UNITED NATIONS ENVIRONMENT PROGRAMME

UNITED NATIONS EDUCATIONAL, SCIENTIFIC, AND CULTURAL ORGANISATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

ADVISORY COMMITTEE ON PROTECTION OF THE SEA

Global Environment Facility

GEF MSP Sub-Saharan Africa Project (GF/6010-0016):

"Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa"

TANZANIA NATIONAL REPORT
PHASE 1: INTEGRATED PROBLEM ANALYSIS

Dr Julius Francis (National Coordinator),
Dr G M. Wagner, Dr A. Mvungi, Ms. Jema Ngwale and Ms Rose Salema

March 2002

Disclaimer:

The content of this document represents the position of the authors and does not necessarily reflect the views or official policies of the Government of Tanzania, ACOPS, IOC/UNESCO or UNEP.

Table of Contents

Page

Executive Summary i

Tanzania Country Profile iii

Chapter 1
1. Background 1

Chapter 2
2. Methodology 3

Chapter 3
3. Scaling and Scoping 4

Chapter 4
4. Assessment of Impacts 5
4.1 Loss and Modification of Ecosystems/Ecotones 5
4.1.1 Environmental Impacts 5
4.1.2 Socio Economic Impact Assessment 22
4.2 Destructive Fishing Practices 23
4.2.1 Environmental Impacts 24
4.2.2 The Socio Economic Impacts 24
4.3 Microbiological Pollution 26
4.3.1 Introduction 26
4.3.2 Environmental Impacts 27
4.3.3 Socio-Economic Impact 29
4.4 Over-Exploitation 30
4.4.1 Introduction 30
4.4.2 Environmental Impacts 30
4.4.3 The Socio-Economic Impacts 32

Chapter 5
5. Causal Chain Analysis of Each Issue 33
5.1 Loss and Modification of Ecosystems/Ecotones 33
5.1.1 Causal Analysis for Loss/Modification of Coral Reef Ecosystems 33
5.1.2 Causal Analysis for Loss/Modification of Mangrove Ecosystems 38
5.1.3 Causal Analysis for Loss/Modification of Seagrass Beds 41
5.2 Destructive Fishing Practices 43
5.3 Overfishing 43
5.4 Microbial Pollution 46
5.4.1 Causal Analysis for Microbial Pollution 46

Chapter 6
6. Commonality, Overlaps and Gaps 49
6.1 Information Gaps 49
6.2 Transboundary Elements 49
6.3 Root Causes 50
6.4 Responses by Government and NGOs 51
6.5 Immediate Causes 51
6.6 Future Trends 51

Chapter 7
7. National Recommendations 53
7.1 Loss and Modification of Ecosystems/Ecotones, Destructive Fishing Practices and Overfishing 53
7.2 Microbiological Pollution 55

References 57

List of Maps

Map 1. Tanzania - Regional Administrative Boundaries 2
Map 2. Map 2: Priority Hot Spots and Sensitive Areas in Tanzania 6
Map 3. Map 3: Conservation Areas in Tanzania 37

List of Figures and Tables

Figure 1. Causal Chain Analysis for Loss and Modification of Ecosystems: Coral Reefs 35
Figure 2. Causal Chain Analysis for Loss and Modification of Ecosystems: Mangroves 39
Figure 3. Causal Chain Analysis for Loss and Modification of Ecosystems: Seagrass beds 42
Figure 4. Linkages Between Issues: Destructives Fishing Practices and Loss/Modification 44
Figure 5. Causal Chain Analysis for Over-Exploitation of Fisheries Resources 45
Figure 6. Causal Chain Analysis for Microbial Pollution 48

Table 1. The Percent Cover of Hard Coral and Soft Coral, and the Percentage of the Hard Coral that is Alive, on Some of the Patch Reefs in the Songo Songo Archipelago 11
Table 2. Impacts/Conditions, Trends and Threats to Coral Reef Ecosystems Near a Representative Village in Each Coastal District of Tanzania, Based on Villagers' Perceptions 13
Table 3. Impacts/Conditions, Trends and Threats to Mangrove Forests Near a Representative21 Village in Each Coastal District of Tanzania, Based on Villagers' Perceptions 17
Table 4. Impacts/Conditions, Trends and Threats to Seagrass Beds Near a Representative Village in Each Coastal District of Tanzania, Based on Villagers' Perceptions 21
Table 5. Total Marine Fish Production (in tons) for Tanzania Mainland: 1985 - 1995 25
Table 6. Average Cases of Disease Per Year for the Period 1993-1997 for Dar Es Salaam 28
Table 7. Pollution Load to Surface Water Resources (Kg/Day) in Dar Es Salaam 28
Table 8. Pollution Loads to Groundwater Sources (Kg/Day) in Dar Es Salaam 28
Table 9. Estimated Annual Costs of Environmental Impacts in Monetary Values for Dar-Es-Salaam 30
Table 10. Sea Cucumber Export from Tanzania 31
Table 11. The Common Breeding Sites for Different Species of Turtles 50

Executive Summary

The Advisory Committee on Protection of the Sea (ACOPS) in collaboration with the United Nations Environment Programme (UNEP) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, is implementing the Global Environmental Facility (GEF)-Medium Size Project (MSP) on the Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa. The ultimate goal of the GEF MSP is to develop a sound portfolio of proposals for interventions to be presented in the Partnership Conference scheduled for September 2002.

One of the main objectives of the GEF MSP is to identify, characterise, and prioritise causes of environmental degradation, as well as hot spots and sensitive areas in selected countries. This objective has been implemented in eleven selected countries. These countries were: Senegal, Gambia, Ivory Coast, Ghana and Nigeria (West Africa) and Kenya, Tanzania, Mozambique, South Africa, Seychelles, and Mauritius.

Through the implementation of this objective, priority areas for interventions have been identified, and they will form the basis for the development of project proposals to be presented at the Partnership Conference.

The GEF MSP project adopted the Integrated Problem Analysis (IPA) methodology to identify, characterise, and prioritise hot spots and sensitive areas as well as the causes of environmental degradation. The IPA methodology comprises of four phases namely: scaling and scoping; impacts assessment; causal chain analysis; and prioritisation.

The Tanzanian component of the GEF MSP was implemented from May – September 2001 by a team which comprised of two natural scientists and two social scientists. The summary of the causal chain analysis and the environmental and socio-economic impact report were presented and discussed in the Meeting of the Science and Technical Working Group of the Tanzania Coastal Management Partnership (TCMP) Programme, held from 19-20 July 2001 in Dar Es Salaam.

In the scaling and scooping phase, a number of priority hot spots (currently suffering measurable degradation) and sensitive areas (likely to be subject to some degradation in the future) were identified. The priority hot spots are: Dar Es Salaam city, Zanzibar municipality and Tanga municipality. Out of the eight sensitive areas identified namely: Rufiji-Mafia-Kilwa complex, Tanga coastal area, Bagamoyo, Pemba, Unguja East Coast, Latham Island and Mtwara-Mnazi bay area, only the first three were selected as the priority sensitive areas. While in hot spots, pollution was identified as the major issue of concern, the sensitive areas are threatened mainly by Over-exploitation; Destructive fishing practices; Modification/loss of ecosystems.

The second phase of the IPA methodology involved analysis of environmental and socio-economic impacts of the four priority environmental issues identified from the phase I. These priority issues were: Modification/loss of ecosystems; Destructive fishing practices; Over-exploitation; and Microbiological pollution. Impacts of these issues were assessed as they affect the priority hot spots, sensitive areas and the whole coastline of Tanzania.

The third phase - causal chain analysis, involved determining causes of the environmental degradation or threat and consequently, developing a series of statements linking the causes of a problem with its effects.

The underlying root causes for the priority issues are almost identical. What differs from one issue to the other are primarily the immediate causes, though, for the issues related to Fisheries, even these are very similar, i.e., various forms of destructive or inappropriate fishing practices.

Poverty/inequality stands out as being a very strong root cause of most of the problems. Coastal communities are generally poor and they are led to improperly exploit or overexploit the marine and

coastal resources as a means of surviving for the day, regardless of future consequences. Demographic changes, particularly migration to coastal urban centres, have also been major root causes of most of the problems.

In the area of institutional drivers, lack of long-term, systematic monitoring of the marine environment and inadequate scientific capacity are also major underlying factors. In the realm of economic structure, alternative resources and income-generating projects are a major concern.

Fisheries is of major importance in the coastal/marine issues since it is the main sector responsible for three of the four issues selected, i.e., loss and modification of ecosystems/ecotones (particularly coral reefs and seagrass beds), destructive fishing practices and over-fishing. Amongst the most pressing problems related to Fisheries are the increase in demand for fisheries resources and inadequate gear and vessels to fish offshore. In addition, government policies are inadequate or inappropriate, in particular the policy of open access, which hinders villagers from becoming motivated about conserving the environment and utilising resources sustainably.

Several transboundary elements related to modification and loss of ecosystems and exploitation of resources were highlighted in the report. These include: migratory species such as turtle; Movement of fishermen from one country to another; and use of destructive fishing methods in shared ecosystems.

On recommendations, a major course of action that could best address most of the causes of environmental degradation, would be the establishment of integrated coastal management programmes and/or marine protected areas in sensitive areas.

The major components that should be incorporated into such programmes/marine parks include the establishment of research and monitoring programmes, community mobilisation (formation of cooperatives and ecosystem restoration), assisting groups of fishermen with appropriate gear and vessels for fishing offshore, the establishment of alternative/supplementary income-generating projects (e.g., seaweed farming, ecotourism, and small-scale prawn farming), the promotion of environmental awareness campaigns, and mechanisms for the resolution of resource-use conflicts.

TANZANIA COUNTRY PROFILE

Geography and Environment		
Surface area:	*total:*	945,087 sq km
Coastline:		1,424 km
Maritime claims:	*exclusive economic zone (distance from shore):*	200 NM
	territorial sea:	12 NM
EEZ:		204,300
Natural resources:		hydropower, tin, phosphates, iron ore, coal, diamonds, gemstones, gold, natural gas, nickel
Land use:	*arable land:*	3%
	permanent crops:	1%
	permanent pastures:	40%
	forests and woodland:	38%
	other:	18% (1993 est.)
Irrigated land:		1,500 sq km (1993 est.)
Environment - international agreements: party to:		Biodiversity, Climate Change, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Ozone Layer Protection, Wetlands
	signed, but not ratified:	Nuclear Test Ban
Population		
Population:		36,232,074 (July 2001)
Population growth rate :		2.61% (2001 est.)
Population density:		12-17,450 habitants per km^2
Life expectancy :	*total population:*	51.98 years
Urban population (% of total 1995):		24.2
Urban population annual growth rate:		4.95 % (1995-2015)
Population living within 100 km from the coast:		21.1%
Literacy:		*total population:* 67.8%

(definition: age 15 and over can read and write)	*male:* 79.4% *female:* 56.8% (1995 est.)
Economy	
GDP: purchasing power parity	$25.1 billion (2000 est.)
GDP - real growth rate:	5.2% (2000 est.)
GDP per capita: purchasing power parity	$710 (2000 est.)
GDP composition by sector:	
agriculture, forestry and fisheries:	49%
industry:	17%
services:	34% (1998 est.)
Population below poverty line:	51.1% (1991 est.)
Labour force:	13.495 million
Labour force - by occupation:	agriculture 80%, industry and commerce 20% (2000 est.)
Industries:	primarily agricultural processing (sugar, beer, cigarettes, sisal twine), diamond and gold mining, oil refining, shoes, cement, textiles, wood products, fertilizer, salt
Industrial production growth rate:	8.4% (1999 est.)
Electricity - production:	2.248 billion kWh (1999)
Electricity - production by source:	*fossil fuel:* 22.24% *hydro:* 77.76%
Electricity - consumption:	2.134 billion kWh (1999)
Electricity - exports:	0 kWh (1999)
Electricity - imports:	43 million kWh (1999)
Agriculture - products:	coffee, sisal, tea, cotton, pyrethrum (insecticide made from chrysanthemums), cashew nuts, tobacco, cloves (Zanzibar), corn, wheat, cassava (tapioca), bananas, fruits, vegetables; cattle, sheep, goats
Exports:	$937 million (f.o.b., 2000 est.)
Exports - commodities:	coffee, manufactured goods, cotton, cashew nuts, minerals, tobacco, sisal (1996)
Imports:	$1.57 billion (f.o.b., 2000 est.)
Imports - commodities:	consumer goods, machinery and transportation equipment, industrial raw materials, crude oil
Currency code:	Tanzanian shilling (TZS)
Exchange rates:	Tanzanian shillings per US dollar - 947.000 (January 2002), 803.34 (2001), 800.41 (2000), 744.76 (1999), 664.67 (1998), 612.12 (1997), 579.98 (1996)
Water Resources and Uses	
Internal flows	45 billion cu. m. 1999
Flows from other countries	5.2 billion cu. m. 1999
Total resources per capita cu. m^3:	1,187
Annual freshwater withdrawals:	13.3 billion cu. m.
% of total renewable resources:	26.6
% for agriculture:	72
% for industry:	11
% for domestic:	17

CHAPTER 1

1. Background

Tanzania has a coastline of 800 km stretching from latitude 4^o 49'S at the border with Kenya to the border with Mozambique at latitude 10^o 28'S. The continental shelf is narrow with the 200km contour depth about 4 km offshore, except at the Zanzibar and Mafia Channels where the shelf extends for up to 80 km. The islands within the continental shelf include Unguja and Mafia, as well as a number of small islets and reefs. Pemba lies beyond the continental shelf and is therefore oceanic. The area of the shelf to the 200 m depth contour for both mainland and Zanzibar combined is about 30, 000 km. The shelf area is commonly used by the artisanal fishermen and due to the narrowness of the shelf, only a small percentage is trawlable.

Tanzania is renowned for the attractiveness of its coastal and marine environment, high marine biodiversity and rich marine and coastal resources The coastal and marine environment include, among others, major estuaries, mangrove forests, coral reefs, sandy beaches, cliffs, seagrass beds and muddy tidal flats. Sandy-muddy flats or rocky reef platforms are found in the intertidal zone, while the sub-littoral zone consists of extensive seagrass beds and coral reefs. Rivers include Pangani, Wami, Ruvu, Rufiji, Matandu, Mbemkuru, Lukuledi and Ruvuma which all flow to the Indian Ocean, influencing the coastal environment through creation of productive brackish water environments in estuaries, maintenance of deltas, tidal flats and shorelines, as well as nourishment of mangroves and seagrass beds. However, they cause breaks in the chain of coral patch reefs as a result of increased sedimentation.

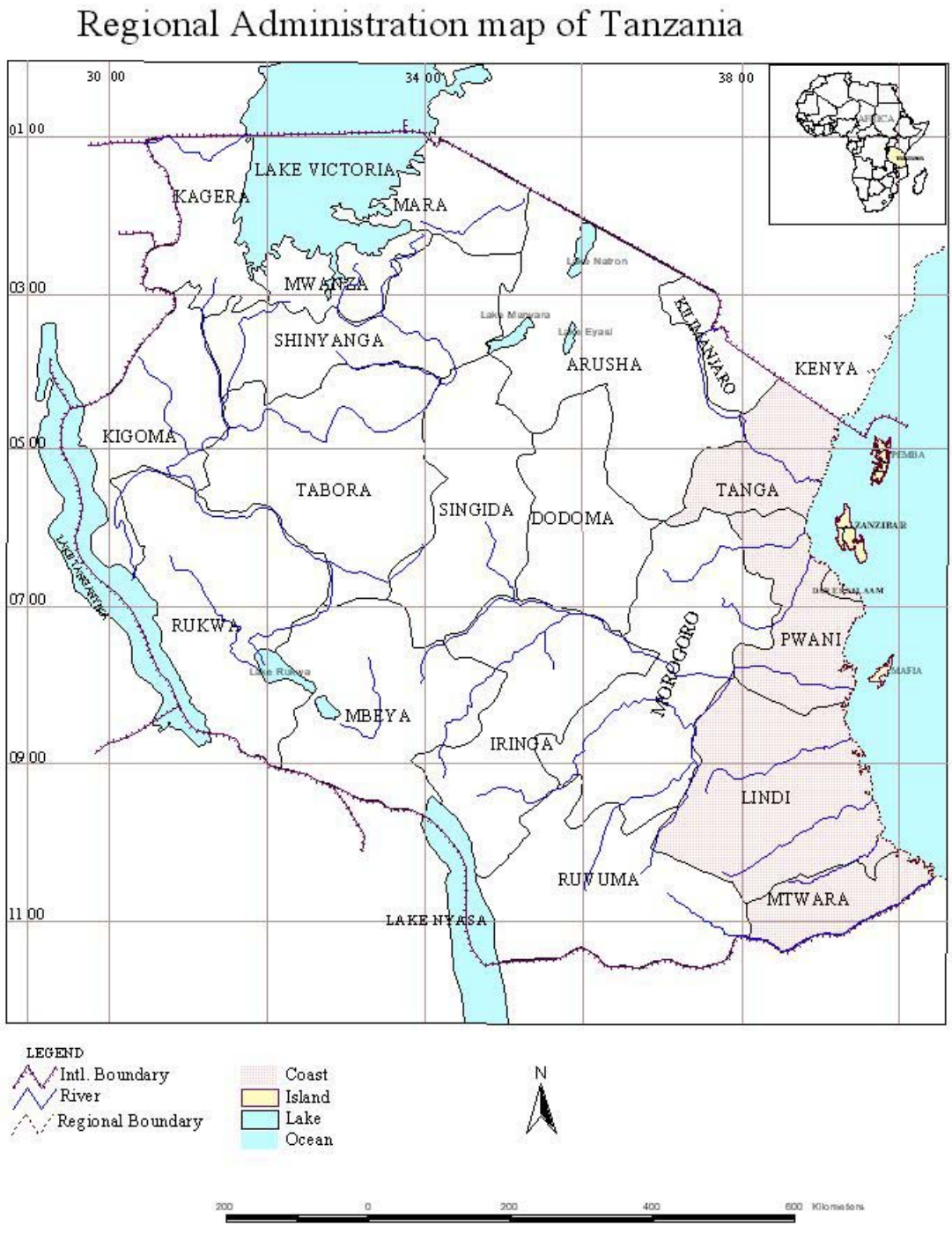
These coastal ecosystems interact with each other and together sustain a tremendous diversity of marine life and are an important source of sustenance for most coastal communities. For instance, a wide range of important and valued species are found including: an estimated 127 species of coral in 13 families; 8,270 species of invertebrates; 5 species of marine turtles; 1,000 species of fish and breeding and sheltering areas for seabirds.

There are five administrative regions situated along the mainland coast: Tanga, Coast, Dar Es Salaam, Lindi and Mtwara. These regions are further subdivided into several districts. The five coastal regions cover about 15 percent of the country's total land area and are the home of approximately 25 percent of the country's population. The populations of these five coastal regions have increased to about eight million, with a growth rate ranging between two and six percent. At this rate, a doubling of the coastal population is expected in as short a period as twelve years.

According to the 1988 census, the estimated population of Tanzania was 23 million and this is projected to have risen to 32 million by the year 2000. Based on a land area of 883,749 km^2, the population density for the country is 36 persons/km^2, while for Dar Es Salaam region, the density is 17,450 persons/km^2. However, in other coastal regions such as Lindi it is less than 12 persons/km^2.

The coastal and marine environments are currently subject to a wide range of natural and anthropogenic disturbances at different intensities and with various combinations. The increasing anthropogenic disturbances are attributed to the growing coastal population, as well as unsustainable use of coastal resources.

This report is structured as follows: Section Two describes the Integrated Problem Analysis methodology used in this study, specifically, highlighting the four phases of the methodology. Priority hot spots, sensitive areas and priority issues are highlighted in Section Three. Section Four presents the results of analysis of environmental and socio-economic impacts of the four priority environmental issues. The results of causal chain analysis of the four priority issues are discussed in detail in Section Five, while Section Six focuses on information gaps, transboundary elements of the environmental causes and the future trends. The Section Seven proposes more specific recommendations to deal with the causes of environmental degradation identified.



Map 1. Tanzania - Regional Administrative Boundaries

CHAPTER 2

2. Methodology

The Advisory Committee on Protection of the Sea (ACOPS) in collaboration with the Intergovernmental Oceanographic Commission (IOC) of UNESCO and the United Nations Environment Programme (UNEP), is implementing the Global Environmental Facility (GEF)-Medium Size Project (MSP) on the Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa. The objective of this project is to identify, characterise, and prioritise causes of environmental degradation, as well as hot spots and sensitive areas in eleven countries. These countries are five from western Africa (Gambia, Ghana, Ivory Coast, Nigeria, and Senegal) and six from eastern and southern Africa (Kenya, Mauritius, Mozambique, Seychelles, South Africa, and Tanzania).

The Integrated Problem Analysis (IPA) methodology was applied by the project to identify, characterise, and prioritise hot spots and sensitive areas as well as the causes of environmental degradation. The IPA methodology is based on the methodology developed by the Global International Water Assessment (GIWA) for the identification of causes and sources of environmental degradation.

The IPA methodology comprises of four phases namely: scaling and scoping; impacts assessment; causal chain analysis; and prioritisation.

Phase I highlighted the priority issues in reference to selected hot spots and sensitive sites, while Phase II identified the environmental and socio-economic impacts. These impacts were identified with the purpose of effectively justifying and supporting the issues selected in Phase I.

Phase III, the Causal Chain Analysis, involved determining causes of the environmental degradation or threat and consequently, designing a causal series of statements linking the causes of each problem with its effects.

The causal chain analysis involved four levels as follows:

- technical immediate causes of the issue;
- sectoral and resource use changes (direct pressures);
- underlying pressures (socio-economic, institutional, etc.); and
- attempted responses (government, market, community).

The Phase IV involves the prioritisation of causes and sources of environmental degradation and refinement of a list of environmental areas (hot spots and sensitive areas).

The summary of the causal chain analysis and the environmental and socio-economic impact report were presented and discussed in the Meeting of the Science and Technical Working Group of the Tanzania Coastal Management Partnership (TCMP) Programme, held from 19-20 July 2001 in Dar Es Salaam. STWG members provided extensive comments on the summary and the report, which were incorporated into the revised report by the Team as appropriate.

CHAPTER 3

3. Scaling and Scoping

The Phase I (scaling and scoping) of the Integrated Problem Analysis methodology involved a number of steps as discussed below:

i) Identification and prioritisation of hot spots and sensitive areas.

The identified hot spots were: Dar Es Salaam city, Zanzibar municipality and Tanga municipality. The identified sensitive areas were: Bagamoyo, Tanga coastal area, Rufiji-Mafia-Kilwa complex, Pemba, Unguja East Coast, Latham Island and Mtwara-Mnazi bay area (Map 2). Based on the information on the Aggregated tables for hotpots and sensitive areas, a list of 3 top prioritised hot spots and 3 top prioritised sensitive areas was prepared. The exercise resulted in selecting Rufiji-Mafia-Kilwa complex, Tanga Coastal Area and Bagamoyo District as the priority sensitive areas. Since only three hot spots were identified, i.e., Dar Es Salaam, Tanga Municipality and Zanzibar Municipality, all three were taken as priority hot spots.

ii) Selection and prioritisation of issues.

