Coastal Profile for Zanzibar 2014
Thematic Volume I
Including Threats Prioritisation

Investment Prioritisation for Resilient Livelihoods and Ecosystems in Coastal Zones of Tanzania

NORDIC DEVELOPMENT FUND

List of Contents

List of Tables

List of Figures

Acronyms[1]

Addax	International oil and gas exploration and production company
AEWA	African-Eurasian Waterbird Agreement
AGIP	Azienda Generale Italiana Petroli (General Italian Oil Company)
BG	British Gas
BMU	Beach Management Units
BoE	Barrels of oil Equivalent
CAMARTEC	Center for Agricultural Mechanization and Rural Technology
CARE	Cooperative for Assistance and Relief Everywhere
CBNRM	Community Based Natural Resource Management
CC	Carrying Capacity
CFMA	Collaborative Fisheries Management Areas
CFMU	Collaborative Fisheries Management Units
CITES	Convention on International Trade in Endangered Species
CMCA	Community Marine Conservation Areas
CMIP	Coupled Model Intercomparison Project
CNPC	China National Petroleum Corporation
CPTDC	China Petroleum and Technology Development Company
CPUE	Catch per Unit Effort
CPUF	Catch per Unit Fisher
CPUFV	Catch per Unit Fishing Vessel
CRIAM	Coastal Rapid Impact Assessment Matrix
CRIF	Coral Reef Information System
CSAG	Climate Systems Analysis Group (University of Cape Town)
CTI	Confederation of Tanzania Industries
DCCFF	Department of Commercial Crops, Fruits and Forestry
DDT	dichlorodiphenyltrichloroethane
DED	District Executive Director
DEM	Digital Elevation Model
DFMP	Department of Fisheries and Marine Products
DoE	Department of Environment
DSFA	Deep Sea Fishing Authority
DSS	Decision Support System
DWT	Dead Weight Tonnage
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
Engen	Energy company focusing on the downstream refined petroleum products
EPZ	Economic Promotion Zone
EPZA	Export Processing Zones Authority
ERA-Interim	Model for near real time reanalysis used by the European Centre for Medium-Range Weather Forecasts
ESRF	Economic and Social Research Foundation
EV	Evaluation Value calculated in CRIAM
EWURA	Energy and Water Utilities Authority
EximBank	China Export-Import Bank

[1] The list of abbreviations and acronyms covers both thematic volumes, i.e. for Mainland Tanzania and for Zanzibar

FDD	Fisheries Development Division
FMP	Fisheries Management Plans
FYDP	National Fisheries Development Plan
GapCo	Gulf Africa Petroleum Corporation
GapOil	Retailers and marketer of petroleum products (GapCo subsidiary)
GCAP	Global Climate Adaptation Partnership
GCM	General Circulation Model
GDP	Gross Domestic Product
GHG	Green House Gasses
GIS	Geographical Information System
GoT	Government of Tanzania
GOZ	Government of Zanzibar
GPS	Global Positioning System
GSM	Global System for Mobile communication
HAT	Hotel Association of Tanzania
HEP	Hydro Electric Power
HIMA	Hifadhi Misitu ya Asili
HIV/AIDS	Human Immunodeficiency Virus/Acquired ImmunoDeficiency Syndrome
IBA	Important Bird Areas
ICM	Integrated Coastal Management
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IDD	Iodine Deficiency Disorder
IIDS	Integrated Industrial Development Strategy
IMS	Institute of Marine Sciences
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
ISCP	Innovation Systems and Cluster Programme
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
KNMI	Koninklijk Nederlands Meteorologisch Instituut (Royal Dutch Meteorological Institute)
LEAT	Lawyers' Environmental Action Team
LGA	Local Government Authority
LNG	Liquefied Natural Gas
LUP	Land Use Plans
MACEMP	Marine and Coastal Environmental Management Project
MAFSC	Ministry of Agriculture, Food Security and Cooperatives
MALE	Ministry of Agriculture, Livestock and Environment, Zanzibar
MANREC	Ministry of Agriculture, Natural Resources, Environment and Cooperatives
MARUHUBI	Zanzibar Institute of Tourism
MCS	Marine Control and Surveillance
MCU	Marine Conservation Unit
MIC	Ministry of Infrastructure and Communications
MIMCA	Mnemba Island Marine Conservation Area
MIT	Ministry of Industry and Trade
MKURABITA	Property and Business Formalization Program
MKUZA II	Zanzibar Strategy for Growth and Poverty Reduction
MLFD	Ministry of Livestock and Fisheries Development
MNRT	Ministry of Natural Resources and Tourism

MoT	Ministry of Transport
MOW	Ministry of Water
MoW	Ministry of Works
MPA	Marine Protected Area
MRPU	Marine Reserves and Park Unit
MSME	Micro, Small and Medium Enterprises
MSY	Maximum Sustainable Yield
MUKUTA	National Strategy for Growth and Reduction of Poverty (NSGRP)
MVIWATA	Mtandaowa Vikundivya Wakulimawa Tanzania (farmers network)
NAPA	National Adaptation Programme of Action
NAWAPO	National Water Policy
NAWESCO	National Sustainable Wetlands Management Steering Committee
NBS	National Bureau of Statistics
NDC	National Development Corporation
NEMC	National Environmental Management Council
NFP	National Forest Programme
NGO	Non-Government Organisation
NICEMS	National Integrated Coastal Environment Management Strategy
NSGRP	National Strategy for Growth and Reduction of Poverty
PCB	Polychlorinated Biphenyl
PMO-RALG	Prime Minister's Office for Regional and Local Government
PSA	Production Sharing Agreement
Ramsar	International convention on wetlands management
REDD	Reducing Emissions from Deforestation and forest Degradation
RIAM	Rapid Impact Assessment Matrix
RV	Range Value calculated in CRIAM
SACCOS	Savings and Credit Cooperative Organizations
SAGCOT	Southern Agriculture Corridor of Tanzania
SCUBA	Self-Contained Underwater Breathing Apparatus
SEC	South Equatorial Current
SESIA	Strategic Environmental and Social Impact Assessment
SEZ	Special Economic Zone
SIDO	Small Industries Development Organization
SIDP	Sustainable Industrial Development Policy
SME	Small and Medium sized Enterprises
SMOLE	Sustainable Management of Land and Environment
SPM	Single Point Mooring
SSHS	Saffir-Simpson Hurricane Scale
SST	Sea Surface Temperature
STCDA	Stone Town Conservation and Development Authority
SUMATRA	Surface and Marine Transport Regulatory Authority
SWMP	Sustainable Wetlands Management
TAA	Tanzania Airports Authority
TAFORI	Tanzania Forestry Research Institute
TAMPA	Tanzania Milk Processors Association
TAMPRODA	Tanzania Milk Producers Association
TANESCO	Tanzania Electric Supply Company Limited
TASONABI	Tanzania Specialist Organisation on Community Natural Resources and Biodiversity Conservation
TASPA	Tanzania Salt Producers Association
TATO	Tanzanian Association of Tour Operators

TAWA	Tanzania Wildlife Authority
TAZARA	Tanzania-Zambia Railway
TCAA	Tanzania Civil Aviation Authority
TCCIA	Tanzania Chamber of Commerce, Industries and Agriculture
TCF	Trillion Cubic Feet
TCMP	Tanzania Coastal Management Partnership
TCPL	Trans Canada Pipeline Limited
TD	Tropical Depression
TEMDO	Tanzania Engineering and Manufacturing Design Organization
TEU	Twenty-foot Equivalent Units
TFCG	Tanzania Forest Conservation Group
TFNC	Tanzania Food and Nutrition Centre
TFS	Tanzania Forest Services
TGFA	Tanzania Government Flight Agency
TIPER	Tanzania Italian Petroleum Oil Refinery
TIRDO	Tanzania Industrial Research Development Organization
TLU	Total Livestock Units
TMA	Tanzania Meteorological Agency
TNBC	Tanzanian National Business Council
TNRF	Tanzania Natural Resources Forum
TPA	Tanzania Ports Authority
TPCC	Tanzania Portland Cement Company
TPDC	Tanzania Petroleum Development Corporation
TPSF	Tanzania Private Sector Foundation
TRAFFIC	The Wildlife Trade Monitoring Network
TS	Tropical Storm
TSH	Tanzania Currency Unit
TTB	Tanzania Tourist Board
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFPA	United Nations Population Fund
URT	United Republic of Tanzania
USD	United States Currency Unit
VAT	Value Added Tax
VICOBA	Village Community Banks
VLFR	Village Land Forest Reserves
VPO	Vice President's Office
WB	World Bank
WCST	Wildlife Conservation Society of Tanzania
WRIAM	Water Resources Impact Assessment Matrix
WWF	World Wildlife Fund
ZATI	Zanzibar Association of Tourism Investors
ZATO	Zanzibar Association of Tour Operators
ZAWA	Zanzibar Water Authority
ZCT	Zanzibar Commission for Tourism
ZECO	Zanzibar Electricity Corporation
ZIPA	Zanzibar Investment Promotion Authority
ZNCCIA	Zanzibar National Chamber of Commerce, Industry and Agriculture
ZPC	Zanzibar Port Corporation
ZPRP	Zanzibar Poverty Reduction Plan

Table of Units

ha	hectare
km	kilometre
km^2	square kilometre
kV	kilo Volt
m	meter
m^2	square meter
m^3	cubic meter
Mm^3	million cubic metres
mmscf	million standard cubic feet
MW	Mega Watt
s	Second

1 INTRODUCTION

Coastal Areas

Vulnerable Areas under Pressure

Coastal areas represent complex and dynamic systems both in terms of human activities and in terms of their biophysical conditions. Today, a significant proportion of the global population lives in coastal areas and the proportion is growing. The effects of the increased pressure are degradation of the environment through pollution and unsustainable exploitation of coastal living and non-living resources. Increasing population density, industrial development, and economic growth have given rise to a variety of additional economic activities, the combined effects of which increase the pressure on coastal areas and their resources. This frequently results in cumulative and complex impacts on the environment, depletion of resources and intensified conflict between competing user groups.

There is a limit to the capacity of coastal environments to sustain human activities without deterioration, and many coastal areas today show signs of severe degradation. One example is exploitation of coastal fish stocks, providing most of worldwide marine fish harvests, which has exceeded sustainable levels in many areas. Another is the loss at an alarming rate of coastal wetlands due to amongst others, interference with hydraulic patterns, conversion to aquaculture and other land uses, pollution, coastal erosion, land reclamation and harbour development. Coastal wetlands such as mangrove swamps, sea grass meadows and lagoons and estuaries are critically important as nursery grounds for a number of coastal fish and shrimp species, they assist in shore protection, and their high biological productivity plays a significant role in impairing or diminishing the effects of organic and nutrient pollution.

Coastal areas are particularly vulnerable to climate variability and climate change, with low-lying areas exposed to inundation through sea level rise and to flooding due to surges during extreme events. Shoreline dynamics will be influenced by changes in wave climates and currents and by alterations in catchment hydraulics. Coastal ecosystems will be impacted by changes in temperatures and in seawater acidity.

Tanzania

Tanzania relies on the rich natural resources of its coastal areas. The coastal environments and their valuable resources of water, fisheries, estuaries, mangroves, coral reefs, seagrass beds, recreational areas and arable land are increasingly under pressure as the country develops. Economic growth and industrialisation are exerting pressure on the sensitive coastal ecosystems.

Some of the dominant sectors in Tanzania are the oil and gas sector, the fisheries sector, the agriculture sector, the forestry sector and the tourism sector. Fisheries are predominantly artisan in the near-shore waters where stocks are exploited near or above sustainable yield levels. Coral reefs are suffering from the effects of unsustainable fishing methods such as the use of explosives, whereas offshore fisheries are only carried out to little extent offering some possibilities for further development. Coastal aquaculture offers some potential, particularly within shrimp farming, seaweed farming and cage culture. Whereas coastal tourism is prominent for Zanzibar, coastal areas in the mainland offer significant unexploited potential for tourism development. Land and water resources use activities inland represent potential threats to the coastal areas due to the risk of disturbing hydraulics and siltation patterns on which coastal ecosystems rely. The oil and gas exploration and production activities cause a potential threat to the coastal zone, both in relation to shipping and to offshore activities. Urbanisation and the increasing population pressure in general exert pressure on the environmental quality along the coasts.

The coastlines in some areas suffer from coastal erosion, which may be further worsened by sand mining.

The present coastal zone management is characterised by insufficient integration, coordination and co-operation among relevant government agencies at state and local levels and other parties with stakes in the coastal areas.

There is awareness in Tanzania of the need to strike a balance between competing coastal activities and uses of coastal resources in ways, which recognise commercial and strategic interests, potential coastal hazard, and the need to conserve important natural resources to ensure sustained food yields. Conventional sector planning and management has shortcomings in addressing the many conflicting interests in the coastal zone and in a long term perspective an integrated multi-sector approach is required to ensure sustainable future development of the coastal zone.

In order to address these management challenges the Government of Tanzania with World Bank assistance has through the project "Investment Prioritisation for Resilient Livelihoods and Ecosystems in Coastal Zones of Tanzania" embarked on identifying and prioritising threats with the view of developing fundable adaptation measures to address the most pertinent threats.

The Project

Partners

The World Bank (WB) finances the study with trust funds provided by Nordic Development Fund (NDF).

The client for the project is Fisheries Department at the Ministry for Livestock and Fisheries Development (MLFD) in Dar es Salaam and the Department of Fisheries and Marine Resources at the Ministry of Agriculture, Livestock and Environment (MALE) in Zanzibar.

The consultants carrying out the study are DHI from Denmark and SAMAKI Consultants from Tanzania.

Objectives

The objective of the study has been to prioritise geographically and thematically the actions to promote sustainable coastal livelihoods and ecosystems in Tanzania (both Mainland and Zanzibar). The results comprise proposals for measures for coastal management and climate change adaptation in Tanzania, which the Government of Tanzania, NGOs, and donors can use to guide their support and investments over a five-year period.

The specific objectives are to:

1. Conduct a review of current coastal management and climate change adaptation studies and planning activities in Tanzania Mainland and Zanzibar, including an inventory of data and information available;
2. Identify, analyse and geographically locate the most important livelihood sources of Tanzania's coastal communities, and the ecosystems on which they depend;
3. Assess the economic costs of climate change on coastal communities and analyse the adaptive capacity of these communities;
4. Identify and geographically locate a gross list of major climate-related threats to sustain these livelihood sources and the ecosystems they depend on;
5. Evaluate the gross list of threats in terms of probability of occurrence, prediction confidence, and consequences if a 'business as usual' scenario is applied;

6. Identify possible adaptation measures to mitigate the threats and evaluate these measures in terms of cost-benefit efficiency and reasonability to implement;
7. Analyse the characteristics of the threats and adaptation measures to prioritise them and identify the most urgent and important investments for sustainable coastal livelihoods and ecosystems;
8. Identify on-going and planned projects supporting coastal management and climate change initiatives in coastal areas, and recognise overlaps with the above found priorities;
9. Identify data monitoring and research needs that should be addressed to augment the implementation and sustainability of the recommended investments;
10. Establish a GIS database to document the results from the above objectives to the extent possible. The data base should be used as the basis upon which to undertake spatial analysis and thereby assist in prioritizing adaptation investments, based in large part on the characteristics and geographic locations of the major threats to sustainable livelihood sources.;
11. Develop an action plan for priority investment in the short-term (next five years) under multiple funding scenarios. The action plan should consider the prioritisation results, total estimated costs compared to assumed available funds, and possible overlaps with existing initiatives. It should be specified whether the investments are targeted for Tanzania Mainland or Zanzibar.

Phases and Activities

The study proceeds in three phases:

- **Extended Inception Phase** during which systematic efforts are made to identify, acquire, and review as recent information on the situation in the coastal areas. This phase is completed with two workshops in Dar es Salaam and Stone Town where feedback is pursued from key stakeholders on the results achieved during the inception period.

  These results are described in an inception report containing a consolidated description of the coastal areas, their resources, socio-economic characteristics and current management, as well as major challenges from both increased anthropogenic pressure and climate change. The report also provides an overview of data and information identified as pertinent for coastal zone management, including a description of the geographical information system (GIS) built as part of the study. The overview is provided as a database of documents and a meta-description of the GIS. The inception report also contains a preliminary list of major threats to coastal areas and a proposed method to analyse these in regard to relevance and adaptation possibilities.

  The inception report is presented in the form of a coastal profile for Tanzania with three volumes as further detailed below.

  The inception report was finalised and distributed in soft copy after the workshops to incorporate feedback from stakeholders on the identified threats. A series of posters were displayed at the workshop presenting selected themes and providing a district level overview.

  Objectives achieved during this phase are 1, 2, 3, 4, 8 and 10.

  Objectives contributed to during this phase are 5, 7 and 9.

- **Prioritisation Study** through which the threats identified in the extended inception phase was examined in more detail with the view of preparing a final list of threats for multi-

criteria assessment, which in turn in the process also served to examine adaptation measures addressing these threats.

The final list of threats and adaptation measures has been reviewed against already existing or planned adaptation projects to ensure that overlapping and duplication is avoided in the final development of a package of adaptation measures for a 5 year period that can assisting in building resilience of coastal livelihoods and ecosystem.

Objectives achieved during this phase are 5, 6, 7, 9 and 11.

- **Reporting and Dissemination** was the final activity under the study and included a validation among major stakeholders through final workshops in Dar es Salaam and Stone Town. The final report from the study describes the list of threats and adaptation measures, the method and results of the multi-criterion analysis, the investment prioritisation and propose adaptation measures.

Schedule

The duration of the study was from the start estimated to be nine months, allocating three months for the extended inception phase, four months for the prioritisation study and two months reporting and dissemination of the results. The project activities started in earnest in November 2013, and reached the completion of the extended inception period by mid April 2014 thus experiencing a delay of almost three months reflecting difficulties in acquiring information required for the updated coastal profile and adjusting to schedules of stakeholders.

The study was completed end January 2015.

Coastal Profile

Presentation of the Coastal Profile

The coastal profile has been based primarily on secondary data, acquired from key stakeholders during the extended inception period. A database has been established listing all relevant documents identified and linkages to soft copies have been included as available.

A Geographical Information Systems (GIS) has been established to contain acquired themes. The GIS has furthermore been used to examine inundation and flooding consequences of various Sea Level Rise scenarios. These analyses have been based on a Digital Elevation Model (DEM) developed for the coastal areas of the country. The GIS has also been used to produce district level statistical information.

The coastal profile is presented in three volumes:

Volume I: Coastal Themes, presenting the situation in the coastal zone thematically, i.e. from the perspective of various sectors and other country wide themes. Further details are provided in the presentation of the volume below.

Volume II: Coastal Districts, offering an overview of the situation in the coastal zone of each district, localising and adding detail to the information in Volume I.

Volume III: Maps and Tables, presenting thematic and district maps in A3 format and offering tabulated information, collected from documents consulted or generated from the GIS.

A key requirement for all themes and all district presentation has been to identify threats to coastal communities and ecosystems, as has an assessment of vulnerability to climate variability and climate change. A long list of thus identified threats has been attached as Annex 2.

Threats Prioritisation

Process

The coastal profiles were presented in detail for key stakeholders at the Inception Workshops in Dar es Salaam and Zanzibar in April 2014 together with a tool for prioritising the threats to local communities and ecosystems that had been identified in the coastal profiles. The participants in the inception workshops are listed in Annex 6.

Full details on the prioritisation tool, the Coastal Rapid Impact Assessment Matrix (CRIAM), are provided in Annex 3 to this version of the coastal profile. It is particularly useful in developing consensus on management issues among multiple stakeholders in situations where baseline information is scarce and or out of date. It is as the name indicates a rapid tool relying substantially on the knowledge, experience and perception among the group of people using the tool.

The participants at the inception workshops engaged in rapid sessions using the tool to assess the relative importance of the threats identified in the coastal profiles, while also allowing additional threats to be included in the assessment.

To consolidate the CRIAM assessments two smaller working groups were formed in Dar es Salaam and Zanzibar to systematically review and assess all identified threats and to outline broad measures that could be undertaken to address these threats. These measures would then provide guidance for further action oriented detailing towards the development of actions in the form of project sheets.

These working groups of around 10 to 15 members were composed of key actors with particular and recent knowledge about the coastal situation and challenges in mainland Tanzania and Zanzibar. The members of the working groups have been attached this report as Annex 7.

Two full day working sessions took place in June 2014 in each group. The results of their work has since then been further processed and included in the current Version 1 of the Coastal Profile. Details are presented as new subsections in each of the thematic chapters. These are:

- CRIAM Ranking of Threats to Local Communities associated with the theme covered in the chapter
- Outline of Broad Measures to Address Threats to Local Communities associated with the theme covered in the chapter

The working groups were also requested to consider and evaluate the threats identified in the District/Regional Coastal Profiles using the CRIAM methodology and these documents have been updated accordingly.

Threats Prioritisation Methodology Brief

All threats identified in the coastal profiles have been systematically assessed using five criteria:

Criterion A_1 - Importance of condition[2], which is a measure of the importance of the threat, which is assessed against the spatial boundaries or human interests it will affect. Values can be allocated between 4 and 0 as follows:

$A_1 = 0$: No importance
$A_1 = 1$: Important only to local condition
$A_1 = 2$: Important to areas immediately outside local condition
$A_1 = 3$: Important to regional/national interests
$A_1 = 4$: Important to national/international interests

Criterion A_2 - Magnitude of change / effect, which is a measure of the scale of the threat. Values can be allocated between 3 and 0 as follows:

$A_2 = 0$: No change / status quo
$A_2 = 1$: Negative change to status quo
$A_2 = 2$: Significant negative dis-benefit or change
$A_2 = 3$: Major dis-benefit or change

Criterion B_1 – Permanence, which considers whether the threat is temporary or permanent. Values can be allocated between 3 and 1 as follows:

$B_1 = 1$: No change / not applicable
$B_1 = 2$: Temporary
$B_1 = 3$: Permanent

Criterion B_2 – Reversibility, which considers whether the threat can be changed and is a measure of the control over the effect of the condition. Values can be allocated between 3 and 1 as follows:

$B_2 = 1$: No change / not applicable
$B_2 = 2$: Reversible
$B_2 = 3$: Irreversible

Criterion B_3 – Cumulative character, which considers whether the threat has a single direct impact or whether there will be a cumulative effect over time, or a synergistic effect with other threats. Values can be allocated between 3 and 1 as follows:

$B_3 = 1$: No change / not applicable
$B_3 = 2$: Non-cumulative / single
$B_3 = 3$: Cumulative / synergistic

The overall assessment of each threat is calculated using the following formula:

$$Evaluation\ Score\ (ES) = A_1 \times A_2 \times (B_1 + B_2 + B_3)$$

According to the severity of threats, the evaluation scores can reach values between 0 and 108. For a simpler overview, these scores translates into problem classes as follows:

[2] The CRIAM methodology has been used to rank threats both in the thematic and in the district/regional volumes of the coastal profile. The resulting evaluation scores cannot be compared directly between these dimensions as the A_1 values differ. In the thematic volume, the value 3 is allocated for a threat distributed throughout the coast, whereas the value 3 in the district/regional volume is allocated for a threat distributed throughout the district/region.

Table 1: Translation of Evaluation Scores into Range Values / Problem Classes

Score (ES)	Range value (RV)	Problem Class
0	0	No importance / Not applicable
1 to 9	1	Slight Problem
10 to 18	2	Problem
19 to 35	3	Important Problem
36 to 71	4	Very Important Problem
72 to 108	5	Major Problem

Full details on the prioritisation methodology are attached in Annex 3: Coastal Rapid Impact Assessment Matrix (CRIAM).

Overall Threats Prioritisation Outcome

Altogether 106 of the threats to coastal communities and ecosystems identified in thematic coastal profile for Zanzibar have been prioritised. Out of these 8 were considered to constitute major problems, 58 very important problems, 15 important problems, 11 problems and 14 light problems. The thematic grouping of the problems are presented in Table 2 below and illustrated in **Error! Reference source not found.** also below.

Table 2: Overview of threat severity distribution within themes considered in the coastal profile for Zanzibar. For each theme, numbers of threats identified within each range of threat severity is provided.

ZANZIBAR	Light Problem	Problem	Important Problem	Very Important Problem	Major Problem	Total
Agriculture		1	3	8	2	14
Fisheries			1	6	1	8
Forestry	2			5	1	8
Freshwater Resources		1	3	4		8
Hydrocarbons	1	1		1		3
Industry			1	6		7
Infrastructure				2		2
Management Framework for CZM			2	4		6
Natural Resources	1	4	1	6	2	14
Ports and Harbours		2	1	1		4
Salt Production	2	1		3		6
Sand and Rock Mining	6	1		2		9
Tourism	1		2	5	2	10
Urbanisation	1		1	5		7
Grand Total	14	11	15	58	8	106

The details of the ranking of threats within each sector are presented in the sector chapters under a separate CRIAM heading. A brief overview of threats within each problem class is tabulated in Table 3 to Table 7.

