Climate Change Adaptation Series: Document 1

COASTAL AND MARINE ECOSYSTEMS IN A CHANGING CLIMATE: THE CASE OF TANZANIA

Prepared by:

Prof. Pius Z. Yanda
Centre for Climate Change Studies
University of Dar Es Salaam

For the Coastal Resources Center, University of Rhode Island

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1. Coastal and Marine Ecosystems in a Changing Climate: the Case of Tanzania.
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3. Village Vulnerability Assessments and Climate Change Adaptation Planning (V & A): Kitonga, Bagamoyo District
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Cover photo caption: An area of eroded beach on the coast of Zanzibar
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ABSTRACT

This paper presents a review of the existing and projected links between climate change and coastal and marine ecosystems in Tanzania. The reviewed literature indicates that the projected climatic-induced disturbances such as rising sea level, increased temperature and enhanced extreme weather events are likely to exacerbate more pressures on coastal and marine ecosystems, such as mangroves, seagrasses, fisheries, beaches and coral reefs. In responding to the projected changes, Tanzanian government is undertaking a number of initiatives. Notably, NAPA is the guiding framework for adaptation priorities; with engineering and mechanical activities to adapt to rising sea levels along the coast being highly preferred. Likewise, with the adoption of the ICM strategy, Tanzania is taking a bigger step to setup harmonised and coordinated coastal and marine resource management. Furthermore, the paper shows how experiences gained from a number of ICM related conservation programmes and projects along the coast provide significant baseline information for developing more adaptation strategies for both people and ecosystems. However, the paper cautions possible setbacks with regard to governance challenges existing in marine protected areas; and dependence on donor funding and technical supports for implementation of the initiatives.

The study recommends on several aspects: (i) the need to undertake socio-ecological and governance studies in understanding how governance structures influence implementation of ICM initiatives – lessons from forestry and wildlife sectors could be useful. (ii) The need to undertake empirical studies to investigate carbon stocking capacity of coastal and marine ecosystems – such as mangroves, seagrasses, and tidal marshes – to provide baseline information for Tanzania to venture into “blue carbon” initiatives. (iii) Lastly, there is a need for enhanced political will that might make it easier the avoidance of donor dependence on financial and technical supports for ICM projects implementation.

1. INTRODUCTION

1.1 Background information

It is now widely acknowledged that coastal and marine environments are experiencing enhanced changes as a result of natural and anthropogenic induced causes (Bindoff *et al*., 2007; Nicholls *et al*., 2007; Chen, 2008; Michel and Pandya, 2010). For instance, over the period 1961 to 2003, global ocean temperature has risen by 0.10°C from the surface to a depth of 700 m; the increase has also been observed even on the global ocean heat content from the surface to a depth of 3,000 m (Bindoff *et al*., 2007). Such an increase and the resulting thermal expansion have been linked with the rise of global mean sea level; that is observed to rise at an estimated projection of 9 to 88 cm between 1990 and 2100, with a central value of 48 cm (Klein *et al*., 2002). Likewise, large-scale, coherent trends of salinity has been observed for the period 1995 to 1998; with pronounced increasing salinities prevailing over most of the Atlantic and Indian Oceans (Bindoff *et al*., 2007). All these changes have been observed to affect the oceanic biogeochemistry[1]. Moreover, such changes are expected to modify and intensify weather-induced hazards – such as storm and wind surges, flooding and erosion – in the coastal zones, and thus threatening the ecosystems and populations depending on them (Klein *et al*., 2002).

On the other hand, increased human's utilisation of coastal and marine resources during the 20th century has induced changes within the coastal and marine ecosystems (Nicholls *et al*., 2007). For instance, associated with increased population[2] within coastal areas, there is a widespread conversion of natural coastal landscapes to agriculture, aquaculture, silviculture,

[1] For instance, it is observed that the total inorganic carbon content of the oceans has increased due to a decrease in the depth at which calcium carbonate dissolves; the fraction of emitted carbon dioxide that was taken up by the oceans has decreased; and oxygen concentrations have decreased due to reduced rates of water renewal in the thermocline in most ocean basins from the early 1970s to the late 1990s (Bindoff *et al*., 2007: 387).

[2] It has been estimated that 23% of the world's population lives both within 100 km distance of the coast and <100 m above sea level, and population densities in coastal regions are about three times higher than the global average (Small and Nicholls, 2003).

as well as industrial, commercial and residential uses (Valiela, 2006 as cited in Nicholls *et al*., 2007: 319). Such human activities have been associated with: drainage of coastal wetlands, deforestation and reclamation, discharge of sewage, fertilisers and contaminant into the oceans; hardening of the coast, changed oceanic circulation patterns, and altered freshwater, sediment and nutrient delivery; and destruction of coral reefs by blast fishing (Nicholls *et al*., 2007; Wong, 2010). Such anthropogenic induced changes compounded by climatic induced changes are expected to expose the coastal populations and ecosystems into several dangers (Michel and Pandya, 2010). For example, the rising sea levels could lead to saltwater intrusion into freshwater; warmer water temperature could degrade coral reef and threaten artisanal and commercial fisheries; and infrastructures and facilities found in the coastal zones could be severely damaged by rising sea levels and associated storm surges (*Ibid*). Such circumstances call for adaptation initiatives especially in coastal zones of developing nations that are expected to be more challenging due to constraints on adaptive capacity (Nicholls *et al*., 2007).

Tanzania is highly endowed with biological diversity found on the coastal and marine ecosystems. It is endowed with: coastal forests – with endemic tree species – covering about 70,000 hectares, extending from the east of Islands of Pemba, Unguja and Mafia to the base of the Eastern Arc Mountains; extensive coral reefs[3] coverage of about 3,580 km^2, supporting artisanal fisheries – as they serve as habitat, nursery, feeding and spawning grounds for many fish species – and coastal tourism; seagrass beds[4], that are found in the sheltered areas of the coast around Kilwa, Rufiji, Ruvu and Moa; beaches, which provide key ecological and

[3] However, since the 1970s, coral reefs have been severely threatened by the use of explosives for fishing. As a dynamite-fisherman simply identifies a clump of coral around which fish are plentiful, he then lights a dynamite charge on a short fuse and tosses it into the water. The blast stuns or kills many of the fish in the vicinity, and then are then scooped up in handnets and taken back to the market for sale (Bryceson, 1978). In addition, the reefs are also subjected to climate change related pressures – especially increased temperatures and changed precipitations, leading to coral bleaching – as they are very sensitive to changes in water clarity and temperature (URT, 2010).

[4] Seagrass beds serve as "breeding, nursery and feeding areas for many invertebrate and vertebrate species; as important food source for herbivorous invertebrates, fish, dugong and green turtles; and also they trap sediments, which reduces sedimentation over coral reefs, thus protecting shorelines and beaches" (URT, 2010: 8).

economical services such as breeding, nesting and feeding sites from marine and bird species, as buffer zone against wave action, and as sites for recreational and touristic activities; and fishery resources[5] found along banks and coral reefs (Jiddawi, 2000; Dallu, 2004; Muthiga *et al*., 2008; URT, 2010). However, most of these resources and their diversities are under immense degradation pressures as a result of rapidly growing human activities along the coastal zones and marine environments (Bryceson, 1978; Dubi, 2000; Francis and Bryceson, 2001; Francis *et al*., 2002; Wagner, 2004; Ahrends, 2005; Masalu, 2009; Rocliffe and Udelhoven, 2010; URT, 2010). Illegal and destructive fishing practices[6], live coral and sand mining, intensive trampling on seagrasses, municipal wastewater, and clearing of mangrove and other coastal forests for commercial and domestic purposes – such as for aquaculture ponds, timber, industrial development, fuelwood and construction materials – are some of the human-induced activities that are threatening the coastal and marine ecosystems (Francis and Bryceson, 2001; Wagner, 2004; Ahrends, 2005; Masalu, 2009).