Nine issues (eight GIWA issues, plus degradation of cultural sites which is not listed amongst GIWA issues) related to the prioritised hot spots and sensitive areas were identified. Based on the scores in the impacts tables, reporting tables for perception of future changes and the summary table for the Scoping exercise, the following issues were ranked in the given order according to their scores: Loss/modification of ecosystems/ecotones; Over-exploitation; Destructive fishing practices; Suspended solids; Modification/reduction of stream flow; Microbial pollution; Excessive by-catch/trawling; and Chemical pollution. The first four priority issues, i.e., Loss/Modification of ecosystems, Destructive Fishing practices, Over-exploitation; and Microbiological pollution, were thus carried forward into the subsequent Impact Assessment and Causal Chain Analysis phases.

iii) Identification of priority habitats and ecosystems/communities.

Seven habitats and communities that are suffering significant loss/modification in the country were identified. These include: coral reefs, mangrove forests, seagrass beds, inshore waters, estuaries, coastal forests, and beaches.

CHAPTER 4

4. Assessment of Impacts

This section presents the results of analysis of environmental and socio-economic impacts of the top four environmental issues identified from the previous section on Scaling and Scoping. Evaluation of impacts in this section is based on information from different sources, including grey literature. Another important source of information has been the "State of the Coast Survey" which was conducted recently. One representative village in each of Tanzania's coastal districts was visited by a research team. Through focus group discussions, the team gathered quasi-quantitative data based on villagers' perceptions of their environment (Tanzania Coastal Management Partnership, 2001). The reliability of this data is somewhat limited since it is based on only one village per district and the villager's perceptions need verification through more scientific studies. Moreover, there appeared to be a tendency in some cases for villagers to make it sound like their environment is somewhat better than it really is. Nevertheless, at least these data give some indication of the status of the coastal and marine environment in those areas.

4.1 Loss and Modification of Ecosystems/Ecotones

Combined assessment of loss and modification of ecosystems

In this impact assessment, it was decided to combine the impacts of loss and modification of ecosystems since both are very important in Tanzania and since it is very difficult to separate the two. Many of the human activities that lead to degradation cause both loss and modification of the habitats, with varying degrees of impact. Moreover, whether the issue is loss or modification, the socio-economic impacts are similar. Thus, a combined approach to this assessment leads to a more integrated problem analysis.

In the analysis of impacts for each ecosystem below (coral reefs, mangrove forests and seagrass beds), there is a subsection on loss versus modification caused by specific impacts on these ecosystems in order to clarify the assessment, i.e., an explanation is given on which impacts lead to loss, which lead to modification and which lead to both.

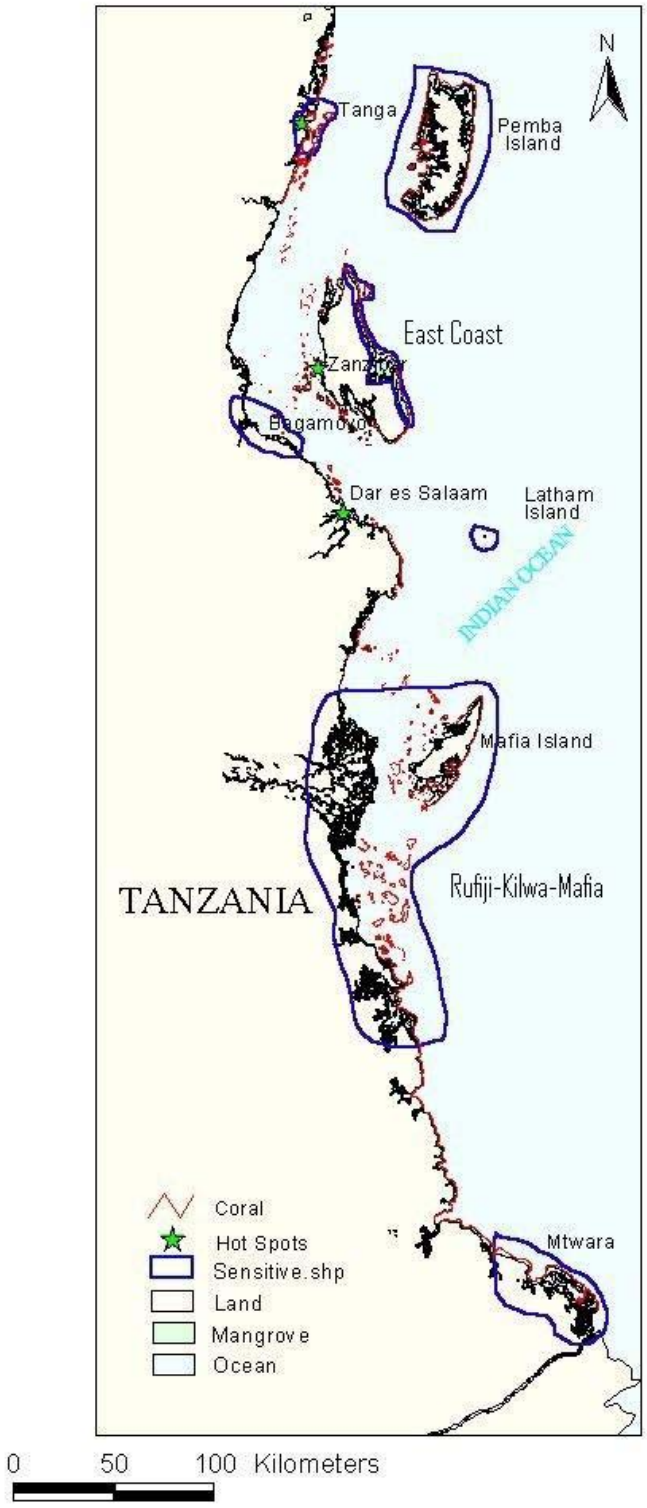
Selection of ecosystems for detailed impact assessment of loss and modification

The types of ecosystems selected for environmental impact assessment, terms of loss and modification are coral reefs, mangroves and seagrass beds. This selection is based on the fact that, in Tanzania, as in many tropical countries, these are generally keystone ecosystems because, though relatively small in size compared to the surrounding expanse of ocean, they provide many, very important ecological services. For example, they are breeding, feeding and nursery grounds for fish and a great variety of invertebrates. They are also high centres of biodiversity and productivity. Both living biomass and detritus are exported from these important ecosystems to other marine habitats. In Tanzania, all three of these habitat types are found in patches almost all along the coast and have significant influence on other ecosystems.

4.1.1 Environmental Impacts

4.1.1.1 Coral Reefs

In order to understand the level of environmental impacts on coral reefs, it is necessary to briefly describe the types of human activities and natural impacts which have affected these ecosystems in Tanzania over the past few decades.



Map 2. Priority Hot Spots and Sensitive Areas in Tanzania

Human Activities/Impacts

There is a whole range of human activities that cause degradation of coral reefs, including destructive or improper fishing methods, over-fishing, excessive movement of boats and people, pollution, coral mining and uncontrolled tourism. Seaweed farming may also have some detrimental effects.

The greatest human impacts on coral reefs are related to destructive or bad fishing practices (Wagner, 1998b). By far the most destructive type of fishing is dynamiting. Dynamite fishing has been practised in Tanzania since the 1960s. In the 1990s, dynamite blasts reached incredible rates. In Mnazi Bay, Mtwara, 441 blasts were recorded over a two-month period (October-November, 1996), while in the Songo Songo Archipelago, 30 blasts were heard every three hours and, at Mpovi reef (near Kilwa Kivunje), 100 blasts were recorded during one six-hour period (Darwall *et al*., 2000).

Besides dynamite fishing, the use of seine nets around coral reefs is destructive in three ways. Firstly, fishermen sometimes hit the coral heads in order to scare the fish out of hiding, known as the *Kigumi* technique, which has been particularly common on Pemba and the south-western side of Unguja (Horrill *et al*., 2000). Secondly, the bottom of the net is weighted down so it breaks corals as it is dragged over the reef. Thirdly, the small-mesh size of seine nets results in the capture of many juveniles.

Another obviously harmful method is the use of poison. Horrill *et al*. (2000) reported that poison (commonly an extract from the *Euphoria* plant) was used for fishing as far back as 1900 and that its use declined during the 1960s though it is still sometimes used today. There is no data on its current extent of usage.

In addition, there are several other fishing methods that may be destructive to reefs, if carried out in an improper fashion. These include octopus fishing, collection of shellfish (which entails reef walking and diving), and the use of basket traps. Other harmful activities related to fishing include the dropping of anchors and boat grounding (Wagner, 1999).

While seaweed farming is thought to be relatively environmentally friendly, it has been reported in Unguja that this activity lowers bacterial production and the abundance of small animals such as nematodes (Horrill *et al*., 2000).

In Dar Es Salaam, Tanga and Zanzibar town, and to a lesser extent, Bagamoyo, Lindi and Mtwara, there are many types of pollution, i.e., industrial, institutional, and domestic discharge; agro-chemical pollutants; and sedimentation brought about by deforestation, poor agricultural practices, and construction activities. These types of pollution affect nearby reefs.

Solandt and Ball (1999) reported that, since coral mining has been a major industry in Mikindani Bay, Mtwara for the past two decades, all p*orites* above a depth of 2m have now been gleaned from its nearby reefs. Coral mining is also common in Mafia.

While tourism is generally beneficial to the country, if uncontrolled and unmanaged, it may have negative impacts on the environment. If tourists are careless while snorkelling or SCUBA diving, they may break corals or disturb other organisms in the reef ecosystem. Others walk along reefs in search of shells, thus causing damage.

Another type of disturbance is the use of motorised vessels, whether by fishermen, tourists or transporters (e.g., the high speed boats that operate between Zanzibar and Dar Es Salaam), which stir up sediments that can affect coral reef ecosystems.

Natural Impacts

Natural impacts that have led to ecosystem modification or loss in Tanzania include storms and coral bleaching. Damage due to strong wave action is common on exposed fringing reefs and on the seaward side of patch reefs and islands all along the coast of Tanzania, though there is no evidence that the extent of storm impact has been any different recently than it was many decades ago.

The coral bleaching event (March to May 1998) coincided with higher than normal seawater temperatures and increased rainfall (lower salinity) (Muhando, 1999). Coral bleaching was reported on all parts of the Tanzanian coast with variable severity. Bleaching was worse in shallow waters (reef flats) than in deeper waters. In Zanzibar, overall more than 60% of the scleractinian corals showed signs of bleaching, with *Acropora* being most affected; while a few corals such as *Diploastrea* and *Pachyseris* were seemingly unaffected (Muhando, 1999). Some species of *Porites* were affected, while others were not (Wilkinson, 1998).

After the bleaching event, the dead corals were colonised by filamentous algae. By November 1998, these were replaced by macroalgae and coralline algae. By January 1999, some areas showed the recruitment of small corals, while others were colonised by corallimorpharians and soft corals. On the economic side, some dive operators reported a decline in tourist potential due to the bleaching event (Muhando, 1999).

At Mbudya Island, the large percentage of dead hard coral (40-60%) was thought to be mainly due to coral bleaching (Wagner *et al*., 20001).

According to studies conducted at Tutia Reef by Ohman *et al*. (1999), following the bleaching event, 88% of the corals died. A year after the event, a large proportion of the dead corals were still standing.

Loss Versus Modification Caused by Impacts on Coral Reefs

Some human and natural impacts cause only modification of ecosystems, while others cause loss. Some cause both. To understand these impacts, an explanation is given of the type of effect caused by each type of human activity or natural impact.

While dynamite fishing actually causes loss of habitat in the immediate vicinity of the blast, the area lost by each blast is not very large (2-5 m in diameter). However, due to repeated blasts day after day over almost three decades, this practice has completely damaged the reef structure on some of the reefs in different parts of Tanzania. On other reefs, on the other hand, where dynamite fishing has not been so intensive, the ecosystems have not been lost, but intermittent patches of the habitat have been lost. On such reefs, the blasts have often been numerous enough to cause significant fragmentation of the ecosystem, this being one of the GIWA indicators of ecosystem modification. Besides breaking the reef structure into rubble, each dynamite blast also kills all fish, plankton and most invertebrates within a 15-20 m radius, a factor which has also contributed to modification of the ecosystem through reduction in the abundance of the biota. Thus, the impacts of dynamite fishing in terms of modification have been substantial in most parts of the country.

In areas of reefs that are suitable for dragging seine nets, large areas of the reef ecosystems have been lost by repeated dragging of the nets, month after month. Due to the severe disturbance of certain patches, dragging seine nets has led to fragmentation of many coral reef ecosystems. However, some coral reefs have not been affected by this practice.

Other destructive fishing practices (spearing, basket traps), over-fishing and the catching of juveniles have caused moderate modification of coral reef ecosystems, disruption of food webs and possible loss of biodiversity, but no significant loss of habitats or ecosystems.

So far, there is no evidence that pollution of various types has caused loss of coral reef ecosystems in Tanzania. However, it appears that some modification of coral reefs that are near sources of pollution has occurred.

Coral mining has caused serious loss of reef habitat in some areas where it has been conducted on a large scale (e.g., Mikindani Bay, Mtwara). However, it has not caused loss of entire ecosystems as such because it is only the reef flat and shallow reef crests where coral can be mined. The reef slopes remain intact, though it is likely that some degree of modification has occurred on reef slopes due to excessive sedimentation cause by the breakage of reefs in shallower areas.

So far, tourism has not caused loss of coral reef ecosystems, but it is possible that moderate modification has occurred on some reefs due to mechanical breakage and the rampant collection of shellfish which has likely altered species composition. Reef trampling is not necessarily done by the tourists, but is often done by young boys from fishing villages who collect the shells to sell them to tourists.

Coral bleaching has actually caused loss of reef habitats and/or serious modification of reef ecosystems over large areas in some parts of Tanzania. Other reefs were only affected in patches dominated by certain susceptible species such as *Acropora* spp., thus causing modification of these ecosystems, particularly in the form of fragmentation. Typically, bleached coral has been overgrown by tuft algae (filamentous algal mats) and macroalgae, thus leading to an increase in the abundance of these primary producers. This has actually been shown to lead to a temporary increase in fish abundance (particularly herbivores) (Ohman *et al*., 1999). Now, more than three years after the bleaching event, the dead reef structures have been observed to collapse into rubble in many parts of the country.

Assessment of Environmental Impacts on Coral Reefs

The present condition of coral reefs in Tanzania and the extent of degradation brought about by various impacts, both human and natural, differ greatly from place to place. Therefore, the current status and condition of Tanzanian reefs are given below according to geographical area. According to Guard and Masaiganah (1997), since dynamite fishing has had widespread and common use in all parts of Tanzania, virtually all coral reefs along the Tanzanian coast have been badly degraded. The 1998 coral bleaching event is another factor that has caused serious and widespread degradation. However, the nature and extent of these and other impacts differ from region to region.

Tanga

Throughout Tanga Region, the reefs have been extensively damaged by human impacts. According to a rapid survey conducted in 1987 (IUCN, 1987), most reefs, at that time had only 20% live coral cover, while some areas had less than 10%. A more extensive survey in 1995 covering 58 reefs (Horrill *et al.*, 2000) showed that 12% of the reefs were completely destroyed, 12% in poor condition, 52% in moderate condition and 24% in good condition. Most of the damage to reefs north of the Pangani River was attributed to dynamite fishing (Horrill, 1997).

Reefs that were adjacent to areas of high population density were found to have the most damage and the lowest abundance of commercially important fish species. Thus, both the number of coral genera and the abundance of associated species were found to highest on the outer patch reefs, followed by the inner patch reefs and finally by coastal fringing reefs (Horrill *et al.*, 2000).

Surveys conducted after the 1998 coral bleaching event showed that 25% of the coral reefs of Tanga had been damaged/killed be the bleaching (Wilkinson, 1998).

Dar Es Salaam Area

Kamukuru (1997) conducted a study in the Dar Es Salaam Marine Reserves System at two sites each on the fringing reefs of Mbudya Island and Bongoyo Island and at one site at Pangavini Island. He observed that the dominant benthic category was hard coral which ranged in area cover from 34.7% on the southwest side of Bongoyo to 81.2% on the southwest side of Mbudya. The second category in importance was algal turf which ranged from 6.5% at Mbudya southwest to 45% at Bongoyo southwest. The third was coralline algae which was highest (17.4%) at Mbudya northwest. Other benthic categories (calcareous algae, fleshy algae, sand, sea anemones, seagrass, soft coral, sponge, and clams) showed low percent cover (<10%) at all sites. While this data gives the impression of fairly healthy reefs, the sites selected were actually amongst the best reef areas on those islands and, in fact, there is much poorer hard coral cover in many other parts of these reefs where serious damage from dynamite fishing, dragging of seine nets and storms has occurred. Thus ecosystem fragmentation has been severe in the Dar Es Salaam reefs (pers. observ.). Moreover, this study was conducted before the 1998 coral bleaching event which caused serious degradation on those reefs.

Recent studies conducted on the fringing reef of Mbudya Island (Ngowo, 1999; Sekadende, 1999; Wagner *et al*., 20001) showed that there was significantly greater hard coral cover on the landward side (47%) than on the seaward side (12%), since the latter is subjected to very strong wave action which breaks the corals. Of the hard coral cover, 40-60% was dead. A substantial area of the Mbudya Island reef (15-40%) was found to have no biocover, which was attributed to dynamite fishing and wave action.

Zanzibar: Unguja and Pemba Islands

Muhando (1999) reported that, even prior to the 1998 coral bleaching event, various surveys indicated widespread degradation of coral reef environments. In Zanzibar, hard coral cover ranged from 13.95% at Mnemba on the north-eastern coast of Unguja Island to 53.11% at Bawe on the western coast.

Horrill *et al*. (2000) reported that the highest live coral cover around Unguja Island is found on the reefs near Zanzibar town on the western side, except for Chapwani Island. It was found that Chapwani had higher growth rates, lower coral diversity and lower coral cover than Chumbe, a marine protected area. Since Chapwani is just north of Zanzibar town and ocean currents generally flow northward along the Tanzanian coast, there are generally higher nutrient levels at Chapwani than at other reefs in the area. This has caused faster growth of a few species of corals, but overall degradation of the reefs due to smothering by algae and attacks by borers.

The reefs on the south-western side of Unguja near Menai Bay generally have lower live coral cover (12-29%), which can be attributed to the rampant use of destructive fishing methods, except for Pungume Island where it reaches 88%. Mnemba and the eastern fringing reefs were found to have 11% or less due to their exposure to strong wave action which causes physical disturbance of the corals (Horrill *et al*., 2000).

Along the western coast of Pemba Island, the fringing reef flat is extensively damaged in places; while the reef slope has few dead corals, with between 21% and 60% coral cover. The eastern fringing reef has not more than 15% coral cover due to its exposure to strong wave action. The highest live coral cover is found in Misali Island on the western side of Pemba, attaining 75% on the northern side and 53% on the eastern side. Misali has high species richness (40 coral genera). There has been some damage of the reefs by dynamite fishing and dragging seine nets (Horrill *et al*., 2000).

After the 1998 coral bleaching event, there was less than 40% survival of corals at Changuu and Chapwani near Zanzibar town. At Bawe, slightly farther from the town, there was 60-80% survival after bleaching. At Chumbe, 80-95% of *Acropora* spp., while in general there was 60-80% of the corals survived after bleaching (Wilkinson, 1998).

Mafia Archipelago

On the fringing reef of Mafia Island, hard coral cover is diverse with good coral cover to 25-30 m. The outer fringing reef was reported to be in good health in 1995 with some damage caused by wave action. Two large, sheltered, shallow (less than 10 m) bays of Mafia Island, Chole and Jujima, have extensive growth of corals (Darwall *et al*., 2000).

As a result of the 1998 coral bleaching event, there was generally 80-100% coral death in Mafia Marine Park. At Chole Bay, there was 100% death of *Acropora* spp. and at Tutia reef, there was more than 95% coral death (Wilkinson, 1998).

Songo Songo Archipelago and Kilwa

All coral reefs throughout the Songo Songo Archipelago and most reefs in Lindi and Mtwara are extensively damaged above a depth of 10 m, primarily by dynamite fishing, though below that level, the reefs are prolific with coral growth and abundant with fish. Shallow reefs, however, are almost completely destroyed (Guard and Masaiganah, 1997). Mpovi and Amani reefs near Kilwa Kivinje, which had previously been very productive (Hasset, 1983), now have large areas of rubble, poor coral cover and low abundance and diversity of fish (Hanaphy and Muller, 1997). The reefs with the least degradation are those which are adjacent to deeper waters such as Poiasi and Pwajuu patch reefs and the outer fringing reef which has dense coral growth to 30 m. The north-western reefs of the Songo Songo Archipelago have low coral diversity due to high sediment emanating from the Mohoro River (Darwall *et al*., 2000).

In a survey of 13 patch reefs in the Songo Songo Archipelago (Darwall *et al*., 1996a,b,c,d), average hard coral cover was found to range from 25% to 55% and the average proportion of hard coral that was alive generally ranged from 70% to 95%. Table 1 shows the percent cover of hard coral and soft coral as well as the percentage of hard coral that is alive for some of the patch reefs.

Table 1. The Percent Cover of Hard Coral and Soft Coral, and the Percentage of the Hard Coral that is Alive, on Some of the Patch Reefs in the Songo Songo Archipelago (Darwall e*t al*., 1996). (Values given are "Unweighted" Averages.)

Reef	Reef position	% hard coral	% soft coral	% of hard coral alive
Jewe	Slope	33.8	18.8	92.5
	Subtidal flat	36.7	10	85
Luala	Slope	38.3	20	-
Pweza	Slope	47.5	25	87.5
Pwajuu	Subtidal flat	55	20	82.5
	Upper slope	31	12	85
	Lower slope	32.5	20	87.5
Poiasi	Subtidal flat and upper slope	25	7.5	88.5
	Lower slope	31	12	93.5
Machangi	Slope	35	15	70
Chocha	Upper slope	55	10	90

Reef	Reef position	% hard coral	% soft coral	% of hard coral alive
	Lower slope	40	20	95
Miza	Subtidal flat	50	10	80
	Slope	35	25	80
Miza Kidogo	Slope	40	25	95
Membeuso	Northern, subtidal flat and Slope	55	10	80
	Eastern, slope	55	15	90
	Southeast and northwest, slope	25	15	80
Membeuso Kidogo	Slope	40	15	95
Banda	Subtidal flat	25	5	80
	Slope	30	15	90
Songo Songo	Western, Slope	20	15	90

Mtwara

In Mtwara, few quantitative studies were done before the 1998 coral bleaching event. However, following the bleaching event, 15-25% of the corals were found to be bleach at Mnazi Bay. At Kinasi Pass, 80-90% of *Acropora* spp. were dead (Wilkinson, 1998).

Evaluation of Impacts According to "State of the Coast Survey"

Table 2 gives a summary of some of the main findings of the "State of the Coast Survey" (Tanzania Coastal Management Partnership, 2001) highlighting fishermen's perceptions of coral reef ecosystems in their area.

