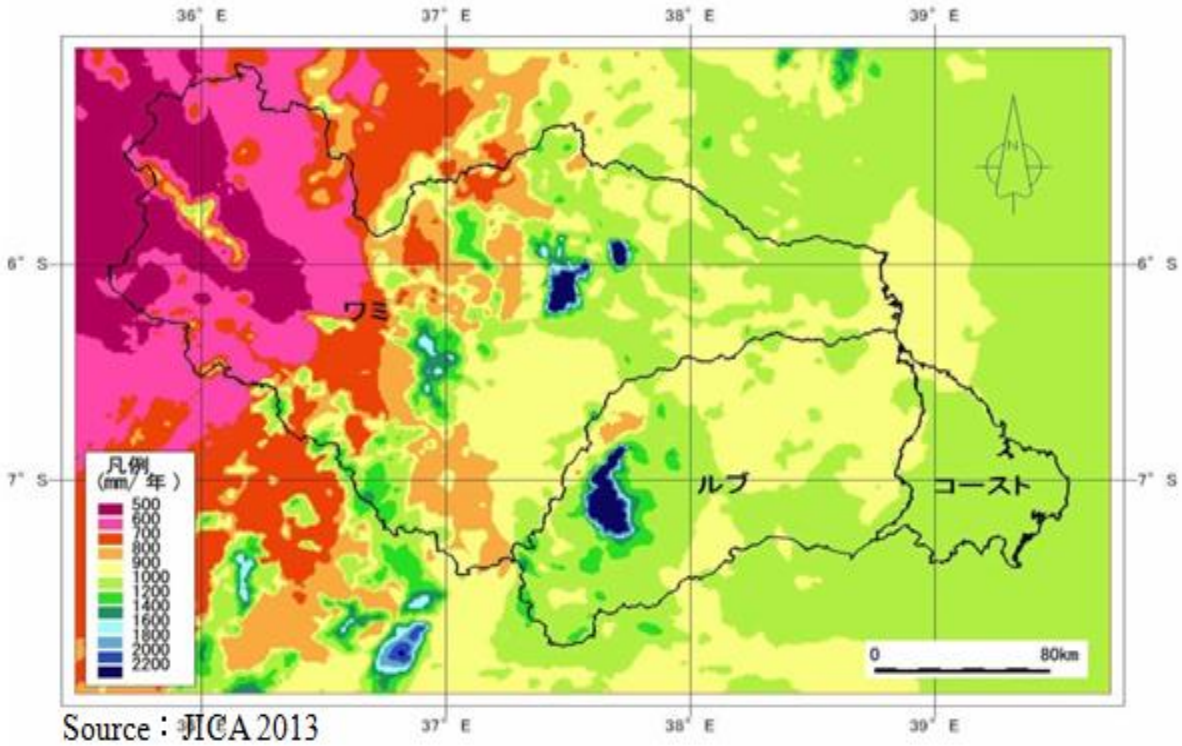
In terms of water use, irrigation is the largest sector that consumes the highest proportion of water in the Wami/Ruvu Basin. Its water usage ratio was 60.01% out of the total water use in 2011 (JICA 2013). The proportion of industrial water usage was 4.86% in 2011 but it is projected to rise to 16.14% by 2035 (JICA 2013). The irrigation uses are mostly in rural areas while industrial demands are concentrated in urban areas of DSM and Morogoro. While there are substantial variations of available water resources and societal needs for water in each Sub-Catchment within this basin**,** a common concern about meeting the future demand for water and maintaining the water quality rises with the projected economic growth in the Basin. On the other hand, it is increasingly recognized through institutional changes that allocating enough water to meet the environmental needs is critical for the provision of a wide range of ecosystem services (e.g. hydrological services, carbon-related services, timber and non-timber forest products, nature-based tourism services, fisheries, wildlife habitat and biodiversity).

Figure 1.3 Map of Land Cover in Wami/Ruvu Basin



(Source: National Land Use Framework Plan Volume I, 2009; Extracted from JICA 2013).

Figure 1.4 Distribution of Annual Mean Rainfall in Wami/Ruvu Basin



1.3. Relevant Water Resource Management Policies in Tanzania

The National Water Policy (2002) and the Water Resources Management Act of 2009 provide the legal and institutional basis that recognizes the environmental demand for water in Tanzania. In terms of priorities, the environmental need is considered second in importance after the basic human needs for water. The National Water Sector Development Strategy (2006-2015) and the Water Sector Development Program (2006-2025) have emphasized the need for sustainable management of the nation's water resources and underscore the role of effective coordination among various sectors. These policies also have emphasized a focus on the river basin as a planning unit to facilitate integrated and inter-sectoral water resource planning. Participatory processes with community involvement are highlighted as a vehicle for integrated water resource management for sustainable development in the region.

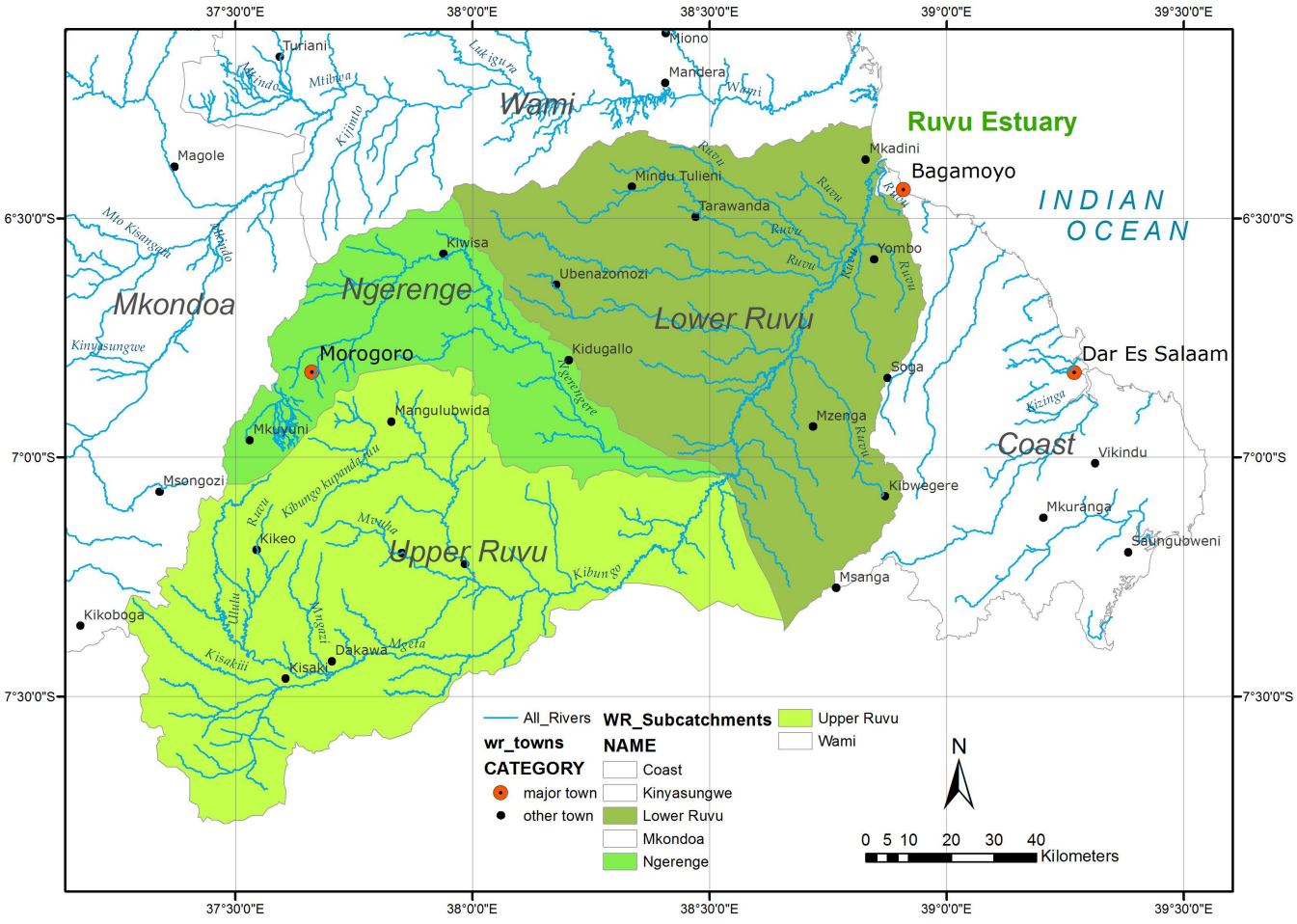


Fig 1.5: Subbasins in Ruvu River Basin, Tanzania. Map credit: Amartya Saha, Florida Internionl University

Chapter 2: Population distribution and potential for growth, assessment of basic needs as related to freshwater

2.1. Introduction

Several districts surround the Ruvu River, while many others are included within its sub-Basin. Figure 2.1 depicts these districts and some of their main towns. The main regions shown in this map are the Morogoro and Coast regions. However, the city of Dar es Salaam relies heavily on the Ruvu for various uses, though it is not located within the sub-basin. Chapter 3, which discusses water demands on the Ruvu, will incorporate more information on Dar es Salaam. For the purposes of the socio-economic context within the immediate regions, this chapter focuses on 7 districts within the Morogoro and Coast regions. In Morogoro, these districts are Kilosa, Morogoro Rural, Mororgoro Urban, and Mvomero, while in the Coast region, the districts include Bagamoyo, Kibaha, and Kisarawe.

Figure 2.1

2.2. Population within the Ruvu Sub-Basin

Along with the expected population growth of Tanzania, the population of the regions dependent on the Ruvu-sub basin is also projected to augment significantly within the next 25 years. Current estimates approximate the population of the regions supported by the Ruvu sub-basin at 5,747,835 in 201l (Kadigi, 2012). Recent estimates suggest that by 2025, the total population (rural and urban) dependent on the Ruvu sub-basin will total 8,317,622 (*ibid*), which represents a **44.71% population increase** by 2025. See Table 2.1 for more details

Table 2.1: Projected human population of the regions dependent on the Ruvu sub-basin.

Region	2002	2005	2010	2011	2015	2020	2025
Morogoro							
Urban	333,294	359,587	411,064	421,875	466,080	523,838	586,513
Rural	830,075	895,558	1,023,763	1,050,688	1,160,781	1,304,627	1,460,721
Sub-Total	**1,163,369**	**1,255,145**	**1,434,827**	**1,472,563**	**1,626,861**	**1,828,465**	**2,047,234**
Coast							
Urban	144,569	155,974	178,303	182,992	202,166	227,219	254,405
Rural	417,440	450,371	514,845	528,385	583,750	656,090	734,589
Sub-Total	**562,009**	**606,345**	**693,148**	**711,377**	**785,916**	**883,309**	**988,994**
Dar es Salaam							
Urban	2,289,388	2,602,584	3,166,426	3,280,418	3,738,945	4,296,706	4,861,324
Rural	197,837	224,902	273,626	283,477	323,100	371,299	420,090
Sub-Total	**2,487,225**	**2,827,486**	**3,440,052**	**3,563,895**	**4,062,045**	**4,668,005**	**5,281,414**
Total Urban	**2,767,251**	**3,118,145**	**3,755,793**	**3,885,285**	**4,407,191**	**5,047,763**	**5,702,242**
Total Rural	**1,445,352**	**1,570,831**	**1,812,234**	**1,862,550**	**2,067,631**	**2,332,016**	**2,615,400**
TOTAL	**4,212,603**	**4,688,976**	**5,568,027**	**5,747,835**	**6,474,822**	**7,379,779**	**8,317,642**

Source:(Kadigi, 2012)

While observing population trends at the regional level gives an accurate representation of the pressure from growing populations the Ruvu will likely observe over the next several years, population data according to distance within from the Ruvu River also achieves a similar effect. Table 2.2 featured below displays the population within 400, 1,000, and 3,000 meters from the Ruvu River, current day (2010-2013). Figure 2.2 displays population data within the wards of the Ruvu sub-basin.

