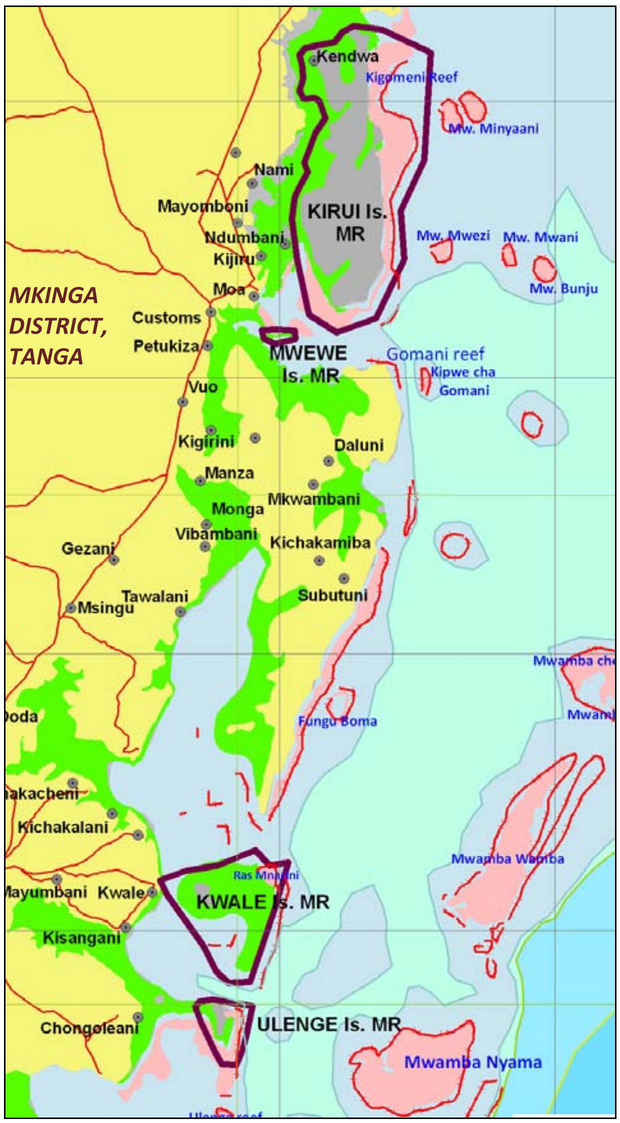
BIOPHYSICAL FEATURES IN THE NORTHERN TANGA MARINE RESERVES, TANZANIA



Christopher A. Muhando

December 2011

BIOPHYSICAL SURVEY IN THE NEWLY GAZETTED MARINE RESERVES OF TANGA

Christopher Adriano Muhando

Prepared for
Marine Parks and Reserves Unit, Dar es Salaam, Tanzania

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EXECUTIVE SUMMARY

MPAs are essential tools for conservation of marine habitats and resources. Currently, there are three Marine Parks and fifteen Marine Reserves in Tanzania. Kwale, Mwewe, Kirui and Ulenge Islands Marine Reserves, here called the Tanga Marine Reserve sytem (TMRs) are the four most recent marine reserves gazetted in June 2010. They are located between Tanga Bay and the border with Kenya. These new MPAs do not have a General Management Plan (GMP), which is usually preceded by biophysical and socio-economic status reports. The main objective of this assignment was to prepare a biophysical status report that will assist the preparation of GMP for the TMRs.

In this report the boundaries of the TMRs are mapped. The physical characteristics and the climate around the TMRs (air temperature, precipitation, sea surface temperature) as well as the oceanography are explained. Biophysical environment including mangroves, coral reefs, seagrass beds and intertidal features in the TMRs is described. Coral cover and species richness as well as seagrass and mangrove species found in the TMRs are described. Commercial fish and invertebrate species or groups landed by artisanal fishers around the TMRs are also provided. Muddy, rocky, sandy and mixed shores present in the TMRs intertidal zones were mapped. Bathymetry around the TMRs was mapped and its implications explained.

All the TMRs had human settlement in the past. Mangrove is the main feature in the intertidal zones of all TMRs. In Ulenge, mangrove covers an area of 72.2 Hectares, about 64 % of the Island area. It covers an area of about 528.1 Ha, or 86.2 % of Kwale the Island. Mwewe Island is also surrounded by mangroves, which covers an area of 14 Ha, which is about 68 % of the Island. The total area covered by mangrove in Kirui is estimated to be 680 Ha; the largest mangrove plot (557 Ha) is found on the north and west sides; Kigomeni mangrove (60 Ha) is on the east coast and Kirui south mangrove (63 Ha) is on the south of the Island. All the mangrove species found in Tanzania were noticed in the TMRs. *Sonneratia alba* was the dominant tree seawards and *Rhizophora mucronata* dominated on wave protected areas. The mangrove trees are heavily utilized for firewood, charcoal, timber and poles and showed signs of overexploitation and deterioration. Island mangroves showed signs of stagnation; low growth and replenishment rates, probably because of low rates (thin layer) of sediment deposition. Fortunately, there are no salt pans within the TMRs.

All TMRs are associated with Bays: e.g., Tanga Bay and Kwale Bay for Ulenge MR; Kwale Bay and Manza Bay for Kwale MR. Mwewe is located within Moa Bay. Kirui MR is just north of Moa Bay. Thus the use and/or conservation actions on the Islands will inevitably be linked to the associated Bays**.** Seagrass beds were the main feature in the Bays and shallow waters adjacent to the TMRs. Health conditions of sea grasses in the Bays appears to be frequently modified by turbidity, sediment and freshwater input from Rivers. More and abundant seagrass beds are found in Moa Bay and eastward of Kirui Island. Manza Bay has more seagrass communities than Kwale Bay, where seagrass growth is negatively influenced by sediment mobility and resuspension.

Coral growth in the Bays is very restricted, mainly because of sedimentation, freshwater input and unsuitable substrate for coral settlement. Very few and scattered coral reef patches were found in Kwale and Manza Bays. In Moa Bay, coral patches were found in the deeper part of the Bay. Continuous coral reefs occurred on the seawards of Ulenge, Kwale and Kirui Islands. Highest average coral cover and species richness was found in Kirui (26.7±28 %, 37 coral genera) followed by Kwale (10±9.5 %, 29 coral genera). Coral cover and species richness was poorest in Ulenge reefs (5±7 %, 16 coral genera).

Visual fish census conducted during this study showed relatively more fish stocks on reefs on the eastern side of Kirui Island, followed by Kwale reefs and Ulenge reefs had the lowest density of fish. Correspondingly, catch per unit effort were better in Jasini and Moa than those around Kwale and Ulenge Islands. Interviews on catch per unit effort trends seem to indicate overfishing of demersal (seagrass and coral reef) stocks and no significant change in catch rates of pelagic stocks, such as dagaa and mackerels. The main threats to fish stocks are coming from the continuing destruction of habitats due to continued use of dynamite and dragnets (beach seine and similar nets) and overfishing of keystone species due to increasing population (demand) of fishers and collectors (free entry) inside and adjacent to TMRs. It was clear during this study that most of the fishing takes place outside the Bays on coral reefs - seagrass beds and/or adjacent deep waters. Fish aggregations occurred where there is a combination or interactions between mangrove, coral reefs and seagrass beds. Edible invertebrates found in the TMRs include mangrove crabs, prawns, octopus, lobsters, clams, sea cucumbers, and shelled molluscs.

A small population of dugong is believed to exist at Mbayae-Kigomeni area, just east of Kirui Island and south of Kenya border, where it was sighted in 1994 and 2004. Coelacanth (*Latimeria chalumnae*) are found and often caught in deep water in and around Tanga Coelacanth Marine Park, which is less than 10 km from Ulenge Island Marine Reserve. The shallow water area extending from south Kenya coast including eastwards of Kirui Island and Moa Bay could be considered as a special habitat. This zone has a complex combination of mangrove influences, extensive seagrass beds and coral reefs, creating good conditions for fish productivity. Besides being important fishing area for Kenya and Tanzania fishers, it is in this zone where dugongs are believed to exist.

There are no sandy beaches suitable for tourism purposes, and there are no reports of turtles nesting sites in the TMRs. However, all TMRs constitute important bird roosting sites. Nature trails and bird watching posts could be created as tourist attractions.

Previous management efforts in and around the TMRs exist. Collaborative Management Area and Mangrove Collaborative Management Plans were developed and implemented during the Tanga Coastal Zone Conservation and Development Pregram (TCZCDP). Village Environmental Management Committees were established and are still active. Thus, the TMRs management plan could take advantage and/or learn from the TCZCDP past experiences and also from the Tanga Coelacanth Marine Park GMP and strategies therein.

The following is a summary of key issues with significant influence on the biophysical environment in the TMRs and actions required:

- Long rooted tradition/customs of the use of the Islands and its resources need to be well considered. Provision of suitable alternative activities and initiation of people-based support to local livelihoods. Local participation must be encouraged by all means.
- Closure of mangrove utilization as well as restrictions on coral reefs in the TMRs will increase pressure on the remaining mangrove forests or coral reef sites. Revisions of the existing mangrove and coral reef use plans and legislation enforcement mechanisms may be inevitable.
- Poor enforcement of general fisheries regulations (legislation) with regard to mangroves and coral reefs is an issue that requires attention. Compliance of regulations in the TMRs will be compromised or undermined by lack of strict enforcement in adjacent areas.
- Continued dwindling of fish stocks while fishing effort is increasing (free entry analysis) should be avoided in the TMRs and adjacent areas.
- Inventory of resource bases (including Island vegetation) in the TMRs and adjacent area is needed and efforts are required to identify (a suite of) socio-ecological sustainability indicators to gauge and monitor exploitation and/or threshold levels over which extinction or stock collapse occurs.
- Management of TMRs may also involve providing advices with regard to agricultural practices as well to minimize impacts from land based pollution.
- Wherever coral reef, sea grass beds and mangroves occur adjacent to each other, biological linkages and ecological dependence usually occurs. Thus, management of the coastal areas should take into consideration management of all key habitats, i.e. Island vegetations, intertidal areas, sea grass beds, mangroves, coral reefs and other physical condition along the TMRs coastline.
- Though complicated during implementation phase, integrated approach that harmonizes social, economical and ecological issues and activities should be adopted rather than the existing sectoral based approaches. In other words, strict Integrated Coastal Area Management and/or Marine Spatial Planning principles should be applied in the TMRs.

1. INTRODUCTION

The Tanzania coastal environment and its resources are extremely important and the ongoing widespread degradation threatens the existence of communities along the coast zone. The need and the will for sustainable utilization of coastal habitats and resources, including sustainable harvesting levels, protection, enhancement, rehabilitation and restoration is high at all levels. All coastal zone stakeholders; government, NGOs, development partners and local communities are involved (TCMP, 2002; Wells, et al., 2007). This is a good sign; wherever there is a will there is a way.

Integrated coastal area management (ICAM) is one of the approaches towards sustainable uses of coastal environment and its resources. ICAM is a dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones. It covers the full cycle of information collection, planning (in its broadest sense), decision making, management and monitoring of implementation. ICAM uses the informed participation and cooperation of all stakeholders to assess the societal goals in a given coastal area, and to take actions towards meeting these objectives. 'Integrated' in ICAM refers to the integration of objectives, instruments needed to meet these objectives, relevant policy areas, sectors, and levels of administration. It means integration of the terrestrial and marine components of the target territory, in both time and space. ICAM seeks, over the long-term, to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics. While principles of ICAM are sound, discussion remains whether its goals have been achieved so far in Tanzania.

Another new but similar approach is called Marine Spatial Planning (MSP). MSP is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas (in form of GIS maps) to achieve ecological, economic, and social objectives that are usually specified through a political process (Ehler and Douvere, 2009). It is a practical way to create and establish a more rational organization of the use of marine space and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems, and to achieve social and economic objectives in an open and planned way. Spatial planning is based on understanding of both characteristics of the issues and their spatial dimensions. Both ICAM and MSP have some features in common; they take into consideration different sector activities/issues, identify relations/interactions, isolate processes acting synergistically or antagonistically, integrate natural, social, economic and GIS sciences and actually use various decision making tools (e.g. group/technical discussion, ground truthing protocols, spatial analytical and visualization tools (GIS/maps) as well as predictive models.

Marine parks and reserves are in practice multi-use controlled zones and in essence they make use of ICAM principles within their boundaries and sometimes beyond. Marine parks and reserves are managed by Marine Parks and Reserves Unit (MPRU), a specialized institution within the Fisheries Division. ICAM principles are also applied in community conservation/collaborative areas, community no-take zones and Government-Community co-managed areas, broadly categorized as Marine Managed Areas (MMAs). MMAs are normally declared at local level by responsible District Councils or other Local authorities, and legally recognized at national level. The key advantage of ICAM processes in Tanzania is the increased education and awareness on coastal issues and local participation. The main problem is inadequate enforcement mechanisms, including inadequate financial, technical and committed personnel to overseen the implementation of actions.

