African Journal of Environmental Science and Technology Vol. 2 (9). pp. 239-248, September, 2008
Available online at http://www.academicjournals.org/AJest
ISSN 1996-0786 © 2008 Academic Journals

Review

Adaptation technologies and legal instruments to address climate change impacts to coastal and marine resources in Tanzania

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Accepted 16 September, 2008

The increase in greenhouse gases in the atmosphere and the consequent pressures related to climate change are having significant impacts on the coastal and marine resources on which much of Tanzania's coastal population depends for its livelihood. A decline in mangrove cover, coral bleaching and mortality and the destruction of seagrass beds are some of these impacts. Coastal erosion also poses threats to the country's coastal tourism infrastructure. This study examines various approaches that integrate protection and conservation of coastal and marine resources. It briefly highlights the global and regional issues while emphasis is put on Tanzanian perspective. Guidelines and reports for management interventions and adaptive technologies are discussed. Environmental protection remains the most preferred approach with variety of options. An overview is given on soft and hard adaptation technologies. Furthermore, Tanzania's relevant policies and legislation that address climate change impacts to coastal and marine resources are reviewed.

Key words: Climate change, coastal and marine resources, adaptation technologies, legal instruments.

INTRODUCTION

Climate change is defined as any long-term significant change in the "average weather condition" that a given region experiences. This change can be caused by dynamic processes on earth, external forces including variations in sunlight intensity, and more recently by human activities (IPCC, 2007). Climate changes reflect variations within the earth's atmosphere and processes in other parts of the earth such as oceans. The external factors that can shape climate are often called climate "forcings" and include such processes as variations in solar radiation, the earth's orbit and greenhouse gas concentrations (Royer et al., 2007).

Climate changes can result from interaction of the atmosphere and oceans. Many climate fluctuations — including not only the El Niño Southern oscillation but also the Pacific decadal oscillation, the North Atlantic oscillation, and the Arctic oscillation — owe their existence at least in part to different ways that heat can be stored in the oceans and move between different reservoirs. On longer time scales ocean processes such as thermohaline circulation play a key role in redistributing heat, and can dramatically affect climate (Primeau, 2005).

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Global climate change and its impacts to coastal and marine environments

Global mean surface temperature has risen around 0.5°C over the last century and is expected to rise by between 2 and 4.5°C during the next century (IPCC, 2007). The most likely value is about 3°C and the rates of increase of the mean air temperature would be higher than any known to have occurred over the last 10,000 years. It is predicted that global mean sea level will rise by about 20 cm by 2030 and by 65 cm by the end of the next century and by the year 2080, millions of people are projected to be displaced by flooding due to sea-level rise (Post and Lundin, 1996; Houghton et al., 2001; Pearson et al., 2001; IPCC, 2007). The ocean is also becoming more acidic. The uptake of anthropogenic atmospheric carbon dioxide since 1750 has led to an average decrease in pH of 0.1 units and this process is continuing (Hoegh-Guldberg, 2007). The resilience of many ecosystems to these pressures is likely to be exceeded during this century. Climate change and sea level rise together will expose many coasts to increasing risks, including coastal erosion and inundation (IPCC, 2007).

Coastal waters are vulnerable to thermal stress and have low adaptive capacity (Hansen, 2003). Increases in sea surface temperature are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatisation by the coral reefs (Wilkinson et al., 1999; IUCN, 2004; Hoegh-Guldberg et al., 2007; Maina et al., 2008). According to Hansen (2003), majority of marine species have an optimal physiological temperature range. Species that find themselves outside the tolerance range are energetically challenged. Coral bleaching presents an excellent example. Corals are highly sensitive to temperature and can only live in water between 18 to 30℃ (Hansen, 2003). Also, coastal wetlands including salt marshes and mangroves are projected to be negatively affected by sea-level rise, especially where they are constrained on their land-ward side or starved of sediments (IPCC, 2007).

Ozone layer depletion is a result of increased ultraviolet (UV) radiation. Tropical warming that result from global climate change may lead to an increase in the penetration of UV into the water column (Hansen, 2003). According to Vodacek et al. (1997), warmer air temperatures result in increased stratification of the water column and decrease dissolved organic matter. This will lead to higher levels of UV radiation deeper in the water column.