Table 3: Threats assessed to impose major problems to local communities and ecosystems. The assessment uses the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Loss of public land (coral rag) to agriculture.	Agriculture	3	3	3	3	2	72	5					
Reduced land for agriculture on Unguja due to intense competition (Coles et al. 2007).	Agriculture	3	3	3	3	2	72	5					
Destructive and illegal fishing - causing decline in productivity due to habitat destruction through beach seine, spear guns and dragnets, adversely affecting the fisher community livelihoods.	Fisheries	3	3	3	2	3	72	5					
Forest degradation due to over-exploitation or poor harvest methods (e.g. slash and burn).	Forestry	3	3	3	2	3	72	5					
Illegal (destructive) fishing damaging seaweed, seagrass beds and coral reefs.	Natural Resources	3	3	3	2	3	72	5					
Invasive Indian house crow causing loss of bird diversity through ferocious predation on eggs of local bird species thus threatening indigenous populations.	Natural Resources	3	3	3	2	3	72	5					
Inadequate sewage infrastructure and waste management causing pollution of the coastal zone, further exacerbated by the illegal dumping of waste and litter from some developments.	Tourism	3	3	3	2	3	72	5					
Reduced freshwater supply now estimated to meet only 51% of the demand (from a rising population and expanding industries and tourism.	Tourism	3	3	3	2	3	72	5					

Table 4: Threats assessed to impose very important problems to local communities and ecosystems. The assessment uses the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	ES	RV	Light problem	Problem	Important problem	Very important problem	Major problem
Social conflicts over land use	Agriculture	3	3	3	2	2	63	4					
Invasion of water sources	Agriculture	3	3	3	2	2	63	4					
High production cost	Agriculture	3	3	3	2	2	63	4					
Salt water inundation	Agriculture	3	3	3	2	2	63	4					
Social conflicts over land due to poor land management	Agriculture	3	3	3	2	1	54	4					
Insufficient water for irrigation	Agriculture	3	2	2	2	2	36	4					
Limited business/financial management skills among producers and suppliers, limits the success of agribusiness.	Agriculture	3	2	3	2	1	36	4					
Insufficient climate information forecasting and early warning systems	Agriculture	3	2	3	2	1	36	4					
Social conflicts over access to resource – where cultural and historical rivalry over "traditional" fishing grounds increases as pressure on the resource increases; also includes increasing resentment of migratory fishing groups of "dago" fishers during seasonal visits, using gears considered destructive or conflict with local traditions.	Fisheries	3	3	3	2	2	63	4					
Weaknesses in management leading to onflicts with tourists over coral reefs to dive and to snorkel, fish landing sites and tourist hotels; to seaweed farming conflict with boat users and tourists; allowing open access fishery, thus increasing fishing pressure and stock depletion is difficult to manage.	Fisheries	3	3	3	2	2	63	4					
Limited alternatives or investment, attributed as causes for current behaviour of fishers.	Fisheries	3	3	3	2	2	63	4					
Absence of weather forecasting resulting in losses of drying seaweed.	Fisheries	3	3	2	2	1	45	4					

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	ES	RV	Light problem	Problem	Important problem	Very important problem	Major problem
Inadequate understanding of fisheries resources biology in support of management	Fisheries	3	2	3	2	1	36	4					
Weak dissemination of aquaculture techniques	Fisheries	3	2	3	2	1	36	4					
Inadequate enforcement of forest management regulations resulting in illegal clearing and over-harvesting of mangrove forests and coastal forests	Forestry	3	3	3	2	2	63	4					
Ineffective land use management resulting in encroachment of expanding agriculture and settlements into forests or clearance for salt works, aquaculture (on Pemba) or tourism.	Forestry	3	3	3	2	2	63	4					
Fire	Forestry	3	3	3	2	2	63	4					
Declining ground water quality.	Forestry	2	3	3	2	3	48	4					
Conflict over illegal mangrove cutting.	Forestry	3	2	3	2	2	42	4					
Population and economic growth leading to increasing demand for freshwater.	Freshwater Resources	3	3	3	2	2	63	4					
Degradation of catchments due to land use changes and livestock keeping.	Freshwater Resources	3	2	3	2	2	42	4					
Lack of updated data on current river discharges on Pemba and aquifer recharges on both islands leading to failure to comprehensively control water supplies.	Freshwater Resources	3	2	3	2	2	42	4					
Lack of information on climate change and its impacts on Zanzibar's aquifers.	Freshwater Resources	3	2	3	2	1	36	4					
Inadequate infrastructure management unable to maintain supply of services (electricity, transport, water), resulting in disincentive for industry attraction to Zanzibar and develop.	Industry	3	2	3	2	1	36	4					
Lack of coordination of the choice of location of new industries underlines the need for integrated planning.	Industry	3	2	3	2	1	36	4					

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	ES	RV	Light problem	Problem	Important problem	Very important problem	Major problem
Failure to monitor industry liquid waste leading to pollution of waterways/ground water.	Industry	3	3	3	2	2	63	4					
Failure to monitor industry solid waste leading to pollution of waterways/open ground.	Industry	3	3	3	2	2	63	4					
Failure to monitor industry air emission leading to air pollution.	Industry	3	3	3	2	2	63	4					
Lack of raw materials leading to less adequate investment potentials	Industry	3	2	3	2	1	36	4					
Poor land use and infrastructure management leading to poor or biased choices for development, for example.	Infrastructure	3	3	3	2	2	63	4					
Inadequate infrastructure management unable to maintain supply of services (electricity, transport, water supply, health and education services and ICT) to coastal regions, resulting in a deterioration of living standards, business development and prosperity.	Infrastructure	3	3	3	2	2	63	4					
Absence of financial capacity to address management issues related to coastal and marine resources.	Management Framework for CZM	3	3	3	2	2	63	4					
Increasing demand of water for irrigation	Management Framework for CZM	3	3	3	2	2	63	4					
Poor capacity and motivation at local district authority level to implement legal mandates governing natural resource use, resulting in continued deterioration of productive resources.	Management Framework for CZM	3	3	3	2	1	54	4					
Poor coordination and monitoring between different sectors leading to ineffective governance and failing of enforcement in coastal and marine areas.	Management Framework for CZM	3	2	3	2	1	36	4					
Poor management of the shores (e.g. coastal developments) and lack of understanding of coastal erosion leading to loss of shoreline.	Natural Resources	3	3	3	2	2	63	4					

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	ES	RV	Light problem	Problem	Important problem	Very important problem	Major problem
Gillnetting threatening turtles (adults and sub-adults). Gillnetting threatening whales, especially migrating Humpback whales and dolphins.	Natural Resources	3	3	3	2	2	63	4					
Predation and disturbance of turtle nesting sites	Natural Resources	3	3	3	2	2	63	4					
Coral bleaching from El Nino sea surface temperature rise damaging coral reefs.	Natural Resources	3	3	2	2	1	45	4					
Pollution through nutrient enrichment, particularly from sewage disposal affecting the structure of coral reef ecosystems.	Natural Resources	2	3	3	2	2	42	4					
Habitat alteration from land use changes (saltpans in mangrove areas, shoreline alterations and inundation).	Natural Resources	2	3	3	2	2	42	4					
Degradation of the natural marine and coastal environment and thus impact on livelihoods, from failure of exploration companies to adhere to environmental and socio-economic safeguards, partly due to weakness in the oversight provided by the Department of Environment, responsible for issuing licences and monitoring the operations that have been subjected to EIAs.	Hydrocarbons	3	3	2	2	2	54	4					
Inefficient operation at Malindi port leading to greater costs of imported and exported goods.	Ports and Harbours	3	2	2	2	2	36	4					
Poor management of shores (e.g. coastal developments), lack of understanding of coastal erosion causative factors leading to loss of shoreline.	Sand and Rock Mining	3	3	3	2	2	63	4					
Corrupt and uncoordinated institutional enforcement of mining policy to protect the natural environment, particularly the coastline.	Sand and Rock Mining	3	3	3	2	2	63	4					
Unsustainable practices resulting in degradation of mangrove forests for ponds and timber (for boiling salt water), causing losses to the wider environment with respect to shelter from wave action to fisheries production.	Salt Production	3	3	3	2	2	63	4					
Solid and liquid wastes from improper disposal	Salt Production	3	3	2	2	2	54	4					

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	ES	RV	Light problem	Problem	Important problem	Very important problem	Major problem
Unplanned urbanization in some areas reduces land availability into which to expand.	Salt Production	3	2	3	2	2	42	4					
Deterioration of marine environment from destructive fishing practices.	Tourism	3	3	3	2	2	63	4					
Deterioration of conservation areas due to failure of management to address encroachment and resource over-utilisation, especially forests.	Tourism	3	3	2	2	2	54	4					
Increased beach erosion from unchecked sand mining for hotel construction or for road construction in Zanzibar.	Tourism	3	3	2	2	2	54	4					
Worsening personal security due to increased crime and violence.	Tourism	3	3	2	2	1	45	4					
Conflicts between local communities and tourism developers over natural resources.	Tourism	3	2	2	2	2	36	4					
Poor urban management leading to overcrowding informal settlements that lack clean water and adequate sanitation, leading to increase health/well-being problems from conta-minated water and from mosquitos and other pests that thrive in unsanitary environments.	Urbanisation	3	3	3	2	2	63	4					
Inadequate solid waste management causing pollution of landscape, watersheds and coast.	Urbanisation	3	3	3	2	2	63	4					
Inadequate sanitation causing pollution and health issues.	Urbanisation	3	3	3	2	2	63	4					
Failure of housing for the youth and children exposing them to human predators, violence, abuse and sexual assault that increase their risk of HIV infection.	Urbanisation	3	2	3	2	2	42	4					
Poor vehicular management leading to increasing vehicular/pedestrian congestion, conflicts and air pollution.	Urbanisation	3	2	3	2	2	42	4					

Table 5: Threats assessed to impose important problems to local communities and ecosystems. The assessment uses the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	ES	RV	Light problem	Problem	Important problem	Very important problem	Major problem
Inadequate agricultural product supply leading to tourism operators sourcing elsewhere.	Agriculture	2	2	2	2	2	24	3					
Poor farming practice	Agriculture	2	2	2	2	2	24	3					
Freshwater scarcity and irregular supply	Agriculture	2	2	2	2	1	20	3					
Social conflicts over fishing gears - where local fishers use gears or methods (some of which are illegal) that are not acceptable by neighbouring villages.	Fisheries	1	3	3	2	2	21	3					
Increased demand from tourism sector exceeding supply.	Freshwater Resources	2	2	3	2	2	28	3					
Inefficient management of water bodies on Pemba, leading to removal of riverine vegetation, erosion of riverbanks, pollution of water bodies from municipal waste dumping, agricultural practices or mining (minerals and river sand) or abstraction for water for agriculture (or livestock).	Freshwater Resources	2	2	2	2	2	24	3					
Inefficient management of piped water supply leading to leaks and loss of water.	Freshwater Resources	3	1	3	2	2	21	3					
Inadequate prioritisation in the industrial sector	Industry	3	2	2	2	1	30	3					
Poor coordination to address solid waste disposal leading to pollution of beaches and coastal waters.	Management Framework for CZM	2	2	3	2	2	28	3					
Lack of sewage treatment facilities in the Stone Town leading to pollution of beaches and coastal waters.	Management Framework for CZM	1	3	3	2	2	21	3					
Waste disposal, in solid and liquid form causing harm to seagrass beds and estuaries and lagoons.	Natural Resources	2	2	3	2	3	32	3					
Erosion of shorelines adjacent to some secondary ports: Mkoani and Wete (Pemba), and Mkokotoni (Unguja).	Ports and Harbours	1	3	3	2	2	21	3					
Loss of employment opportunities by locals to more qualified and better trained staff from mainland Tanzania and Kenya.	Tourism	3	2	2	2	1	30	3					

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	ES	RV	Light problem	Problem	Important problem	Very important problem	Major problem
Increased beach erosion from anarchistic tourism development constructed too close to or below the high water mark, due to inadequate management and enforcement tools.	Tourism	1	3	3	2	2	21	3					
Poor urban management threatening the status of the Stone Town World Heritage Site and thus the tourism industry on Zanzibar.	Urbanisation	1	3	3	2	2	21	3					

Table 6: Threats assessed to impose problems to local communities and ecosystems. The assessment uses the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	ES	RV	Light problem	Problem	Important problem	Very important problem	Major problem
Unpredictable demand by tourism operators due to uncertain occupancy rates mean hotels cannot guarantee long-term orders.	Agriculture	2	1	2	2	2	12	2					
Pesticide and waste water pollution of aquifers on Pemba and Unguja from poor agricultural practices, or pollution from municipal waste dumping or inadequate sewage systems.	Freshwater Resources	2	1	2	2	2	12	2					
Overharvest of invertebrate marine life negatively affecting sea grass meadows.	Natural Resources	3	1	3	2	1	18	2					
Tourist activities damaging seagrass beds and coral reefs.	Natural Resources	1	2	3	2	3	16	2					
Seismic surveys by oil and gas companies deterring whales, especially migrating Humpback whales with calves.	Natural Resources	1	3	2	2	1	15	2					
Sedimentation of coral reefs from river discharges, sewage discharges and dredging.	Natural Resources	1	2	2	2	1	10	2					
Piracy attacks against offshore operations.	Hydrocarbons	3	1	2	2	2	18	2					
Inadequate environmental mitigation during new port construction leading to environmental degradation e.g. siltation of reefs.	Ports and Harbours	1	3	2	2	2	18	2					
Pollution arising from port activities and traffic.	Ports and Harbours	3	1	2	2	2	18	2					
Loss of beach habitats for turtle nesting.	Sand and Rock Mining	1	2	2	2	2	12	2					
Sea level rise threatening infrastructure (dykes and buildings, etc.).	Salt Production	1	2	3	2	3	16	2					

Table 7: Threats assessed to impose light problems to local communities and ecosystems. The assessment uses the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	ES	RV	Light problem	Problem	Important problem	Very important problem	Major problem
Pests and grazing damage	Forestry	1	1	2	2	2	6	1					
Erosion of mangrove stands.	Forestry	1	1	2	2	2	6	1					
Poor upstream land use affecting seaweed and seagrass productivity.	Natural Resources	1	1	2	2	1	5	1					
Social and/or political unrest related to behaviour of the Government and stakeholders.	Hydrocarbons	1	1	2	2	1	5	1					
Economic losses through tourist abandonment	Sand and Rock Mining	1	1	3	2	2	7	1					
Loss of coastal aesthetics	Sand and Rock Mining	1	1	3	2	2	7	1					
Anarchistic sand and rock extraction from coastal zone resulting in increased erosion.	Sand and Rock Mining	1	1	2	2	2	6	1					
Loss of river basin habitat from un-regulated sand extraction.	Sand and Rock Mining	1	1	2	2	2	6	1					
Increase in water borne diseases from quarries that fill with rainwater.	Sand and Rock Mining	1	1	2	2	2	6	1					
Shallow water table contamination from poor citing of rock quarries.	Sand and Rock Mining	1	1	2	2	2	6	1					
Lack of suitable habitat for artisanal (non-pump) and industrial systems into which to expand/adapt, particularly with respect to land and availability of clay to construct dykes.	Salt Production	1	1	3	2	2	7	1					
Local population hazard from low iodisation of salt from small-scale producers in Zanzibar (iodine deficiency disorders).	Salt Production	1	1	3	2	2	7	1					
Increase in water-borne disease such as malaria, dengue fever, typhoid and dysentery.	Tourism	1	1	2	2	1	5	1					
Poor vehicular management leading to increasing vehicular congestion resulting in loss of working hours and fatigue among the workforce.	Urbanisation	1	1	3	2	2	7	1					

2 COASTAL COMMUNITIES

Introduction

Zanzibar is comprised of the two islands of Unguja and Pemba occupying a total area of 2,650 km^2. Being an island state, the livelihoods of its people are largely dependent on the coastal and marine resources that support the fisheries, tourism and other income sources.

The context

Settlements and administrative description

Zanzibar has five administrative regions, namely Mjini Magharibi, Kusini Unguja, Kaskazini Unguja, Kusini Pemba and Kaskazini Pemba. The Stone Town area dominates urban living in Zanzibar. The districts are Wete, Mkoani and Chakechake in Pemba, and South, North B, Mbweni, Mangapwani, Chwaka and Nungwi in Unguja Island.

The non-urban part of the population, about half of them, live in villages and settlements which are located within the boundaries of the coastal area or very close to it. Urbanisation in Zanzibar is covered in a separate chapter (page 77).

The economy

The economy of Zanzibar is dominated by fisheries and tourism, and to a smaller extent agriculture and trade. Tourism in Zanzibar continues to be a major contributor to the National GDP and indications are that the contribution from the sector will continue to increase as the industry grows further. Its share of GDP increased to 51% in 2007 exceeding 43.5% recorded in 2006. The next largest sectors contributing to GDP are agriculture at 27.3%, and industry at 15.4 % (Zanzibar Economic Bulletin, March 2009, in Steck 2010). There are five ports in Zanzibar and Pemba Islands, the largest being Malindi port in Unguja Island. The Malindi Port handles more than 90% of Zanzibar trade and is one of the key hubs for the economy of Zanzibar – sustaining cargo handling and storage services and passenger services from Tanzania mainland, Dar es Salaam. A significant population of Unguja finds employment in this port – permanent and daily-paid work.

Other sectors that support local livelihoods such as agriculture have however not experienced much growth. Subsectors which grew substantially well with their rates in brackets included fishing (2.3%), livestock (3.1%) and forestry and hunting (1.2%). Seaweed procurement increased in 2012, driven by high prices in the world market. The industrial sector grew by 9.2%, higher than 5.8% in 2011, growth associated with a significant increase in mining and quarrying and construction subsectors. Construction in 2012 rose by 14.1% from 4.7% registered in 2011, mainly due to increased imports of capital goods for investment projects including roads construction in Pemba. Transport and communication subsector rose by 18% to KSH 130.6 billion during 2012 compared with KSH 110.7 billion the previous year.

Zanzibar receives electricity through submarine power cables from Tanzania mainland. This power supply that has a capacity of 100 MW has been supporting the industry, but also local livelihoods and businesses within the fisheries and tourism sector. Only a small percentage of local households have been connected to this electricity supply. Pemba was connected to the national electricity grid in June 2010 through a 72 km long subsea cable from mainland Tanzania replacing three old local diesel generators and increasing the overall capacity. This connection has fuelled the development of tourist services such as resorts and local businesses are expanding. Reliable electricity supply will enhance human welfare not the least in terms of improved quality of service provision such as in health and education services.

Population

The rate of population growth in Zanzibar is high and an issue of concern particularly for coastal Unguja. The average annual population growth rate (AAGR) of Zanzibar almost doubled between 1967 and 2002, increasing from 1.8% in 1967 to 3.1% in 2002. The growth rate for Unguja Island was higher (3.6%) than for Pemba (2.2%).

The population of Zanzibar is predominantly rural (68%) and children under 15 years of age make up 44.3% of the population, implying a high dependency ratio limiting domestic savings and reducing the number of women in the labour force (MKUZA II, 2010). By 2012, the population of Zanzibar grew to 1,303,569 of which 672,892 are females and 630,677 are males. Of the total population, Unguja has 622,459 and Pemba 362,166 people. The average annual growth rate between 2002 and 2012 has been 2.8%. The total number of households in 2012 was 253,608.

Zanzibar has seen a rise in population density from around 400 persons/km^2 in 2002 to around 530 persons/km^2 in 2012. Population growth and increased densities in the islands stretch the service provision facilities, including clean water supply and sewerage disposal, affecting the marine environment. Effluents and other pollutants discharge into the sea along the entire coast, with increasing concentrations at the outflows (Mohammed, 2001).

Table 8: Population data for Zanzibar Regions 2002 and 2012.

Region	2002	2012	Average Annual Growth Rate (AAGR) in %	Population density 2012 in persons/km2
Kaskazini Unguja	136,639	187,455	3.2	399
Kusini Unguja	94,244	115,588	2.0	135
Mjini Magharibi	390,074	593,678	4.2	2,581
Kaskazini Pemba	185,326	211,732	1.3	369
Kusini Pemba	175,471	195,116	1.1	588
Total for Zanzibar	981,754	1,303,569	2.8	530

The population growth in Zanzibar increases the vulnerability of people and their livelihoods to climate change as seen in other Small Island Development States (SIDS). Zanzibar is projected to be at risk of increasing floods, coastal erosion, inundation, and salt-water intrusion, which will have impacts on ecosystem and ecosystem services. Among the livelihood systems at risk are those depending on fisheries, mangroves and tourism. With no adaptation strategies, coastal livelihoods in Zanzibar are at risk of being negatively affected.

Livelihood activities

The livelihood of a majority of people in Zanzibar [Unguja and Pemba] are dependent on fisheries, subsistence farming, mangrove cutting, coastal thicket harvesting, livestock keeping, rope making or trades and wage employment. Seaweed farming, aquaculture and tourism are more recent sources of livelihoods. Tourism is a significant local employer, particularly for Unguja Island, but also for Pemba. Clove plantation has been a significant economic activity, especially in Pemba, and the islands produced 7 % of the world's cloves in 2006.

Fisheries

The artisanal/small-scale fishery sector in Zanzibar supports a significant proportion of local livelihoods. In 2000, it was estimated that the activity provided full time employment for over 24,000 people with thousand more part time fishermen (UNEP/FAO/PAP/CDA, 2000). By 2007,

this figure was estimated to be 34,268 (Joint Frame Survey, 2007). Enhanced market demand for fish and other marine products, including prawns, lobster and sea shells for export, has increased access to capital for investment and allowed some Zanzibari fishermen to advance into offshore fisheries increasing incomes for a certain percentage of fish-dependent households. Nungwi village, at the northern tip of Unguja Island is the primary landing site for large pelagic fish.

Fishing targeting the export market is significant in Zanzibar particularly related to prawns, lobsters, sea cucumbers (including seashells and seashell opercula). Bivalves such as cockles and oysters are collected mainly for domestic consumption. The most common fishing vessels are dug-out canoes, outrigger canoes, planked motorised boats and planked sailing boats. In 1997 there were 5,149 of such fishing vessels in Zanzibar, 2,933 of which were found in Unguja Island (UNEP/FAO/PA/CDA, 2000).

Increased effort in fishing has not resulted in increases in fish catches per unit, and reports indicate that the export of lobster and prawns has dropped drastically due to depleted stocks. This is attributed to the use of destructive fishing methods. Due to depletion of resources such as lobster, deeper waters are exploited using SCUBA gear. Destructive fishing methods include the use of drag nets, such as beach seine and *kigumi*, which are known to trample and destroy corals. Records indicate that these methods are used in several areas like Chwaka, Mkokotoni area, Zanzibar Town, and also recently in Fumba area, despite its nature conservation status (UNEP/FAO/PAP/CDA, 2000). The Joint Fisheries Frame Survey (2007) reported that Northern Pemba had an outstandingly high rate of beach seine use compared to all other coastal areas of Zanzibar, as well as of mainland Tanzania.

Tourism

By 2010, tourism contributed about 22% of GDP and about 80% in government revenue but quite little of the income was channelled to community level. The sector is challenged by inadequate infrastructure, banking and financial services, and there are social and economic challenges facing the Stone Town, the world re-known attraction of the islands of Zanzibar, because of improper maintenance of the archaeological buildings and degeneration of cultures.

Despite being the largest contributor to the economy, the tourism sector in Zanzibar has not generated as much employment as expected. In 2002 it was estimated that tourism employed about 20,000 direct jobs and about 40,000 to 60,000 indirect jobs in Zanzibar (UNEP *et al*, 2000). According to MKUZA II there is a feeling among the local communities that it is people from outside Zanzibar that are benefiting most from the employment opportunities generated in the tourism industry. The HBS report (2009) established that local employment is further limited by the weak linkage that it has with the rest of the economy, thus limiting potential multiplier effects in terms of employment and income creation.

Limited development of locally-owned small and medium sized enterprises (SMEs) that would have catered for the production of quality services and goods by local people has also been affected by the inadequate training in tourism management and related services of the local people; hence there have been quite limited employment opportunities for Zanzibaris. To some extent, the food sector, such as the open food 'restaurant' at Forodhani and the few restaurants provide services and employment to local people, but still to a limited extent because of the high set-up costs for these businesses. The tourism retail industry is dominated by foreign imports. Although many of the high-end shops are foreign owned, they generate a high level of local employment. Retail SMEs provide a low entry point for people from a poor background, although with the exception of Zanzibari woodcrafts, the dominance of Maasai stock reflects the local ownership of such business. Informally, youngsters in Zanzibar work as Tour guides, or in tourism support services – e.g. as street vendors for curios and other artefacts. Overall, the tourism sector has a great potential for local employment especially if skills are developed for

the production of quality goods to service the tourist industry (Steck et al, 2010:11). The contribution of the sector to poverty reduction remains to be clearly established.

The ICAM-Zanzibar report (UNEP/FAO/PAP, 2000) states that tourist-related services, which are quite extensive, pose a threat to the marine environment though pollution. Most of the hotels use, or plan to use soak pits for sewage disposal. Because of the porous limestone soils, sewage can seep into the groundwater and from there into the sea. Areas that are most at risk are Kiwengwa, Nungwi, Makunduchi and other areas along the East Coast, where sandy soils dominate the beach areas.

Mariculture

Mariculture in Zanzibar is dominated by seaweed farming but also includes Mabe-pearl farming, fish farming and crab culture.

Zanzibar began commercial seaweed farming in 1989 and this activity has now become a significant contributor to the economy of the island, in addition to tourism and clove production. It is the second most important foreign money earner and contributes about 90% of Zanzibar's marine exports (Msuya, 2013) and has had significant social and economic impacts, providing income to women, which are the primary cultivators, and enabled them to support their households. For Zanzibar alone, it is estimated that the industry employs about 25,000 people and renders benefits to about 150,000 in the islands. The increasing importance of seaweed farming is reflected in its dramatic growth, starting from barely 500 tonnes of dry seaweed per year in 1989 to 7,000 tonnes per year by 2000. Although being a reliable income earner for women, a study in 2010 established that it poses health complications to producers, some of them experiencing fatigue, musculoskeletal pain, hunger, respiratory problems, eye related problems, injuries from hazardous animals and sharp shells in the water and allergies (Frocklin, Sarah; M. de la Torre-Castro; L. Lindstrom; N. Jiddawi and F. Msuya , 2012). The level of income is also meagre because of the very low prices. The producers are locked in fixed price rates by agents and many women cannot venture into the production of higher value seaweed because the cultivation has to be done in deep water and is highly specialised.