Marine protected areas (MPAs) and marine managed areas (MMAs) are essential tools to conserve the biodiversity of the oceans, and to maintain biological productivity, especially of fish stocks. MPAs and MMAs also offer opportunities for creation of institutional frameworks for the management of marine resources in response to increasing human pressure. The establishment of MPAs is one of the techniques for marine conservation that is applied in a defined area and, normally integrates many approaches/mechanisms, including but not limited to biodiversity protection, fisheries management, integrated coastal management, land use planning and adherence to international conventions (MPRU, 2011).

In Tanzania Mainland, MPAs are managed by Marine Parks and Reserves Unit (MPRU). The Unit was established under the Marine Parks and Reserves Act No. 29 of 1994 specifically to oversee and promote the implementation of the Act. The principal role and function of MPRU is to facilitate the establishment and management of all MPAs gazetted under the Act No. 29 of 1994 in the mainland Tanzania. Currently, there are three (3) Marine Parks and fifteen (15) Marine Reserves established and gazetted under this institutional framework. Kwale, Mwewe, Kirui and Ulenge Islands, located between Tanga and the border with Kenya, are the four most recent marine reserves gazetted in June 2010. In this report they are referred to as Tanga Marine Reserves (TMRs). These newly gazetted reserves have not previously intensively studied. Undertaking of biophysical survey in Tanga Marine Reserve systems (TMRs) was deemed necessary in order to get important inputs for development of the General Management Plan (GMP) for these reserves. The GMP is a document that addresses common needs and aspirations of various stakeholders in a particular reserve, and the means for achieving those aspirations and needs.

In Tanga, practice of ICAM principles has a long history. The first MPA in Tanga was the Maziwe Island Marine Reserve, declared in 1975 (Muhando and Francis, 2000). Due to various reasons, the General Management Plan for this reserve is still under preparation. The Tanga Coastal Zone Conservation and Development program (TCZCDP), initiated in July 1994 and continued through to June 2007, provided basic understanding and practice of ICAM principles in Tanga coastal districts (Wells et al., 2007), including Maziwe Island Marine Reserve. Community based Collaborative Management Plans (CMPs) were established. Furthermore a database of mangrove and coral reef resources was developed, as a tool for storing, analyzing, and disseminating various coastal data and information to users. Again due to various reasons including completion of TCZCDP in 2007, implementation CMPs ceased and ICAM practices slowed. Lessons learned from the TCZCDP project are summarized in Wells et al. (2007).

Increased Coelacanth catch rates in 2002 – 2009 along the Tanga coast alarmed marine scientists and managers. A research involving remotely operated underwater vehicle**s (**ROVs) revealed the existence of local populations of coelacanths in Kigombe-Mwarongo area. In order to safeguard coelacanth and also encourage sustainable utilization in the area, the Tanga Coelacanth Marine Park (TaCMP) was declared, somehow also replacing the CMPs that were dormant. A zoning scheme was developed (Muhando, 2011) as part of the TaCMP GPM (Martin, 2011) to facilitate controlled use of core zones and specified use zones within the TaCMP. All stakeholders participated in all stages of the development of the TaCMP GMP (Muhando, 2011) and compliance is expected to be high during the implementation of its regulations. In 2010 after consultations with local authorities, the MPRU identified four Islands (Ulenge, Kwale, Mwewe and Kirui) located north of Tanga Bay to Tanzania-Kenya border as suitable marine reserves. Applying suitable management principles in these Islands will have a positive influence (spillover effects) to the whole northern coastal zone.

1.2 Objectives

The main objective of this assignment was to prepare a status report of the newly declared Tanga Marine Reserves, which include physical characteristics and biodiversity. Physical characteristics include the climate (temperatures, precipitation and sea surface temperatures) and some oceanography (salinity and currents). Biodiversity status include brief description of the available habitats and resources around the reserves, including mangroves, coral reefs health and associated habitats which will include intertidal muddy/sandy/rocky flats, sea grass beds, coral reefs and associated invertebrate and fish communities, as well as endangered species and critical habitats. All these information compose the basic initial ingredients (spatial, temporal and attribute data) for ICAM and/or MSP processes.

2. MATERIALS AND METHODS

2.1 Study area (location of TMRs)

This study was undertaken in the newly declared Tanga Marine Reserves (TMRs); Ulenge, Kwale, Mwewe and Kirui Islands, located north of Tanga Bay to Tanzania – Kenya border (Fig. 1a). Observations were done within the boundaries of the TMRs and adjacent habitats in the Bays and near shore coral reefs areas. Besides the newly declared marine reserves, Tanga region has one marine park, the Tanga Coelacanth Marine Park (with a total area of 552 sq. km) and one older marine reserve, the Maziwe Island Marine Reserve (declared in 1975), both are located south of Tanga Bay (Fig. 1b).

2.2 Physical characteristics: Climate, habitats types and biodiversity

Climate and Oceanography in the TMRs was deduced from literature reviews and interviews with local communities and regional officers. Air temperature and precipitation information was obtained from Tanga Regional Administrative Secretary. Seawater temperature (sea surface temperature) data was extracted from IMS database. Bathymetry around the TMRs was obtained from navigational charts. Biophysical features on the Islands was captured from Google Earth and digitized in ArcGIS 9.2 (ArcMap) after geo-referencing. Intertidal features were observed and mapped after physical inspections (intertidal walks) and interviews with knowledgeable local fishers, who were part of the survey team. Information on location of seagrass and coral reefs was obtained through a rapid search method that involved manta tow and swimming with GPS. The manta tow method involved towing a diver by a slow moving boat for a specified time interval. While being towed, visual observations on seagrass or coral species and frequency of occurrence (counting) was done. When the boat stopped, all identified organisms were tallied and coral cover estimated.

Random swimming method involved swimming along the reefs and after every four to five minutes all corals within the visible range, approximately 3-4m diameter circle, were identified to genus level and counted. Visual coral cover estimate was also done while swimming. Rare corals that were not seen within the range of sampling area but observed during the manta tow or swimming were also recorded. Visual fish counts were also done during manta tows and random swims. A belt transect width was estimated to about 5 m. Fish species (or group) was identified and counted, wherever possible. Fish counts were restricted to coral reef sites due to poor water visibility in the Bays.

Coral reef assessment (manta tow) were undertaken around all the reserves and timed swimming method at selected coral reef points on the seaward side of Ulenge, on the southeast of Manza Bay (at Mnazini 1), and on the seaward side of at Mnazini 2, Mnazini 3 and Mivinjeni, as well as south of Mwewe Island and on the east side of Kirui Island at Kigomeni site 1, site 2, and at Shangani reef. Suitable sites for future monitoring of coral reef change were identified.

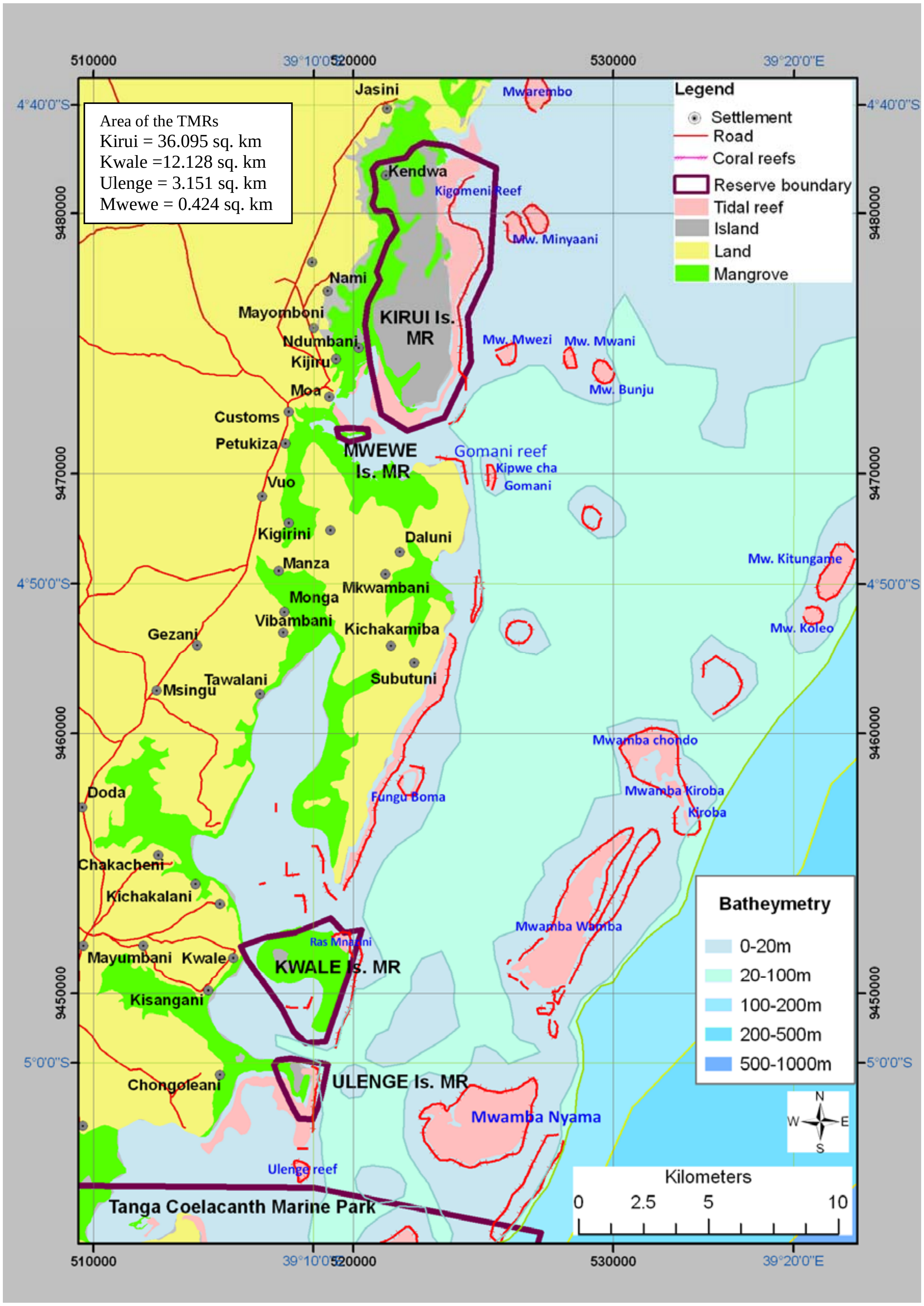


Figure 1a: Map showing the location of the four newly declared Tanga Marine Reserves: Ulenge Island MR, Kwale Island MR, Mwewe Island MR and Kirui Island MR.

Information on the existence of endangered species around the TMRs was gathered through interviews and literature reviews. Information on human activities, threats, impact on habitats and resources, and management implications was deduced from literature reviews, interviews and personal experience of the survey team (Dr. C. A. Muhando, Ali M. Ussi, January Ndagala, Hassan J. Kalombo, local fishers from Kwale and Moa).

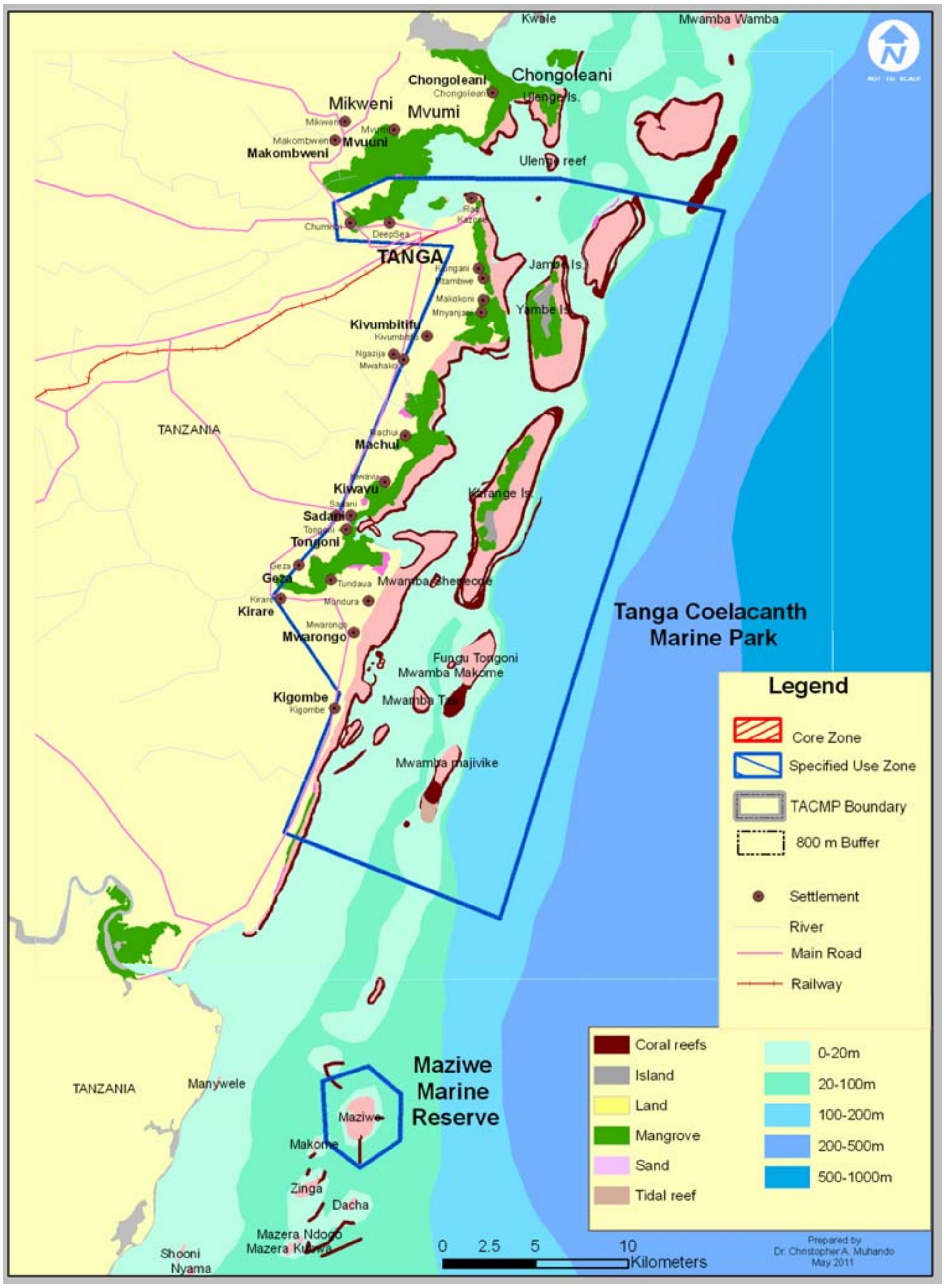


Figure 1b: Map showing the location of Tanga Coelacanth Marine Park and Maziwe Marine Reserve, south of Tanga town.