Regional coastal and marine climatic change and its impacts

Coastal problems caused by climate change are of major significance to Africa as a region. Towards the end of the 21st century, projected sea-level rise will affect low-lying coastal areas with large populations in Africa. African coasts are projected to be exposed to increasing risks, including coastal erosion due to climate change and sea level rise (IPCC, 2007). These effects will be exacerbated by increasing human-induced pressures such as coral mining, unsustainable harvest of the mangroves, over fishing and destructive fishing practices which destroy the natural resource base, including corals reefs and seagrass beds (Downing et al., 1997; Adger et al., 2003; Keme, 2003; Clark and Webster, 2003). By the year 2080s, many millions more people than today are projected to experience floods every year due to sea level rise. The numbers affected will be largest in the densely-populated and low-lying megadeltas of Africa while small islands are especially vulnerable. The cost of adaptation could amount to at least 5 – 10% of Gross Domestic Product (GDP). In Africa mangroves and coral reefs are projected to be further degraded, with negative impacts on fisheries and tourism. Studies confirm that Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity (IPCC, 2007).

The West Indian Ocean (WIO) coastal region, which includes Somalia, Kenya, Tanzania, Mozambique, Mauritius, Madagascar, Seychelles, Comoros, Reunion and South Africa, is characterized by a rich mosaic of mangroves, coral reefs, seagrass beds, major estuaries and deltas, and sandy beaches. These coastal ecosystems are ecologically and economically valuable, providing for the livelihood of local communities, and contributing to the WIO countries' economies (UNEP/DGIC/URT/UDSM, 2001) Francis et al. 2002; Francis and Torell, 2004; Obura, 2002, 2005). In 2001-02, there has been additional damage to Eastern African reefs from threats that may be related to climate-change, including floods in Mozambique, harmful algal blooms in Tanzania and Kenya, and an unknown fungal disease of corals in Kenya and northern Tanzania (Obura et al., 2002). The impact of climate change on the WIO region is related primarily to rising sea water temperatures and associated intensification of the El Niño Southern Oscillation (ENSO). The most significant coral bleaching ever recorded in the WIO region during the ENSO of 1998 resulted in 90 – 95% mortality of corals at the most heavily impacted sites, with 30% mortality on a regional scale (Alusa and Ogallo, 1992; Obura, 2005).

Tanzania's coastal and marine climatic change and its impacts

Tanzania's coastline stretches over 1,424 km, including the two large islands of Zanzibar (Figure 1). The coastal area covers about 15% of the total land area, but supports approximately 25% of the population. The coastal population was projected to increase to 20 million by 2005, with a standard of living generally lower than the national average (Whitney et al., 2003). The coast is characterized by a wide diversity of habitats including coral reefs, sea-grass beds and mangrove forests, which support a wide variety of living organisms. These habitats help to buffer strong waves which in turn help to control the erosion of the coast. Coastal erosion is one of the major problems currently facing Tanzania (Kairu and Nyandwi, 2000). Several factors, including sea level rise, geology, and rapid coastal population growth accompanied by rapid increase of human activities that interfere with natural processes, have been linked to the problem (Masalu, 2002; Obura and Richmond, 2005).

This paper reviews documented work on anticipated climate change impacts on Tanzania's coastal and marine resources. It discusses the current existing climate-friendly adaptation technologies, including those identified in the United Nations Report on Framework Convention on Climate Change (FCCC/TP/1, 1999), the re-