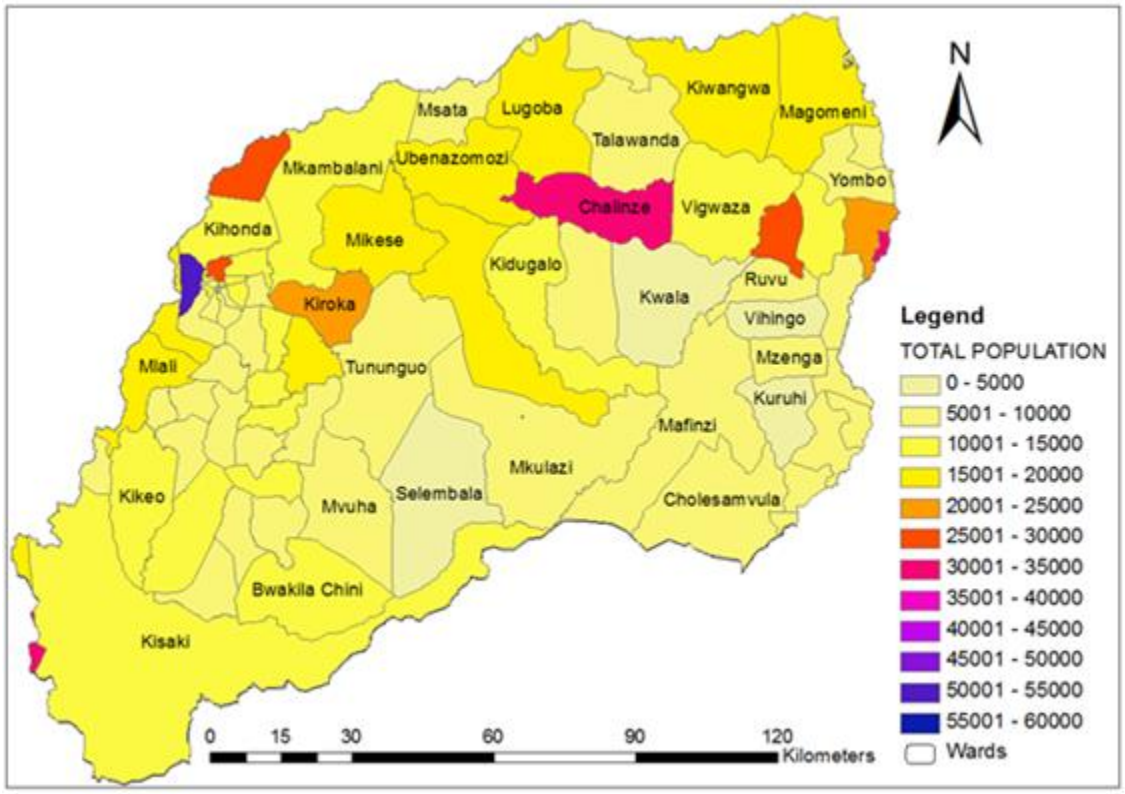
Table 2.2. Population data by distance from the Ruvu River

Population data by distance from the Ruvu River			
Year	**Within 400m**	**Within 1,000m**	**Within 3,000m**
2010	154,157	365,545	739,188
2011	157,703	373,953	756,189

2012	161,330	382,553	773,582
2013	165,040	391,352	791,374

Source: David Taylor, 2013

Figure 2.2: Population data within the Wards of the Ruvu sub-basin



2.3. Population of Districts/Municipalities along the Ruvu River

The seven districts examined in detail by this report are spread across the Morogoro and Coast regions. These regions are both divided into 4 and 5 districts/municipalities, respectively. However, for the purpose of this report, only 7 of these districts/municipalities are relevant, because they fall along the banks of the Ruvu. The parts of Morogoro Region falling within the Ruvu Basin is composed of the Morogoro Urban, most of Morogoro Rural, and small parts of Kilosa, and Mvomero districts/municipalities (JICA, 2013). The parts of Coast Region falling within Ruvu Basin includes part of Bagamoyo, most of Kibaha, and part of Kisarawe. Population approximations in the Morogoro region suggest that the population total between the four districts/municipalities was 1,414,886 in 2011 and that the projected population would reach 2,228,028 in 2035 (JICA, 2013). While the population of 1,414,886 within the Morogoro Region accounts more a few hundred thousand more people living outside the Ruvu sub-basin, the increase in population from 2011 to 2035 represents a **57.47% increase** in population. Population estimations in Bagamoyo, Kibaha, and Kisarawe in the Coast region show that the population was 591,185 in 2011, and is projected to rise to 1,029,731 by 2035, which represents a **42.59% increase** over 24 years. As for total population in Morogoro and the Coast, the population is estimated at 3,823,715 in 2011 and would grow to 6,187,314 people by 2035 (*ibid*), representing a **61.81% increase**. See Table 2.3 for more details.

2.4. Review of Socioeconomic Conditions within the Selected Districts/Municipalities

The regional economies of these districts are dominated primarily by agriculture, industry, and livestock production. As such, the following review of economic production within these districts focuses on these sectors with consideration to the fishing/aquaculture and mining sectors, and the water infrastructure that makes some of this economic production possible. The report also considers the distribution of health care and education facilities across the districts as a primary indicator of socio-economic conditions in the regions.

Table 2.3: Projected human population in the Districts/Municipalities dependant on the Ruvu River

Region	District	2011	2015	2020	2025	2030	2035
Morogoro							
	Kilosa	495,393	538,071	591,980	649,439	711,777	780,098
	Morogoro Rural	291,921	317,070	348,837	382,696	419,429	459,689
	Morogoro Urban	318,761	346,223	380,910	417,883	457,994	501,955
	Mvomero	308,811	335,415	369,020	404,838	443,697	486,286
Sub-Total Coast		**1,414,886**	**1,536,779**	**1,690,747**	**1,854,856**	**2,032,897**	**2,228,028**
	Bagamoyo	288,801	319,062	358,601	401,506	449,413	503,036
	Kibaha*	188,427	208,171	233,968	261,961	293,218	328,204
	Kisarawe	113,957	125897	141499	158428	177332	198491
Sub-Total		**591,185**	**653,130**	**734,068**	**821,895**	**919,963**	**1,029,731**
Total		**3,823,715**	**4,171,647**	**4,615,662**	**5,091,541**	**5,612,502**	**6,187,314**

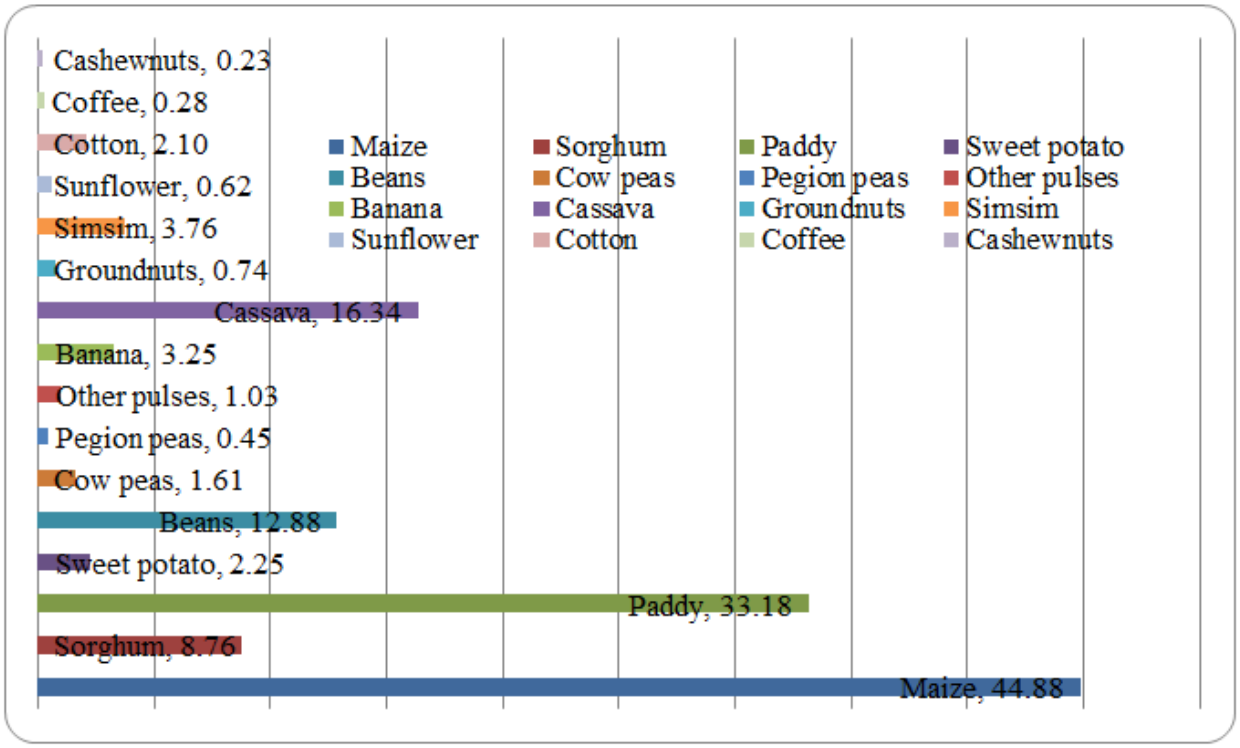
*Source:(JICA, 2013, and author's own calculation); * Kibaha data represents a sum of the Kibaha TC and Kibaha DC*

2.5. Agriculture

Commercial agriculture is the dominant source of employment for Tanzanians, as it accounts for 80% of employment, 50% of national GDP, and 66% of exports (JICA, 2013). In the Ruvu sub-basin, agriculture plays a particularly large role in the Kilosa and Mvomero districts in Morogoro. These districts are considered "wetter districts," since they receive high levels of rainfall and their location near the river valley of the Ruvu endows them with fertile soil (*ibid*). Many smaller scale farmers rely on rain fed agriculture as their main source of irrigation within the sub-basin .However, irrigation schemes do exist in the areas surrounding the highlands of the Uluguru Mountains, particularly in Mgeta where rainfall is not as consistent (Reuben, 2013).