3. PHYSICAL CHARACTERISTICS OF TANGA MARINE RESERVES

The four Tanga Marine Reserves (TMRs): Ulenge, Kwale, Mwewe and Kirui Islands are located north of the Tanga Bay to Tanzania – Kenya Border (Fig. 1a). All the TMRs are associated with Bays: Ulenge Island is adjacent and forms part of Tanga Bay and Kwale Bay; Kwale Island is associated with Kwale Bay and Manza Bay; Mwewe is located within Moa Bay and Kirui Island is associated with Moa Bay to the south and extensive mangrove creeks to the north, west and south. Historically all TMRs were used as residence in the early centuries (Kalombo pers. Comm).

The first people to live in Ulenge Island were the Swahili people from North who were lead by Chief Mwinyi Ulenge. Because of water shortage on the Island, they were forced to go to the mainland. Most of them settled at an area now called Chongoleani. Kwale Island was historically inhabited by tribe of Wadiko, people living along the beaches. Due to frequent attacks by Masai soldiers, Wadigo from Mwandusi village retreated and later settled in Kwale Island, where they were safe as Masai were afraid to cross into the Island. However, they were forced to go back to the mainland due lack of fresh water and family expansion. Most settled in Kwale village. This Island was also used during the first and second World wars as fortress.

Mwewe Island was first used by some people from Kirui Island, but it was later sold to Bin Athmani of Moa (Kalombo pers comm). Kirui Island was first inhabited by Wadiko, but most have now moved to Kijiru, and Ndumbani villages in Moa Ward, Mkinga District. Settlement in the Island was divided in two areas: Kirui at the southern part, Kendwa and Mbayai on the northern part. More than 20 families lived in Kirui Island. They started to move out in early 1960s due to increased death rate, which was linked some kind devils. Some moved to Kiphururwe on the way to Jasini area, and others to Kijiru, and Ndumbani. They still visit and pay respect to their ancestors in Kirui and Mbayai. Thus, all the TMRs are now practically without inhabitants. Mwewe and Kirui Islands are utilized by people from two wards, Mayomboni and Moa while Kwale and Ulenge Islands are utilized mostly by people from Kwale and Mtimbwani wards with population of about 8,226 (Table 1).

Table 1: Population size in Wards surrounding the Tanga Marine Reserves (TMRs)

District	Ward	Number of People		
		Male	Female	Total
Mkinga	Mayomboni	617	610	2,077
Mkinga	Moa	1,669	1,337	3,006
Mkinga	Kwale	502	538	1,040
Tanga	Mtimbwani	975	1128	2,103
	Total	3,763	3,613	8,226

Source: Mkinga District Profile, 2008

4.1 The Topography, Drainage and Climate

The land around the TMRs (Mkinga District and Tanga) has a variety of topographic features. The coastal lowland extends about 20 to 30 kilometres inland from the Indian Ocean and rises to about 100 metres above sea level. Slopes are less than 5 degrees (Mkinga District Profile, 2008). The Zigi River in the south forms the main drainage of the District; it flows southeast into the Indian Ocean, and forms the boundary between Muheza and Mkinga districts.

4.1.1The Climate

High temperatures and high humidity characterize the coastal lowlands, including the TMRs. December to March are usually the hot months with temperatures around 29-30ºC; during May to October, temperatures fall to about 24-28ºC. Seawater temperature (SST) follow more or less the same pattern, but lagging behind. Low SST occur during July to August and warm during February to April. Highest year to year variations are found during January to April (Figs. 2a and b).

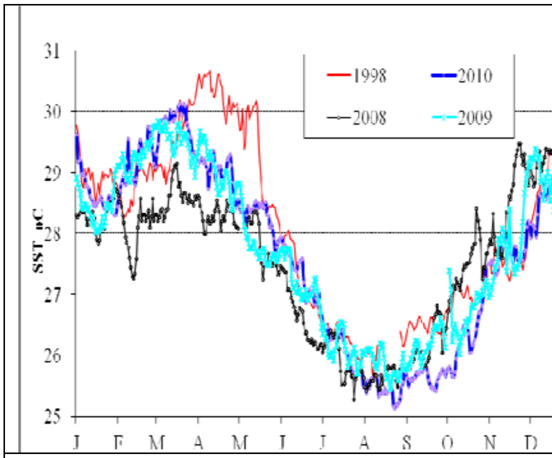


Figure 2a: Seawater Temperature on Chumbe reefs, Zanzibar for 1998, 2008, 2009 and 2010

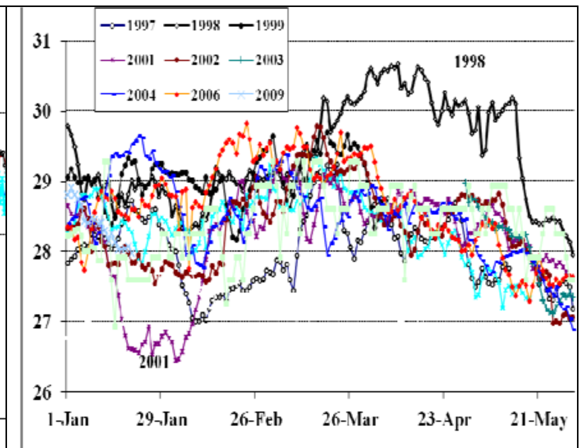


Figure 2b: Year to year Fluctuations in Sea Surface Temperature in Tanzania

The climate of Tanzania is subject to two alternating and distinctive seasons, the southern and northern monsoons, which have a marked effect on air and water temperature, winds, and rainfall. Winds are particularly important feature driving the water circulation and affecting wave action, local climate, biological processes and human activities. From June to September Southeast SE monsoon winds or *kusi* (9 m/s) prevail. During the month of November to March, the prevailing trade wind is the NE monsoon winds or *kaskazi* (5 m/s). It is usually associated with short rains or *mvuli* (short rains) during October, December and sometimes into January. The long rain seasons or *masika* starts after NE monsoon, from March to May. During the *masika* (long rains), it rains heavily almost every day, although seldom for the whole day, and the air can get unpleasantly sticky. According to Mkinga District Profile (2008), Mkinga District generally receives between 1,100mm and 1,400mm of rainfall in a year. The areas further inland to the northwest receive 400-500 mm, especially on the leeward side of the mountains.

Land use patterns and settlement are influenced by the distribution of rainfall and opportunities for agriculture and fishing.

Ocean currents are another important feature that strongly influences the distribution of marine organisms and availability of nutrients. The East Africa Coastal Currents (EACC), which flows northwards is the main current experienced in Tanzania and Kenya coast. During SE monsoon the flow of EACC is increased to 4 knots and during NE monsoon, the northerly flow of EACC is reduced to less than 1 knot.

Freshwater input to coastal waters affects salinity and therefore influences coastal ecology, in particular the growth and development of mangroves, seagrass beds and coral reefs.

The daily raise and fall of sea level is known as tides. The tidal range combined with the shore topography determines the extent of the littoral or intertidal zone. Spring tidal range in Tanga is about 3.3 – 4 m. Mass movement of water during ebb and flood tides cause the reversing tidal currents. The strength of the tidal currents in the TMRs is highly influenced by the occurrence of Islands and Bays. Kwale and Ulenge are low laying Islands dominated by mangroves, and during high tides both flood and ebb tidal water pass through the Island, but with reduced speed. The daily through passage of tidal water make Ulenge and Kwale Island mangrove composition different from the mainland counterpart. Tidal currents play a vital role in dispersal of marine larvae and spores and in mixing coastal waters.

4.1.2 Agro- Ecological Zones

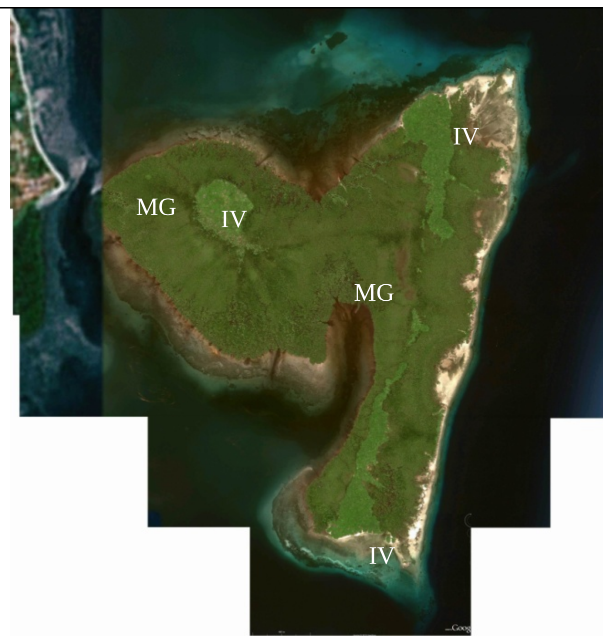
Within Mkinga District there are marked differences in the amount of rainfall, in landforms and soil types, and land use potentials. As a result, four distinct agro-ecological zones have been isolated (fully described in Mkinga District Profile, 2008). Rainfall is usually sufficient to allow the growth of a variety of crops. With exception of some parts of Kirui Island, soils in the TMRs are not suitable for agriculture, but are ecologically suitable zones for fishing and mariculture.

4.1.3 The Islands

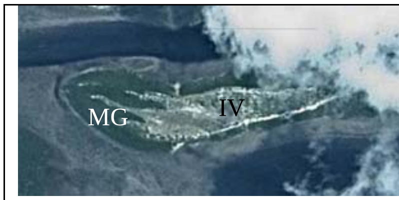
Geologically, all the TMRs appear to have been part of the mainland. Remains of land vegetations are evident in all reserves (Fig. 3). All the TMRs are characterized by large portions of mangroves. Ulenge Island has land vegetation (trees and grass), covering about 41 Ha (38.3 main Island and 2.75 rock blocks), which is about 36 % of the Island area. In Ulenge, mangrove covers an area of 72.2 Ha (3.8 north plot plus 68.8 main plot), about 64 % of the Island area (Fig. 3). Kwale island has three areas with land vegetations; on the northwest (22.6 Ha), on the northeast (30.6 Ha) and on the south (27.0 Ha). Kwale Island mangroves cover an area of 528.1 Ha, about 86.2 % of the Island (Fig. 3). Mwewe Island is also surrounded by mangroves, which covers an area of 14 Ha, about 68 % of the Island (Fig. 3). The land vegetation in the middle of the Island covers an area of 6.4 Ha, about 32 % of the Island. It is believed that at one time the Island was sold to an investor who cleared a stretch of land for landing a small airplane. Kirui Island marine reserve is the largest and it has large true land vegetations. Mangroves surround the south, west and north sides. The total area covered by mangrove in Kirui is estimated to be 680 Ha; the largest mangrove plot (557 Ha) is found on the north and west sides. Kigomeni mangrove (60 Ha) is on the east coast and Kirui south mangrove (63 Ha) in the south of the Island (Fig. 3). The total area of mangroves in the TMRs is estimated to be 1294 Hectares (14 in Mwewe, 72 in Ulenge, 528 in Kwale and 680 in Kirui). Mangroves on the landward sides were found to be healthier than those found on the seaward sides.

All the TMRs have associated Bays. Tanga Bay is just south of Ulenge Island, while Kwale Bay is on the west side of Ulenge and south of Kwale Island. Manza Bay is located northwest of Kwale Island and south of Boma Penninsula. Besides Mwewe, which is located within Moa Bay, all the other reserves have coral reefs on the seaward sides. There are several rivers which empty in the Bays, causing the Bays to become sandy-muddy. Sandy area of the bay has seagrass beds, especially at the lower and subtidal areas. Kirui Island is located north of Moa Bay and is separated from the mainland by a creek, with mangroves on both Island and mainland coast. This creek is also the western boundary of the Kirui reserve (Figs. 1a). The northern boundary of Kirui reserve is also the Tanzania-Kenya border.

