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ANNEXES

Executive Summary

Tanzania is located on the East coast of Africa, bordering the Indian Ocean, and lies between Kenya to the north and Mozambique to the south. Its total area is 945,087 km^2 and this includes the islands of Mafia, Pemba and Zanzibar. Water covers 59,050 km^2 of this area and the coastline along the Indian Ocean is 1,424 km. The population of the country is 40 million with a growth rate of 2.6%. The economy is largely dependent on agriculture, which accounts for about 48% of the GDP.

Tanzania is endowed with a scenic, diverse and resource rich coastal area. This strip of land and water supports a diversity of important natural systems, including coral reefs, beaches, estuaries, sea grass beds and extensive mangrove stands. Tanzania's coastal and marine ecosystems cover the mainland coast, three major islands (Pemba, Unguja, and Mafia) all of which are less than 100 km offshore, numerous small near-shore islands and islets and one oceanic island, Latham Island. The continental shelf covers an estimated 17,500 – 17,900 km^2.

Demersal fish species dominates marine catches with a total catch of 22,290 tons compared to a pelagic catch of 14,014 tons. The main commercial marine species are sardine and anchovy, which together form 30 - 50 percent of total fish landings. The artisanal marine fishery sub-sector employs more than 29,754 full time fishers, using about 7,190 relatively small fishing canoes (Fisheries Division, 1992).

The majority of the coastal communities rely on coastal resources for their livelihood. The coast is of immense strategic importance to many social and economic sectors such as shipping, fishing, tourism, trade, agriculture, settlements and industrial developments. Recently, Tanzania has experienced a significant increase in coastal tourism, mariculture development and natural gas exploitation. Livelihood opportunities for people living along the Tanzanian coastline are changing; coastal areas are experiencing rapidly expanding population, putting increasing pressure on limited resources. As farming employment optiosn decline as a result of lack of financial assistance in the agricultural sector, more people are forced to depend on the easy and very common pool of coastal resources, such as forests, fisheries,coastal land areas, swamps, mangroves and coral reefs. The productivity of these resources is in decline as the environmental carrying capacity decreases due to increased coastal pollution, depletion of fish stocks and coastal resources, extinction of species overall decline in water quality.

The coast's untapped potential must be harnessed, but it must be done with the appropriate safeguards that link growth to wise management. The pressures on these resources will grow and, like other countries faced with an expanding population, are at risk of collapse. People's quality of life, which is inextricably tied to the resource base, will continue to decline unless development moves hand in hand with local goals and aspirations.

Acknowledgements

We would like to express our sincere gratitude to the Government of the United Republic of Tanzania and the Revolutionary Government of Zanzibar for supporting this initiative and efforts both in kind and materially throughout from the start to the end. The Government of the United Republic of Tanzania through its Ministry of Livestock Development and Fisheries; the University of Dar es Salaam through its Colleges of Natural and Applied Sciences (CoNAS) and Arts and Social Sciences (CASS), and the Institute of Marine Sciences (IMS); the Tanzania Fisheries Research Institute (TAFIRI); and the National Environment Management Council (NEMC) are thanked for providing and supporting the experts who prepared this document. The NEMC, the Focal Institution for the ASCLME project in Tanzania, is highly thanked for providing administrative guidance and support of the MEDA process in close collaboration with the IMS which was coordinating the process. The local stakeholders played a key role in guiding the coverage of contents of the document through the several national workshops that were organized. Several regional and international experts provided assistance in the preparation of the Tanzania Marine Ecosystem Diagnostic Analysis (MEDA). Finally, we would also like to thank all who assisted the experts who prepared this document in one way or another including providing them with the relevant data and or information. These include scientists, researchers, stakeholders, local communities, Non-Governmental Institutions (NGOs), Institutions and many others.

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List of Acronyms

ACEP:	African Coelacanth Ecosystem Programe
ASCLME:	Agulhas and Somali Current Large Marine Ecosystems
CBO:	Community Based Organisation
CORDIO:	Coastal Oceans Research and Development in the Indian Ocean
DLIST:	Distance Learning Information Sharing Tool
DoF:	Department of Fisheries
EEZ:	Exclusive Economic Zone
EIA:	Environmental Impact Assessment
ENSO:	El Nino / La Nina Southern Oscillation
FAO:	Food and Agriculture Organization
GDP:	Gross Domestic Product
GIS:	Geographic Information System
GMDSS:	Global Maritime Distress Signalling System
GPA:	Global Programme of Action for Protection of Marine Environment
GOOS:	Global Ocean Observing System
GTS:	Global Telecommunications System
HABs:	Harmful Algal Blooms
HEP:	Hydro-Electric Power
IBAs:	Important Bird Areas
ICZM:	Integrated Coastal Zone Management
ISSG:	Invasive Species Specialist Group
IOC-UNESCO:	Inter-Governmental Oceanographic Commission of UNESCO
IOD:	Indian Ocean Dipole
IOTWS:	Indian Ocean Tsunami Warning System
ITCZ:	Inter-Tropical Convergence Zone
IUCN:	The World Conservation Union
JMA:	Japan Meteorological Agency
MACEMP:	Marine and Coastal Area Environmental Management Project
TAFIRI:	Tanzania Fisheries Research Institute
TCMP:	Tanzania Coastal Management Partnership
TIO:	Tanzania Indian Ocean
TPA:	Tanzania Ports Authority
TMA:	Tanzania Meteorological Agency
MPAs:	Marine Protected Areas
MCS:	Monitoring, Control and Surveillance
NEMC:	National Environmental Management Council
NGO:	Non-Governmental Organisation
NPA:	National Programme of Action
NORAD:	Norwegian Agency for International Development
PSU:	Practical Salinity Units
PTWC:	Pacific Tsunami Warning Center
POPs:	Persistent Organic Pollutants
SADC:	Southern Africa Development Community
SST:	Sea Surface Temperature
SWIOFP:	World Bank-GEF South-West Indian Ocean Fisheries Project
SWOT:	Analysis of Strengths, Weaknesses, Opportunities and Threats
UNDP:	United Nations Development Programme
UNEP:	United Nations Environment Programme
UNESCO:	United Nations Educational, Scientific and Cultural Organisation
URT:	United Republic of Tanzania
USAID:	United States Agency for International Development
USD:	United States Dollar
VTMS:	Vessel Tracking Management System

WCS:	World Conservation Society
WHO:	World Health Organization
WIO-LaB:	UNEP-GEF Project Addressing Land-Based Sources and Activities in the WIO
WIO:	Western Indian Ocean
WWF-EAME:	World Wildlife Fund – Eastern Africa Marine Ecoregion

1. COUNTRY OVERVIEW

The United Republic of Tanzania is the largest country in East Africa covering a surface area of about 945,200 km^2. It consists of two parts; the mainland with an area of 942,800 km^2 and Zanzibar Islands (Unguja Island and Pemba Island) which occupy an area of 2,400 km^2. Approximately 60,000 km^2 of the total area of Tanzania consists of inland water bodies. Tanzania lies just south of the equator, between latitudes 1°-11°45'S and longitudes 29°21'-40°25'E. The country shares its borders with eight countries, namely Kenya and Uganda to the north; Rwanda, Burundi, Democratic Republic of Congo and Zambia to the west and Malawi and Mozambique to the south. Tanzania has an abundance of inland water bodies with several lakes and rivers. Lake Tanganyika runs along the western border and is Africa's deepest and longest freshwater lake and world's second deepest lake. Lake Victoria to the north is the world's second largest lake draining into the Nile River and then to the Mediterranean Sea. The Rufiji River is Tanzania's largest river that drains into the Indian Ocean south of Dar es Salaam. Although there are many rivers, only the Rufiji and Kagera are navigable.

Tanzania's coastal and marine ecosystems cover the mainland coast, three principal islands (Pemba, Unguja, and Mafia) all of which are less than 100 km offshore, numerous small near-shore islands and islets and one oceanic island, Latham Island. The continental shelf, covering an area estimated to range between17,500 and 17,900 km^2 (up to a depth of 200 m) is generally narrow with the narrowest point being 2 km and the widest 80 km. The shelf drops sharply after a depth of 60 m. Pemba and Latham islands are separated from the mainland by relatively deep water channel (about 400-500 m and 200-300 m deep, respectively). Pemba Island is believed to have been part of the mainland that broke away about 10 million years ago. Unguja and Mafia are coral limestone islands established on the continental shelf and were probably part of a Pleistocene inshore coral reef system which is now separated from the mainland by relatively shallow (30-50 m deep) channels (McClanahan 1988).

Tanzania's Great Rift Valley is the country's most distinctive geological feature which was caused by faulting throughout eastern Africa. The Rift Valley is associated with volcanic activity in the north-eastern regions of the country (UN 2002). This faulting led into the formation of two branches of the Great Rift Valley; the western branch which holds Lakes Tanganyika, Rukwa, and Nyasa and the eastern branch that ends in northern Tanzania and includes Lakes Natron, Manyara, and Eyasi (http://news.bbc.co.uk/2/hi/africa/country_profiles/1072330.stm?).

Except for a narrow belt of 900 km^2 along the coast, most of Tanzania lies at an elevation above 200 m above sea level. Much of the country is higher than 1,000 m above sea level (United Republic of Tanzania 2005a). Mount Kilimanjaro located in the north east of the country rises to 5,895 m above sea level - the highest point in Africa. Tanzania's climatic conditions are characterized by a long dry spell from May to October, followed by a rainy season between November and April. The main rainy season along the coast and Mount Kilimanjaro region is from March to May, with short rains occurring in the period between October and December. In the western part of the country, in the Lake Victoria basin, rainfall is high and well distributed throughout the year, with the peak rainy season occurring in the period between March and May (Mongi, *et al.,* 2010).

Agriculture, which comprises crop, animal husbandry, forestry, fishery, and hunting subsectors, plays a key role in the Tanzanian economy. It contributes the largest share to the gross domestic product (GDP). Major exports include coffee, cotton, tea, tobacco, cashew nuts, and sisal. The economy has been growing between 6.7% and 7.8% over the past seven years (United Republic of Tanzania 2009). Despite this impressive economic growth, there has been relatively limited improvement in infrastructure, education and health sectors. Poverty remains high in both urban and rural areas. The growth has remained inadequate to meet development and poverty reduction objectives of the National Strategy for Growth and Reduction of Poverty. The current growth is mainly attributed to the growth in a number of subsectors, mainly agriculture, commerce, tourism (including hotels and restaurants), transport and communication, and financial and business services (United Republic of Tanzania 2005a). The government has put in place measures to sustain the current economic growth rate and reduce nationwide poverty, through the promotion of the private sector participation in the economy.

The current population is estimated to be 40 million with the mainland Tanzania registering a relatively lower population growth rate of 2.9% as compared to Zanzibar (Table 1). There are however large variations in

population growth rate from one region to another (United Republic of Tanzania 2006a). About 51% of the regions in Tanzania have their population growing at a rate above 2.5% per annum and about 71% of the regions have their population growing at a rate above 2% per annum (Figure 1).

Table 1: Population growth in the thirty five years from 1967-2002 (United Republic of Tanzania 2005b)

	Total Population				Growth rate		
	1967	1978	1988	2002	1967-78	1978-88	1988-2002
Tanzania Mainland	11,958,654	17,036,499	22,455,205	33,461,849	3.2	2.8	2.9
Tanzania Zanzibar	354,360	476,111	640,578	981,754	2.9	3.0	3.1

While the population of Tanzania has nearly trebled in the last four decades, the country is still sparsely populated. Population density is however high in some parts of the country. The current population density is estimated to be above 39 persons per square kilometre. The high population growth rate is attributed to high fertility rate and declining mortality levels. According to the 2002 Population and Housing Census, the life expectancy at birth is 51 years (United Republic of Tanzania 2005b). The population is predominantly rural but the proportion of urban residents has been increasing over the years (Table 2).

Table 2: Basic Demographic Indicators (Sources: URT 1967, 1978, 1988, 2002)

Selected Demographic Indicators for Tanzania				
Indicators	Year			
	1967	1978	1988	2002
Population (millions)	12.3	17.5	23.1	34.4
Intercensal growth rate (percent)	2.6	3.2	2.8	2.9
Sex ratio	95.1	96.2	94.2	96.0
Crude birth rate	47	49	46	43
Total fertility rate	6.6	6.9	6.5	6.3
Crude death rate	24	19	15	14
Infant mortality rate	155	137	115	95
Percent urban	6.4	13.8	18.3	23.1
Density (pop/km2)	14	20	26	39
Life expectancy at birth (years)	42	44	50	51

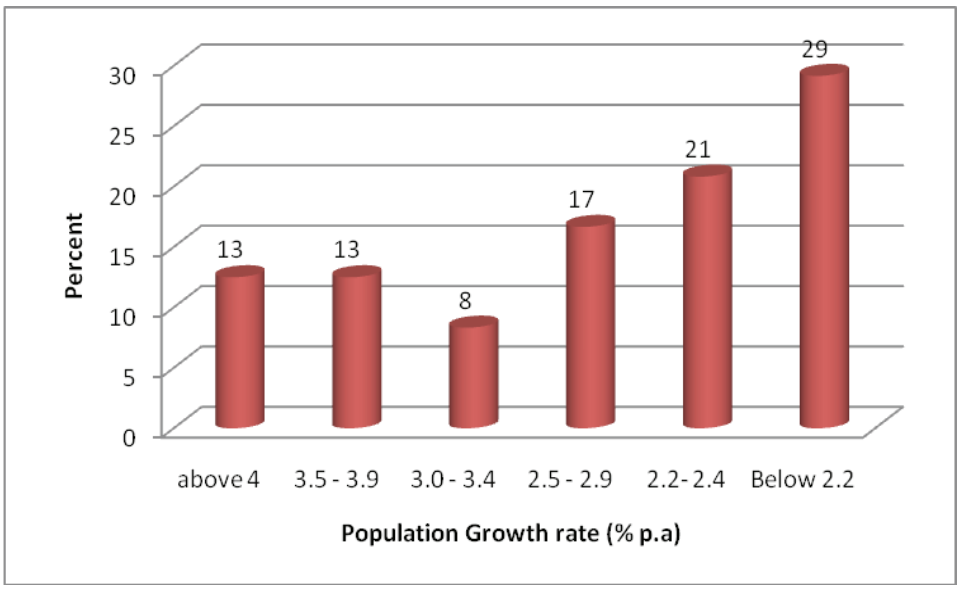

Figure 1: The grouping of population growth rates in regions of Tanzania (URT 2006a)

2. BIOPHYSICAL ENVIRONMENT

2.1 Description of the coast and distinctive features

The coast of Tanzania includes a narrow coastal belt varying in width from 20 to 150 km on the Tanzania Mainland, the offshore waters and the associated islands (Kent *et al.*, 1971). The narrow coastal belt along the Tanzania Mainland runs more or less in a northerly direction for 800 km (Figure 2). This narrow belt is characterized by low-lying coastal plains which rise towards the hinterland to an elevation of about 200 m at the border with the inland plateau (Macmillan 2008). Low-lying coastal plains are also a characteristic feature for the offshore islands, but the highest altitudes on the islands are generally lower than those on the Mainland (Macmillan, 2008; Kent *et al.* 1971). The coastal plains on the islands generally lie between 0 and 100 m above mean sea level.

The coastal belt along the Tanzania Mainland is widest along the Dar es Salaam embayment where it extends 150 km inland (Kent *et al.* 1971, Kapilima 1984). However, it is relatively narrow north and south of the Dar es Salaam embayment where its width is about 20 km (Kent *et al.* 1971). The three major Islands, Pemba, Unguja and Mafia, are all located within 100 km of the Tanzania Mainland coastline. While Pemba is separated from the Tanzania Mainland by a deep channel (800 m), Unguja and Mafia are separated by a relatively shallow channel whose depth is less than 65 m (Mpanda, 1997; Shaghude and Wannäs, 1998; Shaghude, 2001 & 2003). Both Unguja and Mafia lslands are situated on the continental shelf, while Pemba is located off the continental shelf (Figure 3).

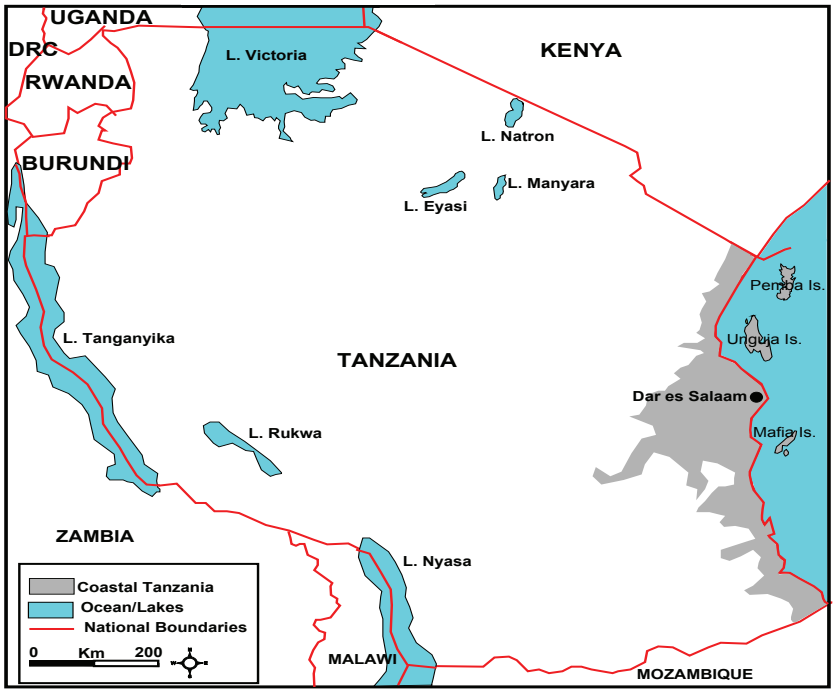

Figure 2: The extent of the coastal belt of Tanzania (Redrawn after Macmillan 2008)

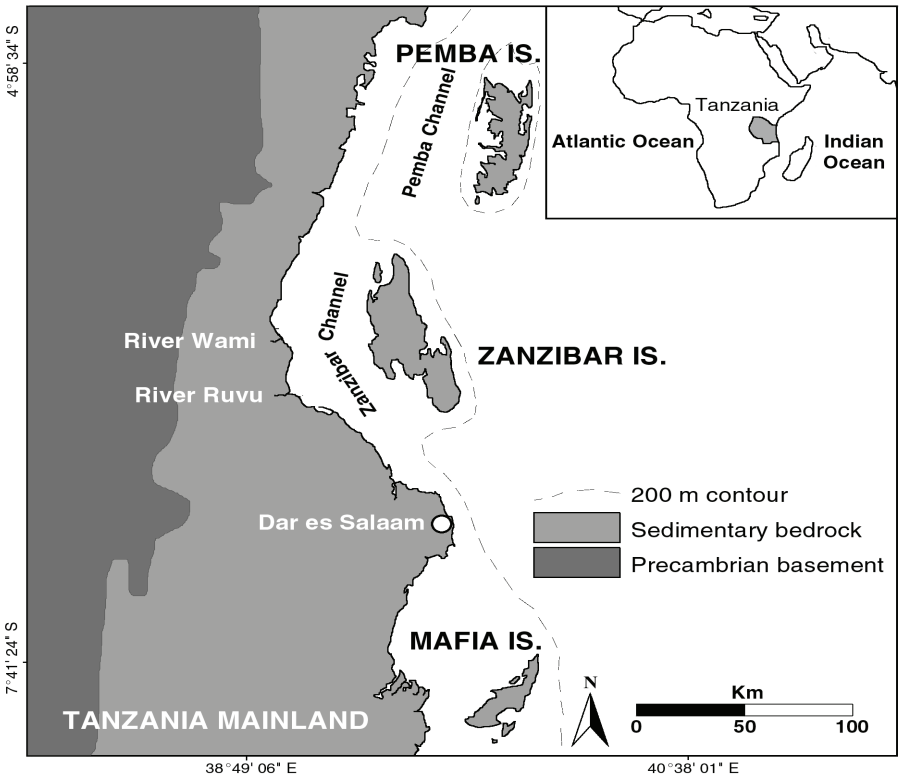

Figure 3: The coastal region of Tanzania including the three major Islands (Source: Shaghude, 2001)

The most prominent primary coastal types along the coast of Tanzania (Figure 4) include:
1- The fringing reef coast with or without beach plains;
2- Patchy reef coast, either with fossil reef terraces and islands or with sand spits, and;
3- Exposed low-lying coasts.

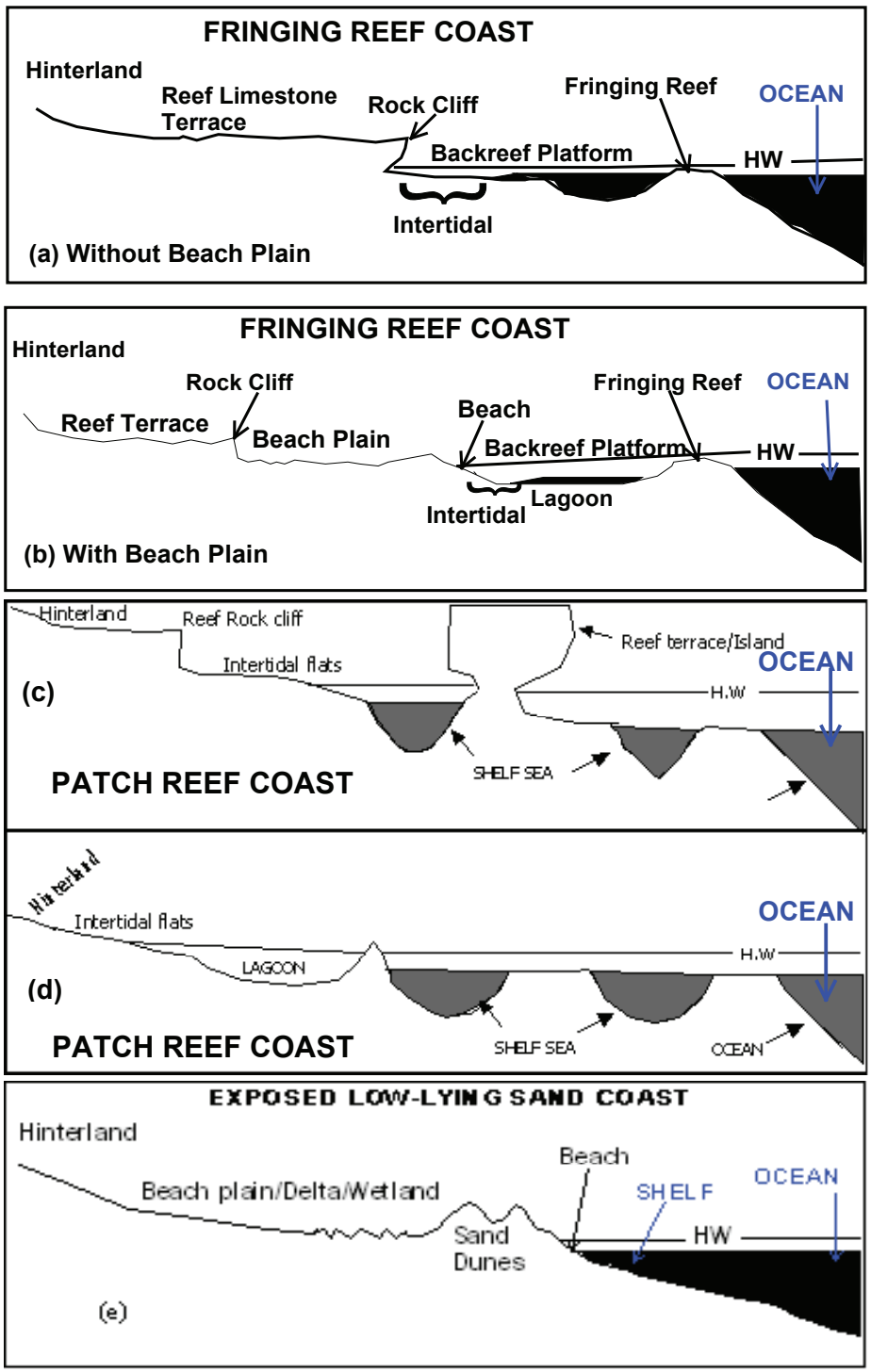

Figure 4: Shore sections showing the most prominent coastal types in Tanzania, namely the fringing reef coasts (a-b), patch reef coasts (c-d) Exposed low lying sand costs (e) (Modified from Kairu and Nyandwi, 2000)

Most of the three primary coastal types also host sheltered tidal inlets, estuaries and creeks. Prime examples of fringing reef coast include much of the eastern coasts of the Unguja and Pemba islands (Arthurton, 2003), while examples of patch reef coasts include much of the western coasts of Pemba, Unguja and Mafia, a number of coastal stretches along the Tanzania Mainland proximal to Tanga, Pangani (Shaghude, 2006), Bagamoyo, Dar es Salaam (Shaghude *et al,*. 2006) and Mnazi Bay. An example of the exposed low-lying sand coast is the coastal section between Mkwaja and Sadani (Shaghude, 2006). Tidal inlets, estuaries and creeks are all associated with well developed mangrove forests and in some instances they are also sites of urban and port development, for example Tanga and Dar es Salaam (Kairu and Nyandwi, 2000) .

Apart from the three major islands mentioned above, there are numerous chains of small islands along the coast (Francis *et al.,* 2001). Most of these islets occur as raised fossil Pleistocene reef platforms or sand banks. The

typical examples include Tumbatu, Changuu, Bawe, Chapwani, Chumbe, Latham and Mnemba (off Unguja Island), Bongoyo, Mbudya, Pangavini, Fungu Yasin, and Makatumbe of the Dar es Salaam Marine Reserve (Wagner, 2007). Some of the islets such as Tumbatu are large enough to support human settlements but others are either too small or lack freshwater resources necessary for supporting human settlements (Francis *et al,*. 2001). However, most of these islets are of significant ecological and socio-economic importance, supporting terrestrial vegetation and fauna as well as providing recreational services for tourists and temporary homes for fishermen.

2.2 Climate

The climate of the coastal region of Tanzania is characterized by tropical humid conditions. Two major factors influence the climate namely; the geographic location within latitudes 4° 30'– 10° 30'S, which creates a truly tropical/equatorial setting, with high temperatures, high humidity and low wind speeds, and secondly its position along the eastern edge of Africa, which places it under the influence of the seasonal monsoon wind regime (Francis *et al.,* 2001).

The monsoon wind changes affect not only the coast of Tanzania but also the entire Western Indian Ocean (WIO) region (Ngusaru, 1997). They are characterized by two seasonal cycles; the South East (SE) monsoon season from April to October and the North East (NE) monsoon season from November to March (Shaghude and Wannäs, 1998). The SE and NE seasonal monsoon winds in Tanzania are locally known as the *Kusi* and *Kaskazi,* respectively. The monsoon wind patterns have marked effect on the patterns of air and water temperatures, winds and rainfall (Ngusaru, 1997) The SE monsoon is generally characterized by relatively lower air temperatures (about 25° C), relatively stronger wind speeds and long rainy season. In contrast, the NE monsoon is characterized by relatively higher air temperatures (>30° C), relatively weaker wind conditions and short rainy season. The months of March-April and October-November are the inter-monsoon periods, locally known as the *Matlai* and the wind conditions during these periods are calmest. Strongest winds along the coast are experienced during June- July period. Occasionally, the SE monsoon is also associated with storms and cyclones (Francis *et al.,* 2001).

Despite this wide generalization of the climate along the coast of Tanzania, there are local variations which are generally influenced by the north-south geographic variation as well as the effects of sea breezes on the coast. Much of the northern parts of the coast of Tanzania (including Dar es Salaam, Tanga, Pemba and Unguja) are characterized by a bimodal rainfall regime, with two rainfall peaks in a given year; a long rainy season from March to May with a peak in April and a short rainy season from October to December with a peak in November (Nyenzi *et al.,*1999, Francis *et al.,* 2001). In contrast, much of southern Tanzania (including, Mtwara, Lindi and Mafia) is characterized by a unimodal rainfall regime, with a continuous rainfall season between December and April (Francis *et al,*. 2001).

Rainfall along the coast of Tanzania generally increases northwards (Figure 5) but the islands receive relatively higher rainfall compared to corresponding coastal areas along the Tanzania mainland. Pemba receives the highest annual rainfall (1916 mm) followed by Mafia (1877 mm) and Unguja (1565 mm), while Lindi receives the lowest amount of rainfall (917 mm) (Francis *et al.* 2001).