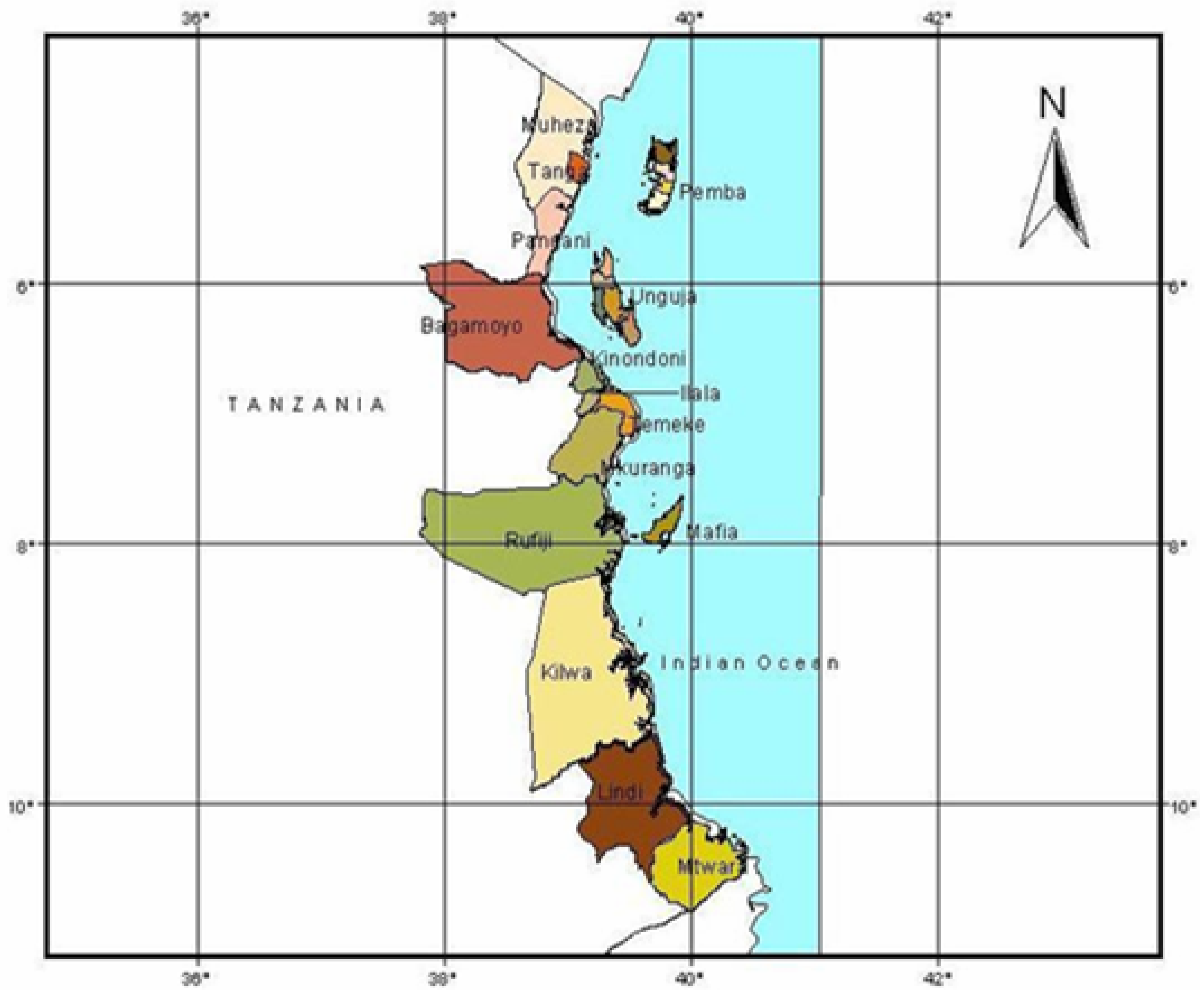

Figure 1. A map showing the coastline and coastal districts of Tanzania.

report of Fourth Assessment for Working Group I, 2 and 3 of the Intergovernmental Panel on Climate Change (IPCC, 2007 and other vulnerability assessment reports for the coastal sector. Sources of information include: published papers (in journals and books), reports from libraries and the available online literature. In addition, climate change-related documents on coastal sector policies, strategies and legislations are reviewed and recommendations proposed. This work will be of interest particularly to marine scientists and environmentalists as a source of updated information. In addition, coastal managers, policy planners, legislators and decision makers will find this work useful in assessing the current situation and charting out future directions in policy and decision making.

State Changes of Climate and Their Impacts on Tanzania's Coastal and Marine Resources

Sea-level rise

Sea level rise will have several impacts such as inundation of low lying coastal areas, accelerated coastal erosion, changes in sediment budgets, rising water tables and saline intrusion (Mwandosya et al., 1998). Sea-level rise will have the most significant impact on coastal natural resources as coastal erosion will further damage coastal built-up structures and coastal ecosystems (Makota et al., 2004). Damage to coastal ecosystems (coral reefs, mangroves and seagrass beds) and the associated habitats, will further result into severe impact on the livelihood of the coastal communities which depend on the resources for their living (Table 1).