Ulenge Is.



Kwale Is.



Mwewe Is.

Kirui Is.

Figure 3: Maps (cut from Google Earth) showing the extent of mangrove (MG) and the true Island vegetation (IV) in the TMRs.

4.2 Bathymetry around the Tanga Marine Reserves

Tanga Bay is generally shallow with maximum depth of 15m in the middle (Fig. 4a). During spring low tides it is difficult for big vessels to pass to Tanga port. The intertidal zone around Tanga Bay is extensive, in some places up to 1 km during spring low tides. In addition to regular river discharges, the low energy nature in the Tanga Bay, favours deposition of soft sediments, hence, extensive mangroves along its banks. As a result Tanga Bay is relatively muddy, especially during rainy and high wind seasons. Kwale Bay is shallower (less than 10 m) and with more sandy intertidal zones, especially in the south. It also experiences more north-south daily tidal water movement, which on the other hand increases sediment movements (smothering impacts) in the Bay, preventing stable benthic productivity. Seagrass dominate on the stable sandy subtidal zones and algal mats on the rocky zones. Despite being shallow, only few and smaller coral reef patches are found in the Tanga and Kwale Bays, mainly because of high turbidity and sedimentation impacts. Extensiveness and diversity of coral reefs along the mainland coast increases northward as you move away from Tanga and Kwale Bays.

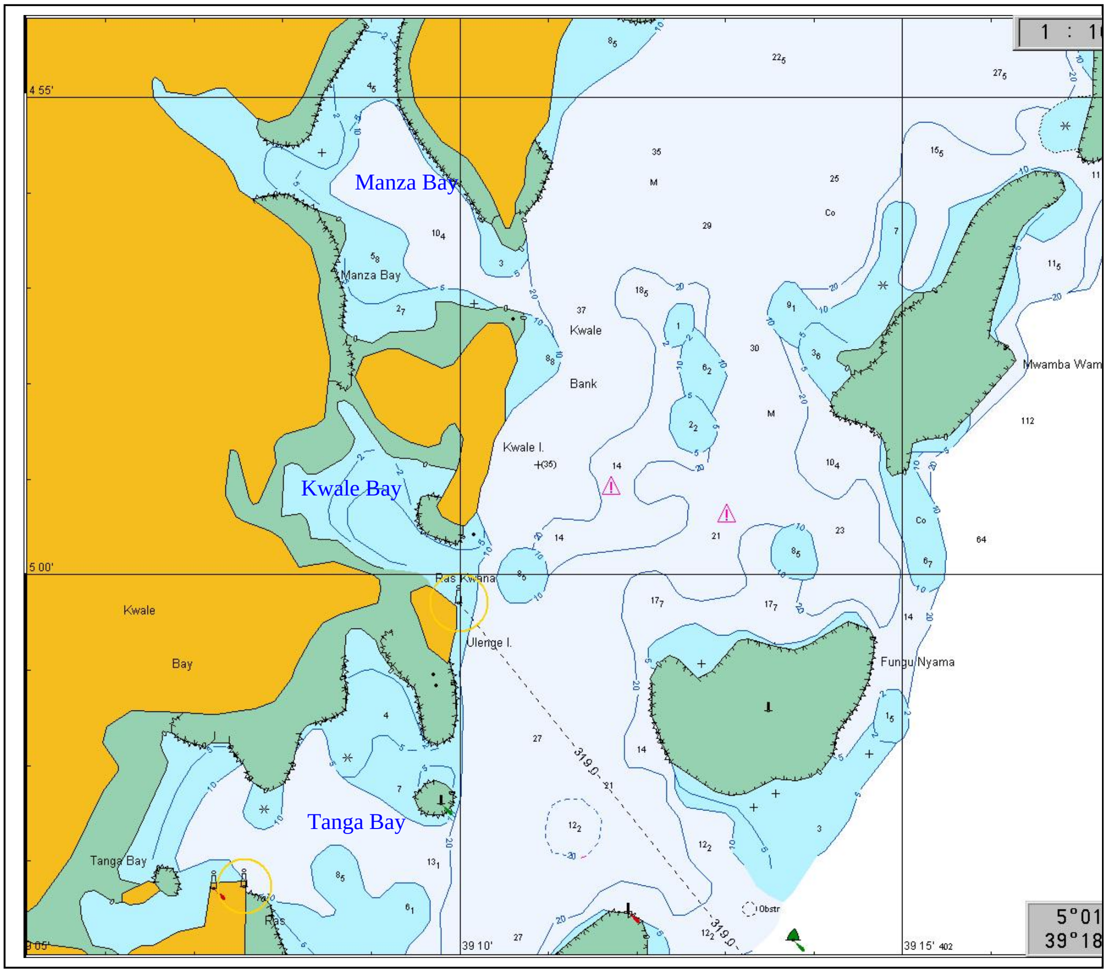


Figure 4a: Bathymetry around Ulenge and Kwale the reserves

Manza Bay is larger and deeper (> 10 m) than Kwale Bay (<10 m) (Fig. 4a). The benthic substrate is more stable than in Kwale Bay and abundant seagrass beds occur in the whole subtidal zones. Extensive coral reefs are found on the northern side of the Bay and along the mouth of the Bay.

Moa Bay is generally shallow, except at the Bay entrance, where the depth is between 10 - 20 m deep. It is only in this zone where coral reefs are found. The rest of the Bay subtidal zone is shallow and the benthic substrate is generally sandy with abundant seagrass beds. The intertidal zone is very extensive, up to 1.5 km on the south (Fig. 4b). The Bay shrinks up to 60 % during spring low tides, i.e. massive water movements occurs during spring tides. The creek between Kirui Island and the mainland coast is passable during high tides only. Fishers from villages on the west of Kirui Island depend on tidal cycles to go in and out. Fish landing and market times are tide dependent.

Shallowness of the bays also means higher possibility for benthic productivity. A combination of water column and benthic productivity make the Bays an important nursery, spawning as well as fishing areas. However, due to previous higher fishing pressures, serious fisheries takes place outside the Bays, where there are still abundant fish stocks. Important fishing areas include the off-shore reefs at Mwamba Wamba and

Mwamba Chondo off Ulenge and Kwale Island. Similarly, the extensive shallow water area adjacent to Kirui, is heavily utilized as common fishing site for Tanzanian and Kenyans.

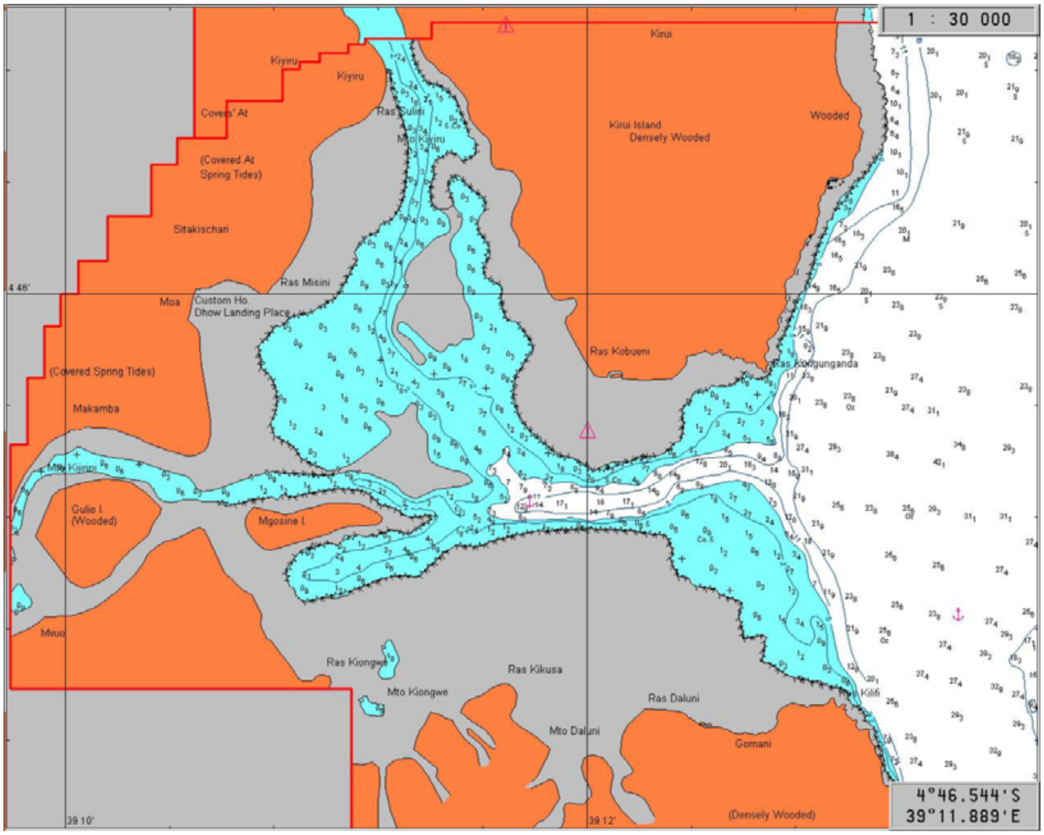


Figure 4b: Bathymetry around Moa Bay and Kirui Island

4.3 Habitats types in and around Tanga Marine Reserves:

4.3.1 Distribution of habitats in Ulenge Island Marine Reserve

Mangrove vegetation is the main biotope in Ulenge Island Marine Reserve (Fig. 4a). All mangrove species are found, but species with strong root systems, e.g., *Rhizophora mucronata* and *Sonneratia alba* dominate. Within Ulenge Island, a variety vegetation (trees and grass) and animal communities (not investigated) occur. Mangrove environment on Ulenge is characterized by daily tidal wash through, as a result there is relatively a thin layer of sediment deposition.

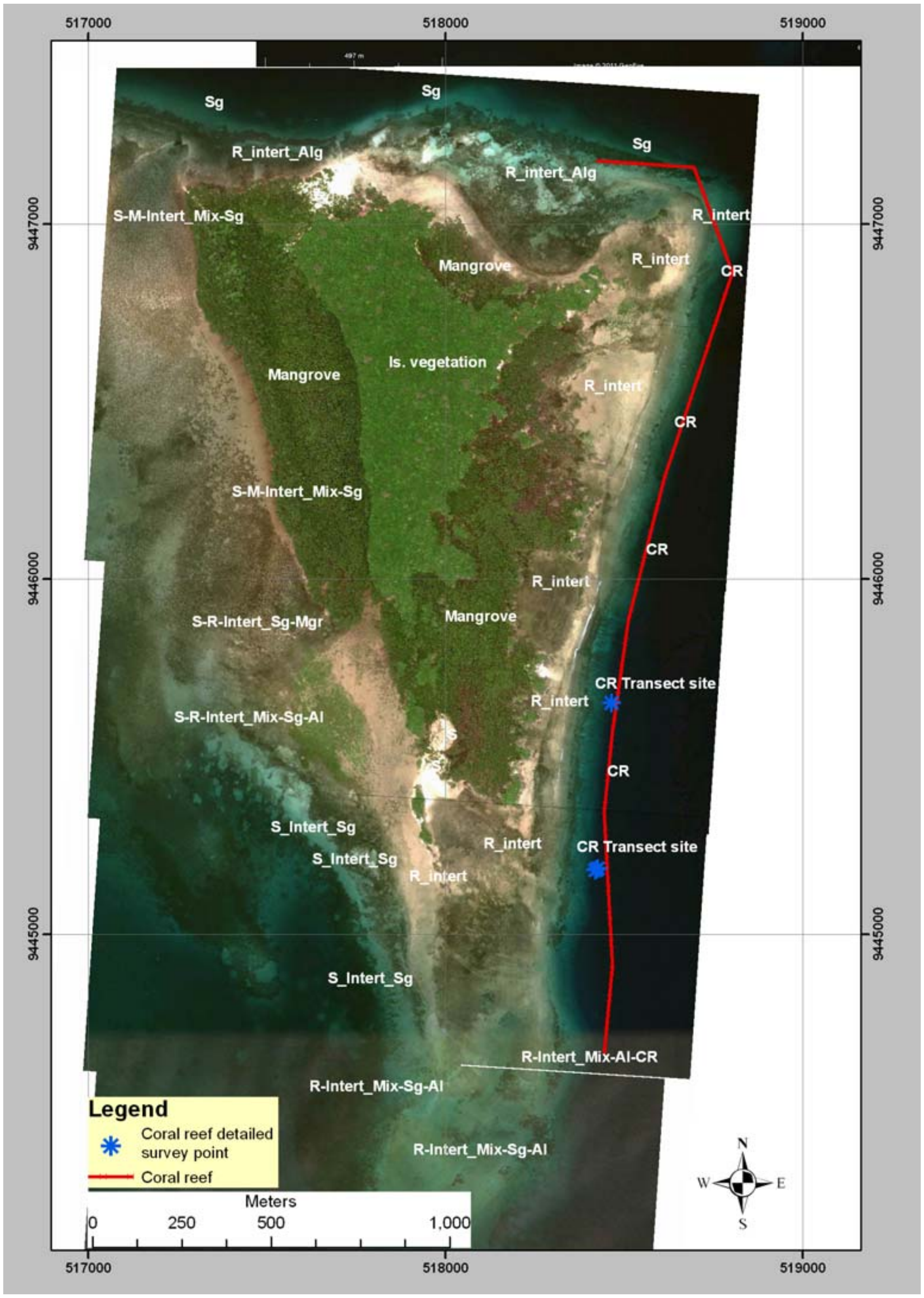


Figure 5a: Distribution of habitats in Ulenge Island Marine Reserve.