As for the wind speeds, Mtwara experiences the highest wind speeds of up to 35 knots, compared to other areas along the coast of Tanzania such as Tanga, Dar es Salaam and Zanzibar, where the mode wind speed is 20 knots (Dubi, 2001). There is also local variation in the timing of the occurrence of the peak wind speeds. According to Dubi (2001), Tanga, Dar es Salaam and Mtwara experience peak wind speeds in the period between July and August while Zanzibar experiences peak wind speeds in January.

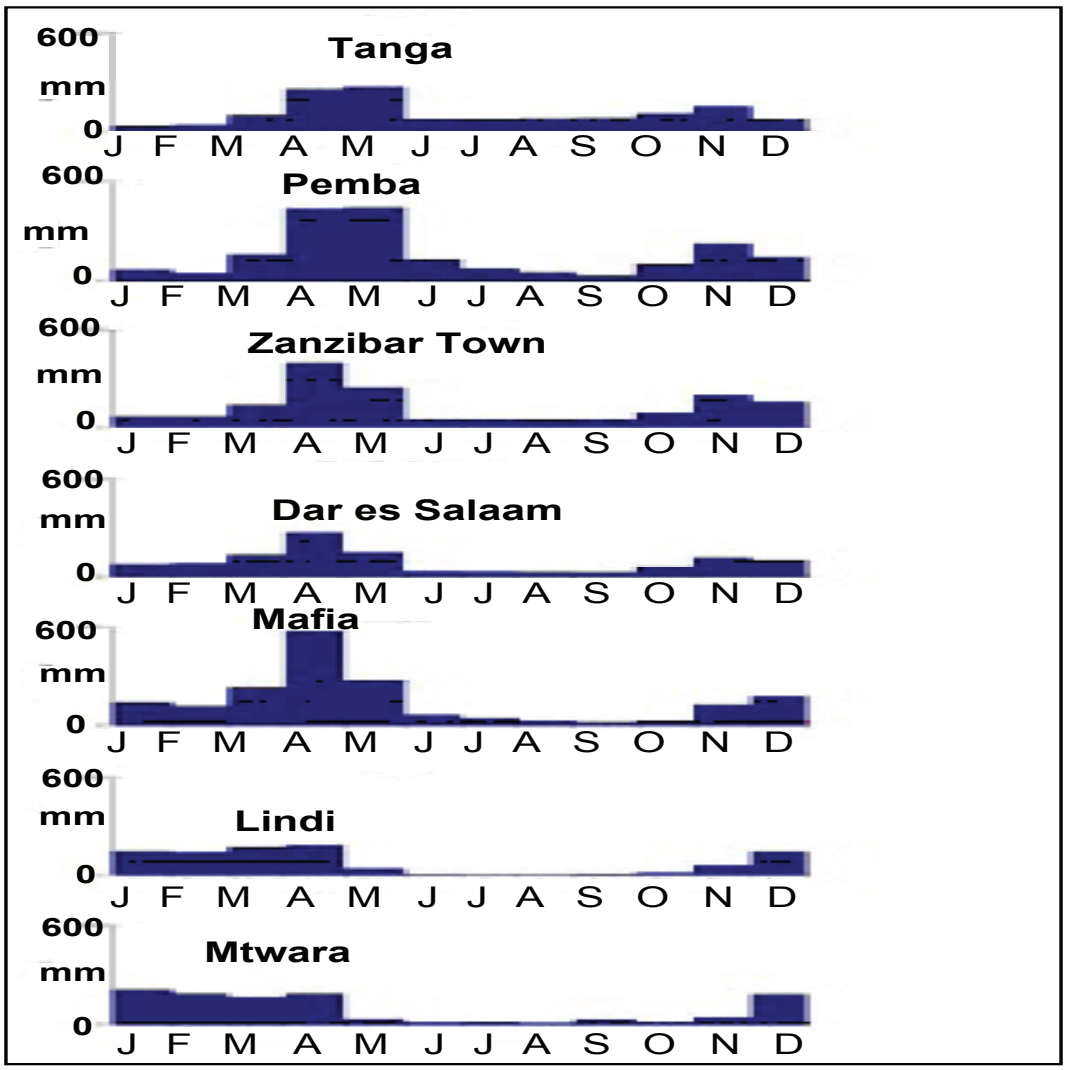

Figure 5: Annual average rainfall distribution along the Coast of Tanzania (Source: Francis *et al*. 2001)

I) Issues

Environmental variability and unpredictability particularly flooding and storm events

ii) Gaps

Analyses of pattern/frequency of extreme climatic events along the coast of Tanzania

2.3 Marine and coastal geology and geomorphology

The coastline of Tanzania with its major islands is about 1,424km long. Along the Tanzania mainland the distinction between the coastal belt and inland plateau is based on rock formations (Alexander 1969, Kent *et al.,* 1971). The bedrock geology of the coastal belt is characterized by sedimentary rocks which vary in age from Jurassic, Cretaceous to Tertiary and Quartenary (Kent *et al.,* 1971). The sediments forming the sedimentary rocks are from both marine and terrestrial sources (Kent *et al.,* 1971, Kapilima, 1984).

In contrast, the interior plateau is dominated by metamorphic crystalline rocks (Alexander 1969, Kent *et al,*. 1971) of the Mozambique belt, believed to have been formed about 550 ± 100 millions years ago (Windley, 1986). The three islands, Pemba, Unguja and Mafia are part of the ancient Miocene Pangani/Ruvu/Rufiji river deltas (Kent *et al.,* 1971; Mruma, 1996). Due to eustatic movements and block faulting over the coast and offshore deltaic zone, at present these islands remain above the sea level as land blocks off the original deltas (Mruma, 1996). The bedrock geology of the three Islands of Pemba, Unguja and Mafia is characterized by relatively younger sedimentary rocks, ranging in age from Miocene to Quaternary (Kent *et al,*. 1971).

The structural trend and the evolution of the coastal basin are closely connected to the Karroo and the Cenozoic rifting as well as the opening of the Indian Ocean (Kent *et al.,* 1971; Shaghude *et al.,* 1994; Shaghude and

Wannas, 1998). A series of transgressions and regressions related to these events resulted in the deposition of thick sediment sequences in the coastal basin (Shaghude *et al.,* 1994; Shaghude and Wannas, 1998). There are two major structural trends which dominate the coastal basin (Figure 6), namely the Tanga Fault with a NNE-SSW direction, which swings to NW in other places, such as Dar es Salaam, Bagamoyo and Zanzibar and the Lindi fault with a NNW – SSE direction (Kent *et al.,* 1971; Mruma, 1996; Mpanda, 1997). Both the Tanga and Lindi tectonic directions were initiated at least during the Karroo time and have influenced both the geomorphology of the coast and the coastal basin in general (Kent *et al,*. 1971). The geomorphology of Pemba is for instance controlled by the Tanga fault trend, whereas that of Unguja Island is a result of superposition of both the Tanga and Lindi fault trends (Mruma, 1996).

Beach ridges and marine terraces are among the most prominent backshore features along the coast of Tanzania. These distinctive geomophological features, which help to unlock the late Holocene to Pleistocene sea level fluctuations (Muzuka *et al.,* 2004), have been discussed by many previous studies (Alexander 1968, 1969, 1985; Muzuka *et al.,* 2004). Alexander (1968) distinguished three marine terrace units along the northern parts of the Tanzania mainland coast (from Dar es Salaam to Tanga) which were named as the Sakura (the highest and oldest terrace unit), the Tanga (the next lower terrace unit) and the Mtoni (the lowest and youngest terrace unit). Each terrace unit represents a major phase of sea level fluctuations (Alexander 1969; Muzuka *et al,*. 2004).

The marine terraces on Pemba and Unguja islands are similar to those discussed by Alexander (1969) on the Tanzania mainland in that all of them consist of steps of coral limestones indicative of marine and tectonic origin (Muzuka *et al,*. 2004). Like the marine terraces, beach ridges are common geomorphological features on the mainland as well as on the major islands, being most prominent on the Mtoni terrace unit.

The information on sea bottom sediment composition, distribution and morphology is generally scarce apart from limited studies conducted in the Zanzibar channel and between Pangani and Wami rivers (Shaghude *et al*. 1998, Shaghude 2003, 2004a, 2004b). The problem of shoreline change, particularly coastal erosion has increasingly become one of the major issues of environmental, ecological and socioeconomic concern in Tanzania, including the islands of Zanzibar (Shaghude *et al*., 2004; UNEP-GPA, 2004).

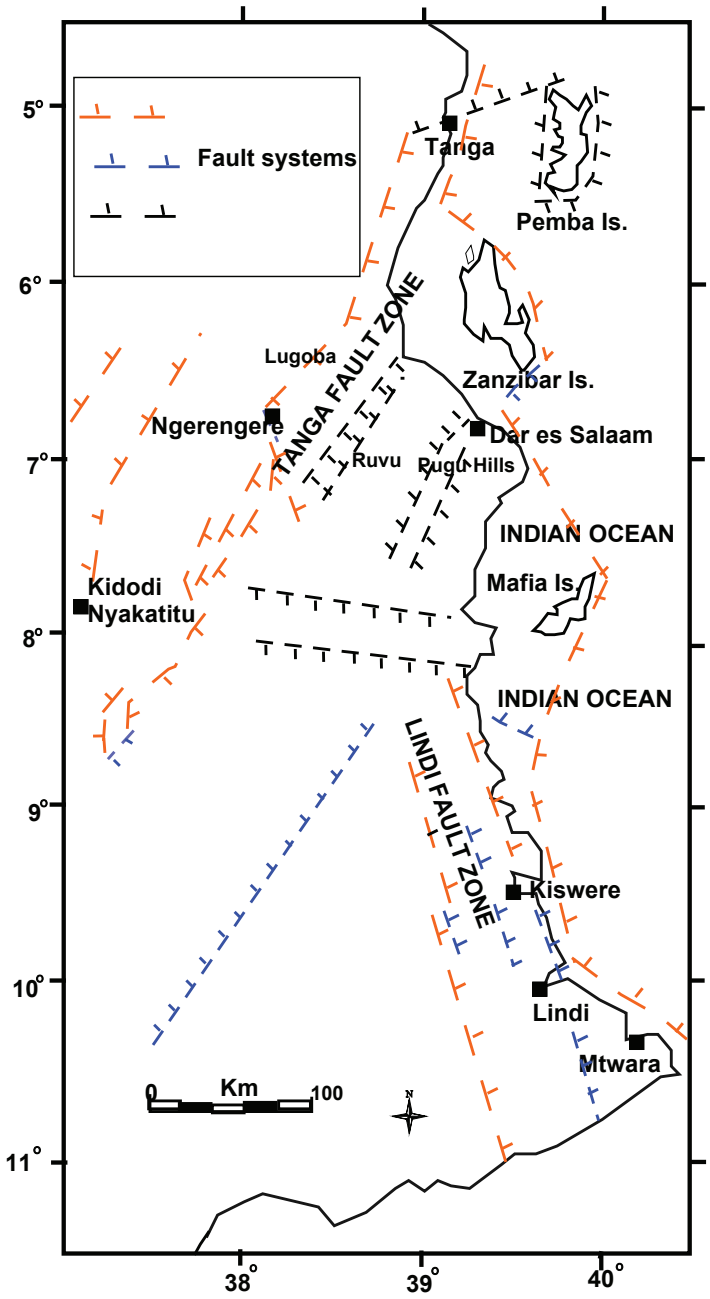

Figure 6: Map of coastal Tanzania showing the major fault trends. The orange, blue and black fault systems represent the three phases of faulting, namely, Karroo and later faulting, Jurassic and later faulting and Miocene and later faulting, respectively (Source: Mruma, 1996)

I) Issues

The ecological and socio-economic impacts due to coastal erosion are increasingly becoming issues of major concern.

Poor management of the shores due to lack of understanding of coastal erosion causative factors and sustainable mitigation/adaptation measures.

ii) Gaps

Most of the existing information on the marine and coastal geology and geomorphology are drawn from studies conducted on the northern parts of Tanzania (from Dar es Salaam to Tanga). There is limited information on the southern parts of the country (between Dar es Salaam and Mtwara).

Information on the sea bottom morphology (bathymetry) is currently lacking for many coastal parts of Tanzania. This is important for running of hydrodynamic models.

2.4 Fresh water resources and drainage

The coastal region of Tanzania has several rivers that discharge into the Indian Ocean. The coastal drainage system covers about 20% of the country and contributes about 50% of the total surface runoff (Francis *et al.*, 2001). The Rufiji is the largest river on the Tanzanian Indian Ocean (TIO) drainage system. Its mean annual discharge is estimated to range between 900 and 1,133 m^3/s. The river contributes 50% of the total fresh water discharges to the sea (Welcomme, 1972; Hafslund 1980; Francis *et al.*, 2001). Other important rivers include the Ruvuma with a mean annual discharge of 475 m^3/s, the Wami with a mean annual discharge of 63 m^3/s, the Ruvu with a mean annual discharge of 63 m^3/s and the Pangani with a mean annual discharge of 27 m^3/s (Welcomme, 1972; Francis *et al.*, 2001; IUCN, 2003; Mikiyasu, 2007). The remaining rivers such as the Matandu, Mbwemkuru and Lukuledi are considered to be relatively less important in terms of freshwater discharges to the Indian Ocean (Figure 7 and Table 3).

Figure 7: River systems draining into the coast of Tanzania (Modified after Francis *et al*. 2001)

Table 3: Major and Minor rivers along the Tanzanian Indian Ocean Drainage system (Modified from Welcomme, 1972; Francis *et al.*, 2001)

River	Length (km)	Catchment area ('000'km²)	Mean annual discharges (m³/s)
Rufiji	640	177.4	900 - 1133
Ruvuma	640	52.1 (in Tanzania)	475
Wami	490	46.4	63
Ruvu	270	18	63
Pangani	395	42.1	27
Matandu	-	18.6	-
Mbwemkuru	-	16.3	-
Likuledi	-	13.0	-

The flow pattern of all the rivers is directly related to the general rainfall pattern (Welcomme, 1972; Hafslund, 1980; Francis *et al.*, 2001; Duvail and Hammerlynck, 2007). Relatively higher river discharges occur during the period November- May (peak flow in March-April) and lower discharges occur during the dry season from June to October (Figure 8).

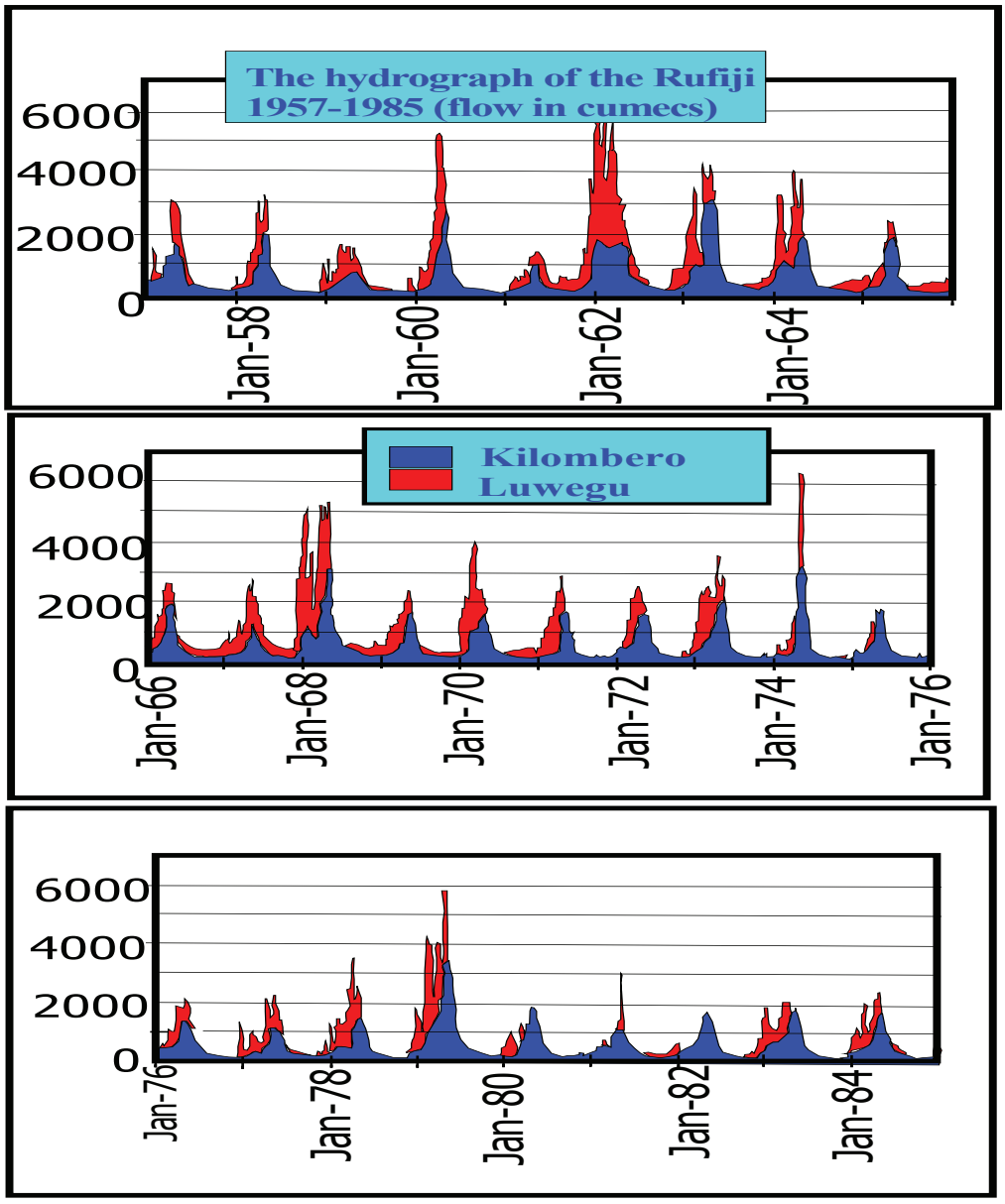

Figure 8: The hydrograph of the Rufiji River (Modified from Hafslund 1980).

The mouths of most of these rivers are characterized by the presence of deltas, estuaries and mangrove forests. The Rufiji delta covering an area of about 1200 km^2, with its associated 7 distributary channels and other interwoven smaller channels and creeks is home to the largest estuarine mangrove forest in East Africa, with an estimated surface area of 53,200 ha. The Rufiji delta mangrove forest constitutes about 46% of the total mangrove forest cover in Tanzania (Semesi, 1991; Kajia, 2000;. IUCN, 2003).

Anthropogenic activities related to demand for water for irrigation and hydropower developments (Figure 9) are considered to have significantly reduced the fresh water discharges of the rivers on the TIO drainage system at list since the last five decades (IUCN, 2003; Shaghude, 2006; Duvail and Hammerlynk, 2007). Anthropogenic activities associated with livestock developments and landuse changes on the upper catchments of the rivers on the TIO drainage system have also contributed to the degradation of the river basins with corresponding reduction in the fresh water discharges of the rivers (Sosovele, 2007). In some of the rivers such as the Pangani, Wami and Ruvu, the situation is considered to be critical with multipliable socio-economic conflicts and potential ecological and environmental impacts at the coast (IUCN, 2003; Shaghude, 2006)

In the Rufiji River Basin for instance (Fig. 9), the total annual discharge is estimated at 28, 382 Mm^3 (million cubic metres), which are contributed by the three tributaries on the Upper Rufiji, namely the Kilombero (17, 597 Mm3), the Great Ruaha (4,257 Mm^3), the Luwegu (5,109Mm^3) and the flows from the Lower Rufiji (1,419 Mm^3). Out this total flow, the irrigation developments on the Great Ruaha River consumes about 1,490 Mm^3, while the planned development on the Lower Rufiji is anticipated to consume about 2022 Mm^3 and the evaporative losses from the Mtera dam are estimated at 1,277 Mm^3, making a total reduced flow of about 4,769 Mm^3, equivalent to 153 m/s (Shaghude, 2008) which is also approximately 17% of the Rufiji Basin annual discharges The reduced flow may have profound effects on the dry season fresh water discharges to the sea by\the Rufiji, which is estimated at 300 m^3/s (Shaghude, 2008).

In the Pangani River Basin, the fresh water contribution from mount Kilimanjaro and other sources had been estimated at 500 Mm^3 and 400 Mm^3, respectively (Fig. 9). As with the Rufiji River Basin the reduced flow due to irrigation developments and evaporative losses in dams had been estimated at 400 Mm^3 and 400 Mm^3, respectively. The reduced flow on the Pangani due to the existing irrigation project and the water impoundment in the Nyumba ya Mungu dam would therefore amount to at least 800 Mm^3 per year, which is a very significant proportion (about 89%) of the total available water on the Pangani River Basin.

i) Issues

Anthropogenic activities have significantly affected fresh water discharges in the TIO drainage system at least during the last five decades (IUCN, 2003; Shaghude, 2006; Duvail and Hammerlynck, 2007). Landuse changes within the upper catchments of the rivers have contributed to the degradation of the river basins with corresponding reduction in the freshwater discharges (Shaghude, 2008). In some of the rivers such as the Pangani, Wami and Ruvu, the situation is considered to be critical with multiple socio-economic conflicts and potential ecological and environmental impacts at the coast (Mwandosya *et al.,* 1998; IUCN, 2003; Shaghude, 2006; Yanda and Munishi, 2007).

The changes in rainfall pattern due to global climate change are also altering the river flow regime in most of the TIO drainage system and parallel impacts at the coast are envisaged (Yanda and Munishi 2007).

Coastal environmental impacts due to increasing water abstraction (for irrigation) and hydropower developments as well as the increasing degradation of the catchments due to landuse changes and livestock keeping.
There is a general lack of information on the patterns of climate change and their impacts on the hydrology of the Tanzanian river systems draining into the coast.

ii) Gaps

There is a need for updated data on current river discharges. In this regard, there is a need to further build the capacity for comprehensive monitoring of river discharges.
There is also a need to identify appropriate climate change adaptation and mitigation measures in all major river basins of Tanzania.

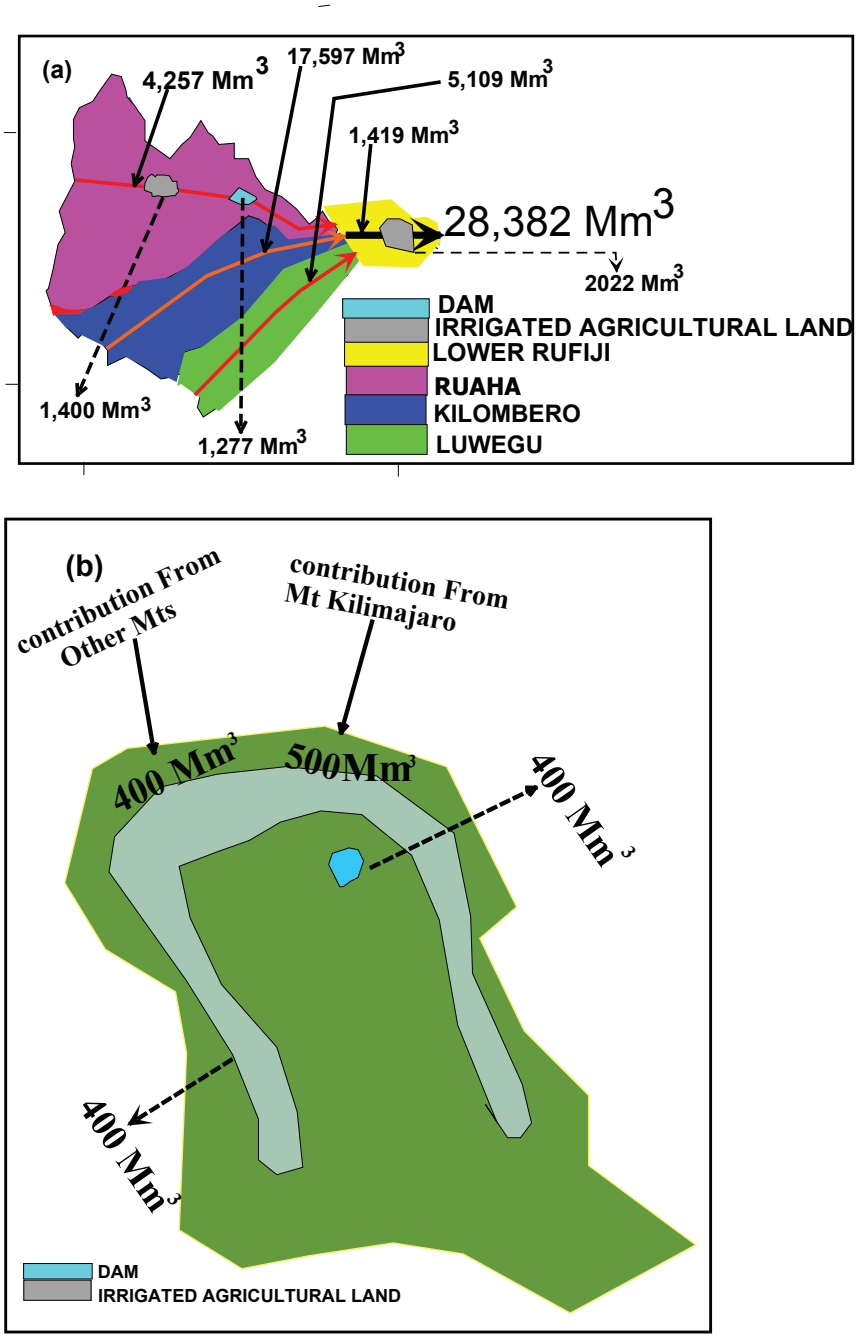

Fig. 9. Figure 8. Rufiji (a) and Pangani River Basins (b) water budgets. The bold arrows in the figures indicates the estimated annual input of fresh water to the systems, while the dotted arrows indicates the water losses due to irrigation and evaporation. Source: Shaghude (2008).

Physical Oceanography

Water circulation within Tanzania's coastal waters is controlled by a number of factors, including the Northeast and Southeast monsoons, the East African Coastal Current, the South Equatorial Current and the tidal regime.

Currents

The East African Coastal Current (EACC), which flows northwards throughout the year, is the dominant prevailing ocean current along the coast of Tanzania (Newell, 1959). The EACC principally originates from the Southern Equatorial Current (SEC) which flows from east to west throughout the year at around latitude 12°S (Swallow *et al*,. 1991). The EACC is strongest during the period April to October with current velocities ranging from 1.5 to 2 m/s when it is accelerated by the SE monsoon winds. During the period between November and March, the current is weaker with low velocities of the order 0.5 m/s as it is impeded by the northeast (NE) monsoon winds.

Tanzania coastal water is characterised by nutrient-poor water resulting in low productivity (El-Sayed, 1989). The coastal dynamics however, are to some extent influenced by the presence of islands (Zanzibar, Pemba, Mafia and numerous smaller islands), orientation of the coast and an almost continuous band of reefs that fringe the coast and islands. Studies carried out on current velocities in inshore water of Tanzania show that there are significant differences from one location to the other. For instance, in the inshore waters off Kunduchi in Dar es Salaam, the current speed recorded during the NE monsoon, averaged over one tidal cycle, is about 0.25 m/s with a maximum of 0.5 m/s. There is however, no remarkable change in both speed and direction during the SE monsoon. In the Kunduchi-Manyema Creek, velocities of up to 3.5 m/s have been recorded during ebb tide (Dubi, 2006).

Within the Zanzibar Channel when the EACC is strongest (June-October), some flow of the EACC is diverted through the southern entrances of the Zanzibar and Pemba channels (Garcia-Reyes et al., 2009). During the NE monsoon, some of the EACC drives a southward flow through the northern entrance of the Zanzibar Channel.