In order to boost incomes, the Zanzibar Seaweed Cluster has supported local farmers to process seaweed and produce items including quality soaps (with or without fragrance), seaweed powder, massage oil, body creams, cakes, cookies, jam, pudding, and salads. Of these, soap, body creams and powder are marketed commercially. One kilogram of seaweed powder is sold at TSH 10,000.00 (USD 6.7). From such an initiative one of the local groups, the Kidoti women's group increased its net profits from value addition on seaweed from TSH 1.5 million in 2006 to TSH 2.7 million in 2009 (Msuya, 2013).

Pearl farming was introduced to Zanzibar in 2006 providing another small income generating opportunity particularly for women. From the piloting of half-pearl (mabe-pearl) farming by women's groups in four villages surrounding Menai Bay in 2006, pearl production has expanded to now involve 7 women groups. Low education and limited marketing skills have however kept incomes from pearl farming low, and has made the women dependent on sustained intervention for advertisement and marketing purposes.

Agriculture

Agriculture in Zanzibar occupies about 60% of the population, and is a dependable source of livelihood, but which is not flourishing well (MKUZA II). In 2012, the sector grew by 1.3% a drop from the 2.7% growth experienced in 2011. Crop cultivation is predominantly rain-fed and thus dependent on weather. Clove production, which flourishes better in Pemba Island than in Unguja has also dropped, mainly caused by un-favourable weather conditions. Clove procurement decreased by 53.1% cent to 1,755.4 tonnes mainly on account of the cyclical nature of the crop, unfavourable weather conditions and decreased world market prices during 2012.

The rubber output dropped mainly on account of ageing trees and the sluggish demand in the market.

A poorly developed agriculture coupled with unreliable weather is affecting agriculture's potential to be a reliable income earner or food security provider. Major challenges include low investments in agriculture, low agricultural output, low education among farmers, lack of off-farm income, poor infrastructure, unreliable marketing channels and low agricultural technology.

Salt production

Salt-production in Zanzibar is more established in Pemba Island than it is in Unguja and involves clearing of mangroves to give room for construction of salt evaporation pans. By 1992, more than 15 locations on the mangrove area had been cleared for this production in Pemba, and it is reported that Unguja Island has several such sites. Salt production has been stimulated as a poverty-reduction activity in Zanzibar. Concern has however been raised that growth of mangrove trees is constrained due to high concentration of salt near production sites, hence disturbing these ecosystems that form the basis for other livelihood activities.

Sand and stone collection

Stone and sand collection is a lucrative income earner, boosted by the growing construction sector. Uncontrolled stone collection and quarrying is however threatening the environment. An assessment of sand and stone collection around Fumba and Kiwengwa area indicates that it may result in the disturbance of the fragile and sparse pockets of top-soil causing thickets and agriculture degradation. Sand collection along the beaches has also been reported in various areas where there is tourist development sometimes resulting in beach erosion.

Other livelihood activities for the coastal communities do not pose serious threats to livelihood sustenance in the sense that they do not damage the environment on which people's livelihoods rely, but these are less lucrative and are usually done as side activities together with other activities such as food retailing, or collection of molluscs. These activities include, rope making, a traditional activity done mostly by women, which uses coconut husks, and the rope is used to make local beds, baskets and also used in the fishing vessels. The increasing influx of synthetic rope and material has overshadowed this activity.

Other resources supporting livelihoods

Land and land use patterns

The land tenure system in Zanzibar has varying implications with regard to land use and risk in relation to coastal livelihoods. This tenure is categorised under three groups – public lands, which are state-owned; privately-owned land which include a 3-acre land area distributed to individuals by the government for farming and lands under traditional tenure systems which are under the control of local elders. Public land which is found in all settlements in the form of beaches and landing sites, small islets, and public burial grounds is accessible for community use. In many areas however, people tend to occupy land, which they inherit from their parents and relatives for habitation and farming.

Varying land uses, e.g. for tourism development may pose threats to coastal livelihoods. For example, violation of the setback distance (30 meters away from the beach) to construct tourist joints has the potential of damaging the beach especially in areas prone to erosion. In places, like Nungwi, Jambiani and Paje, "on the beach" huts and walls are quite common. In addition to the loss of beaches, and property there is also a danger to nesting turtles as a consequence of coastal developments. Beaches at Matemwe and Mnemba, are important nesting sites for green turtles and Hawksbill turtles (Clark & Khatib, 1993; Khatib, 1998). These sites are within areas where

tourism development takes place. Destruction to tourism attractions in turn is a threat to local employment.

Mangroves and Coastal forests [thickets]

Mangrove forests constitute the main source of high-quality construction poles in Unguja, also providing villagers with fuel-wood and other wood products for many purposes, and thus represent a diverse source of local incomes. Mangrove forests are utilised in bee-keeping, traditional medicine harvesting, tannin and salt production and provide for significant non-conventional fishery (crabs, cockles and prawns). These activities are often conducted by women and are particularly common in mangroves around Chwaka, Menai and Makoba Bays. Crabs that are harvested from mangroves are in high demand by hoteliers and fetch relatively high prices. At certain locations, fishermen are reported to collect worms in the muddy substrates within mangroves that are used as bait in line and hook fishery.

The demand for mangrove poles has been on the increase especially in rural and suburban areas. Fuel wood and charcoal produced from mangroves comprise one of the most important sources of household fuel in Zanzibar, with a significant amount of the supply possibly coming from mainland Tanzania. In 1989, the annual per capita fuel consumption in Unguja was 1,075 kg of firewood, and 60 kg of charcoal (UNEP/FAO/PAP, (2000). The emergence of the hotel business has increased the demand for charcoal.

A large percentage of the fishing vessels are locally made outrigger and dug-out canoes constructed from locally available trees. These vessels are suitable for use on inshore fishing grounds, although not considered seaworthy during rough weather conditions or for off-shore fishing. The trees providing timber for vessel construction include "*mtondoo*", "*mkungu*" and "*mninga*" found in the coastal forests, and of late, are claimed to be scarce. Alternative vessels – *ng'wanda* (modern boats) are expensive and therefore not affordable to many fishers. The use of coastal forests to construct the fishing vessels is thus inevitable. High demands mean high prices of the products which create an incentive to engage in the activity. Mangrove wood is also harvested for lime burning, another income generating activity.

Coastal thickets are also harvested for construction poles, fuel-wood, lime making, and for charcoal making. Coastal thickets account for nearly 90% of the energy requirement of Zanzibar. Harvesting of coastal thickets is common for both Unguja and Pemba communities, having access to these products in the rich forests of Jozani (Unguja South), Muyuni (Unguja South) Kiwengwa (Unguja North), Tumbatu (Unguja North), Ngezi (Pemba). These areas are however increasingly threatened by encroachment for settlement and farming, hunting, and fuel wood collection.

The mangrove forests have also provided an opportunity for community-based tourism. Villagers around the mangroves of Pete in Menai Bay near the Jozani Forest Reserve have built a raised board walk inside the mangrove forest to allow tourists to see the complex communities of flora and fauna found in the ecosystem. The money collected from boardwalks is used for community development projects. This community initiative provides an incentive to conserve the resources and offers a platform for education for local people even living far away from mangrove forests.

Implications to Climate Change effects

Coastal livelihood pursuits, accompanied by socio-economic changes in terms of rapid population growth, urbanisation, and spatial population distribution and associated economic

growth including coastal land-use changes have both the potential to stimulate environmental changes and at the same time increase the vulnerability of the coastal communities to vagaries of extreme weather changes.

Summary of climate change impacts

Extracted from Chapters 15 and 16 (in this Volume), the summary of changes that can be expected in the future based on models - themselves with assumptions based on historic events with know very little known about feedbacks, additive, antagonistic and synergistic effects as well as thresholds above which the trends change – reveal the following:

- Temperatures are likely to increase in air and water, with average yearly temperatures at the end of the century likely to be 2 to 2.5°C higher than today. Scleractinian corals would be particularly vulnerable.
- Precipitation in future scenarios are not conclusive but could indicate longer mid-year dryer conditions and (shorter) but wetter wet seasons.
- Increasing problems related to incidences of extreme winds that will affect coastal areas with significant impacts on coastal infrastructure, agriculture biodiversity, and ground water.

The effects of these changes and the possible interacting factors and adaptation approaches to physical impacts include the following:

Natural system effect	Possible interacting factors	Possible adaptation approaches
Erosion of low-lying sand/mud beaches	Sediment supply Dam construction, construction in coastal areas	Nourishment, land-use planning, managed realignment
Wetland/mangrove loss	Sediment supply, Filling, construction in coastal zone	Nourishment, land-use planning, managed realignment, replantation of wetland vegetation
Inundation/flooding	Waves/storms, sediment supply	Dikes, surge barriers, closure of dams, dune management, building codes, set-back lines
Saltwater intrusion	Runoff/rainfall, catchment/water extraction management	Salt water intrusion barriers, change water extraction, freshwater injection
Coral reef loss	Destructive fishing methods, bleaching, sedimentation	Managed fishing, coral replantation, provision of hard substrates for natural coral recruitment

Vulnerability and mitigation

The vulnerability of the coastal communities of Zanzibar depends on physical exposure (determined mainly by geology and topography) and susceptibility, which is related to the types of coastal structures and their predisposition to being affected by the physical or socio-economic change (for example loss of fisheries production). Vulnerability leads to estimation of loss or damage, and thus to costs. Financing adaptation to the physical or socio-economic consequences of changes brought about by the above-listed natural system effects depends on the approach. Four management options are widely recognised: no action, or "do nothing", protection of shoreline from physical changes, accommodation of changes to shorelines through regulation and physical adaptation, and, a strategy of landward retreat away from the

risk. In practice, for a given length of coast a combination of these options is likely, proportionate to the values of the coastal assets at risk.

Economic costs of climate change

Coastal communities are aware of the hazards associated with erosion, as these have been witnessed for some time. Other impacts are less well known, such as the often less-visible impacts on productivity of marine habitats, sediment supply and salt-water intrusion. The latter is a distinct possibility for many coastal areas, especially following storm surges whose likelihood of increased frequency and scale may not be appreciated, especially along the creeks and inlets that are common in most districts, within resulting impacts extending inland several kilometres. Based on the inundation modelling presented in Volume II, the following summarises the impacts for the regions on the two islands:

Island regions	**Significant local impacts from sea level rise scenarios**
Pemba North Pemba South	For projected rise levels of 1 m an inundation of 4.4 % across the entire island of Pemba, increasing to 13.6 % with a 5 m sea level rise. These inundated areas are likely to be in the creeks and bays that are typical of the west coast of the island, in both regions. Significant impacts from sea level rise are felt over the general land area for rise levels of 10 m, equivalent to storm surges, inundating almost 34 % of the island. Significant impacts from sea level rise are felt over the general land area, even for rise levels of 1 m, particularly in the shallow embayments around Chake Chake and Mkoani.
Unguja North Unguja West & Urban Unguja South	For projected rise levels of 4 m an inundation of 5.3 % is calculated across the entire island of Unguja, increasing to almost 7 % with a 5 m sea level rise. These inundated areas are likely to be in the creeks and bays that are typical of the northwest coast of the region, around Mkokotoni. For rise levels of 10 m, equivalent to extreme storm surges, inundation of > 29 % of the island. Even for rise levels of 1 m, particularly in the shallow embayments inshore of Fumba Peninsula, Mbewni creek and sections of the Stone Town seafront and Chwaka Bay and around Uzi Island.

The overall picture for Pemba and Unguja is that most of the coastline will experience some flooding from rises in sea level, should this occur. For most regions, a rise of 4 - 5 m will have significant impacts on land flooding, with creeks and groundwater further vulnerable especially to storm surges and even lower rise scenarios. Fortunately, on Pemba, the large towns of Mkoani and Chake Chake are on higher ground. On Unguja, within the higher population density regions, Unguja West and Urban, such as west coast settlement like Mtoni, Bububu, Mbweni creek and Fumba, and east coast Chwaka Bay, significant impacts will directly affect coastal communities where there is significant infrastructure close to the shore, even with level rises of just 1 metre. This scenario is portrayed by the detailed study by Kebede et al (2010) for Dar es Salaam, from where they note that "it is predicted that on average about 400 m of landward retreat would occur due to erosion in Dar es Salaam under a 1 m sea-level rise. A total land loss estimated at 247 km^2 and 494 km^2 is expected for a 0.5 and 1 meter rise of sea level, which makes "infrastructure worth USD 48 and USD 82 million are vulnerable to a 0.5 m and 1 m sea-level rise, respectively" (2010:13). Infrastructural developments, including port expansion and development of tourist hotels along the shoreline with less considerations of the delicate nature of the ecosystem, expose these structures to risk of destruction in the event of extreme weather changes or shoreline erosion.

Though unlikely to be of the same scale of cost, the urban and dense village areas of Pemba and Unguja, are likely to be impacted by rises of less than 5 m. These are presently experiencing consequences of coastal erosion, a phenomenon that is likely to increase in intensity, if not from sea level rise *per se*, from increases in severe weather and storm surges. Calculating the costs associated with the losses to homes and businesses requires a considerable and detailed effort, beyond the scope of the present study. However, using the Kebede et al (2010) estimate as a measure, and extrapolating to other areas such as on Zanzibar, where populations and infrastructure are significantly smaller (less than half), a crude overall cost would range from between 24 million and USD 41 million. In addition to the loss of infrastructure such as roads,

housing and businesses, included in the latter figures, there are other costs to coastal communities associated with climate change. These include reduced fishing yields from corals reefs impacted by sea water temperature increase and from shrinking mangroves that are retreating into smaller inland spaces, and from reduced freshwater due to saline intrusion into coastal aquifers. Quantifying these costs can only roughly be approached, but they are likely to be of the order of tens of millions of dollars.

Adaptive capacity of communities

The adaptive capacity of the artisanal fisher, farmer and small-scale tourism business from the villages exposed to highest risk is generally low. For much of the poorer areas of the coastline, there are limited 'viable' livelihood alternatives, low human capital and a challenged governance system in most respects that may limit the people's adaptive capabilities in cases of extreme weather, as Kebede et al. (2010) describe. Worse still, the low productivity in the fisheries mainly due to habitat destruction and stock depletion, which may worsen from climate change impacts (described above) is encouraging the use of destructive methods which are attractive because of their quick returns. Low capacities for livelihood enhancement among the local communities also indicate that destructive resource extraction for a living may persist. Considerable awareness raising, education for alternative livelihood development and assistance will be required to prevent the situation from worsening.

Management interventions

Zanzibar Islands are well known for traditional systems and knowledge on marine resource management, but such practises have declined, which is a contributing factor to the degradation of the marine environment. Socio-economic changes and new values attached to resources, population pressures and inter-generational gaps are rendering most of the traditions obsolete and in many communities people do not attach the same sensitivity to resources as before. This in turn is affecting the livelihood sustainability.

Modern systems of community-based management have been established around most of the coastal communities. These operate in conjunction with other Management frameworks such as in the Marine Parks (eg: Mnemba Island Marine Conservation Area (MIMCA), Chumbe Marine Park, Chwaka Bay, Pemba, Tumbatu and others). Similar strategies are also applied for the mangroves as represented in the Hifadhi Misitu ya Asili (HIMA) – Conservation of Natural Forests project that was established in 2010. The project has adopted a pro-poor and gender sensitive approach to ensure the security of local property rights and equitable access for forest-dependent communities in return for their sustainable use and conservation of the forests (UNEP/FAO/PAP/CDA, 2000).

Issues emerging

The assessment of coastal livelihoods Zanzibar has considered the basic gender and socio-economic characteristics of the population resident along and/or dependent on the coastal and marine environment for a living. A consideration of the key livelihood assets, particularly education and skills, infrastructure [markets], and the institutional set up that support livelihoods, allow for diversification or alternatives. The natural resource endowment and the issues surrounding their use for a livelihood is also a key consideration. Finally, environmental and climate change implications are discussed in relation to livelihoods.

- Socio-economic diversity and the income gap[3] among coastal dwellers illustrates that livelihoods vary, and pockets of poverty are evident, between coastal communities or population categories in these communities and which have an implication on the use of coastal and marine resources. Poor households have few other options than direct dependence on coastal resources or the activities related to their exploitation – including fish processing, cleansing, and daily labour.
- Lack of skills, exposure and training to satisfy requirements of the hospitality industry limit access of local people to employment in the better remunerated tourism jobs, despite the growth of this sector.
- Limited development of locally owned SMEs that would have catered for quality services and goods, inadequate training in tourism management and related services of the local people.
- Unregulated development/expansion of tourism is leading to pollution and limiting traditional access to the coastal and marine resources and hence affecting livelihood pursuits.
- Decline in traditional knowledge on resource management due to socio-economic changes and new value systems, population pressures, and intergenerational gaps are rendering community management practices almost dormant.

[3] Research needs to be conducted to establish income and livelihood differences along the coastal area.

3 COASTAL FISHERY AND AQUACULTURE

Introduction

The fisheries sector is a very important contributor to the Zanzibar economy, at around 7% of GDP (RGZ, 2014), important for generating income and employment, the latter, mostly artisanal with a small semi-industrial component (VPO, 2012). The farming of fish, invertebrates and seaweed are also included in this thematic review. Cultivation and export of dry seaweed is a significant economic activity on Zanzibar.

Most fishing takes place near the islands within internal and territorial water. There are two principal focus areas in the finfish fishery of Zanzibar: the inshore demersal fishery and the pelagic fishery (both inshore and offshore). Due to the virtual absence of standing freshwater bodies on the main islands of Zanzibar, fishery of freshwater species is insignificant.

Management of the Fishery Sector

Institutionally, the Ministry of Agriculture, Natural Resources, Environment and Cooperatives (MANREC) oversees an agricultural sector policy, which includes fisheries, while a long-term plan has yet to be developed for the sector. The Department of Fisheries and Marine Products (DFMP), enforces the law, while the Marine Conservation Unit (MCU) manages the Marine Protected Areas (MPA). The Marine Resources Department is responsible for all non-fisheries marine resources, and the Vice President's Office (VPO) and the Department of Environment look after environmental impacts and ICZM. The Marine Control and Surveillance Unit (MCS) is the enforcement part of the Fisheries Department.

The Fishery Policy (1985) objective is to increase the supply of fish, create employment and conserve the marine resources, regulated by the Fisheries Act, 1988 and its Fisheries Regulations (1993). While sustainable management of the marine environment falls under the Environmental Management for Sustainable Management Act ("Environment Act"), 1996, conservation of key breeding and feeding sites is done through the Nature Conservation Areas Management Unit Act, 1999.

The Deep Sea Fishing Authority (DSFA) under the Deep Sea Fishing Authority Act (2007) regulates international fishing vessels using the 223,000 km^2 Exclusive Economic Zone (EEZ) a 40:60 fee sharing structure with the mainland.

Zanzibar has started community-based approaches in fisheries through Community Fishermen Committees (similar to Beach management Units, or BMUs, as seen on the mainland) in all fishing villages. Whereas the sea is publicly owned and every individual has a user right, marine environments adjacent to any village are traditionally under the use interest and monitoring of that village (World Bank, 2003).

Fisheries development programmes include MKUZA II (Zanzibar Strategy for Growth and Poverty Reduction), which recognises the importance of the marine resource and the Integrated Coastal Zone Management (ICZM) project looking into oyster farming (both meat and pearls), deep sea fishing and village conservation.

Seaweed farming on Zanzibar has been divided into zones around the two islands, with allocated areas to the various seaweed companies (RGV 2014). The result has kept prices down but enables growers to have guarantee purchase from companies, in exchange for support to farmers to set-up farms. Recently, some deregulation has allowed farmers to sell product on the open market, but with reduction in materials and extension services from companies and local declines in production (RGV 2014).

Description of the Fishery Resource and its Use

Fishery Types and Fishing Grounds

The main shallow demersal (bottom-living) fishing grounds for Zanzibar artisanal fishermen lie within the 10 meter contour, calculated at about 6,720 km^2 of which 4,000 km^2 (59.5%) are around Unguja and 2,720 km^2 (40.5%) are around Pemba (BoT, 2006). Some deeper waters are also fished, of which around 90 km^2 is living coral (VPO, 2012).

The principal small pelagic fishing grounds are fished by large semi-industrial scale purse seine netting vessels, involving light attraction at night (Muhando, C. and Rumisha, C.K., 2008). This activity is concentrated over sheltered, moderately deep waters, mostly on the western shores of Pemba and Unguja.

The large pelagic species (mainly inshore tuna), are fished within 5-10 km of the coast, are targeted by a local fleet of 9-12 m boats, with large meshed gill nets. Weather conditions are the major constraint to covering that distance, usually operating from Nungwi where 100-150 boats are based. The fishing usually only takes place on darker nights, for 12-15 days consecutive, followed by 5-8 days off.

MACEMP (2009) estimated of fishers that, 82.6 % use gillnets, 15.6% use drift net, 76.5% use hand line, 20.6% use trolling and 2.9% use long lining. Overall landings are dominated by reef fishes (35%), small pelagic (24%) such anchovies and sardines; and large pelagic (13%) including tuna, billfish and Spanish mackerel. The remaining 28% is contributed by shellfishes, invertebrates and other mid water fishes like sharks (Jiddawi, 1998).

The industrial fishery for tuna and other large pelagic species comprises purse seiners and long-liners that are licenced by the Deep Sea Fishing Authority to fish within the Tanzania EEZ. Currently there are around 70-80 vessel licenced. These vessels usually operate beyond the Territorial Sea (12 nm), mostly in the wider EEZ. There may also be 4-5 deep-water trawlers licenced to trawl at depths of 300-500 m.

Seaweed farming was first introduced in 1984 and commercial production started in 1990. Jambiani and Paje were two pilot villages in 1989 producing 261 t/yr. The species cultured are *Eucheuma cotonii* and *E. Spinosium* (citing De La Torre-Castro and Jiddawi 2005, Eklöf, J.F et al, 2005, Jiddawi and Ngazy, 2000), attached to lines anchored in shallow sandy lagoons. Leading districts are Central, South and North 'A' in Unguja and in Pemba main seaweed farming districts are Wete and Micheweni.

Fishing Effort and Yields

The Zanzibar Fisheries Frame Survey (2010) summarises the number of fishers, with just under 15,437 in 1985 and to 34,571 in 2010. Due to variations from year to year and seasons, the total number of full-time fishers on the islands of Zanzibar is likely to be between 28,000 and 37,000 individuals. Fish are landed at 33 and 123 official fish landing beaches on Pemba and Unguja, usually associated with the home villages of fishers. A number of temporary fishing camps exists that house *dago,* or migrant fishermen, seasonally moving up and down the Zanzibar and mainland coasts (notably from Kojani Island, off the NE Pemba).

The Frame Survey data further reveals that there are 8,639 vessels operating, with outrigger canoes and dug-out canoes together accounting for over 6,000 units. Dhows and planked boats are dominant in Unguja while in Pemba the outrigger canoes are more common. For 2010, only 15.6% of fishing vessels in Zanzibar were propelled by motor, the remainder using sails, poles and/or paddles.

Zanzibar's total annual fish yield varies depending on the year and the source. Muhando and Rumisha (2008) consider the total annual catch in Zanzibar was about 20,000 tonnes in the 1980s,

but in the recent years it has dropped. MACEMP (2009) cites 17,922 t in 2000 and 23,582 t in 2007; the 2010 Frame Survey reports on 25,396 for 2010.

Seaweed is now farmed in over 56 villages, employing 21,969 people in 2009 (2010 Frame Survey) and production has reached more than 9-10,000 t/year (MACEMP, 2009). It is sold as a food source, medicine and for the production of agar and carrageenan, to export markets in Asia, Europe and United States of America at a price in 2004 of 350-450 USD/t of dried *Eucheuma cottonii* and 180-220 USD/t for *E. spinosum*, but prices fluctuate, mostly going down (MACEMP, 2009).

Status of the Fishery

Various segments of the inshore fishery sector have recently been showing signs of over-exploitation (Muhando and Rumisha 2008). The estimated potential for Zanzibar is between 25,000 and 30,000 t/year (Mkenda and Folmer 2001, quoting FAO 1991), thus current landings of around 25,000t annually reflect a fully exploited resource. Considering the significant increasing in number of fishers over the years, the catch per unit effort (CPUE) has clearly declined. Mkenda and Folmer (2001) (quoting Lyimo et al. 1997) considers there is contradictory data, in particular, there has been a 127% increase in the number of motorised fishing vessels between 1985 and 1997 accompanied by CPUE data showing significant declines since 1983, suggesting over-fishing rather than a decline in fishing pressure, leading to the drop in catches. Explaining the decline and quoting Nasser (1994) and Muhando (1995), Mkenda and Folmer (2001) note that over-fishing could be a result of illegal fishing techniques, such as the use of small mesh sise nets to catch juvenile fish.

Mkenda and Folmer (2001) stress that the lack of information on the situation of fish biomass in Zanzibar remains a major management problem. Fish biomass surveys (and thus maximum sustainable yield (MSY) estimates), have not covered the inshore fishery, the mainstay of the artisanal sector. These values remain unknown. Earlier studies of the reef fishery has estimated yield to be 5t/km^2/year. Extrapolating for the coral reef, mangrove areas, continental shelf and continental slope, a total area of 4000 km^2, the potential yield could be estimated at 20,000 t/year, plus a further 5,000-10,000 t/year from the pelagic fish. Using CPUE data as "fishing days per month", Mkenda and Folmer (2001) were able to show that there was over-fishing, and obtain an estimate of the MSY for the fishery at 25,000t/year, and an average allowable effort of 30,000 fishing days/month. However, they point out, the actual effort, at twice the sustainable level, at 56,000 fishing days/month, suggests overfishing. MACEMP (2009) data gathered from fishers' perception is that the majority believe that sises of fish have decreased compared to the past, that fish population has decreased in number; that there were too many fishers and vessels; and that coral reef destruction is noticeable.