The intertidal zone is more extensive (up to 800 m) on the west and south of Ulenge Island, while it is shorter (50-350 m) on the seaward (Fig. 4a). The intertidal is rock on the seaside and north of Ulenge Island, with extensive algal mats in the lower intertidal areas. Algal mats were also found on the seaward side lower intertidal zone (Fig. 5a). Seagrass beds are found alongside the Ulenge-Kwale channel, beyond the algal mats and on the south and south west of Ulenge (in the Tanga Bay) as well as in the Kwale Bay lower intertidal zones. Seagrass abundance and distribution is determined by turbidity and bottom sediment type, factors that are influenced by rainfall/river discharge patterns and oceanographic conditions. Coral reefs are restricted on the seaward side. Results of the benthic cover surveys (manta tow and swimming) revealed a very narrow band of patchy coral reefs, stressed with sediments from Tanga Bay and associated rivers. Coral cover was less than 10 % for most areas. Figure 5a provides a snapshot of the distribution of the various habitats in the Island and its intertidal zone.

4.3.2 Kwale Island Marine Reserve

Mangrove vegetation is the main biotope in Kwale marine reserve. (Fig. 5b). Mangrove stand on the west and south coast, facing the mainland and Kwale Bay, where the bottom is characterized by fine muddy sediments, is more densely packed than on the seaside, where the bottom is rather rocky, with only a thin layer of sediment. All mangrove species are found, however, species with strong root systems, e.g., *Rhizophora mucronata* and *Sonneratia alba* dominate. As in Ulenge, mangroves in Kwale Islands are subjected to rather daily tidal water movement which tends to wash through the mangrove. Sediment accumulation is rather poor and seasonal, depending on the ocean current strength and direction. A variety of vegetation and animal communities (not investigated) occur.

Unlike in Ulenge Island, the intertidal zone is relatively less extensive (up to 200 m) around Kwale Island (Fig. 4a). It is extensive on the northeast and south east of the Island. The intertidal is a mixture of sand and mud on the southwest towards Kwale Bay and is rocky on the east, northeast and southeast (Fig. 5b). Algal mats are found on a rather thin rocky intertidal on the seaward side, while seagrass are found abundantly on the northward towards Manza Bay. Due to high sedimentation/turbidity, there is relatively less seagrass beds on the south lower intertidal, towards Kwale Bay. Seagrass beds are also found along sides the Ulenge-Kwale channel as well as along the Kwale-Boma peninsula channel, beyond the algal mats. There are more seagrass communities in Manza Bay than in Kwale Bay. There is no extensive coral reef growth in Kwale Bay. Only few scattered coral reef patches were found on the south, near the northern part of the Bay mouth (Fig. 5b). Continuous and healthy coral reefs are found on the seaward side. Four sites: Mnazini 1, Mnazini 2, Mnazini 3 and Mivinjeni (see Fig. 5b) were surveyed and two sites Mnazini 1 and Mnazini 3 were recommended for the establishment of a monitoring site. Interview with fishers revealed that there are many scattered coral reef patches in Manza Bay as well. Figure 5b provides a snapshot of the location of the various habitats in the Island and its intertidal zone.

Figure 5b: Distribution of habitats in Kwale Island Marine Reserve.

4.3.3 Mwewe Island Marine Reserve

Mangrove vegetation is the main biotope in Mwewe marine reserve (Fig. 4c). There is land vegetation in the middle of the Island, which covers an area of 6.4 Ha. A variety of vegetation and animal communities (not investigated) occur on the island. Healthier mangrove stands occur on the west (towards the creek) and on the north, towards Moa. Mangroves on the east are stressed by accumulation of sand. Most mangrove species were found, with dominance of *Rhizophora mucronata* and *Sonneratia alba*. The rare mangrove species, *Pemphis acidula* was abundant on the upper intertidal zone behind the other mangrove species, especially on the south side of the Island.

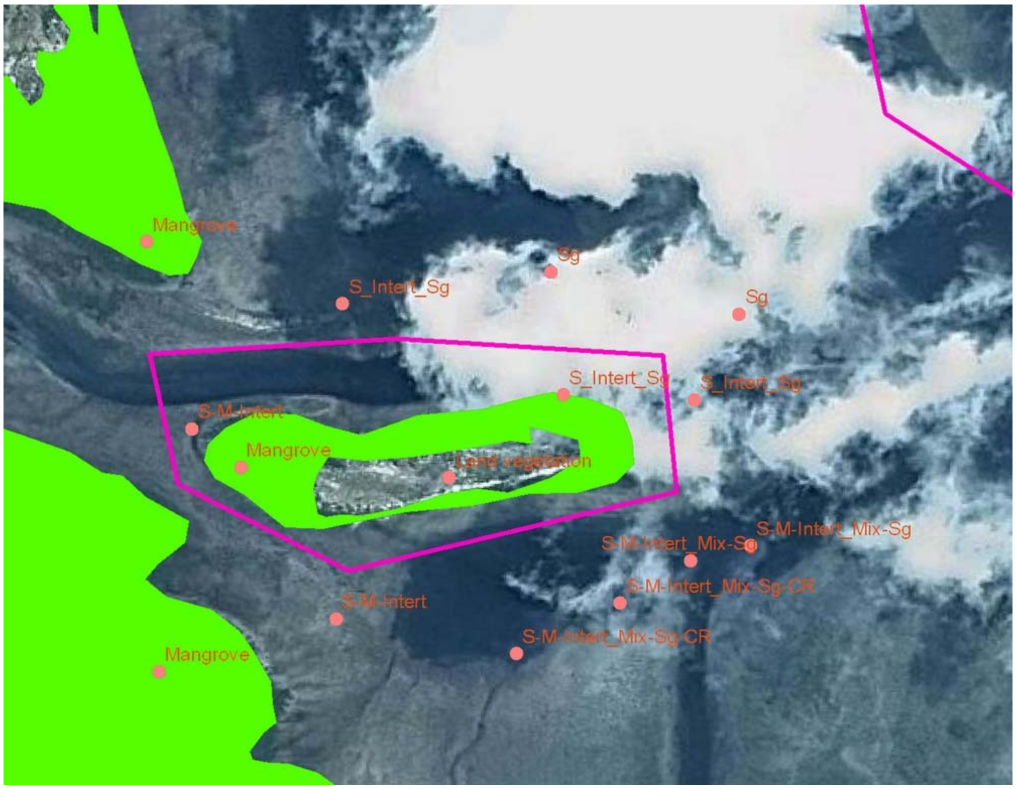


Figure 5c: Distribution of habitats in Mwewe Island Marine Reserve.

The intertidal zone is relatively less extensive on the east and southwest towards mainland mangroves. Like others (Ulenge and Kwale Islands) Mwewe Island is accessible by fishers on foot from mainland villages during spring low tides. The intertidal is a mixture of sand and mud on the southwest towards creeks and mainland mangroves, while it is sandy on the seaward side. There are no rocky intertidal zones and no algal mats were seen. Due to thick muddy on the bottom, high resuspension, and hence turbidity, there is relatively less seagrass beds south of Mwewe Island. Snorkeling in this part of the Bay revealed a mixture of muddy-sand substrate frequently excavated by burrowing organisms making the bottom rough with small hills. Patches of seagrass were seen on the channel with isolated coral patches, mostly composed of *Porites* bomies and few *Acropora* and *Stylophora* species resistant to sediment stress. Figure 5c provides a snapshot of the location of the various habitats in the Island and its intertidal zone. The most spectacular feature was the abundance of the Up-side down jelly fish *Cassiopea Andromeda.* These jelly fish were everywhere on the substrate.

4.3.4 Kirui Island Marine Reserve

Kirui Island Marine Reserve is the largest and it has relatively large portion of true land vegetations, besides mangroves, which surround the south, west and north sides. A variety of land vegetation and animal communities occurs and deserves research attention (out of the scope of this study). Mangrove stand on the west and north appeared healthier than those found on the south facing Moa Bay. All Tanzania mangrove species are found, however, *Rhizophora*, *Avicenia*, and *Cyriops* dominate. Unlike mangroves in Ulenge and Kwale Islands, mangrove in Kirui resembles those on the mainland by not been washed through daily by tidal currents. They have relatively thicker sediment deposits, and are more diverse.

The eastern coastline of the Island is rocky except in the middle part where mangrove flourishes (Fig. 5d). The intertidal zone after mangrove stand is relatively narrow on the north and west, towards the creek separating Kirui and mainland mangrove, while that on south of Kirui Island, the side facing Moa Bay is relatively more extensive and mostly rocky. A thin layer of mangrove grows on almost rock substrate near the southeast tip of the Island. The east coast of Kirui Island has a relatively narrow rocky intertidal zone, except in the middle where it extends up to 600 m (Fig. 5d). The lower intertidal of the extended zone is a famous octopus collection site, accessed by women during spring low tides. The intertidal zone is also extensive in the northeast, mainly due to the influence of creek (river discharge), artificially forming some kind of a Bay southwards Fig. 5d). Around the northeast zone, the upper intertidal zone is rocky but the lower intertidal and subtidal zones are sandy with abundant seagrass growth. Coral reefs occur all along the eastern side of Kirui Island, except at the northeast tip, where river or creak water and sediments prevent coral settlement and growth. Figure 5d provides a snapshot of the location of the various habitats in the Island and its intertidal zone. Generally, Moa Bay is dominated by seagrass beds with patchy coral reef in the deeper part middle of the Bay. Very good coral reefs were observed at Ras Gomani, southern part of the Moa Bay mouth outside the Kirua Island Marne Reserve boundaries.

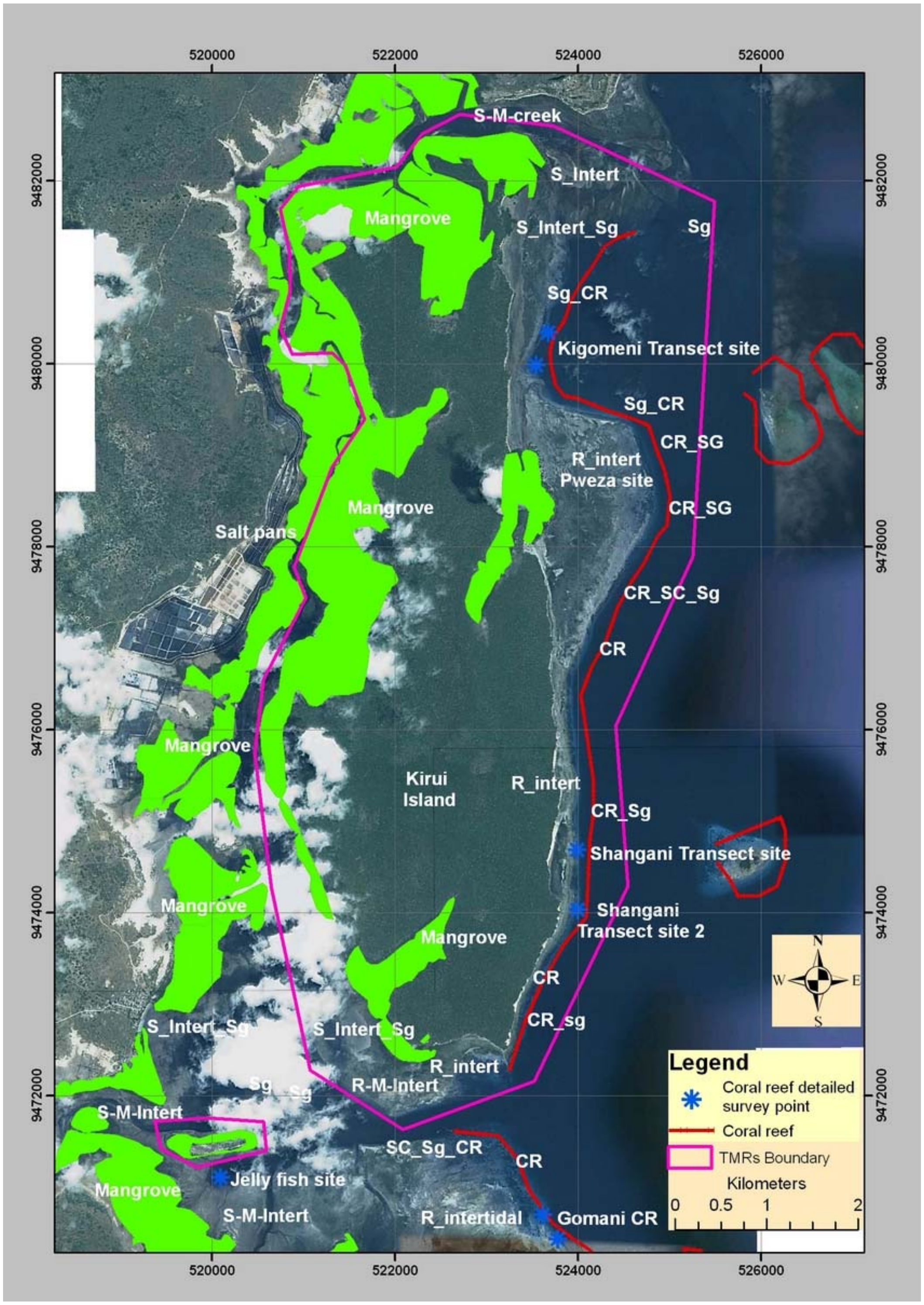


Figure 5d: Distribution of habitats in Kirui Island Marine Reserve.