The shores of the southern border of Tanzania and Mozambique at Mtwara are also of strategic importance because this is where the South Equatorial Current (SEC) meets the coastline of Africa and divides. The SEC waters carry eggs and larvae of numerous marine animals and plants. This area is therefore very important for the settlement and subsequent dispersal of marine organisms, both north and south along the coast of East Africa (Obura, 2004)

Studies have also shown that in the Rufiji delta freshwater is trapped in the nearshore zone due to the orientation of the delta, the prevailing wind regime (always onshore) and current conditions (Iversen et al., 1984; Francis, 1992). The EACC inhibits the flow of nearshore waters offshore, resulting in greater nearshore current flows (Gupta and Desa, 2001).

i) Issues

Cyclonic eddies such as those which have been observed at the small island of Latham may be hazardous to fishers and navigators.

ii) Gaps

Lack of sufficient knowledge of coastal currents and their seasonality. So far only short-term observations covering small areas of interest have been made.
Lack of sufficient knowledge of the effect of the EACC on the coastal dynamics.
Insufficient knowledge of areas with cyclonic eddies and upwellings.
Current patterns in the strategic areas for egg and larval dispersal (such as those in Mtwara and south Mafia) are not clearly understood, there is speculation only.
Lack of an inventory of historical surveys and expeditions

Tidal regime and waves

Tidal ranges

Tides along the Tanzanian coast and islands are predominantly semi-diurnal, with a Form Factor of 0.16 (Pugh 1984). The mean spring tidal ranges vary from 3.0 m at Kunduchi in Dar es Salaam (Lwiza and Bigendako, 1988) to a maximum of 3.6 m at Zanzibar harbour (Odido and Francis, 1999; Cederlöf et al., 1995; Mahongo and Francis, 2010). At Dar es Salaam harbour, the mean spring tidal range is about 3.2 m (Lwiza and Bigendako, 1988. The maximum tidal range in most places in Tanzania is about 4 m (Hartnol 1974). The times of high and low tides are also approximately the same all along the coast (Ngusaru 2002).

Throughout the coast of Tanzania, the mean neap tidal ranges vary from about 0.9 m at Chwaka bay in Zanzibar (Cederlöf *et al.* 1995) to about 1.2 at Zanzibar harbour (Odido and Francis 1999). The age of the semi-diurnal tide (time interval between the times of new and full moon and a measure of delay period of the spring tide) vary between one and two days. The age has a lag of about 26 hours at Zanzibar harbour (Odido and Francis, 1999), and about 32 hours at Dar es Salaam harbour (Lwiza and Bigendako, 1988).

Wave patterns

There are a few studies that document wave characteristics of coastal Tanzania, and these have mainly been undertaken on a short-time basis in a few areas of interest. Average wave heights of about 0.9 m have been observed during the North East monsoons, which increase to about 1.2 to 1.5 m during the South East monsoon (Lwiza, 1994; Nyandwi, 1999). During the North East monsoon, wind-generated waves approach the coast from the northerly sector. During the South East monsoon, waves approach the shore from the south-east direction with periods of 8-10 seconds (Nyandwi, 1999). Highest waves are experienced at the peak of the South East monsoon during the period between July and September. In August the significant wave heights are about 0.4 m and wave periods are about 6-10 seconds (Nyandwi, 1999).

Generally, fringing reefs protect the coastal areas and islands from most storm waves and swells (Brampton, 1996) and play an important role in refracting and diffusing the waves (Lwiza, 1994). Occasionally however, strong wind waves cross the barrier reefs to reach the shores, especially when spring tides coincide with storms and onshore winds. In addition to causing flooding in low lying areas, strong waves are also responsible for coastal erosion. Makota *et al*. (2004) for instance, observed considerable changes of the Kunduchi shoreline off Dar es Salaam between 1981 and 2002, whereby between 2.04 ha and 2.60 ha of the beach was eroded by wave action. Recently, Almström and Larsson (2008) concluded wave generated longshore transport is the governing process for moving sediments along the Kunduchi beach area. Lwiza (1994) also recognised the influence of waves on coastal erosion in Tanzania.

Tanzania is fortunate in not having experienced a major tsunami event. However, in December 2004, the Indian Ocean Tsunami caused by an undersea earthquake in Indonesia resulted in larger-than-normal waves reaching Zanzibar (Merrifield *et al.*, 2005).

i) issues

Coastal erosion which is causing infrastructural damage, loss of valuable land and other impacts with major economic implications.
Extreme waves and storm surges that accelerate coastal erosion processes.

ii) Gaps

The coverage of sea level monitoring is low and tide gauges are yet to be installed in strategic locations along the coast of Tanzania.
Lack of capacity for study of waves, sea level analysis and prediction.
Lack of sufficient knowledge on the effects of local and regional factors on short-term changes of sea level
Lack of capacity in satellite altimetry.
Lack of a warning system for storm surges and tsunamis.

Sea level change

Along the coast of Tanzania, sea level variability is monitored using tide gauges installed in two stations in Zanzibar and Mtwara. The Zanzibar station is considered to be one of the most important Indian Ocean tide gauge stations for monitoring long term changes in sea level in the Western Indian Ocean (Church and White, 2006). The two stations transmit sea level data to the Indian Ocean Tsunami Warning System (IOTWS) on a real time basis through the Global Telecommunications System (GTS). Historical sea level data exist for stations located in Dar es Salaam, Mtwara and Tanga. However, data from these stations cover relatively short periods.

A recent study of trends in mean sea levels in Tanzania indicates falling sea level in Tanga (between 1962 and 1966), Dar es Salaam (between 1986 and 1990) and Zanzibar (between 1984 and 2004). However, sea level is rising in Mtwara (between 1959 and 1962) (Mahongo, 2009). Data from Zanzibar indicate that sea level has been declining at a rate of 3.6 mm/year for the period between 1985 and 2004. Mahongo and Francis (2010) have also given an in-depth analysis of the seasonal variations of sea level at the island of Zanzibar during the period 1985-2004, revealing three major cycles of sea level i.e. semi-annual, annual and four-year oscillations.

Few studies on the past sea levels along the coast of Tanzania have been undertaken. In Tanzania, Muzuka *et al*. (2003) made a preliminary investigation on the Pleistocene/Holocene sea level changes. In this study, it was found that the oldest Palaeo-shoreline is approximately 5 m above the present sea level. This extends landward to more than 1 km. On the islands of Zanzibar, specific localities where Pleistocene/Holocene sea level changes occurred have been preserved in the form of marine terraces and/or beach ridges. These are found in Chwaka, Uroa, Jambiani, Paje and Nungwi in Unguja Island and, Vumawimbi and Kiuyu in Pemba Island (Muzuka *et al*. 2000; Alexander, 1969 & 1985).

Projections of future mean sea level trends in Tanzania are currently not feasible due to insufficient data occasioned by limited duration of monitoring. The longest sea level record is only 25 years at Zanzibar. However, model simulation of long-term sea level trends (1955-2003) using a combination of tide gauge records and satellite altimetry, show a general rising trend in Tanzania ranging from 0.4 to 2.0 mm/yr (Bindoff *et al.,* 2007). The global average within this period is about 0.4 to 3.6 mm/yr (Bindoff *et al.* 2007).

i) Issues

Increased coastal erosion along the coast causing major economic losses due to loss of land and infrastructural damage.
Inundation and displacement of wetlands and lowlands due to flooding.
Saltwater intrusion into estuaries and groundwater aquifers.
Changes in sedimentation patterns.
Increased turbidity of coastal waters reducing productivity.

ii) Gaps

Lack of sufficient knowledge of factors affecting long term change in mean sea level
Lack of long term sea level records.
Lack of capacity in the analysis of satellite altimetry data.

Ocean temperature

Sea Surface Temperature (SST)

Typically, the average Sea Surface Temperature (SST) in Tanzanian offshore waters is around 27°C and the typical range is from 22 to 30°C (Newell, 1957; Iversen *et al.* 1984; Francis *et al*., 2001). The SSTs are generally higher during the North East monsoon as compared to the South East monsoon. The SSTs are also highest in early March and lowest in either August or September (Harvey, 1977). However, higher SSTs of up to 32.5°C occur in shallow coastal areas (Lugomela, 2006).

During the North East monsoon, there is a decrease in water temperature with depth while during the South East monsoon the waters are isothermal from the surface to the thermocline. According to Hartnoll (1974)

and Harvey (1977), the thermocline in the Tanzanian offshore waters lies at a depth of between 25 and 100 m. The temperature of the mixed layer varies quite appreciably from one place to another, mainly due to seasonal variations. There are also diurnal variations particularly in offshore waters which are controlled by variability in the heating of water by the solar radiation during the day and cooling during the night. In the near-shore waters, the seawater temperatures are mainly semidiurnal due to dominant effect of the semi-diurnal tides (Francis *et al.,* 2001).

In Zanzibar, SSTs have been recorded using temperature loggers tied on coral branches at 3 m depth on Bawe and Chumbe coral reefs (Muhando 2001). Recording undertaken since 1997 showed a yearly seasonal pattern with lowest temperatures ranging 24.5–25.5°C occurring in July–August, with an annual peaks (29.2°C - 30.7°C) occurring in the period between March and April. Generally, mean SSTs are always higher during the North East monsoon (about 28°C) than during the South East monsoon (about 26°C). Intrusion of a cold seawater mass in January–February period is attributed to the northward flow component of the EACC (Garcia-Reyes et al., 2009).

i) Issues

Coral bleaching due to increased Sea Surface Temperatures (SSTs)
Fish kills due to harmful algal blooms.
Loss of colour and hence value of seaweeds.

ii) Gaps

Lack of sufficient knowledge of seasonal and spatial variation of SSTs in most areas.
Lack of vertical temperature profiles- only short-term measurements on SSTs which are site specific.

Salinity patterns

The surface water salinity of the Tanzanian coastal waters ranges between 34 and 36 PSU. In estuaries and coastal bays, salinities are usually relatively low due to the influence of freshwater discharge from the river systems. The salinities in offshore waters are highest in November during dry season, and are lowest in May during rainy season following the peak river freshwater outflow (Iversen *et al.* 1984). Bryceson (1982) observed that the salinity starts to decrease before the onset of the rains and attributed this to the advection of lower salinity water from the South.

The salinity of the surface water at Kunduchi in Dar es Salaam reaches a maximum of about 35.3 PSU in November and falls to a minimum of 34.6 PSU in May (Hartnoll, 1974). In the Mafia Channel, the salinity ranges between 34.7 and 34.95 PSU while in the Rufiji delta, salinity range 12-14 PSU inside the estuary and 20-25 PSU at the mouth of the delta (Talbot, 1964; Tafe, 1990). On the East coast of Zanzibar at Chwaka Bay, salinity ranges from 26.3-28.1 PSU on the inner zone of the bay and ranges from 29.5-35 PSU at the entrance (Lugendo *et al.,* 2005, Wolanski, 1989). During the dry season, the salinity in the inner mangrove areas of Chwaka Bay can reach 38 PSU.

Water masses of the Tanzanian coast

There are four water masses in the Tanzanian offshore waters, characterized by typical salinity and oxygen levels. These occur at various depths. They include: (i) Tropical Surface Water characterised by high salinity and high oxygen, (ii) Arabian Sea Water at depth of about 1000m characterized by high salinity and low oxygen, (iii) Antarctic Intermediate Water characterized by low salinity and high oxygen, and (iv) North Indian Deep Water characterized by high salinity and low oxygen (Hartnoll, 1974). The Tropical Surface Water originates from the South Equatorial Current (SEC).

Ocean-atmosphere interaction

Few studies have been undertaken on ocean-atmosphere interactions in Tanzania. A study on heat fluxes at Chwaka bay on the eastern coast of Zanzibar in 1996 established that the major heat fluxes within the bay were due to incoming solar radiation and loss due to evaporation and long-wave back radiation (Mahongo 1998, 1999, 2000). The sensible heat and net long-wave radiation fluxes played minor roles in the heat budget of the bay. The observed and computed values of the fluxes of absorbed solar radiation, evaporation, net long-wave

radiation, sensible heat and reflection at the bay bottom were respectively +275, -156, -38, -18 and -2 W m^{-2}. The heat budget was mainly balanced by heat advection from the bay to the open ocean, with a small portion being due to water-sediment heat conduction (Mahongo 1998, 1999, 2000).

The Indian Ocean Dipole and El-Nino Southern Oscillation (ENSO) phenomenon have some significant influences on the climate of coastal region of Tanzania. However, there are few local studies that have focussed on these two phenomenons. Kijazi and Reason (2005) has established that El Nino is associated with above average rainfall while La Nina is associated with below average rainfall over the northern region of the Tanzanian coast during the North-East Monsoon season, and to lesser extent during the South-East Monsoon season.

Chemical and Biological Oceanography

Nutrients

Increased economic activities and expanding populations in coastal towns of Tanzania have resulted in production of large amount of waste including sewage and industrial effluent. Unfortunately, raw sewage and industrial effluents produced in all coastal towns are directly released into estuaries and other coastal habitats. This is particularly evident in Dar es Salaam, Zanzibar, Tanga, Kilwa and Mtwara. Away from coastal towns, pollution of coastal waters is caused by fertilizer residue contained in run-off from agricultural areas. There is evidence of nutrient enrichment. For instance, high nutrient loads have been detected in waters fronting major towns in Tanzania. Ammonium levels of up to 28.6 µg-at Nl^{-1}, nitrate levels up to 7.8 µg-at Nl^{-1} and phosphate levels of 4.0 µg-at Nl $occur^{-1}$ in Zanzibar (Anderson, 1994). Furthermore, high amounts of faecal coliform and total coliform bacteria of up to several thousands per ml of seawater, occur in the waters off Stone Town, Zanzibar (Mohammed, 2001). Likewise, high nutrient loadings have been recorded in water fronting Tanga Township. Effluents from a fertilizer factory, municipal sewage and sisal decortications plants have enriched coastal waters causing proliferation of macroalgae in Tanga coastal waters (Munisi, 1999; Shilungushella, 1993).

In Dar es Salaam, the inshore waters are characterized by the presence of high levels of nutrients (Lyimo (2009). Nitrate levels of up to 54 µmolL^{-1}, phosphates of up to 45 µmolL^{-1} and nitrites of up to 20 µmolL^{-1} have been recorded. Several thousand counts of microbials ranging between 1,700 and 240,000 for total coliform, 200 to 92,000 for faecal coliform and 11 to 4,900 for enterococci have also been observed in Dar es Salaam inshore waters. The levels of faecal indicator bacteria and nutrients are usually higher during the rainy seasons due to surface runoff from Dar es Salaam city (Bryceson, 1983).

The coastal areas of Dar es Salaam experience heavy loads of pollutants through Msimbazi Creek which receives large quantities of domestic and industrial wastes from the city of Dar es Salaam. The river and creek receive pollutants such as dyes, paint wastes and strong alkalis, oil and tars, as well as organic wastes from breweries and meat plants (Bryceson, 1982).

In Dar es Salaam, raw sewage generated by 15% of the city residents who are connected to the sewer system is discharged directly into the sea, untreated. The situation became worse in the 1990s due to damage of the sewer pipe leading to the discharge of untreated sewage on sandy-mud flats near the harbour (Bryceson et al., 1990). About 79% of the population in Dar es Salaam use onsite sanitation facilities particularly pit latrines (Mashauri and Mayo 1989; Mgana and Mahongo, 1997; Dar es Salaam City Council, 2004). Leachate and overflow from pit-latrines have led to contamination of most surface and groundwater resources including inshore waters. Other sources of coastal pollution in Dar es Salaam are industrial wastes from Keko, Chang'ombe, Kurasini, Mtoni and Temeke which discharge heavy metals, pesticides, paint, nutrients, organic and other pollutants near the harbour (Bryceson, 1983; Machiwa, 2000; Mwevura et al., 2000). Other coastal areas of Tanzania outside the major cities and townships are free from domestic wastes but occasionally suffer from input of agricultural wastes, including pesticide and fertilizer residues. Most of the major rivers in the country drain rich agricultural lands where the application of fertilizers and pesticides to boost crop production is common.

Persistent organic pollutants

High levels of PCBs and organochlorine pesticide residues have been detected in Dar es Salaam harbour (Machiwa, 1992; Mwevura et al. 2002). Chlorinated compounds due to pesticide pollution have been reported in Chwaka bay, Zanzibar (Mmochi, 2005). Heavy metals such as lead (Pb), zinc (Zn), cadmium (Cd), chromium (Cr), mercury (Hg) and copper (Cu) have been reported in waters within Dar es Salaam harbour and nearby coastal areas (Machiwa, 1992; Kondoro 1997; Muzuka, 1997). Concentrations of these metals exceeded maximum values recommended by the World Health Organization (WHO). Similarly, high concentrations of Cr, Pb, Cu, Hg and other heavy metals have been reported in Mzinga creek mangrove sediments in Dar es Salaam (Mtanga and Machiwa, 2007). These metals were found to have accumulated in tissues of Polychaete worms (Mtanga and Machiwa, 2007). Several studies have also been conducted on the impacts of heavy metal on flora and fauna dwelling in polluted habitats in Dar es Salaam coastal areas (Mwandya, 1996; Wekwe et al. 1989). The environmental impacts of Pb, Hg and Cd on calcification rates of the reef building calcareous algae *Amphipora tribulis* have been investigated in Dar es Salaam (Kangwe, 1999).

Primary production

In Tanzania, high plankton biomass and productivity occur during the NE monsoon and is relatively lower during the SE monsoon period. The biomass is usually highest at the surface water column especially during calm weather periods (McClanahan, 1988; Lugomela *et al.*, 2002). The water column primary productivity ranges from 204 to 4142 mg C m^{-2} day^{-1}. Bacterial production varies from 10 to 72 mg C m^{-2} day^{-1}, comprising 5% of the total bacterial standing stock (Lugomela *et al,* 2001). Biofilm carbon fixation rate is estimated to be 0.05, 0.3 and 0.5 kg C m^{-2} y^{-1} for thin (0.5 mm), medium (1 mm) and thick (2 mm) biofilms, respectively with an overall primary production rate of 0.14 kg C m^{-2} y^{-1} at depths of about 5 m (Lugomela *et al.* 2005).

The nitrogen fixation rate in intertidal sediments along the coast of Tanzania is estimated to be 38 mmolN $m^{-2}y^{-1}$. Higher rates of nitrogen fixation occur during the night time as compared to daytime suggesting sediments composed of non-heterocystous diazotrophic organisms (Lyimo and Lugomela 2006). The rates of nitrogen fixation by *Trichodesmium* species in the surface waters were estimated by to be 42.7 mmol N $m^{-3}y^{-1}$ (Lugomela *et al*., 2002)

In Zanzibar, studies on nitrogenase activity found that nitrogen fixation varies from 6.0 to 118.5 nmol C_2H_4 $cm^{-2}h^{-1}$ on mangrove pneumatophores and from 1.3 to 16.8 nmol C_2H_4 $cm^{-2}h^{-1}$ in adjacent sediments (Lugomela and Bergman, 2002). In sandy and muddy areas within a mangrove ecosystem near Zanzibar town, the rates of nitrogen fixation are of the order of 1.64 and 1.34 nmol N $m^{-2}h^{-1}$, respectively, (Kyaruzi *et al*., 2003).

Studies on the impact of mangrove deforestation on nutrients, phytoplankton community structure and biomass in Tanzania have established that there are no significant differences in both water-column and sediment phytoplankton biomass between deforested and conserved sites **(Kyewalyanga, 2005)**. Sediment chlorophyll-*a* was however significantly higher at the conserved site (average of 2.38 ± 1.36 mg m^{-3}) than at the deforested one (1.28 ± 0.91 mg m^{-3}), while water-column chlorophyll-*a* was higher at the deforested than at the conserved site, with averages of 1.52 ± 1.26 and 0.71 ± 0.62 mg m^{-3}, respectively. Organic matter content was much higher at the deforested site (25.98 ± 1.51%) compared to the conserved mangrove site (19.52 ± 0.99%) (**Kyewalyanga 2005)**.

Studies on the cyanobacteria diversity and nitrogenase activity in Paje lagoon, Zanzibar have revealed rich cyanobacterial genetic and morphological diversity and substantial nitrogenase activity especially during the night with the maximum activity reaching 120 nmol C_2H_4 cm^{-2} h^{-1}) (Bauer *et al.*, 2008).

Several potentially harmful microalgae have been found in Tanzanian coastal waters. They are distributed among three major microalgal groups, namely cyanobacteria, mostly dominated by Trichodesmium spp, the dinoflagellates, dominated by both *Prorocentrum* spp. and *Gambierdiscus toxicus* and the diatoms, mostly *Pseudo-nitzschia* spp. (Hansen *et al.,* 2001; Lugomela, 2006 & 2007). Relative abundance and spatio-temporal variability of these organisms has not been well assessed. It is also not known if these organisms are associated with severe poisoning associated with the consumption of shellfish and meat from dead turtles that has happened at several places along the coastal line of Tanzania (The independent 1996, proMED-mail 1996).

Secondary production

In the inshore waters of Dar es Salaam, the main taxa of zooplankton are Calanoida (49. 1%), Larvacea (11. 9%), *Corycaeus* spp. (6.4%), *Cypridina sinuosa* (5.6%), *Oithona* spp. (4.8%), caridean larvae (4.0%), *Sagitta* spp. (3.8%), *Euterpina* (2.1%), *Lucifer* (1.2%), *Oncea* (1.2%), Hydromedusae (1.0%), *Euconchoecia chierchiae* (1.0%), *Creseis acicula* (1.0%), Brachyuran zoeae (0.8%), Ctenophora (0.5%), Mysidacea (0.5%) and other minor species (Okera 1974). All major groups of the zooplankton have an annual cycle of abundance, with relatively high numbers being recorded in the period between February and August during the SE Monsoon. During the NE monsoon, the abundance is relatively low. Relatively richer, more diverse fauna exist at the river mouths and estuaries compared to the upper reaches as demonstrated in the Rufiji Delta (Tafe, 1990). The zooplankton in river mouths and estuaries are more abundant at certain times of the day. However, differences in faunal composition are found between different areas (Tafe, 1990). Estimates of total zooplankton in the Zanzibar coastal area was carried out by Wickstead in 1963. There is a need for updating of information on zooplankton in view of the fact that previous studies are now outdated and many changes have taken place.

A few studies on trophic relationships have also been conducted in Tanzania coastal-marine waters. Lugomela *et al*. (2001) has shown that 77% of the total primary production is channeled through the heterotrophic flagellates, ciliates and heterotrophic dinoflagellates to higher trophic levels. Thus, 28% of estimated carbon demand for mesozooplankton could potentially be met by ciliates and heterotrophic dinoflagellates (Lugomela *et al*. 2001). Another interesting investigation was done on the feeding behaviour of chaetognath species between the monsoons periods conducted in Zanzibar in 2000. The diet, feeding behaviour, feeding rates and estimates of predation impact on standing stock of copepods as well as the impact of cannibalism were presented in this study (Oresland 2000).

Coastal Zone and Continental Shelf

Description and extent of coastal and marine habitats

The coastal zone of Tanzania stretches from latitude 4°49'S at the border with Kenya to the border with Mozambique at latitude 10°28'S. About two thirds of the coastline has fringing reefs, often close to the shoreline, broken by river outlets such as the Rufiji, Pangani, Ruvuma, Wami and Ruvu (Dubi 2001). Features of interest within the coastal zone include the coastline, continental shelf, corals, mangroves, and seagrass beds. The length of the coastline of Tanzania is 3,461 km (United States Mapping Agency, 2003). The width of the continental shelf is 5.8 km except in the Zanzibar and Mafia channels where it reaches a width of about 62km. The total area of the continental shelf is estimated to be 17,900 km^2. The most important coastal ecosystems include coral reefs, mangroves and seagrass beds.

Coral reefs

Coral reefs cover about two thirds of Tanzania's continental shelf. Fringing reefs forming margins along the edge of the mainland or islands and patch reefs dominate the coastal waters of Tanzania (TCMP, 2001a). Due to the restricted drainage and un-indented coastline, well developed coral reefs have only evolved along major sections of the continental shelf. These cover a surface area of about 3,500 Km^2 - the largest area covered by coral reefs in the entire Eastern Africa. Due to narrowness of the continental shelf, the coral reefs are generally situated near the shoreline within a distance of between 1 and 5 km.

The coral reefs in Tanzania are under different types of threats. In some Marine Protected Areas (MPAs) and managed areas (e.g. Muheza, Tanga and Pangani Districts), most of the destructive fishing practices has been stopped. However, dynamite fishing, coral bleaching, seine netting, over-fishing, shell collection, wave action, boat anchoring, coral mining, crown-of-thorns starfish (COTS) and pollution are still the main threats to the existence of the coral reefs (Francis *et* al., 2001; Horril *et al*., 2001; Ngusaru *et al.,* 2001; Whitney *et al.,* 2003).

The coral reefs in Tanzania have also been impacted by rising seawater temperatures. In the period between March and September 1998, a significant coral bleaching event occurred leading to 15 to 100% damage to hard corals. Bleaching was worse in shallow waters than in deeper waters (TCMP, 1999; Muhando, 2003).

The coral reefs of Zanzibar and those found in MPAs are generally in good condition since they have escaped

from serious mortality driven by bleaching events (Wells *et* al., 2004). This is also the case in well managed sites such as Chumbe where the diversity of fish populations is higher as compared to over-fished coral reefs found off Dar es Salaam and Tanga (McClanahan *et al.,* 1999). Reefs around Pemba are extensive, luxuriant and diverse but only few studies have been carried out on them (Wells *et* al., 2004).

Mangroves

A total of 8 species of mangrove, namely *Avicennia marina, Bruguiera gymnorrhiza, Ceriops tagal, Heritiera littoralis, Lumnitzera racemosa, Rhizophora mucronata, Sonneratia alba* and *Xylocarpus granatum* are found in mainland Tanzania. In addition, *Xylocarpus mulluccensis* occurs in Zanzibar (Ngusaru *et al,* 2001). The mangrove ecosystem in Tanzania is under threat due to high demand for mangrove products such as firewood, charcoal, building, boat making, in addition to commercial cutting and over harvesting, coral burning, lime production, salt making, clear-cutting for building sites, solar salt pans, commercial projects and clearance for agriculture (Shunula and Whittick, 1996; Francis *et* al., 2001; Wagner, 2003).

There has also been a decline in mangroves forests due to natural factors. For instance, in the Rufiji delta, the mangrove forests have declined slightly from 49,799 ha in 1990 to 49,032 ha in 2000 due to flooding of Rufiji River (Wang *et* al. 2003). The other main threats to the mangroves include coastal erosion and clear cutting for construction (Francis *et* al., 2001), clear felling for paddy farming and illegal harvesting (Sallema, 2003). The use of DDT and other pesticides on rice farms and the construction of dams and major irrigation schemes upriver are also possing a threat to the mangroves (Semesi and Mzava, 1991).

In Zanzibar, mangrove threats include rice cultivation and debarking of *Rhizophora* sp. for tannin production (Wells *et al.* 2004). This is particularly noticeable in Pemba (Wete District). Mangroves in Zanzibar are also threatened by cutting for fuel, the coral mining industry, firewood, building poles and boat making. Although Micheweni has most important stands with large mangrove trees in Zanzibar, it is threatened by selective cutting and high demand for lime production. In Unguja Island, most mangrove trees are small and few reach 10 m in height as the large ones have been cut for timber and firewood (Shunula and Whittick, 1996). There has been intensive cutting of mangroves in Chwaka Bay. Mangroves are also degraded near Maruhubi (2 km north of Zanzibar town) as a result of high demand for mangrove products by the local community (Kulindwa *et al.,* 2001).

Seagrass beds

In Tanzania seagrass beds are widespread and are found in all bays in most inshore areas and on the west side of most islands. The most extensive seagrass beds are found in Tanga coast, deltas of Ruvu, Wami and Rufiji rivers, Mafia and Songo songo archipelago and around Kilwa. There are 12 species of seagrass off the coast of Tanzania. The area covered by seagrass beds and the relative species densities in Tanzania are however not known (Whitney *et al.* 2003).

Seagrass beds in Tanzania are threatened by natural and human activities that include illegal fishing practices such as beach seining and shallow water trawling (Francis *et al.,* 2001; Muir *et al.,* 2003; Whitney *et al.,* 2003), anchoring of fishing and tourist boats, excessive sedimentation increasing turbidity and reducing light penetration and shoreline dynamics involving sand deposition and removal (Whitney *et al.* 2003, Wells *et al.,* 2004). Natural grazers such as sea urchins and dugongs have also in some places reduced the cover of seagrass beds (Francis *et al.* 2001, Whitney *et al.,* 2003).