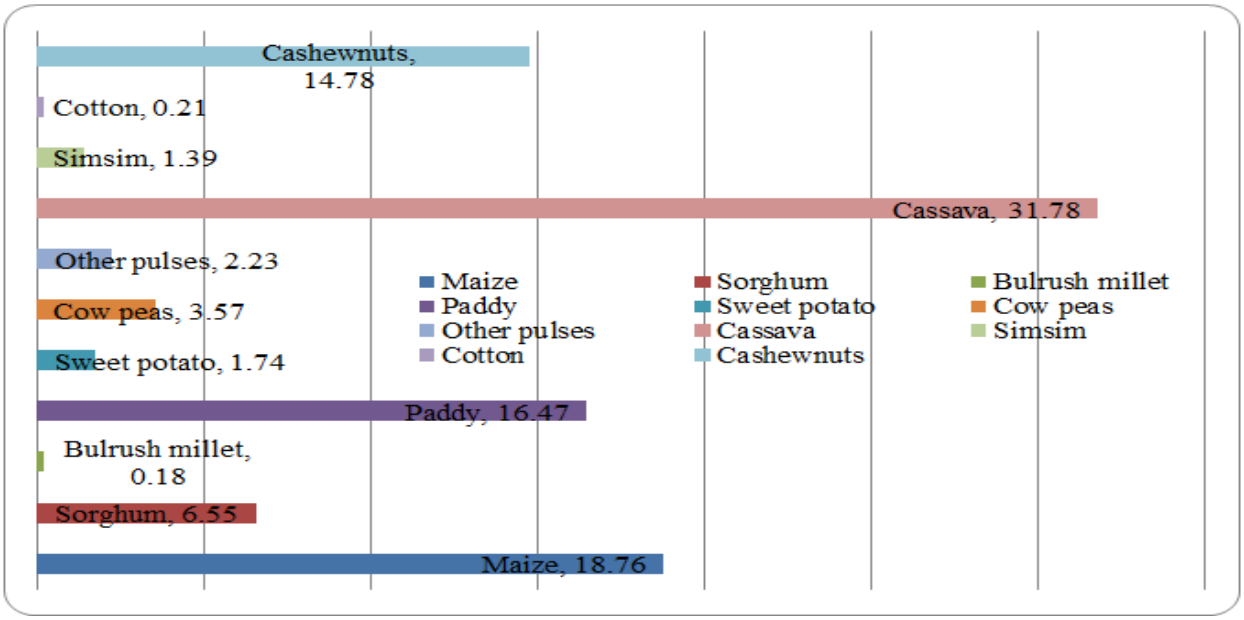
In the Morogoro region, paddy, beans, and maize are the most widely produced crops, while in the Coast region, simsim (an oilseed crop), maize, and sweet potato are the top three crops. Figures 2.3 and 2.4 display the distribution of these crops across their respective regions.

Figure 2.3: Average annual area by crop production in Morogoro region (1995 – 2005) in Thousand Hectares



Extracted from (Kidigi, 2012)

Figure 2.4: Average annual area towards crop production in Coast region (1995 – 2005) in Thousand Hectares



Extracted from (Kidigi, 2013)

2.6. Industry

Industry plays a major role in the Ruvu sub-Basin and is especially concentrated along the coastal rivers in Dar es Salaam. Textiles, pharmaceuticals, sisal production, breweries, soaps, cigarettes are all produced within the basin, resulting in effluent discharge into the surface waters along the river (JICA, 2013). Since enforcement through prosecution of organizations for violating established effluent guidelines is nonexistent, industrial effluents constitute the largest conflict in the Ruvu sub-Basin (*ibid*). Table 2.4 displays the industries within the Ruvu basin and the bodies of water their effluent is discharged into.

Table 2.4: Industries within Ruvu sub-Basin

Name of Industry	Location	Production	Discharging Bodies
Canvas mill	Morogoro Textiles		Ngerengere river
21st Centuery	Morogoro Textiles		Ngerengere river
Highland Sisal Estate	Morogoro	Sisal	Ngerengere river
Tungi sisal Estate	Morogoro	Sisal	Ngerengere river
Tanzania Plastic Manufacturer (1998)	Morogoro	Magunia	Ngerengere river
Royal diary	DSM	Milk, Juice and Cream	Ground water
Dar Breweries	DSM	Chibuku	Ground water
Tanzania Breweries limited	DSM	Beer	Msimbazi River
Tanpak Tz, Sabuni Detergent BIDCO, Cocacola (kwanza), Mikocheni WSP	DSM	Domestic Sewages & Mwenge and Mikocheni Industries effluents	Mlalakua River
Tradeco, Nida Textile, Associate breweries(Serengeti)	DSM	Beer, Textile	Kibangu River
Karibu Textile Mill	DSM	Textiles	Kizinga River
Urafiki Textile Mill	DSM	Textiles	Groundwater
East Hide Group	Morogoro	Ngozi	Ngerengere river
Tanzania Cigarette	DSM	Cigarette	Groundwater
Tanzania Lather associate Industry	Morogoro	Industrial effluent and Domestic Sewage (TLAIWSP)	Ngerengere river
Mansor Daya Chem	DSM	Pharmaceutical	Groundwater
Mkwano	DSM	Soap	Groundwater
Mabibo wastewater sewage pond	DSM	Domestic Seawge	Groundwater
Vingunguti WSP	DSM	Domestic Sewage	Groundwater
Alliance One Tobacco Processor	Morogoro	Tobacco	Groundwater

Extracted from (Kadigi, 2012)

2.7.Livestock

The production of livestock also accounts for significant economic activity in the Ruvu sub-Basin, by contributing to approximately 18% of national GDP and 30% of agricultural GDP, according to the National Sample Census of Agriculture in 1994/1995 (JICA, 2013). National estimates place total cattle and total goat and sheep populations at 21.3 million and 15.2 million, respectively, in 2007 and 2008. As for the Wami/Ruvu Basin, estimates in 2011suggest that 1.15 million cattle and 1.04 million goats and sheep were being raised. Table 2.5 displays the projected populations for cattle, while Table 2.6 displays the projected population for goat and sheep in the Morogoro and Coast Regions. Estimates show the total population of cattle in

Morogoro and the Coast was 400,223 in 2011, while projections show that this number is likely to increase to 758,564 in 2035, which represents an **89.53% increase** (JICA, 2013).Likewise, estimates show the total population of goat and sheep in Morogoro and the Coast was 266,977 in 2011, while projections show that this number is likely to increase to 506,015 in 2035, which also represents an **89.53% increase** in goat and sheep over the next 24 years.

Table 2.5 : Population Estimates for Cattle in the Morogoro and the Coast Regions

Regions	Category	2011	2015	2020	2025	2030	2035
Morogoro	Indigenous	265,500	295,356	337,441	385,523	440,456	503,216
	Improved Beef	792	881	1,006	1,150	1,314	1,501
	Improved Dairy	3,977	4,424	5,055	5,775	6,598	7,538
	Subtotal	270,269	300,661	343,502	392,448	448,368	512,255
Coast	Indigenous	114,860	127,776	145,983	166,784	190,548	217,700
	Improved Beef	581	646	738	843	964	1,101
	Improved Dairy	145,13	16,145	18,446	21,074	24,077	27,508
	Subtotal	129,954	144,567	165,167	188,701	215,589	246,309
	Total	**400,223**	**445,228**	**508,669**	**581,149**	**663,957**	**758,564**

Source: *(JICA, 2013 and author's own calculation)*

Table 2.6: Population Estimates for Goat and Sheep in the Morogoro and the Coast Regions

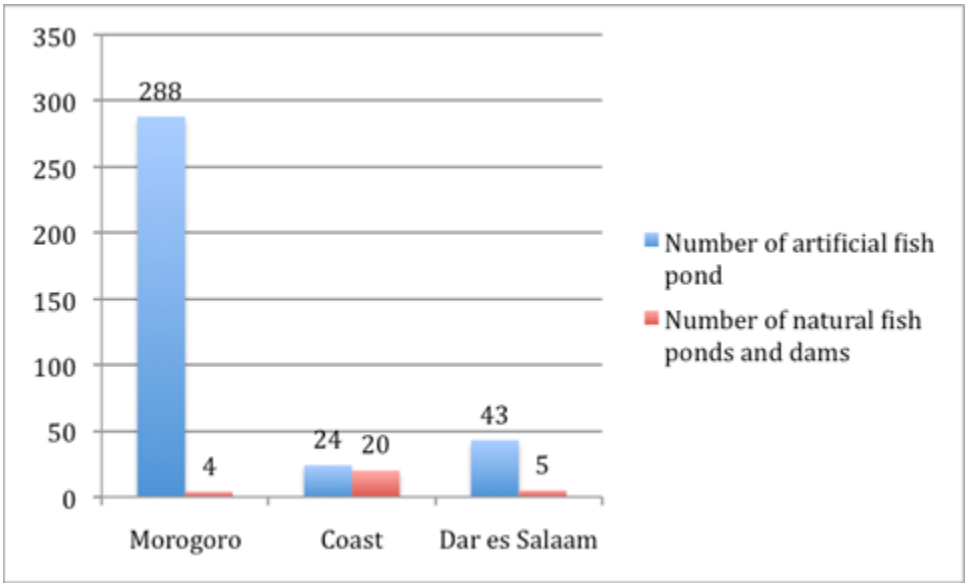
Regions	Category	2011	2015	2020	2025	2030	2035
Morogoro	Indigenous	139,783	155,502	177,659	202,974	231,896	264,938
	Improved Meat	0	0	0	0	0	0
	Improved Dairy	23,812	26,490	30,265	34,577	39,504	45,133
	Subtotal	163,595	181,992	207,924	237,551	271,400	310,071
Coast	Indigenous	87,552	97,397	111,275	127,131	145,245	165,941
	Improved Meat	9,585	10,663	12,182	13,918	15,902	18,167
	Improved Dairy	6,245	6,947	7,937	9,068	10,360	11,836
	Subtotal	103,382	115,007	131,394	150,117	171,507	195,944
	Total	**266,977**	**296,999**	**339,318**	**387,668**	**442,907**	**506,015**

Source: *(JICA, 2013 and author's own calculation)*

2.8. Fishing

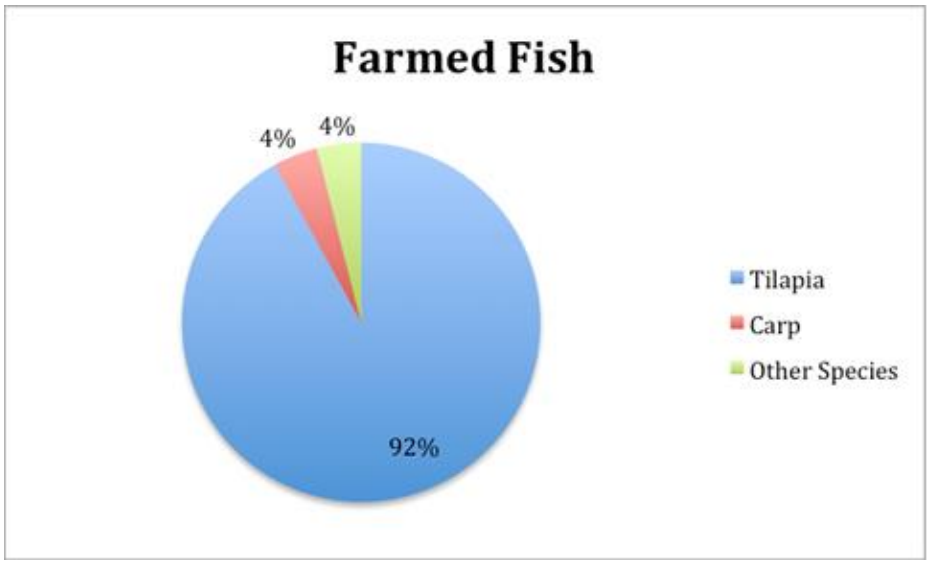
In comparison to other economic sectors, fishing is not as dominant in the Ruvu sub-Basin. Despite this, fishing does provide both employment and food to a significant amount of households, as an estimated 60% of fish farmers raise fish for their own consumption (JICA, 2013). However, aquaculture has been growing an economic sector, as the amount of aquatic ponds used to farm fish outnumbers the natural sourced fish, especially in Morogoro (See Figure 2.5). Artificial fish ponds refer to ponds that are usually created through carving out holes within the ground, while natural ponds refer to naturally occurring water resources such as "numerous river catchments, wetlands, coast lines, and inland lakes (*ibid*). Tilapia is overwhelmingly the most widely fished species, representing 92% of all farmed raised fish in Tanzania's fishing industry (ibid). See Figure 2.6 for more details.