Coastal erosion

Coastal erosion has threatened public and private properties and many beachfronts are now affected. At Kunduchi, north of Dares Salaam, large areas have been lost by erosion and threatening the coastline infrastructure. Coastal erosion is evidenced by collapsed trees, buildings, and other structures, including groynes (Griffiths and Lwiza, 1988; Fay, 1992; Makota et al., 2004).

Table 1. Mariculture successful projects in coastal Tanzania

Year established	Project	Place
1982	Finfish Siganus	Unguja-Zanzibar
1983	Seaweed farming	Tanga, Zanzibar
1985	Seaweed farming	Unguja –Zanzibar
1989	Seaweed farming	Unguja –Zanzibar
1991	Shellfish Anadara	Mji Mwema – DSM
1992	Seaweed farming	Pemba – Zanzibar
1994	Finfish polyculture	Pete – Zanzibar
1995	Seaweed farming	Mtwara, Lindi, Tanga
1996	Oysters	Muheza - Tanga
1998	Finfish, Shellfish & Seaweed farming	Unguja –Zanzibar

Source: UNEP/DGIC/URT/UDSM (2001).

Table 2. Recorded cyclones in coastal areas of Tanzania.

Date	Event	Affected places	No. of deaths
April 1872	Cyclone	Zanzibar, Bagamoyo	Not specified
April 1952	Cyclone	Lindi, Mikindani, Mtwara	34
March1989	Tropical storm	Dar es Salaam	7
August 1994	Cyclone	Zanzibar	5

Source: UNEP/DGIC/URT/UDSM (2001).

2004). At Kunduchi sand mining activities along river beds have resulted in reduced sediment discharge on beaches which in turn led to increased shoreline erosion (Griffiths, 1988; Masalu, 2002). Human activities through damming rivers and construction of coastal protective structures such as seawalls, groynes, and other structures such as jetties have also contributed significantly to the deficit in sediment supply or changes in the mode of sediment transport along the coast. These natural and artificial reductions in coastal sediment supply or interruption in the modes of sediment transport processes along the coast have resulted in the erosion of many beaches, barrier islands and deltas along the Tanzania's coast (Shaghude, 2006).

Extreme weather events such as hurricanes, cyclones, and ENSO patterns could also contribute to coastal beach erosion (Obura and Richmond, 2005). The 1997-1998 *El Niño* event was one of the strongest in this century. In Tanzania, it was associated with floods and increased sea surface temperatures. Various media sources reported more than 100 deaths and 155,000 people were left homeless. Over 128,000 agricultural hectares were flooded, leading to food shortages (UNEP/DGIC/URT/UDSM, 2002). The *El Niño* rains produced substantial fresh water and sediment supply to the coastal zone (Nyandwi and Dubi, 2001). Apart from siltation, change in fish species composition and decline in fish catch could also be attributed to *El-Nino* effects. For example, in the small pelagic fisheries industry in Zanzibar, the catch drastically declined from 600 tonnes in 1986 to 91 tonnes in 1997, and a drastic decline of sea cucumbers throughout the inshore waters of Tanzania was recorded following the *El-Nino* effects (Whitney et al., 2003).

Cyclones have had their share of detrimental effects to Tanzanian coastal areas. The earliest documented cyclones to hit the country were in 1872 at Zanzibar/Bagamoyo and 1952 at Lindi, though they were short-lived and did not cause much damage (Talbot, 1965). Others cyclone and tropical storm events are highlighted in Table 2. Effects of such extreme weather events are projected to have high costs of coastal protection as well as land-use relocation and potential for movement of populations and infrastructure (Nyandwi and Dubi, 2001; IPCC, 2007). The impacts of 1998 ENSO event on the corals of Tanzania's coastal districts are summarized in Table 3.

Inundation of low-lying coastal areas

Sea level rise will also cause inundation of low lying areas. A report by the Tanzania's Vice Presidents' Office (VPO, 2003) indicates specific coastal areas most vulnerable to storm surge. Those areas include Moa (Tanga region), Salale and Mbwera (Dares Salaam/Coast region), Nangurukuru and Mnazi Bay in Mtwara/Lindi region (Figure 1). In these areas, mangroves seem to be

2004). At Kunduchi sand mining activities along rlver

beds have resulted in reduced sediment discharge on beaches which in turn led to increased shoreline erosion (Griffiths, 1988; Masalu, 2002). Human activities through the most vulnerable resources followed by sand and mud flats.