It should be noted that the trends shown for some districts/villages over the past ten years show that degradation has occurred and hard coral cover, etc. have decreased, while in the past one year, conditions have improved. This is probably due to the effectiveness of coastal management and conservation strategies in recent years in some areas, particularly Tanga Region. Also, The threats mentioned in the table are those which the villagers perceive as being threats at the present moment or which have the possibility of becoming threats in the near future.

4.1.1.2 Mangrove Ecosystems

Human Impacts

In Tanzania, various uses of mangroves have led to the modification or loss of mangrove ecosystems. For many years, villagers have used mangroves on a sustainable basis for firewood, building poles, boat making, charcoal making and the making of salt by boiling seawater using mangrove firewood. However, with increased population along the coast, particularly in urban centres such as Dar Es Salaam, Tanga and Zanzibar, the demand for these resources has increased beyond the capacity of the mangrove ecosystems to regenerate and thus these uses are no longer sustainable in many areas of the country. Particularly, the making of charcoal for sale in urban centres has led to severe degradation of many mangrove areas. In some parts of the country where there is coral mining, the burning of live coral in kilns using mangrove firewood has put a heavy demand on the mangrove forests. These uses have caused fragmentation and modification of many of the mangrove forests in Tanzania.

Besides the above-mentioned uses which entail harvesting or selective cutting, there are other human activities which involve clear cutting of substantial areas of mangrove forests. These include clearing for aquaculture, solar saltpans, agriculture (particularly rice farming) and the construction of hotels, industries, roads, houses, etc. Such clear cutting results in loss of ecosystems or portions of them, which has become serious in the past two or three decades. Large-scale clear felling of mangroves hinders natural regeneration (Germanis, 1999; Masawe, 1999; Semesi 1987, Semesi *et al.* 1999) due to alteration of the soil microclimate and the lack of seed-bearing trees as seed sources.

Table 2. Impacts/Conditions, Trends and Threats to Coral Reef Ecosystems Near a Representative Village in Each Coastal District of Tanzania, Based on Villagers' Perceptions.

Region/ District/ Village	Impact/ Condition	Trend (past one year)	Trend (past ten years)	Threats	Comments
Tanga/ Muheza/ Kicharikani	Fairly good condition; very high hard coral cover and diversity of corals, invertebrates and fish.	Increase in coral cover, live coral and fish abundance, constant diversity of corals and invertebrates.	Decrease in coral cover, live corals and fish abundance, diversity of corals and invertebrates constant, increase in damage.	Seaweed farming, Crown-of-Thorns starfish, coral bleaching, dynamite fishing (minor).	Wamba reef is a hot spot, certain reefs need restoration.
Tanga/ Tanga Municipality/ Tongoni	Fairly good condition, high hard coral cover and diversity of corals, invertebrates and fish.	Decrease in coral diversity, increase in fish abundance and invertebrate diversity.	No significant change in the abundance of hard/soft corals.	Seaweed farming, Crown-of-Thorns starfish, coral bleaching, dynamite fishing (minor).	All reefs are critical areas, Karange and Jahazi reefs are hot spots and need restoration.
Tanga/ Pangani/ Kipumbwi	Low hard coral cover and fish abundance.	Decrease in area damaged, hard coral, no change in cover and fish abundance.	Area damaged increased, hard coral cover and fish abundance constant.	Boat anchoring, grounding, movement, tourist activities, poisoning.	Dambwe, Yazinga and Maziwi reefs are preferred fishing grounds (critical areas); Mjimile Ndogo Reef is a hot spot due to severe dynamite fishing and needs restoration.
Pwani/ Bagamoyo/ Kondo	Coral reefs are not accessible from this village.				
Pwani/ Mkuranga/ Kisiju	Reefs good condition, good live hard coral cover, high fish abundance, low damage.	Decrease in area damaged, increase in hard live coral cover and fish abundance.	Area damaged has increased, hard coral cover and fish abundance decreased.	Shellfish collection, coral mining.	Nil.
Pwani/ Rufiji Nyamisati	No coral reefs in the area because of sedimentation from the Rufiji River.				

Region/ District/ Village	Impact/ Condition	Trend (past one year)	Trend (past ten years)	Threats	Comments
Pwani/ Mafia/ Chunguruma	Somewhat more than half of the total area of the reef is hard coral, little damage.	Increase in hard coral cover; decrease in area damaged; increase in fish abundance.	Hard coral cover and fish abundance decreased; area damaged increased.	Anchoring is major cause of damage; dynamite fishing stopped.	15 reefs are preferred fishing grounds.
Dar Es Salaam/ Kinondoni/ Kunduchi Beach	About half the reef area is hard coral cover; half the reef area .is damaged; low fish abundance.	Decrease in hard coral and fish abundance; increase in area damaged.	Same as one-year trend.	High threats: seine netting, overfishing, shell fish collection; low threat is dynamite fishing (10-15 blasts per day), anchoring.	Hot spots badly damaged: Mbudya, Fungu Yasini, Mkadya; critical areas (preferred fishing grounds): Fungu Yasini, Karage.
Dar Es Salaam/ Ilala/ Fish Market	Those interviewed had no information.				
Dar Es Salaam/ Temeke/ Mjimwema	Reefs about half hard coral; almost half the area damaged; average fish abundance.			High threats are dynamite fishing, seine netting, Crown-of- Thorns; medium threats: over-fishing, shellfish collection, boat anchoring.	Critical area: Dege Reef; badly damaged reef: Kuhuri; recommended for closure: Sinda; others recommended for coral restoration.
Lindi/ Kilwa/ Somanga Mbuyuni	Somewhat more than half of the coral reef area is hard coral; almost half the reef area is damaged; high fish abundance.	Increase in hard coral and fish abundance; increase in area damaged.	Hard coral and fish abundance decreased; area damaged increased.	Very high threat: dynamite fishing; high threat: over-fishing; medium threat: seine netting, anchoring, Crown of Thorns.	Preferred fishing grounds: 11 reefs listed; hot spots (dynamited reefs that could be restored): Fisi, Miza, Chocha, Banyanyi.
Lindi/ Lindi/ Mchinga Mbili	Somewhat more than half of the coral reef area is hard coral; almost half the reef area is damaged; high fish abundance.	No change in hard coral; decrease in area damaged; decrease in fish abundance.	No change in hard coral; increase in area damaged; decrease in fish abundance.	High threat: use of poison; medium threats: seine netting, over-fishing, anchoring, coral mining.	Critical reefs: 10; hot spots: 4 reefs: reefs to be closed: 4; reefs needing restoration: 4.
Mtwara/ Mtwara/ Msangamkuu	Half the reef area is damaged; high fish abundance.	Increase in hard coral; decrease in damage; increase in fish abundance.	Area damaged increased.	High threat: Crown -of- Thorns.	Preferred fishing grounds: 13 reefs; hot spots: 5 reefs.

Region/ District/ Village	Impact/ Condition	Trend (past one year)	Trend (past ten years)	Threats	Comments
Zanzibar/ West/ Fumba	Somewhat more than half the reef area is hard coral; about half the area is damaged; fish abundance is medium.	No change in hard coral; decrease in area damaged; decrease in fish abundance.	Same as one-year trend.	High threat: tourists snorkelling/diving; medium threat: dynamite fishing, seine netting, Crown-of-Thorns.	Preferred fishing grounds: Kwale Pungume; hot spots: some parts of Kwale Pungume badly damaged.
Zanzibar/ North A/ Nungwi	About half the reef area is hard coral; somewhat less than half is damaged.	No change in area damaged; decrease in hard coral and fish abundance.	Area damaged increased; no change in hard coral; fish abundance decreased.	High threat: over-fishing; medium threat: tourists snorkelling and diving, seaweed farming.	Preferred fishing grounds: Kipisani, Musemba wa Nungwi; hot spots: almost all reefs damaged.
Zanzibar/ South/ Kizimkazi Dimbani	About half the reef area is hard coral/ somewhat less than half is damaged; fish abundance medium.	Decrease in area damaged; decrease in fish abundance; no change in hard coral.	Same as one-year trend except that area damaged remained constant.	Significant threat: over-fishing.	Preferred fishing grounds: Pungume, Mtende; hot spots: Karage, Misamba Uzi.
Pemba/ Mkoani Pemba/ Mbuyuni	Somewhat more than half the reef area is hard coral; high fish abundance.	Decrease in fish abundance; increase in area damaged.	Area damaged increased; fish abundance decreased.	High threats: over-fishing, coral mining, Crown-of-Thorns, hitting corals to scare fish.	Critical areas: Wambaa, Misali; hot spots: Kwata, Utumbini.
Pemba/ Wete/ Kojani	About half hard coral; about half the area is damaged; fish abundance medium.	No change in hard coral; increase in area damaged.	Same as one-year trend.	High threat: seine netting; medium threat: over-fishing.	Preferred fishing grounds: Malilini, Kiogweni, Mchanga, Mkuu; hot spots: small reefs near Kojani Island.

Yet another way in which human activities have affected mangrove ecosystems is through modification of patterns of water movement, either freshwater or seawater, which is so vital to the maintenance of mangrove forests. Related to this are improper agricultural and forestry practices that have led to soil erosion and change in sedimentation patterns.

Some fishing practices are also harmful to mangroves such as dragging seine nets over the forest floor under the tree canopy. For example, at Mtoni Kijichi, regular dragging of seine nets under the large *Sonneratia alba* trees has resulted in complete lack of seedlings and intermediates to regenerate the stand (Akwilapo, 2001). Digging in the mangrove mud, particularly in the *Sonneratia* and *Rhizophora* zones, in order to obtain polychaetes for fish bait also results in ecological damage of the mangroves (Semesi *et al.*, 1999).

Finally, near Dar Es Salaam, Tanga and Zanzibar town, there have been various types of pollution such as domestic, industrial, agro-chemical and solid wastes that have led to modification of mangrove

ecosystems. Boat traffic that increases erosive boat wakes also may have negative affects on mangroves.

Natural Impacts

Among the natural impacts affecting the conditions of mangroves are floods which change the salinity and level of the water, the diversion of water due to changes in river courses, strong wave action, blocking of normal tidal flow due to sand deposition, and drought which may create hypersaline conditions on the landward side of some mangrove forests. Therefore, in places like the Rufiji delta there is a lot of natural changes. While mangroves on the landward side are sometimes killed by either flooding or hypersaline conditions, new mangroves are recruited on the seaward side as more sediments are deposited. On the other hand, in other mangrove areas such as in Mafia Island, and some parts of Chwaka Bay and Kaole, sediments are sometimes washed away on the seaward side, for reasons not well understood, and mangroves are swept away by wave action (Semesi, 2001).

Loss Versus Modification Caused by Impacts on Mangrove Ecosystems

All the human impacts which involve harvesting of mangroves (i.e., for firewood, building poles, etc.) generally lead to modification of the ecosystem, not loss. In some extreme cases, however, the harvesting has been so intensive that it has led to loss of significant sections of the forest or sometimes the entire forest.

On the other hand, the activities that involve clear cutting of mangroves for various purposes such as construction, agriculture, etc. cause ecosystem loss.

Natural impacts may lead to either loss or modification of ecosystems, depending on the severity of the event.

Assessment of Environmental Impacts on Mangrove Ecosystems

The rate of cutting is high near big population centres and therefore the most degraded mangroves are those close to towns such as that at Mtoni, Kunduchi, Mbweni and Mjimwema in Dar Es Salaam, Maruhubi close to Zanzibar town or those mangroves close to Tanga and Mtwara towns. Some mangroves found on islands in Tanga region such as Ulenge area are also quite degraded because they are readily accessible by boat, so they are cut illegally and exported to Kenya.

However, some parts of Rufiji and Ruvuma deltas have mangrove ecosystems that are in excellent condition because the local communities in the area have low populations and thus use the mangroves on a sustainable basis. Moreover, it is difficult to access them from more highly populated areas such as Dar Es Salaam. There are probably no completely pristine areas of mangroves in Tanzania due to the long dependency of coastal communities on the mangrove resources. Many studies (Banyikwa and Semesi, 1986; Nasser, 1994; Shunula, 1996; Semesi *et al.* 1999, Akwilapo, 2001) have shown increasing degradation of mangroves in various parts of Tanzania.

In some stands of mangroves such as in Maruhubi and Chwaka in Zanzibar or Kunduchi and Mtoni in Dar Es Salaam, the rate of annual removal of trees from the forest is higher than the mean annual regeneration rate. Clearance of mangroves for salt production and charcoal making are the most important factors leading to the destruction of the mangroves of Bagamoyo, Lindi, Zanzibar, Dar Es Salaam, Mtwara and Tanga (Banyikwa and Semesi 1986; Semesi, 1987, 1993; von Mitzlaff, 1990; Shunula, 1996; Kulindwa *et al.*, 1998; Masawe, 1999).

In Ruvu and Rufiji deltas, mangroves are cleared to make rice farms (Semesi, 1991; Sørensen, 1997; Semesi *et al.,* 1999). In the Rufiji delta, approximately 7 years (with a range of 4 to 11 years) after clearing the mangroves, the yield of the rice farms falls drastically and grasses, phragmites, sedges and

Derris invade the farms. Therefore the farms are usually abandoned after this period and new areas of mangroves cleared.

Evaluation of Impacts According to "State of the Coast Survey"

The results of the "State of the Coast Survey" (Tanzania Coastal Management Partnership, 2001) based on villagers' perceptions about mangrove forests in their area are given in Table 3.

Table 3. Impacts/Conditions, Trends and Threats to Mangrove Forests Near a Representative Village in Each Coastal District of Tanzania, Based on Villagers' Perceptions

Region/ District/ Village	Impact/ Condition	Trend (past one year)	Trend (past ten years)	Threats	Comments
Tanga/ Muheza/ Kicharikani	Good condition, high density of trees, high seedling.	Increase in occurrence of seedlings, number mature trees.	Occurrence of seedlings, number mature trees, decreased.	Cutting for domestic use(firewood, building, boat making) commercial cutting ,coral burning, agriculture.	Replanting was done only once (only a few survived), people did this for free.
Tanga/Tanga Municipality/ Tongoni	Good condition with insignificant degradation. High density mature trees and seedling occurrence.	Increase in density of forest, occurrence of seedlings and number of mature trees.	Density of forest, occurrence of seedlings and number of mature trees declined.	Cutting for domestic use however regulated by village authorities.	Replanting is done by village environmental committee (23,000 seedlings in past 5 years).
Tanga/Pangani/Kipumbwi	Good condition high density of mature trees, seedling occurrence.	Increase in density of forest number of mature trees occurrence of seedling, damaged area is constant.	Density of forest number of mature trees occurrence of seedlings decreased, damaged area is constant.	Cutting for domestic use do not regulated by village authorities, pose a serious danger to mangroves.	Replanting is done regularly (each person about 20 seedlings a day).
Pwani/ Bagamoyo/ Kondo	Good condition high density of mature trees, seedling occurrence however their diversity is low.	Density of forest number of mature trees occurrence of seedling is constant. Damaged area is constant.	Density of forest number of mature trees occurrence of seedling was constant. Damaged area is constant.	There is no serious threat to the mangroves.	
Pwani/ Mkuranga/ Kisiju	Good condition high density of mature trees, seedling occurrence. The damaged area is small.	Increase in density of forest and number mature trees, other indicators are stable.	Density of forest and number mature trees increased, other indicators are stable.	There is no serious threat to the mangroves except for the eminent shoreline erosion.	

Region/ District/ Village	Impact/ Condition	Trend (past one year)	Trend (past ten years)	Threats	Comments
Pwani/ Rufiji/ Nyamisati	Good condition, very high density of mature trees, seedling occurrence. Area degraded is insignificant.	Increase in area degraded increased (due to prawn farming). Increase in density of mature trees, seedling occurrence.	Area degraded increased (due to prawn farming), density of mature trees, seedling occurrence increased.	Clear cutting for construction and coastal erosion (due to heavy rainfall and riverbank burst).	No hot spot or specific priority restoration areas.
Pwani/ Mafia/ Chunguruma	Density of the forest height/ maturity of the trees are low, mangrove diversity is high and seedling occurrence is average.	Increase in density of forest, decrease in area degraded.	Density of the forest height/ maturity of the trees decreased, area degraded increased.	All threats are low.	Mangrove forest conservation action: Kichevi.
Dar Es Salaam/ Kinondoni/ Kunduchi Beach	Density and height/ maturity of trees are high, small patches partially or completely cut, occurrence of seedlings is medium.	Increase in density and height of trees, Decrease in areas degraded, increase in occurrence of seedlings.	Decrease in density of tree, increase in height, increase in area degraded, decrease in occurrence of seedlings.	High threat: coastal erosion, medium threat: changes in water regime.	Hot spots (badly degraded) and recommended for conservation actions: Chakomble.
Dar Es Salaam/ Ilala/ Fish market	Inadequate information.				
Dar Es Salaam/ Temeke/ Mjimwema	Density and maturity of trees are very low. Area degraded is insignificant.	Increase in density and maturity of trees and occurrence of seedlings, decrease in area damaged.	Density and maturity of trees and occurrence of seedlings decreased, area damaged increased.	All threats are very low.	Critical areas: Jangusare, Turiari Conservation areas: same.
Lindi/ Kilwa/ Mbuyuni	Density and maturity of trees are average, area degraded is insignificant, high seedling occurrence.	Increase in density and height of trees and area degraded.	Density and height of trees decreased, area degraded decreased.	Medium threats: clear-cutting for salt making, harvesting for building poles and boat making.	Nil.
Lindi/ Lindi/ Mchinga Mbili	Density and maturity of trees are high, area degraded is insignificant, high seedling occurrence.	Increase in density and height of trees and occurrence of seedlings, decrease in area degraded.	Density and height of trees and occurrence of seedlings decreased, area degraded increased.	High threat: clear cutting for solar salt pans, medium threat: harvesting for build poles and boat making.	Nil.

Region/ District/ Village	Impact/ Condition	Trend (past one year)	Trend (past ten years)	Threats	Comments
Mtwara/ Mtwara/ Msangamkuu	Density and maturity of trees are low, area degraded is insignificant.	Increase in density and height of trees and occurrence of seedlings, no change in area degraded.	Density and height of trees and occurrence of seedlings. decreased, no change in area degraded.	All threats very low.	Nil.
Zanzibar/ West/ Fumba	Density and maturity of trees are high, Small patches are partially or completely cut, high seedling occurrence.	Increase in height of trees and occurrence of seedlings, no change in area degraded and density of mangroves.	Same as one-year trend, except area degraded increased.	Medium threat: harvesting trees for building poles.	Nil.
Zanzibar/ North A/ Nungwi	No mangrove forests in the area.				
Zanzibar/ South/ Kizimkazi Dimbani	Density of trees is medium, maturity of height of trees and occurrence of seedlings are above average, half of the forest is partially or completely cut.	Increase in density and height of trees and occurrence of seedlings, decrease in area degraded.	density and height of trees and occurrence of seedlings decreased, area degraded increased.	High threats: harvesting for making charcoal, selling, firewood and coral mining industry.	Critical area and hot spot: Fumbwini.
Pemba/ Mkoani Pemba/ Mbuyuni	Density and height of trees is medium, occurrence of seedlings are high, half of the forest is partially or completely cut.	Decrease in density, increase in height of trees, increase in area degraded.	Decrease in density and height of trees, and occurrence of seedlings, decrease in area degraded.	High threat: harvesting for fuel for coral mining industry, building poles and boat making.	Critical area and hot spot: Matumbini. Makoongwe School plants 1000 seedlings every 6 months .
Pemba/ Wete/ Kojani	Density and height of trees is medium, occurrence of seedlings are high, half of the forest is partially or completely cut.	Increase in density and height of trees and occurrence of seedlings, decrease in area degraded.	Decrease in density and height of trees, and occurrence of seedlings, increase in area degraded.	High threat: harvesting for fuel for coral mining industry, and domestic firewood. Medium threat: harvesting for building poles and boat making.	Critical area (high value) and hot spot: Kisiwa Kikuu

4.1.1.3 Seagrass Beds

There are about 12 species of seagrasses found in Tanzanian coastal waters (Semesi and Shushu, 1988). Seagrass beds are important because of their interactions with other ecosystems in the marine environment, especially mangroves and coral reefs. In Tanzania, seagrasses form dense beds that cover large areas of coastal waters and perform a wide range of biological and physical functions. They provide breeding, nursery and feeding areas as well as shelter for many invertebrates and vertebrate species. The Green turtle *Chelonia mydas* and the dugong\ *Dugong dugon* depend on seagrasses for food and other organisms such as certain species of sea urchins feed on the detritus

produced by seagrasses. Moreover, seagrass roots bind sediments and slow the rate of water flow over the substrate, thus preventing erosion of the ocean sediments.

Human Impacts

Destructive fishing practices are amongst the human impacts affecting seagrass beds in Tanzania, particularly beach seining and trawling. Although beach seining is illegal, it is a very common practice in many areas along the coast of Tanzania. Since the net has weights to hold the bottom of the net down, as it is dragged up the beach it uproots the seagrass and scoops up many of the associated organisms. Trawling has a similar effect on seagrass beds, but in the deeper offshore areas.

Near cities, towns and other concentrations of human populations, excessive movement of boats and people leads to direct damage of the seagrass beds, particularly in fish landing sites. Besides direct damage, sedimentation also occurs which is has negative impacts on seagrasses by blocking of light and interfering with gaseous exchange on the surfaces of the leaves.

Another human activity which does not have a direct effect on the seagrass itself, but which affects the integrity of seagrass bed ecosystems is the collection of shellfish which leads to loss in biodiversity of these habitats.

As with other marine habitats, pollution causes impacts on seagrass beds, particularly those situated near Dar Es Salaam, Tanga and Zanzibar town as well as smaller urban centres.

Natural Impacts

Natural impacts which may affect seagrass beds include heavy rainfall which may cause excessive sedimentation on seagrass beds which are situated near rivers. Also, very heavy wave action can uproot seagrasses.

Loss Versus Modification Caused by Impacts on Seagrass Beds

Most of the human and natural impacts on seagrass beds can lead either to modification or loss of ecosystems, depending upon the severity of the activity or event.

Assessment of Environmental Impacts on Seagrass beds

In permanent seine netting sites, there has been serious damage to seagrass beds, with seagrasses and all associated organisms almost completely absent. Though studies have not been conducted to document this, this trend is obvious in some sites such as Kunduchi (personal observations).

However, a recent study documented damage done to seagrass beds at a fish landing site at Mbweni, north of Dar Es Salaam. The percent cover of seagrass was extremely significantly lower at the fish landing site (28%) than in the adjacent area (63%), even though other factors such as percent pore water and organic matter were homogeneous in the two sites (Mann-Whitney U test: $U = 5554.5$, $n_1 = n_2 = 90$, $p < 0.0001$) (Mwaigomole, 2001).

Though damage done by trawling may be considerably in some areas, no studies have been done on this aspect.

Evaluation of Impacts According to "State of the Coast Survey"

The results of the "State of the Coast Survey" (Tanzania Coastal Management Partnership, 2001) (Section 1.1.4) based on villagers' perceptions of seagrass beds in their area are given in Table 4.

Table 4. Impacts/Conditions, Trends and Threats to Seagrass Beds Near a Representative Village in Each Coastal District of Tanzania, Based on Villagers' Perceptions.