Figure 2.5: Number of artificial ponds versus natural ponds for fishing in Ruvu Sub Basin



Source: (JICA, 2013)

Figure 2.6: Percent of Farmed Fish in Ruvu Sub-Basin



Source: (JICA, 2013)

2.9. Mining

The mining industry in Tanzania grew steadily over the last 15 years. The sector saw a 3% growth from 7.7% to 10.7% in 2001 (JICA, 2013). Consequently, the sector's contribution to GDP increased from 1.4% to 2.7% in 2001. Since then, the mining industry has declined in the Ruvu, though the government has implemented policies through the National Strategy of Growth

and Reduction of Poverty (NSGRP) to strengthen the sector (*ibid*). Table 2.7 displays the estimated water demand to support mining in Morogoro, Dar es Salaam, and the Coast regions.

Table 2.7: Estimated current water demand for mining in the Ruvu Basin.

Region	Material mined/ quarried	Production (Ton)	Water requirement	
			Per unit (m^3/ton)	Total (m^3)
Morogoro	Mineral aggregates	4,199.4	0.4	1,680
Morogoro	Copper ore	40.0	0.4	16
DSM and Coast	Calcite	152.0	0.2	30
DSM and Coast	Limestone	84.3	0.2	17
DSM and Coast	Mineral aggregates	9,216.0	0.4	3,686
DSM and Coast	Galena	22,423.0	0.2	4,485
DSM and Coast	Marble	3.3	0.2	1
DSM and Coast	Geological samples	41.8	0.4	17
Total				**9,931**

Source: Extracted from (Kadigi, 2012)

2.10. Water Infrastructure

The Mindu Dam is the major water infrastructure in the Ruvu sub-Basin, located in the Morogoro region. The dam has an estimated current capacity of 13 million m^3 (Ngana, Mahay and Cross, 2010), and its primary purpose was to meet the water demands of Morogoro through the Morogoro Urban Water Supply Authority (MORUWASA) (*ibid*). MORUWASA provides 94% of Morogoro's water supply, of which 75% comes from the Mindu Dam (*ibid*). Currently, the Tanzanian government is preparing to construct another dam, in Kidunda. The proposed Dam at Kidunda in the Morogoro region is another solution the Tanzanian government developed in order to account for the increase in water demand that the regions will see over the next 30 years. The dam will mostly provide water to Dar es Salaam, Bagamoyo, Kibaha, and other surrounding areas (*ibid*). One of the main justifications for the building of this dam included the scarcity of water during the Ruvu dry season, as well as the river's vulnerability to "climate shocks" like droughts (DAWASA, 2008). Irrigation schemes are also present within the Ruvu sub-Basin, which are normally run by the communities and more prevalent in the lowlands of the sub-basin. Table 2.8 lists these schemes in the Bagamoyo and Kibaha districts and the amount of hectares that receive water from these projects.

Table 2.8: Irrigation Scheme within the Ruvu sub-Basin

District	Name of the scheme	Irrigated area (Ha)
Bagamoyo	Ruvu (Chauru)	720

District	Name of the scheme	Irrigated area (Ha)
	Bagamoyo (B.I.D.P.)	60
	Msoga	150
Kibaha	Kwamfipa	10
	Mkuza	300
	Mwanabwito	5
	Mwendapole	5
	Viziwaziwa	5
Total		**1,255**

Source: Extracted from (Kadigi, 2012)

2.11. Health Facilities

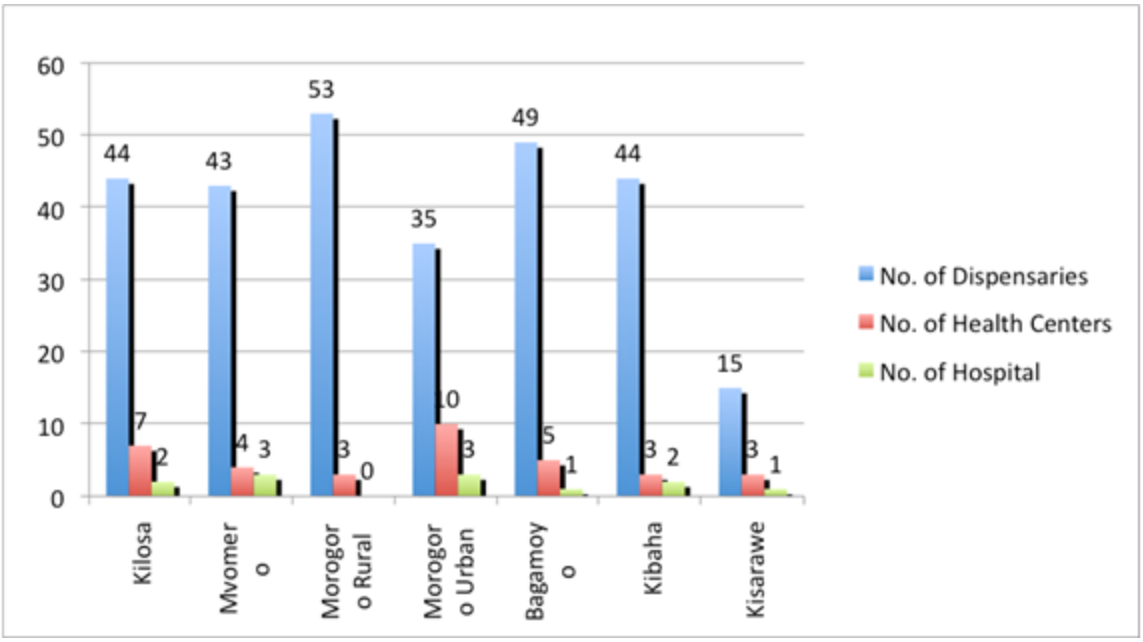
The health services provided in the Ruvu Basin is segmented into a referral system that begins with the dispensary, where 90% of primary care illnesses are handled (JICA, 2013). The remaining 10% of cases are distributed across health centers and hospitals. Table 2.9 shows that the total number of dispensaries in the seven districts is 283, with 35 health centers, and only 12 hospitals. See Figure 2.7 for more details on this distribution.

Table 2.9: Number of Health Care Facilities across the Selected Districts

Districts	No. of Dispensaries	No. of Health Centers	No. of Hospital
Kilosa	44	7	2
Mvomero	43	4	3
Morogoro Rural	53	3	0
Morogoro Urban	35	10	3
Bagamoyo	49	5	1
Kibaha	44	3	2
Kisarawe	15	3	1
Total	**283**	**35**	**12**

Source: (JICA, 2013)

Figure 2.7 Distribution of health facilities across the selected districts



Source: JICA, 2013

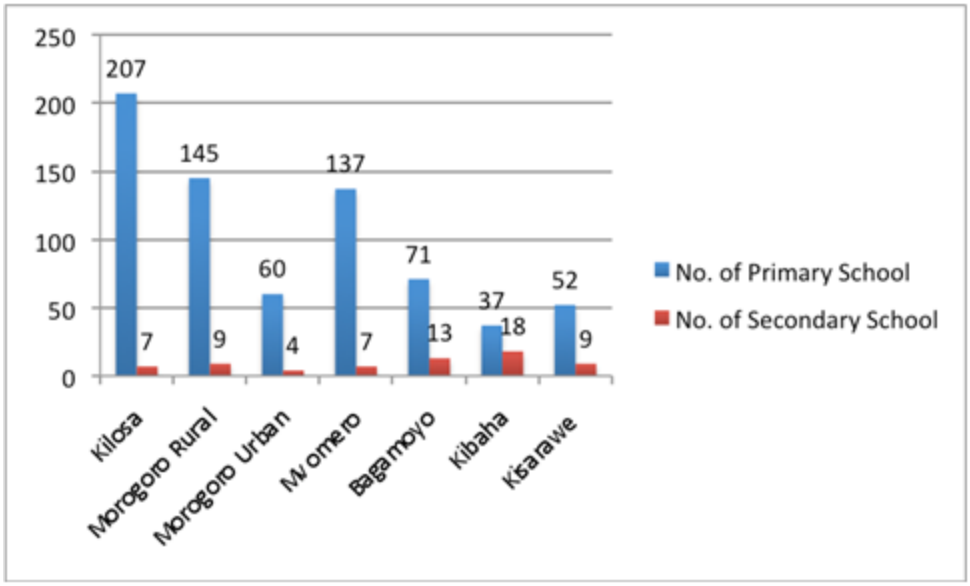
2.12. Education Facilities

As for the education facilities located throughout the selected districts, the amount of primary schools outnumbers the secondary schools by a substantial extent. Table 2.10 shows that the total number of primary schools totaled 709, while the number of secondary school was significantly less with 67 schools, throughout the districts. See Figure 2.8 for more details on the distribution of these facilities.

Table 2.10: Number of Education Facilities across the Selected Districts

Districts	No. of Primary School	No. of Secondary School
Kilosa	207	7
Morogoro Rural	145	9
Morogoro Urban	60	4
Mvomero	137	7
Bagamoyo	71	13
Kibaha	37	18
Kisarawe	52	9
Total	**709**	**67**

Figure 2.8: Distribution of educational facilities across the selected districts/municipalities



Source: JICA, 2013

Conclusion

The population (both rural and urban) within the Ruvu sub-Basin is projected to rise about 45% over the next 24 years, and consequently so will its major economic sectors (agriculture, industry, and livestock). As such, the demands on the Ruvu River will greatly increase in order to supply the necessary amounts of water to accommodate for this growth. The following chapter discusses the current and future demand for water in the Ruvu sub-Basin.

Chapter 3: Current and Future Water Demand by Productive and Economic Sectors

3.1 Present and Future Water Demand by Sectors and Across Districts

As the population and the economic sectors continue to rise, the demands for water on the Ruvu will subsequently rise. From domestic water use to mining, the Ruvu will have to provide substantial amounts of water to various dependents. The following sections outline the projected water demands across the following 6 sectors: domestic use, irrigation, livestock, industry, fishing/aquaculture, and mining. The next sections include the Dar es Salaam region since it relies heavily on the Ruvu, though it is not immediately surrounding the river.

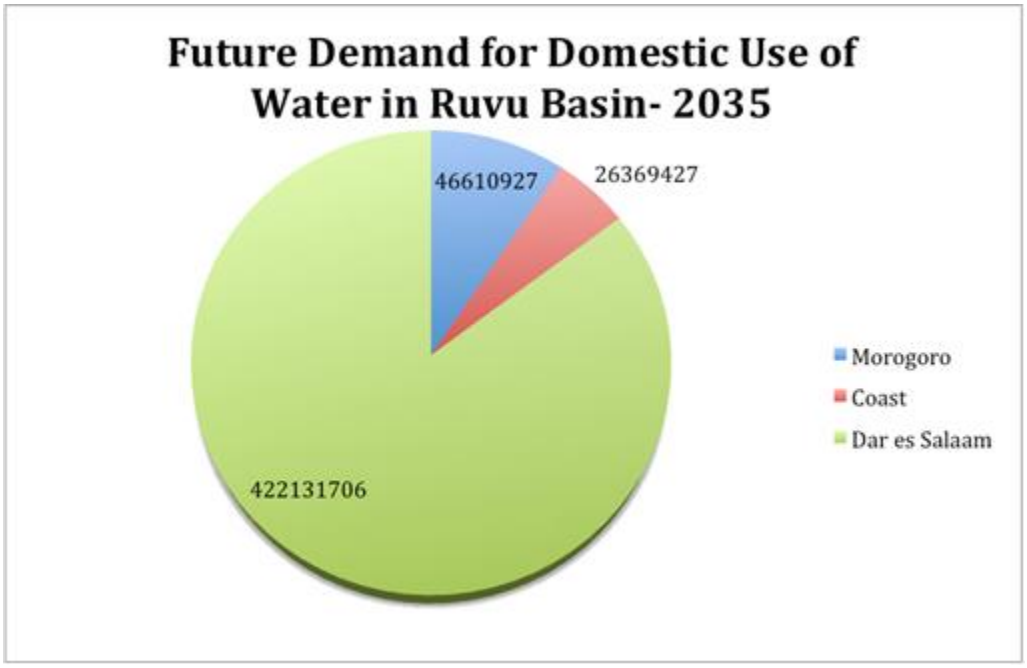
3.2 Domestic Use

The "domestic use" of water refers to the amount of water needed "for drinking, cooking, washing, cleaning, bathing, and so forth…" (JICA, 2013) for both urban and rural populations. Table 3.1 displays the current and future water demand (m^3/year) within the districts in the Morogoro, Coast, and Dar es Salaam region. The estimates were projected through the combined application of the unit consumption rate and ratio of un-accounted water for both rural and urban wards, which are determined by the National Bureau of Statistics (*ibid*). Estimates place the total water demand for domestic use in 2011 at 269,449,195 m^3/year and projections estimate that this demand will reach 495,112,060 m^3/year in 2035, which represents an **83.75% increase** in the demand for the domestic use of water. Figure 3.1 displays a pie chart of the overwhelming amount of water demand that will come from the Dar es Salaam region in 2035.