Maziwi Island, situated 50 km south of Tanga town and about 8 km southeast of the mouth of the Pangani River (Figure 1), completely disappeared in 1978. The island was originally famous for being the most important East Africa's nesting ground for three endangered marine turtles (olive ridley turtle, green turtle and hawksbill turtle). The entire island was submerged and the Casuarina trees, which were common in the island, also vanished. It is believed that sea-level rise and/or the human activities such as cutting of the vegetation in the island accelerated the wave erosion and eventual submergence of the island (Fay, 1992; Shaghude, 2004).

Wave surge currents weaken the coastline and uproot the shoreline-stabilizing coastal mangroves. Also, coastal areas that have been deforested tend to be more vulnerable to wave erosion than those areas that have not been deforested. The decline of mangrove cover in some coastal districts of the mainland Tanzania over a period of years has been reported by Wang et al. (2003). The study indicated that there is a decline of mangrove cover area within the districts of Rufiji and Kilwa between 1990 - 2000. However, in Mtwara, Pangani, Tanga and Muheza an increase in mangrove cover was detected.

Rising sea temperature

Rising sea water temperature along the Tanzanian coastal area associated with ENSO event of the year 1997/1998 have been reported by many workers (Muhando, 1999; Agrawala et al., 2003). Whereas Muhando (1999) reports that during the 1997/1998 ENSO event the water temperatures around many of the Tanzanian coral reefs was about 2°C higher compared to the previous year, Agrawala et al. (2003) estimates that by the year 2100, the mean annual temperature may rise by up to 2.2°C.

Elevated levels of CO_2 and UV radiation

High ocean CO_2 levels are implicated to the mass fish deaths as they tend to greatly reduce plasma Cl^- concentration while slightly increasing Na^+ concentration (Grøttum and Sigholt, 1996). Comparison of data by NASA (2007) between 1989 and 2005 indicates that the WIO region has higher CO_2 concentrations compared to the past. In addition, increase in greenhouse gases, high water temperatures coupled with low wind speed in coastal waters may favour localized heating and a greater penetration of UV radiation into the ocean leading to unforeseen consequences to the marine resources (West and Salm, 2003).

Technological adaptive responses to mitigate the effects of climate change

Adaptation refers to the degree to which a system adjusts itself to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007). In Tanzania, efforts have been made towards recommendation of appropriate management options through production of guidelines and reports (Kairu and Nyandwi, 2000; Francis et al., 2003; VPO Report, 2003; IUCN, 2004). These guidelines and reports cover structural methodologies for the assessment of impacts and address both immediate and long-term information and technology needs. The adaptation measures are classified as "managed retreat", "accommodation" and "protection". The latter option is the most favoured in coastal areas (Downing et al., 1997; IPCC, 2007) and, therefore, this paper reviews the adaptation measures which enforce protection and conservation of coastal and marine areas.

Protection option

The protection option consists of soft and hard technologies. The former enforces biodiversity and conservation endeavours such as establishment and management of protected areas while the latter emphasizes on building hard structures and beach nourishment.

Establishment and management of marine and coastal protected areas

The conservation and maintenance of productivity of marine ecosystems and biodiversity for economic and social welfare of human communities are best achieved through establishment and management of marine and coastal protected areas (Roberts et al., 2003; Sesabo et al., 2006). Only few areas along Tanzania's coast are protected or actively managed to protect biodiversity from human encroachment. The design of new reserves to take account of climate change should consider aspects such as availability of space, effective management and habitat replication (Hansen, 2003).

The concept of reserve networks is widely accepted as a powerful tool for the protection and management of marine ecosystems with a number of advantages (Shanks et al., 2003; Hansen, 2003). In Tanzania, efforts are underway for the development of priority areas for reserve networks. However, compared with terrestrial environment, the dynamic characteristics of the ocean environment make it difficult to geographically plan permanent networks (Wells et al., 2003).

One important aspect of conservation is identification of areas which may remain stable during periods of climate change (Hansen, 2003). These locations could be characterized by strong currents, upwelling or other oceanographic features that make them less prone to thermal fluxes. West and Salm (2003) suggested that such sites could serve as temporary refuges from warming waters resulting from climate change, hence conservation efforts should be extended towards them. They reduce the exposure to light, including UV radiation. However, thermal refugia could be created by other physical features including proximity to deep water, shade, high wave energy and turbidity. Also, protection of climatic refugia can only be carried out with an exact knowledge of their positions. Therefore, adequate resources for research and monitoring are needed in order to identify and maintain climatic refugia.