Region/ District/ Village	Impact/ Condition	Trend (past one year)	Trend (past ten years)	Threats	Comments
Tanga/ Muheza/ Kicharikani	Seagrass abundance is medium.	-	-	No significant threat.	-
Tanga/ Tanga Municipality/ Tongoni	Seagrass abundance is low.	-	-	-	-
Tanga/ Pangani/ Kipumbwi	Seagrass abundance is low.	-	-	-	-
Pwani/ Bagamoyo/ Kondo	Seagrass abundance is high.	-	-	Bottom trawling.	-
Pwani/ Mkuranga/ Kisiju	Seagrass abundance is low.	-	-	Bottom trawling.	Seagrass beds in tidal flats have been badly damaged by dredging and Sedimentation.
Pwani/ Rufiji Nyamisati	Seagrass abundance is medium.	-	-	Bottom trawling.	Hot spot: trawling outside the delta has damaged seagrass beds.
Pwani/ Mafia/ Chunguruma	Seagrass abundance is low.	No change in seagrass abundance.	No change in seagrass abundance.	-	Critical areas (high value): seagrass beds at Kigomani.
Dar Es Salaam/ Kinondoni/ Kunduchi Beach	Seagrass abundance is somewhat less than average.	Decrease in seagrass abundance.	-	-	Hot spots (seagrass beds have been badly damaged): Kunduchi beach.
Dar Es Salaam/ Ilala/ Fish Market	No information.	-	-	-	-
Dar Es Salaam/ Temeke/ Mjimwema	Seagrass abundance is somewhat less than average.	-	-	-	-
Lindi/ Kilwa/ Somanga Mbuyuni	Seagrass abundance is somewhat more than average.	No change in seagrass abundance.	No change in seagrass abundance.	Very high threat: bottom trawling.	-
Lindi/ Lindi/ Mchinga Mbili	Seagrass abundance is high or somewhat more than average.	Seagrass abundance decreased.	Seagrass abundance increased.	-	Critical area (high value seagrass beds): Mkwaja, Lukumbi, Nondo, Mvinjeni, Ng'ululu.

Region/ District/ Village	Impact/ Condition	Trend (past one year)	Trend (past ten years)	Threats	Comments
Mtwara/ Mtwara/ Msangamkuu.	Seagrass abundance is low.	Seagrass abundance increased.	Seagrass abundance decreased.	-	Nil.
Zanzibar/ West/ Fumba.	Seagrass abundance is medium.	Seagrass abundance decreased.	-	-	-
Zanzibar/ North A/ Nungwi.	Seagrass abundance is very high.	-	-	-	-
Zanzibar/ South/ Kizimkazi Dimbani.	Seagrass abundance is high.	-	-	-	-
Pemba/ Mkoani Pemba/ Mbuyuni.	Seagrass abundance is high.	-	-	-	Conservation area: Seagrass beds at Matumbini are recommended for closure.
Pemba/ Wete/ Kojani.	Seagrass abundance is high.	-	-	-	-

4.1.2 Socio Economic Impact Assessment

Introduction

To a greater extent coastal communities rely on the coastal and marine resources for their livelihood in terms of provision of food, fuel, shelter, and income. The state and status of these resources therefore determines their socio-economic status.

Currently there is evidence that there is increased habitat/community degradation which has a bearing on the human life along the coast which is heavily dependent on the marine and coastal resources (Sosovele, 2000; Schultenberg *et al*., 2000; Hatziolos *et al*., 1996). Degradation of habitats and communities alter the ability of the coastal and marine ecosystems to recover from heavy use and other disturbances.

We have alluded to the high dependence of the coastal population on the coastal aquatic and marine ecosystems for food, fuel, shelter and income. This means that as the community and habitats are degraded, the people also lose an invaluable source of livelihood. Discussions that follow focus on socio-economic impacts which arise from the destruction or altering of two types of ecosystems, namely, coral reefs and mangrove forests.

Coral Reefs

Coral reefs in Tanzania support an intensive and mainly artisanal fishery. In terms of the total fisheries catch, virtually all of the demersal fish taken are from coral reefs, and a significant part of the other components of the catch are also taken from coral reef areas. The most important fish families among the coral reef catch include the *Lethrinidae*, *Lutjanidae*, *Siganidae*, *Scaridae*, *Labridae*, and *Mullidae*. The other important components of the coral reef catch include octopus, lobsters, squid, various shells for the curio trade, and sea cucumbers. The export of sea cucumbers (beche-de-mer or trepang) is one

of the more profitable types of marine resource extraction from coral reefs. In addition, seaweed cultivation is presently the most lucrative marine resource related activity for many coastal communities. This is primarily undertaken in the lagoons that exist behind many of the fringing reefs on Unguja Island and, to a lesser extent, on Pemba Island, so that the industry as a whole is dependent on the protection afforded by the reefs.

Fishing plays an important role as a source of cheap protein and employment. The number of full time fishermen operating in Zanzibar is 23,000 fishermen (Lyimo *et al*., 1997) and there are about 15,00 fishermen along the coast of Tanzania (Haule and Kiwia, 1999). The per capita consumption is 25-30kg/person. The contribution of fishery to the GDP varies between 2.1-5% in Tanzania mainland and 2.2-10% in Zanzibar mostly from the export of fishery products (Jiddawi and Ngoile, 1999). Tanzania exports marine fishery products to the tune of around US$ 7,652,700 for the mainland part and US$ 598,203 for Zanzibar (Jiddawi and Ngoile, 1999). These products are shrimp, beche de mer, shells, lobster, crabs, squids, octopus, sardines, and aquarium fish.

The fishery industry also supports a significant number of individuals working in associated sectors such as boat building and repair, gear repair as well as marketing the fishery products.

Coral reef destruction greatly lowers the aesthetic value of the marine environment and hence a decreases in the number of tourists. One of the main reasons tourists come to Zanzibar is to enjoy snorkelling and scuba diving on the coral reefs. It is reported that 68% and 85% of the tourists come to Zanzibar for diving and snorkelling, respectively. Thus, the destruction of the coral reefs means decrease in tourism and, with this, decline of foreign exchange from the tourists which indirectly impacts the locals. This also impacts the local people because they loose direct income which tourists would have paid for food, ornaments and carvings.

Mangroves

Coastal communities in Tanzania have traditionally exploited rich products of the mangrove ecosystems as well as various parts of the mangrove trees themselves. The mangroves have many direct uses, particularly for firewood, boat building, and poles (Semesi, 1986).

In recent years, the rate and variety of human influences on the mangroves have increased to the extent that they are threatened with destruction in some areas. One of the most pressing issues in the mangroves forests is the loss of areas due to conversion for commercial purposes. For instances, conversion to agricultural lands, clearing of mangroves for rice farms in Rufiji Delta (Semesi, 1991), conversion to salt pans (Semesi, 1991), conversion to aquaculture ponds (prawn farming) (Semesi, 1998), and clearance for urban and industrial development (Semesi, 1991). Others threats include alteration of the hydrological conditions (dams upstream of rivers) (Semesi, 1986); pollution through using mangrove forests as rubbish dumps (Shunula, 1998); and over-exploitation of resources, through mainly clearing of mangroves for fuel and construction purposes (Banyikwa and Semesi, 1986).

Fishermen from Rufiji, Ruvu and Wami complain that there is a sharp decline in fish catches in the shallow waters and the catches now consist of juveniles. They also point to the difficulty experienced today in obtaining strong poles and thick logs for boat making (Kulindwa *et al*., 1998).

It may be safely concluded that although there is no quantification of losses arising from mangrove habitat loss or modification, there is clear evidence that coastal communities are losing out in terms of income and wood for other household purposes.

4.2 Destructive Fishing Practices

Fishing methods such as dynamite fishing and beach seines are destructive to the environment in which they are applied, regardless of how limited their operations are. The use of dynamite or explosives for fishing has been the most highly destructive fishing practice in the marine environment

in most parts of Tanzania. Dynamite fishing, is a very destructive fishing method used mainly in shallow waters of less than 10 m deep. This method destroys the basis for reef fish productivity by indiscriminately killing juveniles and adult fish alike and at the same time reducing the reef to rubble. Usually conducted in reef areas, a single dynamite blast kills all pelagic organisms, fish and larvae within a 10-15 m radius of the blast, and completely destroys the 3-dimensional complexity of the reef within an average diameter of 2-5 m. Reef complexity provides essential shelter for juvenile fish and other marine organisms and the productivity and diversity of the reef is drastically reduced over time.

4.2.1 Environmental Impacts

Assessment of Impacts

While destructive fishing practices have been identified as the second most serious issue in Tanzania, these are, in fact, amongst the primary causes of the first issue, i.e., modification and loss of ecosystems, and have therefore largely already dealt with in Section 1. Thus the description of impacts in this section will be rather brief.

In connection with coral reefs, as mentioned above, destructive fishing practices are the main factors leading to the degradation of coral reefs. Dynamite fishing has caused more damage than any other fishing practice in Tanzania. Other destructive and harmful fishing practices include the dragging of seine nets, careless spear-fishing, improper use of basket traps, the use of poison, and the collection of shellfish. Other destructive practices related to fishing are the dropping of anchors and the grounding of boats on the reefs.

There are only a few fishing methods that are destructive to mangrove forests. In some forests, seine nets are dragged under the tree canopy. This uproots any seedlings and greatly reduces the possibility of regeneration.

In seagrass beds, the destructive fishing practices carried out are beach seining and trawling. These practices cause substantial damage to the seagrass beds where they are undertaken.

There is very little impact due to destructive fishing practices outside the three habitats mentioned above. There is likelihood that beach seining and trawling may also cause destruction in algal beds in Tanzania. However, there is no information to substantiate this.

4.2.2 The Socio-Economic Impacts

4.2.2.1 Dar Es Salaam area

The population in Dar Es Salaam, the main commercial and central government administrative city, is growing faster than in any other region in Tanzania. Being the centre of commercial activities and international organizations, Dar Es Salaam is attracting many people from all the regions of Tanzania and beyond. Fisheries provides a major source of income and protein to many people in Dar Es Salaam.

However, like other coastal areas, Dar Es Salaam has been affected by destructive fishing practices. The artisanal fishery in Dar Es Salaam is concentrating in inshore shallow waters because of the limited range of the fishing vessels and crafts. The most productive fishing grounds are coral reefs and seagrass beds. These areas experience very high fishing pressure from the artisanal fishermen, especially as they strive to meet the growing urban demand for fish. Dar Es Salaam residents can access protein from other sources (including fish from other areas in Tanzania); however, unreliable and unstable supply forces many of them to increase pressure on the available fishing areas within the proximity of many fishermen in Dar Es Salaam. This leads to pressure on these resources.

4.2.2.2 Rufiji-Mafia-Kilwa Complex

Commercial fishing accounts for a small proportion of the total fish production in these areas. The main commercial species of interest in this area are prawns and other high value species. Most of the large foreign commercial fishing fleets encroach into shallow waters to fish illegally in those areas. This has created tension between artisanal fishermen and commercial fishermen over fishing territories and rights. Also, local small-scale fishermen complain about the destruction of artisanal fishing gear and the damage to the sea floor by industrial trawlers. Small-scale fishermen blame large-scale commercial fishing vessels for the destruction of their fishing gear, encroachment into their fishing territory and being responsible for over-fishing.

In Rufiji and Mafia, bottom trawling for shrimp and molluscs is also occurring thus being harmful to soft benthic communities due to the continuous disturbance to microhabitats and sediment structure. There has been an extreme increase in shrimp trawling that has resulted in capturing of juvenile fish and non fish species of economic and ecological importance, as well as the destruction of the bottom habitat of the sea, including benthic flora and fauna. Tanzania has prawn resources located in Rufiji delta, the Mafia channel, Ruvu, Wami and Pangani estuaries. With the policy of liberalization of the national economy which commenced in the mid-1980's, private investors (both local and foreign) are currently participating in the fisheries sector. The shrimp trawlers have also increased the supply of fish for local consumption, especially in Dar Es Salaam and other regions. The involvement of many prawn trawlers has increased competition in the exploitation of the marine resources.

4.2.2.3 Tanga Area

Artisanal fishing, though an important activity of the coastal population of Tanga region, has contributed to the severe degradation of the marine environment and reduced catches. The coral reefs were severely damaged during the 1980s by dynamite fishing as evidenced by the present fractured massive framework of coral colonies, craters and rubble patterns. In addition, anchoring techniques employed by artisanal fishermen had exacerbated the damage. The extensive damage caused by these practices reduced the recruitment rate of many species.

Data from the fisheries department MNRT (1996) show that there has been a decrease in landed catch with a slight increase in the number of fishermen and gear from 1985-1986 to 1995-1996.Table 5 illustrates the fisheries statistics 1985-1995 showing the downward trend in catch per fisherman for the 10-year period.

Table 5. Total Marine Fish Production (in tons) for Tanzania Mainland: 1985 - 1995

Regions	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
Tanga	4,547.5	4,402.1	4,864.7	7,617.9	5,440.7	5,544.4	4,187.5	4,187.5	4,855.6	5,373.5	5,373.5	56,394.9
Coast	10739.6	10745.4	11402.3	11950.2	10997.9	16499.9	12631.6	10659.2	8,609.0	9,147.9	9,147.9	122530.9
DSM	6,833.9	10656.4	6,352.1	14001.8	15256.0	14557.4	15451.6	16502.5	14867.3	16615.9	16615.9	147710.8
Lindi	11589.4	14050.9	7,325.2	5,965.2	8,042.4	9,886.0	12071.1	6,378.6	3,270.7	3,605.9	3,605.9	85791.3
Mtwara	7,963.2	5,326.9	7,325.2	7,325.2	7,407.8	8,039.0	8,039.0	4,455.2	2,623.8	2,542.7	2,542.7	63590.7
Total	30084.2	45181.7	37269.5	46860.3	47144.8	54526.7	52380.8	42183.0	34226.4	37285.9	37285.9	476018.6
Commercial	900.1	1,483.2	1,798.9	2,190.0	2,437.6	2,015.2	1,510.2	1,119.1	1,222.7	1,786.8	1,786.8	18250.6

Source: Ministry of Lands, Natural Resources and Tourism. Fisheries Division, 1985 – 1995 Annual Reports Statistics.

From the above table, it is argued that since 1985 there has been a decrease in the total catch per fisherman per year. Moreover, the major component of the landed catch has shifted from inshore demersal fish normally found on reefs and coastal areas to pelagic species, present and migrating in the offshore fishing grounds. This means the diversity of reef fish species had declined due to explosive fishing, improper anchoring techniques and careless fishing methods. Consequent to this downward trend, availability of fish is likely to have been affected too, thereby, leading to increased prices for fish and reduced protein intake. Tanga depends so much on fish and marine resources for protein because of the low rate of livestock keeping in the region. Changes in the availability of fish are likely to have negative impact on the welfare and livelihood of many people who depend on this sector for survival and income generation.

4.2.2.4 Bagamoyo Area

Bagamoyo is a fast growing tourist destination in which fishing and fishery resources can play an important role in raising the local economy. However, due to increasing destruction of the mangrove areas (Kulindwa *et al*., 2000), the breeding places for fish have also been destroyed. Due to this mangrove destruction coupled with destructive fishing practices such as dynamite fishing, beach seining and the encroachment of the trawlers, the fishing industry in Bagamoyo is facing major threats and stocks are declining both in number and fish sizes. Consequently, there has been a shift away from gill-netting operations towards shark-netting operations including greater efforts applied to catching high value pelagic species. The number of fishing vessels and the fishing methods used are uncontrolled and pose major threats to the sector and welfare of the local population. In addition, as the stocks decrease, fishermen tend to use smaller mesh size nets to try to increase catches to meet the market demand, but this has led to catching more juveniles.

Destructive fishing practices in Bagamoyo has led to decreased nutrition and loss of income. .In addition, as the tourism sector expands, it will increase demand on fisheries resources, which will probably be met by these destructive practices, unless measures are put in place to control them. In addition, these destructive practices may force hoteliers in Bagamoyo to import fish from other nearby areas, such as Zanzibar and Dar Es Salaam, thereby denying the local people of the opportunity to improve their economy and livelihoods.

4.2.2.5 Zanzibar

Fishing plays an equally important role in the economy and the life of the people of Zanzibar. Both commercial and artisanal fishing are taking place in Zanzibar. Similar to mainland Tanzania, the fishing sector in Zanzibar is facing the problems of beach-seining, use of nets with smaller mesh size, and dynamite fishing.

These destructive practices could lead to problems such as loss of income, loss of nutrition and increasing social and political conflicts between large-scale commercial fishing vessels and artisanal fishermen.

4.3 Microbiological Pollution

4.3.1 Introduction

Global International Waters Assessment (GIWA) defines microbial pollution as the adverse effects of microbial constituents of human sewage released to water bodies. Inadequately treated human sewage or runoff from husbandry facilities into streams, lakes or drinking water distribution systems are the main sources of microbial pollution.

A much broader definition is adopted in discussing microbial pollution in the Tanzanian context. Rather than restricting the definition to include human sewage only, a broader definition is taken to include municipal wastewater. Municipal wastewater includes all discharges from households

(including small-scale, home-based livestock and poultry projects which are common in suburbs), commercial facilities, and hotels.

Microbial pollution is then attributed to the presence of organic compounds, nutrients, pathogens, and toxic substances in the municipal wastewater. The potential for municipal wastewater to cause impact depends on the volume of the waste, treatment processes employed and the manner in which it is disposed.

The amount of organic material in municipal wastewater is quantified by measuring its Biological Oxygen Demand (BOD), while phosphates and nitrates are indicative of the amount of nutrients in the effluent. Pathogens are indicated by the presence of coliform bacteria and the risks of its contamination are estimated by measuring the faecal coliform levels.

According to UNEP/GPA (2000), the impacts of municipal wastewater are observed at three different levels:

- **Impacts on the living environment.** Domestic wastewater is generated by population activity in a neighbourhood of houses, shops, small factories, etc. Sewage accumulation in settlements poses a serious health risk to the population leading to the spread of diseases, mortality, morbidity, increased public and private medical costs and loss of labour force productivity;
- **Impacts on rivers near the city.** Cities and towns without access to on-site or off-site sewage disposal infrastructure opt to channel sewage into rivers and lakes to dilute the waste and carry it outside the immediate living environment and often away from the area of responsibility of the local municipal authorities. The degradation of river water quality essentially degrades valuable water resources on which several neighbouring and downstream communities draw their water for domestic and agricultural use; and
- **Impacts on the marine environment.** The coastal and marine environment, being the ultimate recipient of all wastes, is a development resource for tourism, fisheries and recreation. The effects of degradation undermine income opportunities and food supply, but the extent of the impacts is often under-estimated when the full damage is not cost-estimated.

4.3.2 Environmental Impacts

The discussions on the impacts of microbial pollution is divided into the following three broad categories:

Impacts on Living Environment

Risk to humans through use of contaminated water and seafood is a concern in Tanzania. As a consequence, waterborne diseases such as cholera, dysentery, gastro enteritis and diarrhoea are prevalent in Zanzibar and Dar Es Salaam.

The available information indicates the number of incidences of diseases typically attributed mainly to poor water quality, which accounts for most of the incidences of diseases in Dar Es Salaam (Table 6).

Impacts on Freshwater Sources

Different surveys have shown that both surface water and groundwater sources in the Dar Es Salaam area are heavily polluted (Tables 7 and 8). With more than 118,822 tons of polluted water discharged to the ground each day, the majority of ground-water sources within the built up area are contaminated as a result of poor sanitary arrangements.

Table 6. Average Cases of Disease Per Year for the Period 1993-1997 for Dar Es Salaam

Diseases	No of cases
Malaria	326,000 (55%)
Diarrhoea	125,000 (21%)
Skin infections	132,000 (22%)
Dysentery	5,200 (<1.0%)
Cholera	1,500 (<1.0%)
Typhoid	400 (<1.0%)
Total	**590,100 (100%)**

Table 7. Pollution Load to Surface Water Resources (kg/day) in Dar Es Salaam

Type	Industrial Effluent	Pit latrines	Septic tanks	Without facilities	Total
BOD	28,330	15,282	3,275	9,897	56,784
COD	29,904	16,131	3,457	10,447	49,776
Suspended solids	47,216	25,470	5,458	16,495	78,429
Dissolved solids	83,940	45,280	9,830	29,325	138,923
Total N	4,145	2,236	479	1,448	6,859
Total P	787	425	91	275	1,302

Source: Sustainable Development Programme (1992).

Table 8. Pollution Loads to Ground Water Sources (kg/day) in Dar Es Salaam

Type	No facility	Pit latrines	Septic tanks	Sewer Domestic	Losses industry	Total (tons)
BOD	1,100	15,282	7,641	1,221	1,899	27
COD	1,161	16,131	8,068	1,289	1,1994	29
Suspended Solids	1,833	6,116	3,832	2,035	3,148	18
Dissolved Solids	3,258	97,857	61,128	3,618	5,596	196
Total N	120	4,829	3,018	3,618	5,596	10
Total P	23	915	572	34	52	2

Source: Sustainable Development Programme (1992).

Groundwater in Zanzibar Town area is contaminated with organic pollutants. High coliform levels are also found in surface streams running across the town area. Faecal and total coliform levels of 1555 and 5500 cells per ml have been recorded in Mto Upepo, 62000 and 96000 cells per ml in Mto Mpepo, and 29000 and 73000 cells per ml at Gulioni, respectively (van Bruggen, 1990).

Impacts on the Marine Environment

The coastal waters off major towns and cities such as Dar Es Salaam, Tanga, Mtwara and Zanzibar are recipients of untreated municipal and industrial wastes. Measurements of pollution loads and pollutants (coliform bacteria, BOD, COD, heavy metals, suspended solids and inorganic nutrients) both in the marine environment have shown high concentrations in these areas.

In Zanzibar, faecal coliform and total coliform levels of up to 70/100 ml and numerous thousands per ml of seawater, respectively, have been reported in the waters fronting the Zanzibar Municipality (Mohammed, 1997). Nutrient levels are also higher than normal for tropical seawaters, indicating anthropogenic inputs. Concentrations of nitrate of up to 7.8 µ-at N/l and phosphate levels of 4.0 µ-at N/l have been reported (Anderson, 1994). Likewise, it has been reported that there is a proliferation of macroalgae in Tanga coastal waters due to excess nutrient loadings from discharges from a fertiliser factory and from the municipality (Munissi, 1999). Coastal pollution in Tanga is also caused by discharge of effluents from sisal decorticating plants in the area. Up to twenty plants discharge their wastes onto the coast via the Pangani, Sigi, Mruazi/Mnyuzi and Mkurumzi Rivers (Shilungushela, 1993).

Effects of excessive loading of nutrients on reefs, that include decrease in coralline algal cover, increased community metabolism and gross production and general stress on corals, have been reported in several studies. Eutrophication associated with the release of inorganic nutrients (phosphate, nitrate and ammonia) into coastal waters from domestic sewage around Zanzibar has been identified as one of the main causes of the decreased cover of coral-reef-building algae (Bjork *et al*., 1995). Furthermore, Bjork *et al*. (1996) showed that calcified algae are sensitive to phosphate and they disappear from phosphate-rich areas.