Such anthropogenic pressures upon the ecosystems are likely to be exacerbated with the climatic-induced pressures[7]. Tanzania, as it is with most of the countries found in the Indian Ocean region, appears to be highly vulnerable to climatic-induced changes, especially rising sea level and increasing ocean temperatures (Kebede *et al*., 2010; Pallewatta, 2010; Rabbani, 2010). Such circumstances are likely to enhance the pressures upon the ecosystems and mostly importantly the coastal zones of Tanzania, which contain high population and significant economic activities that are vital to the country's economy (Kebede *et al*., 2010). Therefore, creating a necessity for understanding how the government is responding to the

[5] There are about 8,000 species of invertebrates, 1,000 species of fish, 5 species of marine turtles and many seabirds (Francis and Bryceson, 2001: 77). In addition, most of the fish caught by artisanal fisherman – through inshore fishery – are demersal species (*Lethrinidae*, *Serranidae*, *Siganidae*, *Mullidae* and *Lutjanidae*), followed by large and small pelagic species (*Carangidae*, *Scombridae*, *Cluepidae* and *Engraulidae*). Other fish types caught include sharks, rays, crustacean, octopus and squids (Jiddawi, 2000: 65).

[6] Such as fishing through the use of poison, dynamite, beach seine, sticks, spears and dragged fishing nets (Francis and Bryceson, 2001).

[7] Notably, the projected increase of mean daily temperature by 3-5°C and mean annual temperature by 2-4°C (URT, 2003a).

changes in terms of setting up adaptation priorities and mainstreaming climate change agendas in coastal and marine related sectors and activities.

Against that background, this paper presents a review of the links between changing climates and coastal and marine ecosystems in Tanzania. It starts with an explanation of the methodological approach adopted in getting the data and information needed. Then, the gathered data are presented and discussed in sections: the first section presents and discusses the projected climatic-induced changes impacts on coastal and marine ecosystems. The second section presents and discusses how the Tanzanian government has responded to the changes, in terms of setting up or reinforcing institutional setup for implementation and coordination of adaptation priorities, as identified in the NAPA. Within this section, also a discussion climate change mainstreaming initiatives within coastal related sectors is done with the aim of identifying the successes, challenges and gaps. The third section presents and discusses Tanzania's development priorities in the coastal zones and the implications of projected changes upon such priorities. Lastly, a discussion on some of ecosystem management initiatives that are carried out, with relevance to climate change agendas is done, with an aim to identify further research areas. The last part of the paper presents a summary of issues that have been presented and discussed; and recommend for further research areas that need to be investigated for enhancing our understanding of the links between climatic changes and coastal and marine ecosystems in Tanzania.

1.2 Objectives of the study

The overall objective of this study was to undertake a comprehensive review of information and data about the links between climatic changes and coastal and marine ecosystems in Tanzania. The intention behind was to determine successes, challenges and gaps that are present in mainstreaming climate change agendas in coastal and marine ecosystems related sectors and activities. To achieve this, specifically, the study intended to:

a) Summarize the projected impacts of climate change on coastal and marine ecosystems in Tanzania;
b) Review governmental progress to date on implementing the NAPA and NAP, institutional mechanisms, and authorities;
c) Identify gaps and challenges for mainstreaming climate change in the coastal zone;
d) Describe donor and local supported adaptation initiatives related to the coastal zone.

2. STUDY AREA AND METHODOLOGY

2.1 The study area

The study used Tanzania as a case area; whereby the country's coastline and important ecosystems found within the coastline, large Islands and some Islets were used as study sites (see the figure 1 below). The Mainland's entire coastline extends 800 kilometres from 4°S to 10°S – Tanga to Mtwara – or from the border with Kenya in the north to Mozambique in the South [covering also Coast, Dar es Salaam and Lindi region] (URT, 2003b and 2010; Wang *et al*., 2003). The coast of Tanzania is hot and humid and home to areas of East African mangroves[8] and mangrove swamps that are ecologically important for coastal and marine ecosystems (URT, 2010). Most of the mangroves are found in the Rufiji Delta, which it has about 50,000 hectares of mangroves; making it the largest single mangrove forest in eastern Africa (Wang *et al.*, 2003). Other key features found in the coastal and marine ecosystems of Tanzania are: major estuaries, coral reefs, sandy beaches, cliffs, seagrass beds and muddy tidal flats (Malleret-King, 2003; URT, 2010). Such features and related ecosystems are pivotal to about 25% of the country's population (roughly about 13 million people), who depend on the ecosystems for artisanal fishing, lime and salt production, seaweed farming, smallholder farming and subsistence forestry (URT, 2003b). In the next section, a description

[8] The total land area covered by mangroves was 115,475 hectares in 1992 (Mangora, 2010); almost similar to an estimate of 115, 500 hectares as provided by URT (2010). But, another study provides different estimates for Mangroves coverage; it approximated Mangroves' coverage of about 109,593 hectares from 1988 to 1990, and about 108,138 hectares in 2000 (Wang *et al*., 2003).

of the methodological approach adopted by this study is presented.

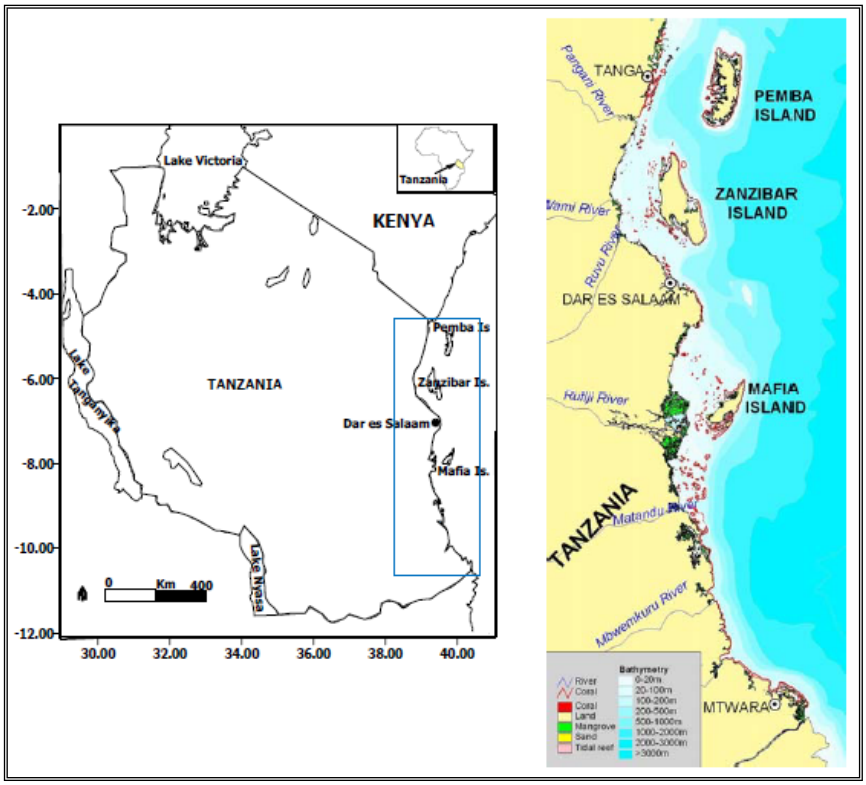

Figure 1: ***A map of the Tanzania's coastline showing important coastal and marine ecosystems*** (Source: Mangora, 2010: 5)