Table 3.1: The Current and Future Demand of Water for Domestic Use (m^3/year)

Region	District	2011	2015	2020	2025	2030	2035
Morogoro	Kilosa	6,397,851	6,949,029	7,645,247	8,387,317	9,192,385	10,074,729
	Morogoro Rural	2,982,976	3,239,961	3,564,570	3,910,558	4,285,918	4,697,308
	Morogoro Urban	16,705,645	18,144,843	19,962,763	21,900,405	24,002,547	26,306,465
	Mvomero	3,513,308	3,815,981	4,198,302	4,605,801	5,047,895	5,532,425
	Subtotal	**29,599,780**	**32,149,814**	**35,370,882**	**38,804,081**	**42,528,745**	**46,610,927**
Coast	Bagamoyo	7,876,007	8,701,270	9,779,547	10,949,636	12,256,128	13,718,508
	Kibaha	3,248,187	3,588,538	4,033,236	4,515,799	5,054,616	5,657,725
	Kisarawe	1,680,959	1,857,093	2,087,227	2,336,957	2,615,799	2,927,911
	Mukuranga	2,333,942	2,578,497	2,898,029	3,244,768	3,631,928	4,065,283
	Sub-total	**15,139,095**	**16,725,398**	**18,798,039**	**21,047,160**	**23,558,471**	**26,369,427**
Dar es Salaam	Kidondoni	133,939,963	152,661,684	175,435,165	198,488,598	223,478,294	251,614,190
	Illala	52,087,266	59,367,865	68,224,135	77,189,273	86,907,395	97,849,028
	Temeke	38,683,091	44,090,096	50,667,287	57,325,330	64,542,583	72,668,488
	Subtotal	**224,710,320**	**256,119,645**	**294,326,587**	**333,003,201**	**374,928,272**	**422,131,706**
	Total	**269,449,195**	**304,994,857**	**348,495,508**	**392,854,442**	**441,015,488**	**495,112,060**

Figure 3.1: Water Demand for Domestic Use in Ruvu Basin- 2035



3.3. Irrigation for Agriculture

As previously stated, agriculture contributes to a significant amount of the Tanzanian GDP, and like other economic sectors, it will continue to grow and thereby demand more water for irrigation. Agriculture is most prevalent in the Coast and Morogoro regions, where paddy, maize, and beans and vegetables are widely produced. Table 3.2 displays the net water requirement for the growth of paddy, maize, and bean and vegetables in (mm/month) by season. Table 3.3 displays the current and future demand for water for irrigation in certain districts within the Morogoro and Coast Regions, along with the projected irrigated area.

Table 3.2: Net water requirement for the growth of crops in (mm/month) throughout the year

Region	Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Morogoro	Paddy	325	221	178	85	133		279	210	245	237		
	Maize	34	111	109	25	66		86	104	177	175	161	
	Bean and Vegetables	42	99	104	39	65		87	104	154	158		
Coast	Paddy	366	255	182	78	131		322	246	275	249		
	Maize	64	138	112	18	63		100	129	206	187	140	
	Bean and Vegetables	65	121	109	37	67		100	129	179	170		

Source: (JICA, 2013)

Table 3.3: Current and Future Demand of Irrigation Water (1,000m3/Year)

		2011		2015		2020		2025		2030		2035	
Region	District	Irrigation Area (ha)	Required Irrigation Water (1,000 m^3)	Irrigation Area (ha)	Required Irrigation Water (1,000 m^3)	Irrigation Area (ha)	Required Irrigation Water (1,000 m^3)	Irrigation Area (ha)	Required Irrigation Water (1,000 m^3)	Irrigation Area (ha)	Required Irrigation Water (1,000 m^3)	Irrigation Area (ha)	Required Irrigation Water (1,000 m^3)
Coast	Bagamoyo	1344	40001	1745	51906	2416	71886	1811	85735	3072	91404	3336	99256
	Kibaha	592	17610	768	22851	1064	31647	926	43829	2040	60701	2825	84067
	Kisarawe	-	-	-	-	-	-	-	-	-	-	-	-
	Subtotal	1936	57611	2513	74757	3480	103533	2737	129564	5112	152105	6161	183323
Morogoro	Kilosa	9202	192349	10819	226175	13259	277214	14190	339470	18578	388849	19824	415277
	Morogoro Rural	2536	53965	2996	63756	3690	78529	4128	92389	4865	103478	5337	113459
	Mvomero	7609	166108	8960	195624	10915	238440	8508	275626	13550	296566	14036	306735
	Subtotal	19347	412422	22775	485555	27864	594183	26826	707485	36993	788893	39197	835471

Source: (JICA, 2013)

3.4. Livestock

By 2035, livestock is expected to grow by 89.53% for both cattle and goat/sheep. This sharp increase in livestock production will require more water to meet this demand. Table 3.4 displays the current and projected water demand for cattle in m^3. Table 3.5 displays the current and projected water demand needed for goat and sheep production also in $m^{3.}$ The total water demand for cattle in 2011 in Morogoro and the Coast was 3,955,728 m^3, while projections show the demand will increase to 7,497,509 m^3 by 2035, representing an **89.54% increase** over the a 24 year period. · The total water demand for goat and sheep in 2011 in Morogoro and the Coast was 487, 234 m^3, while projections show the demand will increase to 923, 477m^3 by 2035, representing an **89.53% increase**.

Table 3.4: The current and projected water demand for cattle ($m^{3)}$

Region	Category	2011	2015	2020	2025	2030	2035
Morogoro	Indigenous	2,422,685	2,695,123	3,079,150	3,517,897	4,019,160	4,591,848
	Improved Beef	7,226	8,038	9,184	10,492	11,987	13,696
	Improved Daily	101,611	113,037	129,144	147,546	168,569	192,589
	Subtotal	2,531,522	2,816,198	3,217,478	3,675,935	4,199,716	4,798,133
Coast	Indigenous	1,048,093	1,165,955	1,332,091	1,521,900	1,738,755	1,986,509
	Improved Beef	5,300	5,896	6,736	7,696	8,792	10,045
	Improved Daily	370,813	412,512	471,290	538,444	615,167	702,822
	Subtotal	1,424,206	1,584,363	1,810,117	2,068,040	2,362,714	2,699,376
Total:		**3,955,728**	**4,400,561**	**5,027,595**	**5,743,975**	**6,562,430**	**7,497,509**

Source (JICA, 2013)

Table 3.5: The current and projected water demand for goat and sheep ($m^{3)}$

Region	Category	2011	2015	2020	2025	2030	2035
Morogoro	Indigenous	255,104	283,791	324,228	370,427	423,209	483,512
	Improved Meat	0	0	0	0	0	0
	Improved Daily	43,458	48,344	55,233	63,103	72,095	82,367
	Subtotal	298,562	332,135	379,461	433,530	495,304	565,879
Coast	Indigenous	159,782	177,750	203,077	232,013	265,073	302,843
	Improved Meat	17,493	19,460	22,233	25,401	29,020	33,155
	Improved Daily	11,397	12,678	14,485	16,549	18,906	21,600
	Subtotal	188,672	209,888	239,795	273,963	312,999	357,598
Total		**487,234**	**542,023**	**619,256**	**707,493**	**808,303**	**923,477**

Source (JICA, 2013)

3.5. Industry

Industry in the Ruvu is highly concentrated in Dar es Salaam and the Morogoro Region. Estimations place the current demand for water necessary to support the industrial sector at 44.15 billion m^3 in 2010, while estimations project this demand to increase to 355.17 billion m^3 by 2035. However, when a 20% growth scenario is placed on the industrial sector, this demand increases to 559.10 m^3 by 2035. Table 3.6 displays the current and future water demand for industry, while Table 3.7 displays the current and future water demand needed for the industrial sector while under a 20% growth scenario.

3.6. Fish farming and Aquaculture

The fish farming and aquaculture sector is substantially more developed in the Morogoro Region than in Dar es Salaam or the Coast Region. Since most of this sector depends on aquaculture, water is needed to fill the artificial "ponds" used to farm the fish, and then refill when taking evapo-transpiration into account (JICA, 2013). Table 3.8 displays the current and future demand of water for fish farming and aquaculture in Mororgoro, Coast, and Dar es Salaam, as well as the number of fishponds and total fishpond area per district from 2010- 2035. In 2010, total water demand across the districts was estimated at 108,392 m^3, while in 2035 projections estimate that the water demand will total 167,244 m^3, which represents a **54.3% increase** by 2035.

3.7. Mining

As previously stated, mining is the only sector that currently is projected to decrease in productivity, which results in a decreased demand in water in the future. However, these trends could change depending on business interests and resources in Tanzania. Table 3.9 displays the current and future demand for water in the mining sector by region, along with material mined, production in 2010, and the projected growth rate. In 2011, the estimated water demand for

mining in the Ruvu sub-Basin was 9,826 m^3, while the projections for 2035 estimated a decline in water demand at 8,343 m^3.

3.8. Water Management Issues:

As the water demands increase per economic sector (the mining sector being the exception), the Ruvu River will be under a considerable amount of stress to meet the needs of all of these sectors. However, other issues pose a significant threat to the Ruvu's ability to meet these freshwater demands in terms of its quality, quantity, and timing. These issues include pollution and climate change. Pollution invariably poses a challenge to water management in Tanzania. The lack of oversight and enforcement of existing pollution laws make management and quantification of various pollutants quite difficult for resource managers who are trying to ensure the availability of safe and clean water for domestic use under the National Water Policy of 2002. However, climate change may present the greatest threat to water resources management in the Ruvu, as changes in precipitation are likely to occur as the temperatures continue to rise (Watkiss et al., 2011). While precipitation models for the region are inconclusive in terms of the degree and direction of change, the models consistently predict changes in the rainfall regime (*ibid*), which may have severe consequences for the wet and dry seasons in the sub-basin.

3.9. Conclusion:

The water demand in the Ruvu sub-basin will greatly increase by 2035, with the greatest demand stemming from domestic use. Water demand from domestic use is projected to grow from 269,449,195 m^3/year in 2011 to 495,112,060 m^3/year in 2035, which represents an **83.75% increase.** The Ruvu will have to accommodate for this demand, as well as additional demands from agriculture, industry, livestock, fishing/aquaculture, and mining, all while facing other pressures such as pollution from deforestation and industry, and the impacts of climate change. The people living within the sub-basin and the economic sectors operating within the sub-basin will undoubtedly be significantly affected if the Ruvu fails to meet this demand.