Ferletta *et al*. (1996), who conducted a baseline study on heavy metal contents in seaweeds collected from different parts of Zanzibar and Dar Es Salaam close to and away from the source of waste effluents, found that in some algal species the heavy metal content had increased ten times since 1989. Significant levels of aluminium and cadmium have been observed in the macroalgae collected from Chapwani and Changuu Islands off Zanzibar (Engdahl *et al*., 1998).

In Zanzibar, high coliform levels in the waters fronting the historic Stone Town have rendered these waters unfit for bathing (van Bruggen, 1990).

Munissi (2000) showed that, with increasing distance from the sewage pipe at Ocean Road, dissolved oxygen increased significantly from 5.79 to 12.93 mg O_2/l (randomized block analysis of variance: $F = 61.73$, $p << 0.0005$), while BOD decreased significantly from 4.4 to 1.88 mg O_2/l ($F = 4.60$, $0.025 << p << 0.05$). *Ulva* spp. and *Enteromorpha* spp., used as bioindicators showed a marginally significant difference at various distances from the sewage pipe (Friedman's test: $X^2_r = 9.333$, $p = 0.0533$). *Ulva* was most abundant at the site closest to the sewage pipe, while *Enteromorpha* was most abundant at the site second closest to the sewage pipe.

4.3.3 Socio-Economic Impact

Urbanisation is the most dynamic factor underlying most of the immediate causes of environmental degradation in Tanzania. Rapid urban population growth imposes heavy demands on the already densely inhabited housing areas, most of which are unplanned and lack organised sanitary and wastewater infrastructure systems. Urban population growth in Dar Es Salaam is currently around 8% per year outpacing the limited capacities of municipal authorities to supply adequate infrastructure facilities. It is estimated that 70% of the population live in over 40 unplanned communities covering an area of 10,000 ha. Uncontrolled disposal of wastewater and solid wastes is a common problem affecting water sources and living conditions in all unplanned settlements, particularly in settlements such as Manzese and Vingunguti. Outbreaks of water-borne diseases are frequent during the rainy seasons.

A recent study by UNEP/GPA and UDSM (2001), using Cost-benefit Analysis methodology, presented results of the assessment, on the basis of the available information concerning the existing impacts from wastewater sources with estimates of their approximate costs. The Table 9 summarises the costs of impacts in monetary values.

Table 9. Estimated Annual Costs of Environmental Impacts in Monetary Values for Dar Es Salaam

Impacts	Annual cost in million US$	*Comments*
Direct Costs:		
1. Fisheries	1.0	Loss of production
2. Tourism	9.0	Loss of tourism income (which is 190 million p.y.)
3. Property	34.4	Reduction of value or lack of appreciation
4. Health	3.1 17.3	Treatment costs and loss of earnings Human capital loss from death
Indirect Costs:		
5. Recreation	Qualitative impacts	Not quantified
6. Mangroves	Qualitative impacts	Not quantified
7. Biodiversity	Qualitative impacts	Not quantified
Total	**64.8**	**Partial estimate**

Over-Exploitation

4.3.4 Introduction

Over-exploitation as applied in the context of Global International Waters Assessment (GIWA) refers to the capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock.

In view of the fact that information on maximum sustainable yields of key stocks is unavailable in Tanzania, discussions on over-exploitation will be based mainly on consistent and continuous decline of some key stocks rather than over-exploitation *per se*.

According to GIWA methodology, the environmental impacts of over-exploitation can be reflected through:

i) changes in biological community structure due to over-exploitation/depletion of one or more key species;
ii) increasing vulnerability of protected species populations;
iii) changes in community structure through restocking and habitat manipulation; and
iv) ecosystem degradation.

4.3.5 Environmental Impacts

In light of the absence of data and information that would have facilitated discussions on environmental impacts of over-exploitation in line with impacts identified by GIWA, a different approach is taken here. Examples of fisheries resources that are showing consistent decline are highlighted in this section as an indication of over-exploitation. Examples of rare, threatened and vulnerable species are also discussed.

Decline of Fisheries Resources

Based on the fishery resources data as well as interviews with fishermen, there are indications that catches of some fishery resources are declining. Here are some examples:

i) the total annual catch in Zanzibar has decreased from about 20,000 tons in 1988 to less than 13,000 tons in 1998. The decline in fish catch has also been observed in some specific areas such as in Chwaka Bay in Zanzibar (Jiddawi, 1999a) and for specific components such as the reef fisheries of Zanzibar (Jiddawi, 1998);
ii) the small pelagic fisheries undertaken by Zanzibar fisheries cooperatives have also experienced significant decline in their catches. Their catch has declined from 600 t in 1986 to 91 t in 1997 (Jiddawi, 1999b);
iii) according to Ardill (1984), the catch rate of long line fisheries in Tanzania has declined substantially, in numbers and weight. Also shark fin trade has declined in Tanzania (Barnett, 1997; Jiddawi and Shehe, 1999). Both shark and ray catches have declined significantly, particularly at Mafia and Songo Songo islands;
iv) furthermore, there is evidence that increased commercialization of octopus, sea cucumber and seashell harvesting has resulted in decline of these species in a number of areas in Tanzania. The export of sea cucumbers (beche-de-mer or trepang) is one of the more profitable areas of marine resource extraction associated with coral reefs (Table 10);
v) overfishing of the triggerfish, results in a proliferation of sea urchins which are known to be bio-eroders of reefs (Kamukuru, 1997); and
vi) Benno (1992) showed that, of the catch landed by beach seining at Kunduchi, 51.3% were immature fish, 37.8% had developing gonads and only 7.8% were in spawning state. This means that about 90% of the beach seine catch had had no chance to spawn during their life time. The mesh size of most of the seine nets used did not exceed 12 mm.

Table 10. Sea Cucumber Export from Tanzania

Year	Dry weight (kg)	Value (USD)
1992	178 373	411 979
1993	326 620	481 098
1994	530 192	884 169
1995	263 870	353 919
1996	296 410	450 405

Endangered Species

Dugongs and turtles are considered endangered in Tanzania. The dugong species *Dugong dugon* and the turtle species loggerhead turtle (*Caretta caretta*) are considered vulnerable, while the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*) and leatherback turtle (*Demochelys coriacea*) are all endangered (Frazier, 1976; Thiagarajan, 1991).

Some of the turtle nesting sites are the beaches between Jambiani and Makunduchi in Unguja Island, Mnemba Island and a small islet at Mwanamwana north of Tumbatu Island as well as Mafia, Latham and Misali Islands. Others are Kipumbwi, Kilwa Kisiwani and Pangani along the Tanzania mainland coast (Frazier, 1976; ZESS, 1993a,b; Khatib, 1998)

Turtle populations have declined, probably due to loss of the nesting sites. Maziwi Island for instance, was an important breeding site for the green, hawksbill and olive ridley turtles. The small island submerged below the high spring tides in the early 1980s and is no longer suitable for nesting (Fay, 1992). The development of hotels along beaches is also another reason for the decline of nesting sites (e.g., on the east coast of Unguja island there are now 22 hotels compared to none in 1988). Turtles are exploited for their meat and eggs and, in the case of the hawksbill, for their carapace, which is used for ornamental purposes. It is the epidermal plate material of this species that is inaccurately termed "tortoise shell". Fishermen using gill nets for fishing also catch the turtles incidentally.

Dugong populations used to inhabit the seagrass beds of Kilwa, Mafia, and Tanga. However, there have been very few recent sightings by local populations or by researchers.

Although turtles are officially protected in Tanzania, there is little effective enforcement and their status continues to be threatened through hunting, egg collection, nesting disturbance, and the incidental capture of nets. In Zanzibar, marine turtles are protected by the 1993 fisheries regulations under the 1988 Fisheries Legislation. Although these regulations prohibit the capture of sea turtles, the law does not prohibit possession of turtle products or meat. Recently, the transport of turtle meat from rural to urban areas in Zanzibar has been prohibited. This has somewhat curtailed the sale of turtle meat in urban areas.

4.3.6 The Socio-Economic Impacts

Over-exploitation of fishery resources may have impacts on the status of the coastal communities in a number of ways similar to those of modification/loss of ecosystems and destructive fishing practices.

Fishing is an important economic activity practised by communities living along the coast. Artisanal fishing contributes more than 96% of the nation's total marine fish landings (TCMP, 1999).

According to fishermen, certain types of fish species are not easily available these days due to over-exploitation. Catch figures however do not reflect great changes in catch per unit effort, which generally declines with a decline in stock. Indeed, although the catches of certain species, e.g., sardines, scavengers, and mackerels, have increased over the past decade, current catch rates are less than 50%. Despite the declining catch per unit, the number of participants in the fishing sector remains high.

CHAPTER 5

5. Causal Chain Analysis of Each Issue

Based on their environmental and socio-economic impacts, four issues were taken through a causal chain analysis. These were:

i) loss/modification of ecosystems/ecotones;
ii) over-exploitation of fisheries resources;
iii) destructive fishing practices; and
iv) microbial pollution.

For each of these issues, immediate causes were identified and the relative percentage contribution to the issue determined. The sectoral pressures affecting the immediate causes were also identified and their relative percentage contributions determined. The underlying root causes were examined based on three major categories. These were:

- social changes which included demographic changes;
- institutional drivers which consisted of institutional governance, insufficient international assistance, limited civil society empowerment and little government commitment; and
- economic structure which included little private sector commitment, development model and macro-economic policies, and regional/global wealth distribution**.**

Also considered were responses favouring or mitigating resource use with respect to aspects of governance (regulations, laws, policies, projects and institutions), market and community responses.

5.1 Loss and Modification of Ecosystems/Ecotones

As mentioned in the Impact Assessment Report, it was decided to combine the analysis of two issues, loss and modification of ecosystems, as one issue since both are very important in Tanzania and since it is very difficult to separate the two. Many of the root causes and immediate causes lead both to loss and modification of ecosystems.

As in the environmental impact assessment, three important coastal/marine habitats are examined separately in this causal chain analysis of loss and modification, namely, coral reefs, mangroves and seagrass beds. While the root causes are in some cases similar for the three types of ecosystems, the immediate/technical causes and sectoral pressures are very different.

5.1.1 Causal Analysis for Loss/Modification of Coral Reef Ecosystems

Step 1: Immediate Causes

In examining the immediate causes of coral reef degradation, it was estimated that 45% of the loss/modification was caused by destructive fishing practices, particularly dynamite fishing and seine netting. A blast of dynamite kills fish and all other living organisms within a radius of 15-20 m (Guard and Masaiganah, 1997) and turns the reef structure to rubble within a radius of several meters. The dragging of seine nets over or around a reef breaks corals, removes other organisms in the by-catch and catches juveniles. In addition, fishermen often smash coral colonies in order to scare fish from hiding into the net. Another 25% of the damage was estimated to be caused by coral bleaching, 10% by coral mining, 10% by storms, 4% by pollution from municipal waste water, 3% by sedimentation caused by speed boats and 3% by breaking of corals due to tourist activities.

Thus, as shown in the Causal Chain Analysis Chart for loss and modification of coral reefs (Figure 1), destructive fishing practices were singled out as the main cause of degradation and one that could be addressed. While coral bleaching also had high impact, since it is largely a natural phenomenon (perhaps also partly due to human activities which lead to global warming), this aspect was not carried further in the causal chain analysis.

The various immediate causes mentioned above are described in more detail in the Impacts Assessment Report.

Step 2: Sectoral Pressures and Changes in Resource Use Patterns (Direct Pressures)

Destructive fishing practices were considered as being entirely (100%) within the Fisheries sector. Other sectors play only a minor role in some of the less important immediate causes mentioned above, i.e., Industry (10%), Urbanization (4%), Leisure/Tourism (3%) and Transport (3%).

Thus, focusing only on destructive fishing in the Fisheries sector, the resource use changes (direct pressures) that have contributed to this issue include increased demand for fisheries resources, inadequate fishing gear and vessels to fish offshore, unwillingness to invest in fishing, little private sector involvement in fisheries, breakdown of traditional fisheries management systems, inadequate enforcement of fisheries laws and regulations, as well as inadequate policies, regulations and standards. In particular, the policy of open access to coastal ecosystems, including fishing grounds, has had a major negative effect on fisheries in that the local communities lack a feeling of ownership and stewardship of their surrounding ecosystems and the natural resources they contain. This leads to misuse or overuse.

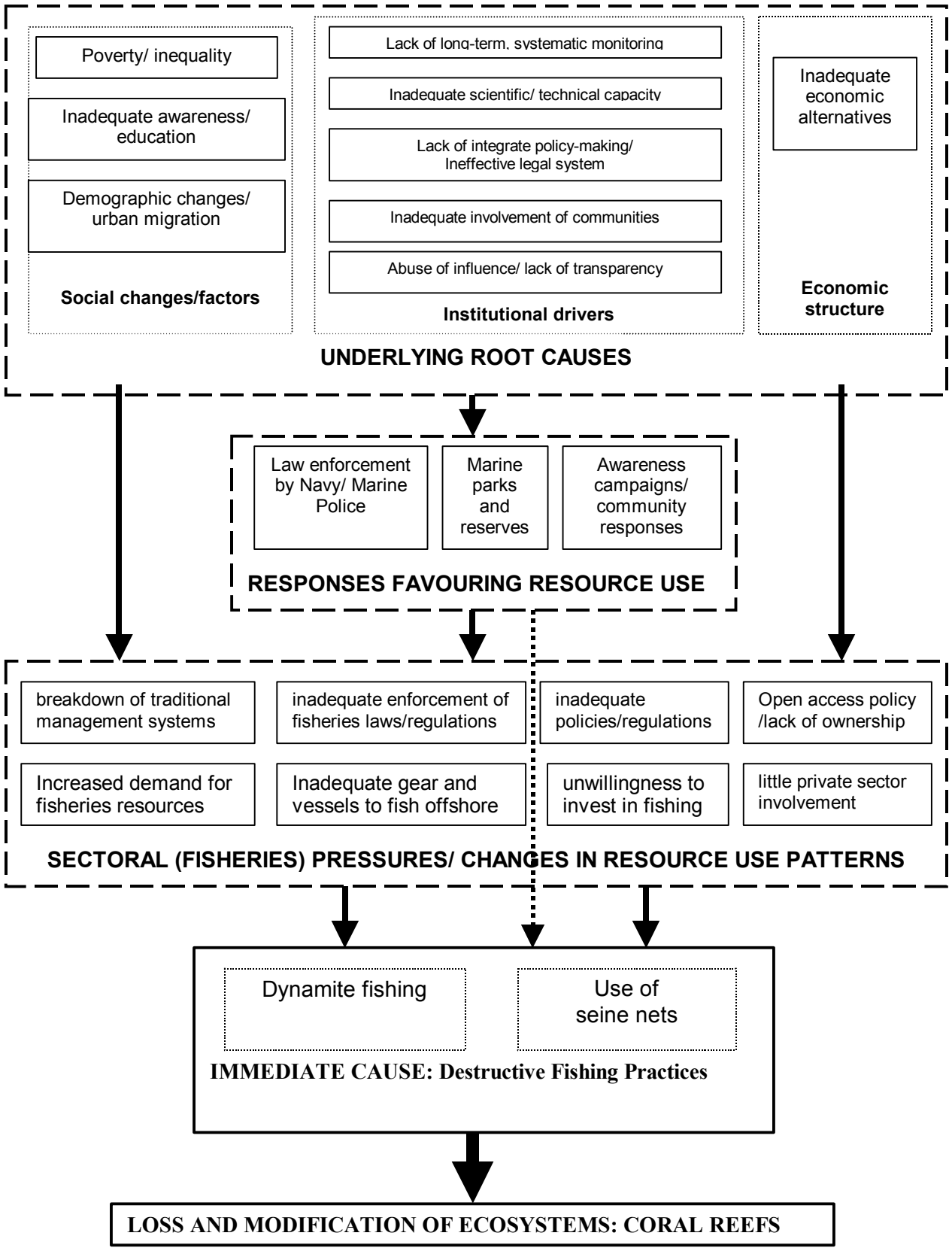
Step 3: Underlying Root Causes

In the area of social problems/change, one of the main underlying root causes of the issue is poverty and unequal distribution of wealth. This can clearly be seen in the case of dynamite fishing that is often established as teamwork between rich businessmen and poor fishermen. Rich businessmen supply boats, iceboxes, fuel and dynamite. They hire poor fishermen to do the “dirty work” of blast fishing. Though the fishermen are paid very little, they accept the arrangement simply because it enables them to survive for the day, which may otherwise be very difficult for them. Other social factors include inadequate awareness amongst resource users and general lack of education as well as demographic change, particularly migration to coastal urban centres and small towns.

In the area of institutional drivers, root causes are inadequacy of long-term monitoring data, including socio-economic data, inadequate coordination and systematisation of data collection, inadequate scientific/technical capacity, inadequate resources (funds and equipment), lack of coherent, integrated policy-making amongst sectors, inadequate involvement of communities in decision-making, inadequate inter-sectoral cooperation, abuse of influence, and lack of transparency in governmental bodies. In addition, inadequate enforcement of laws and regulations and the policy open access to resources, though already mentioned as problems of the Fisheries sector, are also major institutional root causes of the issue that cut across several government sectors.

In the area of economic structure, lack of economic alternatives which could relieve the fishing pressure is one of the underlying causes.

Figure 1: Causal Chain Analysis for Loss and Modification of Ecosystems: Coral Reefs



Step 4: Responses Favouring/Mitigating Resource Use

There have been certain responses on the part of governmental and non-governmental institutions, which have attempted to reduce or eliminate dynamite fishing. In 1998, there was a Workshop to Develop a National Action Plan against Dynamite Fishing in Tanzania held in Dar Es Salaam which involved the Division of Fisheries, Ministry of Environment, Ministry of Works, Ministry of Energy and Minerals, Tanzania People's Defence Force/Navy, Marine Police, Tanga Coastal Zone Conservation and Development Program (TCZCDP), National Environment Management Council (including Tanzania Coastal Management Partnership), Irish Aid, World Wide Fund for Nature, and United States Agency for International Development, amongst other organizations. This resulted in a crackdown on dynamite fishing that was mainly implemented by the Navy and Marine Police. While this action was quite effective initially, it was very expensive and was not a long-term solution because, now that the crackdown has stopped, dynamite fishing appears to be starting up again in many parts of the country, though there is little quantitative data on the current extent of the problem.

In Tanga, efforts have been more successful because TCZCDP cooperated with the Navy (Horrill and Kalombo, 1999) and also launched awareness campaigns in the fishing villages. They mobilized the local communities to themselves take action to eliminate dynamite fishing. These efforts, which were actually a combination of government response and community response, have brought lasting results and the area is still virtually free of dynamite fishing.

When Mafia Island Marine Park was established in 1995 under the Marine Parks and Reserves Unit (Darwall *et al.*, 2000), patrols with a boat carrying a water canon (Mambosho, 1998) effectively eliminated dynamite fishing in the park area. This, combined with campaigns to educate the communities, has succeeded to control of the problem in the area to date.

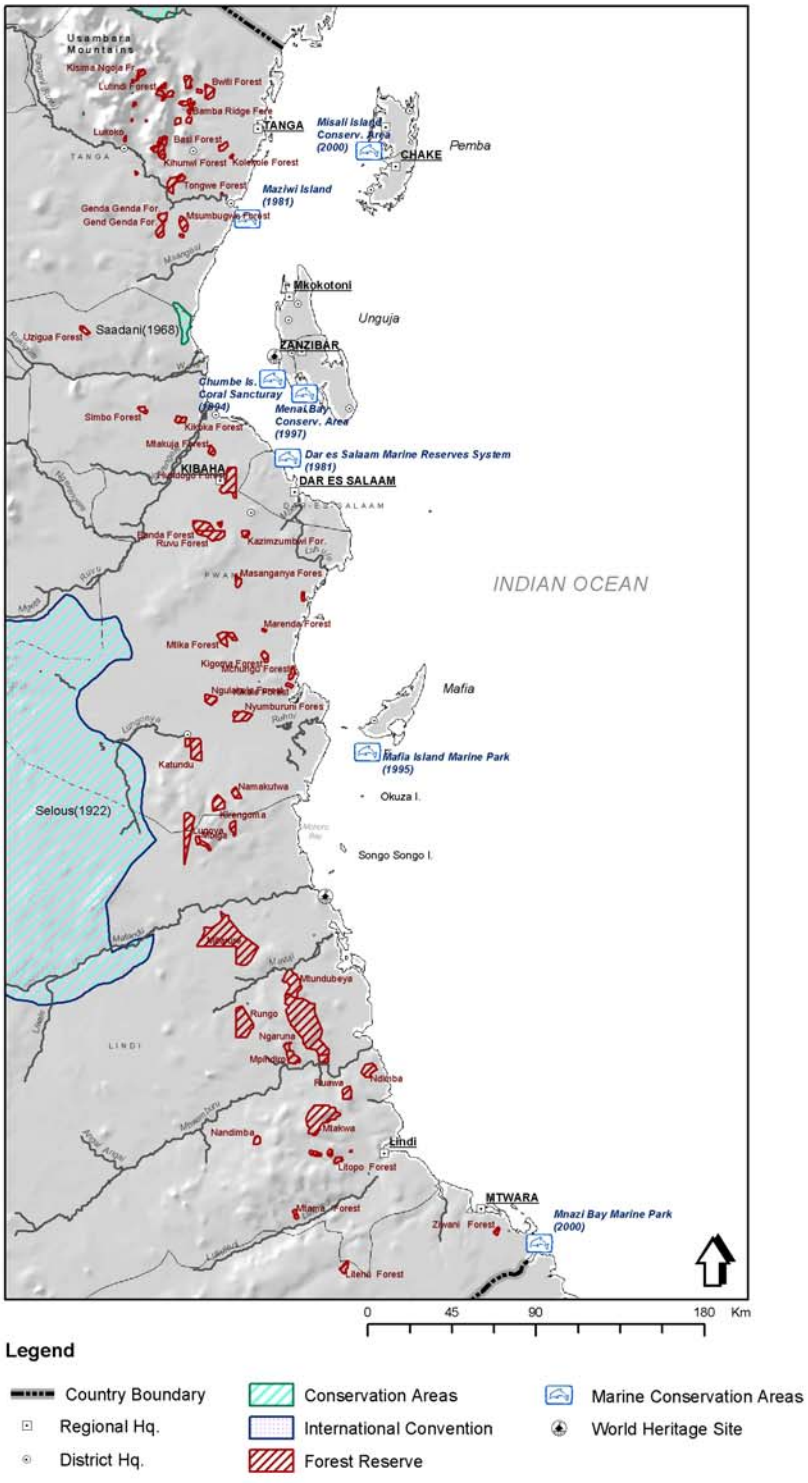
In 1994, the Marine Environmental Protection Program (MEPP) was initiated for Kilwa, Lindi, and Mtwara districts, facilitated by the Rural Integrated Support Program (RIPS) and funded by FINNIDA. This programme has included seaweed farming, patrols for dynamite fishing, a village credit revolving scheme to enable fishermen to buy conventional fishing gear, and the production of media materials to enhance environmental awareness (Darwall *et al.,* 2000). While this effort was quite effective for a time, it seems to have lost strength.