2.2 Methodological approach

The main methodological approach adopted for this report was based on collection and review of numerous relevant literatures on climate change, climate change impacts and climate change adaptation in coastal and marine ecosystems. Government and projects reports, scientific papers, peer-reviewed journal articles, conference papers, policies and strategies formed a significant part of the documentary review and analysis. The textual materials found in the literatures were defined and categorised, and relevant parts selected for answering the study's objectives (Bryman, 2008). In the next section, data and information gathered through the above described methodology are presented and discussed.

3. FINDINGS AND DISCUSSION

3.1 Projected impacts of climate change on coastal and marine ecosystems

In this section, some of the projected consequences of enhanced climatic disturbances to coastal and marine environments are presented and discussed. Significant consequences are expected to impact: fishery resources, coral reefs, seagrasses, mangroves and dependent human systems within the coastal zones.

The abundant biological diversity within the coastal and marine environments of Tanzania face severe threats from increasing ocean temperature, increasing weather variability, changing precipitation patterns and rising sea levels[9] (Alusa and Ogallo, 1992; Kebede *et al*., 2010; Pallewatta, 2010; Rabbani, 2010; URT, 2010). For instance, it is argued that changed patterns of sea surface temperature and precipitation, and sea level rise may have significant spatial and temporal impacts on fisheries (Alusa and Ogallo, 1992). The impacts may include effects on daily, seasonal and general ecology characteristics of fish such as the rate of respiration, metabolic functions, population dynamics – reproductive cycles, rates of growth and mortality, migration etc. – endocrine functions, body structure, cover and coloration and physiological processes (*Ibid*). In addition, fisheries are expected to be impacted through changes in habitat, potential destruction of breeding grounds and mangroves, and coral bleaching; occurrence and spread of some diseases and pests in fisheries; and through changes in the chemistry and physics of the coastal waters and the rest of the oceans, as a result of changes in concentration of gases in the oceans, upwelling, patterns of ocean currents, general cycles of various gases and effects of ultraviolet rays due to ozone depletion (Alusa and Ogallo, 1992; URT, 2010). The changes in the physiology or survivorship and reproduction of fish species will consequently, affect other species – including humans – that depend on it (Pallewatta, 2010).

[9] In Tanzania, a sea level rise of 0.5 m along the 800 km coastline would inundate 247 km^2 of the country; thus, having serious consequences for fisheries and livelihoods of the coastal people (Wong, 2010).

Moreover, increasing ocean temperature might have significant adverse effects on the coral reefs. The reefs are very important resources for humans and marine species, as they provide habitats to plants and animals, and protection of coastal areas from storm and wave damage; and they act as attractive scenery for tourism activities along the coast (Wagner, 2004; Pallewatta, 2010). The increasing ocean temperature might lead to coral bleaching[10], whereby zooxanthellae that live within the coral in a symbiotic arrangement die and finally, in turn, so does the coral (*Ibid*). Likewise, ocean acidification is argued to affect coral reefs as it corrosive to coral growth; and it is predicted that "by the middle of the next century, the process of coral calcification will decrease to the level where erosion will be greater than new growth" (Pallewatta, 2010: 11). Such circumstances will have devastating impacts on the coastal communities that have some kinds of dependences[11] on coral reefs, as the reefs "constitute the basis of food security and incomes for many coastal people" (Muthiga *et al*., 2008: 96).

Furthermore, seagrasses are ecologically important for the coastal and marine environments as they provide services such water oxygenation, organic carbon production and export, nutrient cycling and regulation, sediment stabilisation, trophic transfers to adjacent habitats; they also protect shorelines by restricting water movements, provide food for finfish, shellfish and mega herbivores including green turtles and dugongs; and they support commercially and recreationally important fisheries (Orth *et al*., 2006; Connolly, 2009). In Tanzania, seagrass farming has become a well developed industry, a significant export earner as well as an income and employment generator, and as a livelihood diversification strategy in coastal

[10] On March to May 1998, Tanzania experienced a coral bleaching event – reported in all parts of the Tanzanian coast – that coincided with higher than normal seawater temperatures and increased rainfall (leading to lower salinity). Bleaching was worse in shallow waters than in deep waters. The event had a negative implication on coastal tourism, with reported decline in touristic potential (Wagner *et al*., 2001: 471).

[11] Coral reefs support 70% of artisanal fish production in East Africa as well as being important for commercial fishing, as they are abundant with finfish, lobsters, prawns, crabs, octopuses, molluscs and sea cucumbers (Wagner, 2004). In addition, coral reefs are one of the major tourist attractions; as coastal tourism brings foreign currency, it also provides a livelihood for coastal people (*Ibid*).

communities (Crawford and Shalli, 2007). However, their dependence on light, temperature, carbon dioxide, nutrients and suitable substrate make them highly vulnerable to climatic change impacts[12], as these factors are affected by climate change (Connolly, 2009). For instance, as atmospheric carbon dioxide increases, so as the production and biomass of epiphytic algae on seagrass leaves (Björk *et al*., 2008). This may adversely impact seagrasses by causing shading, and changed competition between seagrass species and between seagrasses and algae may also have devastating consequences on seagrass ecosystems (*Ibid*). Likewise, the increased temperature and projected temperature increase within the marine ecosystems may add temperature stress[13] on seagrasses, resulting into "distribution shifts, changes in patterns of sexual reproduction, altered seagrass growth rates, metabolism, and changes in their carbon balance" (Short *et al*., 2001; Short and Neckels, 1999 as cited in Björk *et al*., 2008: 22). Moreover, enhanced extreme weather events like storm surges may have disastrous consequences on seagrass meadows; as such surges may cause massive sediment movements, leading to uprooting or burying of seagrasses (Björk *et al*., 2008). In addition, the increased turbidity may remain long after storm subsides, causing shading-out of the plants (*Ibid*).

Mangrove forests occur along the coastline of Tanzania, where they provide numerous ecosystem services such as fisheries production and nutrient cycling. They are also said to be amongst the most carbon-rich[14] forests in the tropics (Donato *et al*., 2011). However, as climatic factors such as temperature and moisture affect their distribution, mangroves become amongst the vulnerable ecosystems to climate change impacts, within the coastal zones (McLeod and Salm, 2006). For instance, it is projected that with increasing global

[12] For instance, the rising sea levels may adversely affect seagrass communities as a result of increases in water depths above present meadows – thereby reducing light (Björk *et al*., 2008).

[13] When temperatures reach the upper thermal limit for individual species, the reduced productivity will cause plants to die. In addition, Elevated temperature may increase the growth of competitive algae and epiphytes, which can overgrow seagrasses and reduce the available sunlight they need to survive (Björk *et al*., 2008: 22).