4. BIOLOGICAL RESOURCES IN THE TMRS

Important biological resources in TMRs include mangroves, coral reefs, invertebrates, fish and mammals.

5.1 Mangroves

Mangrove acts both as a habitat and as an important resource. Mangrove is one of the key resources found in the TMRs. Mangrove trees are also found on sheltered shores of deltas, alongside river estuaries, creeks and where the intertidal zone has suitable deposition of fine-grained sediment or soils (e.g., Figs. 6a, b and c). Other useful resources in the mangrove environment include crustaceans (prawns and crabs), edible shelled mollusks and fish.

Figure 6a: *Rhizophora mucronata* mangroves on Kirui west creek

Figure 6b: *Sonneratia alba* Mangrove on Mwewe south creek

Figure 6c: *Rhizophora mucronata* Mangrove on Ulenge (south)

Mangrove just like other forests play a significant role in stabilising the local climate, particularly in terms of influencing rainfall patterns, as well as improving air quality and enriching soils. Mangroves ecosystems serve important functions such as protecting the coastal land against storms, providing critical habitat for coastal biodiversity, spawning areas for coastal marine and inland aquatic terrestrial species and birds. In addition, mangroves trap sediments, thus playing a vital role in coastal protection by reducing erosion. Addressing sustainable use of mangrove forest ecosystem is of key importance to the coastal people that rely on them for their livelihoods in terms of food, energy, income and biodiversity. Economically mangroves are a source of firewood, charcoal, building poles, construction materials, boat building, fish traps, fishing stakes, tannin and traditional medicines.

All the mangrove species found in Tanzania (Table 2) were found in the TMRs. *Sonneratia alba, Rhizophora mucronata* and *Avicennia marina* were more abundant. Details of mangrove coverage and species composition for the different mangrove areas around Kirui Island, Mwewe Island, Moa Bay villages, Kwale and Ulenge mangroves are described in Table 3 and Figure 7a.

Table 2: Mangrove Tree Species found in Tanzania

No.	Tree species	Local name
1	*Avicennia marina*	Mchu
2	*Bruguiera gymnorrhiza*	Msinzi or muia
3	*Ceriops tagal*	Mkandaa
4	*Heritiera littoralis*	Msikundazi or mkungu
5	*Lumnitzera racemosa*	Kikandaa or mkandaa dume
6	*Rhizophora mucronata*	Mkoko
7	*Sonneratia alba*	Mililana
8	*Xylocarpus granatum*	Mkomafi
9	*Xylocarpus molluccensis*	Mkomafi dume
10	*Pemphis acidula*	Mkaa pwani

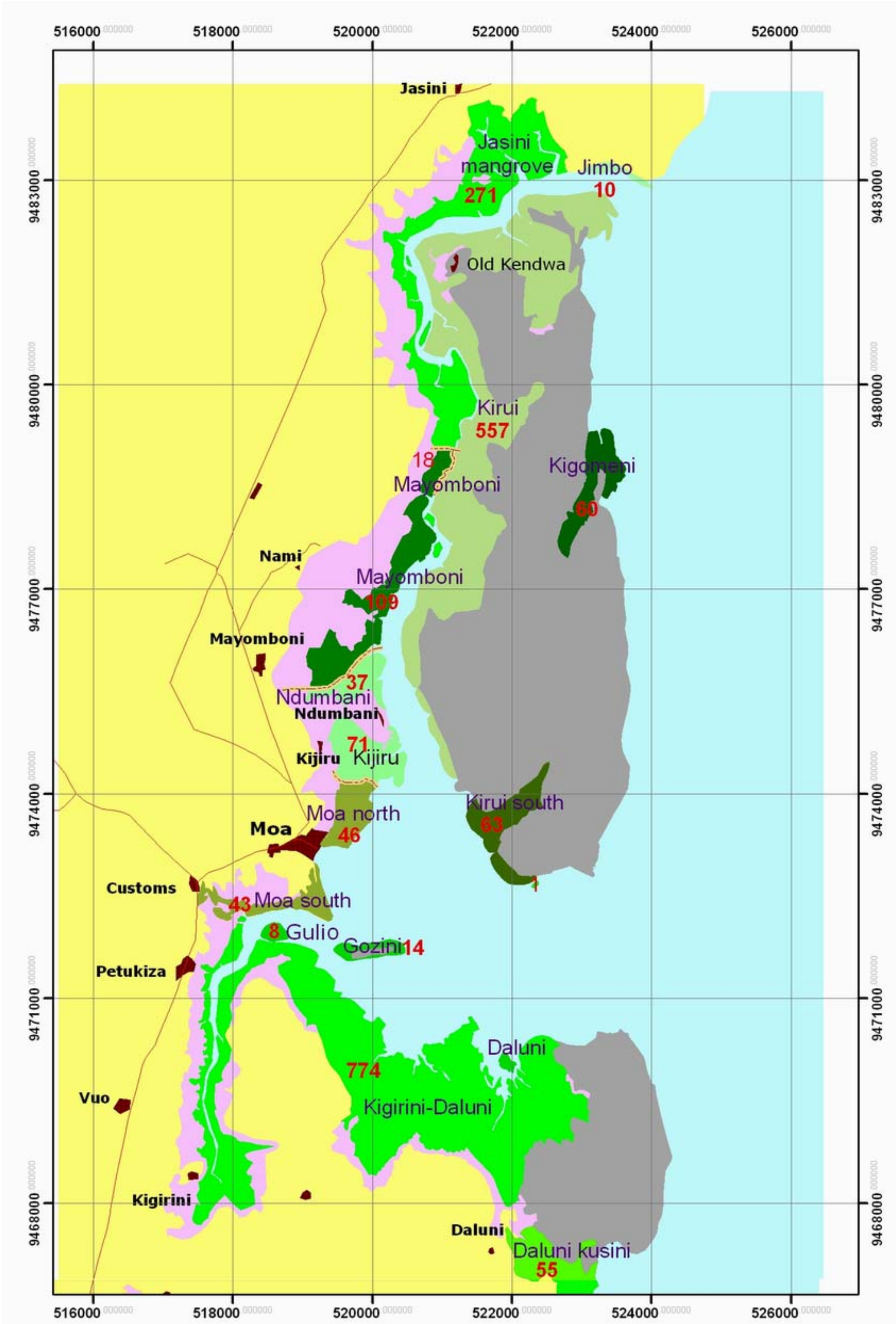


Figure 7a: Mangrove zones and the corresponding area cover (in hectares) in and around Kirui and Mwewe (Gozini) Islands.

Table 3: Mangrove communities in the different TMRs zones

NAME	Area in Hectares	Forest classification
Kirui (north-west)	557	North and northwest: *Rhizophora* dominance with occurrence of *Avicenia, Cyriops, Sonneratia, Bruguira, Heritiera* and/or *Xylocarpus* Southwest: *Sonneratia*, dominant with *Avecennia, Bruguiera* and/or *Rhizophora*
Kirui south	63	Seaward: *Sonneratia,* dominant with *Avecennia, Bruguiera* and/or *Rhizophora.* Middle part: Mixture of *Avecenia* and *Ceriops* In the notch: *Rhizophora* dominance with occurrence of *Avicenia, Cyriops, Sonneratia, Bruguira, Heritiera* and/or *Xylocarpus*
Kigomeni (Kirui east)	60	Seaward: *Rhizophora* dominance with occurrence of *Avicenia, Cyriops, Sonneratia, Bruguira, Heritiera and/or Xylocarpus* In the notch: Mixture of *Avecenia* and *Ceriops*
Mwewe (Gozini)	14	*Sonneratia* dominant with *Avecennia, Bruguiera* and/or *Rhizophora*. *Pemphis acidula* was present
Kwale	528	Seaward: *Rhizophora* dominance with occurrence of *Avicenia, Cyriops, Sonneratia, Bruguira, Heritiera* and/or *Xylocarpus* Middle part: *Sonneratia,* dominant with *Avecennia, Bruguiera* and/or *Rhizophora.*
Ulenge	72	Northwest: Sonneratia – almost pure stands Middle part: *Rhizophora* dominance with occurrence of *Avicenia, Cyriops, Sonneratia, Bruguira, Heritiera* and/or *Xylocarpus* Seaward: *Sonneratia,* dominant with *Avecennia, Bruguiera* and/or *Rhizophora*

(Modified from Semesi, 1991)

Mangrove utilization patterns and threats

Coastal and mangrove forest ecosystems in Tanzania are being altered by uncontrolled human activities, mainly through over-exploitation, habitat destruction, urban/tourist developments, agriculture/aquaculture and pollution (domestic and industrial). Mangroves in the TMRs appeared to be over-harvested for firewood, charcoal, timber and poles. In some areas, natural processes, such as flooding, land erosion and sedimentation appeared to alter some coastal forests and mangrove ecosystems. These threats are likely to intensify as coastal population increases and the demand for investment developments continues.

Large scale conversion and construction of evaporation ponds for solar salt production is regarded as the greatest threat to mangrove resources in Tanzania (Muhando and Rumisha, 2008; Fig. 7b). About 75% of the salt pans are located in mangrove areas. Extensive salt works is found along the mainland mangroves on west of Kirui Island. Fortunately, there are no salt pans within the TMRs.

Figure 7b: Salt pan in Mchangwahela, Bagamoyo. About 75% of the salt pans in Tanzania are located in mangrove areas.

Mangroves in the TMRs are likely to be influenced by climate change, especially oceanographic factors such as stronger and unpredictable wind and wave actions than those on the mainland.

Dramatic changes in water movements (fresh or seawater), e.g. flooding, changes in river courses, tsunami and drought can influence mangrove condition. Dumping of wastes in mangroves or wastes discharged to rivers, as well as oil and industrial pollution in some places, silt from erosion, and pesticides contained in runoff can directly or indirectly influence mangroves. Fortunately, the TMRs are slightly buffered from such disasters by mainland mangroves and the Bays. Conversion of mangrove areas to mariculture sites has not taken place in the TMRs. Fish culture and prawn culture ponds are found just outside the TMRs, e.g., in Chongoleani village, north of Tanga Bay and in Jasini mainland mangroves, near Kenya-Tanzania border.

The underlying causes of the prevalent unsustainable use of mangrove natural resources include; i) The low levels of environmental education which is manifested in form of inadequate understanding of the functions and values of mangrove ecosystems, ii) Economic existence drives that cause insensitivity to mangrove resources, iii) Deep-seated cultural attitudes, behaviors' and practices, iv) Unsustainable agricultural activities and lack of suitable alternative activities.

5.2 Beaches

There are no sandy beaches as such in Ulenge and Kwale Islands. The prevailing rocky substrate is not suitable for tourism purposes. Similarly, Mwewe is completely surrounded by mangrove with an exposed sandy beach seawards, which is only accessible during low tides. There is also no useful sandy beach on the north, west and south of Kirui Island. Very small stretches of sandy beach and mangrove are found on the east side of Kirui (Fig. 8), otherwise it is dominated by cliffs and rocky intertidal. There are no reports of turtles nesting sites in the TMRs. However, all TMRs constitute important bird roosting sites. There are no sandy beaches as such in Ulenge and Kwale Islands.

Figure 8: East coast of Kirui Island. Very small stretches of sandy beach are found, otherwise the coastline is dominated by cliffs and rocky intertidal with minimal tourist value.

5.3 Rocky shores

Rocky shore (Fig. 9) ecosystems comprise animal and plant communities adapted to periodic inundation and exposure by the tides. Photosynthetic seaweeds normally form the base of the rocky shore food chain. Seaweeds are either consumed directly, or fragmented to form fine particulate food resources for filter feeders. Much of the marine living resources of the coastal zone are supported by the productivity of rocky shore ecosystems, since these systems are intrinsically linked via coastal food chains. Rocky shores are famous for mollusc communities and considerable gleaning for edible and ornamental shells as well as octopus collection was observed in the TMRs, especially on the northern Ulenge and Kirui Island eastern intertidal areas. Although there were no signs of overcrowding, excessive trampling endangers and reduces the productivity of rocky shores. Seasonal closure for octopus has been introduced in the core zones and Islands in the Tanga Coelacanth Marine Park (Muhando, 2010; MPRU-TaCMP GMP, 2010) and the same could be proposed in the TMRs.