In addition, Marine Action Conservation Tanzania (MACT) contributed to reducing dynamite fishing in Dar Es Salaam, but, due to lack of resources, this effort has not been continued and dynamite fishing is again becoming a serious problem in the Dar Es Salaam area. MACT has also been carrying out coral transplanting in conjunction with ecotourism. Fishermen and tourists together transplant corals in dynamite-blasted areas as an integral part of the ecotour. Proceeds from the ecotourism funds the coral transplanting activity (Wagner *et al*., 2001).

There has been no known market response to the problem of dynamite fishing.

The problem of seine netting seems to not have aroused as much mitigating response. However, through community awareness campaigns, this problem has largely been controlled in Mafia Island Marine Park. In addition, with the recent purchase of a patrol boat for the Dar Es Salaam Marine Reserve System, Marine Parks and Reserves Unit has initiated an attempt to control both seine netting and dynamite fishing in this Reserve.

In general, there has been considerable effort on the part of the government and various parastatals, NGOs and CBOs to enhance community awareness about environmental issues, but more effort is still needed to make coastal communities aware of the seriousness of the situation and to themselves take action to conserve, manage and restore the coastal and marine ecosystems.



Map 3. Conservation Areas in Tanzania

Technical Bottlenecks for Loss/Modification of Coral Reefs

One of the important technical bottlenecks for efforts to address the problem of loss/modification of coral reefs is inadequate resources to enable fishermen to fish offshore and to use environmentally friendly methods. In addition, there is a lack of viable alternative/supplementary sources of income that could relieve some of the pressure off the marine resources. Another bottleneck is inadequate law enforcement.

5.1.2 Causal Analysis for Loss/Modification of Mangrove Ecosystems

Step 1: Immediate Causes

In examining the immediate causes of mangrove ecosystem degradation, it was estimated that 46% of the loss/modification was caused by over-harvesting of mangroves for firewood, charcoal-making, building poles and boat-making; while 30% was caused by clear-cutting for aquaculture, agriculture, solar salt works, road construction, urbanization and hotel construction; 8% by changes in freshwater/ sediments and nutrient supply; 5% by coastal erosion; 5% by partial conversion or loss of the ecosystem due to natural disasters/global change; 3% by destructive fishing practices (particularly dragging seine nets under the tree canopy) and 3% by partial conversion or loss of the ecosystems due to natural disasters/global change.

Thus, over-harvesting and clear-cutting were selected as the main causes of degradation and were then further examined through causal chain analysis as shown in the chart in Figure 2.

Step 2: Sectoral Pressures and Changes in Resource Use Patterns (Direct Pressures)

The sectors thought to play a key role in the issue of mangrove degradation are Energy (in the case of over-harvesting) and Industry, particularly in the form of solar salt making (in the case of clear-cutting).

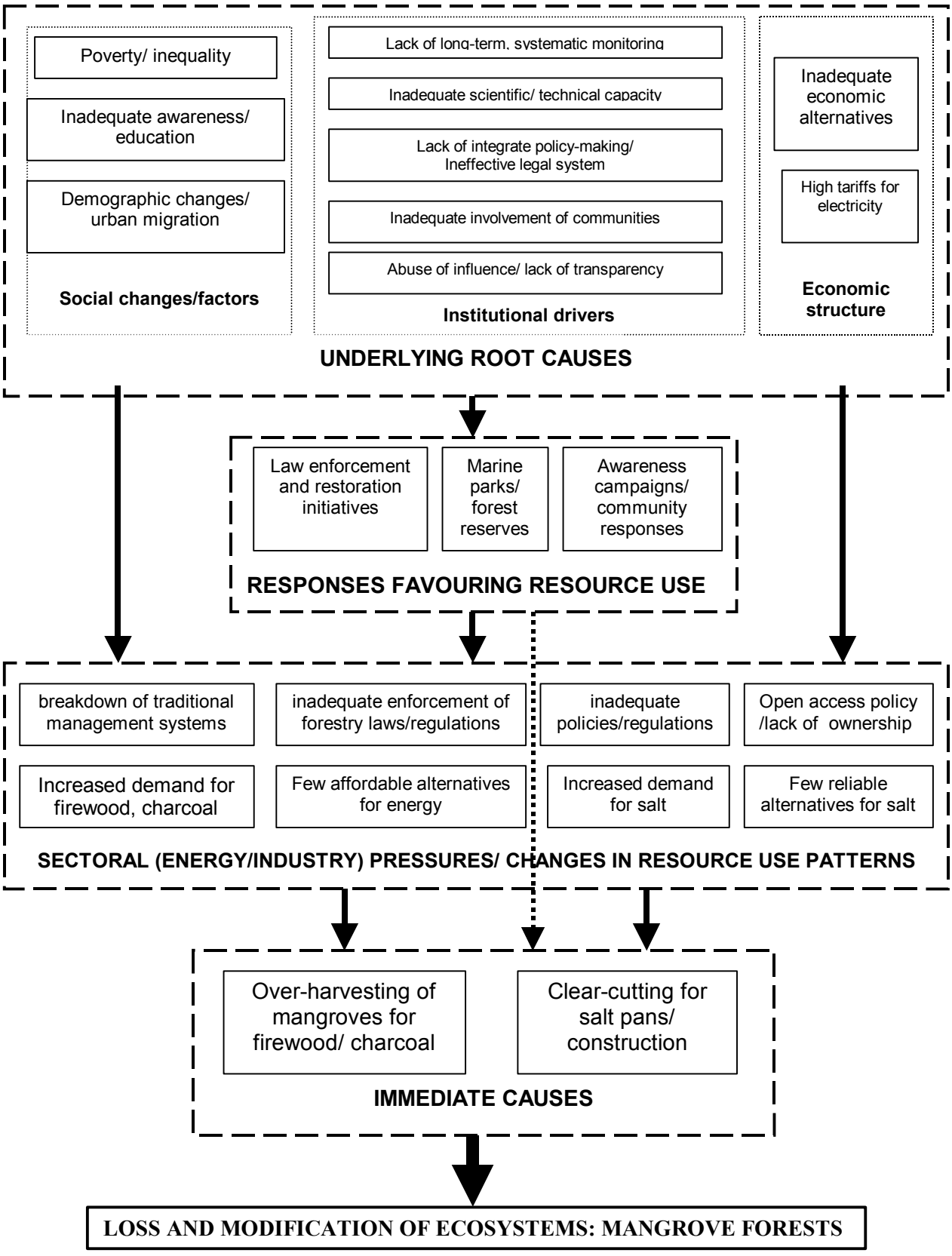
Thus, focusing only on over-harvesting and clear-cutting, the resource use changes (direct pressures) that have contributed to these issues include increased demand for firewood and charcoal, few affordable alternatives for energy, increased demand for salt, and few reliable alternatives for salt. As for coral reefs, the policy of open access to coastal ecosystems, has had a major negative impact on mangrove forests in that the local communities lack a feeling of ownership and stewardship of their surrounding ecosystems and the natural resources they contain and thus have no motivation for conserving or restoring these forests.

In addition, breakdown of traditional fisheries management systems, inadequate enforcement of forestry laws and regulations, as well as inadequate policies, regulations and standards have all contributed to the direct pressure on mangrove resources.

Step 3: Underlying Root Causes

As for coral reefs, in the area of social problems/change, one of the main underlying root causes of the issue is poverty and unequal distribution of wealth. For people living in coastal fishing villages, firewood is often the only affordable source of energy. Mangroves provide high-energy firewood and are often the most accessible trees for fishing communities. The only type of housing that most coastal people can afford is to build a framework of poles compacted with mud. Again, mangroves, particularly *Rhizophora* mucronata, provide the most durable and readily available building poles. Moreover, as a means of acquiring a meagre income, coastal villages make charcoal from mangroves and sell it to transporters who carry it to large urban centres and small towns. The richer businessmen control the prices, paying very low rates to the poorer villagers.

Figure 2: Causal Chain Analysis for Loss and Modification of Ecosystems: Mangroves



Other social factors include inadequate awareness amongst resource users and general lack of education as well as demographic change, particularly migration to coastal urban centres and small towns.

In the area of institutional drivers, root causes include inadequate, long-term monitoring data, including socio-economic data; inadequate coordination and systematisation of data collection; inadequate scientific/technical capacity; lack of coherent, integrated policy-making amongst sectors, inadequate involvement of communities in decision-making, inadequate inter-sectoral cooperation, abuse of influence, and lack of transparency in governmental bodies.

There are often conflicts among the sectors. Although the Forestry Division has the main authority over mangroves, conflicts arise among various branches of the government responsible for forests, fisheries, wildlife, agriculture, ports, surveying and mining (Semesi, 1991).

In the area of economic structure, inadequate affordable alternatives for energy (in the case of over-harvesting) and salt (in the case of clear-cutting) are major root causes.

Step 4: Responses Favouring/Mitigating Resource Use

All mangroves of Tanzania mainland were gazetted as Forest Reserves in 1928-1932 and are not allowed to be cut unless a permit is granted. This law, however, is rarely enforced.

An extensive study of the entire coastline of Tanzania conducted by Semesi (1991) developed the Mangrove Management Plan. This Plan divided mangrove forests into four management zones: Zone I, forests that should receive total protection; Zone II, forests that are ready to be brought into production; Zone III, degraded areas that should be closed to allow recovery; and Zone IV, areas that should be set-aside for different developments. Although 10 years have passed since that plan was developed, it has not been followed closely and community involvement is minimal (Semesi, 1998). Moreover, the condition of many mangrove forests has changed since that time, so re-evaluation and planning is required.

The Mangrove Management Plan/Project has been promoting and coordinating mangrove planting in various parts of the country. Their efforts have had positive impacts, but in many areas continued cutting has interfered with the long-term success of the programme.

In addition, there have been a number of community-based mangrove restoration projects in various parts of the country such as those initiated by TCZCDP in various coastal villages in Tanga as well as by MACT and Mbweni Environment and Women's Group in Mbweni (Wagner *et al.*, 1999).

Technical Bottlenecks for Loss/Modification of Mangrove Ecosystems

One of the serious technical bottlenecks for dealing with the loss and modification of mangrove ecosystems is the lack of alternative sources of energy, building materials and salt for domestic purposes.

In addition, there is a lack of viable alternative/supplementary sources of income that could relieve some of the pressure off the mangrove forests in terms of charcoal-making, commercial cutting for building poles and salt-making. Another bottleneck is inadequate law enforcement. On many parts of the coast, people continue to cut mangroves, with little effort being made to stop them.

5.1.3 Causal Analysis for Loss/Modification of Seagrass Beds

Step 1: Immediate Causes

In examining the immediate causes of mangrove ecosystem degradation, it was estimated that 64% of the loss/modification was caused by destructive fishing practices. As far as seagrass beds are concerned, the destructive methods are beach seining, which is done by artisanal fishermen, and trawling, which is carried out by large-scale, commercial operations. Although the former is done in the intertidal and shallow subtidal zone, while the latter is done in deep waters, both involve dragging the gear over the substratum, scrapping up seagrasses and benthic fauna as well as disturbing the habitat. Beach seining is done in seagrass beds near villages all along the coast of Tanzania, while trawling is mainly done off the estuarine areas of Rufiji and Ruvu/Saadan.

In addition, 20% of the loss/modification of seagrass beds is caused by movement of boats and people, 5% by pollution, 6% by heavy rainfall and runoff, 3% by collection of shellfish, and 3% by heavy wave action.

Thus, destructive fishing practices were singled out as the main cause of degradation and were then further examined through causal chain analysis as shown in the chart in Figure 3.

Step 2: Sectoral Pressures and Changes in Resource Use Patterns (Direct Pressures)

The sector concerned with destructive fishing practices is, of course, Fisheries alone. The main resource use change (direct pressure) that has contributed to destructive fishing practices in seagrass beds is increased demand for seafood for local consumption and export. In addition, prawns are the main marine resource that has attracted the interest of commercial fisheries for the purpose of export. Since prawns are mainly found in seagrass beds areas, this has put significant pressure on seagrass bed ecosystems.

As for coral reefs and mangroves, the policy of open access to coastal ecosystems, has had a negative impact on seagrass beds.

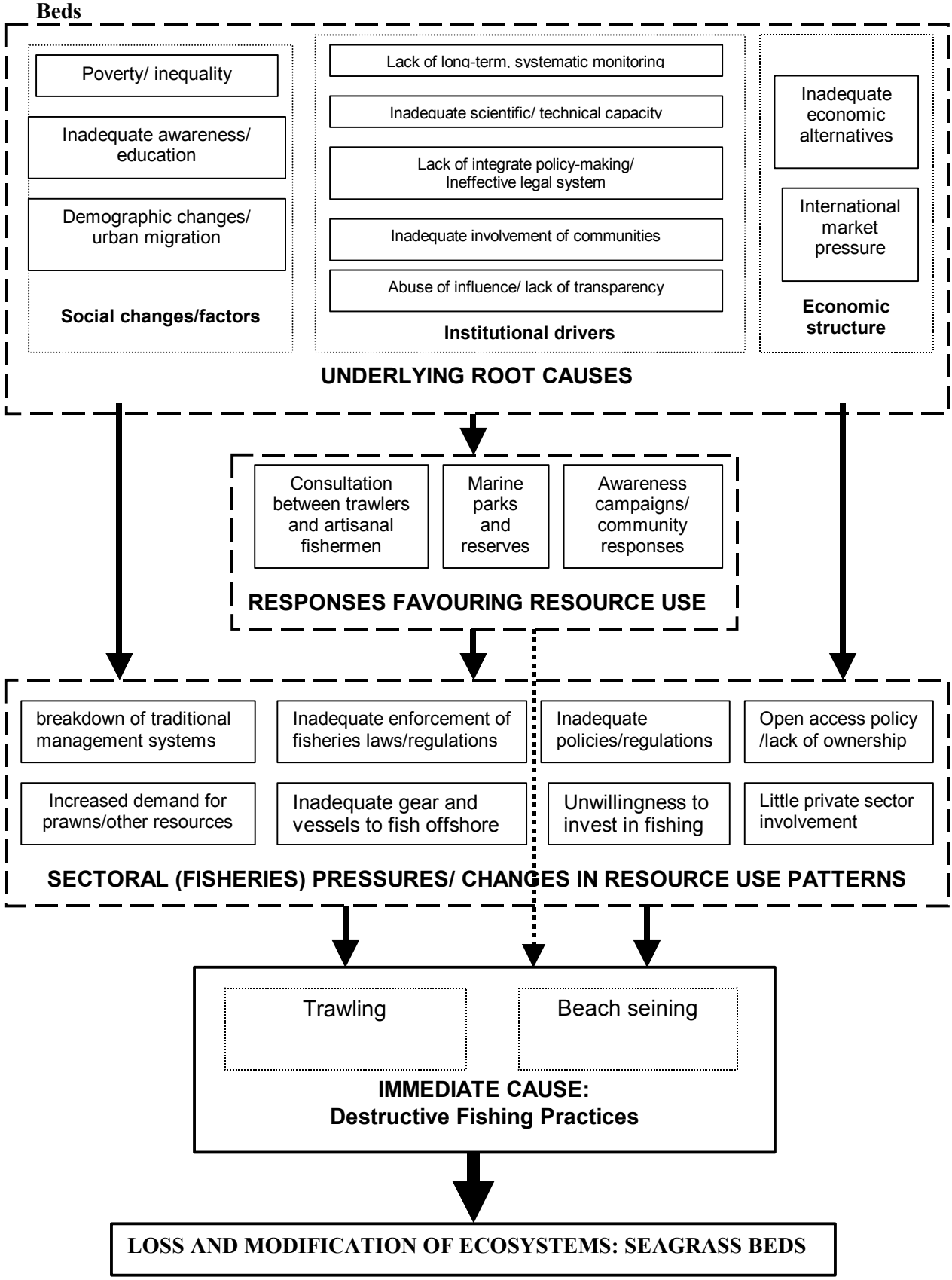
In addition, inadequate fishing gear and vessels to fish offshore, unwillingness to invest in fishing, little private sector involvement in fisheries, breakdown of traditional fisheries management systems, inadequate enforcement of fisheries laws and regulations, as well as inadequate policies, regulations and standards have all contributed to increasing the direct pressure on seagrass beds.

As for coral reefs and mangroves, in the area of social problems/change, one of the main underlying root causes of the issue, in the case of artisanal fisheries, is poverty and unequal distribution of wealth. Since artisanal fishermen, generally cannot afford appropriate gear and vessels for offshore fishing, they resort to beach seining. There has also been a conflict of interest between artisanal fishermen, who are generally poor, and the richer, commercial trawlers. The former claim that trawlers intrude into nearshore waters and even, upon occasion, disturb or damage their fishing gear.

Other social factors include inadequate awareness amongst resource users and general lack of education as well as demographic change, particularly migration to coastal urban centres and small towns.

In the area of institutional drivers, root causes include inadequate, long-term monitoring data, including socio-economic data; inadequate coordination and systematisation of data collection; inadequate scientific/technical capacity; lack of coherent, integrated policy-making amongst sectors, inadequate involvement of communities in decision-making, inadequate inter-sectoral cooperation, abuse of influence, and lack of transparency in governmental bodies.

Figure 3: Causal Chain Analysis for Loss and Modification of Ecosystems: Seagrass Beds



Step 3: Underlying Root Causes

In the area of economic structure, inadequate affordable alternatives for food and income as well as international market pressure are major root causes.

Step 4: Responses Favouring/Mitigating Resource Use

In Tanga, TCZCDP has launched awareness campaigns in the fishing villages. They mobilized the local communities to themselves take action to eliminate beach seining. In Mafia Island Marine Park efforts have been fairly successful in controlling beach seining.

The government and NGOs have also made efforts to enhance community awareness about the harmfulness of beach seining.

There has also been consultation between trawlers and artisanal fishermen in order to resolve the conflicts in resource utilisation that have arisen due to the intrusion of trawlers into inshore waters.

Technical Bottlenecks for Loss/Modification of Seagrass Beds

One of the technical bottlenecks for dealing with the loss and modification of seagrass beds is the lack of appropriate gear and vessels for offshore fishing.

In addition, there is a lack of viable alternative/supplementary sources of income that could relieve some of the pressure off the marine resources. Another bottleneck is inadequate law enforcement.

5.2 Destructive Fishing Practices

Destructive fishing practices are considered as one of the GIWA issues. However, since such practices have been found to be amongst the major immediate causes of loss and modification of ecosystems, which have already been described in detail in the above sections, no further explanations will be given in this section. The diagram in Figure 4 demonstrates how the various destructive fishing practices link with other GIWA issues.

5.3 Overfishing

While the immediate causes of overfishing are unique, the other aspects of the causal chain analysis are almost identical to those for loss and modification of coral reef ecosystems. This is because destructive fishing practices (which are the main immediate cause of coral reef degradation) and overfishing are both conducted by the same artisanal fishermen and in the same area, i.e., inshore waters. Offshore waters have not been overexploited.

Therefore, this section will only go into describe those aspects that are different from the analysis of coral reef loss/modification. As shown in Figure 5, the immediate causes for over-exploitation of fisheries resources are increased fishing effort, in terms of gear, vessels and fishermen (estimated to be 40% of the immediate cause), and decreased habitat and nursery grounds (also estimated to contribute 40%). Decreased level of recruitment is thought to only contribute 20% and was therefore not carried forward in the analysis.

Overfishing involves two aspects, firstly, catching total quantities of fish that are in excess of the sustainable yield and, secondly, catching juveniles, which reduces the capacity of stocks to regenerate in the future. Juveniles are caught by the use of nets with small mesh size such as beach seines. Benno (1992), investigating the practice of beach seining at Kunduchi, found that 90% of the catch had had no chance to spawn during their life time.