Issues

The main issues in as far the critical ecosystems are concerned include increasing degradation of the ecosystems due to various anthropogenic activities including destructive fishing methods and over-exploitation. The rapid increase in coastal population is putting high pressure on finite coastal natural resources. Degradation of critical coastal ecosystems has the potential to reduce the ecosystem goods and services offered by these mangroves, coral reefs and seagrass beds. This has the potential to affect the socio-economic livelihoods of the local communities in Tanzania.

ii) Gaps

- Lack of information on the impacts of sedimentation of coral reefs, seagrass beds and mangrove forests.

- Lack of information on the key features of some coral reefs.
- Lack of comprehensive descriptions and identification keys for Tanzanian coral species.
- Lack of regular systematic monitoring for coral reefs.
- Lack of detailed information on cover and species densities of seagrass beds and extent to which threats pose a problem.
- Lack of maps showing distribution of seagrass beds and coral reefs .
- Lack of current nationwide information on mangroves stock, condition and diversity.
- Lack of current information on mangrove changes from year 2000 to date.

Productivity of the Coastal zone

The coastal and marine environments of Tanzania are characterized by high marine biodiversity and rich marine and coastal resources which amongst others, include major estuaries, mangrove forests, coral reefs, sandy beaches, cliffs, seagrass beds and muddy tidal flats (Francis and Bryceson, 2001). Rivers such as Pangani, Wami, Ruvu, Rufiji, Matandu, Mbemkuru, Lukuledi and Ruvuma all flow to the Indian Ocean and to a certain extent influence the coastal environment through creation of productive brackish water environments in estuaries, maintenance of deltas, tidal flats and shorelines and nourishment of mangroves and seagrass beds (Francis and Bryceson, 2001). These coastal ecosystems subsequently interact with each other and together sustain a tremendous diversity of marine life, which supports the livelihood of coastal communities. A wide range of important and valued species are found along the coast, including an estimated 150 species of corals in 13 families; 8,000 species of invertebrates; 1,000 species of fish; 5 species of marine turtles, and many seabirds (Francis and Bryceson, 2001).

Coral reefs

Coral reefs support one of the most productive and diverse marine ecosystems in Tanzania waters and, with their associated habitats support a variety of marine species. Over 500 species of commercially important fish and other invertebrates are commonly found in coral reefs. It is estimated that 95% of artisanal fishing, which employs over 50,000 full time fishermen, is carried out on coral reefs. Coral reefs also support over 70% of the artisanal fish production in Tanzania (Saada, 2005). It is estimated that a sustainable yield of 15 tonnes of fish can be obtained per km^2 in depth of less than 30 m in some coral reefs (Munro and Williams, 1985).

Generally, there is good coral reef growth and a high coral diversity in many areas in coastal Tanzania. Hamilton and Brakel (1984) recorded 140 coral species in Tanzania. Mafia Island has extensive reefs especially in the south, many in good condition. Medium diversity is found on the reefs of Mnazi Bay (Mtwara), Kunduchi (Dar es Salaam) and Tanga region. Overall reef health is probably good in most parts especially in less accessible and deeper areas i.e. the Mafia, Songo Songo and Kilwa (Saada 2005). The most degraded coral reefs are those found in shallow waters (1-10 m), especially near urban centres of Tanga, Dar es Salaam and Mtwara (Mohammed *et al.* 2002).

Over the past few decades, a number of factors have contributed to the degradation of coral reefs. The closeness of the reefs to land make them particularly prone to human impact, either from exploitation or from indirect terrestrial influence such as sedimentation and pollution. Many of the reefs were severely affected by the coral bleaching event of 1997-1998 that reduced the average live coral cover from 52% before bleaching to about 27% after the event (Wells *et* al., 2004). Follow-up assessments and monitoring indicated that although the impacts were not uniform, generally recovery has been very slow (Mohammed *et al.,* 2002). Corals are also harvested by the local population, to exploit their rich biological and mineral value for jewellery, ornaments and building purposes.

Mangroves

Mangrove ecosystems include much more than just the trees and encompass terrestrial, fresh water, marine and estuarine systems. According to Francis *et al*., (2001), there are 8 common species of mangroves in Tanzania mainland either in pure stands or in mixtures (Figure 9). The relatively good condition and high species diversity in the mangrove communities provides important ecological and socio-economic services. Apart from shoreline protection, pollution filtration, and nutrient and sediment trapping, the most notable is their function as breeding and nursery grounds for valuable fish and shellfish species and feeding and protection of various mammals and bird species (Francis *et al.* 2001).

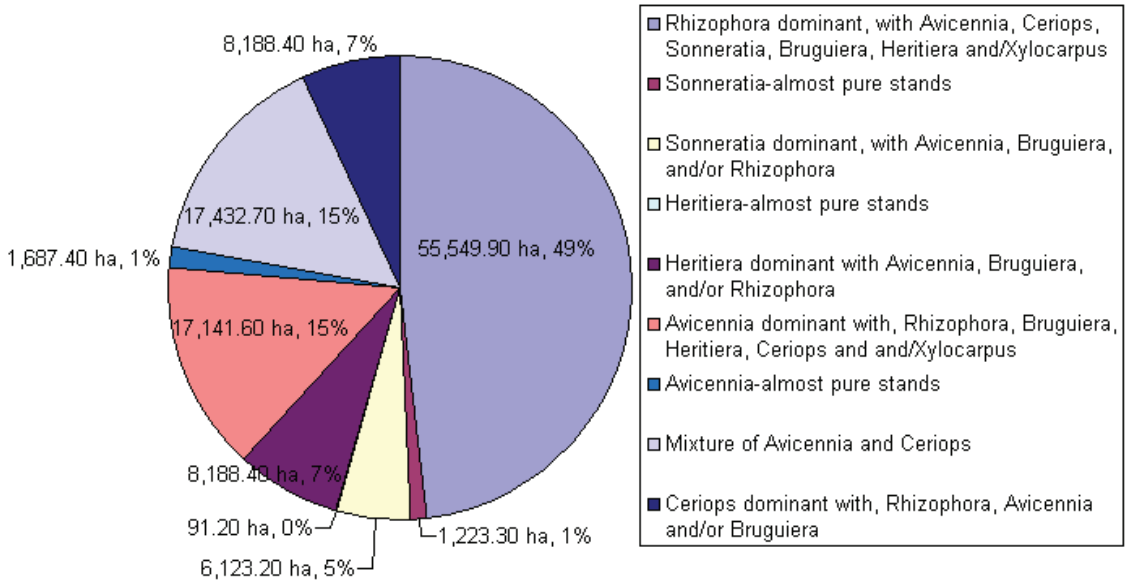

Figure 9: Species Composition of Mangroves in Tanzania (Source: Francis *et al*. 2001)

Coastal communities use mangroves to supply local needs for fuelwood, charcoal making, fences, house construction, boat building, fish traps, fish stakes and for medicine. It is estimated that over 150,000 people make their living directly from mangrove resources in Tanzania (Saada 2005). The largest mangrove forest in Tanzania is found in the Rufiji Delta. Commercial fisheries of crabs, prawn and fish are directly dependent on the mangrove ecosystems thus the two main prawn fishing grounds are areas adjacent to the Rufiji Delta and Bagamoyo. Likewise the fishing for crab is an important activity in the Pangani river mangroves. The direct value of the mangrove habitat which includes values for the fuelwood, timber and poles and wood products, the animals and birds and the honey it provides has been estimated to be USD 0.9 million per year (Turpie 2000).

Seagrass beds

Seagrass beds are highly productive and serve many ecological functions. Seagrasses form dense beds that cover large areas of sandy or muddy coastal bottom. The species found in Tanzania include *Cymodocea rotunda, C. serrulata, Cymodocea sp., Enhalus acoroides, Halodule wrightii, H. uninervis, Halophila minor, H. ovalis, H. stipulacea, Syringodium isoetifolium, Thalassodendron ciliatum* and *Thalassia hemprichii)* (Whitney *et al.,* 2003). The most dominant species are *T. ciliatum, T. hemprichii* and *S. isoetifolium* (Francis *et al.,* 2001). Usually several seagrass species occur together in mixed stands that forms extensive meadows. Their importance results from their ecological interactions with other ecosystems in the marine environment, especially mangroves and coral reefs, and in their wide range of physical functions (Saada 2005). Sea grasses are associated with nitrogen fixing microorganisms and support complex food webs through dead and living biomass. Thus, among other services, they provide breeding, nursery and feeding areas for a number of invertebrates and vertebrate species including commercially important species of finfish and shellfish (Wells *et* al., 2004). Moreover, seagrass roots filter and bind sediments and thus prevent sedimentation over coral reefs hence protecting the shoreline from erosion (Saada 2005). Recent studies of dugong distribution and migration along the Tanzania coast show that they are associated with areas of extensive seagrass beds particularly in the Rufiji delta and Mafia-Kilwa area which has a viable dugong population.

i) Issues

The main issues are over-exploitation of mangroves, unsustainable mangrove harvesting, pollution, sedimentation, clearance of mangrove areas for agriculture, construction of salt pans and coastal development.

ii) Gaps

- Lack of experimental and applied studies of critical ecosystems.
- There are no or limited projects which apply already-known techniques for restoring or protecting reefs.
- Limited knowledge on the sustainability levels of resources utilisation particularly mangroves.

- Lack of information on coral recruitment patterns.
- Lack of detailed understanding of the threats to seagrass beds.
- There is no continuous monitoring of critical ecosystems using standardized approaches.
- Limited financial capacity for coral reef research.
- Limited knowledge on the taxonomy of corals.
- There are no detailed maps showing the distribution of coral reef and sea grass beds.
- Lack of knowledge on the distribution of seagrass beds.

Microfauna and meiofauna

Meiofauna status in Marine Ecosystems of Tanzania

Little research has been done on micro and meiofauna in Tanzania. Some of these studies include those of Ndaro *et al.* (1995); Ndaro and Ólafsson (1999); De Troch *et al.,* (2001); Carlén and Ólafsson (2002); Vanhove *et al.*, (2002); Ólafsson *et al.*, (1995); Ólafsson (1995); and Raes *et al., (*2007). The dominance of epistrate feeders and the paucity of selective deposit feeders and other feeding guilds in coarse sands which are an indication that sediment granulometry influences fauna assemblage, have been carried out in the east coast of Zanzibar. The bottom meiofauna of shallow lagoons in Zanzibar have distinct nematode assemblages, principally determined by sediment chemistry in sea grass bed, fine sand and coarse sand habitats (Ndaro and Ólafsson, 1999). In Zanzibar, the variations in the structure of the microhabitat and differences in environmental conditions occur on very small spatial scales and these small-scale differences are the predominant factors determining the structure of nematode assemblages in coral degradation zones (Raes *et al.,* 2007).

Studies have shown that seaweed *Eucheuma spinosum* does not affect the density of the major infauna taxa. Factors such as increased predation by benthic feeding fauna and the mechanical disturbance of the sediments better explain the variations of infauna abundance inside and outside seaweed farms. It was further revealed that low water areas have in general higher density than mid and high water areas (see also Hodda and Nicholas 1985, Alongi 1990a, Alongi 1990b, Nicholas *et al* 1992).

In a study investigating the effect of spring tide inundation on meiobenthos in a tropical mangrove ecosystem it was suggested that there was significant immigration of meiofauna from the lower shore into the hypersaline area during spring tide flooding. It was further observed that apart from chironomids, the meiofauna are not affected by salinity variations (89–160 ppt) and other environmental factors are therefore important in regulating the meiofauna numbers within this habitat. It was concluded that the meiobenthos were able to cope with very high salinities (Ólafsson *et al* 2000). Ndaro *et al.* (1995) has established that meiofauna varies substantially over small distances in mangroves, coastal lagoons and subtidal reefs. Recently, Gheerardyn *et al.* (2007) found that the composition and diversity of the harpacticoid fauna is different in different microhabitats, with a trend of changing copepod composition across these microhabitats. It appears that harpacticoid fauna associated with different microhabitats were controlled by the structural differences between coral, and gravel and sediment, and by changes in sediment grain size (Gheerardyn *et al.* 2007). Microhabitat type is important in structuring the harpacticoid assemblages. The coral fragments sport a specific assemblage composed of epibenthic or phytal taxa with an addition of sediment-dwelling species (Raes *et al.* 2007).

New species of *Acari* have being discovered in Tanzania. These are three halacarid mites of the genus Copidognathus (Acari: Halacaridae), a new species of the genus Arhodeoporus (Acari: Halacaridae) and Atelopsalis (Acari: Halacaridae) (Chatterjee *et al.* 2006, 2008, 2009). Also, a new species of *Agauopsis ornata* (Acari: Halacaridae) was found in Zanzibar.

Microfauna status in the Marine Ecosystems of Tanzania

In general, studies of microfauna in Tanzania marine environments are very scarce. One study has been carried out on plankton composition and cycling of carbon in a tropical coastal ecosystem, Zanzibar, Tanzania (Lugomela *et al.* 2001). The second study was on diel feeding of the chaetognath *Sagitta enflata* in the Zanzibar Channel (Øresland 2000). There is therefore a need for further studies in this area.

i) Issues

- Water level fluctuations which may determine the diversity and abundance of micro- and meiofauna.

- Global warming which may bring about the effect of temperature on the well being of micro- and meiofauna.
- Dredging which will cause burial of resident fauna. The fate of buried fauna is important in terms of possible recolonisation of a beneficial use of site.
- Habitat instability arising from for instance intense salinity fluctuations, infrequent tidal cover and water stress.
- Physico-chemical parameters such as vertical pH changes, vertical decreases in oxygen, vertical decreases in interstitial water content, vertical differences in organic matter.
- Heavy storm surges, tsunamis, flooding, extreme waves
- Other issues are coastal erosion, siltation, habitat destruction and acidification.

ii) Gaps

Only a handful of studies on meiofauna assemblage structure in mangrove sediments of Zanzibar have been undertaken. Almost none have been conducted on the Tanzanian mainland. Further studies need to be done on micro and meiofauna, focussing on:

- Ecophysiological studies of the micro- and meiofauna to determine the effects of temperature and photoperiod on their growth, especially during juvenile stages.
- Effects of changes in physico-chemical parameters on the micro and meiofauna.
- Use of micro- and meiofauna as bioindicators of marine ecosystem health.
- Large scale patterns in meiobenthic diversity and community composition such as the effect of environmental/geographical factors (e.g. region, depth, sediment type etc.) and what taxonomic level is needed to discriminate these patterns, what factor is most important in discriminating the assemblages.
- Feeding relationships in micro and meiofauna.
- Species assembly rules to understand factors enabling high diverse communities to co-exist and to estimate the relative importance of biological processes versus abiotic factors and stochastic processes in structuring communities.
- Patterns in harpacticoid copepod community composition and diversity with a focus on the relation between diversity and density and diversity-related rarity.
- Effect of predation or avoidance by downward migration and/or competition for food resources on the abundance of micro-and meiofauna.
- Fauna assemblage structure in different habitats.

Macrofauna

On the Tanzania mainland, fisheries frame surveys have been conducted on annual basis from 1967 up to 1991. From 1992 the survey was scheduled on biannual basis. However, since then, the surveys were only carried out in 1998, 2001 and 2005 because of budgetary limitations. In Zanzibar, fisheries frame surveys were conducted in 1980, 1985, 1989, 1997 and 2002. The first ever Joint Marine Fisheries Frame Survey between Tanzania mainland and Zanzibar was carried out in 2007. The objective of the survey was to obtain information on the composition, magnitude and distribution of the fishing effort as well as facilities and services at landing sites in order to guide development and management of the fisheries resources. The 2007 survey recorded 36,297 fishers compared to 29,754 in 2005, from Tanzania mainland and 34,268 fishers compared to 18,618 in 2002 from Zanzibar (United Republic of Tanzania, 2008). The results of the survey are summarized in Table 4.

Table 4: Summary of the Joint Marine Fisheries Frame Survey in Tanzania carried out in October 2007

S/N	Type of Information	Tanzania Mainland	Zanzibar	Total
1.	Number of Landing sites	232	166	398
2.	Number of Seaweed farmers	5,423	24,570	29,993
3.	Number of fishing vessels	7,342	7,155	14,497
4.	Number of foot fishers	8,287	7,602	15,839
5.	Number of fishers using fishing vessels	28,010	26,666	54,676
6.	Number of handlines	13,990	18,865	32,855
7.	Number of longlines	2,269	706	2,975
8.	Number of gillnets	31,210	5,329	36,539
9.	Number of castnets	169	1,046	1,215
10	Number of Ringnets	1,076	180	1,256
11.	Number of Traps	4,185	10,599	14,784
12.	Number of purse seines	363	215	578
13.	Number of sharknets	4,299	1,647	5,946
14.	Number of beach seines	615	938	1,553
15.	Number of spears	1,764	2,349	4,113
16.	Number of scoop nets	306	264	570
17.	Number of weirs	544	13	557
18.	Number of anglings	20	0	20
19.	Number of trawl nets	9	0	9
20.	Number of Outboard Engines	672	815	1,487
21.	Number of Inboard Engines	71	34	105

Invertebrates

There is little information on the status and distribution of invertebrates that constitute a substantial fisheries resource in Tanzania. Indicative information on species and abundance is obtained from data on catches of the resource. Important marine invertebrates include prawns/shrimps, lobsters, crabs, sea cucumbers, octopus, squids and molluscs. These are described in more details in the following sections.

Prawns/shrimps

Prawns/shrimps of Tanzania fall under the three families, namely Hippolytidae (Hunter shrimps), Palaemonidae (River prawns or spider prawns) and Penaeidae (Shrimps/ prawns). The commercially important Penaeid prawn species are *Penaeus indicus, P. semisulcatus P. monodon, Metapenaeus monoceros* and *M .stebbingi.* Others of less economic importance because of their low catches in the fishery are *P. japonicus, P. latisulcatus* and *P. canaliculatus*. The Hippolitydae are represented by *Exhippolysmata ensirostris* and the Palaemonidae represented by *Macrobrachium rude* and *Nematopalaemon tenuipes.* Haule (1985) reported that the white prawns *Penaeus indicus* make up to 66% of the catch, 18% were giant prawns *Penaeus monodon* and tiger prawns *Penaeus semisulcatus,* 15% were brown shrimp *Metapenaeus monoceros* and the flower shrimp *Penaens japonicus* made up 1%.

The prawns/shrimps landings from the commercial trawlers was about 500 tonnes in 1970, and then declined to about 200 tonnes when the joint venture company (New Mwananchi Ocean Products) was disbanded (Bwathondi and Mwaya, 1984). A new company, Tanzanian Fisheries Corporation, was subsequently established but as a consequence of operational difficulties, the annual landings from trawling remained at substantially below 200 tonnes (Brownell, 1982). However, in the period between 1988 and 2005, the total landings have ranged from about 312 to 1320 tonnes (Table 5).

Table 5: Trends in the prawn fishery from 1988 to 2007

YEAR	NO.OF VESSELS DEPLOYED	NO. OF FISHING DAYS	PRAWN CATCHES (kg)	PRAWNS CATCH RATE (kg/day)
1988	13	1476	650,929	441.01
1989	13	2166	688,837	318.02
1990	9	1574	960,686	610.35
1991	13	1315	669,016	508.76
1992	15	1560	663,852	425.55
1993	10	1462	597,211	408.49
1994	16	2513	1,014,087	403.54
1995	18	2108	795,436	377.34
1996	12	1779	769,651	432.63
1997	16	2091	699,059	334.32
1998	17	2778	995,564	358.37
1999	17	2252	688,006	305.51
2000	20	3352	909,715	271.39
2001	21	3882	1,193,685	307.49
2002	23	2521	926,079	367.35
2003	25	3664	1,320,056	360.28
2004	25	3037	661,062	217.67
2005	17	1528	467,037	305.65
2006	13	1082	312076	288.43
2007	10	666	202455	304.00

Source: Annual Fisheries Statistics Reports

Artisanal Fisheries Landings

The annual landings from the artisanal fishery ranged from 250 to 500 tonnes in the period between 1965 and 1972 (FAO/IOP, 1979). Landings from artisanal fishermen are nearly equal to landings from the trawlers. The principal fishing methods used are stationary traps, cast nets and seines Bwathondi and Mwaya (1984).

Stock Assessments

Exploratory trawling for shallow-water shrimps was carried out by the East Africa Marine Fisheries Research Organization (EAMFRO) in 1959 using the R/V MANIHINE and R/V CHERMIN (Venema, 1984). During the period between June and December 1968, R/V SAGAMA MARU of the Kanagawa Prefectural, Japan was also used for surveys along the Tanzanian coastal waters (Kanagawa Prefectural Government, 1969). The Bagamoyo and Rufiji regions were identified as having shrimp fishery potential, and commercial trawling commenced in 1969. The potential yield in these fishing grounds combined was estimated to be 1830 tonnes (FAO, 1979).

Prawn stock assessments have been undertaken using various techniques. Haule (1981) studied some biological aspects of *Penaeus japonicas, P. semisulcatus, P. monodon* and *Metapenaeus monoceros* of Kunduchi mangrove creek in Dar es Salaam. Male prawns were found to mature earlier than females and breeding was found to take place in the period between July and September. In order to conserve juvenile prawns as well as the mangrove areas which form their nursery grounds, Haule (1981) recommended that fishing for prawns in mangrove areas should be prohibited and that any activity (e.g. establishment of salt works or factory) that will affect or alter the ecology of a mangrove area should be prevented.

Sanders (1989) made a preliminary assessment ofthe shallow water shrimp trawl fishery of Tanzania based on catch and effort data. The study found that the potential yield (i.e. MSY) from the fishery is not greater than 1,400 tonnes. The South West Indian Ocean Fisheries Commission (SWIOFC) in 1990 estimated the prawn fishery's potential to be 1,050 tonnes. In 2001, the Tanzania Fisheries Research Institute (TAFIRI) estimated shrimp fishery MSY to be only 497 tonnes (Mushi and Kalikela 2002).

Some preliminary work on the abundance and reproductive biology of the Penaeid prawns of Bagamoyo coastal waters was also done by Teikwa and Mgaya (2003) and Mwakosya (2004) also carried out an assessment of the resource. Tanzania Fisheries Research Institute (TAFIRI) has carried out two main surveys; the first survey in 1992 made an assessment of crustacean resources in the Rufiji – Mafia channel (Nhwani *et al.* 1993). The second study investigated the species composition, distribution and abundance in Bagamoyo and Rufiji delta (Bwathondi *et al.* 2002). In both surveys there was evidence of declining catches.

i) Issues
There has been unsustainable over-harvesting of prawns. The major causes have been increased pressure due to the fact that the fishery is open access and fisheries management is inadequate.
Most of the available data on industrial prawn landing does not include landings by small-scale operators, meaning that shrimp landings are underestimated. This makes management of the fishery difficult.

ii) Gap
No comprehensive stock assessments have been done on the prawn resources. Thus decreased catches of the commercially valuable prawn resources have been frequently used as indicators of heavy exploitation and over-fishing.

Lobsters
Shallow water lobsters found in Tanzania include *Panulirus ornatus, P. longipes, P. versicolor, P. homarus* and *P. penicillatus*. The first two are the most abundant, contributing more than 80% of landings (Bwathondi 1980). The most common lobster fishing method involves the use of a hand-held net and an octopus- the latter is used to flush the lobsters out of their hiding areas so that they can be scooped up by the net. Lobsters are also caught by traps and gillnets set for catching fish and by divers using spear guns. The landings in the period between 1966 and 1975 reached 80 tonnes (Bwathondi and Mwaya, 1984). The mean catch rate is 6.15 kg/man/day in lightly exploited areas in Zanzibar and 4.53kg/man/day for heavily exploited areas (Hall, 1960).

Deep-water lobsters identified as *Linuparus somniosus* and *Metanephrops andamanicus* are caught in depths of 250 to 320 m in the southern end of the Zanzibar Channel (Burczynski, 1977; Birkett 1978; VNIRO, 1978). The catch rates reached up to 50 kg/hr. These lobsters are yet to be subjected to commercial exploitation.

i) Issues
Unsustainable harvesting of lobsters. The root causes are increased pressures in the context of open access harvest for commercial artisanal species, as well as lack of management of the fishery.
The growth of the lobster fishing industry in Tanzania is considered to be at its upper limit as the resource is fully exploited. Observations show that size of lobster that are being harvesting has being decreasing over the years.

ii) Gap
There are no recent assessments of the lobster biomass or potential yields.

Cephalopods
Cephalopods represent a significant fishing resource in Tanzania. The major cephalopod resources are the octopus, cuttlefish and squids. The common octopus, *Octopus vulgaris* is the cephalopod species with the highest landings in Tanzania particularly among the artisanal fleet. Traditionally, this species has been caught by the artisanal fleet using spears, traps and hand collection during low tides. Regulation has been proposed to include a minimum legal capture of an individual octopus weighing not less than 500 grammes with no closed season or any other restriction. Other species are the White-spotted octopus, *O. macropus* and the Big blue octopus, *O. cyaneus*.

Traditionally fishing of octopus is done by artisanal fishers by hand collection on exposed reefs using sticks and spears along the inter-tidal zones during low water spring tides. Artisanal fishers use locally made non-motorized traditional crafts ranging in length from 4 to 10 m. The most common vessels are the dugout canoes. There is no industrial fishing for octopus; all exporters collect their octopus from artisanal fishers.

The South West Indian Ocean Fisheries Commission (SWIOFC) has classified the octopus fishery as over-fished in the SWIO region. Tables 6-8 present statistics for the octopus fishery between 2000 and 2007. . The present state of octopus stocks can be explained by the changes in the octopus fishing practices catalysed by market demands. Traditionally, harvesting of this marine resource was done by women in the intertidal areas for four to five days in each spring tide. In 1980s, in Kilwa district for example, octopus population was high and distributed all over Kilwa Kivinje and Masoko with the dominant species being *Octopus vulgaris*. Fishing without gear was the most common method used by coastal women for local markets and domestic consumption. In the 1990s, the improved marketing conditions and rising prices, led to over-exploitation and subsequently decline of the catches. Increased prices attracted men into octopus collection both on intertidal flats and by free diving.

Table 6: Production data for octopus fishery in the three districts of the Tanga region (Muheza District), 2004-2007 (Pangani District) and 2005-2007 (Tanga District)

Year	Catch in Kg			
	Muheza	Pangani	Tanga	Total
2002	3,391			3391
2003	10,927			10927
2004	18,095	8491.5		26586.5
2005	5,116	4850.5	18,341	28307.5
2006	9,390	707.5	17,086.5	27184.0
2007		2739	16,938.9	19677.9
	46919	16766.5	52366.9	116073.9

Source: *Ministry of Natural Resources and Tourism, Fisheries Division, Annual Fisheries Statistics Reports*

Table 7: Export data for Octopus from SEA PRODUCTS (T) Ltd based in Tanga

	Monthly exports in Kg		
Month/Year	2005	2006	2007
January	4911.54	7513.07	1861.75
February	5318.82	7899.35	3835.49
March	6185.27	9433.33	6357.29
April	3523.25	5664.78	3847.52
May	2134.08	4731.85	2186.2
June	5048.29	2663.06	1557.52
July	7223.38	2246.33	2757.28
August	15095.42	4974.3	3292.56
September	18629.01	4346.97	3081.47
October	16736.41	4252.38	3733.72
November	15885.71	6207.3	3142.46
December	9110.52	2358.63	3123.82
Total	109801.70	62291.35	38777.19

Source: *Ministry of Natural Resources and Tourism, Fisheries Division, Annual Fisheries Statistics Reports*

Table 8: Production of octopus between 2000 and 2007 (Annual statistics from Department of Fisheries Tanzania mainland)

Year	Weight (kg)
2000	430,000
2001	460,940
2002	387,979
2003	307,700
2004	22,600
2005	56,650
2006	55,972

Year	Weight (kg)
2007	57,045

Source: *Ministry of Natural Resources and Tourism, Fisheries Division, Annual Fisheries Statistics Reports*

A closed period has been introduced in Mafia Island Marine Park where no fishing is allowed during neap tides. According to information from the park authorities, this management has been effective; most of the octopuses caught in Marine Park area are of a large size and quantity. Additional management options for the octopus fishery are to impose restrictions on allowable catch and observe closure periods during breeding seasons.

i) Issues

Data on the production and export of octopus are hard to find. Catches of octopus are declining rapidly which is attributed to overfishing stimulated by high prices in international markets.

Uncontrolled fishing effort due to the fact that Octopus is a near-shore resource that is easy to catch especially during low tides.

Destruction of breeding areas due to destructive fishing practices especially dynamiting of the coral reefs.

Unregulated fishing in areas with the exception of Marine Park areas. Harvesting takes place throughout the year with no time spared for breeding and recovery.