Major issues

The growing demand for fish has increased with population growth and the expansion of tourism, causing increases in fish prices, increased fishing pressure and increased use of gears that are destructive (i.e. beach seine, spears, and *juya la kigumi* - a dragged purse-seine net used around reefs). The latter is one of the more difficult to control because the net used is not illegal but the way it is used (involving smashing corals to force fish out) is destructive and illegal.

Damage to habitats cause loss of spawning and nursery grounds, loss of biodiversity and diminished habitat resilience. Reduction in fisheries productivity due to habitat destruction, can takes years, even centuries to recover. Haule, (2013) reports a loss in capital, notably reef habitat and fish stocks that would perpetuate production (estimated USD 33,900-306,800/km^2 of coral reef) where there is a low and high potential value of tourism and coastal protection), and loss in tourism "attractiveness of the coral reef for recreational angling, snorkelling and diving, and damage to Tanzania's conservation image as a biodiversity tourism destination. MACEMP

(2013) estimates reef recovery from severe storm damage to take 40-70 years (quoting Dollar and Tribble, 1993), and recovery is likely to extend to centuries**.** NEMC (2009) considers that any threats on seagrasses, seaweeds, coral reefs and the mangroves (from global warming or physical degradation) would greatly impinge on the fishery, adversely affecting the fisher community livelihoods.

Economic Importance of the Fishery

The fisheries sub-sector contributes about 4.5% to GDP (BoT, 2006), based on direct fish value generation as well as exports.

Finfish Fishery Revenue

In 2007 catch averaged 24,803 t/year valued at USD 36.8 million (DFMR, 2008) rising to a total of 29,411 t/year with a value of TSH 103 billion (USD 70 million) in 2012, split broadly 2:1 between Unguja and Pemba (RGZ, 2012). Unguja Island contributes an average of 57% of the fish catch compared to Pemba Island and the Urban and Mkoani districts have the highest number of households involved as fish producers (DFMR, 2008). Estimates on the offshore tuna fishery in the EEZ are vague and from few data sources.

Overall Fishery and Seaweed Exports

Exports of marine fishery products are valued at USD 598,203 from Zanzibar and include fish, sea cucumber, shells, lobster, crabs, squids, octopus, sardines and aquarium fish (DFMR, 2006). However, the local market for seafood's, especially from the tourism sector, creates a strong demand for fish and shellfish, with little surplus for export. As a result, Zanzibar exports on average only a few tonnes of fresh fish, which provides a small percentage of revenue (Table 9).

Seaweed accounts for 1% of total agricultural production, but 23% of cash crop production in 2007 (SMOLE, 2010, quoting OCGS, 2008) and is a significant source of foreign exchange earnings, averaging 13% of merchandise trade exports. Zanzibar exports on average 7,128 t/year, which is considerably more valuable than the total sum of all the other export products (Table 9).

Table 9: Export product and value ('000 TSH) for Zanzibar (2004-2007). Source: DFMR (2007).

Product	2004		2005		2006		2007	
	Tonnes	Value	Tonnes	Value	Tonnes	Value	Tonnes	Value
Seaweed	7,595.00	613,050.5	7,756.0	732,395.0	7,339.0	908,025.0	9,059.0	1,614,032.2
Sea cucumber	50.9	41,979.1	60.3	45,839.2	59.1	50,928.0	36.8	48,869.8
Octopus	12.6	13,957.5	38.6	32,475.0	87.3	95,349.6	50.4	48,103.7
Shell operculum	1.3	12,520.0	2.1	16,520.0	1.5	12,568.0	0.8	6,760.0
Shark fin	1.3	9,160.0	1.7	11,920.0	2.0	19,620.0	3.5	16,060.0
Fresh fish	0.003	18.9	8.4	4,800	2.6	2,803.5	0	0

Socio-economic Importance of Fisheries and Aquaculture

Finfish and Invertebrate Fisheries

According to MACEMP (2009), livelihood studies on Zanzibar showed that fishing is the most dominant livelihood source, with 28.7% occupation on average over all districts, followed by crop farming (24.2%) and seaweed farming (14.4%), while tourism and other activities jointly accounted for 32.6%. The fishing industry also supports a significant number of individuals

working in associated sectors such as boat building and repair, gear selling and repair, and marketing of fishery products, involving a total of 34,268 individuals were directly employed in fisheries related sectors (Jiddawi & Khatib, 2007; Jiddawi & Yahya, 2002). SMOLE (2010) reports that despite the tendency of a lower fish CPUE, fishermen have a higher than average income, USD 765/year compared to average incomes of USD 415/year (quoting Lange and Jiddawi, 2009).

The per capita consumption of fish was 25-30kg/person, suggesting its importance to food security and the contribution of fishery to the GDP varies between 2.2-10%, mostly from export of fishery products (citing Jiddawi and Ngoile 1999). More recent estimates consider fish are major sources of animal protein to most people in Zanzibar contributing to 98% of animal protein in the diet of the low-income population, with estimates of fish consumption in 2005 of around 17 kg/capita/year (DFMR, 2006).

Muhando and Rumisha (2008) consider that although edible molluscs and bivalves are not commercially important, they are a significant component in the dishes of many coastal households. Gleaned at low tide on the intertidal mud and sandy or rocky flats they are hand-picked mostly by women and children, processed at home or right on the beach where the flesh is removed from the shell, cooked and consumed or sold. They are harvested for food, for medicinal use and as a source of lime or crushed for chicken food.

Sea Weed Farming

Seaweed is now farmed in over 56 villages, employs 18,000 people and has become an alternative source of income for coastal communities, a supplement to fishing, livestock and agriculture activities especially for women who account for 88% of the seaweed growers. They are supported by six seaweed companies who supply farming input, techniques and purchase the dry product.

Incomes and production have however changed over time. In 1991, farmers produced an average of 1.5t annually, earning farmers nearly US$200 a year at 2007 prices. Production has dropped to an average of 0.5t per farmer in 2009, with only 6% of farmers earning $148 or more annually (SMOLE, 2010). The price has increased over time, but not enough to keep pace with inflation, despite the 2006 government increase in the minimum price. Growers, however, still continue to farm as they have no livelihood alternatives and despite DFMR efforts to encourage divergence from the on-foot, lagoon-based *E. spinosum* culture to the deep water growing of the more profitable *E. cottonii*. The main difficulty, especially among women, has been that most are not competent swimmers.

Mariculture

Other emerging mariculture activities described by MACEMP (2009) are finfish culture, culture of pearls, oysters and crab fattening (citing Jiddawi et al, 2007, Dubi et al, 2006). All are very small scale and some still in their experimental phases, hence employment and socio-economic significance remains low.

Threats to Coastal Communities Relying on Fisheries for their Livelihoods

The summarised specific threats to livelihoods related to fisheries and aquaculture, and the natural environment, are as follows:

- **Social conflicts over fishing gears** - where local fishers use gears or methods (some of which are illegal) that are not acceptable by neighbouring villages.
- **Social conflicts over access to resource –** where cultural and historical rivalry over "traditional" fishing grounds increases as pressure on the resource increases; also

includes increasing resentment of migratory fishing groups of "dago" fishers during seasonal visits, using gears considered destructive or conflict with local traditions.

- **Destructive and illegal fishing** - causing decline in productivity due to habitat destruction through beach seine, spear guns and dragnets, adversely affecting the fisher community livelihoods.
- **Lack of resource management –** leading to conflicts with tourists over coral reefs to dive and to snorkel, fish landing sites and tourist hotels; to seaweed farming conflict with boat users and tourists; allowing open access fishery, thus increasing fishing pressure and stock depletion is difficult to manage.
- **Poverty and lack of education –** combine with absence of alternatives or investment, are all attributed as the causes for the current behaviour of fishers.

Vulnerability to Climate, Climate Variability and Climate Change

Zanzibar's economy is very dependent on the climate and a large proportion of GDP, employment and livelihoods are associated with climate sensitive activities such as fishing, and farming. MACEMP (2009) and GCAP (2012) note that the climate of Zanzibar is changing, with recent decades seeing rising temperatures, increased rainfall variability, higher wind speeds and high-tide levels, and an increase in extreme events (climate variability), notably droughts and floods which have had major economic costs in terms of impacts on GDP. Livelihoods of Zanzibar are therefore sensitive to climate change. Based on assessments made by MACEMP (2009), SMOLE (2010) and GCAP (2012) the specific vulnerabilities can be summarised under the principal climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Run-off and river flows affecting salinity and siltation and thus fisheries productivity in estuarine, mangrove, seagrass and coral reef habitats and feeding and breeding grounds.
- Unseasonal precipitation affecting various activities e.g. sea-weed farming and drying (affect quality of the dried product).
- Changes in wind pattern may change fishing behaviour.

Extreme Weather Events

- Fishing effort reduced due to limited access to fishing grounds in small vessels, e.g. from increase in wind speeds (and ocean swells).
- Boats moorings and fisheries infrastructure (fish landing sites, coastal villages) affected by erosion.

Sea-Level Rise

- Retreating mangroves with no space to occupy because of land-based activities and/or infrastructure.
- Sea level rise will increase beach erosion, threatening coastal infrastructure and nearshore marine habitats (from smothering from suspended particles in the water column, as well as from reduced light penetration).

Seawater Temperature Rise

- Alteration of marine biodiversity, possibly resulting in extinctions and/or species migration, potentially affecting coastal fisheries.
- Warmer waters can favour plankton transition and enhance fish growth rates.

- Coral bleaching is temperature related and in turn affects fisheries.
- Farmed sea-weed die-off along the coast has been attributed to sea surface temperature as the most likely cause, leading to movement of sea weed farming to deeper water (where possible).

Seawater Acidification

- Increasing acidity as CO2 is absorbed by water to become carbonic acid, resultant drop in pH, is expected to have major effects on shell-forming organisms (notable corals and molluscs) but will also enhance primary production. Combined with bleaching impacts on corals, coral reefs (physically important in coastal surge protection, nurturing fisheries and protecting shoreline fisheries infrastructure) are vulnerable to degradation.

CRIAM Ranking of Threats to Local Communities associated with Fisheries

Table 10: Prioritisation of threats to local communities and ecosystems associated with fisheries. The assessment uses the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_Fish_03	Destructive and illegal fishing - causing decline in productivity due to habitat destruction through beach seine, spear guns and dragnets, adversely affecting the fisher community livelihoods.	Fisheries	3	3	3	2	3	72	5					
Z_Fish_02	Social conflicts over access to resource – where cultural and historical rivalry over "traditional" fishing grounds increases as pressure on the resource increases; also includes increasing resentment of migratory fishing groups of "dago" fishers during seasonal visits, using gears considered destructive or conflict with local traditions.	Fisheries	3	3	3	2	2	63	4					
Z_Fish_04	Weaknesses in management leading to conflicts with tourists over coral reefs to dive and to snorkel, fish landing sites and tourist hotels; to seaweed farming conflict with boat users and tourists; allowing open access fishery, thus increasing fishing pressure and stock depletion is difficult to manage.	Fisheries	3	3	3	2	2	63	4					
Z_Fish_05	Limited alternatives or investments are causes for the current behaviour of fishers.	Fisheries	3	3	3	2	2	63	4					
Z_Fish_06	Absence of weather forecasting resulting in losses of drying seaweed.	Fisheries	3	3	2	2	1	45	4					
Z_Fish_07	Inadequate understanding of fisheries resources biology in support of management	Fisheries	3	2	3	2	1	36	4					
Z_Fish_08	Weak dissemination of aquaculture techniques	Fisheries	3	2	3	2	1	36	4					
Z_Fish_01	Social conflicts over fishing gears - where local fishers use gears or methods (some of which are illegal) that are not acceptable by neighbouring villages.	Fisheries	1	3	3	2	2	21	3					

Outlook for Fisheries

The pragmatic outlook on the fisheries sector on Zanzibar is that there is little room for expansion and the current pressure is damaging the productivity. Catches are unlikely to increase with more fishing effort. Some potential increase may be gained from deeper water operations, improvements in efficiency and/or value-added in the small pelagic fishery and from coastal aquaculture. The current policy of "open access" (confirmed by World Bank, 2003) raises concern that, together with the findings that there is over-fishing (Mkenda and Folmer, 2001), the current policy goal is not feasible and regulation is needed so that the catch realised is the MSY.

4 TOURISM

Introduction

The attraction of Zanzibar to international tourists is very high, being based on the fascinating history of the islands, their architecture, cultural identity, production of cloves and spices, and the natural environment - particular the coast and the sea. Four interest groups are broadly identified: wildlife tourism (focused on Jozani Forest Reserve and other conservation areas, and water birds); marine-based tourism (focused on marine parks, diving, snorkeling, deep sea fishing, etc); cultural tourism (historical, heritage and cultural sites); and beach tourism (beaches, hotels, restaurants, shops, handicrafts, etc). There is considerable overlap within these interest groups, but the bulk of present interest is the coastal beach experience.

For 2012, the number of international tourists arriving at Zanzibar (Unguja) airport was 124,062 and for Zanzibar Port 45,161, giving a total of 168,223 visitors for that year (MACEMP, 2012 b); (VPO, 2012). Over 70% of Zanzibar's economy is driven by the tourism sector, which includes the hotel trade plus a diverse array of associated activities, from SCUBA diving and kite surfing to cultural tours. The growth in tourism since the early 1990s has overtaken the traditional, subsistence based livelihood activities such as agriculture and the contribution of the tourism to GDP rose to 20% in 2005, worth USD 117 million. MACEMP (2009) estimated that tourism is worth over 35% of GDP, and that it represents 78-80% of all foreign investment (SMOLE, 2010).

The tourism sector employs about 35,000 - 45,000 people in direct and indirect employment and estimates suggest it is likely that tourism will surpass agriculture as Zanzibar's leading revenue earner by the year 2015. Some 200,000 people on Zanzibar benefit from the tourism sector.

Management of the Sector

Of direct importance as guiding instruments is the Tourism Policy (2004) which governs the sector, assisted by the Investment Policy (2002). The Land Tribunal Act (1994) sets regulations and standards for the hotel industry, and in particular the Stone Town Act (that still needs to be aligned to tourism and its status as a World Heritage Site). The Ancient Monuments Preservation Decree (1927) amended in 1971 and 2002 protects and conserves historical sites and monuments as tourist related sites.

The government institutions managing the tourism industry include Zanzibar Commission for Tourism (ZCT), regulated by the Department of Environment (DoE-MANRE). The Department of Archives, Museums and Antiquities looks after preservation of historical sites including those of tourism interests. The Zanzibar National Chamber of Commerce caters for business growth and Ministry of Tourism Trade and Investment markets Zanzibar as a tourism destination and Zanzibar Investment Promotion Authority (ZIPA) promotes and facilitates investment and trade in Zanzibar.

Zanzibar Institute of Tourism (MARUHUBI) offers training in the sector. Stone Town Conservation and Development Authority (STCDA) looks after its conservation as a World Heritage Site and major tourist attraction. The Marine Conservation Unit (MCU) manages marine conservation areas (MCA and MPA), under the Fisheries Department.

Stakeholder institutions managing the tourism industry, include over 130 registered tour operators organised as Zanzibar Association of Tour Operators (ZATO) for the purpose of marketing Zanzibar by promoting the highest standards and supported by the Zanzibar Association of Tourism Investors (ZATI) which is a membership based association of hotels and tourism investors.

The sector is guided by several plans of which Zanzibar Vision 2020 embraces tourism to eradicate poverty, and includes it in the Zanzibar Poverty Reduction Plan (ZPRP). Tourism is elaborated in the Tourism Development Plan (1983) and Tourism Master Plan of 2003 that looks to coastal zone management and finding ways to address the increasing pressure on marine resources elaborated in the Tourism Zoning Plan (1993) for better control of land allocation and development in tourist areas through improved security of land tenure and Land Use Plans (LUP).

Description of Tourism and Resource Use

The islands of Zanzibar present a complex interconnection of a variety of ecosystems that are attractive to tourists, both terrestrial and aquatic, in addition to the historic main town and rural landscapes with exotic agriculture. Of the estimated 168,223 international tourists visiting Zanzibar, about 40% come to Zanzibar as an extension from a wildlife safari on the mainland, while the remaining 60% choose Zanzibar as a single destination, indicating the growing importance of the coastal or beach experience. About 50% of visitors are part of packages as mass tourism. The overall origins of tourists, ranked by numbers of visitors is Italy, UK, South Africa, Germany, France, Australia, Scandinavia, other European, USA/Canada and Kenya.

From 1998 to 2005, many hotel establishments were constructed and the number of beds increased more than tripled (ZCT, 2010). In 2002, there were 173 hotels catering for 3,089 rooms and 6,159 beds. The numbers increased to 1,229 hotel units with more than 10,522 beds by 2010 (ZCT 2010). These figures have continued to rise in recent years. Most contain modern tourist facilities such as swimming pools and conference rooms and are located adjacent to sandy beaches. Some of these tourism centres have stimulated the development of support infrastructure, such as the improvement of the ports of Zanzibar and the operation of high quality sea and air transport services between Dar es Salaam and Zanzibar.

Attractions in Zanzibar can be categorised into cultural features (including various annual festivals) and centres, historical places, museums, beaches, nature conservation areas (three terrestrial and six MPAs), parks and recreation facilities (MACEMP, 2009). There are 44 historical sites and monuments listed which date from the 9th to the 20th Century, with 21 on Unguja and 23 in Pemba (Muhando, C. and Rumisha, C.K., 2008). Tourists in Zanzibar were found to spend around 40% of their vacation time diving and snorkelling (World Bank, 2003).

The sensitivity of the tourism industry on Zanzibar to global financial markets is reflected by the fact that the historical growth in visitors dropped significantly during the 2008 global economic crisis and is only now returning to the pre-crisis levels (MACEMP, 2012 b). Similarly, visitors to Pemba island dropped to 2,981 visitors in 2002, after 9/11 (2001) and is now returning to 7,830 in 2005.

Issues

Increasing environmental and social challenges from tourism activities create a great concern for the integrity of the coastal zone ecosystems as such activities exert pressure on water resources, nature, landscape, air quality, coastal areas, and natural and landscape values that are fragile assets. Moreover, tourism activities also impinge on the cultural values of the local community if the business is not operated in a manner that is compatible with the culture of the local community.

The rapid increase in tourism is causing high pressure on the natural resources and on tourist attractions imposes a high demand for building materials. The ability of the island to handle the large numbers of hotel development and the increasing international tourist arrivals is in question.

Local villagers have complained that the types of jobs offered by hotels and other tourism related businesses are mainly menial jobs, with little or no chance of promotion within the industry, and that hotels have shown a preference of outsiders the argument being for sufficient skills.

Economic importance

Tourism on Zanzibar brings in foreign exchange earnings, contributes to the National and local GDP and offers means to diversifying the economy. The sector creates employment and promotes infrastructure projects which also serve other sectors of the economy.

Between 77-80% of foreign direct investment went to the tourism ventures, 15% to industries and only 1% to agriculture (SMOLE, 2010). The average growth of the tourism sector on Zanzibar is 10% per annum, directly or indirectly responsible for 80% of Zanzibar's economy. Overall, tourism contributes 47% of GDP, most of which goes to Government in the form of various fees and taxes, estimated at USD 250 million per year by the Zanzibar Association for Tourist Investors (ZATI, 2011). Consequently, the Government is very supportive of the sector, permitting a substantial increase in the number of hotels and tourism activities each year. The Zanzibar Investment Promotion Authority (ZIPA) indicates that by March 2008 there were 618 small and medium scale tourism projects, 291 accommodation units, 11,044 beds and 5,623 rooms, 60% to international standards. There were also 193 tour operators, 49 sea sport companies, 40 restaurants and 45 souvenir shops. Unguja has far more tourist facilities than Pemba, mainly concentrated in the East Coast, North Region and Stone Town.

SMOLE (2010) notes, although tourism is now the most important economic sector in Zanzibar it is only around 20% of the earnings that benefits the local population (e.g. 80% of all vegetables within the tourist sector are imported). The greatest benefits to local communities are generated by budget tourism (63% of income) and, to a lesser degree, mid-range tourism (25% of income). Small-scale, up-market tourism also generates significant benefits for Zanzibar, while the 'Club' tourism and large-scale up-market tourism generate the fewest benefits, as packages are paid off-shore.

Socio-economic Importance of Tourism

Of the five main economic livelihood activities within the ten districts of Unguja and Pemba (agriculture, fishing, livestock, seaweed farming and tourism), tourism accounts for an average of 10.8% nationwide, but more significantly, 40.2% in Zanzibar Urban and 15.3% in Unguja Central ((MACEMP, 2009)).

Tourism on Zanzibar is currently regarded as one among the major job creators. Commission for Tourism (2008) figures for tourism-related employment assess that there are 10,000 direct jobs and about 30,000 to 45,000 indirect jobs. Of these, livelihoods include tour guiding (43.4%), sale of agricultural products (11.2%), handicraft production/sale (15.9%) and hotel employment (29.5%). In general, males are dominant in most activities as tour guides and in retail, except in West district where females are leading in their participation in tourism activities. Hotel work and hand crafting are dominated by women.

Threats to Coastal Communities Relying on Tourism for Livelihoods

The largest threat to the tourism industry of Zanzibar is any failure of tourists to visit the islands. This may come about for a myriad of reasons, including better options elsewhere, cost of international flights, or reduction in the quality of the experience. The latter can arise due to many reasons. The principal threats to the quality of the local experience, to those engaged in the tourism sector and to the wider environment are described below:

- **Worsening personal security** due to increased crime and violence[4].
- **Deterioration of conservation areas** due to failure of management to address encroachment and resource over-utilisation, especially forests.
- **Increase in water-borne disease** such as malaria, dengue fever, typhoid and dysentery.
- **Deterioration of marine environment** from destructive fishing practices[5].
- **Destruction of cultural buildings and historical sites for instance the House of Wonders is currently falling apart**
- **Inadequate sewage infrastructure and waste management** causing pollution of the coastal zone, further exacerbated by the illegal dumping of waste and litter from some developments[6].
- **Reduced freshwater supply** now estimated to meet only 51% of the demand (from a rising population and expanding industries and tourism[7].
- **Increased beach erosion** from anarchistic tourism development constructed too close to or below the high water mark, due to inadequate management and enforcement tools[8].
- **Increased beach erosion** from unchecked sand mining for hotel construction or for road construction in Zanzibar[9].
- **Loss of employment opportunities** by locals to more qualified and better trained staff from mainland Tanzania and Kenya.

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[4] MACEMP (2009) reports an increase in crime of 79.6%, more dominant in South district (24.4%).

[5] Failure in marine resource management to cope with the increased pressure on marine resources arising from the demand for seafood from the tourism sector. This has weakened traditional restrictions on fishing of certain species (especially octopus, squids and shellfish), during the breeding seasons.

[6] There is no formal sewage disposal system in Zanzibar and as a consequence, many hotels allow their effluent to soak away into the sea.

[7] Open inland waters are often being polluted by waste and litter, and the continuing construction of settlements on watersheds. Water resources in the coral rag areas along the East Coast of Unguja are scarce and increased use could lead to saline intrusion. Importantly, water demand is highest in the dry season months which are the longest peak season of visitors, when rainfall is lowest.

[8] For example Kiwengwa and from hotels at Uroa and Chwaka (all on Unguja Island). Beach erosion is also exacerbated by structures that modify the hydrodynamics, like sea walls and jetties (e.g. Mtoni jetty has led to intensive erosion at Maruhubi Restaurant to the south during the NE monsoon; Jambiani sea wall on the east coast of Unguja (in 1977) has protected the beach from erosion, but erosion has continued or shifted to the north, and at the Mkoani Port Jetty in Pemba there are also signs of erosion taking place).

[9] e.g. Unguja Ukuu where sand extraction has led to a dramatic loss of beach sand, a similar situation is expected at Chuini.

- **Conflicts between local communities and tourism developers** over natural resources[10].
- **Conflicts between local communities and outsiders** seeking employment opportunities[11].
- **Increased cost of living due to tourism industry** where prices of fish and other foodstuff have gone up, to the detriment of the local consumers who risk loss of valuable protein inputs to their diets.
- **Erosion of local traditions and culture** due to influences from tourists and non-Zanzibaris in the industry[12].

[10] e.g. coral reefs for pleasure versus fishing, beaches for recreation versus seaweed farming and hotel resorts.

[11] 43.9% of employment goes to mainland Tanzanians rather than locals.

[12] e.g. from language, dress code, manners and habits; loss of village elder authority to preside over disputes; increases in prostitution, robbery and alcohol abuse; goods and services offered freely in the past (e.g. land, thatch (roofing materials) and assistance to the elderly or during times of hardship, are eroded by the 'money economy' of wage employment.