Figure 4: Linkages between issues: destructives fishing practices and loss/modification

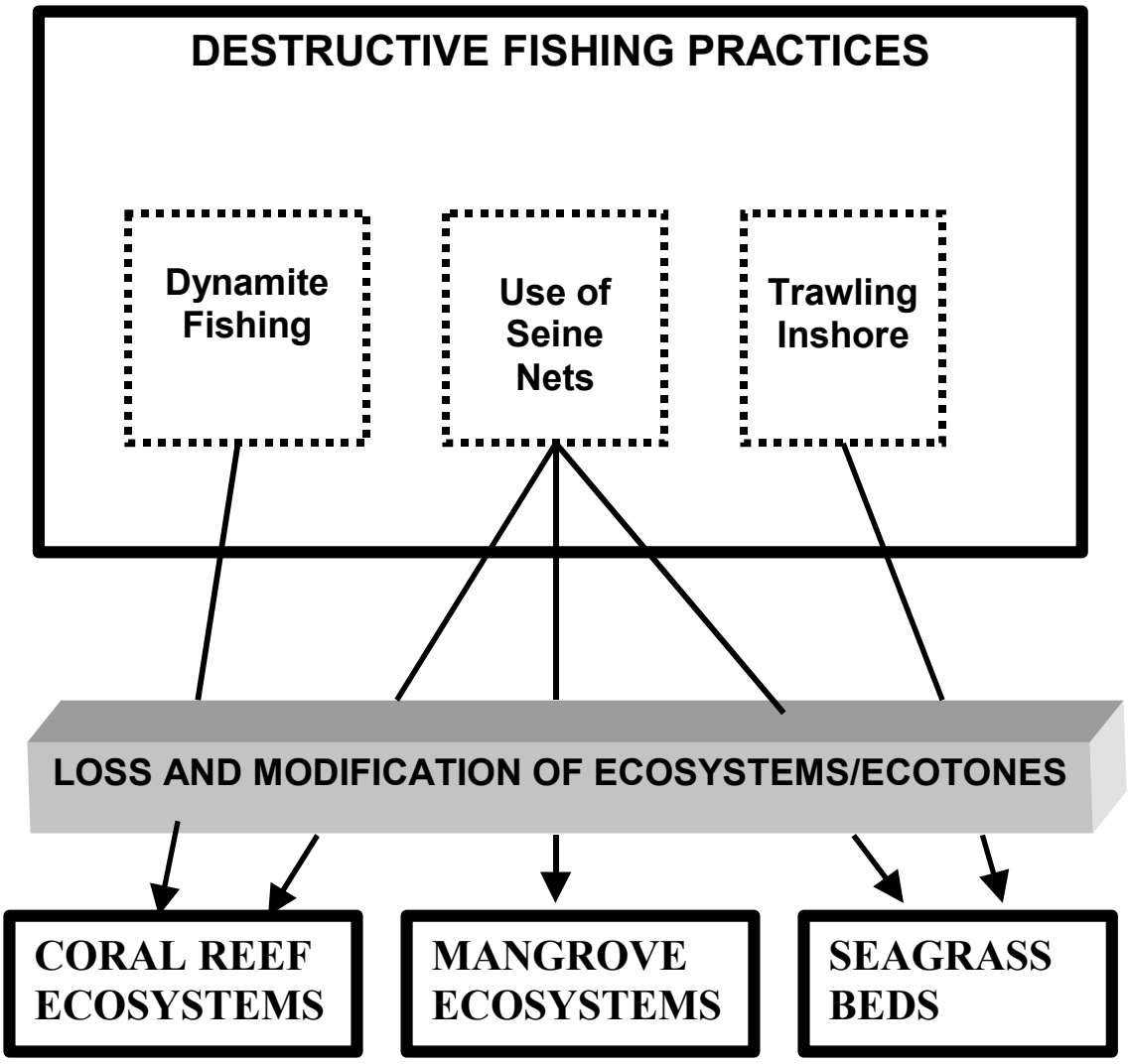


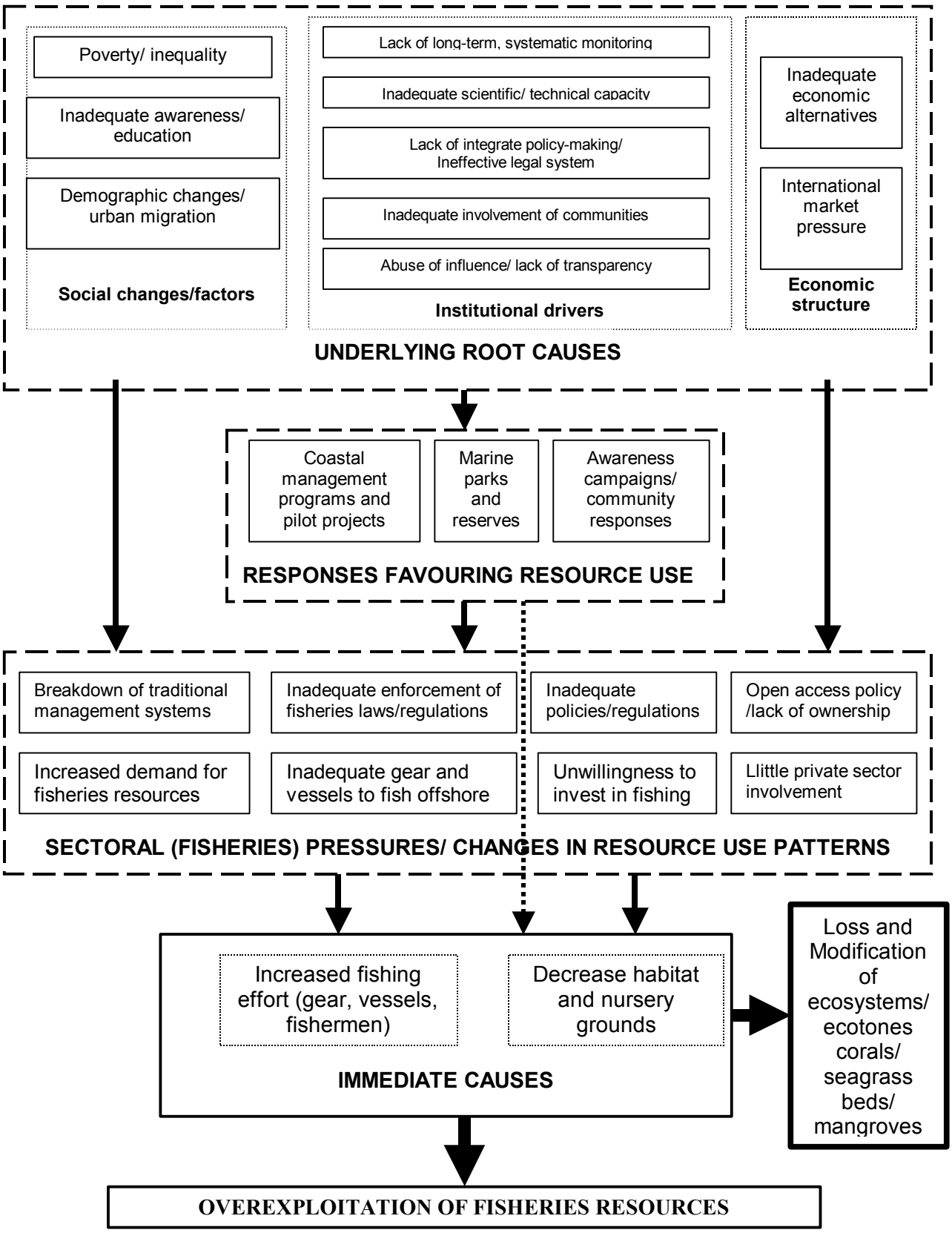
Figure 5 also shows the link between the above-mentioned immediate causes of overfishing and loss and modification of ecosystems/ecotones.

The sector entirely responsible for this issue is Fisheries and the sectoral pressures are identical to those for loss and modification of coral reef ecosystems. The underlying root causes are also identical except that an added root cause for overfishing is international market pressure since some of the overfishing is carried out by commercial fishermen who export their catch.

Responses favouring resource use are also identical except that law enforcement by Navy/Marine Police, which was important in the case of destructive fishing practices, has not been one of the responses in the case of overfishing.

Most of the aspects of transboundarity and managerial/political aspects that were discussed for loss and modification of coral reefs also apply to overfishing.

Figure 5: Causal Chain Analysis for Over-exploitation of Fisheries Resources



5.4 Microbial Pollution

5.4.1 Causal Analysis for Microbial Pollution

Step 1: Immediate Causes

The immediate cause of microbial pollution is discharge of untreated wastewater, which has two aspects, namely, discharge of effluents as well as storm water and runoff inputs (Figure 6).

In Dar Es Salaam, 80 per cent of the population is served by on-site sanitation systems: septic tanks, soak-away pit, and traditional and ventilated pit latrines. It should be noted that the soak-away pits and septic tanks have severe problems with overflows particularly during the rainy seasons.

The Dar Es Salaam sewerage system is an old system built in the late 1950. Though the system was rehabilitated in the 1980s (under the Dar Es Salaam Sewerage and Sanitation Project financed by World Bank) it is increasingly proving inadequate to serve the ever-increasing population of the city. Only 15% of the total population of the city is served by the central sewage system. The areas served by this system include the City Centre, parts of Sinza, Ubungo and Vingunguti. The system is linked to eight oxidation ponds located at Mabibo, Kurasini, Mikocheni, Lugalo military camp, Gerezani, Ukonga air force, Vingunguti and University of Dar-Es-salaam. Due to financial resources only four of these (i.e. those at University of Dar-Es-salaam, Kurasini, Mikocheni and Vingunguti) are currently operating. The sewage collected is discharged through a 1.6 km long sea outfall near Ocean Road Hospital. The outfall is exposed during low tide and leaks in several points due to lack of maintenance.

In Zanzibar, out of 290,000 individuals living in the Municipality, only 19% are served by sewers (mostly in the old Stone Town), as compare to the 78% who use pit latrines or septic tanks with soak pits while about 3% of the population have no access to toilets. Zanzibar does not have sewage treatment facilities. In Zanzibar, only 12 out 24 tourist hotels surveyed in 1998 had fully concreted tanks, while the rest had open ones leaking into fissures and caves. Treatment of any kind is generally not provided (Gossling, in press).

Step 2: Sectoral Pressures and Changes in Resource Use Patterns (Direct Pressures)

The sectors thought to play a key role in the issue of microbial pollution are Water, Health and Lands. The technical aspects of resource use changes (direct pressures) that have contributed to microbial pollution include inadequate treatment facilities, poor maintenance of disposal systems and sewage discharge to storm drains. These technical aspects are primarily linked to limited financial resources and inadequate recovery of operational costs, which could otherwise assist in the maintenance and improvement of facilities.

In addition, inadequate policies and regulations, as well as inadequate enforcement of those regulations and standards already in place, have contributed directly to microbial pollution.

Step 3: Underlying Root Causes

The social changes/factors and institutional drivers related to microbial pollution are identical to those of other issues. Aspects of economic structure differ, however, involving inadequate incentives for alternatives and inadequate economic instruments/systems.

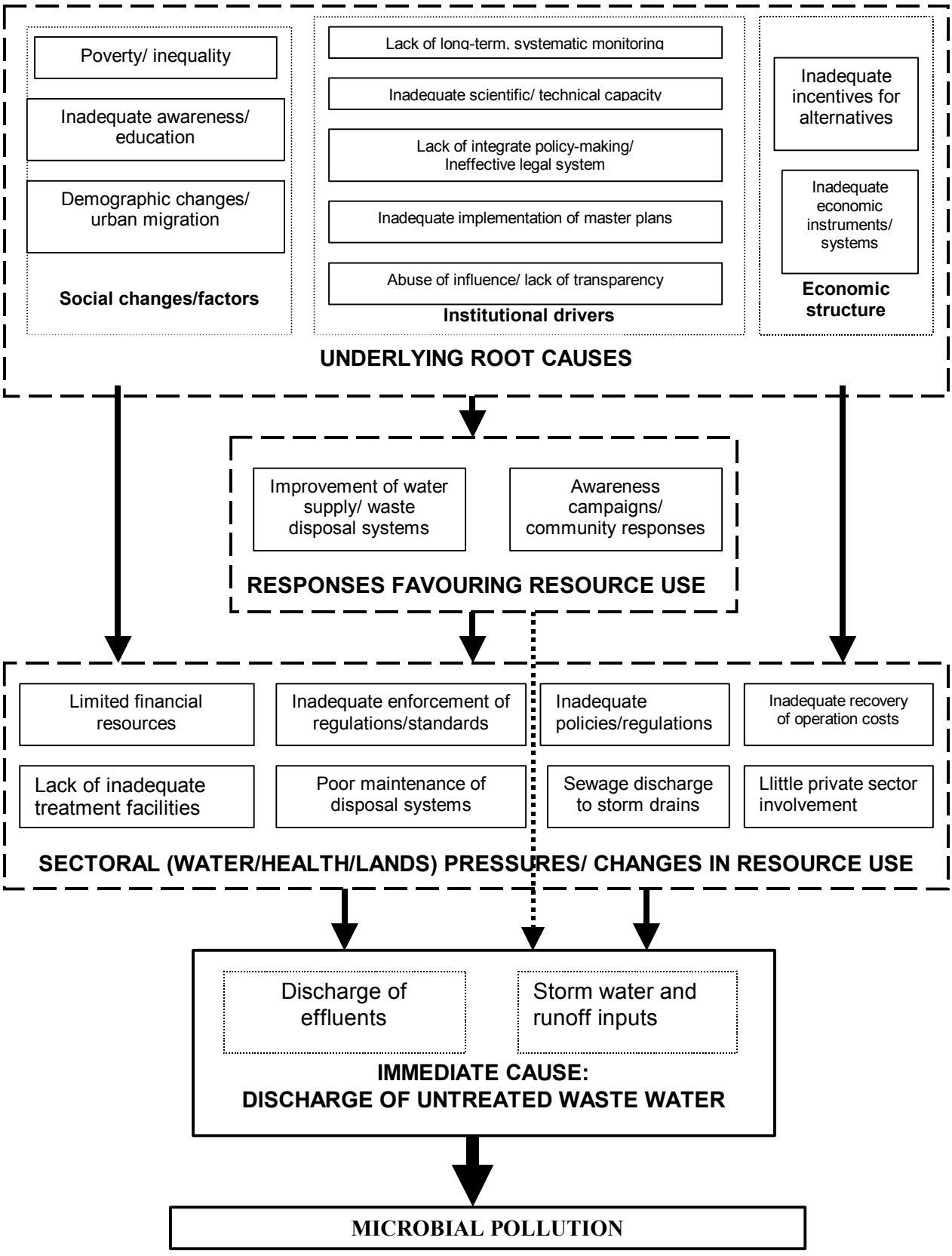
Step 4: Responses Favouring/Mitigating Resource Use

There have been two main responses favouring resource use. One is the improvement of water supply and waste disposal systems. Some improvements have been carried out in Zanzibar town in recent years and there are plans for improvement of systems in Dar Es Salaam. The second is awareness campaigns, which the government and NGOs have been carrying out.

Technical Bottlenecks for Microbial Pollution

The main technical bottleneck is lack of financial resources, materials and equipment for improvement and maintenance of treatment facilities and disposal systems.

Figure 6: Causal Chain Analysis for Microbial Pollution



CHAPTER 6

6. Commonality, Overlaps and Gaps

6.1 Information Gaps

With respect to coral reefs, there is at least some information about reefs in most parts of the country. However, the type of monitoring or other studies done vary a lot from one place to another, so making comparisons is difficult. Moreover, in many cases, only small areas of certain reefs have been examined while the bulk of the reef area has never been examined. Also, monitoring studies need to be updated because reefs have been exposed to a number of human and natural impacts since previous monitoring studies were conducted.

At the same time there are some coral reefs in Tanzania about which virtually nothing is known, for example the fringing reefs of Lindi Region, the patch and fringing reefs between Dar Es Salaam and Rufiji, some of the Pemba reefs as well as a few other reefs scattered in various parts of the country.

Although municipal wastewater pollution seems to be relatively studied in the three hot spots of Dar Es Salaam, Zanzibar Town and Tanga, yet several information gaps exists. Most of the studies conducted in the three places have been very limited in terms of geographical and subject coverage.

- in Dar Es Salaam, most of the studies have concentrated on studying pollution problems in the harbour area and in the Msimbazi River and Creek, while the area off Zanzibar Stone Town has been the main area of focus in Zanzibar. In Tanga, the studies carried out have focused mainly on specific target areas that are recipients of either municipal wastes or wastes from the fertilizer factory (Munissi, 1998);
- most of the studies have looked and reported mainly on nutrient loads and distribution, BOD levels and coliform counts, however data and information is limited on the linkages/relationship between pollution from municipal wastewater and their impacts on the natural environment and on human health; and
- of more concern is the absence of long-term data and information on the amounts and effects of different contaminants on human health and coastal and marine environment. Most of the studies on pollution due to municipal wastewater have been conducted for very short periods of time.

6.2 Transboundary Elements

There are some strong transboundary elements related to the modification and loss of ecosystems/ecotones. In particular, damage done to coral reefs in Tanzania, especially in Tanga Region, through destructive fishing methods such as dynamite fishing and beach seining, has a negative impact on the release of coral larvae, the supply of juveniles of various animal groups and the migration of fish species. This undoubtedly has an effect on the coral reefs in Kenya since the East African coastal current flows northward. However, there are no hard data to assess the extent of this negative impact and little is known about the distances such impacts can affect larval and juvenile dispersal. It is very unlikely, on the other hand, that damage done to reefs in Kenya would affect the reefs of Tanga. At the same time, it is likely true that damage to reefs in northern Mozambique has a negative impact on reefs in Mnazi Bay, Mtwara Bay and perhaps farther northward.

In the case of mangrove forests, there are also transboundary effects. This is particularly true along the border between Mozambique and Tanzania where there is an important mangrove forest along estuary of the Ruvuma River which, in fact, forms the boundary. The border between Tanzania and Mozambique is formed by the Ruvuma River. The estuary of this river supports a major mangrove forest which is utilized by people on both sides for various purposes, such as firewood and building

poles. Definitely, any impacts on one side would also affect the other side since this is essentially one mangrove forest ecosystem.

Since seagrass beds are also breeding, nursery and feeding grounds for invertebrates and fish, damage to beds near the borders as a result of beach seining and trawling is likely to have adverse impacts on similar ecosystems across borders, particularly to the north.

It is likely that fishermen near the border between Kenya and Tanzania and the border between Mozambique and Tanzania cross these borders to carry out beach seining. Commercial trawlers also often disregard boundaries, thus making it an international issue.

Any disruption of seagrass beds near the borders, of course, affects seagrass beds across the border, particularly those to the north (due to the prevailing northward ocean currents). Not only the seagrasses are affected, but also the many fish and invertebrate species that are associated with these beds.

There are several transboundary elements related to exploitation of resources. Here are some of the examples:

i) **Migratory species.** Migratory species such as turtles are nesting in different places in the Western Indian Ocean region as shown in the Table 11:

Table 11. The Common Breeding Sites for Different Species of Turtles

Species	Breeding Area
Hawksbill	Aldabra and other small Islands in the region
Green	Mainland and Island beaches
Olive Ridley	Northern Mozambique
Loggerhead	Mozambique, South Africa
Leatherback	Northern Natal, South Africa

ii) **Movement of fishermen.** The Tanzanian sea cucumber fishery is on the verge of being wiped out. Consequently, Tanzanian fishermen have moved southwards into Mozambique and approximately half of the sea cucumbers now exported from Tanzania probably originated from Mozambique; and

iii) **Illegal fishing.** Illegal fishing in the Exclusive Economic Zone (EEC) is reported to be on the increase. The Government of Tanzania estimated 70 foreign vessels are illegally fishing in the EEZ annually.

There are no transboundary aspects for microbial pollution since the main centres of pollution, i.e., Dar Es Salaam, Zanzibar and Tanga, are far from the borders. Near the borders, in fact, microbial pollution is nil.

6.3 Root Causes

The underlying root causes for all the selected issues are almost identical. In particular, poverty/inequality stands out as being a very strong root cause of most of the problems. Coastal communities are generally poor and they are led to improperly exploit or overexploit the marine and coastal resources as a means of surviving for the day, regardless of future consequences. Demographic changes, particularly migration to coastal urban centres, have also been major root causes of most of the problems. The question of inadequate awareness/ education is perhaps less important, since many

coastal people are actually fairly aware of environmental issues, but feel compelled to misuse resources because of poverty.

In the area of institutional drivers, lack of long-term, systematic monitoring of the marine environment and inadequate scientific capacity are also major underlying factors. In the realm of economic structure, lack of alternative resources and income-generating projects is a major concern.

Fisheries is of major importance in coastal/marine issues since it is the main sector responsible for three of the four issues selected, i.e., loss and modification of ecosystems/ecotones (particularly coral reefs and seagrass beds), destructive fishing practices and overfishing. Amongst the most pressing problems related to Fisheries are the increase in demand for fisheries resources and inadequate gear and vessels to fish offshore. In addition, government policies are inadequate or inappropriate, particularly in relation to the policy of open access, which hinders villagers from becoming motivated about conserving the environment and utilising resources sustainably.

6.4 Responses by Government and NGOs

Amongst the responses made by the government and NGOs, awareness campaigns seem to have been most common. There are also integrated coast management programmes and marine parks, which have attempted to address several, if not all, of the selected issues. Their influence, however, has been confined to relatively small geographical areas in comparison with the long coastline of Tanzania.

6.5 Immediate Causes

What differs from one issue to the other are primarily the immediate causes, though, for the issues related to Fisheries, even these are very similar, i.e., various forms of destructive or inappropriate fishing practices.

6.6 Future Trends

Due to the accelerating increase of human populations in coastal areas, negative impacts and pressures on marine and coastal resources are likely to increase. In a few areas of the country where there is a relatively effective integrated coastal management programme, such as Tanga, or a Marine Park, such as Mafia, or where there are programmes likely to active in the near future, such as Dar Es Salaam, some of the environmental issues such as the practice of destructive fishing methods are likely to be dealt with and impacts may be mitigated. The Mnazi Bay Marine Park is also likely to mitigate impacts in that area of Mtwara Region. Other issues, however, such as pollution, are difficult to control and are likely to get worse near urban centres.

On the other hand, along most of the coast of Tanzania, there are no comprehensive coastal management programmes likely to be launched in the near future. In the absence of such intervention, the degradation of coral reefs, mangrove forests, seagrass beds and other types of ecosystems is likely to increase rapidly. Thus, the overall trend in terms of ecosystem loss and modification is that such degradation is likely to increase.

Municipal wastewater pollution in Tanzania is principally caused by poor waste collection and disposal practices. These include direct discharge of untreated sewage into coastal habitats such as mangroves and beaches and discharge of untreated or inadequately treated wastewater into coastal waters through sewers, streams and storm water drains.

While the rate of urban growth has continued to increase substantially over the years, the necessary municipal wastewater management infrastructure to match this growth has been slow to develop leading to inadequate waste collection and disposal.

Given the current pace of urban growth and development of coastal tourism industry, if the necessary municipal wastewater management infrastructure is not going to be improved, wastewater pollution is likely to be a more serious problem in the future.

CHAPTER 7

7. National Recommendations

From the scoping of priority issues, the assessment of the major impacts and the analysis of common causes, it is recommended that a major course of action that could best address all these aspects would be the establishment of integrated coastal management programmes and/or marine parks in all the critical areas of the coast of Tanzania.

The major components that should be incorporated into such programmes/marine parks include the establishment of research and monitoring programmes, community mobilisation (formation of cooperatives and ecosystem restoration), assisting groups of fishermen with appropriate gear and vessels for fishing offshore, the establishment of alternative/supplementary income-generating projects (e.g., seaweed farming, ecotourism, and small-scale prawn farming), the promotion of environmental awareness campaigns, and mechanisms for the resolution of resource-use conflicts.

7.1 Loss and Modification of Ecosystems/Ecotones, Destructive Fishing Practices and Overfishing

Summary of Impacts:

The present condition of coral reefs in Tanzania and the extent of degradation brought about by various impacts, both human and natural, differ greatly from place to place. There is a whole range of human activities that cause degradation of coral reefs, including destructive or improper fishing methods, overfishing, excessive movement of boats and people, pollution, coral mining and uncontrolled tourism.

Natural impacts that have led to ecosystem modification or loss in Tanzania include storms and coral bleaching. Damage due to strong wave action is common on exposed fringing reefs and on the seaward side of patch reefs and islands all along the coast of Tanzania, though there is no evidence that the extent of storm impact has been any different recently than it was many decades ago.

In Tanzania, various uses of mangroves have led to the modification or loss of mangrove ecosystems. For centuries, mangroves have been used on a sustainable basis for firewood, building poles, boat making, charcoal making and the making of salt by boiling seawater using mangrove firewood. However, with increased population along the coast, particularly in urban centres such as Dar Es Salaam, Tanga and Zanzibar, the demand for these resources has increased beyond the capacity of the mangrove ecosystems to regenerate and thus these uses are no longer sustainable in many areas of the country. These uses have caused fragmentation and modification of many of the mangrove forests in Tanzania.

Seagrass beds, or meadows, are highly productive and are high in species diversity, supporting a wide variety of marine fauna. Because seagrass beds are mainly found in shallow water close to shore and human activities, they are very vulnerable to pressure from those activities. Major threats to the survival of seagrass beds come from excessive sedimentation of coastal waters resulting from different activities. Increased turbidity tends to reduce light penetration. Inshore prawn trawling and seine nets destroys seagrass beds. Although beach seining is illegal, very little effort has actually been made to stop this harmful practice.

While destructive fishing practices have been identified as the second most serious issue in Tanzania, these are, in fact, amongst the primary causes of the first issue, i.e., modification and loss of ecosystems. Moreover, overfishing, the third priority issue, also leads of modification of ecosystems. For these reasons, the second and third priority issues will not be dealt separately as descriptions of their impacts have already been described. Moreover, the recommendations given below are primarily

focused on loss/modification of ecosystems, but also encompass recommendations of destructive fishing practices and overfishing.

Summary of Causes:

The leading immediate causes of coral reef degradation were destructive fishing practices, particularly dynamite fishing and seine netting (45 %); coral bleaching (25 %); coral mining (10 %); and storms (10 %).