Figure 9: Rocky shore at northeast of Ulenge Island

5.4 Seagrass beds resources

Sea grasses (Fig. 10) are marine flowering plants, form dense beds that cover large areas of sandy or muddy coastal bottom, a common feature in subtidal and lower intertidal mud and sand flats, coastal lagoons, and sandy areas around the bases of shallow fringing and patch reefs. They grow best in lagoons and protected areas on stable sandy substrates up to 25 m depth (Semesi et al., 1999). The fronds of seagrass and its epiphytes represent an important food resource for some browsing species such as the dugong, turtles and fish. Sea grasses trap the nutrient associated with mangroves converting them into lush plant biomass. Extensive sea grass beds stabilize sediment by the roots thereby reducing suspension and lateral movement of sand and mud. A considerable amount of seagrass productivity is exported in the form of particulate material derived from the fragmentation of dead and decaying plants. This material plays a central role in many coastal food webs and is utilised by a variety of filter-feeding organisms.

Fig. 10: Seagrass beds in subtidal zone northeast of Kirui island.

In the vicinity of coral reefs, seagrass is linked to coral reefs physically and in terms of energy flows. Seagrass beds support finfish and invertebrates fishery in the Bays and areas adjacent to all TMRs. Seagrass bed is highly correlated with demersal fisheries in TMRs, just like in other coastal fisheries (Muhando and Rumisha, 2008). Interviewed fishermen suggested that fish catch rates are higher where seagrass beds occur adjacent to coral reefs. It was clear during this study that most of the fishing takes place outside the Bays around seagrass beds adjacent to coral reefs.

Within the seagrass normally there is animal community that includes sea cucumbers, starfish and sea urchins as well as mollusks such as cowries, bivalves. Crustacean such as shrimps and crabs are also common in mangrove creeks and muddy mangrove substrates, respectively. Many invertebrates and fish lay egg masses and their young spend some time on the seagrass beds. Thus sea grass beds provide breeding, nursery, and feeding areas for many invertebrate and vertebrate species including commercially important species of finfish and shellfish; and shelter and refuge for resident and transient adult animals such as dugong, green and hawksbill turtles. Some species of sea urchins feed on detritus from sea grasses. Additional ecological functions of sea grass include the trapping of sediments, which reduces sedimentation over coral reefs and the dissipation of wave energy, which also provides protection to the beaches and therefore protects shorelines. Furthermore seagrass provides substrates for epiphytic algae. In seagrass beds nitrogen fixing micro-organisms are common.

Table 4: Seagrass species recorded in the TMRs

	Species	Swahili name
1	*Cymodocea rotundata*	Simodosea bilameno
2	*Cymodocia serrurata*	Simodosea meno
3	*Halodule univervis*	Haloduli au Uliti mwembamba
4	*Halodule wrightii*	Haloduli au Uliti mwembamba
5	*Halophila ovalis*	Halofila duara au Uliti duara
6	*Halophila stipulacea*	Halofila refu
7	*Syringodium isoetifolium*	Nyasi tambi
8	*Enhalus acoroides*	Nyasi mlala au Utili mpana
9	*Thalassia hemprichii*	Thalasia au Mitimbuli
10	*Thallasodendron ciliatum*	Thalasodendron au Chani

Source: Richmond 1997, Oliviera et al., 2005 and Mohamed et al., 2007.

Seagrass beds in the TMRs were vulnerable to pressures from human activities. Major threats to the survival of seagrass beds come from excessive sedimentation from land based activities. Increased turbidity cut down the light penetration and negatively influences seagrass health. In TMRs, concerns have also been expressed about the effects of inshore seine or drag nets and intensive trawling activities on the seabed, which destroy seagrass beds. Intensive trampling on seaweed farms and adjacent areas (including passages) has been observed to cause physical alterations. Frequent dynamite blasting, common in the TMRs, also threaten seagrass.

5.5 Coral reefs

Reef-building (hermatypic) corals that produce calcareous skeleton contain symbiotic algae called zooxanthellae. Zooxanthella derives their food resources from photosynthesis, transferring some of these resources to the coral polyp, which fuses calcium with carbon to form the calcareous skeleton. Sunlight and clear waters are therefore critical to the development of coral reefs and they are consequently restricted to depths of less than 25 metres or so. Consequently, reefs usually occur along coastal margins or in areas where the seabed is shallow. The coral reef ecosystem comprises of reef-building corals themselves as well as a vast array of other organisms that depend on the habitats provided by the reef environment. A variety of commercially important fish and invertebrates reside on coral reefs. Coral reefs also act as nursery, spawning and feeding areas for migration fish stocks. More than 70 % of fishing occurs adjacent to coral reefs (Jiddawi and Muhando, 1991).

Fish aggregations occur where there is a combination or interactions between mangrove, coral reefs and seagrass beds. Such a combination occurs just outside the Moa Bay and eastwards of Kirui Island, and just off Manza Bay, beyond Kwale-Ulenge channel to outer reefs. Coral reef also protects the inshore areas from wave action and erosion, and therefore plays an important role in coastal defence as well as in determining patterns of sediment transport along the coast.

There are very few coral reefs within the TMRs boundaries, except on the seaward sides of Ulenge, Kwake and Kirui Island Marine reserves (Fig. 1a). The average coral cover at Ulenge reef was estimated at 5-7 %. The coral cover in around Kwale Island varied from 10-15 % at Mnazini 1, 0-5 % at Mnazini 2, 20-45 % at Mnazini 3 and 5-8 % at Shangani reefs. The coral cover on the east side of Kirui was 8-15 % at Kigomeni site 1, 5-12 % at Kigomeni site 2, 5-18 % at Shangani 1 and 30 – 40 % at Shangani 2 reefs. Mnazini 1 and Mnazini 3 in Kwale and Kigomeni site 1 and Shangani 2 reef were identified as suitable sites for monitoring changes in coral reef condition. Combined results, showed the highest average coral cover was in Kirui (26.7±28 SD) followed by Kwale reefs (10±9.5 SD) and was lowest in Ulenge reefs (5±7 SD) percent.

Coral reef surveys indicated also that coral species richness (or diversity) increases northwards (Table 5). The number of coral genera was 37 in Kirui, 29 in Kwale and 16 in Ulenge reefs. *Acropora* was the most abundant genera followed by *Porites*, *Fungia* and *Platygyra* in Kirui while in Kwale, *Porites* was most abundant followed by *Pocillopora, Goniopora, Galaxea* and *Acropora*. In Ulenge reef *Porites* dominated followed by *Acropora, Astreopora* and *Millepora*. There was no significant coral reef patches around Mwewe Island, except few coral outcrops, most of which were composed of stressed or dead *Porites*, overgrown by a combination of sea anemones, sea fans, soft corals and bivalves (Fig. 11b). The striking feature on the benthic substrate south of Mwewe subtidal zone was the abundance of the Up-side down jelly fish *Cassiopea Andromeda* (Fig. 11b). The list of the coral genera encountered in each marine reserve is shown in Table 5.

Ras Gomani, located in the southern entry of Moa Bay was not part of the study site. However, local fishers recommended it as one of the spectacular coral reef site for divers and snorkeling. Indeed, rapid assessment revealed it as a continuous (1.5 km) reef and its coral diversity was the highest of all surveyed reefs during this study. The average coral cover was about 35-50 %, much higher than what was observed on Kirui reefs. This coral reef zone is naturally protected by strong but reversing tidal currents. The change over or slow water window is less than two hours, too short for dragnet or dynamite fishers to complete their operations. The drop-off at the end of the reef slope is also very high for smooth operation of any seine or drag nets. The list of coral genera in Kigomani reef is shown on the right side column in Table 5. Interview with fishers revealed that there are even better coral reefs outside the Bay, where most fishing takes place. The coral reefs and seagrass beds east of Kirui and south of Kenya deserve further research attention.

All reefs surveyed (in the TMRs) share one characteristic of being damaged by destructive fishing practices, especially dynamite and dragnets. A similar observation was revealed during socio-economic study in the area (Mangora and Shalli, 2011). Extensive coral rubble areas, were observed (a result of human destruction), especially on Shangani reefs, east of Kirui Island.

Table 5: List of Coral genera and their relative frequency of occurrence during the survey in Ulenge, Kwale and Kirui coral reef areas and list of coral genera in Ras Gomani, Moa (right column in the table).

	GENUS	ULENGE	KWALE	KIRUI		RAS GOMANI
1	*Acropora*	10	34	510		*Acanthastrea*
2	*Porites*	61	223	276		*Acropora*
3	*Fungia*	0	30	252		*Astreopora*
4	*Platygyra*	2	35	195		*Coscinarea*
5	*Galaxea*	3	36	85		*Cyphastrea*
6	*Astreopora*	9	7	83		*Diploastrea*
7	*Goniastrea*	0	13	74		*Echinopora*
8	*Synarea*	3	4	70		*Favia*
9	*Favites*	7	23	60		*Favites*
10	*Halomitra*	0	2	56		*Fungia*
11	*Montipora*	0	11	45		*Galaxea*
12	*Favia*	1	14	38		*Goniastrea*
13	*Echinopora*	1	22	36		*Goniopora*
14	*Oxypora*	0	4	35		*Halomitra*
15	*Pavona*	1	16	31		*Hydnophora*
16	*Hydnophora*	2	14	31		*Leptastrea*
17	*Lobophyllia*	1	5	30		*Leptoria*
18	*Goniopora*	2	38	27		*Lobophyllia*
19	*Pocillopora*	3	95	25		*Millepora*
20	*Seriatopora*	0	1	22		*Montastrea*
21	*Millepora*	8	7	18		*Montipora*
22	*Herpolitha*	1	2	15		*Oxypora*
23	*Leptoria*	0	0	12		*Pavona*
24	*Acanthastrea*	0	0	10		*Platygyra*
25	*Turbinaria*	0	0	9		*Pleisiastrea*
26	*Echinophyllia*	0	1	9		*Pocillopora*
27	*Diploastrea*	0	0	9		*Porites*
28	*Leptastrea*	0	2	8		*Psammocora*
29	*Cyphastrea*	0	14	5		*Seriatopora*
30	*Stylophora*	0	22	3		*Stylophora*
31	*Merulina*	0	0	3		*Turbinaria*
32	*Physogyra*	0	0	2		
33	*Montastrea*	0	0	2		
34	*Gardinoseris*	0	2	2		
35	*Coscinarea*	0	2	2		
36	*Podabacia*	0	11	1		
37	*Pleisiastrea*	0	0	1		
	Species richness	16	29	37		34
Avg cover (mean±SD) (%)		5±7	10±9.5	26.7±28		40±21 SD

Figure 11a: Kwale: Mnazini 1 (left) and Mnazini 3 (right) coral reefs

Figure 11b: The Up-side down jelly fish *Cassiopea Andromeda* (left) and a patchy reef on the sandy-muddy bottom south of Mwewe Island.

Figure 11c: Kirui: Kigomeni (left) and Shangani (right) coral reefs

Destructive fishing practices notably dynamite and bottom dragged nets (e.g., Kigumi or Muroami), overfishing, sedimentation and pollution constitute the main human induced sources of physical alteration and degradation of coral reefs in the TMRs, just as in other parts n Tanzania (Mohammed et al., 2000, 2002; Muhando 2003). Besides the 1998 coral bleaching event (Muhando, 1999; Wilkinson et al., 1999), there has been no serious coral bleaching mortality reported in recent years in Tanzania (Muhando and Mwaipopo, 2008; Fig. 2). Other natural threats to coral reefs include hurricanes, sedimentation loads (from eroded inland sources), floods (excessive freshwater intrusion), pollution (nutrient pollution causing eutrophication), outbreak of predatory species (e.g. crown-of-thorn starfish, coral eating crabs) and algal blooms and other competing species. The impact of these threats, including climate change related factors or processes were not evaluated during these studies.

5.6 Mangrove and Coral reef invertebrates

Edible invertebrates found in the TMRs include mangrove crabs, prawns, octopus, lobsters, clams, sea cucumbers, and shelled molluscs. Some of the shelled molluscs are harvested and sold as ornaments. All commercial invertebrates are probably overexploited. Interviewed collectors reported reduced catch per unit effort. They also reported an increase in the number of collectors. Intertidal gleaning for shell and octopus is conducted by everyone interested; men, women and children during spring low tides. Crab collection in the mangroves is also common. Species mostly exploited includes *Portunus pelagicus* and *Scylla serrate*. Lobster fishery was common in the past but few people are engaged now because of paucity of stocks. The free entry to harvesting of stocks, weaknesses in enforcing fisheries regulations and the lack of suitable alternative livelihoods has attracted almost everyone to glean in the lower intertidal zones for anything of economic importance. Interviewed fishers reported that higher catches of octopus, sea cucumbers and big shelled molluscs are landed more by skin and scuba diver collectors who are able to venture in relatively deeper seagrass and reef areas. Shallow water seagrass beds and coral reefs were dominated by sea urchins, brittle stars and starfishes, also regarded as trash species.