CRIAM Ranking of Threats to Local Communities associated with Tourism

Table 11: Prioritisation of threats to local communities and ecosystems associated with tourism. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_Tour_05	Inadequate sewage infrastructure and waste management causing pollution of the coastal zone, further exacerbated by the illegal dumping of waste and litter from some developments.	Tourism	3	3	3	2	3	72	5					
Z_Tour_06	Reduced freshwater supply now estimated to meet only 51% of the demand (from a rising population and expanding industries and tourism.	Tourism	3	3	3	2	3	72	5					
Z_Tour_04	Deterioration of marine environment from destructive fishing practices.	Tourism	3	3	3	2	2	63	4					
Z_Tour_02	Deterioration of conservation areas due to failure of management to address encroachment and resource over-utilisation, especially forests.	Tourism	3	3	2	2	2	54	4					
Z_Tour_08	Increased beach erosion from unchecked sand mining for hotel construction or for road construction in Zanzibar.	Tourism	3	3	2	2	2	54	4					
Z_Tour_01	Worsening personal security due to increased crime and violence.	Tourism	3	3	2	2	1	45	4					
Z_Tour_10	Conflicts between local communities and tourism developers over natural resources.	Tourism	3	2	2	2	2	36	4					
Z_Tour_09	Loss of employment opportunities by locals to more qualified and better trained staff from mainland Tanzania and Kenya.	Tourism	3	2	2	2	1	30	3					
Z_Tour_07	Increased beach erosion from anarchistic tourism development constructed too close to or below the high water mark, due to inadequate management and enforcement tools.	Tourism	1	3	3	2	2	21	3					
Z_Tour_03	Increase in water-borne disease such as malaria, dengue fever, typhoid and dysentery.	Tourism	1	1	2	2	1	5	1					

Vulnerability of Tourism to Climate, Climate Variability & Climate Change

There are many potential threats from climate change on a number of sectors that are linked to tourism, including fisheries, health, infrastructure, water resources and ecosystem services. VPO (2012) considers that tourism has been largely unaffected by climate variability and extremes, because tourist numbers are low in the rainy season, and the sector is generally protected in food production and water availability. Based on assessments made by VPO (2012), GCAP (2012) and SMOLE (2010) the specific vulnerabilities can be summarised under the principal climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Less frequent but more intense precipitation will cause more surface runoff and erosion and less recharge of ground water.
- Longer dry periods between rains can lead to deficiency of soil water affecting plant growth and lowering the water table.
- Decline in agricultural production due to changes in weather, would create problems for hotel supply chains.
- More frequent flooding especially in urban areas can increase frequency of food and water borne diseases.
- Unpredictable climate that alter biodiversity negatively affecting the tourism experience[13].

Extreme Weather Events

- Inundation of coastal areas affecting hotel foreshores and hotel landscapes.
- Recreational tourism, notably diving, snorkelling and deep sea fishing activities, adversely affected by rougher sea conditions.

Sea-Level Rise

- Degradation of coral reefs which are crucial for coastal protection and tourism, leading to increased erosion.
- Saltwater intrusion in wells near the coast due to rising sea level and over abstraction.
- Threats to tourism hotels and infrastructure from coastal erosion, flooding and storm surges and sea level rise, and in the longer-term, to key tourist areas such as Stone Town[14].

Seawater and Air Temperature Rise

- Rising sea temperatures and ocean acidification (below), will impact on marine ecosystems, particularly coral bleaching[15].

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[13] Species may struggle to adapt to changing conditions (Lovett et al., 2005) resulting in extinctions, while invasive species, with high fertility and dispersal capabilities are more adaptive to variable climatic conditions (Malcolm et al., 2002).

[14] Zanzibar is particularly vulnerable to coastal inundation and other coastal impacts because it has an extensive coast line and large areas of low lying land.

[15] This will adversely affect marine recreational activities (snorkelling and diving). IPCC (2007) reports that the coral bleaching event in 1998 led to reduced tourist revenue for Mombasa and Zanzibar of USD 12 to 18 million

- Warming temperatures negatively affecting some fisheries, reducing fish supplies to hotels.

Seawater Acidification

- Influencing coral reef development and structures, leading to greatest exposure of beach hotels to wave surges.

Outlook

The Government of Zanzibar tourism policy aims at sustainable, environmentally and culturally friendly tourism, which benefits hoteliers, villagers and the nation as a whole. The public expectation was and still is that tourism will bring many socio-economic gains to improve the standard of living of the local population, mindful that as the industry has expanded, there has been a wide range of negative effects. Climate impacts aside, if the present state of affairs is left unattended, harmony and prosperity of the local population in the future will be highly uncertain (VPO, 2012). This calls for a tourism policy reform, adoption of more eco-friendly tourism practices, with incentives for environmental conscious investors, ICZM zoning and enforcement of related sector laws, and inclusion of climate change adaptation and mitigation.

Other Matters Specific to Tourism Sector or of Particular Importance

As a strategy for the development of the tourism sector came up with a number of interventions from policy development, market strategy, management and skills development, however, throughout, no mention nor analysis of climate change is incorporated into the actions proposed.

5 AGRICULTURE

Introduction

Agriculture is one of the key economic sectors of Zanzibar, contributing around 30% of GDP with crops contributing just over 20% and livestock just under 5% ((VPO, 2012), citing Office of the Chief Government Statistician, RGZ, 2013). Agriculture dominates exports (at 95% by value) with cloves and seaweed making up 66-75% of the foreign exchange value. Agriculture is the main source of employment for 80% of the population who derive their livelihood directly or indirectly from the sector. There is also a high proportion of mixed (agriculture and livestock) farming, with approximately 160,000 cattle on the islands, 50,000 goats and over a million chickens, and VPO (2012) notes that the livestock sub-sector is expanding rapidly. However, the sector is very climate-sensitive, mostly dependent on rain-fed agriculture making production vulnerable to adverse rainfall patterns such as drought or intermittent dry spells during the rainy season.

Zanzibar is not self-sufficient on agricultural production, and relies on food imports, particularly rice and wheat, but also beans, pulses, maise flour, sugar, fruits and vegetables. While most of the staples required for food security, such as rice, wheat flour and sugar are imported from East Asia and Europe, maise, flour and pulses come mainly from the mainland.

Management of the Agriculture Sector

The main institution responsible for management of agriculture in Zanzibar is the Ministry Of Agriculture Livestock and Environment (MALE). The sector is environmentally regulated by Department of Environment (DoE) and guided by Department of Commercial Crops, Fruits and Forestry (DCCFF). Department of Lands and Registration facilitates proper land use, including agriculture while Zanzibar Water Authority manages water used in irrigation and Ministry of State, Prime Minister's Office for Regional Administration and Special Department (Zanzibar), is responsible for agriculture development at Local Government Authority (LGA) level.

The main policy instruments regulating agriculture development in Zanzibar include the National Environmental Policy for Zanzibar, which is the overall legislative framework for sustainable development, including agriculture and managed by the Environmental Management for Sustainable Development Act No. 2: Enacted in 1996, and encompasses sustainable agriculture. New policy initiatives in agriculture and land use are underway through Sustainable Management of Land and Environment (SMOLE) supported by National Land Use Plan (1995) and Zanzibar Irrigation Master Plan (RGZ, 2002).

Other stakeholders include MVIWATA (Mtandaowa Vikundivya Wakulimawa Tanzania) a farmers' network. SMOLE (2010) notes that around 30% of farmers, which includes a high proportion of women have formed producer groups for collective marketing and credit.

Description of the Agriculture Sector

Agro-ecological Zones

Only 9.4% (25,034 ha) are classified as agriculture land in Zanzibar (MACEMP, 2009). Over 32% (85,084 ha) are in some form of agro-forestry, the rest is forest, mangrove, plantation and coral rag forest of wooded vegetation. The distribution of farming activities and population centres of Pemba and Unguja is therefore mainly determined by geography (VPO, 2012): 74% of Pemba is cultivated land because it contains only 30% coral rag area, while in Unguja only 42% is cultivated because some 60% is unsuitable coral rag. The islands (particularly Pemba) are dominated by mixed agricultural use. Despite their small size, SMOLE (2010) considers that there

are a wide range of agro-ecological zones on both islands and very different soil types, described as follows:

- **Unguja Agro-ecological Zones:** Broadly, the island can be split into four soil types, reflecting the non-calcareous soils on the west of the island, the free draining fertile soils in the central zone of the island (the source of much of the islands agricultural produce), the clay soils in the plains (rice cultivation) and the coral rag soils, which cover approximately 60% of the land area of the island and are only suitable for forestry and shifting cultivation.
- **Pemba Agro-ecological Zones:** The island soils can be grouped into upland soils (from sandy to impermeable soils) and lowland soils (sandy, clay and coral rag soils). There are important coconut and rice production areas and a large zone covering the central part of the island where clove and multi-cropping systems dominate. Pemba is a major producer of cloves and consequently, Zanzibar as a whole is often known as the "Spice Islands".

Crop Production

The main crops grown in Zanzibar are cassava and rice (by production and value), though banana and sweet potatoes are also important, with small amounts of yams, legumes (cowpeas, green gram and pigeon peas), fruits and vegetables (VPO, 2012). Cereals such as maize, millet and sorghum are also grown although not widely and coconuts are a cash crop. Cassava is the primary staple, virtually grown by almost every rural household. Cloves are the major cash crop, while rice production is encouraged under agricultural reforms, instituted in 1964. Seaweed farming as a cash crop is described under the Fisheries theme (page 18).

NBS (2008/9) noted permanent crops occupied an area of 78,494 ha (MACEMP 2009 suggest even higher), which seem double the 32,120 ha recorded in 2002/03 but in terms of proportion of crop land, it has remained the same at 42%. The largest area (47,991 ha, 61%) was grown to other crops (e.g. cloves) followed by banana (14,011 ha; 18%), and coconut (8,058 ha; 10%).

The three leading districts both in terms of percent of area planted and average planted area per household with permanent crops were Mkoani (14%, 0.69 ha) and Wete (14.4%, 0.78 ha) on Pemba and Central (14%, 0.91 ha) on Unguja. Mkoani (3,312 ha, 21%), Chakechake (2,342 ha, 15%), and Central (2,186 ha, 14%) were the three districts with the highest percent of the total area planted with banana as well as average planted area per household planted with the crop. Central district recorded the highest percent (19%) of the total area planted with coconuts followed by North B (17%) and West and Wete districts (16% each). Wete and Mkoani district respectively accounted for 26% and 22% of the total area planted with cloves. Central district accounted for almost over a third (37%) of the area planted with mangoes. About 50% of the area planted with oranges was recorded in Central district. Central district accounted for 51 % of the total area planted with sugar cane followed by Micheweni (18%). With respect to fertilisers, 48.6% of the communities used compost manure, 38.3% used farm yard manure whereas 13.1% of the household use industrial fertiliser (MACEMP, 2009).

Livestock Production

The livestock sector is not well developed due to several constraints including a shortage of grazing areas and the sector employs very few people. Animal production is somehow traditional in Zanzibar, and characterised by low production and low quality return resulting from poor local breeds.

A total of 45,684 households were raising livestock on Zanzibar in 2009 (NBS 2008/9). The main types and number of livestock and poultry are listed in the 2007/08 Agricultural Sample Census

where the number of cattle was 155,624. The average number of livestock per household was 13 for cattle, 9 for goats and 9 for sheep, while for chicken the average was 11 chicks.

MACEMP (2009) quoting MALE (2006), that there is an increasing number of households that keep poultry under intensive system. The number of farmers who keep dairy cattle and improved beef is also increasing, but no data could be found.

Irrigation

SMOLE (2010) notes that supplementary irrigation, mostly for vegetables, is either pumped and piped from aquifers through government-provided infrastructure, often via elevated storage tanks, or extracted from wells (manually or mechanically). The infrastructure is poorly developed and localised: availability of water tends to decrease with increasing distance from main pipes (lower pressure with increased distance from hydrostatic head and smaller volume through smaller diameter pipes).

The Zanzibar Irrigation Master Plan (RGZ, 2002) has identified 8521 ha of land in 39 low-lying areas of Unguja and Pemba (of which 18 are in Unguja) as suitable for irrigated cultivation of rice and vegetables. Development agencies from Japan and Korea have committed funding for implementation of the plan in Kibokwa and Bumbwisudi. Proposals are underway to improve the irrigation infrastructure around 8 villages in North B District and drip irrigation pilot schemes are in progress.

SMOLE (2010) notes that as yet, no attempt has been made by government in Zanzibar to develop an Integrated Water Resources Management (IWRM) plan and an associated Decision Support System (DSS). There is a lack of inter-sector coordinated to water resources management within the government circles and there is a need for a systematic approach to IWRM.

Issues

The deep soils on the western parts of Unguja and Pemba have a good structure and the area has precipitation level more than double the potential evapotranspiration. This area in terms of food crops, trees and cash crops could meet 100% of Zanzibar's requirements, with a surplus to export, but needs an injection of technical assistance to capture and utilise rain water. Estimates suggest that current rain water utilisation is only at 1% of the available water. An investment of USD 6.5 million in rainwater harvesting over eight years would create an annual water storage per capita of 1,624 m^3, allowing more commercialised agriculture and forestry, and advocate for additional water management strategies.

A lower yearly export value of 30 Billion TSH (mostly spices and seaweed), was offset by an import expenditure of 130 Billion TSH, of which 80% of all vegetables and 20% of all fruits, are imported (SMOLE, 2010).Zanzibar has abundant areas with good, deep soils and plenty of rain which technically could give very good agricultural yields and high development potential of cropland. However, this needs attention to improve current low agricultural production of < 1t/ha/year a result of intra-seasonal dry spells and drought, exacerbated by climate change and variable weather risk (SMOLE, 2010).

Economic Importance of Agriculture and Livestock

Economic Value of Agriculture

With a population above 1.1 million and a GDP of USD 415/capita in 2007, 50% of Zanzibar population fell below the basic needs poverty line and 13% below the food poverty line (i.e. could not meet minimum daily food requirements) (SMOLE, 2010). More recently, VPO (2012) lists GDP per capita of USD 638. Contribution to GDP is listed as agriculture (20%), livestock (4-5%),

forestry (<0.5%), fisheries (5-7%). The current (2012) export value is 63 Billion TSH, was dominated by permanent crop products (94%) (i.e. cloves, seaweeds, copra, clove stem).

Zanzibar is known as the "home of spices" that are exported internationally, including cloves – the predominant economic spices for many years, as well as cinnamon, cardamom, nutmeg, black pepper and chillies. For a long time production and export of cloves, has been the mainstay of the economy, however, the recent collapse of the price of cloves in the world market has had a profound impact, and as a consequence the government has adopted a policy of diversifying the economy by promoting other sectors, including fishery and tourism (Mkenda and Folmer 2001).

Economic Value of Livestock

The main types of livestock and poultry covered in the 2007/08 Agricultural Sample Census (NBS, website) are cattle, goats, sheep, pigs, chicken, ducks, turkeys, rabbits, and donkeys. There was an equivalent of 170,715 livestock units representing a total of 228,538 major livestock of different species, of which goat livestock units were about 13,794, sheep 114.8 and pigs 1,005 units. Chicken were kept by 60% of the households, while cattle were kept by 30% of the agricultural households.

Socio-economic Importance of Agriculture Sector

Though traditionally coastal communities have several income generating sources and diversified livelihood strategies based on agriculture, animal husbandry, seaweed farming and fishing, agriculture in Zanzibar is an extremely important economic activity and the main source of food, employing about 24.2% of the coastal population (MACEMP, 2009). Agriculture still remains subsistence in Zanzibar, but is considered more secure than fishing.

Generally small scale, the common farming practice is mixed cropping in the coral rag areas, which varies by district. An estimated 14.1% of households in the coastal district North A are involved in agriculture, 13.3% in West, and Mkoani and Micheweni districts 12.4% each. Most households (81.4%) are involved in annual crop cultivation (MACEMP 2009).

Cash crop farming is mostly small scale, of crops such as cloves, citrus fruits, coconuts, mangoes, and vegetables, important for 41.8% of households, whereas 58.2% of the households grow for their own consumptions. Land ownership ranges between one to five acres, but the area of land under cultivation is gently decreasing as are the yields (MACEMP 2009).

Threats to Coastal Communities Relying on Agriculture for its Livelihood

The following list summarises specific threats to livelihoods related to agriculture and livestock keeping, and the natural environment, after MACEMP (2009) and SMOLE (2010):

- **Social conflicts over land due to poor land management**[16]
- **Loss of public land** to agriculture.
- **Reduced land for agriculture on Unguja** due to intense competition (Coles et al. 2007).
- **Invasion of water catchment areas**[17]

[16] Land allocated to agriculture and/or livestock grazing and tourism restrict access to shoreline.

[17] Farmers' invasion into springs, small seasonal streams, ponds and wetlands, leads to drying up and contamination of ground and surface waters, with periodic outbreak of water borne diseases.

- **Inadequate agricultural product supply** leading to tourism operators seeking suppliers elsewhere.[18]
- **Unpredictable demand by tourism operators** due to uncertain occupancy rates mean hotels cannot guarantee long-term orders.
- **Local prices of agriculture produce uncompetitive**[19].
- **Poor freshwater resources management** leading to scarcity and irregular supply.
- **Poor farming practice amongst others** due to shortage of land[20].
- **Dependence on rain-fed agriculture and insufficient water for irrigation**[21]
- **Lack of business/financial management training** of producers and suppliers, limits the success of timely distribution.
- **Salt water intrusion**[22]
- **Insufficient climate information forecasting and early warning systems**[23]

[18] Unreliable/seasonal supply and quality turn tourism operators towards importation of produce.

[19] More expensive than equivalents imported in bulk from mainland Tanzania, Kenya or elsewhere.

[20] The coral rag bush fallow system has been progressively reduced to 1-2 years instead of the customary 10-15. Shortage in availability, timing, price, variety and quality of essential seed varieties and chemicals hinders optimal production, thus limiting output and returns. Poor agricultural and soil management techniques have resulted in loss of topsoil, erosion, structural deterioration and declining fertility.

[21] Commonly cited by Unguja's fruit and vegetable farmers as their biggest constraint.

[22] Seen in many of the coastal areas with good soils for agriculture (especially on Pemba, e.g. at Tumbe, Jiondeni, Mkoani and Makoongwe Island and Kisiwapanza), which are frequently flooded by seawater during spring tides and 150 such sites have been identified. The actual cause is complex including over-abstraction for domestic and agriculture irrigation, sea level rise, damage to coral reef and mangroves reducing the dampening effect on sea surges during storms or increased incidence of storms (SMOLE 2010; CARE 2011).

[23] There is a need to strengthening climate information and agro-meteorological services and seasonal forecasting, and strengthened early warning systems (including communication) and enhanced disaster risk management (VPO 2012).

CRIAM Ranking of Threats to Local Communities associated with Agriculture

Table 12: Prioritisation of threats to local communities and ecosystems associated with agriculture. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_Agr_02	Loss of public land (coral rag) to agriculture.	Agriculture	3	3	3	3	2	72	5					
Z_Agr_03	Reduced land for agriculture on Unguja due to intense competition (Coles et al. 2007).	Agriculture	3	3	3	3	2	72	5					
Z_Agr_01	Social conflicts over land use	Agriculture	3	3	3	2	2	63	4					
Z_Agr_04	Invasion of water sources	Agriculture	3	3	3	2	2	63	4					
Z_Agr_07	High production cost	Agriculture	3	3	3	2	2	63	4					
Z_Agr_12	Salt water inundation	Agriculture	3	3	3	2	2	63	4					
Z_Agr_14	Social conflicts over land due to poor land management	Agriculture	3	3	3	2	1	54	4					
Z_Agr_10	Insufficient water for irrigation	Agriculture	3	2	2	2	2	36	4					
Z_Agr_11	Limited business/financial management skills among producers and suppliers, limits the success of agribusiness.	Agriculture	3	2	3	2	1	36	4					
Z_Agr_13	Insufficient climate information forecasting and early warning systems	Agriculture	3	2	3	2	1	36	4					
Z_Agr_05	Inadequate agricultural product supply leading to tourism operators seeking suppliers elsewhere.	Agriculture	2	2	2	2	2	24	3					
Z_Agr_09	Poor farming practice	Agriculture	2	2	2	2	2	24	3					
Z_Agr_08	Freshwater scarcity and irregular supply	Agriculture	2	2	2	2	1	20	3					
Z_Agr_06	Unpredictable demand by tourism operators due to uncertain occupancy rates mean hotels cannot guarantee long-term orders.	Agriculture	2	1	2	2	2	12	2					

Vulnerability of Agriculture to Climate, Climate Variability & Climate Change

The Zanzibar economy is very dependent on the climate and a large proportion of GDP, employment and livelihoods are associated with climate sensitive activities such as fishing, and agriculture. VPO (2012) and GCAP (2012) note that agriculture in Zanzibar is climate vulnerable as the bulk is dependent on rain-fed production systems. VPO (2012) notes that the potential impacts of climate change on agriculture involve a range of complex factors, which will affect crops and farming systems differently, including potential positive as well as negative impacts.

Based on assessments made by MACEMP (2009), SMOLE (2010) and GCAP (2012) the specific vulnerabilities can be summarised under the principal climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Unseasonal precipitation affecting various farming activities, potentially shift agro-zones[24].
- Invasive species and weeds with high fertility and dispersal capabilities have been shown to be highly adaptive to variable climatic conditions will invade farms.
- More intense rain allowing more aggressive surface runoff and water loss to the sea reduces ground water recharge[25].
- New or more severe crop diseases may result from changing environmental condition like increasing temperature (CARE 2011)

Extreme Weather Events

- Damaging crops, through strong winds, or inundation of coastal farmlands[26].

Sea-Level Rise

- Flooding of farmland with seawater due to rising seawater and stronger wave action.
- Warm sea surface temperatures, more extreme weather events, and sea-level rise may lead to the destruction of coral reefs and mangroves, which are crucial for coastal protection of coastal farms.

Seawater and Air Temperature Rise

- Higher temperature stress will increase livestock disease and affect pasture and milk production.

Seawater Acidification

- No impact.

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[24] The sensitivity was evident during the poor and erratic rains in 2006/7, which significantly reduced agricultural production, affecting GDP, and led to a large-scale hunger crisis in 2008, affecting over 20% or the population (300,000 people), particularly in Pemba. It also led to deaths of many livestock (see MALE, 2006). Farmers cannot be sure when to prepare, plant, sow and harvest.

[25] The widespread decline in the ground water level, up to 1 m in Jozani Forest, is often attributed to a decrease in precipitation and less recharge of ground water coupled with more intense extraction of water for a growing population, more intense irrigation of fields and establishment of new hotels, and partly due to climate change (SMOLE 2010).

[26] Tree crops (cloves, an import export crop), or coconuts are vulnerable to increased storm and high winds.

Outlook

Agriculture is key priority for adaptation in the ZAPA, which calls for awareness raising, institutional strengthening (particularly for extension services and research), and early (no regret) benefits from better information, with short-term and seasonal forecasting, and early agro-meteorological warning systems (e.g. for heavy rain and flood risks, and droughts).

In a survey, VPO (2012) noted there was a strong preference for rainwater harvesting, agroforestry and crop switching, as well as sustainable agriculture and soil and water conservation, complemented with capacity building and agricultural research. SMOLE (2010) considers that there is a large potential for growth, especially based on the agricultural sector, and advocates for the ZAPA.

6 FORESTRY

Introduction

Forests resources on Zanzibar can be categorised as true forests, limited to the protected reserves of Jozani in Unguja Island, and Ngezi and Msitu Mkuu in Pemba Island (SMOLE, 2010), all with high and often unique bio-diversity; coastal forest and thickets on general land, mostly on the coral rag areas and used mostly for timber, charcoal or agriculture; and mangrove forest that are protected under law, but used for amongst others timber, poles, and charcoal. The true forests, like their associated isolated patches on mainland hilltops, are remnants of the once extensive ancient forests of East Africa.

Zanzibar's forests and woodlands cover an estimated 60% of the total land coverage and provide key elements to the livelihoods of over 80% of Zanzibar's population. Direct benefits include firewood and charcoal, building materials and dyes, while indirectly the forests of Zanzibar serve as an attraction for tourism and in fisheries ecosystem services. Remnants of true forests in Zanzibar are all found on the coral rag zone or on areas left behind during the establishment of coconut and clove plantations, while mangroves forests mainly on the western shores on the two main islands, occupy 18,000 ha and contribute in diverse ways to local livelihoods.

Management of the Sector

The main institution responsible for forest management is the Department of Forestry and Non-renewable Resources, responsible for mangrove and coastal forest management, with the Department of Commercial Crops, Fruits and Forestry (DCCFF), focused on conservation and protection of forest resources and reserves and fruit plantations. All mangrove forests are gazetted as forest reserves where conservation and management are guided by the Environmental Policy. The Department of Energy and Minerals manages sustainable energy, firewood and charcoal production and the Department of Environment in the office of First Vice President (VPO) is concerned with environment and climate change, led by a Climate Change Steering Committee.

Policy and legislation governing forests include such instruments as Zanzibar National Forest Policy (1995), Zanzibar Environmental Policy (1996), Zanzibar Agricultural Policy (2000) and Zanzibar Forest Resources Management and Conservation Act No. 10 (1996). All promote the protection, conservation and development of forest resources.

The principal institutional program to manage forests is the Zanzibar National Forest Plan, while the Reducing Emissions from Deforestation and Degradation (REDD) strategy is at a pilot stage in reforestation and with energy saving stoves. The National Land Use Plan (1995) has adopted an ICZM framework which extends landward one kilometre from the high water mark (MACEMP, 2009).

Description of the Forest Resource and its Use

True Forests

Zanzibar has about 15,000 ha of reserved forest, of which MACEMP (2009) note, three, Jozani, Ngezi and Masingini are strictly for biodiversity conservation (see Natural Resources, page 101) while the rest (Unguja Ukuu, Chaani, Kibele, and Dunga) are for exploitation and conservation.

Coastal Thickets

About 37% of Zanzibar is coastal forest and thicket, mostly on the less fertile coral rag area, with an additional 7.4% of mixed wooden forest (MACEMP, 2009, quoting Liskinen et al 1997). The

semi-deciduous to evergreen thicket areas, that occupy about land area, mainly in the eastern part of Zanzibar, are major sources of wood products.

The current poor state of the coral rag bush is the outcome of a degraded fallow system where the fallow period has been progressively reduced in some cases to the extremely short term of only 1-2 years instead of the customary 10-15 years. Shortage of farm land is to blame. Coral rag thicket and forests are heavily exploited for poles, fuel and non-wood products and bush meat. Of 98,329 ha of coral rag forest (MACEMP 2009, quoting Leskinen et al 1993 and 1997) about 530 hectares (0.5%) are cleared or destroyed annually.

Mangrove Forests

Mangrove ecosystems cover more than 18,000 ha in Zanzibar mostly in estuaries and protected bays such as in the Makoba and Chwaka, and are found along the entire coast (Muhando, C. and Rumisha, C.K., 2008) of Pemba and Zanzibar, covering an area of 12,146 ha and 6,073 ha, respectively.