Table 3.6: Current and Future Water Demand for the Industrial Sector (m^3)

Region	Commodity	Production (Unit)	Production Growth Rate (2004-	Unit Water Demand	2011	2015	2020	2025	2030	2035
Dar es Salaam	Standardized milk	1,516 Ltr 000	6.4%	3.25 m3/m3	5,241	6,713	9,145	12,459	16,975	23,126
Dar es Salaam	Canned fruits and vegetables	21,344 Tons	4.1%	10.75 m3/ton	238,753	279,900	341,446	416,524	508,111	619,837
Dar es Salaam	Fish products	3,772 Tons	2.5%	6.5 m3/ton	25,125	27,705	31,307	35,377	39,977	45,174
Dar es Salaam	Vegetable oils and fats	620,556 Tons	13.1%	6.4 m3/ton	4,490,324	7,337,437	13,555,885	25,044,441	46,269,499	85,482,706
Dar es Salaam	Biscuits	20,500 Tons	10.9%	4 m3/ton	90,916	137,389	230,192	385,682	646,201	1,082,695
Dar es Salaam	Africafe Inst	504 Tons	14.7%	2.7 m3/ton	1,561	2,705	5,375	10,684	21,234	42,202
Dar es Salaam	Blended tea	177,912 Tons	13.7%	2.7 m3/ton	545,967	911,081	1,728,006	3,277,431	6,216,153	11,789,893
Dar es Salaam	Honey	16 Tons	0.0%	1.8 m3/ton	29	29	29	29	29	29
Dar es Salaam	Spirits	52,744 Ltr 000	8.2%	7.7 m3/m3	439,484	602,645	894,250	1,326,956	1,969,039	2,921,809
Dar es Salaam	Bottled beer	550,456 Ltr 000	7.4%	7.7 m3/m3	4,550,124	6,043,144	8,616,135	12,284,630	17,515,062	24,972,457
Dar es Salaam	Chibuku	84,148 Ltr 000	0.1%	2.5 m3/m3	210,658	211,815	213,270	214,734	216,209	217,694
Dar es Salaam	Soft drinks	710,448 Ltr 000	1.7%	2.6 m3/m3	1,878,545	2,009,488	2,186,076	2,378,182	2,587,170	2,814,523
Dar es Salaam	Blankets	364 Num 000	5.7%	100 m3/ton	38,489	48,115	63,600	84,069	111,126	146,891
Dar es Salaam	Knitted garm	1,476 Num 000	13.1%	100 m3/ton	166,983	273,534	506,916	939,423	1,740,948	3,226,344
Dar es Salaam	Polythene Bags	247,184 Num 000	3.4%	6.25 m3/ton	1,597,293	1,825,247	2,156,468	2,547,794	3,010,133	3,556,370
Dar es Salaam	Sisal ropes and twines	3,488 Tons	0.9%	2.6 m3/ton	9,155	9,507	9,966	10,448	10,952	11,481
Dar es Salaam	Paper products	49,384 Tons	2.1%	41 m3/ton	2,066,670	2,243,235	2,485,303	2,753,494	3,050,624	3,379,818
Dar es Salaam	Industrial & Medical gases	4,424 cu.m 000	9.4%	30 m3/ton	145,175	207,832	325,454	509,643	798,073	1,249,738
Dar es Salaam	Insecticides & pesticides liquid	48 Ltr 000	4.4%	30 m3/ton	1,503	1,785	2,213	2,744	3,401	4,217
Dar es Salaam	Insecticides & pesticides powder	2,720 Tons	11.4%	7 m3/ton	21,210	32,663	56,033	96,125	164,902	282,888
Dar es Salaam	Paints	111,104 Ltr 000	9.2%	2.6 m3/ton	315,378	448,070	695,006	1,078,030	1,672,143	2,593,678
Dar es Salaam	Syrups	13,612 Ltr 000	2.9%	2.6 m3/ton	36,424	40,867	47,191	54,493	62,925	72,662
Dar es Salaam	Soap and laundry / toilet	505,720 Tons	10.3%	3 m3/ton	1,674,000	2,481,143	4,057,626	6,635,786	10,852,073	17,747,331
Dar es Salaam	Adhesives & ind.Detergents	12,160 Tons	10.5%	1.5 m3/ton	20,162	30,099	49,668	81,961	135,249	223,183
Dar es Salaam	Plastic articles	44,552 Tons	0.0%	23 m3/ton	1,024,696	1,024,696	1,024,696	1,024,696	1,024,696	1,024,696
Dar es Salaam	Glass	95,324 Tons	9.7%	12.5 m3/ton	1,307,300	1,894,206	3,011,216	4,786,927	7,609,771	12,097,244
Dar es Salaam	Cement	4,389,048 Tons	8.7%	3.8 m3/ton	18,123,930	25,272,381	38,294,677	58,027,071	87,927,129	133,234,021
Dar es Salaam	Corrugated Iron sheets	230,624 Tons	11.4%	0.4 m3/ton	102,737	158,041	270,753	463,849	794,659	1,361,398
Dar es Salaam	Rolled steel	305,348 Tons	11.0%	0.4 m3/ton	135,515	205,361	345,289	580,560	976,137	1,641,249
Dar es Salaam	Steel sheets/billets	101,384 Tons	19.8%	0.4 m3/ton	48,588	100,120	247,180	610,245	1,506,592	3,719,522
Dar es Salaam	Aluminum circles/sheets	236 Tons	3.2%	0.4 m3/ton	97	110	129	151	177	207
Dar es Salaam	Galvanized Pipes	39,040 Tons	8.9%	0.025 m3/ton	1,063	1,492	2,282	3,489	5,334	8,156
Dar es Salaam	Alumin wares	5,748 Tons	3.5%	0.4 m3/ton	2,379	2,728	3,236	3,839	4,554	5,402
Dar es Salaam	Metal containers	4,708 Num 000	9.5%	0.4 m3/ton	2,061	2,959	4,650	7,307	11,481	18,041
Dar es Salaam	Wire products	74,084 Tons	4.8%	0.4 m3/ton	31,060	37,485	47,417	59,980	75,871	95,973
Dar es Salaam	Electrical motors	688 Num	2.3%	5.4 m3/vehicle	3,802	4,171	4,684	5,259	5,905	6,630
Dar es Salaam	El cabl/wires	6,396 Tons	11.7%	0.4 m3/ton	2,857	4,440	7,707	13,376	23,216	40,295
Dar es Salaam	Motor bodies and trailers	1,028 Num	10.9%	5.4 m3/vehicle	6,156	9,310	15,615	26,190	43,925	73,671
Dar es Salaam	Radiators	276 Num	12.1%	0.04 m3/radiator	12	20	34	61	108	190
				Sub-Total In Dar es S	**39,361,423**	**53,929,669**	**81,546,126**	**125,794,136**	**197,627,763**	**315,833,440**
					-					
Morogoro	Sugar	709,372 Tons	6.8%	0.6 m3/ton	454,775	592,764	825,541	1,149,728	1,601,223	2,230,019
Morogoro	Tobacco,cured	70,112 Tons	1.5%	2.6 m3/ton	185,096	196,754	212,364	229,213	247,398	267,026
Morogoro	Canvas	8,780 mtr 000	8.8%	80 m3/ton	764,076	1,069,901	1,629,683	2,482,346	3,781,130	5,759,449
Morogoro	Cotton yarn	724 Tons	7.4%	2.6 m4/ton	2,021	2,688	3,837	5,478	7,821	11,167
Morogoro	Textile bags	6,376 Num 000	3.9%	100 m3/ton	662,545	772,472	935,874	1,133,840	1,373,683	1,664,259
Morogoro	Knitted fabrics	24,644 Sq.m 000	10.4%	100 m3/ton	2,721,324	4,046,288	6,643,585	10,908,075	17,909,924	29,406,233
			0.0%	**Sub-Total in Morogo**	**4,789,837**	**6,680,868**	**10,250,883**	**15,908,681**	**24,921,180**	**39,338,153**
				Grand Total	**44,151,260**	**60,610,537**	**91,797,010**	**141,702,817**	**222,548,943**	**355,171,593**

Figures are estimated based on the following sources:

1: NBS (2011), Production of Selected Commodity

2: DFID (2003), Handbook for Assessment of Catchment Water Demand and Use

Extracted from: (JICA, 2013)

Table 3.7: Current & Future Water Demand for the Industrial Sector under Growth Scenario (m^3)