[14] Mangroves contain on average 1,023 Mg carbon per hectare; with organic-rich soils ranged from 0.5 m to more than 3 m in depth, accounting for 49-98% of carbon storage in mangrove ecosystems (Donato *et al*., 2011).

temperature, thermal stress on mangroves may also increase, and thus, affecting mangrove root structures and establishment of mangrove seedlings (*Ibid*). Other studies have projected that the increasing air temperature will force mangrove species to move poleward, to higher latitudes (UNEP, 1994; Field, 1995; Ellison, 2005 as cited in McLeod and Salm, 2006: 13). Likewise, damage to coral reefs through bleaching as a result of increased temperature and enhanced carbon dioxide concentrations, might adversely impact mangrove ecosystems that depend on the reefs to provide shelter from wave action (McLeod and Salm, 2006). In addition, sea level rising and enhanced weather events such as storm surges might affect mangrove health and composition due to changes in salinity, inundation and changes in the wetland sediment budget (Gilman *et al*., 2006 as cited in McLeod and Salm, 2006). All these consequences will put at increasingly risk coastal ecosystems and infrastructures that people and the country depend upon.

Furthermore, as climate change is projected to affect weather variability, there will be an increase of frequency and intensity of extreme weather events such as storm and tidal surges, tropical cyclones etc. For instance, with rising sea levels, the base on which storm surges is raised, making storm waves higher and carrying them farther inland (Rabbani *et al*., 2010). These may worsen coastal flooding and erosion[15], cause saltwater intrusion into freshwater ways, salinisation of soils and destruction of coastal infrastructure (Pallewatta, 2010; Rabbani *et al*., 2010). For instance, it is estimated that such weather events and associated sea level rise of 0.5 m and 1 m might lead to loss of important structures along the Dar es Salaam coastline, estimated at Tsh. 49.8 billion and Tsh. 85.9 billion respectively (URT, 2010).

3.2 Governmental response to the changes and consequences

In response to the above projected consequences, the government of Tanzania in collaboration with development partners and non-governmental organisations has taken a

[15] In some coastal areas of the Indian Ocean, a 30 cm rise in sea level can result in 45 m of landward retreat that will put vital coastal infrastructure increasingly at risk (Rabbani *et al*., 2010).

number of initiatives, based on institutional setups, adaptation priorities and mainstreaming activities. Some of these initiatives have been recently formulated; however, most pre-existed and/or have just been reformulated to correspond to the adaptation agenda. Below are some of the initiatives:

3.2.1 Institutional framework and coordination for coastal and marine ecosystem management

Tanzania has well developed management structures – in terms of policy and institutional frameworks – for overseeing the development and administration of coastal and marine resources (see figure 2 below for an overview of relevant policies and legislations in Tanzania mainland[16]). Such structures have been strengthened by the development of the *National Integrated Coastal Environment Management Strategy* in 2002 (URT, 2003b). The strategy provides a framework to overcome the previously dominated, fragmentation inherent in single-sector approach to coastal and marine resource management (URT, 2003b).

Policy or Law	Relevance
Policies and Frameworks	
National Environmental Policy (NEP, 1997)	Overarching national environmental policy focused on the conservation of the environment and effective use of natural resources
National Integrated Coastal Management Policy (2003)	Outlines commitment to sustainable coastal governance and champions integrated coastal management
National Wildlife Policy	Sets out simple, transparent procedures for stakeholder participation in the wildlife-based tourist industry, as well as for investment in other wildlife activities.
National Fisheries Policy	Gives priority to artisanal fishermen to help them improve their fishing methods and gear
National Tourism Policy	Aims to promote environmentally friendly tourism in protected areas. Also highlights the need for conservation of wildlife parks, reserves and other important natural areas
Legislation	
Environmental Management Act (EMA, 2004)	Overarching legal framework for the management of Mainland Tanzania's environment
Marine Parks and Reserves Act (1994)	Provides for the establishment, monitoring and management of marine protected areas
Wildlife Conservation Act (1974)	Gazettes national parks
Fisheries Act (2003)	Regulates the fishing industry, especially in MPAs
Forest Act (2001)	Designates Mangrove Forest Reserves and encourages community-based management
Sources: (Mwaipopo 2008; UNEP/Nairobi Convention Secretariat and WIOMSA 2009; WWF 2007; WWF 2004b; Hatton 2001; Kamukuru et al. 2004; Sterner & Andersson 1998)	

[16] Environmental matters are not within the Union issues; thus, Mainland Tanzania and Zanzibar each has its own institutional frameworks.

Figure 2: ***Key policies and legislation relating to coastal and marine resources management in Mainland Tanzania*** (Source: Rocliffe and Udelhoven 2010: 34)

The adoption of the national integrated coastal management strategy repealed such a sectoral based administration of coastal and marine resources. The strategy developed a new institutional structure that caters the needs for all coastal related sectors, with an overarching aim of achieving sustainable coastal and marine resources development and management. The newly created structure has three tiers: (a) national steering committee on integrated coastal management, (b) integrated coastal management unit, and (c) intersectoral working groups (URT, 2003b).

a. National steering committee on integrated coastal management

The committee is made up of directors from relevant coastal and marine resource related sectors[17] and representatives from the local level to coordinate actions and decisions related to Integrated Coastal Management – ICM (TCMP, 1999; URT, 2003b). The directors provide a filter between the technical level activities and the more sensitive political decisions made at the ministerial level (TCMP, 1999). While, the representatives from the local level provide a vital link between decision making at the central level and locally based goals and activities (*Ibid*). Generally, the committee provides policy oversight and guidance on the overall vision and implementation of ICM activities (Akwilapo, 2011). The committee also endorses formation of issue specific working groups, within the third structural level. It also facilitates the resolution of intersectoral conflicts, and conflicts between national and local interests related to ICM activities (*Ibid*).

b. Integrated coastal management unit

This unit serves as a secretariat to the national steering committee (Akwilapo, 2011). It has the role of supporting ICM through provision of accurate and timely information related to

[17] The relevant sectors are: fisheries, forestry, tourism, industry and trade, agriculture, mineral and energy, water, lands and human settlements, and environment (TCMP, 1999).

ICM activities (TCMP, 1999). The disseminated information largely covers on new and updated international agreements and national policies and legislation that affect coastal and marine resources management (*Ibid*). The unit convenes and supports the intersectoral working groups. In collaboration with relevant authorities, the unit also identifies and facilitates the process of establishing new ICM projects and programs for donor funding. In addition, it works with the sectors to ensure that cross-boundary and marine contingency issues and actions are incorporated, as appropriate, in district-level ICM planning and implementation (*Ibid*). However, the coastal management unit has not been active since its function has been mainly dependent on project funding.

c. Intersectoral working groups

These are the engines of for successful ICM in Tanzania. They are composed of technical experts representing different disciplines and sectors, including representatives from the private sector and communities (TCMP, 1999; URT, 2003b; Akwilapo, 2011). Under this tier, three sub-groups are present: (i) Core technical working group – with members from relevant sectors. The group provides technical assistance to districts as they develop local action plans; and works with districts to solve specific problems. (ii) Issue specific working group – draws its members[18] from relevant sectors to develop issue specific guidelines. The group also provides a venue for sectors related to specific management issues to work together on specific problem solving that considers multiple perspectives. (iii) Science and technical working group – provides advice and guidance related to scientific questions, studies, data management, and sampling and monitoring efforts necessary for improvement of the scientific foundation of the national steering committee's activities. However, functions of these working groups have been mainly dependent on project funds. This raises a question on sustainability of such coordination mechanisms.