Zanzibar's mangrove forests comprise up to ten tree species, and provide permanent or temporary habitats for many aquatic organisms which move in and out as the tide rises and falls, including feeding and nursery grounds for many economically valuable marine species (Muhando and Rumisha, 2008). These are extremely productive ecosystems, generating about 600 t/year/km^2 plant mass (Muhando, C. and Rumisha, C.K., 2008) from detritus and recycling of nutrients and trapping land-based debris, sediments, and suspended particulate matter carried to the coast by rivers. Mangroves grow between the estuary and the surrounding land, and provide a number of important ecosystem services.

Mangrove forests have multiple uses, from sources of fodder and honey, poles and charcoal to fish, crustacea and mollusks, as well as serving as buffers to storm surges, tsunamis, and floods, thus reducing erosion and beach degradation. All forests on Zanzibar, with the exception of the protected areas, are under pressure from overexploitation, mostly due to over-cutting for timber and for charcoal production. Mangroves in some instances are cleared for salt works.

Issues

Recent estimates for overall forest loss on Unguja Island are of 0.8–1.2%/year, in addition to issues of degradation of the remaining stands (Kukkonen, 2013). The destruction of forests on Zanzibar is a result of limited income generation activities, demographic changes and high demand of wood-based products. Clearing is usually for agriculture and/or settlements or development programmes. Only half of Zanzibar's estimated 16,000 ha of mangrove forest was considered undamaged and, in Pemba, increasing development of salt farms is threatening mangrove stands (SMOLE 2010, quoting Zanzibar's State of the Environment Report 2005).

A number of areas are protected through conservation, legislation or otherwise through local, national or international agreements. Additional protection zones are set out in the Community Forest Management Agreements. In northern Unguja Island, MACEMP (2009) reports that communities of Makoba, Bumbwini and Muwanda have shown high level of awareness on tree conservation. Several areas have been set aside for general forest conservation and exploitation around Unguja Ukuu, Kibele, Dunga, and Chaani. Community restoration programs have increased mangrove cover of Kisakasaka, Pete, Gawani, Mkoani, Muungoni, Kisiwa Panza, Makoongwe and many other areas in Zanzibar (MACEMP 2009 quoting Shunula, 2002, Kitwana 2004).

Economic importance

Though forests (including mangroves) and their products and services make a clear and significant contribution to livelihoods on Zanzibar, their contribution to the GDP is poorly

presented (MACEMP, 2009). Similarly, the intangible non-monetary values (e.g. environmental amelioration, water conservation, contribution to rainmaking, wind breaking, and protection of land against erosion, shelter to both human and wild animals) remain un-documented.

Fuel wood remains the most important use of wood and accounts for the bulk of Zanzibar's energy use. Zanzibar's annual wood demand is about 2.5 million m^3 (67% of which is for wood fuel), but the annual allowable and sustainable cut from the Zanzibar forests is estimated at only 0.7 m^3/person, and there is therefore a major biomass supply deficit, which is growing with population growth (VPO 2012). The deficit is filled by overharvesting or importing wood, including wood fuel and charcoal from the mainland.

Mangrove forests have substantial commercial value primarily in terms of timber as well as other non-wood products such as firewood, charcoal, building and construction materials, dyes and as a recreational and fishing area (Muhando and Rumisha, 2008).

Socio-economic Importance of Forests

Zanzibar's forests provide the major source of biomass for energy on the islands, as well as timber for building, wood for fuel, fruit crops, and medicinal plants, materials for handicrafts, honey, and employment and it is estimated that 80% of the population obtain at least some of their livelihoods from forests (VPO, 2012, citing Draft Forest Policy, 2012). MACEMP (2009) quote the household budget survey of 2004/05, reporting that at national level 75% of the households in Zanzibar use firewood as the major fuel for cooking, in the rural areas the number is 93%. Charcoal use is only used by 8% of households, and electricity or gas is rarely used.

Threats to Coastal Communities Relying on Forests for Livelihoods

The following list summarises specific threats to livelihoods related to coastal and mangrove forests, and the natural environment, after MACEMP (2009):

- **Forest degradation** due to over-exploitation or poor harvest methods (e.g. slash and burn).
- **Inadequate enforcement of forest management regulations** resulting in illegal clearing and over-harvesting of mangrove forests and coastal forests[27].
- **Pests and grazing damage**[28].
- **Erosion** of mangrove stands.
- **Conflict between villages** over illegal mangrove cutting[29].
- **Ineffective land use planning** resulting in encroachment of expanding agriculture and settlements into forests or clearance for salt works (on Pemba) or tourism.
- **Land tenure uncertainty** discourages long-term investment in village land and protection of sensitive areas as water catchment areas and forests.
- **Declining ground water**

[27] Reasons amongst others include harvesting for charcoal and domestic firewood, conversion to agricultural land, and for salt works (Pemba).

[28] 10% of surveyed areas reported problem of pests and disease affecting mangroves, e.g. including larvae during dry season, borers and flies, and impacts from goats, or termites feeding on young mangroves.

[29] e.g. between Fuoni Kibondeni, Kisakasaka, Kibele, Ukongoroni and Bwejuu.

CRIAM Ranking of Threats to Local Communities associated with Forestry

Table 13: Prioritisation of threats to local communities and ecosystems associated with forestry. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_Forest_01	Forest degradation due to over-exploitation or poor harvest methods (e.g. slash and burn).	Forestry	3	3	3	2	3	72	5					
Z_Forest_02	Inadequate enforcement of forest management regulations resulting in illegal clearing and over-harvesting of mangrove forests and coastal forests	Forestry	3	3	3	2	2	63	4					
Z_Forest_06	Ineffective land use management resulting in encroachment of expanding agriculture and settlements into forests or clearance for salt works, aquaculture (on Pemba) or tourism.	Forestry	3	3	3	2	2	63	4					
Z_Forest_09	Fire	Forestry	3	3	3	2	2	63	4					
Z_Forest_08	Declining ground water quality.	Forestry	2	3	3	2	3	48	4					
Z_Forest_05	Conflict over illegal mangrove cutting.	Forestry	3	2	3	2	2	42	4					
Z_Forest_03	Pests and grazing damage	Forestry	1	1	2	2	2	6	1					
Z_Forest_04	Erosion of mangrove stands.	Forestry	1	1	2	2	2	6	1					

Vulnerability of Forests to Climate, Climate Variability & Climate Change

As GCAP (2012), and others note, forests are potentially very vulnerable to climate change with potential impacts involving a range of complex factors. Tree growth may be enhanced by some processes related to climate change (including CO_2 fertilisation and longer growing seasons), while certain losses and impacts, may be irreversible. Any negative impacts on forests will have wider deleterious effects on forest reliant biodiversity and human communities, as well as on wider ecosystem services that forests provide (e.g. soil protection, flood prevention, natural resources, water catchment). Particularly vulnerable areas in Zanzibar include the drier coral rag (from water scarcity and heat stress). Specific vulnerabilities identified by SMOLE (2011) and others can be summarised under the principal climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Unseasonal precipitation affecting various forest and related activities, potentially with changes in plant species composition and shifting forest zones, though trees are not very resilient to change.
- Invasive species and weeds with high fertility and dispersal capabilities have been shown to be highly adaptive to variable climatic conditions and may therefore invade forests.
- More intense rain leading to more aggressive surface runoff and increased soil erosion.
- New or more severe forest diseases may result from changing environmental condition like increasing temperature.
- The risk of forest fires will increase as a consequence of the increase in temperatures and decline in precipitation and resultant desiccation of forests.

Extreme Weather Events

- Damaging forests, through strong winds, or inundation of coastal forests or flooding of mangroves.

Sea-Level Rise

- Salt water intrusion (also influenced by changes in precipitation) in low-lying forest areas near the coast due to rising sea level or over abstraction for irrigation.
- Wind burn from salt spray onto coastal forests.

Seawater and Air Temperature Rise

- Accelerated reduction in soil fertility and structure due to warmer temperatures affecting composting rates in forest soils.
- Forests are prone to extreme events such as drought.

Seawater Acidification

- No impact.

Outlook

Regardless of climate change, the deforestation rate of Zanzibar's forest estimated to be 0.8–1.2%/year is likely to increase as demand for forest products grow in the absence of alternatives, particularly fuel for cooking. Meanwhile, the ability of the management institutions to contain or reduce the degradation is questionable, despite the large number of initiatives, NGOs and donors that support forest conservation programs. With 80% of Zanzibar's population using fuel

wood for cooking there is a need to address fuel alternatives as the area with greatest potential for reducing forest degradation.

Other Matters Specific to Forest Sector or of Particular Importance

The REDD Strategy 2012, addresses the current use of forest resources, proposing strategies to halt forest deforestation and degradation, so as to raise significant carbon financing through the 'Reducing Emissions from Deforestation and forest Degradation (REDD+) scheme.

7 INDUSTRY AND MANUFACTORING

Introduction

Industry and manufacturing on Zanzibar contribute a very small amount to GDP, partly because there is very little activity and secondly because most production is done so in the informal sector, by small-scale producers. Processed clove oil and other natural oils as well as honey are well known products from Pemba, while production of woodcarvings, tourist souvenirs and the like are mainly undertaken on Unguja. Textiles were a major industry on the isles until recently.

Management of the Industry Sector

The Zanzibar National Chamber of Commerce, Industry and Agriculture (ZNCCIA) is the major representative authority of the business community in Zanzibar, while the Ministry of Trade, Industry and Marketing oversees the sector.

Alongside the initiatives to boost industrialization, the Revolutionary Government of Zanzibar has introduced a list of related policy instruments in the last two decades. The key policies with relevance in particular for industrial development are:

- The Zanzibar Industrial Policy (1998)
- The Zanzibar Vision 2020 (2000)
- The Zanzibar Investment Policy (2005)
- The Zanzibar Trade Policy (2006)
- The Zanzibar SME Policy (2006)
- The Zanzibar Export Development Strategy (2009)
- The Zanzibar Strategy for Growth and Reduction of Poverty 'MKUZA II' (2010).

Despite these policies, and while structural change in Tanzania mainland has shown some positive signs in the last decade, Zanzibar has not yet managed to initiate a shift towards industry-led development.

Description of Industry and Manufacturing

On Zanzibar, the industry sector is characterized by small businesses and the manufacturing sector in Zanzibar is dominated by Small and Medium Enterprises (SMEs). The current leading manufacturing activities are furniture, soft drinks, mineral water, articles of concrete cement and plaster, bakery products, clothing, printing, other fabricated metal products, cordage, rope, twine and netting, reproduction of recorded materials, etc, with most of them basically Micro, Small and Medium Enterprises (MSMEs).

In general, unreliable supply from key utilities such as electricity and water, and the high costs related to these have restricted (or reduced) further investments in the manufacturing sector (Office of Chief Government Statistician, Zanzibar, 2005). According to the Zanzibar National Chamber of Commerce (2013), the manufacturing sector in Zanzibar has been plunged into the doldrums. The sector's contribution to GDP was 18% in 1995, 14% in 2005 and now it is 4.5%. Lack of raw materials forced the closure of major manufacturing industries like sugar, shoes, soap and detergents, cigarettes and dairy products.

Since the above industries, constituting mainly of manufacturing (and construction) sectors, are small-scale operators whose businesses are actually mostly not registered in any professional board, their contributions to GDP are not recorded.

Issues

Zanzibar's level of industrialization deteriorated by an average minus 5% per annum from USD 15 per capita in 2002, due to a decline in value addition in the face of a significant increase in population. While the deterioration of Zanzibar's industrial competitiveness is the result of several serious constraints, the transition from a centralized to a liberalized economy, the hesitancy of local entrepreneurs towards risk taking associated with manufacturing and the weak outreach of local manufacturing companies to global markets are key factors (UNIDO 2103).

The development of the manufacturing sector requires interventions to promote investments in productive capacity, empowering private sector specifically SMEs, access to credit and reasonable cost of utilities. Currently Zanzibar's manufacturing faces major challenges in gaining access to financial resources to invest in new, higher quality productive capacity (RGZ, 2010).

In a nutshell, the first stage of structural change has not yet been reached in Zanzibar. Agriculture and services (tourism) are still the key economic activities, while manufacturing does not yet play a significant role in economic growth and employment generation. Given the large role of exports of raw spices, increased value addition in that sector could present a starting point for diversification (UNIDO 2013).

Economic Importance

Contribution of construction sector to GDP over the period 2007–2012, from 7.8% to 5.0%. The decline is probably due to the relative increase of other sectors, namely tourism. Manufacturing was stable at around 4% (Zanzibar Chamber of Commerce, 2013).

The isles' manufactured export volume declined from USD 133,000 to USD 113,000 between 2002 and 2009. This represents one of the lowest per capita levels of less than USD 1, when discounted by the population size of roughly 1.2 million inhabitants (UNIDO 2103).

Socio-Economic Importance

The importance of the manufacturing sector in terms of employment creation and development of linkages with the rest of economy is recognized. One area of strategic importance is agro-processing. Between the two main islands, the number of those employed in the manufacturing, industry and construction sub-sector is like to range from a 5,000 to 10,000.

Threats to coastal communities relying on Industry sub-sectors for livelihoods

The principle threats to those dependent on industry and to the wider coastal environment are described below:

- **Inadequate infrastructure management** unable to maintain supply of services (electricity, transport, water supply), resulting in a disincentive for industry to be attracted to Zanzibar and develop.
- **Lack of coordination** of the choice of location of new industries underlines the need for integrated planning.
- **Failure to monitor industry liquid waste** leading to pollution of waterways and ground water.
- **Failure to monitor industry solid waste** leading to pollution of waterways and open ground.
- **Failure to monitor industry air emission** leading to air pollution.

CRIAM Ranking of Threats to Local Communities associated with Industry and Manufacturing

Table 14: Prioritisation of threats to local communities and ecosystems associated with industry and manufacturing. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_Industry_01	Inadequate infrastructure management unable to maintain supply of services (electricity, transport, water supply), resulting in a disincentive for industry to be attracted to Zanzibar and develop.	Industry	3	2	3	2	1	36	4					
Z_Industry_02	Lack of coordination of the choice of location of new industries underlines the need for integrated planning.	Industry	3	2	3	2	1	36	4					
Z_Industry_03	Failure to monitor industry liquid waste leading to pollution of waterways and ground water.	Industry	3	3	3	2	2	63	4					
Z_Industry_04	Failure to monitor industry solid waste leading to pollution of waterways and open ground.	Industry	3	3	3	2	2	63	4					
Z_Industry_05	Failure to monitor industry air emission leading to air pollution.	Industry	3	3	3	2	2	63	4					
Z_Industry_06	Lack of raw materials leading to less adequate investment potentials	Industry	3	2	3	2	1	36	4					
Z_Industry_07	Inadequate prioritisation in the industrial sector	Industry	3	2	2	2	1	30	3					

Vulnerability to Climate, Climate Variability and Climate Change

A number of specific vulnerabilities of industry and those that engage in it are summarised under the principle climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Increased rainfall volumes water leading to faster deterioration of roads.
- Greater standing water increases contamination risk for drink water supplies leading to increased diseases such as cholera etc. affecting work force at industries.
- Flood damage to transport, communication and electricity supply infrastructure.

Extreme Weather Events

- Damage to power infrastructure from fallen trees, or from direct impacts of weather affecting industry power supply.
- Damage to ICT infrastructure from direct impacts of weather, affecting industry.

Sea-Level Rise

- Coastal inundation on in low-lying coastal areas affecting roads and affecting supply chain of products to factories and exports.
- Possible elevated salinization of coastal aquifers affecting safe water supplies to industries.

Seawater and Air Temperature Rise

- Drought increases vulnerability of crops that provide the supplies to drinks and food processing factories.
- Increased damage to roads affecting supply chain of products to factories and exports.
- Greater cooling costs for generators and other industry machinery.

Seawater Acidification

- No impact.

Outlook

Given the serious current challenges, Zanzibar will need to actively promote its manufacturing sector over a substantial period to tap into the potentials that do exist.

8 PORTS AND HARBOURS

Introduction

Zanzibar and Pemba Islands are served by five ports (Malindi and Zanzibar ports, plus minor ports located in Mkokotoni (Unguja), Mkoani and Wete on Pemba Island (UNEP/FAO/PAP, (2000) Given the island's strategic location, the port at Malindi (known as the Zanzibar Port) is one of the principal ports in East Africa and handles around 90% of Zanzibar's trade (RGZ, 2004). The port also services passenger ferries commuting between Dar es Salaam, Pemba and at time Tanga, handling over 1,000 ferry passengers daily, including a large proportion of the tourism visits (see Tourism, page 39). From the ports to the consumers, road transportation infrastructure is responsible for delivery and movement on land. Harbours are thus integrally dependent on roads to move goods and people.

A recent refurbishment was completed in 2009 but still the need for a new port exists with plans for a container port at Maruhubi area (north of the existing port) which will facilitate Zanzibar's economic development and the growth of trade as well as the movement of cargo along Africa's east coast (RGZ, 2010).

Management of the Sector

The Zanzibar Port Corporation (ZPC) is a public entity, which has full autonomy for operation and development of ports in Zanzibar.

Description of Ports and Harbours and their Use

Constructed in 1925, Zanzibar port's infrastructure has been poorly maintained, with capacity to service only one ship of 13,000 tonnes dead weight tonnage (DWT) or two ships of 7,500 tonnes DWT at one time (UNEP/FAO/PAP, (2000). However in 2004, the Ministry of Finance signed an agreement with the European Union for 34 million Euros of funding to refurbish the port, including the lengthening of quays and reconstruction of wharfs. Under the new project, reconstruction of the West and North Wharves of the Malindi Port, with a total quay length of 382 m was completed in 2009. Malindi port currently handles between 140,000 and 160,000 tonnes of general cargo per year, including break bulk and about 25,000 tonnes of liquid cargo mainly petroleum products and edible oils, amounting to 90 % of Zanzibar trade.

There are two port sheds that are used for the storage of imported motor vehicles, but there is no storage within the perimeter of the port for bulk or break bulk cargo, and empty container are presently stored in an open area which is approximately 50 m from the Harbour entrance, with a capacity to accommodate 3,000 containers over 26,400 m^2. Nevertheless, Malindi port remains with very limited operational area and storage facilities and Zanzibar needs a new port to ease congestion at its main port. In addition, authorities in Zanzibar have said that there are indications that land at the main port is gradually being submerged.

The new port, to be located at Mpiga Duri (Maruhubi) in Unguja will be constructed to increase the island's capacity to handle large ships and cargo, with expectation to double the capacity of the island to handle more ships, containers and cargo. Development plans include improving berthing capacity and construction of a new container terminal to enhance port efficiency.

The Aga Khan Trust for Culture and the ZPC have also entered into a Memorandum of Understanding to jointly design a development plan for a section of the old port area. Redevelopment of this historic gateway to the Stone Town is expected to protect and preserve the urban fabric as it enhances the area's value as a vibrant public space.

Issues

Like mainland Tanzania's coastal ports, Zanzibar's posts are located close to their city centres, where their operation contributes to traffic congestion and other adverse environmental effects, especially in the largest port of Malindi in Stone Town. Difficulties in acquiring land have led to cramped and inefficient port layouts, and imposed serious constraints on port expansion plans. Finding a new location and constructing a new port is much required.

Economic importance

The ports of Zanzibar handle over 90% of all trade, as would be expected of relatively small islands, where air transport is significantly more expensive. The importance of the port is easily more than the financial provide or turn-over they generate or the number of employees associated with the trades the ports generate. Their value to the economy of the islands is without comparison. Compared to the volumes and values of trade, and the personnel associated with the Dar es Salaam ports on the mainland, Zanzibar's port generate significantly less, equivalent to a secondary mainland port.

Socio-economic importance

The ZPC has over 2,500 employees. Several hundred staff is engaged in supporting services and as stevedores.

Threats to coastal communities relying on sector for livelihoods

The largest threat to the port industry of Tanzania is simply the failure of the ports to continue to function as a gateway for goods and passengers or that goods and passengers fail to require the facilities. The principal threats to those engaged in the port sector and to the wider environment are described below:

Inefficient operation at Malindi port leading to greater costs of imported and exported goods.

Inadequate compensation for land for a new port development at Maruhubi.

Inadequate environmental mitigation during new port construction leading to environmental degradation e.g. siltation of reefs.

Erosion of shorelines adjacent to some secondary ports: Mkoani and Wete (Pemba), and Mkokotoni (Unguja).

CRIAM Ranking of Threats to Local Communities associated with Ports and Harbours

Table 15: Prioritisation of threats to local communities and ecosystems associated with ports and harbours. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_P&H_01	Inefficient operation at Malindi port leading to greater costs of imported and exported goods.	Ports and Harbours	3	2	2	2	2	36	4					
Z_P&H_03	Erosion of shorelines adjacent to some secondary ports: Mkoani and Wete (Pemba), and Mkokotoni (Unguja).	Ports and Harbours	1	3	3	2	2	21	3					
Z_P&H_03	Inadequate environmental mitigation during new port construction leading to environmental degradation e.g. siltation of reefs.	Ports and Harbours	1	3	2	2	2	18	2					
Z_P&H_03	Pollution arising from port activities and traffic.	Ports and Harbours	3	1	2	2	2	18	2					

Vulnerability to Climate, Climate Variability and Climate Change

Changes in Weather Patterns (precipitation, and water availability)

- Increased subsidence at Malindi ports, but not known for other ports.

Extreme Weather Events

- Erosion of shorelines adjacent to some ports (see above).
- Increased subsidence at Malindi port.

Sea-Level Rise

- Erosion of shorelines adjacent to some ports (see above).

Seawater and Air Temperature Rise

- No impact.

Seawater Acidification

- No impact.

Outlook

Since approximately 90% of Zanzibar's trade transits through the port of Malindi, improvements to this facility (especially efficiency) should be prioritised. The planned construction of a new port at Maruhubi will improve the efficiency and lower cost of trade, so important for these small islands.

9 INFRASTRUCTURE

Introduction

Zanzibar has a vast rural population (60%), with most living in villages, far removed from urban life. Supplying infrastructure to all Zanzibar citizens is a challenge that is slowly being overcome. Zanzibar's economic growth is healthy and presently the Zanzibar Gross Domestic Product (GDP) was estimated to 6.7% in 2009 (RGZ, 2010). The contribution of Zanzibar's infrastructure sector to annual GDP is not known, but are likely to be significant, primarily due to very strong developments in the information and communication technology (ICT) sector, though possibly offset by the electricity supply sector that had a significant negative effected on growth during the three-month blackout (2009-2010).

Management of the Sector

The Ministry of Infrastructure and Communications (MIC) is responsible for developing policy, plans and regulations of transport and communication infrastructures and services in Zanzibar. Among other things, the MIC is responsible for formulation of transport and ICT policies, legislations, regulations, standards and supervision; planning, developing and maintaining transport and communications infrastructures; research development in ICT and transportation sector; and encouraging public-private partnership in the provision of various transport and communications services.

Moreover, the MIC coordinates the provision and development of telecommunication, postal, meteorology, and civil aviation services in Zanzibar that are being provided by respective public bodies under portfolio of the Ministry of Transportation, Ministry of Science and Technology and the Ministry of Works of the United Republic of Tanzania. The Zanzibar Airport Authority, Ports Corporation, Maritime Authority, Shipping and Agency Corporation are institutions within the MIC.

The Zanzibar Water Authority (ZAWA), established in 2006, is a semi-autonomous entity with the overall management of water supply services and water resources management in Zanzibar. ZAWA has also an obligation of setting water tariffs to be collected as revenue from water supply so as to meet all direct and indirect costs of operation and maintenance including capital expansion of minor services. The authority works with development partners to achieve its goals. The Zanzibar Ministry of Education and Vocational Training is responsible for education on the islands, which is provided free to all.

The Local Government Finance Act (amended in 1999) appoints local authorities to be licensing authorities, sourcing local income from various sectors, in addition to block grants from government to meet the cost of development and maintenance of services particularly education, health, water, roads and agriculture.

Description of Infrastructure of the Coast

The proportion of people living in urban areas has increased from less than 10% in 1975 to 40% in 2012, ranking it among one of the most rapidly urbanising countries in the region (UN-HABITAT 2009a). This trend is positive with respect to delivery of infrastructure services since delivery of certain infrastructure directly to the public is usually easier and more cost effective when targeted people are grouped in urban centres rather than scattered in small villages across wide areas of the country. This is especially true for power supply, water supply and sanitation, education and health services, and ICT networks. There are however a recognised number of issues associated with urban existence in Zanzibar. A summary of the status of the various sub-sectors is presented below.

Power and Energy

Zanzibar is connected to the National (Tanzania) power grid with electricity transmitted and supplied by a sole utility agent - Zanzibar Electricity Corporation (ZECO) - through an underwater marine cable 132 kV submarine cable connection with a capacity of 45 MW. Peak demand in 2008 was 44 MW. As the cable had been in operation since 1980 it was of old age, faulty and not performing at maximum capacity, and a new submarine cable installation (2013) now supplies the island with an additional of 100 MW. For Pemba plans are underway to install a submarine cable, although of smaller capacity (20 MW) linking with mainland Tanga. The new supply in Pemba would replace power from diesel generators of very low standard (RGZ, 2010).

In Zanzibar, the demand for electricity has grown fast and the amount of billed electricity increased with more than 50 % from year 2003 to year 2007. The highest increase can be seen in the medium sised industries sector, where the tourism sector consisted of a large proportion (Islkog, 2011). All main towns on the two islands are now connected to the national grid, though there are large rural areas that still have no electricity infrastructure, and reliable availability of electricity in most parts of Zanzibar is still a challenge. A three month black out crippled business and household energy sources in 2009-2010.