5.7 Fish stocks in and around the TMRs

Artisanal fishing is one of the main livelihood activities in Tanga. Up to 80% of the adult male population in the villages such as Kwale and Moa (adjacent to TMRs) are fishers (Wells e al., 2007). Men do most of the fishing although some women fish in shallow water for prawns and a large number process fish and collect mollusks during low tides. Fishery around the TMRs is multi-gear and multi-species, as in other parts of Tanzania. Multiple landing sites and fish sales at fishing grounds complicate the monitoring of artisanal fisheries.

For many years there has been no detailed study to estimate the fish stocks in non-trawlable areas, such as shallow coral reef, seagrass bed and mangrove areas. The relative abundance of fish at different fishing grounds has been evaluated or deduced from long term trends on the type and size of landed fish, as recorded by fisheries officers. Interviewed fishers around the TMRs during this study suggested reduced catch rates for almost all harvested demersal fish stocks, while there was no significant change in catch rates for pelagic stocks, such as dagaa and mackerels. Serious fishing takes place outside the Bays, in the outer reefs. Fishers claimed that only small (juveniles) are abundant in the Bays. When asked about fish stocks and sustainable fisheries strategies, most fishers did not have straight answers. However, they all admitted that they are now fishing relatively further off shore than before. Moa fishers reported some kind of competition with Kenyan counterparts for stocks off Kirui coast and beyond. The use of drag nets (juya) was associated with the destruction of habitats and depletion of fish stocks in the Bays. Fishers in Moa and Kwale were bitter regarding the apparent failure to stop the use of dynamite and cautioned that lack of control somehow attracts others to use, and eventually cause further reduction of stocks even in the off shore fishing sites.

Almost all fish caught are auctioned at local fish markets (Fig. 12). Jasini, Moa and Kwale are the most important fish markets around the TMRs. The common marine fish species caught in and around the TMRs is similar to that recorded for other parts of Tanga. Some people believe that relatively bigger fish are landed in Moa and Jasini compared to those landed in Kwale and Chongoleani, near Tanga town (Kalombo pers community.). Table 6 below gives a comprehensive list of common commercial fish and invertebrates landed by artisanal fishers.

Table 6: Some of the common marine fish and invertebrates landed by Tanga fishers

S/N	LOCAL NAME	COMMON NAME	SCIENTIFIC	PLACE
1	Changu Ndomo	Emperor	*Lethrinus* spp.	Reef fish
2	Changu Njana	Emperor	*Lethrinus lentjan.*	Reef fish
3	Changu Doa/Dizi	Thumbprint emperor	*Lethrinus harrak*	Reef fish
4	Kangu	Blue fish	*Calotomus* sp.	Reef fish
5	Pono	Parrot fish	*Scaridae* sp.	Reef fish
6	Mlea	Sweet lip	*P. gaterinus*	Reef fish
7	Kitamba, Mchone	Sweetlips	*Gaterin* sp.	Reef fish
8	Kangaja	Surgeon fish		Reef fish
9	Mkundaji	Goatfish	*Upeneus* sp.	Reef fish
10	Mbono/Numbi	Fusiliers	*Caesio* sp.	Reef fish
11	Chafi	Rabbit fish	*Siganus* sp.	Reef fish
12	Kikande/Kidui	Triggerfish		Reef fish
13	Puju	Unicornfish	*Naso hexacnthus*	Reef fish
14	Sharifu	Unicom leatherjacket	*Aluterus* spp.	Reef fish
15	Chewa	Grouper	*Cephalopholis* sp.	Reef fish
15	Mjombo	Peacock grouper	*E. punctatus*	Reef fish
17	Kui	Jarbua berapon	*Trepon jarbua*	Reef fish
18.	Chaa	Silver-biddy	*Gerres* sp.	Reef fish
19.	Tembo/Janja	Snappers	*Lutjanus* sp.	
20	Koana	Bream	*Nemipterus* sp.	
21.	Paramamba	Grunter	*Pomadasys* sp.	Mud/Mangrove
22	Kambisi	Trevally	*Caranx tille*	Deep waters
23	Kolekole	Jarks	*Caranx* sp.	Reef fish
24.	Mikizi	Mullets	*Mugil* sp.	Mangroves
25	Msusa	Obtuse barracuda	*Sphyraena obtusata*	Seagrass/reef
26	Kisumba		*Sphyraena* sp.	Seagrass/reef
27	Mzia	Barracuda	*Sphyraena barracuda*	Offshore pelagic
28	Nguru	Kingfish	*Scomberomorus commersoni*	Offshore pelagic
29	Nguru Msumari		*Scomberomus* sp.	Offshore pelagic

30	Kanadi	Kanadi Kingfish	*Scomberomorus plarilineutus*	Offshore pelagic
31	Kibua/Gololi	Indian mackerels	*Rastrelliger kanaguta*	Bays, Lagoons
32	Jodari na Sehewa	Tunas	*Gymnosarda* sp.	Offshore pelagic
33	Hongwe/Fumi	Catfish	*Netuma* sp.	Estuaries, Mangroves
34	Mwatiko	Milk fish	*Chanos chanos*	Reef associate
35	Kamba	Lobster	*Panulirus* sp..	Reef invertebrates
36	Kamba/Kaji	Prawns	*Penecus* sp.	Sand, Mud areas
37	Pweza	Octopus	*Octopus cyanea*	Reef invertebrates
38	Kipepeo	Butterfly fish	Chaetontidae	Reef fish
39	Mwasoya	Angle fish	*Holacanthus* sp.	Reef fish
40	Chazanda	Red Snapper	*L. Campechanus*	Reef associate
41	Kohe/Heriya mboga		*D. pictum*	Reef associate
42	Mkunga	Eels	*Echdina* sp. *Muraneosox* sp. and *Conger* sp.	Reef fish
43	Ngogo	Stripped eel cat fish	*Ptotosus*	Reef associate
44	Kidau	Lutkes halfbeak	*Hemiramphus*	Reef associate
45	Kifuu	Squirrelfish's	*Myripristis* sp.	Reef associate
46	Jongoo bahari	Seacucumbers	Holothurians	Reef organisms
47	Kiti cha pweza		Sea stars (starfishes)	Reef organisms
48	Kombe	Sea shells	Shelled Mollusks	Reef organisms
49	Pweza	Octopus	*Octopus* sp.	Reef organisms

(Source: Tanga Coastal Resource Centre and this study)

5.8 Endangered species and critical habitats in the TMRs

Dugongs (*Dugong dugong*) are reported to have been relatively common in the 1950s, and often caught as food just off the TMRs (Muir et al., 2003 in Wells et al., 2007). Due to various factors, dugongs disappeared and Fisheries Act of 1970 declared it as a protected species. A small population is believed to exist at Mbayae-Kigomeni area, just east of Kirui Island and south of Kenya border, where it was sighted in 1994 and 2004 (Muir et al., 2003 in Wells et al., 2007). Although turtles have been observed in the area, there is no significant sandy beach that is known to be utilized as turtle nesting site inside the TMRs. Coelacanth (*Latimeria chalumnae*) are found and often caught in deep water in and around Tanga Coelacanth Marine Park, which is less than 10 km from Ulenge Island Marine Reserve.

Ulenge and Kwale Island Marine Reserves fall within the important bird area, IBM 35, as defined by Birdlife International (Baker and Baker, 2002). Bird fauna including Greater Sand Plover, Curlew Sandpiper, Crab Plover, migrating waders, and many others are found in this bird area. Mangrove and coral reefs are not endangered as such but can be considered threatened by human activities and climate change related factors.

The shallow water area extending from south Kenya coast to include Moa Bay and seawards of Kirui Island could be considered as special habitat. This zone has a complex combination of extensive seagrass beds and coral reefs, good conditions for fish productivity. Besides being important fishing area for Kenya and Tanzania fishers, it is in this zone where dugongs are believed to exist. The problem is the use of destructive fishing practices, dynamite and dragnets. This area deserves special conservation attention. Corrective measures involving Tanzania and Kenya cross-border arrangements are urgently required. A combination of legislations as well as continued education and environmental awareness campaigns should result in reduced pressure, protected and preserved marine species and habitats. Besides the area discussed above, there are no other critical habitats found in the TMRs during this study.

5.9 Previous management efforts

Previous management efforts in and around the TMRs exist. Boma Mahandakini Collaborative Management Area plan was developed and implemented during the Tanga Coastal Zone Development and Conservation Project to serve Mayomboni and Moa wards, including Kirui and Mwewe Island marine reserves. Kwale and Ulenge Island reserves were under the DeepSea – Boma Collaborative Management Area plan. Various conservation activities including coral reef and mangrove management related were planned and carried out, however because of various reasons (also read Wells et al., 2007) these initiatives are not functioning today as expected.

The forest act of 2002 laid further amendments and specifically provides for the joint management of mangroves by local communities and the Mangrove Management Unit of the Forest and Beekeeping Division. Mangrove Collaborative Management Plans were drawn to guide use and conservation of mangrove ecosystems. Village Environmental Management Committees were established and are still exist. Forest users have exclusive rights to the products, but the forests remains the property of the Central government. There are specific guidelines and regulations, sometimes including patrols, to ensure sustainability in both mangrove forests and coral reefs resources (Wells et al., 2007).

Local NGOs in Mkinga District such as Tanzania Coastal Environmental Conservation Network (TACOECONT) have also participated in mangrove management by organizing education and awareness campaign to enhance conservation behaviors as well as sensitizing community participation in monitoring and zoning of mangrove areas, e.g. in Mahandakini – Moa area (Muhando, 2010). Local authorities are also keen in sustainable harvest of coastal resources, including tourism related plans (Mkinga District Profile, 2008).

5. SUMMARY OF ISSUES AND RECOMMENDATIONS

- Long rooted tradition/customs of the use of the Islands and its resources need to be well considered. Local participation must be encouraged by all means. Provision of suitable alternative activities and initiation of people-based support to local livelihoods, e.g. targeted education and environmental awareness.
- Closure of mangrove utilization as well as restrictions on coral reefs in the TMRs will increase pressure on the remaining mangrove forests or coral reef sites. Revisions of the existing mangrove and coral reef use plans and legislation enforcement mechanisms may be inevitable. Appropriate guidelines to preserve the ecological and economical functions of mangrove as well as coral reefs must be devised.
- Poor enforcement of general fisheries regulations (legislation) with regard to mangroves and coral reefs is an issue that requires attention. Compliance of regulations in the TMRs will be compromised or undermined by lack of strict enforcement in adjacent areas. Continued over use of drag nets must be controlled and dynamite use stopped.
- Although not statistically proved during this study, over collection of commercial intertidal mollusks including ornamental shells and octopus is an issue in the TMRs. Closed seasons principles should be investigated and applied when found useful.
- Continued dwindling of fish stocks while fishing effort is increasing (free entry analysis) should be avoided in the TMRs and adjacent areas
- Lack of tourism in the TMRs is an issue that requires attention. Ecotourism based on mangrove and coral reef is possible and should be encouraged. Creation of nature trails and bird watch posts is feasible in the Islands and should be investigated.
- Inventory of resource bases in the TMRs and adjacent area is needed to guide sustainable environmental and resource utilization. Similarly, there is a need for identification (of a suite) of socio-ecological sustainability indicators to gauge and monitor exploitation and/or threshold levels over which extinction or stock collapse occurs. Changes in mangrove and coral reef conditions as well as number of users and their levels of income will be part of such a suite of factors.
- Baseline surveys targeting Island vegetation biodiversity is important to reveal species that deserve special attention and will be the bases upon which conservation impacts (change) could be gauged after GMP implementation.
- Sediment and chemical pollution from land based sources, e.g., agriculture close to river banks, deforestation, and the use of pesticides and fertilizers was not evaluated as a threat but is clearly a potential threat to TMRs, especially Kwale Bay. Management of TMRs may also involve providing advices with regard to agricultural practices as well.
- The reversing tidal movement means water passes through Island mangroves in Kwale and Ulenge twice every day. Island mangroves are thus more controlled or impacted by oceanographic processes, tides waves and currents. The species composition of mangrove forest was seen to reflect these oceanic pressures, e.g., reduced settlement success of young mangrove, low sediment deposition and abundance of strong rooted species. Specific conservation attention will be

required for Kwale and Ulenge mangrove ecosystems. The TMRs are guarded by mangroves and cliffs (rocky intertidal). However, substantial beach erosion has been reported in adjacent areas, e.g. in Moa.

- Wherever coral reef, sea grass beds and mangroves occur adjacent to each other, biological linkages and ecological dependence usually occurs. Thus, management of the coastal areas should take into consideration management of all key habitats, i.e. Island vegetations, intertidal areas, sea grass beds, mangroves, coral reefs and other physical condition along the coastline.
- Learn from previous management programs – especially the TCZCDP. The concept of listening, piloting, demonstration and mainstreaming is useful.
- Integrated approach that harmonizes issues and activities rather than sectoral approach
- Aquaculture for finfish (e.g., Tilapia and milk fish), oysters, prawns, crab fattening and seaweed farming activities should be introduced and/or improved without compromising mangrove health. Similarly, beekeeping for honey production should be encouraged as well.

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