The octopus fishery is mainly artisanal and landing sites are numerous. As a result, direct monitoring of octopus catches and enforcement of many types of fishing rules is impractical.

Currently, there is no management plan for the octopus fishery in Tanzania although there was a proposal to review the Fisheries Regulations (2005) and impose restrictions on allowable size (ban fishing of undersized octopus below 500 grams) in all Tanzanian marine waters. However, the challenge is that the minimum size management measure does not guarantee protection of octopus recruitment and survival of an adequate number of breeding adults at the end of each fishing season. There is also no management plan to include the monitoring of landings by biologists and managers.

There is an increase in knowledge especially in the control and protection of coral reefs/breeding areas by villagers. The principles and ethics of co-management are well understood among the coastal fishing communities especially in Tanga and Mafia. The challenge is the reluctance of some fisher groups to accept the concept of fisheries co-management.

ii) Gap

Only a few studies have been carried out on the octopus fishery in Tanzania. There are limited studies on the biology of *O. vulgaris* especially maturity weight and breeding period. There is no strategy for the *O. vulgaris* fishery management in Tanzania.

Squid and Cuttlefish

Squid and cuttlefish species that are known to inhabit the Tanzanian coastal waters include the Brodclub cuttlefish (*Sepia latimanus*), Pharac cuttlefish (*S. pharaonis*), Hooded cuttlefish (*S.prashadi*), Indian squid (*Loligo duvauceli*), Veined squid (*L. forbesi*), Common clubhook squid (*Onychoteuthis banksi*), Neon flying squid (*Ommastrephes bartrami*), Purpleback flying squid (*Symplectoteuthis oualaniensis*) and Diamondback squid (*Thysanoteuthis rhombus*) (Gabriella Biachi/FAO, 1985).

i) Issue

The status of squids and cuttlefish in Tanzanian coastal waters is poorly known.

ii) Gap

Studies on squids and cuttlefish are inadequate and out of date. The biology, sustainable off-take and management techniques are inadequately understood.

Sea cucumbers

Sea cucumbers constitute one of the important marine resources of Tanzania (Semesi *et al.*, 1998). The country has unquantified sea cucumber resources though the fishery provides income to local collectors and generates export earnings (Mmbaga and Mgaya, 2004). Twenty species of sea cucumbers are harvested in Tanzania and their distribution is described in Rowe and Richmond (2002). The importance and historical significance of

this fishery to the local coastal communities is indicated by the presence of at least 50 different Swahili names for different species (Marshall *et al.*, 2001).

A study conducted on Mafia Island revealed that *Actinopyga miliaris, Bohadschia argus, B. marmorata* and *Stichopus variegatus* occurred are most preferred in trade. The most valuable species including *Holothuria scabra, H. nobilis, H. spinifera* and *Holothuria sp*. form a very small percentage of the total cucumber catches. There has been a shift from more highly valuable commercial species such as *H. scabra* and *H. nobilis* that previously dominated the catch (Marshall *et al*. 2001).

Mmbaga (2002) and Kithakeni and Ndaro (2002) conducted studies on some aspects of the biology of *Holothuria scabra* along the coast of Dar es Salaam at Kunduchi, the most exploited shore, and Buyuni, a shore with no history of exploitation. The total catch of *H. scabra* at Buyuni was significantly higher compared to that from Kunduchi. The stomach contents revealed sand, small gastropods, detritus, debris of red algae and fresh pieces of polychaetes and unidentified animal parts mixed with sediments (Mmbaga, 2002). Studies of the gonads indicated that although reproduction was continuous throughout the year, gonad indices showed two peak periods - June to August and December to January. Using a length distribution for 240 specimens of *H. scabra* measured between January and December 1999, Kithakeni and Ndaro (2002) showed that the frequency distribution was unimodal, with most individuals ranging in length from 8.5 and 26.5 cm. The most frequent length category was 17.5 cm. The total catch consisted of individuals measuring between 7 and 27 cm. Kithakeni and Ndaro (2002) reported size at first maturity of *H. scabra* at Dar es Salaam coast to be 16.8 cm.

The sea cucumber fishery is largely artisanal with a small commercial operation monopolized by a few exporters. The level of exploitation differs from shore to shore depending on fisher folk's experience, the number and category of fishers, fishing techniques and season. A study by Mgaya *et al.* (1999) on sea cucumbers in Bagamoyo reported that local exploitation occurred year-round on reef flats close to the shore or sheltered from the prevailing winds and that the main collection seasons were October to December and April to May. This is the period when the winds were usually light, and trips could be made to the off-shore reefs. Collection methods in Bagamoyo area included hand-picking either from the intertidal reef flats or by snorkel diving over sand and seagrass areas, collection by free divers, using both manufactured and home-made goggles and collection using SCUBA. The latter technique is becoming increasingly popular as shallow water areas are depleted and fishers are moving to deeper waters. The use of SCUBA diving to collect deepwater cucumbers makes the species vulnerable to over-harvesting and can deplete breeding stocks causing recruitment overfishing.

Depletion of sea cucumber resources in Tanzania was first reported at Songo Songo by Darwall (1996a, 1996b). Other studies that reported depletion included that of Jiddawi (1997) in Zanzibar, Guard (1998) in Mtwara, Horsfall (1998) and Mgaya *et al.* (1999) in Bagamoyo and Kithakeni and Ndaro (2002) at Kunduchi, Dar es Salaam. Interviews conducted by Mgaya *et al.* (1999) with sea cucumber collectors in Bagamoyo indicated that the stocks were declining and the average size of individuals was decreasing. Removal of large individuals may affect reproduction and lead to recruitment overfishing. Although the collectors recognize that part of the problem is harvesting of juveniles due to lack of effective policing, they continue to collect juveniles as "others will do so if they don't" - a typical tragedy of the commons scenario (Hardin, 1968).

Open access to unmanaged sea cucumber resources has definitely led to depletion of the stock. Importation statistics for sea cucumbers reported in Hong Kong during January–March 1996 showed that Tanzania ranked high in the Western Indian Ocean region for the level of exports. Tanzania produced up to 1,644 tonnes by the end of 1996 (Conand, 2004a & 2004b). Although it is difficult to accurately estimate historical and current production of sea cucumbers in Tanzania, the available data indicates a very serious decline in production in the last decade, from >1500 tonnes in 1994 to 10 tonnes in 2004. The number of exporters has also decreased over time from 23 to 8 on mainland Tanzania and from 6 to 2 in Zanzibar between 1993 and 1997. This is an indication of the reduction in the profitability of the sea cucumber fishery (Marshall *et al.* 2001).

i) Issues

Fisheries regulations vary between Mainland Tanzania and Zanzibar. For example, a ban prohibiting sea cucumber fishing was implemented in September 2006 on Mainland Tanzania but not on Zanzibar. The impacts of such regulations on the fisheries are difficult to assess due to the lack of adequate monitoring of the

catch during the period the ban is in force.

Cross border transfers of sea cucumber from Tanga to Vanga in Kenya and from Mozambique to Mtwara in Tanzania complicate the export statistics. The need for generating up-to-date information on the status of the resources cannot be overemphasized.

ii) Gap

The sea cucumber fishery developed without baseline data on the biology and reproductio and without any monitoring. Very few studies have been carried out on the general biology of sea cucumbers in Tanzania. No studies on the growth, larval ecology, recruitment, or mortality of any sea cucumber species has been conducted in Tanzania. These gaps need to be filled as soon as possible.

Shells

In Tanzania, shells particularly those of queen snails (*Turbo marmoratus*), helmet snails (*Cypraecassis rufa*), tiger cowrie (*Cypraea tigris*), money cowrie (*C. moneta*) and the most valuable cowrie (*C.mauritiana*) are collected and exported for curio trade. Most of the curio shells are rare and threatened species. Shells for ornamental purposes are also collected all along the coast. They are gathered along the beaches and in reef areas during low tide. Although intended for the tourist market, a large proportion was exported by the Tanzania Fisheries Corporation and Zanzibar State Trading Corporation. A great deal of damage to the intertidal and near shore areas has been caused by shell collectors through trampling. This activity was very intensive along the shore of Zanzibar in the late 1970s (Halsted and Halsted 1986).

i) Issues

Over-harvesting of shells: most of the curio shells are rare and threatened species
Habitat destruction in the process of harvesting shells.

II) Gap

No recent scientific studies have been carried out on shell collection. The damage caused on the coral reefs by shell collectors and open water seining may in certain areas be of the same magnitude or even greater than that of dynamite fishing. There is a need for regulatory measures to be imposed on shell collection.

Fish and fish resources

Fish resource assessment surveys conducted in the mid 1980s in Tanzania marine waters, gave estimates on the standing stocks for coastal waters ranging from 94,000 tonnes to 174,000 tonnes (Iversen *et al,*. 1984). Annual fish yield was estimated to be about 38,000 tonnes per year for demersal species and about 23,000 tonnes for pelagic species, such as sardines and small tuna. This gave an overall yield of 60,000 tonnes per year for commercial marine fish resources for the Tanzanian mainland.

For Zanzibar the potential fish yields has been estimated to be 20,000 tonnes per year for pelagic species (FAO, 1988). An optimistic estimate of a potential annual yield in Tanzania's territorial waters is 100,000 tonnes (Linden and Lundin, 1996). Currently, landed fish catch is estimated to be 50,000 tonnes per year. Marine fish production and value for Tanzania Mainland and Zanzibar in the period 1988 – 1992 are presented in Table 9.

Table 9: Marine fish production and values for Tanzania 1988- 1992
(a) Mainland

Year	Number of fishers	Number of vessels	Artisanal catches (tons)	Industrial catches (tons)	Total	Value (Tsh) (1000Tsh)
1988	13,855	4,390	47,193	2,190	49,383	2,568,859?
1990	16,178	4,354	54,527	2,015	56,542	4,663,069?
1991	16,361	4,402	52,380	1,510	53,891	6,159,297?
1992	15,027	3,514	42,183	1,119	43,302	6,014,473?

Source: *Fisheries Division, Ministry of Tourism Natural Resources and Environment, Dar es Salaam*

(b) Zanzibar

Year	Number of fishers	Number of Vessels	Catches (tons)	Value (Tsh) (x 1000) Quote in USD
1988	9,637	2,860	10,438	321,500
1989	15,564	2,956	12,629	765,830
1990	16,000	3,000	8,887	635,280
1991	16,000	3,000	7,999	695,751
1992	16,500	3,500	11,781	1,382,674

Source: Jidawi and Muhando 1989

The main groups of fish that dominate marine catches in Tanzania are demersal fish species such as bream, grouper, parrot fish, snapper, rabbit fish, emperor, sharks and rays. These are caught using hand lines, traps and nets. The small pelagics consist primarily of sardines, small tuna and mackerel. These are caught mainly using purse seine nets or ring nets. Large pelagics such as kingfish, tuna, sailfish and marlin, are caught by surface gill nets and trolling lines. Over 95% of the catch is attributed to small-scale artisanal fishing using primitive crafts and gear (Table 10) (Linden and Lundin, 1996).

Table 10: Artisanal fish landings (in tonnes) by species group and region for 1992

Species group	Tanga	Coast	DSM	Lindi	Mtwara	Total
Dermersal:						
Sharks	218	472	225	82	283	1280
Rays	331	346	466	156	276	1575
Scavengers	676	2368	5828	899	528	10299
Parrot Fish	568	217	1310	142	328	2565
Milkfish	2	0	15	7	7	31
Rabbitfish	312	423	1813	477	375	3400
Rockcod	66	113	65	38	201	483
Queenfish	11	345	53	10	45	454
Catfish	33	477	9	5	1	525
Threadfin	33	69	29	1	6	138
Cobia	49	83	42	68	64	306
Mullets	11	213	11	62	52	349
Flatfish	1	30	4	0	1	36
Octopus	37	28	27	5	23	170
Prawns	48	513	26	92	0	679
Subtotal	2386	5697	9923	2094	2190	22290
Pelagics:						
Sardines	16	1578	1757	644	115	4110
Mackerels	104	495	1203	1332	434	3568
Halfbeaks	31	719	118	593	138	1599
Jacks	220	92	640	345	568	1865
Kingfish	101	171	551	86	29	938
Tunas	68	23	525	52	165	833
Swordfish	51	0	150	68	104	373
Silversides	81	406	36	105	100	728
Subtotal	672	3484	4980	3225	1653	14014
Others:	1130	1478	1600	106	612	5880
Total	4188	10659	16503	6379	4455	42184
Number of fishers	4008	4551	3276	1287	1508	14630
No of vessels	947	996	577	573	423	3516
CPU wt/vessel	4.4	10.7	28.6	11.1	10.5	12.0
Effort/Fisher	1.05	2.34	5.04	4.96	2.95	2.88

Source: Fisheries Division, Ministry of Livestock and Fisheries Development

Table 11: The status of Tanzanian fish stocks occurring in the South West Indian Ocean (FAO 2008).

Species group	Stock	Trans-boundary (T)/ Straddling (S) / EEZ	Stock status	Management Measure(s)
Spiny and rock lobsters	Territorial reef areas	T	F	
Tuna and related species	Pelagic	S	U	Control/ reducing effort
Shrimps	Shallow waters		D	Present
Sharks	Demersal	S/T	M	
Octopus	Demersal shallow waters		O	
Cuttlefish and squids	Pelagic	T	F	
Sea cucumber	Demersal shallow waters		O	
Bivalve	Demersal shallow waters	R	O	
Reef fish	Reefs	T	F	Trawling not permitted in territorial waters
Demersal	Demersal	T	M/F	
Small pelagics	Pelagics		M	
Shells	Demersal shallow waters	R	O	

Coelacanth		EEZ	?	

The Coelacanth

The sighting of Coelacanth in Tanzania started in September 2003, when a single fish was caught off the coast of Songa Mnara near Kilwa by deep-set gillnets. Since then, more than 35 captures of Coelacanths have been reported by rural fishers in the fishing villages of Kigombe, Mwarongo and Mwambani, South of Tanga, Mtwara, Lindi and Dar es Salaam (Marine Parks and Reserves Unit, 2005). The unprecedented catches of coelacanths in Tanzania especially in Kigombe in Tanga called for urgent measures to stop catches of this highly endangered species (Marine Parks and Reserves Unit, 2005). The National Committee for the African Coelacanth Ecosystem Programe (ACEP) organized a Stakeholder workshop to initiate the process for creation of a marine protected area to conserve the coelacanths and other marine resources in Tanga region in 2009. Subsequently, the Tanga Coelacanth Marine Park was established to conserve coelacanths and their habitats.

Issues

Overharvesting

At present, coastal fisheries in Tanzania are dominated by artisanal fisheries which contribute more than 96% of the total marine fish catches. The artisanal fishery is concentrated in shallow inshore waters because of limited range of fishing vessels and crafts. Most of the fishermen use simple gear and vessels of limited operational range. Fishing vessels include dugout canoes, outrigger canoes, sailboats and dhow. These vessels are normally driven by sails but can be fitted with outboard engines. The operational range of a vessel is determined by its size and whether it is sail or motor driven. Vessels driven by sails rarely go further than 4km from the shore. Their fishing gear includes traps, hooks and lines, nets and harpoons. The most productive fishing grounds are coral reefs, sea-grass beds and reef flats. These areas are experiencing very heavy fishing pressure and are showing signs of over-exploitation (Tarbit, 1984). Nylon gill nets introduced in the late 1960s, are non-degradable and if lost continue fishing indefinitely. Monofilament gill nets have been banned, although there are still being used by fishermen in certain areas.

Destructive fishing methods

The most destructive fishing practice in Tanzanian coastal waters is dynamite fishing. This type of fishing has been used in the inshore waters since the early 1960s. It is mainly used in coastal areas near urban centres such as Dar es Salaam, Tanga and Lindi. It causes major destruction of the coral reefs and fish of different sizes and species are killed indiscriminately. Part of the decline in the productivity and catches of artisanal fishery can be attributed to dynamite fishing. Dynamite fishing has degraded the coral reefs to such an extent that only two (Latham and Mafia) of the eight coral reef sites recommended for marine parks in 1968 had intact coral reefs in 1983 (Salm, 1983). The rest of the reefs have been reduced to rubble. Surveillance of dynamite fishing is done by the Fisheries Department in collaboration with the police. However, this is usually ineffective. The number of fishermen caught while dynamite fishing has however increased since it was banned in 1972 (Ngoile, 1982).

Habitat destruction

In Tanzania, seine nets are operated either on the beaches or in open waters around patch reefs. In the latter case the fishermen survey the reefs and select the one which has a high concentration of fish. The selected reef is encircled with nets and the fish are then scared by breaking the coral heads. As the fish try to escape, they are caught in the seine. This is a destructive form of fishing, as it not only damages reefs, but it is indiscriminate catching also immature fish. Unfortunately, it is a common method in Zanzibar and Pemba islands. There were 2608 seine nets in the islands in 1982 (Ngoile, 1982).

Regional issues (shared by neighbouring countries)

To date, industrial fishing in Tanzania has been limited to prawn trawling. The EEZ has not been exploited significantly, although there is a potential to increase landings of tuna and similar fish species. In order to benefit from the potential fish catches in the EEZ, vessel licensing has to be combined with effective monitoring, surveillance and control system in collaboration with neighbouring coastal and island states. This is a very difficult task that requires significant capacity building.

GAP
Inadequate knowledge on the resource base

Mammals
Whales, dolphins, dugongs and porpoises are some of the marine animals which frequently occur in the marine coastal waters of Tanzania. Eight species of dolphins have been observed in various places including the Rufiji delta, Mtwara, Tanga, Saadan, Latham Island, Menai bay, Nungwi and Matemwe. Humpback Whales have also been observed near the coast of Tanga and Mnazi Bay. Ray (1968) identified Rufiji and Kilwa as the last remaining refuges for dugongs along the Tanzania coast.

Until recently, dugongs were thought to have disappeared from northern Tanzania -their former stronghold. Their presence in the south was unknown (Marshall *et al.* 2001). The first documented records of dugongs were of 3 animals netted by local fishermen in afia Island in 1930 (Dollman, 1933).

The Pemba-Zanzibar channel in northern Tanzania is also recognized as an important dugong habitat (Bryceson, 1981; Korrubel and Cockcroft, 1997; Howell, 1998; UNEP, 2001), although it is believed dugongs in this area are already locally extinct since the last one was reported in 1990 (Chande *et al.* 1994; Cockcroft and Krohn, 1994; Marshall *et al.* 2001). Populations have declined significantly in recent decades possibly to the point where they cannot recover. Dugong numbers are estimated to be no more than 100 individuals (Ngusaru *et al.,* 2001).

Prior to the mid-1970s, dugongs were both abundant and widely distributed along the Tanzania coast. During this period, they were actively hunted in some areas using "dugong nets" and occasionally dynamites. Over the past 25-30 years, dugong numbers have declined dramatically and sightings are now rare. Small resident populations exists in just two remaining areas: the Rufiji-Kilwa-Mafia area and at Moa in Tanga region, near the Kenyan border.

Nylon filament gillnets introduced in Tanzania in the late 1960s (Amir *et al,* 2002), posses the greatest threat to dugongs. InMuheza District dugongs were actively hunted using dynamite until the 1970s (Amir *et al.,* 2002).

Rapid population growth, rapid urban expansion and industrial development are resulting in the reduction in the quality of coastal waters due to pollution of important dugong feeding grounds (Pratap, 1988). Estuarine and coastal habitats are being degraded and this is threatening future survival of dugongs (Cockcroft and Krohn, 1994). Gas and oil exploration in the Songo Songo archipelago, off the southern Rufiji delta is also a potential threat particularly due to general disturbance (e.g. pipe laying) and oil/gas leaks. Population declines are also attributed to low reproduction rates of dugongs.

i) Issues
There have been reported incidences of unexpected Dolphin deaths in Zanzibar. The causes of the deaths are yet to be established.
Dugong is one of the most endangered species on the African continent and is on the IUCN Red list (IUCN, 2000). It is almost extinct in Tanzania, threatened by degradation of its main habitat; sea grass beds. It is also slaughtered for its meat and oil. The other main threats to dugongs in Tanzania are accidental capture in gillnets, seagrass damage from trawlers and seine nets, disturbance from boat traffic, dynamite fishing and offshore gas and oil extraction activities, and coastal development

ii) Gap
Information on dugong distribution and abundance in Tanzania is mostly from anecdotal reports and incidental sightings. There is a need for comprehensive research to determine the current distribution and population dynamics.

Reptiles

Marine Turtles

Five species of marine turtles occur in Tanzania's coastal waters. These are the green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*) and leatherback *(Dermochelys coriacea)* turtles. The first studies on the status, distribution, uses of and threats to turtles in Tanzania were conducted by Frazier (1976, 1980). However, it was not until the early 1990s that more widespread efforts to conserve turtles were made, and it was only recently that more comprehensive surveys were conducted in Mafia, Pemba, Unguja, Saadani, Temeke and Mtwara.

Green turtle

The green turtle is the most common nesting species in Tanzania. Population size estimates from the mid 1970s put the total number in the whole of Tanzania at approximately 300**.** The majority of these were thought to nest on a single island, Maziwe, south of Tanga, which was considered the most important breeding ground for turtles in Tanzania and East Africa as a whole. The other sites include the small islands near Mafia (Frazier, 1976). In the 1980s, Maziwe Island submerged as a result of erosion and now exists as a shifting tidal sand bank on top of Maziwe reef (Howell and Mbindo, 1996)**.** It is no longer a suitable nesting site (Howell, 1993)**,** although local informants report that green turtles continue to nest on the sand bar even though the nests are inundated during both spring and neap tides (Muir, 2005).

The concentrated nesting activity occurs on Misali Island (Pemba), Mnemba and Matemwe Island (Unguja), Mafia Island (Juani Island and Kungwi), Saadani (Madete) and Mtwara (Msimbati and Litokoto and Kingumi Islands) (Khatib, 1998a, 1998b; Pharaoh *et al,*. 2003; Muir 2005).

Anecdotal reports also highlight a number of other important nesting sites in Zanzibar and along the mainland coast. While low density nesting has been reported along the mainland coast from Tanga in the north to Mtwara in the south, the most concentrated numbers of nests appear to be on the offshore islands of Zanzibar, Mafia and Songo Songo archipelago. The main nesting season is between February and July. Evidence from tag returns indicate that some green turtles are probably resident while others are highly migratory, moving to other nesting and feeding grounds in Kenya, Seychelles, Comoros, Mayotte, Europa Island and South Africa. It is estimated that the annual nesting population of green turtles in Tanzania is about 150 (Muir, 2005).

Hawksbill turtle

Hawksbills are also widely distributed but are less abundant. There are few records of hawksbill in small remote offshore islands such as Misali and Mnemba Islands in Zanzibar, the small islands off Dar es Salaam, Shungi-mbili Island and Juani Islands in Mafia and the Songo Songo archipelago. No nests have been recorded on the mainland coast (Muir, 2005). The most important nesting sites in Tanzania are Misali Island, off Pemba, and Mafia Island. On Misali Island, 42 hawksbill nests were recorded between 1998 and 2002, peaking during the month of March. In Mafia Island, 30 hawksbill nests were recorded between 2001 and 2008, of which 16 were laid on Shungi-Mbili Island in the North West and 14 on the east coast at Juani and Kungwi. The main nesting season is during the North East monsoon between December and April. Hawksbill is a migratory species and Tanzania coast harbours both residents and migrants (Muir, 2005).

Olive Ridley turtle

This species was observed nesting on Maziwe Island south of Tanga in the mid-1970s but the island has subsequently submerged and no further nesting records for this species have been made (Muir, 2005). Local fishermen note that they are occasionally accidentally caught in gillnets along the Tanzania coast. Net captures have been confirmed in Mtwara, near the border with Mozambique, particularly within Mnazi Bay Ruvuma Estuary Marine Park.

Loggerhead turtle

Loggerhead turtles are relatively rare in Tanzania. However, evidence from tag returns indicate that southern Tanzania and the Mafia area are important foraging grounds for this species. Three tagged animals were caught in southern Tanzania in 1976. One animal swam a distance of at least 2,640 km in 66 days between its release in Natal and its capture at Kilwa Masoko (Frazier, 1976)**.** Since 2001, tags had been recovered by Sea Sense from

5 loggerhead turtles caught in gillnets: 3 at Jibondo Island off southeast Mafia, and 2 off Songo Songo Island (Muir, 2005). All were tagged while nesting in Tongaland and Natal in South Africa (Muir, 2003).

Leatherback turtle

The leatherback turtle nested in Zanzibar in the 1970s (Frazier, 1976). In 1997-1998, five leatherback turtles, mostly dead individuals, were found in Unguja Island (Khatib, 1998a &1998b). Two leatherback turtles were also caught in offshore waters on Pemba Island in 1997 (Slade *et al.,* 1997) and three washed up on Mafia beaches in 2002 and 2003 (Muir, 2005). This suggests that they may be feeding in the area or they were migrating to nesting sites in Natal, South Africa.

Turtles foraging and developmental grounds

Tanzania has extensive seagrass beds and coral reefs which can support considerable numbers of turtles (Howell and Mbindo, 1996). The extensive seagrass beds off the southern Rufiji Delta (Kichinja Mbuzi and Toshi) including Mohoro Bay (Fungu ya Kasa) are important feeding grounds for green turtles. On Mafia Island, immature and adult green and hawksbill turtles are found in Chole Bay and along the east coast of Juani Island where seagrass and corals occur. Off Ras Kisimani on the west coast of Mafia, green turtles have been observed digging pits in the sand at a depth of 10-15 meters where they appear to nest (Muir, 2005).

In Mtwara, important turtle foraging habitats exist in Mnazi Bay and off Msimbati (Guard, 1998; Muir, 2003). In Zanzibar, green and hawksbill turtles are found in Nungwi and the coral reefs around Mnemba Island. The main turtle developmental habitat, where small and immature green and hawksbill turtles concentrate, is Uroa in the Central District of Unguja. The area comprises of seagrasses, corals and algae and, as late as 1996, was unprotected. The reefs off Zanzibar are also important feeding grounds for loggerhead and leatherback turtles (Khatib *et al,*. 1996).

Legislation to protect marine turtles

In mainland Tanzania, turtles protection is the responsibility of the Fisheries Development Division (Ministry of Livestock and Fisheries Development), through the Fisheries Act of 2003. In addition to Fisheries legislation, the Marine Parks and Reserves Act No. 29 of 1994 provides for the establishment of marine protected areas and the protection and conservation of coastal and marine life including turtles.

In Zanzibar, where marine turtles are protected through the Fisheries Act of 1988. Marine turtles are also protected by the 1993 Fisheries Regulation which prohibits fishing of turtles as well as possession of hawksbill or any other species of "fish" that are considered endangered or threatened under international conventions or agreements.

i) Issues

Reduction of egg harvesting

Traditionally, turtle egg collection has been ubiquitous along the Tanzanian coast, and unlike the killing of turtles themselves, it is not generally perceived to be contravening the law. There is evidence of egg collection along the coast at Saadani, Temeke, Mapanya Island (Mkuranga), Rufiji, Kilwa and Mtwara. However, at sites where effective monitoring and conservation education are underway, the threat of egg harvesting has been significantly reduced. On Mafia Island, for example, 49% of nests recorded during the first year of monitoring by Sea Sense were poached by local fishers (Muir 2005). However, in 2002, following the implementation of beach patrols, the introduction of a nest protection incentive scheme and a public awareness campaign, the incidence of poaching fell to 8% and has declined further to less than 1% in 2003 and 2004 (Muir, 2004a, 2004b, 2004c). A similar change in behaviour has been recorded in MBREMP where the number of nests poached fell from 100% in 2003 to 0% in 2004 following initiation of a turtle conservation programme (Mahenge 2004). In Temeke district, since monitoring began in July 2004, only 1 out of 16 nests recorded has been poached (Muir, 2005).