[18] It is suggested that, at least 25% of the membership will be drawn from the core technical working group to maintain consistency and exchange of information (TCMP, 1999).

Additionally, in recognition of the observed and projected sea level rising within the Indian Ocean, Tanzania[19] has been a member of the Intergovernmental Oceanographic Commission (IOC). The country has cooperated with other members in the development of a Global Sea Level Observing System (GLOSS) (Nhnyete and Mahongo, 2007). The system was established in 1985 to monitor global sea levels and support member countries' capacities to assess and anticipate changing risks (*Ibid*). The two major stations for monitoring sea levels – the Dar es Salaam and Zanzibar stations – are operated by the Tanzania Ports Authority and Department of Surveys and Urban Planning respectively (*Ibid*).

3.2.2 National adaptation priorities for coastal and marine ecosystems

The guiding framework for the country's climate change adaptation priorities is provided through the *National Adaptation Programme of Action* (NAPA). The overall aim of NAPA is to identify immediate and urgent adaptation actions that are robust enough to lead to long-term sustainable development in a changing climate (URT, 2007). NAPA acknowledges that climatic-induced changes pose a threat – in terms of rising temperature and sea levels – to coastal and marine environments, and the dependent human systems. The threat is largely, due to the fact that the environments contain resources which are vital for socio-economic wellbeing of the coastal people and the country as a whole. In terms of the country's adaptation priorities, coastal and marine resources, as a sector, was ranked 9th out of 11 priority sectors (URT, 2007). Such a ranking raises a lot of questions, bearing in mind the socio-economic significances of the coastal and marine ecosystems for the country's economic gains. However, the ranking is not based on scientifically credible vulnerability assessment information, rather on expertise opinion which is subject to biasness. Construction of artificial structures such as sea walls – to protect the coastal infrastructures

[19] The Tanzanian sea level network consists of two operational stations of Zanzibar and Dar es Salaam; and four nonoperational historical stations at Mtwara, Tanga, Latham Island and Mkoani in Pemba. The Zanzibar station has a satellite transmission centre that has been operating since 1984, while Dar es Salaam has a mechanical float gauge (Nhnyete and Mahongo, 2007).

against rising sea levels and enhanced extreme weather events – is ranked as the highly prioritised adaptation activity under the sector (*Ibid*). The other prioritised adaptation activities with their ranks in brackets are: restoration of degraded habitats (2), reduction or elimination of non-climate stress and monitoring (3), relocation due to sea level rise of small island communities (4), establishment of protected areas (5), and desalination of saltwater where possible (6). In addition, NAPA has given a priority number three to one adaptation project related to coastal zones. The project titled *Shifting of Shallow Water Wells Affected by Inundation on Coastal Regions of Tanzania Mainland and Zanzibar*; aims at constructing new water wells to enable people have reliable access to safe and clean drinking water and for other development processes (*Ibid*). The projected was planned to run for three years with a budget of US$ 3,300,000, in the five coastal regions of Tanzania.

Furthermore, Tanzania through a proposed project titled *Implementation of Concrete Adaptation Measures to Reduce Vulnerability of Livelihood and Economy of Coastal and Lakeshore Communities in Tanzania*, aims at reducing the vulnerability of livelihoods, infrastructure and economy through implementation of concrete and urgent adaptation measures (URT, 2010). The project was planned to start in March of 2011 and end in June of 2016; and was expected to be implemented alongside, and in collaboration with NAPA. Of great interest to this study are two of the project's expected outcomes: (a) reduced adverse impacts of sea level rise on coastal infrastructure and settlements, and (b) implemented coastal and shorelines ecosystem rehabilitation and ICM (*Ibid*). In the outcome (a), the project planned to spend US$ 2,667,663 in a number of activities: (i) assessment of coastal engineering needs, (ii) assessment of climate change impacts on infrastructure and adaptation needs, (iii) raising and rehabilitation of sea walls in areas showing damage, and (iv) strengthening of districts' capacities to adequately manage rehabilitated infrastructure. In outcome (b), the project planned to spend US$ 1,743,225 in these activities: (i) rehabilitation

of mangroves through planting of resilient seedlings, (ii) coral reef rehabilitation and protection in coastal sites, (iii) beach nourishment and coastline reforestation, (iv) shoreline management and rehabilitation using trees and grasses, (v) wetland rehabilitation, and (vi) approving of one ecosystem-based ICM plan for the coastal region.

Likewise, Zanzibar through an ongoing project[20], titled *Strengthening environment and climate change governance for Zanzibar*, aims at putting in place strategies for climate change adaptation in Zanzibar and at improving the level of availability and awareness on climate change impacts and adaptation strategies among the general public (UNDP, 2012). The project is designed to strengthen the foundation for climate change governance and initiating long term mechanisms for supporting Zanzibar to cope with current and future climate change challenges (*Ibid*). The central focus of the project is on 'soft' adaptation measures, which aim at strengthening institutional frameworks for managing climate related risks and opportunities. In addition, the project also supports initiatives for putting in place mechanisms and governance systems for effective use of climate change funds that are to be used for adaptation activities (*Ibid*).

3.2.3 Climate change mainstreaming in the coastal and marine related sectors

The adoption of the national integrated coastal management strategy signals the intended will of Tanzania in linking and coordinating coastal and marine related sectors, with the aim to achieved sustainable resource development and management. This strategy provides a better framework upon which climate change related activities could be integrated into the broader coastal and marine ecosystems and development priorities. There are a number of projects and programmes that have been initiated and implemented in an integrated manner. Some of these projects (detailed discussion follows in section 3.4 below) are: (i) *Tanga Coastal Zone Conservation and Development Programme*, (ii) *Rural Integrated Project Support*

[20] The project is valued at US $2,800,000; it is implemented for 3.5 years from April 2012 to June 2015.

Programme, (iii) *Mangrove Management Programme*, (iv) *Rufiji Environment Management Project*, (v) *Kinondoni Coastal Area Management Programme*, and (vi) *Marine and Coastal Environment Management Project*.

To understand how the strategy has performed in terms of its main goal, it is important to look at the strategy's main elements. Even though, an analysis of the created institutional structures may be included. The strategy has seven elements: (i) support environmental planning and integrated management at the local level and provide means to harmonise national interests with local needs, (ii) promote integrated and sustainable approaches to the development of major economic uses of the coastal resources to optimise benefits, (iii) conserve and restore critical habitats while ensuring coastal people continue to benefit from sustainable resource use, (iv) establish an integrated planning and management mechanism for coastal areas of high economic interest and with substantial environmental vulnerability to natural hazards, (v) develop and use of an effective coastal ecosystem research, monitoring and assessment system that will allow available technical and scientific information to inform ICM decisions, (vi) provide meaningful opportunities for stakeholder involvement in coastal development process and implementation of coastal management policies and (vii) build both human and institutional capacity for interdisciplinary and intersectoral management of coastal environment (Delaney, 2002; Robadue, 2005).