Since climate change is expected to alter habitat requirements of certain species, it would be imperative to incorporate a variety of habitat types into a protected area (Hansen, 2003). For example, the main ecosystems of Saadani National Park in coastal Tanzania provide a heterogeneous forest-savanna-grassland mosaic that offers a unique combination of terrestrial and maritime ecosystems. Another example is the ancient coastal forest on the Zaraninge Plateau, a maritime ecosystem with salt flats, coastal fringe forests, herbaceous dune vegetation and mangrove forests (Wells et al., 2003).

Protection of resistant and resilient populations and communities

There are populations or communities that possess endogenous factors that make them more adaptive to deal with the added stress of climate change. Coral reefs have been most studied in the context of “resilience” because the extent to which high sea surface temperatures affect them is proving to be very variable. The intensity of bleaching, species affected, depth, and extent of mortality all vary according to where a reef is located and the local conditions affecting it (West and Salm, 2003). For instance, reefs off Zanzibar Town and at Chole Bay in the Mafia Marine Park were not severely affected by the wide spread coral bleaching event of 1998 (Mohammed et al., 2002). In some cases, coral bleaching events are caused by synergistic effects of high temperatures and UV radiation (Wells et al., 2003). Zooxanthellae, which reside in the coral polyp, produce compounds called mycosporine-like amino acids (MAAs) and can serve as effective sun screens (Hansen, 2003).

In addition, “diverse gene pools and natural diversity” is a concept of the variability within species, as measured by the variation in genes within a particular species, variety, subspecies and breed. It is presently not feasible to make predictions as to how any location will change. Since it is also difficult to know which gene or trait in the population might confer a future advantage, then, possession of more options will increase the likelihood that there will be a combination of genes that survives. The anticipation is that some species will survive and help the system through a stressful period (Dodd and Rafii, 2001).

Restoration of degraded habitats

Coastal ecosystems are created, maintained or restored using living resources such as mangroves and corals. In Tanzania, mangroves and corals have been substantially degraded but currently restoration efforts are underway. Rehabilitation of coral reef is a new technology and has not been widely applied as a management option. However, studies by Wagner (1999) on the coral reefs of coastal Tanzania have produced suitable methods of transplanting corals on artificial substrates.

Furthermore, Vetiver grass (*Vetiveria zizanioides*), common reeds (*Phragmites mauritianus*) and *Typha macronata* cultivation is a cheap technology which comprises cultivation of rigid, dense and deeply-rooted saline-tolerant vegetation types that slow down runoff, allowing sediments to stay on site, eventually forming natural terraces (The World Bank, 2000). The vegetation can grow on extreme soil types regardless of nutrient status, pH, and toxic minerals (Senzia et al., 2003).

Engineered coastal protection

Hard engineering technologies have recently been introduced in Tanzania to address the problem of shoreline degradation. Sea walls are restraining barriers made of concrete or interlocking rocks to hold or prevent erosion from wave action. Groynes, on the other hand, are wooden, concrete and/or rock barriers or walls perpendicular to the sea. Groynes are extremely cost-effective coastal defense measures, requiring little maintenance, and are one of the most common coastal defense structures. The Tanzanian government and private investors have embarked on placing groynes along Kunduchi Beach and building sea walls at Ocean Road area in Dar es Salaam and adjacent to Zanzibar harbour. In the case of the groynes, however, there has been insignificant change in the rate of erosion (Makota et al., 2004). Sea walls are more expensive but much more effective. In Tanzania, it has been shown that protecting the whole coastline of Dares Salaam alone by using sea walls would cost about 270 billion US dollars (VPO Report, 2003). However, local materials such as timber piles and coconut by-products can instead be 2004). At Kunduchi sand mining activities along used as in the case for Pangani, Tanga, on the northern coast of Tanzania. The latter option has been demonstrated and proven to be an effective technology if properly implemented and maintained. However, although this technology is simple and realistic, the supply of timber resistant to biodegradation is costly. Also, the local materials have limited capacity in withstanding waves and, as with all sea walls, may have some adverse hydraulic effects (FCCC/TP/1, 1999). Beach sand nourishment is a viable engineering alternative for shore protection. Sand fill creates a soft structure to make a larger sand reservoir and a wider beach to effectively dissipate wave energy to prevent erosion,

Table 3. Summary of the extent of damage due to coral bleaching event in 1998 in various areas of Tanzania.