Monitoring programme

In January 2001, a community-based marine conservation initiative was established by Sea Sense in Mafia district (Mafia Island) to promote the long-term survival of endangered marine species and their habitats,

in collaboration with Mafia District Council, Mafia Island Marine Park and local communities. Direct conservation, monitoring, tagging, public awareness, training and research were undertaken by a team of 8 village-elected "Conservation Officers". A nest protection incentive scheme was initiated in 2002. Under this scheme, individuals who reported a nest received a financial reward (Muir 2005)

On Zanzibar and Mafia, involvement of local communities in nest protection, monitoring, data collection and awareness-raising played a key role in reducing threats to turtles. The provision of financial incentives was a conservation option, and was practiced in some areas in the region. There were of course dangers associated with incentive-driven conservation, the most important of which was financial sustainability. However, in areas where mortality (through turtle and egg poaching) had reached critical levels, financial rewards were considered to be the only realistic short-term solution. It was envisaged that in the longer term it could be possible to generate revenue to fund turtle conservation through turtle tourism and park entry fees (Muir, 2005). On Zanzibar, cash incentives were found to be counter-productive to obtaining committed public participation (Khatib *et al.* 1996). However, in Mafia and Mtwara provision of modest incentives proved to be highly effective in involving local communities and in protecting nests (Muir, 2005).

Eco-tourism programmes

Sea Sense has initiated eco-tourism activities in Temeke, Mafia and Pangani Districts. Tourists are encouraged to watch turtle hatchling events and adopt nests (Muir, 2005).

Economic uses and cultural values of marine turtles in Tanzania

Current information on turtle uses and myths in Tanzania is based on questionnaire surveys conducted in Pemba and Unguja between 1995 and 1998 (Clark and Khatib, 1993; Slade *et al.,* 1997; Khatib, 1998a & 1998b) and a national questionnaire survey (450 respondents) conducted between April and June 2003 by the TTDCP and direct observations. Many Tanzanians enjoy eating turtle meat and the sale has traditionally provided a valuable source of local income (Muir, 2005). The meat and eggs are eaten by many Muslims, not only on Zanzibar, where they comprise 95% of the population, but also in other predominately Islamic locations (e.g., Mafia) (Khatib *et al.* 1996). The local trade in turtle meat in Mtwara district is an important and lucrative business.

There has been a long history of exploitation of hawksbill turtles. Zanzibar was one of the world's major clearing houses for tortoise shells, exporting mainly to Japan and Hong Kong (Slade, 2000). In 1979, when exports to Japan reached their highest levels, annual exports averaged 3,600 kg (Fraiser, 1980). However, with the closure of the centre for international trade in hawksbill shell, banning of international trade through CITES, the closure of the Tanzania markets and the ceremonial burning of turtle shells in Zanzibar in 1995, trade in tortoiseshell and other turtle products has ceased (Thiagarajan, 1991). The sale of turtle shells has however been recorded in Mtwara market (Darwall and Choiseul, 1996) and Rufiji district (Muir, 2005).

In Zanzibar, Clark and Khatib (1993) report that many residents believe turtle products (meat, oil, eggs, shell, skin and internal organs) have medicinal properties and use them to treat a wide range of diseases. During the 2003 survey, 14% (63) of respondents mentioned uses for turtle oil, most commonly as a cooking fat (33%). In Tanga, oil is used mainly as a cure for earache and in Mtwara turtle oil is applied to the skin to heal burns and rashes. In other parts of Tanzania, oil is used to treat asthma, hernias and muscle ache and is occasionally used to waterproof traditional wooden dhows (Clark and Khatib, 1993).

Shrimp Trawling

One of the major threats to turtles in Tanzania is shrimp trawls. 16 Turtles (green, hawksbill and loggerhead) were caught during a by-catch survey conducted in 2007 in the industrial prawn trawl fishery (Muir, 2007b).

Gillnetting

Gillnets also pose a major threat to all species of turtles (adult and subadult) in Tanzania. Most captures are incidental (Muir, 2005). However, at some key known foraging grounds, nets are set deliberately to catch turtles. Such sites include Ras Fikirini (west Mafia), Matanango and Nanano reefs off Msimbati in MBREMP and Kimbiji (Temeke district). More recent estimates for the whole Mafia area suggest annual capture rates of between 1,000 and 2,000 turtles. In Songo Songo, 30 turtles (green, hawksbill and loggerhead) were caught

on 76 fishing trips recorded during a catch monitoring survey by Frontier in 1996 (Darwall, 1996a, 1996b). A survey of turtle by-catch in gillnets in Mtwara in 1996 indicated that turtles are caught in a third of all fishing trips (Darwall and Choiseul, 1996) and in 2003, fishers from Mtwara reported that the average number of turtles caught accidentally in nets ranged from 2-3 per month in Mnazi Bay to as many as 2-3 per day at Litikoto (Muir, 2003). Many turtles were also said to be caught during fishing forays to northern Mozambique for sale in Mtwara town.

Habitat destruction

Habitat destruction caused by erosion, in some cases as a result of coastal developments, live coral mining, destructive prawn trawling practices and clearing of mangroves are also threatening sea turtles (Khatib, 1998a, 1998b, Muir 2007b). The threat of erosion is illustrated by the case of Maziwe Island which submerged in the 1980s. The turtle nesting sites are being eroded in Zanzibar, the most threatened being Nungwi, Bwejuu, Jambiani and Mnemba Island (Khatib, 1998a, 1998b).

ii) Gaps

Little is known about the status of olive ridley turtles in Tanzania although they are no longer reported to nest.

Very little information is available on leatherback turtles in Tanzania because they are so rarely sighted and because indigenous knowledge is limited.

Potentially important nesting and feeding sites in Tanga, Muheza, Pangani and Lindi districts have not been surveyed because of funding and resource limitations.

Very little is known about the main turtle foraging and nursery grounds in Tanzania.

Birds

The avifauna of Tanzania includes a total of 1,108 species of which 23 are endemic, 4 have been introduced by humans, and 43 are rare or accidental. There are 36 species which are globally threatened. (http://en.wikipedia.org/wiki/List_of_birds_of_Tanzania). A wide variety of coastal birds and seabirds are found particularly in mangrove forests, intertidal flats and on rocky cliffs. Waders and shorebirds visit Tanzania in large numbers each year between August and May to feed on intertidal flats during low tides. 10 Important Bird Areas (IBAs) have been designated by Birdlife International along the coast of Tanzania

i) Issues

Loss of bird habitats due to unsustainable human activities threatens existence of the Tanzanian avifauna.

The Indian crow is known to be feed ferociously on eggs of other bird species thus threatening indigenous populations of birds and their continued existence in Tanzania.

ii) Gaps

Birds are not covered in the implementation of the Fisheries policy. There is a need for collaboration with the Wildlife sector responsible for bird life, in order to ensure the continued existence of the coastal avifauna of Tanzania.

Very little research has also being carried out on marine birds in Tanzania. This gap need to be addressed as soon as possible.

Exotic and Invasive Species

The Invasive Species Specialist Group (ISSG 2005) of the IUCN Species Survival Commission has identified the following invasive species: *Musculista senhousia* (mollusc), *Salmo trutta* (fish), *Tilapia zillii* (fish), *Vibrio cholerae* (micro-organism), *Acanthophora spicifera* (algae), *Gracilaria salicornia* (algae), *Tubastraea coccinea* (coral) and *Lutjanus kasmira* (fish). However, very few studies have been carried out on invasive species in marine waters of Tanzania.

i) Issue

The National Fisheries Policy and Coastal Area Management Strategy do not explicitly address marine invasive species.

ii) Gap

Very few studies have been carried out on invasive species in marine waters of Tanzania. Studies on invasive species in Tanzanian waters need to be carried out.

Long term predicted atmospheric changes

Air temperature and rainfall

The projections of long term atmospheric changes in Tanzania have basically focused on air temperature and rainfall. Agrawala *et al*. (2003) made projections on the changes in area averaged temperature and rainfall over Tanzania using outputs from General Circulation Models (GCMs). These simulations anticipate an increase in annual mean temperature of 0.9°C, 1.3°C and 2.2°C by 2030, 2050 and 2100, respectively. The corresponding changes in rainfall are 4.1%, 5.9% and 10.2%, respectively. Rainfall is expected to reduce in the months of June-August, and to increase in the remaining months of the year.

By the year 2100, the increase in air temperature is expected to be relatively higher (2.6 °C) over the months of June to August, and lower (1.9 °C) during December through February (Agrawala *et al*., 2003). Obviously, this increase in air temperature will have implications for the coastal and marine environment such as the increase in the thermal expansion of the ocean leading to increase in the level of the sea.

Predictions using GCMs shows that temperature will increase by 2.5 -2.9 °C during the warmest months of December-February, and by 3.0-3.5 °C during the coolest months of June to August. The corresponding change in rainfall will be -5 to 10%, with an increase in the northern and southern parts of the coast, and a decrease at the central portion (Mwandosya *et al*., 1998).

Other attempts to assess the possible consequences of global change on climate on the coastal ecosystems of Tanzania have been made by several authors (Wemba-Rashid, 1991; Fay, 1992; Mgaya, 1997; Paavola, 2003; Mwandosya *et al*., 1998; Kaser *et al*., 2004).

Wind patterns

The monthly means of the NE and SE monsoon winds speeds between the period 1985 and 2004 measured from the island of Zanzibar, have shown an increasing trend (Mahongo and Francis, 2010). The wind data records for the period 1972 - 1996 in some coastal locations indicates that maximum wind speeds have increased since 1972 (Dubi 2002). However, in Tanga, Dar es Salaam and Zanzibar, the wind speeds shows a declining trend. Mtwara is also experiencing strongest winds, which results in increased wave activity, stronger currents and wind set-up. Lwambuka (1992) found extreme gust speeds to be 30 ms^{-1} for Tanga, 29 ms^{-1} for Zanzibar, 27 ms^{-1} for Dar es Salaam and 38 ms^{-1} for Mtwara.

Extreme events

The ongoing change in global climate is leading to increased frequency and intensity of tropical cyclones, changes in wind patterns, floods, wave action and storm surges. However, no comprehensive study has been carried out in Tanzania to forecast these events. Although Tanzania is largely not within the Indian Ocean cyclone zone, historical records show that the coast has in the past been hit by several cyclones. The affected places included Zanzibar and Bagamoyo on 4th April 1872, Lindi, Mikindani and Mtwara on 15th April 1972, Dar es Salaam in 1989 and Zanzibar in August 1994 (Francis *et al.,* 2001). A review of adaptation technologies and legal instruments to address climate change impacts to coastal and marine resources in Tanzania is given by Sallema and Mtui (2008).

i) Issues AND GAPS

Few studies have been carried out on ocean –atmosphere interactions in Tanzania. There is therefore lack of knowledge in this area
Uncertainties in the results of global circulation models.
Available data have not been analyzed

HUMAN ENVIRONMENT

Coastal and island populations

There are five administrative regions situated along the mainland coast of Tanzania: Tanga, Coast, Dar es Salaam, Lindi and Mtwara. The islands of Unguja and Pemba make up Zanzibar, the other part of the Union of Tanzania). The five coastal regions of Tanzania cover about 15 percent of the country's total land area and are home to approximately 25 percent of the country's population. According to the 1988 population census, the population of Tanzania was 23 million (United Republic of Tanzania, 2002). The current population is estimated to be 40 miilion. Based on a land area of 883,749 km^2, the average population density for the country is 38.6 persons/km^2 (Table 12). A high percentage of Tanzania's population is under the age of 15 with significant implications on health and educational facilities (cf. Torella *et al.* 2004).

Table 12: Population Density of Coastal Regions (URT, 1967, 1978, 1988, 2002)

Region	Area (Km^2)	Population density (persons/km^2)			
		1967	1978	1988	2002
Tanga	26,808	29	39	48	62
Coast	32,407	13	16	20	25
Dar es Salaam	1,393	256	605	977	1,745
Lindi	66,046	6	8	10	12
Mtwara	16,707	37	46	53	61
Zanzibar	2,460	149	201	260	353
TANZANIA	881,300	14	20	26	38

Cultural diversity

Tanzania is a home to approximately 120 ethnic groups, most of them comprised of small communities that are gradually being assimilated into the larger ethnic groups due to changes in land use and the economic reasons. Tanzanians place a high value on their country's multi-cultural heritage. However, the promotion of multi-cultural diversity of communities in Tanzania is not allowed in any formal domain in the country. Some of the ethnic languages are spoken by millions of people in Tanzania.

The 'Spice Islands' of the Zanzibar , Pemba, Mafia, and the entire Tanzanian coast is home to the Swahili people- a vibrant mix of Arab, Indian and Bantu origins who historically based their livelihoods around Indian Ocean trade. The Swahili Coast as the region is predominantly Islamic with old mosques and palaces. Swahili culture centres on the dhow- a wooden sailing boat powered by the seasonal monsoon wind. Historically, the boats connected the Swahili Coast with Arabia and India and allowed trade between the regions to flourish (http://news.bbc.co.uk/2/hi/africa/country_profiles/1072330.stm)

Age and gender structure

Approximately 50% of the coastal population in Tanzania is made up of young people aged between 0 to 19 years (Figure 10). This is mainly school going age which suggests a high dependence ratio. Such a large proportion of young people indicate a future of rapid population growth in the absence of significant out-migration. This is due to a large number of children who will soon enter into their childbearing ages.

As shown in Figure 10 in the early ages i.e. 0-14 years, males dominate the coastal population. However, the trend is reversed as the population reaches mature age. Migration plays a large and important role in the demographic profile of Tanzania (URT, 2002). The coastal population is greatly influenced by in-migration and out-migration, with Dar es Salaam, Zanzibar and Urban West-Unguja experiencing a positive net migration. This suggests that there is a high movement of people from rural to urban areas (Table 13).

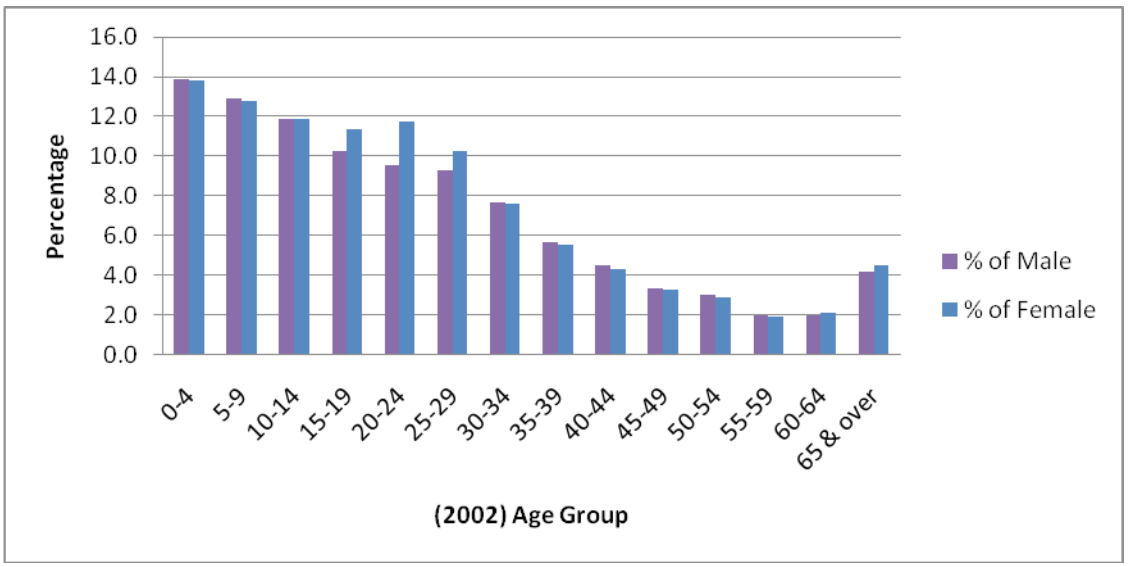

Figure 10: Coastal regions Population structure by sex. Source: URT, 1967, 1978, 1988, 2002)

Table 13: In-migration and Out-migration of the Coastal Population (URT, 2006b)

Region	In-migration	Out-migration	Net-migration
Tanzania	4,671,642	4,671,642	-
Mainland	4,442,528	4,449,580	(7,052)
Tanga	96,343	289,227	(192,884)
Pwani	159,276	222,254	(62,978)
Dar-es-Salaam	1,319,361	187,904	1,131,457
Lindi	79,484	158,617	(79,133)
Mtwara	43,554	177,214	(133,660)
Zanzibar	229,114	222,062	7,052
N & S Unguja	43,136	82,614	(39,478)
Urban-West	166,947	47,465	119,482
Pemba	19,031	91,983	(72,952)

i) Issues

Pollution
Accessibility (hospitals, markets) - lack of infrastructure (see infrastructure section)
Population pressure
Resource degradation
Increased unplanned settlement
Crime

ii) Gaps

No sufficient disaggregated data by gender.
More research needs to be done in the area of population and population structure of the coastal regions

Sites of religious or cultural significance

The cultural heritage sites found along the coastal region of Tanzania include monuments and old buildings that represent important events or eras in local history and traditional lifestyles, such as the performing arts and handicrafts. Some of the world-class cultural sites include the ruins of Kilwa Kisiwani and Songo Mnara, designated as UNESCO world heritage sites. Others include Bagamoyo town, Kaole ruins, Amboni caves, Tongoni ruins, Kunduchi ruins, Mkindani and Kilwa Kivinje. The National museum, village museum and Bagamoyo Catholic Museum are also important cultural heritage sites. Furthermore, Ras Mkumbuu-, a demonstration site for the ASCLME project for Distance Learning Information Sharing Tool (DLIST), is an

important historical information site. All these have an unlimited potential to attract tourists. Additional sites that are not adequately publicised include Kua Ruins of Juani Island, Mafia.

At present most of the cultural heritage sites are in poor condition, and are also threatened by both human activities and natural weathering processes. Controlled economic development such as agriculture, grazing, construction and the clarification of tenure rights and titling are important management issues that have to be addressed through land use planning. A major issue is involving communities directly in the preservation of ruins or other points of attraction.

In some places, local communities had traditional systems of rights over marine and coastal areas and resources. Although these useful for developing community involvement in the management process of the coastal and marine resources, there are being eroded at a rapid rate. It is important to note that religious and cultural beliefs and customs used to have great relevance in the management of the marine and coastal resources. However, such customs and practices are now rare in Tanzania. Also, influx of people from other areas, leading to population heterogeneity, the superimposition of colonial or government systems of resource control, have led to the deterioration of traditional understandings of ownership and territoriality.

An example in Tanzania of a traditional management system is the one established in Kizimkazi village in Zanzibar for Menai Bay, where there was system of seasonal closures of fishing areas, particularly for octopus. However, with increasing pressure from fishers, this traditional system eventually collapsed. However, with the support of the government, the system was recently re-introduced.

Misali Island in Pemba was another important area with religious importance and support of the local Muslim elders had been sought in the management of Misali Island conservation area. Many Islamic teachings and concepts are relevant to marine conservation such as the recognition that animals should reproduce before they are killed, the duty to treat all creatures well and the guardian or stewardship role given to humans to protect the environment. The Islamic messages were used to promote conservation, with religious leaders assisting through their sermons and teachings.

i) Issues

Accessibility

Cultural erosion through loss of appreciation of the importance of cultural sites, social and cultural interaction.

Physical erosion of culturally important sites

Economic pressures Leading to over-exploitation of natural resources.

ii) Gaps

Lack of sufficient information on the areas of cultural and religious importance.

Inadequate research on the importance and current status of the areas of cultural and religious importance**.**

Health situation and health service delivery

Health status is a big challenge in most of the coastal region of Tanzania. Malaria is still a major cause of illness and death. The disease is more common in Dar es Salaam whereas diarrhoea is more prevalent in rural areas (URT, 2007b). Pregnant women and young children are especially vulnerable to the two diseases. The government has come up with the National Malaria Policy and Strategy with an aim of increasing the use of insecticide-treated mosquito nets and to improve treatment for malaria. Unlike mainland Tanzania, Malaria has to a large extent been controlled in Zanzibar. However, Zanzibar faces other challenges in safeguarding public health. For instance, the availability of basic social services such as water, electricity and roads are still inadequate.

A high illiteracy rate of 24.2% and 27.2% is prevalent in Zanzibar and Mainland Tanzania, respectively. This is a great impediment to the achievement better health status to the people. About 30% of the coastal people especially in rural areas still have no access to safe drinking water. In most areas in coastal region of Tanzania, malaria are the most commonly reported diseases being reported by 62 % of adults and almost 77 % of children (Figure 11) (NEMC 2009).

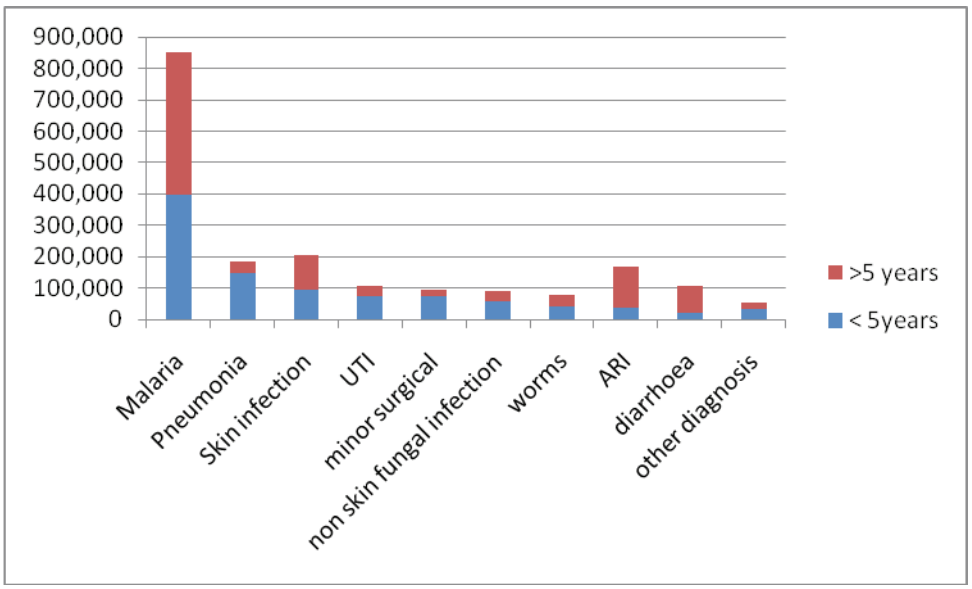

Figure 11: Common Diseases inflicting coastal populations in Tanzania (NEMC 2009)

People in rural areas rely heavily on government health facilities compared to urban residents (United Republic of Tanzania, 2007a, and 2007b). Majority of the private health facilitate are concentrated in urban areas. The use of traditional healers has also reduced significantly in the recent past (United Republic of Tanzania 2007b). Table 14 provides a summary of the reported cases of illness as established during the 2007 household budget survey.

Most households are generally not far from primary health care facilities, even in rural areas. The distance to the nearest hospitals appeared to have decreased since 2000/01, particularly in rural areas as would have been expected. The 2007 Household Budget Survey indicated that 68 % of households are less than 6 Km away from a primary health facility and over 84 % of households are within 10 Km of a dispensary (United Republic of Tanzania, 2007b). In Zanzibar on the other hand, the 2004/05 Household Budget Survey indicates that more than 75% of the households in the rural area are within 1 Km from the health centre (OCGS, 2004/05 Household Budget Survey). The government's intention is to provide health services to the level of primary, tertiary and secondary levels. The private sector and parastatals also play an important role in delivering health care to the public (Table 15).

Table 14: Percentage of ill or injured individuals who consulted any health care provider by sex and area (HBS 2000/01, HBS 2007) (URT 2007b)

	Dar es Salaam		Other Urban Area		Rural area		Mainland Tanzania	
	2000/01	2007	2000/01	2007	2000/01	2000/01	2000/01	2007
Both sexes	80.2	83.7	76.2	75.7	67.1	66.5	68.7	69.0
Male	75.9	83.3	74.2	76.3	66.2	66.6	67.7	69.2
Female	84.3	84.0	77.9	75.2	67.8	66.5	69.7	68.9

Table 15: Distribution of Health Facilities by District and Type, 2006 (Revolutionary Government of Zanzibar 2009)

District	PHCU 1st Line	PHCU 2nd Line	PHCC	District Hospital	Tertiary	Special	Private Facilities	Parastatal
North 'A'	9	3	1	0	0	0	3	0
North 'B'	7	3	0	0	0	0	2	2
Central	18	3	0	0	0	0	4	0
South	7	2	1	0	0	0	0	0
West	9	2	0	0	0	0	20	4
Urban	6	4	0	0	2	1	78	4
	9	3	1	0	0	0	2	2
Wete	17	1	0	1	0	0	3	1
Chake Chake	10	2	1	1	0	0	4	2
Mkoani	13	2	0	1	0	0	2	0
Total	105	25	4	3	2	1	118	15

Access to Reproductive and Child Health care is a major health issue in coastal Tanzania and is linked to infant and maternal mortality. The number of people reported to have died because of AIDS related diseases is increasing. In the Pwani region, which includes the Bagamoyo district, the prevalence rate among women is almost three times that of men (10.5% vs. 3.9%). In the Tanga region, which includes the Pangani district, women are twice as likely to be infected as men are (7.4% vs. 3.2%) (Tanzania Commission for AIDS 2005).

Protein malnutrition is the most widespread and leading nutritional disorder in Tanzania. Children less than five years of age are the most affected. This often results from consumption of inadequate food and is frequently aggravated by infections. Malnutrition among children increases their risk of morbidity and mortality and causes impaired mental development (TDHS 2010).

Nearly two-thirds of rural households in Tanzania have access to an improved source of drinking water. More than 90 per cent of households have toilet facilities, mostly pit latrines (United Republic of Tanzania 2007a). The coastal districts are among those with the lowest percentage of households with access to clean and safe water sources (e.g. piped or protected source). These include Mkuranga (9%), Liwale (16%), Mafia (17%), Rufiji (21%), Kilwa (22%), Lindi (rural-23%) Tandahimba (25%), Mtwara (rural) (26%). There is a close link between water supply, poor sanitation, poor hygiene and waterborne diseases such as cholera. Since the first major cholera epidemic was reported in Rufiji in southern Tanzania in 1977-78, the disease has spread to other regions of the country. In some regions such as Dar es Salaam, cholera is considered endemic (United Republic of Tanzania 2007b).

Infrastructure

Transportation is an important sector in the economy of the country in general and also the economy of the Coastal regions. Table 16 provides details on roads in Tanzania. The majority of Dar es Salaam roads are under the Municipal authorities and are either paved or unpaved. Some of the coastal cities are interconnected with a good road network. Table gives details of the coastal region's roads network.

Table 16: Road networks in coastal regions (TANROADS 2008)

	PAVED (KM)	UNPAVED (KM)	Total (KM)
Coast	314.60	644.10	958.70
Tanga	485.10	1135.46	1620.56
Dar es Salaam	123.43	339.70	463.13
Mtwara	161.80	916.64	1078.44
Lindi	362.04	821.00	1183.04

Harbours

Dar es Salaam is the largest seaport in Tanzania followed by Tanga and Zanzibar. The port handles cargo destined for land locked countries such as Burundi, Rwanda, Uganda, Malawi and Zambia. Tanga is the second largest seaport with a handling capacity of 500,000 tons of cargo a year. The port handles mostly cargo -copper concentrates from the Kahama mines, bulk wheat, cement, fish fillets/octopus and hide and skins. Sisal and coffee are also exported to European and Asian markets. There are container handling and cold storage facilities as well.

Other coastal regions with ports include Lindi, Mtwara and Coast (Mafia). The new initiative of the Mtwara corridor is likely to make Mtwara more active in handling cargo destined for Southern African countries. Fishing harbours are however missing in all the coastal regions.

Airports

Apart from Julius Nyerere International airport which is in Dar es Salaam, Zanzibar airport is the second largest international airport in the coastal zone, handling both local and international flights. Tanga city also has airport facilities capable of handling small passenger planes.

Other coastal regions also have airports to cater for domestic transport. These include the Mafia Airport in Pwani Region, Lindi and Mtwara Airports which are popular for the domestic flights. In addition there are small airstrips which cater for private needs such as the air strip in the Selous game reserve for those visiting the area, Utete air strip, and Mnazi Bay air strip. All these are important infrastructure which provides a good reflection of the growth of the economy and investment into the region.

Energy

All coastal regions depend on different sources of energy, such as electricity, kerosene, charcoal, firewood and solar. The main source of power for lighting, business and industry is electricity which is generated, transmitted and supplied by a sole utility agent - Tanzania Electric Supply Company Limited (TANESCO). All coastal regions and districts are connected to the national grid. The availability of electricity in most parts of coastal region of Tanzania is still a challenge. Lack of alternative enegy for cooking, especially in rural areas has imposed severe demands on forest resources due to unsustainable harvesting of wood for cooking. Fuelwood and charcoal are the main sources of energy for most people in the coastal region of Tanzania.

i) Issues

Lack of investment / poor maintenance
Level of education
Deforestation
Pollution

ii) Gaps

Lack of good quality data on the coastal infrastructure
Inadequate research on the coastal regions infrastructure status.