With extensive support from the Tanzania Coastal Management Partnership[21], Tanzanian government has achieved some successes in the context of ICM. First of all, TCMP has supported the creation of the scientific working groups[22] that have done number activities in studying and planning for sustainable management of coastal and marine resources. TCMP

[21] A joint initiative between: USAID, NEMC and Coastal Resources Center at the University of Rhode Island

[22] TCMP supported the creation of the core working group that embarked in policy adoption process – briefing on the need for ICM policy to the executives – and supporting district level planning; and the creation of the scientific and technical working group, whose first activity was to prepare a state of the coast reports, which it successfully did (TCMP, 2000).

together with the working groups and relevant sector ministries have been able to prepare economic sector reports and guidelines for sustainable economic development activities along the coast (Delaney, 2002). The *Coastal Tourism Situation Analysis*[23] , *Guidelines for Coastal Tourism Development in Tanzania, Guidelines and Procedures for Development and Investment in Marine Parks, Reserves and Small Island*[24] and *Tanzania Mariculture Investor's Guide*[25] provide a pro-active approach upon which coastal and marine development activities will be informed. Moreover, with the successful publication of the *Tanzania State of the Coast Report 2001 and 2003*, it is clear that ICM activities have baseline measurements and relevant performance indicators to measure their effectiveness (Delaney, 2002). TCMP has also supported development and creation of district ICM plans in Mkuranga, Bagamoyo and Pangani districts (Robadue, 2005). These have provided platforms for enabled conversations and collaborations among people and relevant agencies that typically had not integrated their activities. In addition, they have enabled to raise awareness and trainings on ICM issues amongst district level natural resources officials (*Ibid*).

Furthermore, there has been a considerable success in terms of conserving and restoring critical coastal and marine habitats. This is evidenced with a number of existing marine protected areas in Tanzania: marine parks (Mafia Island, Mnazi Bay–Ruvuma Estuary and Tanga Coelacanth), collaborative management areas in Tanga (Boma-Mahandakini, Deepsea-Boma, Mwarongo-Sahare, Mtang'ata, Boza-Sange and Mkwaja-Sange) and marine reserves (Maziwe Island – located in Pangani, Dar es Salaam with small islands [Bongoyo, Makatube, Sinda, Kendwa, Mbudya and Pangavini], Nyororo, Mbarakuni and Shungimbili located north of Mafia Island; and small islands of Kwale, Mwewe, Ulenge and Kirui). In total, there are

[23] The report provides a broad assessment of the status of coastal tourism and identifies priority actions needed to develop a sustainable coastal tourism industry (TCMP, 2001a).
[24] The guidelines provide frameworks to ensuring environmentally friendly coexistence between coastal and marine resources and investment ventures.
[25] The guide provides guidance on how to develop and invest environmentally sound mariculture development initiatives (TCMP, 2001b).

three marine parks and 15 marine reserves covering a total land of 2,172.74 km^2 (MACEMP, 2012). These have been supported with several specific integrated coastal initiatives such as seaweed projects, beekeeping in mangroves and community based fisheries management in Dar es Salaam Marine Reserves (Robadue, 2005).

However, some governance challenges are noted within the marine protected areas, with presence of limited substantial benefits from such initiatives to the communities; lost livelihood options as a result of expulsion from traditional fishing grounds; and mistrust of government and nongovernmental organisations that lead to violations of rules and regulations (Mwaipopo, 2008). Another major challenge to ICM related initiatives is the dependence on donor funded projects or programmes. Most of the local ICM initiatives taking place or that have taken place in Tanzania are donor funded projects or programmes. Thus, their successes literally depend on the availability financial and technical assistance from the donor. If donors cease the support, then initiatives become susceptible to failure.

Furthermore, with the implementation of the project *Strengthening environment and climate change governance for Zanzibar*, Zanzibar's Vice President's Office (ZVPO) with support from the United Nations Development Programme (UNDP) aims to mainstream climate change adaptation into the implementation of the Zanzibar's Strategy for Economic Growth-II (UNDP, 2012). The central focus is to integrate principles of sustainability into the strategy and initiate mechanisms at all levels for consideration of climate change concerns (*Ibid*). Thus, the strategy recognises the need to integrate, harmonise and coordinate environmentally sustainable policies for growth, and the need to strengthen adaptation responses at all levels (*Ibid*). In addition, one of the project's tasks is to conduct risk assessment; the assessment aims to provide an opportunity for assuring climate resilient economic growth in Zanzibar. The assessment is supposed to be conducted in line with a

vulnerability assessment that aims at planning, delineating and allocating funds for adaptation support to identified priority sectors (*Ibid*).

3.3 National coastal development priorities

Tanzania's development priorities in the coastal zones can be grouped into four categories: (i) tourism, (ii) mariculture, (iii) natural gas and petroleum exploration and exploitation, and (iv) infrastructural. The coastal ecosystems are of vital for the country's social and economic development. The coastal zones contain some of important country's infrastructures such as: major ports[26] in Dar es Salaam, Tanga, Mtwara and Zanzibar; 75% of all industries in the country; mariculture schemes (largely seaweed farms); and considerable natural gas exploration and exploitation (Alusa and Ogallo, 1992; TCMP, 1999 and 2001b; URT, 2003b; Nhnyete and Mahongo, 2007 ;). Likewise, the zones contain untapped tourism attraction sites all over the country's coastline.

Tanzania has realised that the bulk of tourist activities are located in the Northern Circuit. Such a realisation has necessitated planners to identify new areas around the country that should receive special attention in development new tourism ventures (MNRT, 2003). One of the identified areas is the country's extensive coastline. The coast of Tanzania is home to many excellent natural and cultural resources that have the potential to serve as world-class tourist attractions (TCMP, 2001a). Such an attention corresponds to what the ICM strategy noted on facilitating appropriate investment in emerging economic opportunities of the cost (MNRT, 2003). However, coastal tourism potential was untapped for long due to infrastructural constraints – impassable roads, inconsistent ferry services, infrequent and expensive flights and undeveloped accommodation facilities – in most of the coastal zones in Mainland Tanzania (*Ibid*). To tap the touristic potential of the coastal zones, while ensuring

[26] These ports handle Tanzania's cargo and transit goods to land-locked countries of Burundi, Rwanda, Democratic Republic of Congo, Malawi, Zambia and Uganda (Nhnyete and Mahongo, 2007).

sustainable development, five priorities have been recommended: (i) to develop streamlined investment procedures for coastal hotel development, (ii) identify priority areas for coastal tourism development and develop comprehensive tourism management plans, (iii) improve accessibility to coastal tourism areas, (iv) promote local investment in coastal tourism areas, and (v) conduct economic analyses on the costs and benefits of different types of coastal accommodation and develop right mix of investment incentives (TCMP, 2001a). If realised, the following coastal areas are likely to attract significant tourism investment: Kilwa Masoko, Saadani National Park, Mafia Island, Dar es Salaam city, Mnazi Bay and certain areas of the Rujifi Delta (MNRT, 2003).