It was estimated that 46% of the loss/modification of mangrove ecosystem was caused by over-harvesting of mangroves for firewood, charcoal-making, building poles and boat-making; while 30% was caused by clear-cutting for aquaculture, agriculture, solar salt works, road construction, urbanization and hotel construction.

Destructive fishing practices is the main immediate cause of the loss/modification of seagrass beds, accounting to 64 per cent of the total loss/modification of that ecosystem. The destructive methods are beach seining, which is done by artisanal fishermen, and trawling, which is carried out by large-scale, commercial operations.

The main underlying root causes of loss/modification of ecosystems/ecotones are: poverty and unequal distribution of wealth. Other social factors include inadequate awareness amongst resource users and general lack of education as well as demographic change, particularly migration to coastal urban centres and small towns.

Underlying causes related to institutional drivers include: inadequate resources (funds and equipment), lack of coherent, integrated policy-making amongst sectors, inadequate involvement of communities in decision-making, inadequate inter-sectoral cooperation, and lack of transparency in governmental bodies. In addition, inadequate enforcement of laws and regulations and the policy of open access to resources, are also major institutional root causes of the issue that cut across several government sectors.

An underlying root cause related to economic structure is lack of economic alternatives which could relieve pressure on resources.

Recommendations:

There are a number of concrete measures that can be undertaken with respect to the management of ecosystems/ecotones which will prevent further loss or modification or help to restore those ecosystems already seriously degraded. These measures include:

- assisting groups of fishermen to obtain proper gear and vessels to enable them to fish offshore and thus take some of the pressure off the inshore fisheries resources;
- fishing communities should also be assisted to establish alternative or supplementary income-generating activities that could also relieve pressure on marine resources;
- efforts to raise environmental awareness in fishing communities should be further strengthened such that the people themselves are motivated and organised to take action. In particular, the communities should be mobilised to report destructive incidences such as dynamite fishing and indiscriminate cutting of mangroves as well as finding ways of controlling all destructive fishing practices and degradation of mangroves;
- the closure of reefs on a rotating basis for a period of one year or so can be a very effective management strategy. This allows fish abundance to increase and the reef ecosystem to revive;
- efforts to restore reefs by coral transplanting and mangrove forests with community participation, such as those by Wagner et al. (1999) and Wagner et al. (2001) should be

increased and should become more widespread and larger in scale. Ecotourism should be further promoted as a means of funding on-going coral reef restoration activities and providing motivation to the villagers;

- programmes aimed at involving local communities in replanting badly degraded forests have often been unsustainable because it is difficult to motivate people to expend their energy on something that does not belong to them and which they are not likely to benefit from directly. Therefore, consideration should be made of allowing CBOs to organise communities to use mangroves on a sustainable basis if they are also replanting at a satisfactory rate;
- an EIA should be conducted before initiating any aquaculture, salt-making or other projects in or near mangrove areas. Generally such projects should be small-scale and should be periodically re-evaluated. As much as possible, projects should involve people in the local communities so as to alleviate poverty and to take pressure off natural resources; and
- more effort must be made to enforce the law prohibiting beach seining. In the case of trawling, there should be stricter control over the licensing of commercial trawlers and closer surveillance of their activities.

7.2 Microbiological Pollution

Summary of Impacts:

The coastal waters off major towns and cities such as Dar Es Salaam, Tanga, Mtwara and Zanzibar are recipients of untreated municipal and industrial wastes. Measurements of pollution loads and pollutants (coliform bacteria, BOD, COD, heavy metals, suspended solids and inorganic nutrients) both in the marine environment and freshwater bodies have shown high concentrations in these areas.

Risk to humans through use of contaminated water and seafood is a concern in Tanzania. As a consequence, waterborne diseases such as cholera, dysentery, gastro enteritis and diarrhoea are prevalent in Zanzibar and Dar Es Salaam.

Summary of Causes:

The immediate cause of microbial pollution is discharge of untreated wastewater, which has two aspects, namely, discharge of effluents as well as storm water and runoff inputs

Two sectoral issues were identified as the main technical causes that are contributing to microbial pollution:

i) inadequate treatment facilities; and
ii) poor maintenance of disposal systems and sewage discharge to storm drains.

These technical aspects are primarily linked to limited financial resources and inadequate recovery of operational costs, which could otherwise assist in the maintenance and improvement of facilities.

The social changes/factors and institutional drivers that were identified as being underlying root causes of microbial pollution are identical to those of loss/modification of ecosystems, over-fishing of fisheries resources and destructive fishing practices. Root causes related to economic structure differ, however, involving inadequate incentives for alternatives and inadequate economic instruments/systems.

Recommendations:

Solving the problems of microbial pollution requires thorough planning at the municipal level, adequate funding for the construction and maintenance of facilities, as well as strict implementation of plans and enforcement of regulations. More specifically, the following are recommended:

- the importance of land-use plans and environmental management plans should be emphasized. Land-use changes that are incompatible with town plans and environmental considerations should not be permitted; thus, good governance is mandatory. Planning should take into consideration sensitive ecosystems, such as wetlands, which are vulnerable to pollution. Sensitivity maps would be a useful tool for this purpose;
- levels of community collaboration, in addressing municipal wastewater issues should be increased and incentives for participation should be created., accompanied by an enhancement of the communities understanding of the gains and potentials. There should be an effort to actively develop and implement community-based activities and approaches that better incorporate the local community in the management process;
- public - Private Partnership (PPP) in wastewater management should be encouraged by establishing a proper policy and legal framework; through capacity building and by creating the required awareness;
- work to define monitoring needs and to develop a national water quality monitoring program. This should be underpinned by regular inter-calibration exercises and support for capacity building as required; and
- an EIA should be conducted for any project that is initiated which may contribute to microbial pollution.

References

Akwilapo, F.D. *The Distribution and Abundance of Mangrove species and associated macrobenthos in ecosystems with varied anthropogenic degradation*. A thesis to be submitted for the award of a Master of Science degree at the University of Dar Es Salaam, Tanzania, 2001.

Anderson, B. *An environmental monitoring approach to sewage pollution issues along the west coast of Zanzibar*. SIT Marine Ecology Tanzania, 1994, 31p.

Ardill, J.D. *Tuna fisheries in the south west Indian Ocean*. The Proceedings of the NORAD-Tanzania Seminar to Review the Marine Fish Stocks and Fisheries in Tanzania, 1984 .

Banyikwa, F.F. and A.K. Semesi. Endangered mangrove ecosystems: The case of the Kunduchi and Mbweni mangrove forests. In (J.R. Mainoya and P.R. Siegel, eds*.) Proceedings of the workshop on "save the mangrove ecosystems in Tanzania"*. 21-22 February, 1986. Faculty of Science, University of Dar Es Salaam, 1986, pp. 103-132.

Barnett, R. The shark trade in mainland Tanzania and Zanzibar. p. 39-67. In (N.T. Marshall and R. Barnett, eds.) *The trade in sharks and shark products in the Western Indian and Southeast Atlantic Oceans.* TRAFFIC East/ Southern Africa, 1997,132 p.

Benno, B.L. *Some features of beach seine fishery along the Dar Es Salaam coast, Tanzania*. M.Sc. thesis, University of Kuopio, Finland, 1992, 68 pp.

Bjork, M., Mohammed, S.M., Bjorklund, M. and A. Semesi. Corraline algae, important coral reef builders threatened by pollution. *Ambio*, 24 (7-8), 1995, pp. 502-503.

Bjork, M., Mohammed, S.M., Bjorklund, M. and I. Naaslund. Distribution of coral associated algae at four locations near Zanzibar Town, Tanzania. In (M. Bjork, A.K. Semesi, M. Pedersen and B. Bergman, eds.) *Current trends in marine botanical research in the East African region. Proceedings of the symposium on the biology of microalgae, macroalgae and seagrasses in the Western Indian Ocean*. 3-10 December, 1995. University of Mauritius, 1996, pp. 347-357.

Darwall, W.R.T., Guard, M., Choiseul, V.M. and M. Whittington. *Report 6: Survey of thirteen patch reefs*. Volume 1: Jewe, Luala, Pweza and Pwajuu Reefs. Marine Biology and Resource Use Surveys in the Songo SongoArchipelago. Frontier-Tanzania Marine Research Programme. The Society for Environmental Exploration and the University of Dar Es Salaam. ISSN 1369-8788, 1996a.

Darwall, W.R.T., Guard, M., Choiseul, V.M. and M. Whittington. *Report 6: Survey of thirteen patch reefs*. Volume 2: Poisai, Nyamambi, Baniani and Imbi Reefs. Marine Biology and Resource Use Surveys in the Songo SongoArchipelago. Frontier-Tanzania Marine Research Programme. The Society for Environmental Exploration and the University of Dar Es Salaam. ISSN 1369-8788, 1996b.

Darwall, W.R.T., Guard, M., V.M. Choiseul and M. Whittington. *Report 6: Survey of thirteen patch reefs*. Volume 3: Machangi Reef Complex; Chocha Reef; Miza, Membeuso and Banda Reef. Marine Biology and Resource Use Surveys in the Songo Songo Archipelago. Frontier-Tanzania Marine Research Programme. The Society for Environmental Exploration and the University of Dar Es Salaam. ISSN 1369-8788, 1996c.

Darwall, W.R.T., Guard, M., Choiseul, V.M. and M. Whittington. *Report 6: Survey of thirteen patch reefs*. Volume 4: Appendices. Marine Biology and Resource Use Surveys in the Songo SongoArchipelago. Frontier-Tanzania Marine Research Programme. The Society for Environmental Exploration and the University of Dar Es Salaam. ISSN 1369-8788, 1996d.

Darwall, W.R.T., Guard, M. and G. Andrews. Southern Tanzania. In T.R. McClanahan, C. Sheppard, and D.O. Obura, (eds.), *Coral reefs of the Western Indian Ocean: their ecology and conservation.* Oxford University Press, New York, 2000.

Engdahl, S., Mamboya, F., Mtolera, M., A. Semesi and M. Björk. The brown macroalgae *Padina boergesenii* as an indicator of heavy metal contamination in the Zanzibar channel. *Ambio*, 27, 1998, pp. 694-700.

Fay, M.B. *Maziwi island off Pangani (Tanzania): history of its destruction and possible causes*, UNEP Regional seas Reports and Studies No. 139 UNEP, 1992, pp. 43.

Ferletta, M., Bramer, P., Semesi, A.K. and M. Bjork. Heavy metal contents in macroalgae in the Zanzibar channel - an initial study. In (M.Bjork, A.K. Semesi, M. Pedersen and B. Bergman, eds.) Current Trends in Marine Botanical Research in the East African Region. *Proceedings of the symposium on the biology of microalgae, macroalgae and seagrasses in the Western Indian Ocean*. University of Mauritius, 3-10 December, 1996, pp. 332-346.

Frazier, J. *Sea turtles in Tanzania*. Tanzania Notes and Records, 77 and 78, pp. 11-21.

Guard, M. and M. Masaiganah. *Dynamite fishing in southern Tanzania, geographical variation, intensity of use and possible solutions*. Marine Pollution Bulletin 34 (10), 1997, pp. 758-762.

Hanaphy, F. and C. Muller. *Report 8: Survey of six reefs*: Amana; Mpovi; Mwanamkaya; Kisiwani; Fungu Wongo; and Rukyira, Kilwa District. Marine Biology and Resource Use Surveys in the Songo Songo Archipelago. Frontier-Tanzania Marine Research Programme. The Society for Environmental Exploration and the University of Dar Es Salaam. 1369-8788, 1997.

Haule, V.W. and M.A. Kiwia. Status and potential of the artisanal fishery in the Tanzania mainland coast. In (N.S. Jiddawi and R. Stanley eds.) Fisheries Stock Assessment in the Traditional Fishery Sector: The Information Needs. *Proceedings of the national workshop on the artisanal fisheries sector,* Zanzibar. September, 22-24, 1997, Zanzibar, Tanzania Institute of Marine Sciences, University of Dar Es Salaam, Zanzibar, Tanzania, 1999, pp. 21-24.

Horrill, J.C. *Case study of collaborative fisheries management in Tanga Region*, Tanzania. IUCN Wetlands Programme, Gland, Switzerland, 1997, 15 pp.

Horrill, J.C. and H. Kalombo. *Navy presence evaluation report*. Tanga Coastal Zone Conservation and Development Programme, Tanga, Tanzania, 1999, 4 pp.

Horrill, J.C., Kamukuru, A.T., Mgaya, Y.D. and M. Risk. Northern Tanzania, Zanzibar and Pemba. In: McClanahan, T.R., Sheppard, C. , and Obura, D.O. (eds.), *Coral reefs of the Western Indian Ocean: their ecology and conservation*. Oxford University Press, New York, 2000, pp. 171-

Jiddawi N.S. Status of the fishery resources of Chwaka bay. In (Mohammed, S., (ed.) *The ecology and socio-economy of Chwaka bay*. Report prepared for CARE, Tanzania, 1999a, pp. 24-31.

Jiddawi, N.S. Dolphins. In recommended in Zanzibar. *A Quarterly Guide*, 1(5), 1998a, pp. 30-31.

Jiddawi, N.S. Hali halisi ya kisiwa cha Mnemba. In (Kombo, A. (ed.) *Proceedings of the seminar on the future of Mnemba Island*. Fisheries Sub-Commission/Mnemba Reports 1, 1998b, pp. 1-6.

Jiddawi, N.S. and M.A.K. Ngoile. *Fish for the future: the history of marine fisheries research in Tanzania*. Paper presented at the Conference on Advances in Marine Sciences in Tanzania, 28th June - 1st July, 1999, Zanzibar, Tanzania, 1999.

Jiddawi, N.S. and M.S. Shehe. The status of shark fishery in Zanzibar, East Africa: a case study. In (N.S. Jiddawi and R. Stanley, eds.) Fisheries Stock Assessment in the Traditional Fishery Sector: The Information Needs. *Proceedings of the national workshop on the artisanal fisheries sector,* Zanzibar. September, 22-24, 1997, Zanzibar, Tanzania Institute of Marine Sciences, University of Dar Es Salaam, Zanzibar, Tanzania, 1999, pp. 87-92.

Kamukuru, A.T. *Assessment of biological status of the Dar Es Salaam marine reserves system off the Kunduchi Coast*. WIOMSA report/IOC/UNEP, 1997, 31pp.

Khatib, A.A. Sea turtles nest recording program: Unguja Island. *Ambio*, 27, 1998, pp. 763-764.

Lyimo, E., Juma, B.A., Bhai, I.O. and A.H. Juma. *Report of the fisheries frame survey conducted in Unguja and Pemba*, 1997, 27 pp.

Mambosho, H.H. Mafia Island Marine Park. In: Johnstone, R.W., Francis, J., and Muhando, C.A. (eds.), *Coral reefs: values, threats, and solutions, proceedings of the national conference on coral reefs*, Zanzibar, Tanzania, 2-4 December 1997. Institute of Marine Sciences, Zanzibar, 1998, pp. 62-67.

Mohammed, S.M. *Water quality assessment in the coastal waters fronting the Stone Town*, Zanzibar. Dorsch Consult, Zanzibar (Part 1-3), 1997.

Muhando, C.A. Assessment of the extent of damage, socio-economic effects, mitigation and recovery in Tanzania. In Linden, O. and Sporrong, N. (eds.), *Coral reef degradation in the Indian Ocean: status reports and project presentations 1999*. CORDIO, SAREC Marine Science Programme, Stockholm, 1999, pp. 43-47.

Munissi, J.J. *A comparative study of polluted and unpolluted intertidal floral communities near Tanga Town*. A report submitted for the fulfilment of the forth term programme at the University of Dar Es Salaam. Department of Zoology and Marine Biology, 1998, 17 pp.

Munissi, J.J.E. *Dissolved oxygen, biochemical oxygen demand and selected green algae as indicators of marine pollution near Dar Es Salaam*. A report submitted in partial fulfilment of the Degree of Bachelor of Science at the University of Dar Es Salaam. Department of Zoology and Marine Biology, University of Dar Es Salaam, 2000, 18 pp.

Mwaigomole S. *Sea grass and macrofaunal abundance at Mbweni fish landing site in comparison with adjacent undisturbed area*. A report submitted in partial fulfilment of the Degree of Bachelor of Science at the University of Dar Es Salaam. Department of Zoology and Marine Biology, University of Dar Es Salaam, 2001.

Ngowo, R.G. *Habitat survey and distribution of coral genera on landward and seaward sides of Mbudya Island*. A report submitted in partial fulfilment of the Degree of Bachelor of Science at the University of Dar Es Salaam. Department of Zoology and Marine Biology, University of Dar Es Salaam, 1999, 25 pp.

Ohman, M.C., Lindahl, U. and C.K. Schelten. Influence of coral bleaching on the fauna of Tutia Reef, Tanzania. *In* Linden, O. and Sporrong, N. (eds.), *Coral reef degradation in the Indian Ocean: status reports and project presentations 1999*. CORDIO, SAREC Marine Science Programme, Stockholm, 1999, pp. 48-52.

Sekadende, B.C. *Abundance and distribution of reef fishes and invertebrates on the landward and seaward sides of Mbudya Island*. A report submitted in partial fulfilment of the Degree of Bachelor of Science at the University of Dar Es Salaam. Department of Zoology and Marine Biology, University of Dar Es Salaam, 1999, 24 pp.

Semesi, A.K. Zonation and Vegetation Structure of Mangrove Communities in Tanzania. In (J.R. Mainoya and P.R. Siegel, eds*.) Proceedings of a workshop on save the mangrove ecosystem in Tanzania*. 21-22 February, 1986. Faculty of Science, University of Dar Es Salaam, 1986, pp. 15-36.

Semesi, A.K. *Reports on the mangroves, salt production, Marine algae and seagrasses of Tanga*. The report is based on the Consultancy study done on the coastal resources of Tanga Region, Tanzania for IUCN East Africa and Regional Natural Resources Office, Tanga region. October1987 (Funded by NORAD), 1987.

Semesi, A.K. Management plan for the mangrove ecosystem of Mainland Tanzania, Vol. 7. *Mangrove management plan of Rufiji Delta*. Ministry of Tourism, Natural Resources and Environment (MTNRE), Forestry and Beekeeping Division, Catchment Forestry Project, Dar Es Salaam, 1991.

Semesi, A.K. *Management plan for the mangrove ecosystem of mainland Tanzania*, Vol. 11 (Vols. 1-10 joined). Ministry of Tourism, Natural Resources and Environment (MTNRE), Forestry and Beekeeping Division, Catchment Forestry Project, Dar Es Salaam, 1991, 292 pp.

Semesi, A.K. *Coastal communities in Tanzania and their mangrove environment: a case of communities living in Rufiji Delta mangroves*, 1993.

Semesi, A.K. Mangrove management and utilization in Eastern Africa. *Ambio*, 27 (8), 1998, pp. 620-626.

Semesi, A.K. Mangrove of Tanzania. In TCMP (ed.) *The present state of knowledge of marine science in Tanzania: synthesis report*, 2001 .

Semesi, A.K, Muruke, H.H.S. and Y.D. Mgaya. Mangroves of Ruvu River and Kaole, Bagamoyo District. In (K.M. Howell & A.K. Semesi, eds.) *Coastal resources of Bagamoyo District, Tanzania. Proceedings of a workshop on coastal resources of Bagamoyo*. 18-19 December, 1999. Faculty of Science, University of Dar Es Salaam, 1999, pp. 17-26.

Semesi, A.K., Muruke, M.H.S. and Y.D. Mgaya. Introduction to the mangroves, seagrasses, seaweeds and coral reefs. In: K.M. Howell and A.K. Semesi (Eds.). *Coastal resources of Bagamoyo District, Tanzania. Proceedings of a workshop on coastal resources of Bagamoyo,* 18-19 December 1997, Bagamoyo. Faculty of Science, University of Dar Es Salaam, 1999, pp. 1-10.

Shilungushela, J.M.S. *Inventory of destructive activities to the freshwater bodies and the marine environment along the Tanga region coastal area*. Report commissioned by National Environment Management Council (NEMC), Dar Es Salaam, 1993, 57 pp.

Shunula, J.P. *Ecological studies on selected mangrove swamps in Zanzibar*. PhD thesis. University of Dar Es Salaam, 1998, 270 pp.

Shunula, J.P. and A. Whittick. *The mangroves of Zanzibar*. Institute of Marine Sciences, University of Dar Es Salaam, 65p. ISBN 0-88901-308, 1996.

Solandt, J.L. and R. Ball. *Coral mining in Mikindani Bay*. Frontier-Tanzania Marine Research Programme. The Society for Environmental Exploration and the University of Dar Es Salaam, 1999, 6 pp.

Tanzania Coastal Management Partnership (TCMP). *Tanzania state of the coast survey: people and the environment*. Technical Report for WWF Eco-Region Project prepared by the Science and Technical Working Group of Tanzania Coastal Management Partnership, 2001.

Thiagarajan, T. *Status of sea turtles in Zanzibar: commission for lands and environment* (COLE), Zanzibar, 1991.

Van Bruggen, J.J. A preliminary study on environmental pollution on Zanzibar. *Zanzibar Environmental study series* No. 6, 1990.

Van Bruggen, J.J. *Pollution measurements in Tanzania*. Institute of Marine Sciences/Commission for Lands and Environment, Zanzibar, 1990.

Von Mitzalaff, U. *Coastal communities in Tanzania and their mangrove environment: A socio-economic study*. NORAD/Catchment Forestry Project, Forest and Beekeeping Division, Dar Es Salaam, 1990, 60 pp.

Wagner, G.M. Conservation, monitoring and restoration of the marine environment. In: *Report of the preparatory workshop for the international year of the ocean*, 28 February 1998, 9 pp.

Wagner, G.M. Coral reefs: importance, threats, conservation and restoration. In: Howell, K.M. and Semesi, A.K. (eds.), *Coastal resources of Bagamoyo District, Tanzania. Proceedings of a workshop on coastal resources of Bagamoyo*, 18-19 December 1997, Bagamoyo. Faculty of Science, University of Dar Es Salaam, 1999, pp. 27-32.

Wagner, G.M., Mallya, U., Juma, S., Mgaya, Y.D., Wahure, O., Mahika, G. and S.M. Wagner. *A preliminary investigation for an integrated, community-based approach to conservation and restoration of marine ecosystems along the Dar Es Salaam coast*. African Development Foundation, Dar Es Salaam, 1999, 124 pp.

Wagner, G.M., Mgaya, Y. D., Akwilapo, F.D., Ngowo, R.G., Sekadende, B.C., Allen, A., Price, N., Zollet, E.A. and N. Mackently. Restoration of coral reef and mangrove ecosystems at Kunduchi and Mbweni, Dar Es Salaam, with community participation. In: Richmond, M. D. and Francis, J. (eds.), *Marine science development in Tanzania and Eastern Africa.* Proc. 20th Anniv. Conference on Advances in Marine Science in Tanzania, 28 June - 1 July 1999, Zanzibar, Tanzania. UDSM/Sida-SAREC/CIDA/USAID/ WIOMSA (in press), 2001.

Wilkinson, C. (ed.). *Status of coral reefs of the world*. Australian Institute of Marine Sciences, Townsville, 1998, 184 pp.