4. COASTAL LIVELIHOODS

A comprehensive coastal livelihoods assessment has been carried out. Chapter summaries are presented below, and the full Coastal Livelihoods Assessment may be found in Annex XII for further information.

4.1 Small-Scale Fisheries

The small-scale fishery in Tanzania accounts for 98% of total fish production, 1.3% of GDP and contributes up to 9.9% of fish exports worth an estimated 12.4 million USD. While the contribution of small-scale fisheries to the GDP may appear marginal, the sector is a vital source of food, employment and income for coastal communities. This helps in sustaining the economy of the five coastal regions. The small-scale fisheries sector is however constrained by inadequate infrastructure, including lack of capacity for processing, storage and transportation facilities. The post-harvest fish losses due to lack of storage and processing facilities is estimated to be 20%.

Deleterious fishing techniques such as dynamite are a large threat to small-scale fisheries sector in view of degradation of habitats. Weak institutional infrastructure required to monitor and regulate such activities has also weakened the ability of authorities to prevent such bad fishing practices. Despite these obstacles, some degree of oversight and planning has been decentralized to the community level through Beach Management Units (BMUs) and Collaborative Fisheries Management Areas (CFMAs), which empower local fishers to monitor and become responsible for the resources and habitats they depend on. Likewise, as micro-finance continues to be made available by international organizations to the sector, sustainable practices should be strengthened.

Relatively high taxes on fish exports and financial services tend to constrain development of the commercial sector, and credit remains scarce in the coastal zone. However increasing global demand for tropical fish products could be an incentive to the investors in the sector. This could subsequently allow the sector to gradually move away from its over-dependence on external finance.

In general, the high potential for the growth of mariculture, availability of a wide range of fish species, presence of supporting development institutions and good legislation are strengths in the sector. Improved implementation of existing policies, legislation and guidelines, and strengthening of the role of BMUs in co-management initiatives are key areas for improvement, while the role of Marine Protected Areas as a viable management option need to be promoted.

4.2 Tourism.

Tourism is important for the Tanzanian economy as it accounts for 17.2% of GDP. This makes up 25% of foreign exchange earnings and employs 288,700 people. The sector also continues to grow with foreign exchange receipts from tourism increasing from US$259.44 million in 1995 to $1,269.68 million in 2008. The total arrivals increased from 295,312 to 770,376 over the same period. While much of this activity is concentrated around wildlife-based tourism in the hinterland, coastal tourism is witnessing some growth. For instance, in Mafia Island, arrivals increased from 484 in 2000 to 3,107 in 2007. Coastal tourism is not however, growing as rapidly as inland tourism, which has been partly attributed to lack of a national strategy on diversification of the sector into the country's coastal regions.

Numerous constraints have been documented in the tourism sector, despite the aforementioned growth rates. For example, it is estimated that between 75% and 90% of funds paid for vacations in Tanzania are actually collected by outbound operators, source country airlines and other imports from the visitor's country of origin, which also corresponds to the leakages in the sector experienced by other least developed countries in Africa. Similarly, lack of appropriate facilities for international clients, low-levels of entrepreneurship and lack of confidence in the private-sector all highlight the weaknesses that continue to constrain the sector. Numerous environmental threats have also been identified, with large-scale erosion, strip development, over-fishing and deterioration of coastal ecosystems due to climate change and pollution all being highlighted, which is problematic considering the sector's dependence on the country's natural landscape and wildlife.

There are however strengths and opportunities prevalent in the sector which could be utilized to mitigate

some of the aforementioned constraints. For example, improvements in electricity infrastructure in the coastal towns around Lindi and Mtwara will encourage private-investors, while upgrades in the port and airport at Mtwara will increase accessibility. The country's long coastline and attractive offshore islands, world renowned attractions and traditional cultures could also be utilized as pillars for further growth in the sector, while the presence of regulations around marine parks, eco-tourism development, as well as conservation support from international donors such as the World Bank and WWF, should be helpful in reducing environmental degradation of the coast. Nevertheless, despite the presence of a Tourism Master Plan, tourism growth in the coastal zone continues to lag behind activity in the hinterland, which is expected to continue without a proper strategy to grow the sector around coastal communities.

4.3 Mariculture

Mariculture is an important sector in the Tanzanian economy, with finfish, seaweed and mudcrab being farmed in all coastal regions, and pearls and prawns also being farmed in Mafia and Tanga. Regulation and infrastructure development has lagged behind in this sector. However, high quality seawater, large numbers of candidate species and existing research and support capacity highlight the untapped potential in the sector. The government has also committed to developing the sector, as evident in the Seaweed Development Strategic Plan and the Aquaculture Development Strategy proposed in 2005 and 2008, respectively. Despite constraints in governance, several experimental farms are currently operational and the strategies have been applauded for their credibility. The private-sector has also been established in the seaweed and prawn industries, while NGO's and international organizations with expertise in mariculture continue to provide support. Many mariculture projects are, however, largely dependent on the knowledge and finance provided by international donor organizations, which has magnified the need for greater private-sector involvement and local capacity building in the sector.

Despite the potential for over-exploitation of certain species due to the requirement of wild-caught seed, and high levels of theft and vandalism, the opportunities for diversification into new markets are immense. With greater NGO participation, expansion into undeveloped intertidal lagoon and mud flats, as well as improved production of aquafeeds, mariculture has the potential to become a mainstay in the Tanzanian economy.

4.4 Agriculture and Forestry

Agriculture is the country's leading sector, employing 82% of the population. The sector contributes 45% of GDP and 60% of total export earnings. The sector also employs three million people. The forest sector accounts for 4% of GDP, making up 10% of foreign exchange earnings equal to 14 million USD annually. Subsistence farming is, however, the most dominant form of income generation in the coastal zone. Thus, any increases in unemployment are expected to place further strain on the region's natural resources. Fuel wood also accounts for more than 92% of the country's energy use, also placing extensive strain on the country's coastal forests.

Forest depletion, a lack of information on sustainable agriculture and limited export opportunities have all been highlighted as major obstacles in the sector, this is apart from the threat posed by demand of extensive land for export oriented production, including bio-fuels, which in the lack of careful management will be detrimental rather than being beneficial to coastal livelihoods. However, current projects and planning being implemented by coastal residents, the government and the international community are very promising. The promotion of participatory forest management by the government, as well as the sustainable development projects being promoted by the World Bank and WWF, have all focused on the empowerment of local communities to manage their own resources. Likewise, alternative sources of income generation, such as beekeeping, honey production, and tree nursery management have highlighted potential substitutes present in the sector. The government has also recognized coastal forests, particularly mangrove areas, as a key resource under threat, which is a significant step from a conservation perspective.

Despite the high pressures on coastal land from population increases, as well as the conflicts between coastal residents and commercial companies, the government has begun to recognize that the fishery is not the only sector of importance in the coastal region. The Poverty Reduction Strategy Paper aims at facilitating partnerships between the public sector, private sector and civil society in order to reduce poverty and subsequently reduce the strain on the country's natural resources. However, almost half of the country's forests are severely threatened, hence, more aggressive action will be required to sustain the sector.

4.5 Energy

Activities in oil, gas and biofuels in Tanzania are highly promising, with current natural gas production at Songo Songo reaching 70mcf in 2008, and production at Mnazi Bay reaching 1mcf in 2008. The country also has strong hydrocarbon potential and numerous companies are currently exploring potential oil reserves, with 13 offshore blocks expected to be conceded in the near future. Only about a quarter of potential arable land is currently cultivated, providing opportunities for bio fuel production. It is estimated that between 20 and 24 companies have requested land for commercial bio fuel production.

Although the refinery in Dar es Salaam was closed in 1999, the region still remains a center for downstream activity, as it handles imports of liquid petroleum gas (LPG), stores oil products, receives gas from the 230 km pipeline connected to Songo Songo, supplies Burundi, Uganda, Rwanda and Eastern Conco and transports crude oil through a pipeline to the Indeni oil refinery in Zambia. Despite all this activity, it is estimated that only 0.1% of the population is employed in the electricity and gas sectors.

Numerous constraints have been identified in the energy sector. For example, weak petroleum regulations, as well as an inconsistent environmental impact assessment (EIA) framework, have both been highlighted as weaknesses. Similarly, a lack of financial, operational and human resources capacity has constrained management and law enforcement in the sector, particularly prevalent at lower-levels of government. Many large-scale biofuels projects have also been implemented without a clear and consistent framework, which could lead to unsound development in agro-fuels and threaten food security, small-scale food crop producers and local livelihoods. It is also likely that any increases in oil operations, both upstream and downstream, will intensify the risk of spills and accidents, which could negatively impact local livelihoods.

A number of strengths and opportunities have however, been identified, which could be utilized to alleviate some of the aforementioned constraints. For example, there is interest from foreign investors, particularly in biofuels, which could mitigate some of the financial strains in the public sector, while the availability of land is highly supportive of biofuels development. The government is also committed to developing domestic energy resources, which is very positive considering the current domestic and regional demand for energy. Oil and gas development also has the potential to benefit livelihoods through employment, while companies in the sector, such as Songas, are likely to further engage in the community and support local development. There are also plans to construct a new oil refinery in Dar es Salaam, as well as upgrading of oil storage capacity in Dar es Salaam and increasing of capacity at the Songo Songo gas field, all of which should be conducive to growth in the sector. Numerous international organizations, such as the World Bank and USAID, are also involved in coastal zone management projects, which could again be beneficial in terms of community development in the coastal regions. Thus, while it is not likely that the current upstream activities will provide significant employment to coastal communities, the prospects inherent throughout the sector highlights the great potential in the Tanzanian energy sector.

4.6 Ports and Coastal Transport

Tanzania has well established ports and coastal transport sector, with ports in Mtwara, Lindi, Kilwa, Dar Es Salaam and Tanga, as well as an extensive rail and road network. While the ports are managed by the Tanzania Ports Authority (TPA), the rail network is jointly managed by the Zambian government and the Tanzania Railway Corporation (TAZARA). Some concessions have been proposed, however, the transport sector is largely funded and managed by the public sector, which does constrain capacity and service delivery in the sector.

There are numerous opportunities in the transport sector despite the presence of corruption and lack of training and skills in ports and coastal transport. The introduction of new navigational aids in Mtwara could make the port operational twenty-four hours a day. In Dar Es Salaam, modernization of the road and rail corridor could greatly expand business opportunities on the coast. Likewise, there are also opportunities to expand Tanga port into a deepwater port. The discovery of an offshore gas field near Songo Songo Island could also provide power for industrial development near Kilwa.

Inadequate infrastructure and a poor manufacturing sector have constrained growth in the sector, however, physical location of the ports, as well as the proposed development of Mtwara and Central Development

Corridors, which will effectively link Tanzanian coast to the interior of the continent, highlight the prospects for further growth in the sector. If further concessions can be negotiated with the private-sector, as seen in the container sub-sector, capacity and service delivery both have the potential to dramatically improve.

4.7 Coastal Mining

Being Africa's third largest gold producer, the world's sole producer of the gemstone tanzanite, and a producer of cement, diamonds, sapphire and garnet, Tanzania has an extensive and diverse mining sector. The sector contributes nearly 4% to GDP and it formally employs 8,000 people. An estimated 500,000 artisanal miners are also active throughout the sector. The sector also contributes 42.9% of total foreign exchange earnings.

The majority of precious metal mining takes place inland. However, the coastal zone does have mining operations focused on cement, coral and lime, with both lime and cement being produced for export throughout East Africa. Companies controlling these operations, such as Tanga cement, have also invested in community development, a testament to the social benefits provided by coastal mining activities. The Twiga and Tanga cement projects have also produced over 200 billion TZS in tax revenue, which could potentially be reinvested into the coastal communities with the construction of housing, schools and clinics. Likewise, recent investments in the Twiga and Tanga mines are expected to generate more employment and training for employees in the coastal region. While financial resources are limited and environmental management remains uncoordinated, strong mining regulations, NGO involvement in coastal zone management and the development of new cement projects on the coast all highlight the potential for further sustainable growth in the sector. Despite some of the environmental issues surrounding the mining sector on the coast, the incentive to invest in the region also remains high. Poverty and unemployment does, however, remain a constraint across coastal communities, which could facilitate the over-exploitation of resources in the future.

Conclusions

Each livelihood sector has had, and will continue to have a distinct impact on the socio-economic and environmental status of the coastal communities concerned. There are many constraints that remain constant across sectors, such as political stability, over-exploitation of natural resources and limited infrastructure, all of which have had a widespread impact on all of the sectors. There are also many strengths and opportunities apparent, such as potential alternative income generating activities, the provision of microfinance and opportunities for business and investment. In this respect, while each of the seven sectors have their own distinct institutions and processes that are unique to the sector in question, they are nevertheless extensively linked economically, socially and environmentally.

One clear link between the sectors is the constraint of governance and capacity. In the small-scale fisheries, the lack of institutional infrastructure to monitor the sector has led to destructive fishing practices going unchecked. In mariculture, the responsible government agencies lack resources and funding to meet their proposed objectives. In agriculture and forestry, community capacity is too weak to sustainably manage their resources, while government ownership in ports and shipping sector continues to weaken capacity and service delivery. Likewise, in the energy sector, capacity to manage and enforce laws has been highlighted as a weakness, particularly at the lower-levels of government. Despite these constrictions, progress is being seen. For example, decentralization and microfinance has the potential to further empower local communities in the small-scale fisheries, while NGO's continue to provide technical support in the development of the mariculture sector. Likewise, concessions to the private sector in the ports and shipping sector, as well as strong regulation in the mining sector, highlight the development of governance capacity in the coastal zone.

Across many sectors, environmental degradation also remains a threat. The destruction of marine habitats, forest depletion, pollution and the potential for over-exploitation all highlight the environmental challenges confronting coastal communities in Tanzania. While the government has promoted sustainable development practices across most sectors, lack of capacity has made it difficult moving forward. Despite this, positives can be seen. For example, substitutes in the agriculture and forestry sector, such as beekeeping, honey production and tree nursery management, have the potential to reduce the strain on forests and land. Likewise, various NGO projects continue to promote sustainable practices in the small-scale fishery and coastal zone management in the mining sector.

Business and investment opportunities are also evident across the sectors. In coastal mining, the cement and lime industries continue to attract investment, while upgrades in road and railway corridors linking the coast to inland areas could present new opportunities in the ports and shipping sector. Similarly, the private sector has been promoted with the Poverty Reduction Strategy Paper, while the demand for fishery products should highlight the commercial opportunities existing in the small-scale fishery. In the energy sector, there is also great interest from foreign investors, particularly in biofuels, which could be very promising for both government and coastal communities. Despite this potential, private-sector involvement does remain weak in the mariculture sector, while high taxes continue to limit the competitiveness of the country's fishery products. Likewise, conflicts between coastal communities and commercial companies have become a threat in the agriculture and forestry sector, while biofuels investors have shown an inclination to target rich land that is occupied by small-scale food crop producers in the energy sector.

Overall, weak infrastructure, a lack of capacity and the over-exploitation of natural resources present many challenges to the Tanzanian coastal zone. However, a commitment to sustainable social and economic development by government, NGO's and communities is apparent. Opportunities for private-sector investment are also evident, particularly in the mining and ports and coastal transport sectors, which demonstrates the potential for growth and development moving forward. Investment in these sectors also makes evident the significance of spillovers, whereby, the private-sector could stimulate the coastal economy and potentially reduce the affects of rapid rural-urban migration. These opportunities also magnify the utility and importance of creating employment and alternative streams of income to reduce poverty and, in turn, reduce the strain being placed on coastal resources. By promoting private-sector investment, international support and community management in new sectors, the government has the opportunity to facilitate the growth of a sustainable economy in the coastal zone while simultaneously empowering the coastal population.

5. POLICY AND GOVERNANCE

A comprehensive report was prepared on Policy and Governance, which is Annex V to this MEDA. A summary is presented below.

Tanzania is negotiating with Mozambique, Comoro and Seychelles on the delineation of the EEZ boundaries.

Tanzania has quite a number of laws which provide for legal and institutional frameworks that adequately address coastal and marine resources and environment management. Although financial and human resources have constrained them from operating in their full capacity, yet they complement each other. In the long run they will be allocated sufficient funds to enable them to improve their enforcement operations. Tanzania is still in the process of implementing reforms in its legal sector. Old and outdated laws are repealed and replaced by new ones. The current trend in the enactment of new laws indicates a great likelihood that there will be very strong enforcement machinery.

The major recommendations for the effective application of the ecosystem based approach are:

- There is need for the Tanzanian Government to establish coordination and monitoring institutions in order to enhance its effective governance of its coastal and marine areas.
- There is a need to build the capacity of coastal districts to align well with the central government especially on coastal and marine issues. This could be done through training (Strategic Planning) and awareness raising to district policy makers on the importance of such alignment.

Marine fisheries and Environmental issues are not union issues - each side of the Union is dealing with these issues separately in spite of them occurring in the same geographical setting. Both Mainland and Zanzibar Governments have different policies, laws, regulations and plans that are not harmonized. This situation creates some difficulties and confusion to resource users and management. There is a need to harmonize those policies and laws for effective governance and at the same time reduce unnecessary conflicts that are common every day. Environment,

Marine resource theft at sea, IUU, Dynamite fishing, Piracy, drowning of mariners and oil spill are some of the threats and challenges to Tanzania coastal and marine areas. Most of the responsible institution lack capacity to deal with these challenges. Either, they don't have the right and appropriate equipment, trained personnel or plan to deal with those existing challenges. It is recommended to build institutional and individual capacity of responsible institutions and personnel in order to halt the existing alarming situation.

Incomes obtained from licensing legal businesses related to Mangroves, prawn fishery, deep sea fishery, natural gas, marine transport, etc., to a large extent are all and always directed to the central government with less or non to the local government or community directly. This licensing system makes the local Government become weak in doing its business at local level because it lacks the financial capacity to deal with management issues of those coastal and marine resources. It is important if the distribution of these incomes can be adjusted to enable the local governments to cope with rising management challenges at local level.

There is a need to constantly raise the knowledge and awareness on the importance of coastal and marine system to all stakeholders using different means. Use of several and different media like radio, TV, theatre arts, posters, electronic media etc., are among the recommended means to enhance knowledge and awareness to many stakeholders. As such there is a need to revive the semi-annual retreats and coastal and marine forums to enable the practitioners to share knowledge and experience on coastal and marine issues.

6. PLANNING AND MANAGEMENT

National Disaster Management Plans

Tanzania has experienced both natural and man-made disasters. Drought, floods and earthquakes are just a few examples. Lack of awareness and information among the disaster risk management stakeholders and the general public has been one of the leading factors which contribute to peoples' vulnerability to disasters and destruction of infrastructure. Disasters also affect livelihoods and cause poverty, food insecurity and health problems. Evidence indicates that disasters will occur with greater frequency and intensity in years to come (URT 2009).

One of the leading factors reported to be contributing to peoples' vulnerability to disasters is lack of awareness and information among the disaster risk management stakeholders and the general public (URT, 2002, 2003). Tanzania has an upper organ known as the 'Tanzania Disaster Relief Committee (TANDREC)' that constitutes Permanent Secretaries of Sector Ministries, which convenes whenever necessary and makes decisions to utilize relief funds in responding and giving relief to victims (URT, 2002, 2003). Other policies that address disaster risk management include the National Land Policy (1995), the National Human Settlements Development Policy (2000), and the National Environmental Management Policy (1997). Furthermore, there is a standing legislation referred to as "The Disaster Relief Act No. 9 of 1990". which was enacted in 1990 to oversee and help in the coordination of relief operations at national level. The government also has selected organizations and institutions which are responsible for the early warning system, namely the Tanzania Meteorological Agency, Seismology unit under the Ministry of Energy and Minerals, Emergency Preparedness and Response Unit (EPRU), Plant Protection, Food Security Department and Famine Early Warning System Network (FEWS NET) under Ministry of Agriculture.

Moreover, according to the UN (2009), persistent and emerging disaster risks have highlighted the need to strengthen national structures in Tanzania to minimize these risks, prepare for potential disasters and support the building of sustainable capacities to manage responses in case a disaster strikes. In the spirit of UN reform and the UN Development Assistance Framework, the vision of the UN in Tanzania is closer cooperation of UN agencies in supporting the Government in disaster management. The overall goal of this joint programme, which is part of the One UN Programme, is to enhance national capacity to reduce vulnerability and mitigate disasters. Tanzania has also endorsed Hyogo Framework of Action, and the African Union Regional Disaster Reduction Strategy, which clearly commit countries to address disaster risks in a proactive and participatory way. According to an Interim national progress report on the implementation of the Hyogo Framework for Action (URT, 2002; 2003), the National Operational Guidelines for Disasters (2003) and National Disaster Management policy of 2004 outlines National goals and objectives for hazard risks and emergency management. Furthermore, Mango (2007) explained that the National Land Use Planning Commission has land use plans and squatter upgrading programme which incorporate risk management measures.

i) Issues

Need for effective coordination between agencies responsible for disaster management.
Awareness and communication of government disaster mitigation plans or strategies.
Weak implementation of the disaster mitigation plans
Poor land use planning leading to development in disaster prone areas.
Disaster monitoring networks and early warning system.

ii) Gaps

Lack of flood inundation maps for low lying regions.
Lack of awareness and information among the disaster risk management stakeholders.
Lack of financial support in integrating disaster risk reduction in the land use planning process and other development programmes.
Lack of a monitoring and evaluation system in the implementation of land use plans to get feedback on the impact of land use plans on disaster reduction.
Lack of financial support to research better ways to prepare land use plans that respond to disaster risk reduction and preparedness.

Lack of mainstreaming of the land use planning and disaster management projects by the International Financial Institutions such as World Bank and European Union.
Lack of frequent public awareness programmes on disaster preparedness and response at District and Community levels.
Inadequate capacity in timely response to disasters, lack of early warning system on disasters and contingency plans for DRR.
Lack of good water circulation models for example to show oil spill movement, tsunami/other seismic incidences run-up, storm surges, among others.
Lack of featuring media in all stages of disaster management cycle.

Environmental Sensitivity Mapping

Tanzania`s coast faces threats from the maritime transportation of oil including other chemical substances, and offshore drilling of oil. Tanzania's territorial waters are among the busiest shipping lanes in Africa, but the country has never experienced a serious oil spill incident (Guardian 2008). According to SUMATRA, it is estimated that there are 50 ships in the major shipping lanes off Tanzania's coast at any given time. An average of nine oil tankers with capacities ranging from 50,000 to 250,000 tonnes, sail through the shipping lanes daily (The Citizen 2009).

Tanzania's National Marine Oil Spill Contingency Plan (NMOCP) is currently under review. The Contingency Plan includes oil spill control and cleaning modes, methods of reporting oil spill incidents, establishment of a response headquarters and formation of national and response teams. Moreover, the country is in the process of preparing the National Oil Spill Response Contingency Plan (NOSRCP). In August 2008, stakeholders from the National Environment Management Council (NEMC), Navy (TPDF), Tanzanian Petroleum Development Corporation (TPDC), Energy and Water Utilities Regulatory Authority (EWURA), National Land Use Planning Commission (NLUPC) and representatives of several ministries sat together to discuss this initiative. The co-ordination of this exercise is done by the Surface and Marine Transport Regulatory Authority (SUMATRA).

A Danish consultancy company- Geological Survey of Denmark and Greenland (GEUS), is undertaking a preparatory study for an Environmental Sensitivity Atlas for Tanzanian Coast. The preparatory study, funded under the Study and Consultancy Fund of the bilateral co-operation between the government of Belgium and the government of Tanzania, is the first and most important step towards drawing up the Environmental Atlas. It is expected that this Environmental Atlas will be completed by June 2012. WWF (Tanzania) has also prepared an environmental sensitivity map for the Tanzanian coast (Guardian 2008).

i) Issues

There is need to have sensitivity maps for the entire coastline of Tanzania.
Raising awareness on oil spill and associated impacts on the marine and coastal ecosystems.
Need for improved collaborations between different institutions and organizations involved in disaster management.

ii) Gaps

Prepare the sensitivity atlas through building on WWF sensitivity maps.
Sensitizing the public on issues related to oil spills.
Poor collaborations between different institutions and organizations involved in disaster management.

Coastal Management/Development Plans

A National Integrated Coastal Management (ICM) Strategy was officially launched in April 2003. It is a framework for linking and harmonising different sectors role in the management of coastal resources including decentralisation and harmonisation with existing initiatives and participatory approaches (Rweyemamu 2003). Currently there are no marine fisheries projects in implementation based on the Fisheries Master Plan.

i) Issues
Coordination between agencies involved in coastal planning and development.
Rapid coastal population growth putting additional stress to coastal and marine environment.
Weak capacity for integrated planning and management.
Emerging socio-economic problems due to poor planning of coastal development.

ii) Gaps
Lack of current data on the extent of urban sprawling.
Lack of alternative energy sources to reduce dependency on the exploitation of mangroves.
Lack of or limited access to beaches as a result of coastal development particularly hotels in areas such as Bagamoyo.
Inadequate tourism information centres.

Areas under special management

Marine Protected Areas

Tanzania started its marine conservation initiatives in 1975 by declaring the first Marine Reserves under the Fisheries Act of 1970. Over the years, the country has established several marine protected areas, mostly for biodiversity protection. The exception is Dar es Salaam marine reserves which were created largely for tourism and recreation. The more recent MPAs have been established to conserve marine resources for sustainable use by local communities within and outside the protected areas. Most of the MPAs are focussed on the coral reefs while mangroves and other wetlands are under represented (Saada 2005).

The estimated total coverage of the Marine Protected Areas (MPAs) in Tanzania is currently 1,380 km^2. The Marine Parks and Reserves Act No. 29 of 1994 is the main legal instrument for the establishment of marine protected areas in Tanzania mainland. In Zanzibar, the overall mandate for protected areas lies with the Ministry of Agriculture, Natural Resources, Environment and Co-operatives (MANREC). Two main approaches are used in protected area management: co-management arrangements between local communities and the government (e.g. in Misali Island, Menai Bay and Kiwengwa), and agreements with tourist companies that manage lodges within the MPAs (e.g in Chumbe and Mnemba Islands) (Wells *et al.* 2004).

Marine Managed Areas

Mangrove Forest Reserves

All mangrove forests in Tanzania are gazetted as Forest Reserves under the forestry legislation. Also mangrove areas are classified into four categories according to their quality and use; those designated as "core zones (Zone 1) might technically qualify as protected areas. In other zones, controlled harvesting of poles (selective cutting) is permitted where mangroves are ecologically stable and have sufficient regeneration potential (Saada 2005). In Zanzibar, Forest Resources Management Act of 1996 provides for the gazettement of Forest Reserves (The Revolutionary Government of Zanzibar 2009).

Collaborative Fisheries Management Areas

Collaborative fisheries management areas have been established in Tanga, Muheza, Kilindi, Pangani and Bagamoyo Districts through Tanga Coastal Zone Conservation and Development Programme (TCZCDP) and Tanzania Coastal Management Partnership (TCMP), respectively (Saada, 2005). CFMAs are implemented jointly by local villages and the Districts. The boundaries of these areas are determined by ascertaining the use of the area by a group of villages- they are therefore based on resource use rather than biodiversity characteristics or administrative arrangements. Selected reefs within the six fisheries management areas have been closed by the villages to fishing e.g Maziwe Island marine reserve. The plans for each area are approved at national level by the Fisheries Department and legal backing is provided by village and District by-laws. In Zanzibar, the Environment Act allows for national ICM planning and village level ICM plans co-ordinated by the Department of Environment (cf. Wells *et al.* 2004).

Saadani National Park

There are 14 National Parks that are managed by Tanzania National Parks (TANAPA). However, Saadani

National Park (SANAPA) is the first National Park to include both terrestrial and marine habitats in its area. The terrestrial part of this park was a Game Reserve, and its gazettement has involved the inclusion of an area of marine habitat, extending protection into the sea (Saada 2005).