Furthermore, Tanzania is endowed with a big potential in aquaculture both in marine and freshwater (MLFD, 2011). Such a potential is supported with an existence of desirable organisms which can be used for propagation. They are: marine water shrimps (*Penaeus monodon*), milkfish (*Channos channos*), crabs (*Scylla seratta*) and oyster for meat and pearls production (*Ibid*). Likewise, seaweed farming is another prioritised venture in the coastal zones, with *Eucheuma spinosum* and *E. cotonnii* being the most farmed and desirable species. Currently, only 30% of the potential area for seaweed farming is utilised along the country's coastline (*Ibid*). In showing the desire to utilise mariculture potential of the coastal zones, the government in collaboration with development partners has developed two important guiding tools: the *Mariculture Investor's Guide* and *Investment Opportunities in the Fisheries Industry*. In one of the tools, it is observed that there are 3,000 hectares suitable for shrimp farming along the country's coastline with a production potential of over 11,000 metric tonnes annually (MLFD, 2011). Other prioritised mariculture investment opportunities are: mud-crab farming, pearl production, finfish culture and collection and culture of ornamental fish (*Ibid*).

The natural gas sector is a new and booming development priority in Tanzania's coast zones. Two of the operating production sites – at Songo Songo and Mnazi Bay – are located along the coast of the country. In addition, there are several exploration blocks located along the coast and in deepwater sea. And there are more blocks located in deepwater sea that are either under bidding process or waiting for future bidding rounds. The sector is being seen as potential for curbing power shortages and crises in Tanzania. This is due to the fact that, Tanzania has abundant natural gas with 45 billion m^3 of proven reserves (URT, 2011). In ensuring an environmental friendly sector, the draft natural gas policy has an objective of ensuring environmental compliance and standards are adhered in natural gas activities. Likewise, effective adoption and implementation of Integrated Water Resource Management (IWRM) will assure that the sector complies with environmental sustainability. This is due to the fact that IWRM provides opportunities for cross-sectoral coordination and harmonisation of policies, plans, strategies and laws related to water resources. In addition, as within IWRM there is an integration of water and land management, i.e. a concern on the need to integrate water and land resources utilisation. Thus, the framework requires that any development along the coast should ensure environmental sustainability.

Currently, Tanzanian coastline houses four major ports. However, with a plan to create an Economic Processing Zone (EPZ) in Bagamoyo district, and with limited port expansion at Dar es Salaam, due to lack of space, a new port is expected to be build in the district (URT, 2011). Likewise, Tanzanian government has plans to undertake port upgrading activities in its existing ports to cater rapidly increasing development needs and opportunities.

3.4 Ecosystems management initiatives with relevance to climate change agendas

Tanzania has been undertaking several conservation initiatives with the aim of achieving sustainable coastal and marine resources management. Although, these initiatives may not directly relate to climate change adaptation, but they do provide critical information that

could be used in adaptation agendas along the coastal zones. Bearing in mind the fact that, anthropogenic pressures on these resources are likely to be exacerbated by climatic-induced pressures. Below is a presentation of some conservation initiatives that have been and are being implemented along the coastal zones of Tanzania.

***a. Tanga Coastal Zone Conservation and Development Programme* (TCZCDP)**

The programme started in 1994 with an aim of enhancing the wellbeing of coastal communities through management of coral reefs and mangroves in a collaborative approach (TCZCDP, 2003). Since its inception, the programme has received financial support from the Irish Aid and technical advice from the IUCN – Eastern Africa Regional Office (*Ibid*). The programme has passed several phases: phase 1 (1994-1997), phase 2 (1997-2000) and phase 3 (2001-2003). Several successes were noted: 32 out 40 villages were implementing collaborative fisheries management; 80% of the coastline was monitored[27] regularly, leading to a 67% reduction in dynamite fishing; and a draft of teachers' coastal environmental education manual book was prepared (TCMP, 2000). However, in 2005, IUCN handed over the programme to the government and Irish Aid's financial support ceased in 2007 (Samoilys and Kanyange, 2008). Under significantly reduced budget, a range of activities have been also reduced to fit the available budget. Although monitoring of reefs and fisheries is still enforced by district officers in collaboration with the village monitoring team, trained under TCZCDP (*Ibid*).

***b. Rural Integrated Project Support Programme* (RIPS)**

The programme was initiated since 1988 covering the Mtwara and Lindi regions (Eskola, 2003). It was receiving financial and technical support from the Finnish government. It is said to be one of the biggest rural development programme in which Finland has ever engaged in terms of total budget (*Ibid*). Its overall goal was to enhance livelihoods of the rural population

[27] Regular monitoring resulted into increased density of commercially important fish population as a result of improved coral reef health (TCMP, 2000)

and works with the coastal communities to reduce dynamite fishing and raise awareness on the importance of coastal and marine resources. The main underlying principle of the programme is to encourage local government and civil societies to use "participatory methods for collaborating with communities in the analysis of development needs and opportunities, the mobilisation of community and external resources, and the implementation and monitoring of development activities" (Eskola, 2003: 20). The programme passed through three phases: phase 1 (1988-1993), phase 2 (1994-1999) and phase 3 (1999-2005). In 1994, a *Marine Environmental Protection Programme* was initiated for the Lindi and Mtwara districts with facilitation from the RIPS (Wagner, 2004). The program included seaweed farming, patrol for dynamite fishing, a village credit revolving scheme to enable fishermen to buy conventional fishing gear and the production of media materials to enhance environmental awareness (*Ibid*).

***c. Mangrove Management Programme* (MMP)**

This national programme was initiated in 1988 to promote mangrove conservation and sustainable utilisation. The programme has continued to undertake sustainable management of the country's 115,500 hectares basing on these strategies: (i) involvement of local communities through the formation of village natural resource committees which oversee community based conservation activities, (ii) intersectoral coordination through collaborative meetings and workshops involving various relevant sectors and stakeholders, and (iii) awareness raising through sensitisation activities on mangrove conservation undertaken through training, seminars, radio programmes and interactive video (TCMP, 2000).

***d. Rufiji Environment Management Project* (REMP)**

The project was initiated – with a five year phase (1998-2003) plan – within Rufiji district in the ecosystems affected by flooding of the river (floodplains), downstream of the Selous Game Reserve and several upland forests of special importance(Mwilawa, 2003). Its main

goal was to promote long-term sustainable conservation through wise use of the lower Rufiji forests, woodlands and wetlands. The project was implemented with technical support from IUCN and financial assistance from the Royal Netherlands Embassy (*Ibid*). The project has some considerable successes: (i) economic valuation of natural resources was carried out in nine villages, (ii) land cover and land use map was revised, (iii) meteorological station at Utete was re-established and one district officer was trained in data collection, (iv) district environmental management plan for the delta and floodplain was established and (v) a study on fuelwood use and potential alternative was undertaken (TCMP, 2000).

e. Kinondoni Coastal Area Management Programme (KICAMP)

The programme was set up in 2000 to develop a local ICM strategy through identification of priority coastal issues and development of a strategy to address them. With support from SIDA, the programme started with two pilot areas of Mbweni and Kunduchi wards with an overall aim of improving the understanding and management of marine and coastal resources in Kinondoni district (TCMP, 2000). It had four major components: (i) coastal land and water use planning, (ii) coastal community development, (iii) coastal surveys, assessments and monitoring, and (iv) education, information and communication (*Ibid*). To achieve such interventions under collaborative approach, the programme and its activities were merged within the Kinondoni municipal council [in the department of natural resources] (Muthiga *et al*., 2008). The program was able to facilitate community-based monitoring of several aspects of the environment including coral reefs, although the practice had some irregularities (Wagner, 2004). Some of its activities in component (iii) were undertaken in the Dar es Salaam Marine Reserves; thus, supporting the management of critical habitats (MNRT, 2006).