Zanzibar's rural communities are about 60% of the total population and most of these households do not have access to electricity, equivalent to 42% of the total population. Rural regions are particularly poorly served, and people rely on different sources of energy, kerosene, charcoal, firewood and solar. The main source of power in urban centres, used for lighting, business and industry, is electricity. The Household Budget Survey (HBS) (Office of Chief Government Statistician, Zanzibar, 2006) shows about 57% of urban households use electricity, though only a very small proportion (1%) of rural households use electricity for cooking. Instead the overall results of the HBS revealed that firewood continued to be the major fuel for cooking in Zanzibar while for lighting it is paraffin (Ilskog, 2011).

The potential and feasibility of renewable energy along the coast of Zanzibar (primarily wind energy) has not yet been systematically assessed, but in some places solar power panels are used in rural Zanzibar for local light generation.

Transportation

Transportation is an extremely important infrastructure sector in the economy of the country in general and also the economy of the coastal regions. Transportation includes movement of goods and people from place to place as well as the importation and export of good to and from the coastal districts, respectively.

Zanzibar's ports and airports are integrally dependent on roads of rail to move goods and people. Of note is that the port of Malindi (Zanzibar's main port) suffers from performance problems as rapid traffic growth increasingly exposes deficiencies in storage and access to the port. Because of the importance of shipping and their specific interaction with the marine environment, this sub-sector is treated in a separate theme. Unlike mainland, there is no longer a railway functional on Zanzibar. The remaining transportation sub-sectors are described below:

<u>Roads</u>

A network of tarmac trunk road covers most parts of Zanzibar, totalling some 120 km. A passable network of tertiary roads reaches all rural areas. The national trunk road network has undergone substantial improvements across Zanzibar in particular over the last 15 years, including the main road connecting the three main cities of Pemba.

<u>Air Transport</u>

Zanzibar International Airport is capable of handling diverse sizes of aircraft, which can be used

to fly in tourists and cargo. Currently the airport is undergoing major rehabilitation for the extension of its runway and the enhancement of the passenger terminal and other facilities. There is also a secondary airport on Pemba, outside Chake Chake. The coverage and standards are generally good, in part due to its immense tourism demand.

Water supply and sanitation

The overall national coverage of water is currently at 65% at an average of daily service of 12 hrs (ZAWA 2011), thus leaving 35% of the population, especially in rural areas, with no access to safe drinking water (ASCLME, 2012). The major urban centres (Stone Town, Mkoani, Chake Chake, Wete) have piped water, with few villages having access to piped water to their homes; most households are either sharing a public stand pipe or well, or have their own well. Harvesting of rain water is becoming more commonplace, at least for cooking and bathing.

SAWA utilizing 208 boreholes on Ungaua Island for varying depths, from 15 to 111 m depth plus 96 boreholes on Pemba of similar depths (ZAWA 2011). The challenge to safe water supply is exacerbated by poor budget execution in the sector. With reforms and increased financing, performance has improved, and access to clean and safe water has risen significantly since 2000.

Health Services

People in rural areas rely heavily on government health facilities compared to urban residents (URT 2007a, 2007b), since the majority of private health facilitate are in urban areas. The use of traditional healers has reduced significantly in the recent past (URT 2007b), reflecting increased confidence in medical facilities. Health status is a big challenge in most of Zanzibar (ASCLME 2012) though most households are generally not far from primary health care facilities, even in rural areas. The 2004/05 Household Budget Survey indicates that more than 75% of the households in the rural area are within 1 km from the health centre (OCGS, 2004/05 Household Budget Survey). The government's intention is to provide health services to the level of primary, tertiary and secondary levels. The private sector and parastatals also play an important role in delivering health care to the public (ASCLME 2012),

Education Services

The EFA 2000 Assessment (Whitman et al 2000) is the first comprehensive analysis of the state of education in Zanzibar since 1990. The study found that that in 1986 about 38.5% of adult population was illiterate. Effort to reduce the illiteracy rate has not been so successful as most learners are not attending classes and even those who attend drop out before gaining literacy. In recent years the department of adult education has been conducting demand driven adult education classes targeting women income generating groups, fishermen and farmers. Attendance in these classes has been much better as it is the facilitator who follows the learners rather than the other way round.

In spite of this, illiteracy seems to be on the increase due to the fact that there are number of school age children who do not attend schooling either due to shortage of space in schools or lack of parent's awareness in some pockets of remote places (Whitman et al 2000). Another contributing factor are incidences of pupils dropping out of schools early even before completing lower primary. When these factors are put together it is fair to conclude that illiteracy among adults in Zanzibar is on the increase (Whitman et al 2000).

Information and Communication Technology (ICT)

The country has also seen significant gains in ICT networks, with substantial progress in modernising its institutional framework for ICT. There are now seven wireless operators, achieving one of the most competitive mobile markets in Africa. However, at 28%, mobile tax rates are among the highest in Africa and Tanzania is lagging behind its neighbours in extending

mobile coverage to rural areas (Shkaratan 2012). Only around 75% of the population lives within range of a GSM signal, compared with more than 90% in neighbouring Kenya and Uganda.

Issues

The rate of population growth, urbanisation and the need for infrastructure is taking place in many parts of Zanzibar places enormous pressure on the local authorities to match the provision of basic services (clean water supply, power and energy, transportation, health, education, etc.). Some of the sub-sector fare better than others, for example the ICT developments over recent years are far more impressive than the development in provision of electricity.

Evidence from enterprise surveys suggests that infrastructure constraints are responsible for about 34% of the productivity handicap faced by the private sector in Tanzania over the period 2002-2006, with the remainder being due to governance, red tape, and financing constraints (Shkaratan 2012).

Economic Importance

The importance of the various infrastructure sub-sectors to the economy on Zanzibar cannot be overstated. Matching the cost to upgrade and extend the coverage is the main challenge. The spending on upgrading of roads was USD 27.6 million (with 90% granted by donors). That project consists of the construction of four bridges and upgrading of five gravel roads in five districts to asphalted concrete standard on a 6-metre wide carriage way with 1.0 meter to 1.5 meter wide shoulders on each side over a distance of 87.5 km, with 10% financed directly by the Zanzibar Government. Finance for infrastructure alone on Zanzibar, accounts for 20% of total spending (2006/07) and 7% (2007/08).

The power sector poses Zanzibar (and Tanzania's) most serious infrastructure challenge, despite significant improvements in pricing and operational performance in recent years. Inefficiency still absorbs about 1.4% of GDP. Moreover, due to heavy reliance on hydroelectricity the sector remains vulnerable to climate variability (Yager 2002). Numerous constraints have been identified in the energy sector, including weak petroleum regulations, lack of financial, operational and human resources capacity and law enforcement in the sector (particularly at lower-levels of administration) (Shkaratan 2012). The second largest source of inefficiency is under-collection of the fuel levy for road maintenance, which represents a loss on the order of USD 100 million a year.

Socio-Economic Importance

The social and economic importance of the various sub-sectors under the broad term of infrastructure, in some cases a basic human right (e.g. access to education, safe water supply, and health services) cannot be overstated. The percentage of the coastal population employed in the various sub-sectors is not significant.

Threats to coastal communities relying on infrastructure sub-sectors for livelihoods

The principal threats to those relying on infrastructure and to the wider coastal environment are described below:

- **Poor land use and infrastructure management** leading to poor or biased choices for development, for example.
- **Inadequate infrastructure management** unable to maintain supply of services (electricity, transport, water, health and education services and ICT) to coastal regions, resulting in a deterioration of living standards, business development and prosperity.

CRIAM Ranking of Threats to Local Communities associated with Infrastructure

Table 16: Prioritisation of threats to local communities and ecosystems associated with infrastructure. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_Infra_01	Poor land use and infrastructure management leading to poor or biased choices for development, for example.	Infrastructure	3	3	3	2	2	63	4					
Z_Infra_02	Inadequate infrastructure management unable to maintain supply of services (electricity, transport, water supply, health and education services and ICT) to coastal regions, resulting in a deterioration of living standards, business development and prosperity.	Infrastructure	3	3	3	2	2	63	4					

Vulnerability to Climate, Climate Variability and Climate Change

A number of specific vulnerabilities of infrastructure and those that utilise it were identified by Hepworth (2010), combined with additional ones, summarised under the principle climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Increased rainfall volumes water leading to faster deterioration of roads.
- Increased rainfall volumes water leading to failure of road drains and accumulation of standing water resulting in water borne diseases.
- Greater standing water increases contamination risk for drink water supplies leading to increased diseases such as cholera etc.
- Flood damage to transport, communication and electricity supply infrastructure

Extreme Weather Events

- Damage to power supplies from fallen trees, or from direct impacts of weather.
- Damage to ICT infrastructure from direct impacts of weather.

Sea-Level Rise

- Coastal inundation on in low-lying coastal areas affecting roads.
- Possible elevated salinization of coastal aquifers affecting safe water supplies.

Seawater and Air Temperature Rise

- Drought increases vulnerability of hydro-electric power supply from Pangani Falls and other stations that contribute to the electricity exported to Zanzibar.
- Increased damage to roads.
- Greater cooling costs for generators and other infrastructure machinery.

Seawater Acidification

- No impact.

Outlook

The Zanzibar Vision 2020's policy on socio-economic infrastructure is to facilitate the expansion, improvements and increase in the provision of water, power, communication facilities, transport, marine, air and road networks. It is envisioned to use fiscal and other type of incentives to encourage private sector industrial investors to participate in the infrastructural development, especially in the areas proved to have valuable resource endowments.

Zanzibar is likely to continue to see considerable development in business and tourism in the coming 5-10 years. Oil and gas development has commenced in Zanzibar waters, and may produce the benefits that are beginning to be seen on the mainland. Agricultural output, development and general trade are likely to witness accelerated growth in the near future, especially in the urban industrial zones. Improved roads and upgraded electricity (with the new submarine cable installed in 2013) will support the trend. The challenge will be for the responsible ministries and local authorities to implement and maintain the infrastructure sub-sectors that need developing.

10 URBANISATION

Introduction

Zanzibar is a predominantly rural archipelago within a largely rural population (60%), with most people living in villages, far removed from urban life. From the 1980s, the growth of some villages into small towns and towns into large cities has been transforming the physical and social landscape.

Presently, one of every four Tanzanian children lives in an urban area, and one of every three babies born this year is likely to live in a city before reaching the age of 20 (UNICEF 2012). The population of Zanzibar is estimated at over 1 million, of which 40% now live in urban areas. Cities like Zanzibar Stone Town (including surrounding suburbs) are growing at a rate of between 7% and 11% per annum.

Urbanisation is the physical growth of the urban areas due to the global change. It is closely linked to industrialisation and modernisation and the process of rationalisation. Urbanisation occurs naturally from the individual and other corporate efforts to reduce time and expense in commuting and to improve jobs and education.

Management of the Sector

The isles of Zanzibar are administratively divided into five regions Zanzibar, that are further divided into districts, which are then further subdivided into divisions. The local governments were reinstalled in 1986 and during that period there was no authority to control spatial developments in the islands. The local government is divided into urban and rural authorities on Zanzibar.

Urban authorities are made up of town councils and municipalities, while rural authorities comprise the district councils. Below the local authorities exists a number of democratic bodies to debate local development needs. In the rural system, the "vitongoji", the smallest unit of a village, is composed of an elected chairperson who appoints a four member advisory committee. In the Urban areas the "mtaa" (or sub-ward) is the smallest local management unit, which unlike the "vitongoji" has a fully elected membership comprising of a chairperson, six members and an executive officer.

The basic functions of the local government are: 1) maintenance of law, order and good governance; 2) promotion of economic and social welfare of the people within their areas of jurisdiction; and, 3) ensuring effective and equitable delivery of qualitative and quantitative services to the people within their areas of jurisdiction. In Zanzibar, the main legislation regarding local government is the Zanzibar Municipal Council Act 1995 and the District and Town Councils Act 1995.

The National Land Use Plan of 1995 and policy document for coordinating land use development of the whole Zanzibar. The plan aimed at integrating physical, environmental and economic planning for effective and sustainable land use development. The main areas dealt with in this plan include growth of the economy, balance development of socio-political/administration at all levels and localising of land use planning to the local bodies (Haji et al 2006).

The Tourism Zoning Plan 1996 is the plan and strategy document and also the product of the National Land Use Plan aiming at distributing the national economy evenly with respect of preventing distraction of natural environment and resources at large. The plan objective was to contribute to the implementation of the Economic Reform Policy of Zanzibar. The plan zoned potential areas for tourism development, which also have less potential for agricultural

development and enhancing employment opportunities for the residents of such areas. Stone Town was not included in this plan because it had its own Master Plan prepared by the UNDP.

The Department of Survey and Urban Planning in cooperation with the Department of Lands and Registration as the central government institutions bear the responsibility of planning and allocating land for various purposes under the same planning legislation (Cap 85 of the 1955 Town and Country Planning Decree). Haji et al (2006) conclude that there has been no further development since 1955 whereby the Town and Country Planning Decree was enacted. The principal legislation remained the same although some regulations have been made to enhance planning procedures. The Zanzibar Government is in a process to prepare and enact new legislations. Departments of Land and Registration and Survey and Urban Planning (under the support of the Sustainable Management of Land and Environment Programme - SMOLE) have started to review lands and planning policies for betterment of the spatial planning in Zanzibar.

Most local government income comes from government allocations, which amount for 72% of the entire local authority budget. The Local Government Finance Act was amended in 1999 to appoint local authorities to be licensing authorities. The main sources of local income come from fees (including taxi registration, bus stands, forestry products, valuation, scaffolding, inoculation and ambulance); licences including road, liquor; property taxes and rents; charges including for refuse collection, hire of vehicles, markets; fines; others including sale of assets and recovery of public fund. In 2001/2002 the aggregate revenue for local government was USD 282 million. Legislation was also amended to require the central government to pay block grants to local authorities to meet the cost of development and maintenance of services particularly education, health, water, roads and agriculture. Block grants may vary from one authority to the other depending on the grades and standards as may be prescribed by the Ministry of Local Government."

Description of Urbanisation of the Coast

The proportion of people living in urban areas has increased from less than 10% in 1975 to 40% in 2012. Despite rapid urbanisation, there has been a threefold increase in the rural population, adding to pressure on land and other resources in rural areas (Wenban-Smith 2014). The advantages to citisens of urban life are many, the most obvious being access to facilities, services, infrastructure and amenities, more options for jobs and education.

On the isles of Zanzibar five areas are classified urban: the cities of Wete, Chake Chake and Mkoani on Pemba and Zanzibar Stown Town (in Urban West Region) and Makunduchi on Unguja. The principal urban centre of the isles is the Stone Town, described below.

The example of Stone Town

The largest city and capital of Zanzibar, Stone Town, had a population of about 68,000 in 1968, increased to 1.3 people million by 2012 (UNFPA, 2013). The Urban West region, with a population of 593,678 accounts for 46% of the total population of Zanzibar (UNFPA, 2013). Much of the growth of Zanzibar's main urban centre has been informal, in the suburbs that fringe the Stone Town, particularly to the east, including an area known as Ng'ambo, growing due to rural-urban migration.

The Revolutionary Government of Zanzibar implemented the Housing Policy of providing decent housing for residents and managed to develop houses in urban and rural areas. This exercise resulted in the demolition of several houses in Ng'ambo areas of Michenzani that were replaced by the Block of Flats known as Development Houses of Michenzani (Haji et al 2006). The construction exercise of this scheme has been going on till today though at very slow pace. Among the impacts of this exercise was the shifting of the Ng'ambo dwellers further to the urban periphery where public services were lacking. Also, the exercise attracted new urban migrants

from outside the city that added pressure on existing services and resources. More dwellings emerged on which followed no building regulations or development guidelines (Haji et al 2006).

Within the urban areas of Zanzibar exist the Development Authorities of Zanzibar Municipal Council (responsible for Municipality jurisdiction), the Stone Town Conservation and Development Authority (responsible for Stone Town Jurisdiction), the Western District Authority (responsible for West District jurisdiction) and above all, the Department of Survey and Urban Planning and Department of Land and Registration responsible for all urban and country areas, acting as planning board and land development controller respectively. The overlapping of responsibilities provides a loophole for un-authorised developments and encroachment of public lands such as open spaces. In addition, sectoral organisations can issue building permits (Haji et al 2006).

Issues

The speed at which urbanisation is taking place in Zanzibar places enormous pressure on the city authorities to match the provision of basic services (including clean water supply, sewage and waste management, transportation, health, education). Among the main issues that the National Land Use Plan identified are: a) unbalanced settlement system and uneven distribution of economic activities, social services and recreation activities with Stone Town being better provisioned than other areas; b) persistent growth of uncontrolled settlement development, uneconomic land use, intrusion of settlements in good agricultural land, land environmental degradation and pollution risk and c) poor capacity to manage urban development (i.e. planning capacity, managing development and development control, provision and coordinating the provision of public utilities and social services into the implementation of physical plans).

The International Sustainable City Program through Zanzibar Sustainable Program carried out an attempt to reduce the problems in Zanzibar Municipality. Issues outlined by this plan included high population density in urban area (sise of household in Ng'ambo area reached 6.7 in 1998 while the average of the Nation was 6.2); insufficient and inefficient public services (e,g. missing central drainage system and the existing storm water drains were not functioning properly, inadequate clean and safe water supply, improper collection and disposal of solid wastes). The area also faces environmental issues such as haphazard housing construction, land degradation due to illegal sand and soil mining, water contamination due to encroachment of catchment's areas, and flooding in various places of the city (Haji et al 2006).

Poor land ownership is an issue related to financial stability, resulting in households with insecure land tenure being less likely to invest in that land, and also less able to access formal finance, since land titles can be used as collateral for loans (Collin, 2014). The population living below subsistence level (food poverty) ranges from 7.4% to 12.9% in Tanzania's cities, meaning that between one in eight and one in 14 urban households are destitute. Due to population growth and reclassification of formerly rural areas, the number of poor urban residents has kept growing. Around the year 2012 just over 27% of Zanzibar's poor lived in urban areas, including many who are not even able to afford the cost of a minimum basket of essential foodstuffs (UNICEF, 2012).

Economic Importance

The proximity and economies of scale present in urban centres permit cities to become engines of growth. Urban centres offer more options for jobs and economic resources (and political visibility) enhance the scope for investments in critical services and infrastructure that can make service provision less costly and more widely available than in the sparsely populated hinterland (UNICEF, 2012). Urban areas are also hubs of technological innovation. Urban areas contribute less to the GDP of Zanzibar than large cities on the mainland (contributing 50% of GDP) because on Zanzibar most of the economic activities are scattered throughout the isles, with tourism

(contributing 26% of GDP) mostly on coastal sites and agriculture (engaging 65% of the workforce) in the more fertile western areas of the Unguja and Pemba islands.

Socio-Economic Importance

Most of the urban population of the coastal cities engages in informal activities and micro-enterprises. On Zanzibar the informal sector, which is important for providing additional income and basic needs, with typical example being manufacturing, restaurants and hotels or in the construction industry, accounts for 44% of employment, much of which is in urban centres (Awadh et al. 1998). Consequently, the private sector is largely a part of the informal sector (UN-HABITAT, 2009b).

Threats to coastal communities relying on urbanisation for livelihoods

The principal threats to those living in urban centres and to the wider coastal environment are:

- **Poor urban management** leading to overcrowding informal settlements that lack clean water and adequate sanitation, leading to increase health and well-being problems from contaminated water and from mosquitos and other pests that thrive in unsanitary environments.
- **Inadequate solid waste management** causing pollution of the landscape, watersheds and the coast.
- **Inadequate sanitation** causing pollution and health issues.
- **Failure of housing for the youth and children** exposing them to human predators, violence, abuse and sexual assault that increase their risk of HIV infection.
- **Poor vehicular management** leading to increasing vehicular/pedestrian congestion, conflicts and air pollution.
- **Poor vehicular management** leading to increasing vehicular congestion resulting in loss of working hours and fatigue among the workforce.
- **Poor urban management** threatening the status of the Stone Town World Heritage Site and thus the tourism industry on Zanzibar.

CRIAM Ranking of Threats to Local Communities associated with Urbanisation

Table 17: Prioritisation of threats to local communities and ecosystems associated with urbanisation. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_Urban_01	Poor urban management leading to overcrowding informal settlements that lack clean water and adequate sanitation, leading to increase health and well-being problems from contaminated water and from mosquitos and other pests that thrive in unsanitary environments.	Urbanisation	3	3	3	2	2	63	4					
Z_Urban_02	Inadequate solid waste management causing pollution of the landscape, watersheds and the coast.	Urbanisation	3	3	3	2	2	63	4					
Z_Urban_03	Inadequate sanitation causing pollution and health issues.	Urbanisation	3	3	3	2	2	63	4					
Z_Urban_04	Failure of housing for the youth and children exposing them to human predators, violence, abuse and sexual assault that increase their risk of HIV infection.	Urbanisation	3	2	3	2	2	42	4					
Z_Urban_05	Poor vehicular management leading to increasing vehicular/pedestrian congestion, conflicts and air pollution.	Urbanisation	3	2	3	2	2	42	4					
Z_Urban_07	Poor urban management threatening the status of the Stone Town World Heritage Site and thus the tourism industry on Zanzibar.	Urbanisation	1	3	3	2	2	21	3					
Z_Urban_06	Poor vehicular management leading to increasing vehicular congestion resulting in loss of working hours and fatigue among the workforce.	Urbanisation	1	1	3	2	2	7	1					

Vulnerability to Climate, Climate Variability and Climate Change

The specific vulnerabilities of the urban environment and those that utilise it, were identified by UNICEF (2012) and can be summarised under the principal climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Increased standing water leading to greater risk of water-borne diseases (e.g. malaria, dengue fever, etc.)
- Greater standing water increases contamination risk for drink water supplies leading to increased diseases such as cholera etc.
- Increased rainfall likely to impact on the poor quality housing of the urban informal settlements.
- Increased rainfall may exceed capacity of storm water and drainage systems

Extreme Weather Events

- Severe flooding likely to impacts more significantly on the urban poor settlements where the majority of urban dwellers live.

Sea-Level Rise

- High water table leading to sewage disposal problems and diseases
- Inundation of low laying areas
- Increased exposure to flooding during extreme events

Seawater and Air Temperature Rise

- Drought increases vulnerability in urban areas by reducing the availability of safe drinking water and contributing to food scarcity and higher food prices.

Seawater Acidification

- No impact.

Outlook

Urban growth in Zanzibar is projected to continue in the coming decades, and could even accelerate. If the current predicament in urban centres is not addressed soon, conditions will deteriorate. As density increases and unplanned settlements become more congested, investments in facilities, services and infrastructure are likely to become costlier, both financially and socially. Already Zanzibar has one of the highest proportions of urban residents living in unplanned settlements in all of sub-Saharan Africa (UNICEF, 2012). If present trends continue unabated, Tanzania could then find itself facing a daunting scenario: not only are today's urban children exposed to one of the most hazardous environments, but climate change is poised to further increase their vulnerability (UNICEF, 2012).

Zanzibar's 2020 Vision recognises the need to address among others the challenge to transform the economy from a predominantly rural-based subsistence agricultural to a diversified and semi-industrialised economy with a modern rural sector. It also aims at improving socio-economic infrastructure through facilitating the expansion, improvements and increase in the provision of water, power, communication facilities, transport, marine, air and road networks. It is envisioned to use fiscal and other type of incentives to encourage private sector industrial investors to participate in the infrastructural development, especially in the areas proved to have valuable resource endowments.

11 NON-RENEWABLE EXTRACTIVE INDUSTRY

Hydrocarbons

Introduction

The island of Pemba has long been known to contain hydrocarbons, with a natural seep of oil on the west coast. Suck a seep indicates that the conditions required to produce hydrocarbons are present, but there is no guarantee that commercial quantities are available. Unlike on mainland Tanzania, there has been very little exploration drilling to date on Zanzibar and no commercial reserves of oil (or gas) have been discovered.

The reason for the little exploration is that the Constitution clearly states that all oil and gas reserves are union property, contrary to the perception and beliefs of the people and government of Zanzibar. The standoff has deterred further exploration. More recently, the first draft constitution of the United Republic of Tanzania is proposing removal of the gas and oil on the list of union matters and under a recent agreement (still awaiting ratification by the union government) between the mainland and Zanzibar governments, exploration in and around Pemba and Unguja islands, and northernmost offshore blocks (numbers 9 to 12), will be managed by the Department of Energy on Zanzibar. The result of this landmark change in policy is that exploration will rapidly begin on Zanzibar. The long impasse has indeed delayed a number of exploration activities, including a drilling program in four offshore blocks operated by Royal Dutch Shell PLC, which acquired the licenses in 2002.

In addition to the upstream exploration results, this sub-section also includes the mid-stream and downstream sectors, namely the importation, storage and transportation of oil (and gas) and the refining, marketing and sale of the products (mainly methane, diesel, petrol and kerosene).

Management

Zanzibar will be entitled to exploration in and around Pemba and Unguja islands, and the four northernmost offshore blocks, numbers 9 to 12 (see Fig. 1), to be managed by the Department of Energy on Zanzibar. The Government of Zanzibar, (GOZ), does not have an explicit energy policy and is in the process of finalizing its own Zanzibar Energy Policy. The Environmental Policy (2013) states that "Although Zanzibar is not currently exploring or operating oil and gas production, concrete environmental policy statement related to these activities needs to be stipulated due to the strong likelihood that such activities will commence in the future (exploration is on-going in several areas adjacent to Zanzibar waters)". The Policy further states that "in the implementation of this policy, the institution responsible for energy will be responsible for promotion of reliable, renewable and affordable sources of energy, public awareness on efficiency use of energy. Furthermore, the Institution will be responsible for promotion of national environmental capacity to deal with oil and gas exploration and production".