Rufiji- Mafia - Kilwa Marine RAMSAR Site

The site is located in the three districts of Rufiji, Mafia and Kilwa, within the Coast and Lindi regions of southeast Tanzania. It was designated on 29th October 2004 and it has an area of 596,908 ha (URT 2009). According to the Directory of Wetlands of International Importance, this site is a good representative wetland of East Africa as it contains a large diversity of wetland types, which are ecologically interlinked. This includes the threatened estuarine, coastal and marine wetland habitats (Directory of Wetlands of International Importance 2004).

i) Issues

Poaching activities
Coastal development
Conflict between users
Insufficient education and awareness of the value of managed areas.

ii) Gaps

Lack of CFMA in other areas.
Review of the existing Management Plans and Zoning Schemes, Mangroves and Marine Parks.
Review of the responsibilities of the different government institutions and departments responsible for forests, fisheries, wildlife, agriculture, ports, surveying of land and issuing of titles, and mineral mining in order to avoid conflicts arising between those branches of government regarding management of mangrove areas.

Monitoring, Control and Surveillance

Tanzania's 12 nautical miles of territorial sea and 200 nautical mile EEZ covers 223,000 km^2. The fishing is carried out mainly within the continental shelf which covers a surface area of 30,000 km^2. **Tanzania has formed Deep Sea Authority (DSA) - a corporate body with powers to regulate and control fishing activities in the country's Exclusive Economic Zone (EEZ)**. For the high-seas fishing, mainland Tanzania and Zanzibar are both issuing licenses to foreign fishing vessels. The royalties received from licensed foreign vessels provide foreign currency. However, there is complete lack of control over the operations of these vessels while in offshore waters (Saada 2005).

Monitoring, control and surveillance system is weak and most of the EEZ is uncontrolled and probably regularly fished by mostly unlicensed tuna vessels. The area at present is not fully explored and therefore the stock abundance is not fully known. Tanzania lose billions of US dollars through fish smuggling by foreign fishing vessels in the EEZ due to absence of local observers to monitor fishing activities of the vessels. In Tanzania the reporting of fishing effort is done voluntarily and most data reports underestimates actual catch since some vessels breach license conditions by fishing in restricted areas, such as marine protected areas. Statistics from the Fisheries Department show that although over 171 vessels were registered in 2004. However, none docked in Tanzanian ports.

The Division of Fisheries has the largest share of authority compared to other government institutions over many issues related to coastal marine resources in mainland Tanzania including fisheries and mariculture development and marine park formulation and management. However, according the Fisheries Regulations (Ministry of Natural Resources and Tourism 2005) No. 104 (3) states that "*Every person engaging in fisheries activities including fish processors, traders, gear repairers, and boat builders with the Beach Management Unit (BMU) shall be registered as members of such Beach Management Unit*". It continues in part 4 that the functions of the BMU shall include, but not limited to "*engaging in monitoring, control and surveillance in such a way to reduce the incidence of illegal gears, fishing and fish trading practices within the BMU area*".

Patrols carried out in 2009 under the auspices of SADC that involved South Africa, Mozambique, Tanzania and Kenya managed to seize a commercial trawler, TAWARIQ 1, which was illegally fishing in Tanzania's Exclusive Economic Zone (EEZ) with a haul of 296 tonnes of fish (This Day 2009). In 2004/2005, about 20

illegal fishing vessels were captured in Tanzania's waters in the Indian Ocean (Daily News 2008).

Illegal, unreported and unregulated fishing activities by industrial-sized foreign vessels have traditionally been denying the country significant revenue. Tanzania harvest only 5,000 tonnes of fish annually, which is small compared to the established potential (Tanzania Standards Newspapers 2006).

Government of Tanzania has embarked on a special countrywide operation against use of illegal fishing gears and illegal export of fish products. This includes establishing more patrol and management centres in various districts. Patrols are carried out in collaboration with Marine Police, Navy and judiciary with mobile courts. According to the Minister for Livestock Development and Fisheries (2008), the Tanzania People's Defence Forces (TPDF) is stepping up patrols in the country's Exclusive Economic Zone (EEZ) to curb theft of marine resources (Daily News 2008).

i) Issues

Inadequate capacity to enforce regulations in the EEZ,
High cost of monitoring, control and surveillance.
Capacity for effective MCS.
Low budgetary allocation for MCS for the coastal and marine resources.
Permits are issued for quotas and there is no monitoring of catches by foreign vessels.

ii) Gaps

Insufficient research on issues related to fishing in general including research on the level of awareness among fishermen on hazards of using illegal fishing gears.
Assessment of the achievement of the BMUs based on the functions stipulated in fisheries regulations.
Inadequate information on issues related to community-based monitoring of coastal and marine resources.
Lack of information on the optimum level of effort that produces maximum yield that can be sustainable without affecting the long-term production.
Based on the fishing challenges in the EEZ as explained above, there is insufficient Vessel Monitoring Systems (VMS).
Lack of regular patrols -Lack of enough patrol boats and planes.
Lack of necessary inputs to fisheries experts to enable them to collect data, process, store and above all be able to timely disseminate the information to consumers.
Lack of accessible fisheries resource data bases.

Cost-Benefit Analysis

Fisheries

The number of fishermen who are permanently employed in artisanal fisheries is approximately 36,297 and many others obtain their livelihood from the sector by being employed in the fishing and fishery related activities. The artisanal fishermen produce about 95% of the total fish catch in the country; only 10% is derived from industrial fishing. The sector makes up 9.9% of fish export worth an estimated US$12.4 Million per annum. While its contribution to GDP may appear marginal, (1.6 to 3.1%), the sector is a vital source of food security, employment and income for coastal communities, which subsequently stabilizes the five coastal regions which, when including all sectors, make up 32% of Tanzania's GDP. The fisheries in the marine waters of Tanzania are highly. Various studies suggest that artisanal fisheries along the coast are valued at more than US$ 23 million per annum. This includes the kind of employment it generates, both direct and indirect, fishing, intertidal collecting and beach netting. Artisanal fishing for octopus is a highly important economic and subsistence activity for local coastal communities and is extensively practiced in Tanzania (Guard & Mgaya, 2002; Guard, 2003; Humber et al., 2006). Women participate more in the octopus fishery and they commonly capture octopus without gear. In 2007 the production of catch totalled to 57,045kg with the annual catch value of US$1.2million.

Commercial fisheries in Tanzania include fish fillets, prawns, lobsters, crabs, seashells, beche-der-mer, octopus, sardines, shrimp, fish maws, squids and aquarium fish. The total marine fisheries export value was about USD7,652,700 from Tanzania mainland (Jiddawi, 1999b). Apart from that, about USD0.5 million were obtained in 2001 in government benefits from revenues from licenses and loyalties. The industrial fisheries of Tanzania account for about 5 percent of total marine catches. The industry comprises of three vessels that trawl for shrimp and seining for sardine within economical exclusive zone. Shrimp production from the industrial fishing ranges between 1 000 tons to 1 500 tons per annum. The fisheries are believed to have a total landed value of USD 7million per annum. The number of foreign vessels licensed to operate in the EEZ (Mainland and Zanzibar) has increased from less than ten in 1998 to more than 170 in 2004 corresponding to revenue of USD 3.3 million. 99 percent of the decentralized revenue collection comes from fish levy, with 34 percent originating from marine fisheries and 66 percent from freshwater fisheries.

The total revenue collected by the fisheries sector was close to Tsh.7 billion in 2002/2003 and close to Tsh.9.7 billion in 2003/04. Marine Fisheries in Tanzania are dealt with separately by the Fisheries Departments of Mainland Tanzania and Zanzibar. Therefore, marine fisheries can in principle be divided into two Territorial Seas and two Exclusive Zones: The EEZ is emerging as an important revenue source for Tanzania and the sector itself. Table 17 below shows various marine Fisheries resources and their estimated value for Tanzania Mainland.

Table 17: Marine Fisheries Resources and their value (Base year 2000)

Fisheries	Type	Total Value in US$	Export value in USD	Remarks
Prawn	Industrial Artisanal	Estimated at 7million per year	5-6 million annually	13-21 trawlers all Tanzania flag. Closed season March-Nov
Artisanal	Artisanal reef and inshore, crustaceans	Estimated at 23.5 million per year	5.5 million	Up to 13,000 traditional fishing vessels
EEZ/Off-shore	Industrial –large pelagic	Unknown	1.9 million	Boats from far East and the EU. Most do not land in Tanzania and records are incomplete.

(Source: Fisheries Department)

There is scant information on the Exclusive Economic Zone (EEZ) Fisheries in the Tanzanian territorial seas. Of the approximately 25 industrial boats fishing in the EEZ at any given season, only four land in Tanzania (Dar es Salaam).The fishing states supply only limited information on the fish removal from EEZ and their value. Although the Fisheries Department (FD) closely monitors these registered vessels, they only represent about one sixth of the entire fishing effort. It could be surmised from the figures that are available from the FD that the potential value of the fishery is about USD 12 million per annum but this is not substantiated by scientific research.

Table 18: Estimated catches and Values from EEZ

	Estimated Catch (Tonnes)	Estimated Value of Catch (USD)
Longliner		
Total Fleet	900-18,000 tons out of which 4,500-8,800 tons tuna and billfish	47.6-254.6 Million
Per vessel per year	70 tons tuna and billfish and 150 tons of other species	0.39-2.06 Million
Total Fleet	26,000-32,800 ton of tuna	27.6-85.6 Million
Per vessel per year	900-1,000 ton	0.67-2.09 Million

Source: Chopin, 2005) Based on average annual price for tuna for the **Sashimi** *Market and canning*

The greatest potential for increasing government revenue from fishery is in the licensing of vessels to fish in the EEZ. The FD started issuing licenses to foreign vessels in 1998, mainly to European tuna seiners and Asian long liners. The license period ranges from a month to one year. The cost of a license depends on its duration, but the following general rules apply:

- The annual license fee is set at USD 18,000-30,000;
- The registration fee is set at USD 2,000;
- A license can be issued for a period of 1 month, 3 months, 6 months or one year; and
- Where the license period is less than one year, the license fee is pro-rated but the registration fee remains fixed at USD 2,000.

Since licenses were introduced in 1998 the numbers of foreign vessels fishing Tuna and Tuna like big pelagics has risen rapidly. In 2004 the total number of registered vessels was 171 of which 41 were tuna seiners and 123 longliners. The mainland issued 85 licenses and Zanzibar 86 (mainly to longliners from the Far East). Increased control and compliance in 2004 have increased the number of licenses and reduced illegal fleets. In 2004 the total revenue from license fees that accrued to the Tanzanian FD was USD 3.3 million (171 licenses @ USD18,000). This is not even reflecting the total amount that the government could earn. Expert's estimate that the real catch is most likely much higher than what has been assumed as a basis to set the license fees (between 200 and over 400 tons a day per boat). Notably, there is no catch based license or fee, and the vessels are allowed unlimited catch once they are in possession of a valid license. In addition, the Government earned USD 300,000 in license fees from Tanzanian Flag Prawn Trawlers (there are 25 with a license fee of 16,000 US$).

Table 19: Contribution of fish to household subsistence in coastal areas

Activity		Percentage of Households engaged in activity (Total Sample size 749)
Marine Fauna	Fish	47.4
	Crustaceans	15.6
	Sea cucumbers	4.3
	Mollusks	2.4
Seaweed Farming		25.9
Farming –Various crops	Cassava	50.1
	Bananas	32.7
	Rice	27.5
Farming-Agroforestry	Coconuts	14.7
Livestock keeping	Poultry	12

Source: Ruitenbeek et al (2005)

While commercial fisheries, in particular in the EEZ, represent potential for economic growth, the impact on poverty reduction depends crucially on how the license revenue earned by the Government is translated into benefits for local people. The effect of Fisheries Agreements on poverty reduction will depend on the creation of economic 'spin-offs' and associated development activities. These are expected to be negligible as no fish is expected to be landed ashore and few supplies will be sourced from the country. This study could not establish the actual financial benefits which could be earned by the country if transhipment was done in the country, but it is obvious that this is a substantial amount. Tables 20 and 29 summarize some details of the gross rent earned form the tuna seiners and longliners

Table 20. Estimation of Gross resource Rent for Tuna Seiners

Gear type	Tuna seiner				
Fleet catch (t)	8,000	16,000	24,000	36,000	48,000
No. Vessels buying licenses	39	39	39	39	39
No. vessels fishing in the EEZ	39	39	39	39	39
Days spent in the EEZ	25	25	25	50	50
Nominal fishing effort	975	975	975	1950	1950
Vessel Catch per day (t)	8.2	16.4	24.6	18.5	24.6
License fee (USD/t/yr)	17,550	17,550	17,550	17,550	17,550
Registration fees (USD)	1,950	1,950	1,950	1,950	1,950
Compensation	0	0	0	0	0
License fee paid (USD)	760.500	760,500	760,500	760,500	760,500
Gross Fee per one (USD/t)	95,063	47,531	31,688	21,125	15,844
Revenue from Seining @ 910 (USD/t)	7,280,000	14,560,000	2,184,000	3,315,000	43,680,000
Revenue from seining @1040 (USD/t)	8,320,000	16,640,000	24,960,000	37,440,000	49,920,000
Revenue from seining @1,170 (US$/t)	9,360,000	18,720,000	28,080,000	42,120,000	56,160,000
license as % of value @ 1,040 (USD/t)	9.1%	4.6%	3.0%	2.0%	1.5%

(Source: Chopin, 2005)

As shown in Table 20 above, the gross resources rent ranges from 9.1 percent for 8,000 tons catch to 1.5 percent for 48,000 tons catch. The 5 percent gross resource rent is reached when the catch is limited to 14,300 tons. It can also be reached by increasing the license fee to US$ 42,000 and allowing a total catch of 28,000 tons.

Table 21. Estimate of Gross Resources Rent for Longliners

Fleet catch	9225	18,450
No. vessels buying licenses	123	123
Days spent in the EEZ	50	100
Nominal fishing effort	6150	12,300
Vessel catch per day ton (tunas)	0.5	0.5
Vessel Catch per day ton (Others)	1.0	1.0
License fee (USD/tonne)	0	0
License fee (USD)	1,775	1,775
Registration fees (USD)	195	195
Compensation	0	0
License fee paid	2,878,200	2,878,200
Gross Fee per tonne (USD/tonne)	312	156
Revenue from fishing (@ 9,750 USD/t)	89,943,750	179,887,500
Revenue from Seining (@ 11,050 USD/t)	101,936,250	203,872,500
Revenue from seining @ 12,090 USD/t)	111,530,250	223,060,500
License as % of value (@ 9.750 USD/t)	2.8%	1.4%

Source: Chopin, 2005

To reach a 5 percent gross resource rent, the catch would either have to be limited to 4000 tons or the license fee increased to USD 42,000 allowing a total catch of 9000 tons.

Coastal Agriculture and Forestry

Mangrove forests in Tanzania occupy about 225,000 ha which is about 0.3% of the forest cover in the country (Mariki, 2000). Of these, the Rufiji Delta, located about 150 km south of Dar es Salaam, contains the largest continuous block of mangrove forest in East Africa, comprising some 53,000 hectares. This delta also supports the most important fishery in Tanzania's coastline, accounting for about 80% of all shrimp catches in the country. The Delta is home to about 41,000 people, many of whom are small farmers and traditional fishers. Up to the mid 1990s, exploitation of mangroves for poles (for construction) and bark (for tannin extraction) for export was common in the region (Mainoya, et al., 1995). Significant income in foreign exchange encouraged the exploitation of mangroves. For instance in 1979 Tanzania earned 4 million Shillings in foreign exchange after selling 30,000 scores of mangrove poles (Havnevik, 1980 in Mainoya, et al., 1995). A more recent study on mangrove exploitation in the Rufiji Delta has revealed uncontrolled harvesting of mangroves logs and poles that are cut for commercial and domestic use within and outside the areas. This is vivid at the following places: Kikale, Konde, Chaka Nganuni A & B, Kifuruni and Mnyali areas (TCMP/STWG, 2003).

Coastal Agriculture

Agriculture and forestry is the country's leading sector, employing 82% of the population, contributing 45% of GDP and 60% of total export earnings. The sector employs three million people, with forestry alone accounting for 4% of GDP, making up 10% of foreign exchange earnings equal to 14 million USD annually. Subsistence farming is, however, the most dominant form of income generation in the coastal zone, thus, any increases in unemployment are expected to place further strain on the region's natural resources. Fuelwood also accounts for more than 92% of the country's energy use, also placing extensive strain on the country's coastal forests.

Coastal Forestry

In addition to the high biodiversity values of the coastal forests, they are also important because of their many and varied uses to people. Coastal forests are used as a source of medicinal plants, fuel wood, building materials, food and they help to maintain a regular water supply for towns and villages. They play an important role in reducing soil erosion, maintaining ecological cycles and micro-climates and carbon sequestration. Several studies have attempted to put a monetary value on carbon sequestration services of the forests. The findings show that the value of avoiding the carbon fluxes associated with changing land use range from USD650 to USD3400 per ton (equivalent to USD20 to USD100 per ha per year), depending on the forest type and the subsequent land use (Brown and Lugo, 1992; Fearnside et al., 1993). For the purpose of this study, we adopt the conservative estimates by taking the average values, which will imply USD60 per ha per year. Hence with a

total area of 617,562 ha of coastal forest, this will translate into USD 37,053,714 per annum as the economic and social value of the coastal ecosystem in terms of avoiding carbon fluxes associated with changes in land use. This figure is arrived by taking into account commercial products such as timber, beeswax, honey, fuelwood, poles, charcoal, wattle-bark, wild fruits etc.

Existence value derives from the knowledge of a resource's continued existence, independent of any use. There are several plausible underlying motivations for existence value which have been widely covered in social science literature (e.g. Randall and Stoll, 1983). From the methodological standpoint, measurement of existence value is perhaps the least tractable and most contentious aspect of natural resource valuation. The available developed country evidence (summarized in Pearce, 1993), suggests that non users have typically indicated values in the range US$1.2 - 64 per annum per person for wild species, while per annum WTP for scenic and wilderness areas range between USD9 and USD107. To estimate this value for forests in our study area, we used data from a synthesis of global economic values of forest ecosystems. This synthesis indicates considerable variability in estimates of existence value for various forest regions, which is associated with differences in both methodology and attributes of the forests that were valued. We chose to be conservative and therefore selected a value of USD5/ha per annum for household WTP for the existence of forests in the area, a value based on debt-for-nature swaps for all tropical forests. We assume that the forests in our region are representative of tropical forests in general, and that they would qualify for additionality based on rapid conversion rates outside protected areas. On the basis of this evidence, indicative per hectare values would appear to be in the range (0.03 - 10.4 USD ha^{-1}). Multiplying the upper bound of that range over the extent Coastal forests (approximately 617,562 hectares) provides a conservative estimate of USD 6,422,643.

Value of critical ecosystems

Coastal mangrove forests cover a total area of about 115,500 ha. It is estimated that over 150,000 people in Tanzania earn their living directly from mangrove resources. Mangrove exploitation for poles for construction and bark (for tannin extraction), both for export, was common in Tanzania up to the mid-1990s (UNEP/ Nairobi Convention 2008).

Coastal communities use mangroves to supply local needs for fuelwood, charcoal making, fences, house construction, boat building, fish traps, fish stakes and for medicines. Overall, it is estimated that over 150,000 people make their living directly from mangrove resources in Tanzania (Saada 2005). Commercial fisheries of crabs, prawn and fish are directly dependent on the mangrove ecosystems thus the two main prawn fishing grounds are areas adjacent to the Rufiji Delta and Bagamoyo. Likewise the fishing for crab is an important activity in the Pangani river mangroves. The potential catch of the large mangrove crab (*Scylla serrata*) was estimated to be 5 – 10 tonnes wet wt/month in Pangani and in 1989 the price of the crab was TShs. 75/Kg (Semesi and Mzava 1991). Today the price of the crab is ranges from TShs 2500-6000/kg. The direct value of the mangrove habitat which includes values for the fuelwood, timber and poles and wood products, the animals and birds and the honey it provides was estimated to be US$ 0.9 million per year (Turpie 2000).

Coral reefs support one of the most productive and diverse marine ecosystems in Tanzania waters and, with their associated habitats support a variety of marine species. It is estimated that 95% of artisanal fishing, which employs over 50,000 full time fishermen, is carried out on coral reefs and that they support over 70% of the artisanal fish production in Tanzania (Saada 2005). It is estimated that a sustainable yield harvest of 15 tons of fish can be obtained per km^2 of coralline areas in depth of less than 30 m (Munro and Williams 1985). Thus with 3,580 km^2 it would suggest that about 340 tons are harvested annual from the coral reefs. With approximately USD 1000 per tons this will translate into USD 340,000 per annum.

Tourism

Tourism in Tanzania plays a vital role in the country's economic development. It is one of the major sources of foreign exchange. The sector accounts for 17.2% of the GDP and nearly 25% of total export earnings. It directly supports an estimated 288,700 jobs (TTB, 2008). Foreign exchange receipts from tourism grew from USD259.44 million in 1995 to USD,269.68 million in 2008. Tourist arrivals have shown a steady increase from 295,312 in 1995 to 770,376 in 2008 (MNRT, 2008). USA, UK, Italy, Canada, Australia, Netherlands, Sweden, France, South Africa, India and China, remain the major tourist source markets for Tanzania.

At a macro level tourism has been consistently contributing to employment and GDP and hence positively affecting the macroeconomic conditions of the country. The GDP contribution averaged an impressive 15 percent a year from an average growth of international tourism arrivals of 6.8 percent during this period. At the same period for every 1 percent increase in tourist arrivals the GDP grew by an average of 2.2 percent (Scott, 2009). At the micro level the importance of tourism to the Tanzanian tourism industry is reflected within various planning and policy documents. The Rural Development Strategy identifies tourism as a key tool in rural poverty alleviation, advocating that "the rural economy is linked to the new engines of economic growth, particularly tourism," in order to stimulate "pro-poor growth".

List of standard accommodation facilities are presented in the Table 22 below. In addition to these clusters of hotels and guesthouses in urban areas, a number of smaller hotels and guesthouses are scattered along the coast, primarily in and around Pangani, Kilwa and on Mafia Island. Local guesthouses are scattered throughout the rest of the coast, including Muheza, Mkuranga, Rufiji and Lindi. At Lindi one luxury beach hotel is operational.

Table 22 Distribution of Coastal Accommodation Facilities

Region	Number of Rooms		Number of Beds		Number of Staff		No. of Establishments	
	2006	2009	2006	2009	2006	2009	2006	2009
Dar es Salaam	4,412	6,123	5,873	9,230	3,852	5,282	107	170
Coast	568	1,341	866	1,446	687	970	18	40
Tanga	449		730		300		39	39
TOTAL	5,429	7,464	7,469	10,676	4,839	6,252	164	249

Ports and Harbours

Port activity in Tanzania is one of the country's economic strongholds, command significant amounts of bulk cargo for the country and its neighbours. The country's ports also offer sizeable employment opportunities. Tanzania has four major harbours, namely Dar es Salaam, Mtwara, Tanga and Zanzibar. The mainland ports are under the Tanzania Harbours Authority (THA). THA had 3163 permanent employees in 2003, a reduction from the 9349 employees in 2002. Despite the yearly reduction of staff, the activities of the port and harbour are still a dependable source of employment for local populations since they offer casual labour opportunities and subsidiary jobs such as food vending during periods of peak activities. The intake of casual labourers ranges from 20 to 250 people a day earning an income of TShs 2500 a day and 5000 on weekends (on average USD 2.5 - 5). Currently the port has 8 deep-water berths for general cargo, 3 berths for container vessels, eight anchorages, a grain terminal, an oil jetty and offshore mooring for super tankers.

Coastal Mining

Tanzania has a large and growing mining industry exporting US$ 995,000,000 worth of minerals in 2008. In 2007 the mining sector contributed 3.7% of the gross domestic product. This contribution has been attributed to both large scale mining operations as well as medium- and small–scale mining activities. However, medium- and small scale mining has been an important contributor to local economies, providing a means where large numbers of people can complement income derived from other primary activities, such as subsistence or seasonal agriculture.

Tanzania is Africa's third largest gold producer exporting gold valued at US$ 932,000,000 in 2008. The Williamson diamond mine in Tanzania produced 134,000 carats of diamonds in 2008. Tanzania is also the world's sole source of the gemstone tanzanite and is a producer of other precious stones, notably sapphire and garnet. The sector contributes nearly 4% to GDP and formally employs 8,000 people. The sector also makes up an extensive 42.9% of total foreign exchange earnings. An estimated 500,000 artisanal miners are also active in the mining sector. The majority of precious metal mining takes place inland. However, the coastal zone does have mining operations focused on cement, coral and lime, with both lime and cement being produced for export throughout East Africa.

Tanzania has a substantial cement industry producing 1.76 Million tonnes of cement in 2008. Expansion of

the cement industry since 2008 has Tanzania producing over 3Mta in 2010 with new plants coming on line in 2011.

Coastal Resources and Poverty Alleviation

Fisheries dependent communities have been mentioned to be economically better off than purely agricultural dependent livelihood earners as earlier discussed (DFID undated). Yet determination of profit margins for fishers and related activities requires complex analysis involving many variables and assumptions. This is complicated by the different gear types used, the use or non-use of boats, whether or not boats used are motorised. Whereas men go out to fish in boats, women mostly glean the intertidal areas for gastropods, bivalves and sea cucumbers (Jiddawi 2000). There is no periodic survey programme for fisheries households and therefore no official information on fishers' income other than data collected in the preparation of the Fisheries Master Plan Project. Survey outcome showed that the income of fishers is approximately US $ 1 per day, which exceeds the national average, with incomes of Tshs 120,000/= per month for a boat owner with a circle net in the marine waters. This is categorised as one of the highest income generating groups engaged in fishing activities (Tables 23 & 24). There is a distinct difference in income between boats with and without engines, though both practice the same fishing methods. Obviously fishers without boats earn little, basically for home or subsistence consumption.

Table 23: Macro Economic Index for Fisheries Sector

	1996	1997	1998	1999	2000
Fisheries GDP (USD 1,000)	-	165,232	189,787	211,704	
Fisheries GDP/Total GDP (%)	-	3.0	2.9	2.9	
Employment (full-time fishers	75,621	-	-	78,682	
Fisheries Exports (Million USD	61.8	70.1	72.5	61.8	75.6
Fish Export/Total Exports (%)			12.3	11.4	11.4

Source: Tanzania Fisheries Master Plan 2002

Table 24: Comparison in monthly Incomes and Profits per sales among different fishing methods for Marine Fishers

Fishing method	Night purse seine with engine	Circle net with engine	Gill net without engine
Income for crew (Tshs)	46,940	21,250	28,250
Income for a boat owner (Tshs)	120,483	191,389	39,750
Profit per sale (%)	5.2	18.2	18.9

Source: MNRT/JICA 2002

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LAND-BASED ACTIVITIES	RESPONSIBLE DEPARTMENT (SECTOR)	PROBLEM											
		Siltation	Modification of streambeds	Coastal erosion	Destruction of dunes & sandy shores	Destruction of coastal habitat	Microbial contamination	Eutrophication	High Suspended solids	Marine litter	Thermal pollution	Toxic chemical pollution	Alteration of salinity distribution and nutrient supply
Climate change	Environment Affairs	●		●	●	●			●				●
Coastal infrastructure development (Includes transport and recreational activities)	Environment Affairs Housing Municipalities Department of Local and Provincial Government	●	●	●	●	●	●		●				●
Mining	Minerals and Energy Environmental Affairs	●	●	●	●	●			●			●	●
Freshwater abstraction and flow modification	Water Affairs	●	●	●	●	●			●				●
Municipal wastewater (Sewage and septic tank seepage)	Water Affairs Environmental Affairs Municipalities Industries		●				●	●	●	●		●	●
Industrial wastewater*							●	●	●		●	●	●
Urban storm water (Includes runoff from informal settlements)	Water Affairs Environmental Affairs Municipalities Housing						●	●	●	●		●	
Agricultural practices	Agriculture	●					●	●	●			●	●
Port and harbour operations	Transnet: NPA	●	●	●	●	●	●	●	●	●		●	●
Off-road Vehicles	Environmental Affairs			●	●	●							
Solid waste disposal (and littering)	Environmental Affairs Municipalities									●		●	
Atmospheric deposition	Environmental Affairs Municipalities							●				●	
Introduction of alien vegetation	Environment Affairs Conservation Boards					●							
Harvesting of living resources**	Environmental Affairs					●							
Aquaculture**	Environmental Affairs Water Affairs Department of Aquaculture				●	●	●	●	●			●	

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