Region	Commodity	Production (Unit)	Growth Rate (2004-2009)	Unit Water Demand	2011	2015	2020	2025	2030	2035
Dar es Salaam	Standardized milk	1,516 Ltr 000	7.7%	3.25 m3/m3	5,241	7,125	10,303	14,899	21,546	31,157
Dar es Salaam	Canned fruits and vegetables	21,344 Tons	4.9%	10.75 m3/ton	238,753	290,979	369,012	467,970	593,467	752,618
Dar es Salaam	Fish products	3,772 Tons	3.0%	6.5 m3/ton	25,125	28,381	32,853	38,029	44,021	50,956
Dar es Salaam	Vegetable oils and fats	620,556 Tons	15.7%	6.4 m3/ton	4,490,324	8,225,218	17,034,675	35,279,327	73,064,554	151,318,902
Dar es Salaam	Biscuits	20,500 Tons	13.0%	4 m3/ton	90,916	151,402	279,544	516,140	952,984	1,759,557
Dar es Salaam	Africafe Inst	504 Tons	17.7%	2.7 m3/ton	1,561	3,070	6,926	15,626	35,252	79,531
Dar es Salaam	Blended tea	177,912 Tons	16.4%	2.7 m3/ton	545,967	1,025,949	2,191,205	4,679,936	9,995,323	21,347,833
Dar es Salaam	Honey	16 Tons	0.0%	1.8 m3/ton	29	29	29	29	29	29
Dar es Salaam	Spirits	52,744 Ltr 000	9.9%	7.7 m3/m3	439,484	649,793	1,039,649	1,663,406	2,661,398	4,258,153
Dar es Salaam	Bottled beer	550,456 Ltr 000	8.8%	7.7 m3/m3	4,550,124	6,468,499	9,871,740	15,065,512	22,991,858	35,088,455
Dar es Salaam	Chibuku	84,148 Ltr 000	0.2%	2.5 m3/m3	210,658	212,105	213,854	215,617	217,395	219,188
Dar es Salaam	Soft drinks	710,448 Ltr 000	2.0%	2.6 m3/m3	1,878,545	2,043,281	2,260,219	2,500,189	2,765,638	3,059,270
Dar es Salaam	Blankets	364 Num 000	6.9%	100 m3/ton	38,489	50,784	70,851	98,849	137,910	192,406
Dar es Salaam	Knitted garm	1,476 Num 000	15.8%	100 m3/ton	166,983	306,793	637,684	1,325,456	2,755,023	5,726,442
Dar es Salaam	Polythene Bags	247,184 Num 000	4.1%	6.25 m3/ton	1,597,293	1,885,908	2,302,188	2,810,353	3,430,687	4,187,948
Dar es Salaam	Sisal ropes and twines	3,488 Tons	1.1%	2.6 m3/ton	9,155	9,596	10,155	10,746	11,371	12,033
Dar es Salaam	Paper products	49,384 Tons	2.5%	41 m3/ton	2,066,670	2,289,113	2,588,001	2,925,914	3,307,949	3,739,865
Dar es Salaam	Industrial & Medical gases	4,424 cu.m 000	11.3%	30 m3/ton	145,175	226,285	385,812	657,803	1,121,542	1,912,209
Dar es Salaam	Insecticides & pesticides liquid	48 Ltr 000	5.3%	30 m3/ton	1,503	1,862	2,407	3,111	4,022	5,199
Dar es Salaam	Insecticides & pesticides powder	2,720 Tons	13.7%	7 m3/ton	21,210	36,145	68,615	130,256	247,273	469,412
Dar es Salaam	Paints	111,104 Ltr 000	11.0%	2.6 m3/ton	315,378	487,018	821,083	1,384,295	2,333,838	3,934,709
Dar es Salaam	Syrups	13,612 Ltr 000	3.5%	2.6 m3/ton	36,424	42,040	49,937	59,319	70,462	83,700
Dar es Salaam	Soap and laundry / toilet	505,720 Tons	12.4%	3 m3/ton	1,674,000	2,722,482	4,885,383	8,766,621	15,731,344	28,229,257
Dar es Salaam	Adhesives & ind.Detergents	12,160 Tons	12.6%	1.5 m3/ton	20,162	33,080	59,992	108,800	197,317	357,849
Dar es Salaam	Plastic articles	44,552 Tons	0.0%	23 m3/ton	1,024,696	1,024,696	1,024,696	1,024,696	1,024,696	1,024,696
Dar es Salaam	Glass	95,324 Tons	11.7%	12.5 m3/ton	1,307,300	2,067,967	3,589,012	6,228,825	10,810,293	18,761,551
Dar es Salaam	Cement	4,389,048 Tons	10.4%	3.8 m3/ton	18,123,930	27,353,425	44,861,057	73,574,494	120,666,043	197,898,663
Dar es Salaam	Corrugated Iron sheets	230,624 Tons	13.6%	0.4 m3/ton	102,737	174,845	331,392	628,104	1,190,476	2,256,367
Dar es Salaam	Rolled steel	305,348 Tons	13.1%	0.4 m3/ton	135,515	226,448	419,837	778,385	1,443,136	2,675,595
Dar es Salaam	Steel sheets/billets	101,384 Tons	23.8%	0.4 m3/ton	48,588	117,807	342,227	994,161	2,888,014	8,389,610
Dar es Salaam	Aluminum circles/sheets	236 Tons	3.8%	0.4 m3/ton	97	114	137	166	200	241
Dar es Salaam	Galvanized Pipes	39,040 Tons	10.6%	0.025 m3/ton	1,063	1,618	2,682	4,445	7,368	12,214
Dar es Salaam	Alumin wares	5,748 Tons	4.2%	0.4 m3/ton	2,379	2,820	3,460	4,244	5,207	6,387
Dar es Salaam	Metal containers	4,708 Num 000	11.4%	0.4 m3/ton	2,061	3,224	5,519	9,448	16,175	27,689
Dar es Salaam	Wire products	74,084 Tons	5.8%	0.4 m3/ton	31,060	39,238	51,956	68,795	91,092	120,616
Dar es Salaam	Electrical motors	688 Num	2.8%	5.4 m3/vehicle	3,802	4,268	4,903	5,632	6,470	7,432
Dar es Salaam	El cabl/wires	6,396 Tons	14.0%	0.4 m3/ton	2,857	4,924	9,476	18,238	35,100	67,553
Dar es Salaam	Motor bodies and trailers	1,028 Num	13.1%	5.4 m3/vehicle	6,156	10,262	18,970	35,068	64,826	119,836
Dar es Salaam	Radiators	276 Num	14.5%	0.04 m3/radiator	12	22	43	84	165	324
				Sub-Total in Dar es Salaam	**39,361,423**	**58,228,615**	**95,857,483**	**162,112,990**	**280,941,462**	**498,185,452**
Morogoro	Sugar	709,372 Tons	8.2%	0.6 m3/ton	454,775	631,748	937,697	1,391,815	2,065,856	3,066,329
Morogoro	Tobacco,cured	70,112 Tons	1.8%	2.6 m3/ton	185,096	199,754	218,889	239,857	262,834	288,012
Morogoro	Canvas	8,780 mtr 000	10.5%	80 m3/ton	764,076	1,159,097	1,912,736	3,156,388	5,208,655	8,595,297
Morogoro	Cotton yarn	724 Tons	8.9%	2.6 m3/ton	2,021	2,877	4,398	6,723	10,277	15,710
Morogoro	Textile bags	6,376 Num 000	4.7%	100 m3/ton	662,545	801,997	1,008,782	1,268,883	1,596,048	2,007,568
Morogoro	Knitted fabrics	24,644 Sq.m 000	12.5%	100 m3/ton	2,721,324	4,443,007	8,010,188	14,441,372	26,035,996	46,939,662
				Sub-Total in Morogoro	**4,789,837**	**7,238,480**	**12,092,690**	**20,505,037**	**35,179,667**	**60,912,578**
				Grand Total	**44,151,260**	**65,467,094**	**107,950,173**	**182,618,027**	**316,121,129**	**559,098,029**

Figures are estimated based on the following sources:

1: NBS (2011), Production of Selected Commodity

2: DFID (2003), Handbook for Assessment of Catchment Water Demand and Use

Extracted from (JICA, 2013)

Table 3.8: Current and future demand of water for fishing & aquaculture in regions dependent on the Ruvu sub-Basin (m^3)

Region	District	# of fish pond	Total fish pond area(m^2)	2010	2011	2015	2020	2025	2030	2035
Morogoro	Morogoro Urban	105	15,750	3,326	3,384	3,627	3,955	4,314	4,705	5,131
	Morogoro Rural	137	20,550	27,934	28,423	30,466	33,226	36,237	39,521	43,102
	Mvomero	2	300	57,531	58,538	62,744	68,430	74,631	81,394	88,769
	Subtotal	244	36,600	88,791	90,345	96,837	105,611	115,182	125,620	137,002
Coast	Bagamoyo	10	1,500	682	694	743	811	884	964	1,052
	Kibaha	35	5,250	2,386	2,427	2,602	2,838	3,095	3,375	3,681
	Kisarawe	1	150	1,704	1,734	1,858	2,027	2,210	2,411	2,629
	Subtotal	46	6,900	4,772	4,855	5,203	5,676	6,189	6,750	7,362
Dar es Salaam	Temeke	15	2,250	6,207	6,316	6,770	7,383	8,052	8,782	9,578
	Kinondoni	6	900	7,587	7,719	8,274	9,024	9,842	10,733	11,706
	Illala	0	0	1,035	1,053	1,128	1,231	1,342	1,464	1,596
	Sub-total	21	3150	14,829	15,088	16,172	17,638	19,236	20,979	22,880
	Total	**311**	**46,650**	**108,392**	**110,288**	**118,212**	**128,925**	**140,607**	**153,349**	**167,244**

Source: (JICA, 2013)

Table 3.9: Current and Future Water Demand for Mining in regions dependent on the Ruvu sub-Basin (m^3)

Region	Material Mined/Quarried	Production (2010) in Tons	Growth Rate (1999-2009)	2011	2015	2020	2025	2030	2035
Morogoro	Mineral Aggregates	4,199	-2.70%	1,635	1,467	1,282	1,120	978	855
Morogoro	Copper Ore	40	-3.30%	15	15	11	10	8	7
	Sub-total			1,650	1,482	1,293	1,130	986	862
DSM and Coast	Calcite	152	-0.60%	30	30	29	28	27	26
DSM and Coast	Limestone	84	1.10%	17	18	18	20	21	22
DSM and Coast	Mineral Aggregates	9,216	-2.70%	3,588	3,220	2,813	2,458	2,147	1,876
DSM and Coast	Galena	22,423	0.80%	4,523	4,677	4,677	5,088	5,307	5,535
DSM and Coast	Marble	3	4.10%	1	1	1	1	1	2
DSM and Coast	Geological Samples	42	0.80%	17	17	18	9	20	20
	Sub-total			8,176	7,963	7,556	7,604	7,523	7,481
	Total			**9,826**	**9,445**	**8,849**	**8,734**	**8,509**	**8,343**

Source: (JICA, 2013)

Chapter 4: Valuation and Payments of Ecosystem Services in Ruvu Basin and Surrounding Areas

As seen the preceding chapters, the Ruvu sub-Basin provides a substantial amount of water for the capital city, Dar es Salaam, and its surrounding regions. However, the populations of these areas are expected to rise substantially over the next 20 years, which will place undue stress on the Ruvu River's ability to deliver freshwater for a variety of economic sectors, for domestic use and for meeting the environmental needs in order to continuously produce key ecosystem services (e.g. water quality, fishing, tourism etc.). As such, a comparative evaluation of the socio-economic and environmental dependence on the competing uses of water is important to inform the decision makers for its sustainable management Reliable economic values and tradeoffs on the benefits we receive as a society from the goods and services the ecosystem provides can be key inputs for informed decision making for sustainable water resource management. Unfortunately, there are not many valuation studies in this specific context and the study focusing on the Eastern Arc Mountains (EAM) region in the Ruvu Basin deserves detailed discussion.

In 2007 the Natural Capital Project began work in the Ruvu, specifically in the Eastern Arc Mountains (EAM) with the objective to analyze several ecosystem services and develop mechanisms to ensure their provisioning in a sustainable way. Under this project the team produced the ecosystem services maps (see Figure 4.1) for the Eastern Arc Mountains and surrounding watersheds (with the InVEST software suite and related GIS-based models) to inform planning decisions for forest conservation and watershed management in the area. Building on this work, subsequently the Equitable Payments for Watershed Services (EPWS) program is designed to provide economic incentives to farmers to adopt sustainable land management (SLM) practices in the Uluguru Mountains of Tanzania. Two agencies, Cooperative for Assistance and Relief Everywhere (CARE) International and World Wildlife Fund (WWF) were mainly involved in designing this project.