Area or reef	Estimate of coral damage
Tanga	25% of corals bleached
Zanzibar area	25-50% of corals bleached
Changuu & Chapwani, Zanzibar	less than 40% survival after bleaching
Bawe, Zanzibar	60-80% survival after bleaching
Chumbe, Zanzibar	80-95% of *Acropora* spp. bleached,
	60-80% survival of corals after bleaching
Mafia Marine Park	80-100% coral death
Chole Bay, Mafia	100% *Acropora* death
Tutia Reef, Mafia	more than 95% coral death
Mnazi Bay, Mtwara	15-25% of corals bleached, with 50% survival of corals after bleaching
Kinasi Pass	80-90% *Acropora* death
Mbudya, Bongoyo and Pangavini	Bleached and recovered (Wagner 2001)

Source: Wilkinson, (1998); Obura (2002).

storm and floods. This technology of beach filling has been practiced in the United States, Europe, Australia, and has just been introduced in some parts of Japan (Kojima, 2004). In Tanzania, sand filling initiatives are underway along Kunduchi Beach areas (Makota et al., 2004). These protection options will go a long way towards protecting the beaches of coastal Tanzania.

Legal instruments to address climate change in Tanzania

Tanzania has no specific policy or strategy on climate change in strict sense. However, at national level, many government sector policy statements now recognise the need for a participatory resource management approach to resolve issues and take advantage of development opportunities. Table 4 summarises the national and coastal sector legal instruments that are relevant to climate change. In general, policies, measures, strategies, and acts adopted to implement broad development objectives have not been formulated with climate change in mind. Even the coastal sector policies are themselves not integrated. The National Environment Management Act and the National Science and Technology Policy, however, address the need to develop technologies and adapt the existing ones to conserve resources, and to develop a scientific knowledge for understanding ozone layer depletion and other components of the stratosphere that are detrimental to public health and the environment. In view of these policies and strategies, the existing Integrated Coastal Management (ICM) programmes and those of the Integrated Coastal Environmental Management Strategy, together with other resource conservation programmes, emphasize the importance of building the capacity of coastal communities in participatory land-use planning and resource conservation.

Further to this, the National Environmental Policy particularly stresses the need for formulating environmental legislation and sectoral legislation as an essential component for effective and comprehensive environ-mental management and improvement of life. Currently, legal aspects for dealing with ICM issues do not consider the empowerment of coastal communities. The motivation of coastal communities is vital for development. Giving people power to monitor their own resources will later broaden the conservation efforts. This approach enhances a sense of “ownership” of those ecosystems and, consequently, such awareness motivates people to protect and conserve the coastal and marine environment.

Other policies and strategies are the National Environment Action Plan (NEAP), National Land Policy, National Conservation Strategy for Sustainable Development (NCSSD), Agricultural Sector Policy, National Fisheries Policy and Strategy Statement, National Forestry Policy, Wildlife Policy, National Tourism policy and Industry Policy (Table 4).

Where implemented, the policies and legislations have produced intended results of ensuring conservation and sustainable utilization of coastal and marine resources. It is noteworthy, however, that the legal instruments have met some challenges. The existence of two types of some of legislations for Tanzania mainland and Zanzibar islands complicates the implementations (UNEP/DGIC/URT/UDSM, 2001). This is due to the fact that Zanzibar is a semi-autonomous entity of the United Republic of Tanzania. Although the legislations described in this review are the cross cutting ones, there is need for harmonization of the few non-cross cutting ones. All the legal documents intended to address climate change need to be more vigorously implemented in order to protect the Tanzania’s coastal and marine ecosystems.

Table 4. Legal instruments addressing coastal and marine resources in Tanzania (the documents are available at the national library and ministries' headquarters).