f. Marine and Coastal Environment Management Project (MACEMP)

It was a 6 years project (2005-2010) with an aim of strengthening the sustainable management and use of exclusive economic zone, territorial seas and coastal resources (MNRT, 2006). The project expected outcomes were: (i) enhanced revenue collection, (ii) reduced threats to the environment, (iii) better livelihood for participating coastal communities, and (iv) improved institutional arrangement (*Ibid*). Under component 2 of the project, "sound management of the coastal and marine environment", the project had an intervention of building ICM strategies to empower and benefit coastal communities (MACEMP, 2012). Some successes were noted: (i) own-revenue generation as percentage of recurrent costs rose from 40% at the baseline to 150% by the end of MACEMP, (ii) management plans were operational and implemented in all existing and emerging marine protected areas, (iii) a number of training seminars and workshops on issues related to ecotourism, entrepreneurship and conservation of coastal and marine environments were carried out at community level, (iv) various awareness and sensitisation materials – such as leaflets, articles, TV programmes and documentaries – were developed, and (v) consultative meetings were held with neighbouring coastal states in the Western Indian Ocean region including Kenya and Mozambique, with attention to transboundary management of coastal and marine ecosystems (*Ibid*).

g. Other related conservation initiatives

Rufiji-Mafia-Kilwa Seascape Project: financed by WWF, with an aim to have a marine ecoregional approach to biodiversity management of the Eastern African Marine Ecoregion. It has assisted in integrating coastal zone management in Rufiji, Mafia and Kilwa districts, to include incentives for alternative economic generation activities to reduce pressure on coastal resources. A specific management effort is tackling the use of live massive corals to make lime in the Mafia Island, Mtwara and Lindi areas (Muthiga *et al*., 2008).

Turtle and dugong conservation programme: initiated in January of 2001 on Mafia Island and its associated island in collaboration with Mafia Island Marine Park and district natural resource office, with funding from WWF and Borne Free Foundation (MNRT, 2006). In April of 2004, the programme was expanded to include the entire Tanzanian coastline. The main goal is to promote conservation of turtles and dugongs, and their habitats in Tanzania and the Western Indian Ocean region. It aims also at enabling coastal communities to manage the coastal and marine environments for their benefits (*Ibid*).

The UNDP/GEF Mnazi Bay-Ruvuma Estuary Marine Park Project: took off in April 2002 with an emphasis on biodiversity conservation and sustainable use of marine resources by communities in and around the marine park (MNRT, 2006).

Furthermore, with a close connection between freshwater and marine ecosystems, Tanzania – through the national water policy of 2002 and national water sector development strategy 2005-2015 – has developed a water governance framework that supports integrated management for water resources in both terrestrial and coastal hydrological systems. The framework – Integrated Water Resource Management (IWRM) – supports a multi-sectoral and multidisciplinary water resources management and planning that integrates freshwater systems and coastal zones, and also land and water uses (MWLD, 2002). Currently, Pangani and Rufiji basins are the only basins – amongst the nine basins found in Tanzania – that have started implementing IWRM in Tanzania. In Pangani River Basin[28], the government of Tanzania with support from UNDP is implementing a project titled *Mainstreaming Climate Change into Integrated Water Resources Management in Pangani River Basin*, with the aim of supporting the equitable provision of freshwater for the environment – such as coastal and marine ecosystems – and for current and future livelihoods (UNDP, 2007; SMEC, 2012). Likewise, since 2001, WWF-Tanzania Country Office with support from WWF-UK has been

[28] The basin drains Mount Kilimanjaro and Mount Meru and flows into the Indian Ocean

implementing IWRM related activities within the basin (Kangalawe, 2010). By the year 2010 IWRM plan and guidelines for the whole basin were prepared. The implementation of IWRM in the basin has been argued to be amongst the reasons for the restoration of year round flows of the Great Ruaha River and reduced water use conflicts (*Ibid*). Generally, if IWRM is to be implemented effectively, it offers the best way for Tanzania to improve the ability to cope with today's water challenges, such as pollution and climate variability. Thus, if there are improvements in the ways water is used and managed today, it will be easier to address water challenges of tomorrow, such as the projected climate changes.

In addition to the above presented initiatives, there has been a presence of considerable research and monitoring activities undertaken by local and foreign research institutes, and nongovernmental organisations (Masalu, 2009). These institutions have been involved in research and monitoring studies dealing with diverse coastal and marine ecosystems – have dealt with coral reefs, mangroves, seaweed farming, seagrass beds, coastal erosion etc. These institutions are: the Institute of Marine Science (IMS), Faculty of Aquatic Science and Technology (FAST), Tanzania Fisheries Research Institute (TAFIRI), Mbegani Fisheries Development Centre (MFDC), Marine Parks and Reserve Unit (MPRU), Research and Monitoring sections in Fisheries Division and TCMP (*Ibid*). For instance, MPRU in collaboration with TAFIRI, IMS, FAST and African Coelacanth Project (ACEP – South Africa) did carry out studies on Coelacanth and associated habitats in Tanga. Significant financial and technical supports to research and monitoring activities have been obtained from WWF and IUCN; who have for long supported studies on different themes within Tanzania's coastal zones (*Ibid*). Monitoring activities have even taken a community based approach. For instance, community-based coral reef monitoring has been undertaken in Tanga, Dar es Salaam, and Bagamoyo; and new areas such as Mkuranga, Mnazi Bay, and Kilwa (Songosongo) are being added (Muthiga *et al*., 2008; Masalu, 2009). In addition,

SCUBA based reef monitoring by IMS team has continued in Zanzibar and Dar es Salaam sites, although inadequate financial resources has hindered their undertakings (Masalu, 2009).

4. CONCLUSIONS AND RECOMMENDATIONS

The study has presented a review of the existing and projected links between climate change and coastal and marine ecosystems in Tanzania. Reviewed literature and information has indicated that the projected climatic-induced disturbances such as rising sea level, increased temperature and enhanced extreme weather events are likely to exacerbate more pressures on coastal and marine ecosystems, such as mangroves, seagrasses, fisheries, beaches and coral reefs. In responding to the projected changes, Tanzanian government has undertaken a number of initiatives. Notably, NAPA is the guiding framework for adaptation priorities; with engineering and mechanical activities to adapt to rising sea levels along the coast being highly preferred. Likewise, with the adoption of the ICM strategy, Tanzania has taken a bigger step in setting up harmonised and coordinated coastal and marine resource management. The experiences gained from a number of ICM related conservation programmes and projects along the coast could provide significant baseline information for developing more adaptation strategies for both people and ecosystems. However, caution should be taken with regard to governance challenges that are said to exist in marine protected areas; and dependence on donor funding and technical supports for implementation of the initiatives.

The study recommends on several aspects: (i) there is a need to undertake socio-ecological and governance studies in understanding how governance structures influence implementation of ICM initiatives – lessons from forestry and wildlife sectors could be useful. (ii) With most of coastal and marine ecosystems – such as mangroves, seagrasses, and tidal marshes – being argued to have higher carbon stocking capacity than other ecosystems like tropical forests, there is an urgent need to carry out empirical studies that could provide baseline information for Tanzania to venture into “blue carbon” initiatives. (iii) Lastly, there

is a need for enhanced political will that might make it easier the avoidance of donor dependence for financial and technical supports in implementing ICM projects.

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