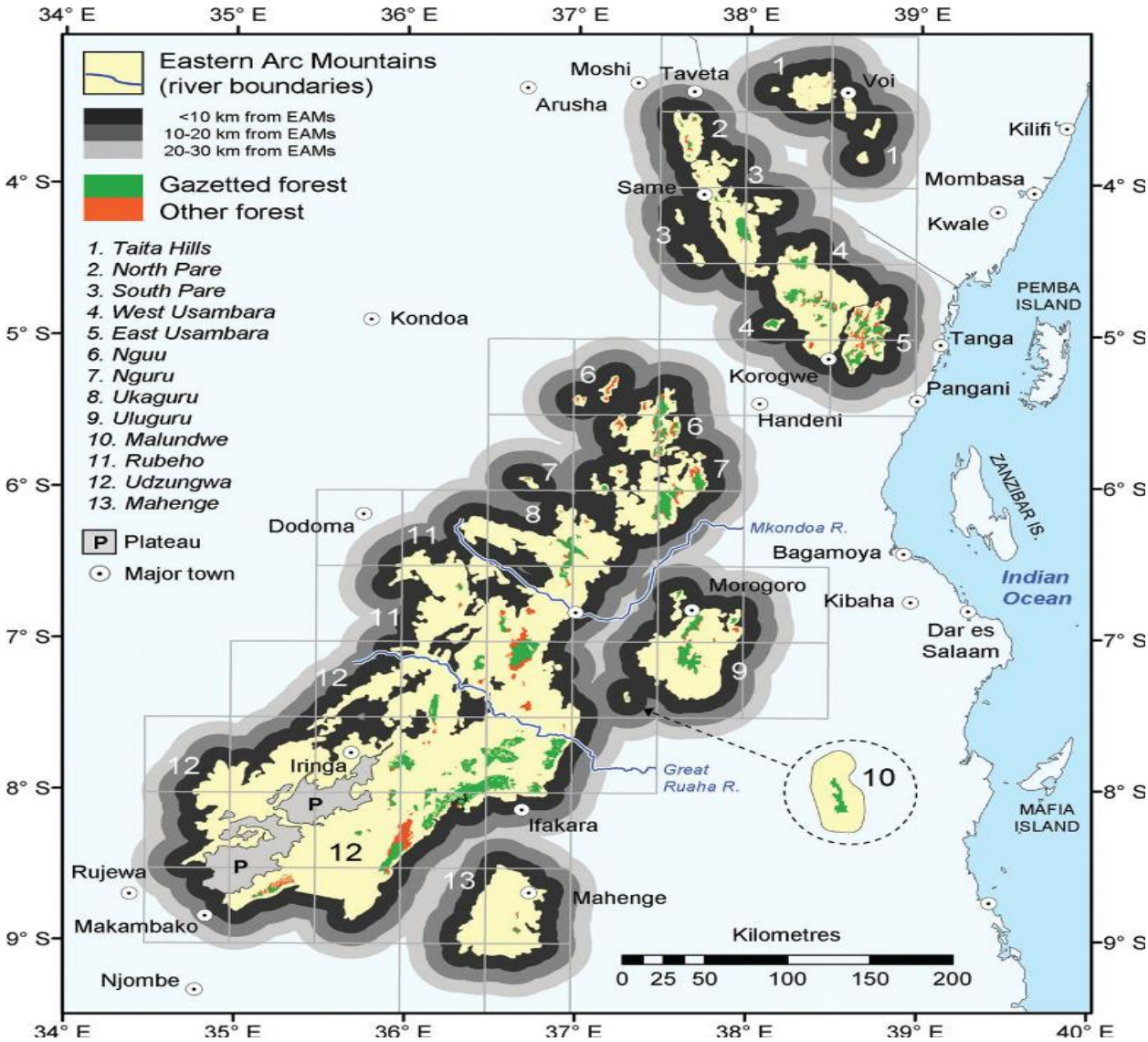
The EPWS project focused on the catchment of the Ruvu River, which is the source of 90% of the water used by domestic and industrial users in the city of Dar es Salaam (Lopa, 2009). In this area, the rapid expansion of farming has increased the siltation in the river and significantly raised water treatment costs in recent years. After several feasibility studies related to livelihoods, hydrology, related policy and legal framework and cost benefit analysis of sustainable land management practices, the project was successful in securing support from one of the major private sector water users (Coca Cola), which is served by Dar es Salaam Water and Sewerage Corporation (DAWASCO) (Lopa, 2009).

Table 4.1 shows the cost of implementing sustainable land management (SLM) practices in the Kibungo sub-catchment over the 4-year pilot (Branca et al, 2009). It is claimed that this project led to reduction in sediment load in Ruvu River, which reduced DAWASCO's treatment costs by 10 per cent (i.e. US$200,000 per year). Branca et al (2009) also projected that by 2018 DAWASCO can reduce costs up to US$400,000/year from the implementation of SLM practices in the Uluguru area (Branca et al., 2009). Based on the preliminary findings of the EPWS program, it could be interesting to examine if similar programs could be extended to other sub-catchments in the Ruvu Basin. Incentives for other potential ecosystem services that have

increasing demands (e.g. carbon storage with the advent of United Nations 'Reduced Emissions from Deforestation and Degradation' program) can be combined into the existing framework to develop a more stable institutional framework for ensuring continuation of these types of programs.

A better understanding about the tradeoffs corresponding to different management scenarios (which can be gathered through more valuation studies of key ecosystem services (e.g. eco-tourism, fisheries, biodiversity, power generation, timber and non-timber forest products etc. in addition to hydrological services that are already considered), will be very useful. Valuation studies focusing on these ecosystem services will be able to quantify their contributions to human wellbeing in order to take actions to sustain them. Integrating multiple ecosystem services into a synergic framework can potentially increase ecological connectivity among different watersheds and ecological boundaries to reduce soil erosion and increase net primary production (e.g. by reducing water deficiency and improve water quality for human, animal and plant consumption). However, there are other operational challenges beyond these issues related to knowledge and information. Major challenges to implement sustainable payment for ecosystem services (PES) programs include establishing better coordination and institutional frameworks among upstream providers and downstream beneficiaries. Resolving conflicts among heterogeneous user groups and effective monitoring and sanctioning for compliance among participants are also difficult to ensure which can potentially undermine success of these types of programs.

Figure 4.1. Ecosystem Services Maps for the Eastern Arc Mountains.



Source: Natural Capital Project: Eastern Arc Mountains (2011)

Table 4.1. Costs of implementing SLM practices in the Kibungo sub-catchment over the 4-year pilot (Branca et al, 2009).

	Implementation area (ha)	Establishment costs Yr1 (US$/ha)	Maintenance costs (Yr1-4) (US$/ha)	Opportunity cost (Yr 1-4) Us$/ha	Total cost by Yr 4	Trial total cost (US$/HA)

					(US$/ha)	
Afforestation, reforestation	300	87	76	756	3415	1024500
Kilaka terraces (with Agroforestry and grass strips)	100	334	192	1058	5334	533400
Pineapple contours (with agroforestry and grass strips)	940	58	116	176	1226	1151970
Fanya juu terraces (with grass strips)	600	320	38	44	648	388800
Riparian restoration, sugar cane planting, tree planting	300	8	40	58	400	120000
Average implementation costs	-	137	83	242	1437	-
Total	2240	-	-	-	-	3 218 670

Chapter 5: Discussion and Conclusions

The Ruvu River sub-Basin is one of the most important river systems in Tanzania, overlapping with areas of critical ecological significance and economic activities. The largest city of Tanzania, Dar-es-Salaam and a number of smaller towns rely on the Ruvu River system for water to meet domestic, industrial, and irrigation needs. While there are substantial variations of available water resources and societal needs for water within this basin, a common concern about meeting the future demand for water and maintaining the water quality rises with the projected population growth and economic development. At the same time, it is also increasingly recognized that allocating enough water to meet the environmental needs is critical for the provision of a wide range of ecosystem services (e.g. hydrological services, carbon-related services, timber and non-timber forest products, nature-based tourism services, fisheries, wildlife habitat and biodiversity).

The National Water Policy (2002) and the Water Resources Management Act of 2009 provide the legal and institutional basis that recognizes the environmental demand for water in Tanzania. In terms of priorities, the environmental need is considered second in importance after the basic human needs for water. The National Water Sector Development Strategy (2006-2015) and the Water Sector Development Program (2006-2025) have emphasized the need for sustainable management of the nation's water resources and underscore the role of effective coordination among various sectors. These policies also have emphasized a focus on the river basin as a planning unit to facilitate integrated and inter-sectoral water resource planning. Participatory processes with community involvement are highlighted as a vehicle for integrated water resource management for sustainable development in the region.

The population (both rural and urban) within the Ruvu sub-Basin is projected to grow significantly (about 45% over the next 24 years), and so will its major economic activities (agriculture, industry, and livestock). As the population and the economic sectors continue to rise, the demands for water on the Ruvu will subsequently rise. Water demand from domestic use is projected to grow by more than eighty presents by 2035. The Ruvu will have to accommodate for this demand, as well as additional demands from agriculture, industry, livestock, fishing/aquaculture, and mining, all while facing other pressures such as pollution from deforestation and industry, and the impacts of climate change. The people living within the sub-basin and the economic sectors operating in it will undoubtedly be significantly affected if the Ruvu fails to meet this demand through sustainable natural resource management.

Generating reliable economic values and tradeoffs on the benefits we receive as a society from the goods and services the ecosystem provides can provide key inputs for informed decision making for sustainable management. Unfortunately, there are not many valuation studies in this specific context more valuation studies of key ecosystem services (e.g. eco-tourism, fisheries, biodiversity, power generation, timber and non-timber forest products etc. in addition to hydrological services that are already considered) will be very useful. Valuation studies focusing on these ecosystem services will be able to quantify their contributions to human wellbeing and can provide better understanding about the tradeoffs corresponding to different management scenarios. Insight from these types of valuation studies can be used for designing incentives for providing key ecosystem services, and simultaneously balancing environmental needs and socio-economic drivers, as done in the EPWS program (Lopa 2009).

However, there are many operational challenges to implement sustainable payment for ecosystem services (PES) programs which require better institutional frameworks among upstream providers and downstream beneficiaries. Innovative ways for resolving conflicts among heterogeneous user groups and effective monitoring and sanctioning mechanisms can potentially overcome some of these challenges.

Reference:

Ahrends et al. (2008) Coupled Hydrological-Economic Modeling for Optimized Irrigated Cultivation in a Semi-arid Catchment of West Africa, Environmental Modeling & Software, 23 (4): 385-395.

Branca, G., Lipper, L., Neves, N., Lopa, D., Mwanyoka, I., (2009) New tools for old problems: can Payments for Watershed Services support sustainable agricultural development in Africa?, ESA Working Paper. FAO: Agricultural Development Economics Division, Rome.

David Taylor (2013). Through Personal Communication with The Tanzania Integrated Water Sanitation and Hygiene Program ((iWASH) Team.

DAWASA, (2008) Environmental Impact Assessment (EIA) Statement for Kidunda Dam: Executive Summary. The United Republic of Tanzania and the Dar es Salaam Water and Sewage Authority. Available at http://www.wildlifebaldus.com/download/KIDUNDA%20EIAExecutive%20Summary.pdf

Fisher, B., R. K. Turner, N. D. Burgess, R.D. Swetnam, J.Green, R. E. Green, G. Kajembe, K. Kulindwa, S. L. Lewis, R. Marchant, A. R. Marshall, S. Madoffe, P.K.T. Munishi, S. Morse-Jones, S. Mwakalila, J. Paavola, R. Naidoo, T. Ricketts, M. Rouget, S. Willcock, S. hite and A. Balmford (2011). Measuring, Modeling and Mapping Ecosystem Services in the Eastern Arc Mountains of Tanzania, Progress in Physical Geography 35(5):595-611.

JICA (February 2013). The Study on Water Resources Management and Development in Wami/Ruvu Basin in the United Republic of Tanzania. Interim Report: Main Report. (2). Japan International Cooperation Agency (JICA) and Water Resources Division (WRD). Ministry of Water (MoW).

Kidigi, R. (February 2012). Ruvu EFA: Literature Review Reports. GLOWS-WRBWB\EFA\RUVU\REPORTS\1-1

Kidigi, R. (May 2012). Socio-economics of Riparian Communities in Ruvu Sub-Basin: Ruvu River Environmental Flow Assessment (EFA).Global Water for Sustainability (GLOWS) and United States International Development Agency (USAID).

Lopa, D., Mwanyoka, I., Jambiya, G., Massoud, T., Harrison, P., Ellis-Jones, M., ... & Burgess, N. D. (2012). Towards operational payments for water ecosystem services in Tanzania: a case study from the Uluguru Mountains. Oryx, 46(01), 34-44.

Lund, J. R. R. E. Howitt, J. Medellín-Azuara, M. W. Jenkins (2009). Water management lessons for California from Statewide Hydro-Economic Modeling. A Report for the California Department of Water Resource.

Ngana, J., Mahay, F., & Cross, K (2010). Ruvu Basin: A Situation Analysis. IUCN.

Noel, S. (2011). *The Economics of Climate Change in Tanzania*. Stockholm Environment Institute. SEI-Africa Centre. Institute of Resource Assessment, University of Dar es Salaam.

Watkiss, P., Downing, T., Dyszynski, J., Pye, S., Savage, M., Goodwin, J., ... & Lynn, S. (2011). The economics of climate change in the United Republic of Tanzania. Global Climate Adaptation Partnership (GCAP).

You, G. J.-Y., and C. Ringler (2010). Hydro-Economic Modeling of Climate Change Impacts in Ethiopia. IFPRI Discussion Paper No. 960, Washington, DC: International Food Policy Research Institute.

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