No	Policy (year)	Relevance to coastal and marine resources
1	The National Environment Action Plan – NEAP (1994)	It identifies five major problematic areas which require urgent action, one of these areas being the deterioration of marine and freshwater systems.
2	The National Land Policy (1995)	Highlights the needs for protecting beaches, coastline and islands from degradation and addresses the mechanisms to protect them.
3	The National Conservation Strategy for Sustainable Development (NCSSD)(1995)	It is a framework which addresses priority areas with regard to environment and development. It highlights issues related to environmental education, public awareness and participation, and environmental research and technology.
4	The National Science and Technology Policy (1996)	The policy provides a framework on how science and technology (S&T) can support the national natural resource conservation and economic development goals. Major strategies include the establishment and strengthening of a database for the inventory, planning and management of natural resources.
5	The National Environmental Policy -NEP (1997)	NEP provides the framework for mainstreaming environmental considerations in decision-making processes. It presents guidelines on plans, priority actions, monitoring, and evaluation, as well as sectoral and cross-sectoral policy analysis which will serve to achieve compatibility among the sectors and interest groups.
6	The Agricultural Sector Policy (1997)	The policy addresses the need to conserve the quality of the marine environment and fight activities which contribute to its degradation.
7	The National Fisheries Sector Policy and Strategy Statement (1997)	It addresses the need to conserve aquatic natural resources and environment protection through the integration of conservation and sustainable utilization of fishery resources. It recognises the need to protect the biological diversity of coastal and aquatic ecosystems through the prevention habitat destruction.
8	The Wildlife Policy of Tanzania (1998)	The Policy underscores the need to manage and conserve wildlife and other natural resources including areas of scenic beauty.
9	The National Forest Policy (1998)	The policy addressed the importance of conserving forest biodiversity and recognises the importance of research, increased awareness and participatory resource monitoring.
10	The National Tourism Policy (1999)	It advocates the promotion and development of ecologically friendly and environmentally sustainable tourism and specific strategies for eco-tourism plan.
11	The Industry and trade Policy (1999)	The policy puts emphasis on ensuring promotion of environmentally-friendly and ecologically sustainable industrial and trade development together with creation environmental awareness.
12	The Integrated Coastal Management (ICM) Strategy (2003).	The policy guides and ensures cross-sectoral coordination of coastal environmental issues pertaining to stakeholder participation, compliance of laws and regulations, support for research and training.
13	The National Environment Management Act (2004)	The law emphasizes on protection of the coastal environmental zone, conservation of biological diversity and protection of the atmosphere. It empowers the National Environmental Management Council to cooperate with local government authorities to formulate strategies to deal with coastal and marine management.
14	National Adaptation Programme of Action (NAPA, 2007)	NAPA identifies the urgent and immediate needs of a country to adapt to the present threats from climate change. Addressing these needs will expand the current coping range and enhance resilience in a way that will promote the capacity to adapt to current climate variability and extremes, and consequently to future climate change as well.

Conclusions and Recommendations

In Tanzania, the complex ecology of coastal and marine ecosystems is appreciated but not fully understood by the public or decision-makers. Without appropriate manage-ment, the coastal ecosystems will continue to be vulne-rable to environmental pressures caused by climate change. In addressing adaptation technologies, it is important to assess how each ecosystem will be affected and how well these technologies will work in Tanzania. The strong interaction between all species of the coastal seascape and the adjoining terrestrial and open ocean areas should be emphasized.

Adaptation technologies may be more meaningful to Tanzania if the following points are adhered to:

- Monitoring of individual sites to determine which strategies should be implemented.
- Assessment, improvement and implementation of coastal sector legislation, policies and other regulatory frameworks to reflect the problems currently encoun-tered.
- Restructuring of existing policies to cover gaps, such as awareness on climate change, need to be done.
- Implementation of human capacity building through training and establishment of climate-related information centres, such as libraries.
- Research in order to address knowledge gaps, such as identification of species that are adaptable to climate change.
- Re-evaluation of other forces that may accelerate

impacts of climate change, such as urban migration resulting in coastal population growth and subsequent destruction of coastal ecosystems.

• Emphasis on local participation and management of coastal and marine resources, contributing positively towards economic and social development.

Both soft and hard adaptation technologies, coupled with relevant policies and legislation, need to be implemented in order to respond effectively to the degradation of Tanzania's coastal and marine resources.

ACKNOWLEDGEMENTS

The Center for Energy, Environment, Science and Technology (CEEST) is acknowledged for financial support of the initial study. Mr. J. Daffa of Tanzania Coastal Management Partnership (TCMP) is thanked for providing working space and guidance.

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