Management of environmental and social aspects are the responsibility of the proponent, under the guidance and supervision of the Department of Environment who is responsible for issuing environmental licences and monitoring the operations that have been subjected to environmental impact assessments (EIAs). The Surface and Marine Transport Regulatory Authority (SUMATRA) is finalizing the National Oil Spill Contingency Plan, however it is not clear whether this plan specifically covers Zanzibar.

Description of Hydrocarbons and their Use

Hydrocarbons are organic compounds consisting of hydrogen and carbon that may occur in three forms: solid, like coal; liquid such as crude oil or diesel; or gas (e.g. methane or propane). These compounds are predominantly used as fuel, for generation of electricity, combusted as a fuel in cars, trucks, planes or ships; or refined into diverse products and mixed with other chemicals to make plastics and related products.

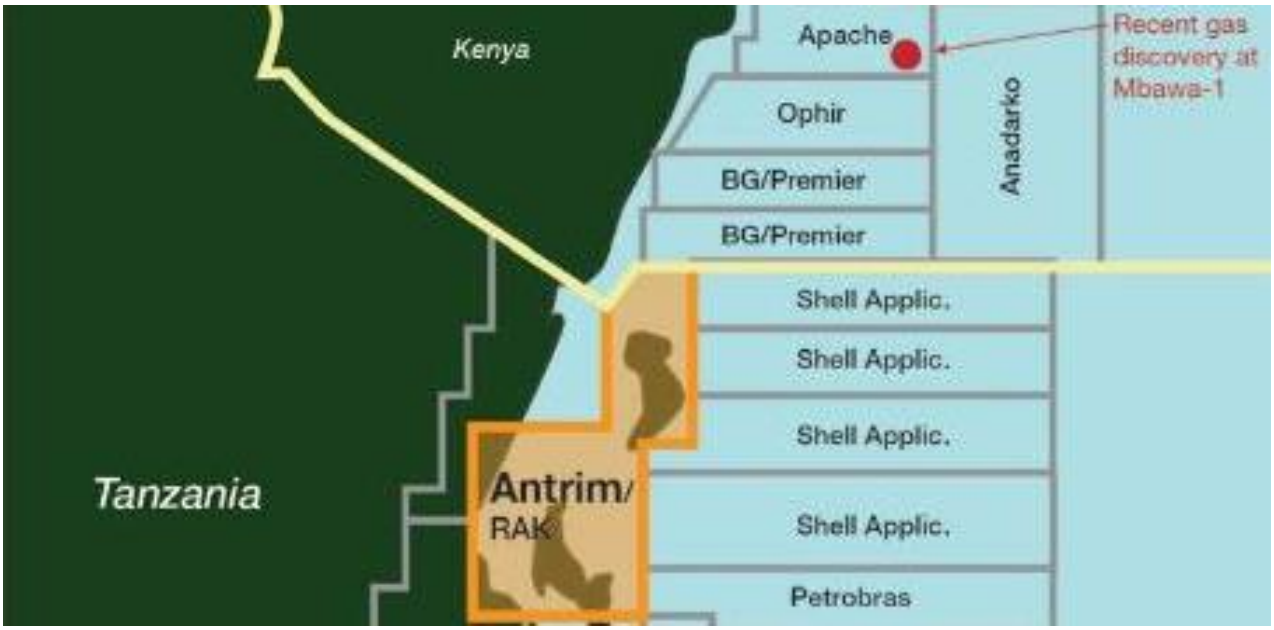

Figure 1: Zanzibar's main onshore block (held by Antrim/RAK) and the four deep-water offshore blocks (held by Shell) (Source: modified from Antrim).

In some places, due to the lack of traps, or of breached traps, hydrocarbons may leak to the surface. The presence of such leaks is a clear indication of hydrocarbon generation but is not proof that deeper traps or pools exist. Geologists say that such oil is proof of a working hydrocarbon system, possibly of biogenic origin, thus not necessarily implying the presence of significant hydrocarbon reserves. On the west coast of Pemba Island off Tanzania there is one such natural oil seep. Bubbles of methane periodically emerge from the seabed around Songo Songo Island.

In Zanzibar (and Tanzania), exploration drilling started in the 1950s but initially found little reason to be enthusiastic. After extensive geological and geophysical surveys plus a few exploratory wells, no hydrocarbons were found in sufficient quantities to justify further drilling at a time when better opportunities were available in the Middle East. By 1964, exploration in Tanzania had stopped. Apart from some exploratory well drilling close to shore in the 1970s and early 1980s, with the discovery of viable methane gas reserves in southern and central Tanzania, not much happened for another 40 years. This was also partly due to local government policy, price of oil, global markets and lack of local infrastructure. By the year 2000, only 21 wells had been drilled in Tanzania, including a few on Zanzibar, but things began to change rapidly thereafter.

Stimulated by high global oil prices, support from local governments and favourable investment conditions, as well as support from international banks and even donor agencies, well-known oil companies started to explore in Tanzania. However, due to the impasse between the mainland and ZOG, there was no development in this sector until recently. Two oil and gas exploration multinationals have shown interest to search for oil and gas in Zanzibar since the late 1970s.

Licences had been issued by the union government Tanzania Petroleum Development Corporation (TPDC) to Dutch Shell Exploration Corporation for a permit to prospect for oil and gas in blocks 9, 10, 11, and 12 in the offshore deep sea areas east of Pemba and Unguja. Similarly, Antrim Resources of Calgary, Canada had been given the permit to prospect for oil and gas on the onshore blocks of Pemba and Unguja islands. At that time, the GOZ nullified the licenses and exploration was stalled. Despite no exploration drilling, seismic surveys were conducted over onshore areas of Pemba and the deeper Pemba Basin to the east. Since early 2014, the situation has changed and seismic exploration is soon to commence in the offshore blocks.

The oil and gas industry is usually divided into three major sectors: upstream, midstream and downstream.

Upstream – This sector includes the exploration and production phases, that includes the search for potential underground or underwater crude oil and natural gas fields, drilling exploratory wells, subsequently drilling and operating wells that recover and bring the crude oil and/or raw natural gas to the surface (the production phase), and corresponding developments in liquefied natural gas (LNG) processing.

Midstream – This sector involves transportation, storage and marketing of various oil and gas products. Transportation options can vary from small connector pipelines to massive cargo ships making trans-ocean crossings, depending on the commodity and distances involved. Most oil is transported in its current state, though natural gas must be either compressed or liquefied for transport. The only fuel depot on Zanzibar is that at Mtoni, north of the Stone Town, which stores fuel discharged from small tankers that anchor close-by. From there it is distributed to re-sellers and consumers by road. Similar but small depots are present on Pemba Island, near Chake Chake and at Wesha.

Downstream – Refining and processing (and purifying) of raw natural gas and oil (e.g. into usable products such as gasoline, jet fuel and diesel) are downstream activities. The marketing and distribution of products derived from crude oil is included in this sector. Only refined products are imported as there is no refinery capability on Zanzibar. Distribution and marketing of fuels and lubricants is carried out by BP, GapCo and others, mostly transported by road.

Services and Consulting – This "sub-sector" is an increasingly important part of the oil and gas industry, assisting effectiveness and efficiency in all three major streams. Typically companies specialist in repairs, maintenance, troubleshooting, construction and operation of projects (including drilling, water filtration, engineering design), project design, implementation and environmental management, and can help with project economics, staffing, financing, risk management, geological assessment and community outreach, for example.

Major Issues

Zanzibar has no human resource development policy or and plan for energy sector (ESRF 2009) and there are very few locals trained in geology and fewer yet on Zanzibar. There is limited national capacity to properly managed oil and gas exploration and production activities as well as handling oil spills and pollution (RGZ 2013).

Economic Importance

The importance of Zanzibar reserves of natural gas or oil cannot be quantified at present and can only be speculatively considered until there are discoveries that begin to be utilised. Given that all fuel is currently imported to the islands, any discovery of oil or gas that can be used for energy or vehicles will provide an enormous benefit to Zanzibar, potentially reducing its dependence on electricity supplied form the mainland.

Socio-Economic Importance

With no discoveries of oil and gas thus far, only downstream operations (mainly of storage, distribution and sale of hydrocarbon products), generate employment, probably for several hundred personnel.

Threats to Sustainable Livelihoods of Coastal Communities

The baseline study by ESRF (2009) found that there are an increasing number of complex primary and secondary constraints and risks affecting the performance in oil and petroleum exploration in Tanzania and Zanzibar. One risk of international consequence is that the operational currency is the US dollar, and that a major portion of the operational expenses, and a significant portion of investments are denominated in that currency. Similarly, the international demand and hence world market prices for oil and gas may threaten development of the sector in Zanzibar. More local threats are included in the summary below:

- **Degradation of the natural marine and coastal environment** and thus impact on livelihoods, from failure of exploration companies to adhere to environmental and socio-economic safeguards, partly due to weakness in the oversight provided by the Department of Environment, responsible for issuing licences and monitoring the operations that have been subjected to EIAs.
- **No oil spill response plans, equipment and technology are in place** as well as absence of a joint industry response organization and very limited capacity for pollution mitigation by the local coast guard
- **Piracy** attacks against offshore operations.
- **Damage to infrastructure and environment** from engineering design failure.
- **Social and/or political unrest** related to behaviour of the Government and stakeholders.

CRIAM Ranking of Threats to Local Communities associated with Hydrocarbons

Table 18: Prioritisation of threats to local communities and ecosystems associated with hydrocarbons. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_O&G_01	Degradation of the natural marine and coastal environment and thus impact on livelihoods, from failure of exploration companies to adhere to environmental and socio-economic safeguards, partly due to weakness in the oversight provided by the Department of Environment, responsible for issuing licences and monitoring the operations that have been subjected to EIAs.	Hydrocarbons	3	3	2	2	2	54	4					
Z_O&G_02	Piracy attacks against offshore operations.	Hydrocarbons	3	1	2	2	2	18	2					
Z_O&G_04	Social and/or political unrest related to behaviour of the Government and stakeholders.	Hydrocarbons	1	1	2	2	1	5	1					

Vulnerability to Climate, Climate Variability and Climate Change

Climate change is unlikely to have any impact on the resource itself, though any change to maritime conditions (including coastal weather) may impact the upstream oil and gas sector, from as well as any future power generation facilities, especially to pipelines, sites and infrastructure located in the sea or close to the shore.

Changes in Weather Patterns (precipitation, and water availability)

- No impact.

Extreme Weather Events

- Extreme sea conditions and winds may lead to leaks or worse with subsequent impacts on the wider natural environment and livelihoods.

Sea-Level Rise

- No short-term impact; possible long-term need to strengthen infrastructure.

Seawater Temperature Rise

- No significant impact.

Seawater Acidification

- No impact.

Outlook

The outlook for oil and gas industry in Zanzibar, from upstream to downstream operations is potentially likely to witness significant increase in volumes extracted and traded, income generated and employment created. Depending on the size of hydrocarbon reserves found this sector may completely change the entire nature of the local economy

Zanzibar Coastal Sand and Rock Mining

Introduction

Being Africa's third largest gold producer, the world's sole producer of the gemstone tanzanite, and a producer of cement, diamonds and other gemstones, Tanzania has an extensive and diverse mining sector (ASCLME 2012). However, most of the mining takes place in the interior and west of the mainland. The islands of Zanzibar are of a different geological origin that does not generate the high value minerals and gemstones present on the mainland. However, mining operations do exist and are focused on fossil coral rock (limestone) for building and baked for production of lime, as well as beach sand for the construction industry. With no significant rivers on Unguja and few small rivers on Pemba, there is virtually no excavation of sand from river beds. On Zanzibar live coral is no longer extracted from the sea for the construction industry.

This subsection describes sand extraction from beaches and the mining of onshore coastal rock. Sand extraction is also known as 'sand mining'. In Tanzania sand is indispensable for many economic development activities, such as road building and concrete production, as well as other uses such as in glass-making, and glazing for pottery. Good quality sand is sourced primarily from relatively limited sources, mainly around Lake Victoria (Yager 2002), while marine and terrestrial deposits are the two main sources of sand for building in the coastal zone.

The mining of rock produces a range of grades from moorum chipping to aggregate and larger boulders used for foundations of homes. Mining is usually in open quarries that may be on village or private land.

The Zanzibar mining sector contributes a very small amount to the GDP of the isles and probably employs a few thousand people, though figures are not available mainly because the excavation and trade is mostly unregulated. Excavated sand and rock that are mined for the building industry are usually sold by volume, with little if any royalties or taxes accrued to the government, other than fees to the quarry owner.

Management of the Sector

The Commission for Natural Resources (CNR) and the Commission for Lands and Environment, together with regional authorities and village Shehas are responsible for controlling mining while the Department of Environment is responsible for monitoring the operations that have been subjected to environmental impact assessments. After the Government became aware of the impact of sand mining, a law was established banning the practice (MACEMP 2010). Despite the law banning beach sand extraction, the activity continues in many places.

Description of Sand and Rock Resources and their Use

A variety of materials are used for hotel construction, but the cottage–type developments being erected in Zanzibar make heavy use of building and roofing poles, palm fronds for roofing, sand and coral rock. The same materials are highly demanded by local people for construction of their houses.

Sand

The sand excavated from beaches or sandy areas just above the coast is usually of carbonate origin and not ideal for the construction industry though adequate for small buildings and roads. After the Government became aware of the impact of sand mining a law was established banning the practice. However, beach sand is still extracted by local people at varying rates from almost every beach around Zanzibar Island, including by hotels.

On Zanzibar, beach sand has been traditionally used for constructions of small houses along much of the coasts of the two main islands; mixed with lime and used as a mortar to bind together larger rocks or bricks. The volumes and locations are not well documented, yet evidence of beach sand mining is easily seen along many shores of Zanzibar, usually undertaken by small-scale operators, often for single building projects. Often beach sands are used for construction of hotel facilities. In Kiwengwa and Nungwi, for example, hoteliers collect sand from the beach and transfer it to the playgrounds and paths of the hotels.

Beach sand extraction requires little equipment or expertise and is mainly undertaken by groups of youth who pile the sand up the shore nearest access sites for trucks to collect and transport to the building site or a middleman re-seller.

As constructions proceed, sand and coral mining is increasing. Sand mining is currently unregulated and typically occurs adjacent to the construction site on the beach causing down current erosion. This often happens at the East Coast of Unguja and Nungwi. To solve this problem CNR has designated appropriate sites where sand and rocks could be mined for construction purposes (UNEP/FAO/PAP, 2000).

Rock

Rock mined from quarries in Zanzibar, is generally for use in the construction industry. Coral rag vegetation provides stones for building houses especially in rural areas. However, concrete blocks have largely superseded coral stones in the construction industry in urban area, as they are a much cheaper alternative. Stone continues to be used in urban area for foundations and underlay concrete floors, latrines, etc.

In 2011, the Department of Environment identified about one hundred excavation spots (mining sites) on both Unguja and Pemba, which are areas of major activities for both domestic and industrial scale of excavation of non-renewable natural resources. The size of these open mines ranges between 0.25 to 6 km^2 and it was further observed that very little rehabilitation had been initiated (RGZ 2013). The concentration of these activities in the less fertile, coral rag areas, where population densities are less and the land is used for seasonal agriculture or fire wood collection.

Issues

Several factors, including sea level rise, geology, and rapid coastal population growth accompanied by rapid increase of human activities that interfere with natural processes, have been linked to coastal erosion in Zanzibar, but one human activities that is believed to have a strong linked to the problem of coastal erosion is illegal sand mining along beaches, and other restricted areas (Masalu 2002). This causes localised severe coastal erosion and enormous environmental degradation and threat to coastal properties, to the environment, infrastructure, and local residences (Menda, 2002).

The adverse effects and environmental impacts of land degradation caused by unsustainable excavation of non-renewable natural resources in Zanzibar is a major concern (RGZ 2013). There is concern that if this is not addressed properly, land degradation will continue and become irreversible. Major impacts associated with mining in Zanzibar are loss of fertile, agricultural lands previously used for growing crops and for livestock grazing, increased soil erosion, increased deforestation, loss of productive agro-forestry areas with, pollution of fresh water sources and exposure of ground water aquifers causing lowering of the groundwater table and increased sea water intrusion (RGZ 2013). Uncontrolled stone collection and quarrying especially around Fumba and Kiwengwa area may result in the disturbance of the fragile and sparse pockets of top-soil leading to thickets and agriculture degradation.

Sand mining and rock quarrying on Zanzibar employs many youths, and has become a social, economic, and environmental problem. Thus, it is a sensitive issue. Other macroeconomic

impacts have also been observed such as changes in land use patterns (Myers 1999) and increased public health costs (Myers & Muhajir I997, Mensah, 1997).

Economic Importance

The contribution from mining of sand and rock to GDP on Zanzibar is estimated at 1% for 2011 (RGZ 2013). Mining and quarrying activities in Zanzibar are limited to quarrying of stones, sand and clay with 14 establishments employing 373 people as per 2008 Industrial Census records. The value added in 2008 stood at USD 0.6 million (RGZ 2013).

Socio-Economic Importance

Officially, the mining and quarrying sector's 14 establishments is employing 373 people as per 2008 Industrial Census records (RGZ 2013), or 0.5% of the total labour force (ILO 2013), yet the livelihoods associated with beach and river sand extraction operations is likely to involve several thousand casual workers and in some cases women and children. Since much of the excavation of sand, rock and aggregate and mining of live coral is undertaken in the informal sector, with no regulation or management, figures of those involved are unreliable.

Threats to coastal communities relying on mining sector for livelihoods

The principal threats to those engaged in the exploitation of the coastal sand and rock (including live coral mining) and to the wider coastal environment are described below:

- **Poor management** of shores (e.g. coastal developments), lack of understanding of coastal erosion causative factors leading to loss of shoreline.
- **Corrupt and uncoordinated institutional enforcement** of mining policy to protect the natural environment, particularly the coastline.
- **Anarchistic sand and rock extraction** from coastal zone resulting in increased erosion.
- **Loss of river basin habitat** from un-regulated sand extraction.
- **Loss of beach habitats for turtle nesting**.
- **Economic losses** through tourist abandonment
- **Loss of coastal aesthetics**
- **Increase in water borne diseases** from quarries that fill with rainwater.
- **Shallow water table contamination** from poor citing of rock quarries.

CRIAM Ranking of Threats to Local Communities associated with Coastal Sand and Rock Mining

Table 19: Prioritisation of threats to local communities and ecosystems associated with coastal sand and rock mining. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_S&R_01	Poor management of shores (e.g. coastal developments), lack of understanding of coastal erosion causative factors leading to loss of shoreline.	Sand and Rock Mining	3	3	3	2	2	63	4					
Z_S&R_02	Corrupt and uncoordinated institutional enforcement of mining policy to protect the natural environment, particularly the coastline.	Sand and Rock Mining	3	3	3	2	2	63	4					
Z_S&R_05	Loss of beach habitats for turtle nesting.	Sand and Rock Mining	1	2	2	2	2	12	2					
Z_S&R_06	Economic losses through tourist abandonment	Sand and Rock Mining	1	1	3	2	2	7	1					
Z_S&R_07	Loss of coastal aesthetics	Sand and Rock Mining	1	1	3	2	2	7	1					
Z_S&R_03	Anarchistic sand and rock extraction from coastal zone resulting in increased erosion.	Sand and Rock Mining	1	1	2	2	2	6	1					
Z_S&R_04	Loss of river basin habitat from un-regulated sand extraction.	Sand and Rock Mining	1	1	2	2	2	6	1					
Z_S&R_08	Increase in water borne diseases from quarries that fill with rainwater.	Sand and Rock Mining	1	1	2	2	2	6	1					
Z_S&R_09	Shallow water table contamination from poor citing of rock quarries.	Sand and Rock Mining	1	1	2	2	2	6	1					

Vulnerability to Climate, Climate Variability and Climate Change

The specific vulnerabilities of the coastal sand and rock resources and those that utilise them, can be summarised under the principal climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Run-off increased from deforested and damaged river banks due to unregulated sand extraction.

Extreme Weather Events

- Destruction of shoreline infrastructure and natural habitat from increased erosion due to loss of beach sand and live coral.

Sea-Level Rise

- Increased erosion due to loss of beach sand and live coral.

Seawater and Air Temperature Rise

- No impact.

Seawater Acidification

- No impact.

Outlook

With Zanzibar's GDP growth rate reaching 6-7%, there have been significant increases in mining and quarrying and construction sub-sectors. The extraction and mining of these materials and resulting impacts could increase substantially (Yager, 2002).

Given the rapid rate of urbanisation along parts of Zanzibar, especially Stone Town suburbs, the accompanying rates of sand and rock extraction are likely to continue to rise. The outlook for beach sand extraction in Zanzibar is likely to witness significant increase in volumes traded, income generated and employment created if left un-regulated.

While financial resources are limited and environmental management remains uncoordinated, NGO involvement in coastal zone management and the development of new cement projects on the coast suggest further growth in the mining sector. Despite some of the environmental issues surrounding the mining sector on the coast, the incentive to invest in the region also remains high. Thus industrial mechanical dredging of sand away from the shore could become a more attractive alternative source of sand in the future.

Salt Production from Evaporation of Sea Water

Introduction

This subsection provides an overview of the industry that produces salt (sodium chloride) from the evaporation of seawater. One litre of seawater contains approximately 36 g of salt. The majority of salt production in Africa, including Tanzania, is based on solar salt works situated in the upper intertidal zone, usually inland of mangrove forests. The main use of solar salt is for human consumption, as a vital component in diets, particularly when iodised. Other uses of lower grade, non-iodised salt, include livestock feed, use in food preservation (slated fish) and in industry.

Global demand for salt currently exceeds 230 million tonnes. Around 40% of global salt production is by the solar evaporation of seawater. Until the 1960s, China and India dominated the production of solar salt worldwide, and they still remain major producers.

Production of salt per hectares varies due to weather (e.g. reduced production due to rain and cloud cover) and increases with dryness and wind. The procedures used in making salt vary by geographic region, resources locally available and quantity desired by the producer and local population. The process may involve techniques such as leaching, extraction and filtering, the final step in salt production invariably required evaporation of water from brine to precipitate salt crystals (Akridge, 2008).

Based on satellite imagery analysis, on Zanzibar there are 105 hectares (ca. 1 km^2) of salt pans, (www. tansea.org 2013). Most production is on Pemba, producing approximately 2,000 tonnes of salt every year, usually for local consumption (UNICEF, 2013). Most of the industry is unregulated and does not contribute significantly to the national GDP.

Management of the Solar Salt Production Sector

On Zanzibar, permits for the construction of salt farms are supposed to be issued through the Department of Forestry after consultation with the Department of the Environment. People interested in salt farming are supposed to first contact the local leader of the village, or Sheha, and then submit a letter to the Department of Forestry. In accordance with the Environmental Management for Sustainable Development Act of 1996, which specifies that projects involving reclamation of land requires environmental impact assessments, the Departments of Forestry and the Environment are supposed to jointly carry out a preliminary site survey. However, some farmers begin construction prior to receiving permission. The Department of Forestry has not approved any new farms since 2002 (Wolchok, 2006). In 2011, the government introduced the Food Security and Nutrition Act, legislation that promotes the use of iodised salt.

Representation of the industry is achieved through the Association of Zanzibar Salt Processing Organisations.

Description of Solar Salt Production

Types of Salt Production Systems

Tanzania has more rain than ideal for solar salt production. Despite that, solar evaporation is the most widely used method and the one that is the least capital-intensive. Others include thermal evaporation, vacuum evaporation and foothills salt collection. Solar evaporation is normally carried out during the dry seasons, with very little production during the rainy season.

Salt works usually consists of a series of evaporation ponds from the seawater intake point to the crystallizing ponds. Pond walls are constructed using impermeable clay soils available on site,

hence local availability of clay is critical. The only machinery required for commercial pond systems is water pumps. Ditches and gate structures between ponds and pipes under roads are also needed. Salt is also produced at very small-scales through boiling seawater in pans, whereby two truckloads of wood are needed to produce 1.4 tonne of salt (Muhando et al, 2010).

Production Rates

Production rates vary significantly depending on the intensity and industrialisation of the process. On Pemba, small-holders produced 28.8t/ha/year (Wolchok, 2006), whereas a large-scale, commercial salt works at full efficiency in Bagamoyo should produce at least 100 t/ha/year, though most salt works are probably producing under 50 t/ha/year (Stanley, *pers. comm*.).

Including the salt works on Unguja, total Zanzibar solar salt production is likely to be in the region of 2,000-3,000 tonnes per year, compared to an annual production estimated for coastal Tanzania at between 1.0-1.5 million tonnes.

Salt Production Distribution

Of the total 105 ha of saltpans on Zanzibar, more than half are situated in Wete District of Pemba, the remaining being split between North B and Micheweni district on Unguja (see Table 20).

Table 20: Solar salt works per district (Tansea 2013).

Zanzibar	Saltpan area (ha)
Unguja	
Kaskazini B	13.21
Kaskazini Pemba Region	
Micheweni	10.82
Pemba	
Wete	81.23
Total islands (ha)	105.26

Salt Prices and Taxes

Prices vary depending on whether salt is iodised and the quality. A small-scale salt producer on Pemba retails sale in 50Kg bags at equivalent to USD 17/t (Wolchok, 2006), whereas large-scale producers on the mainland of Tanzania expect to receive closer to the world price solar salt, between USD 50-60/t.

Salt for human consumption

Healthy humans require iodine, an essential component of the thyroid hormones, thyroxine and triiodothyronine. Failure to have adequate iodine leads to insufficient production of these hormones, which adversely affects many different parts of the body, particularly muscle, heart, liver, kidney, and the developing brain, resulting in the disease states known collectively as the iodine deficiency disorders (IDD). Consequences include mental retardation and other defects in development of the nervous system, goitre (enlarged thyroid), physical sluggishness, growth retardation, reproductive failure, increased childhood mortality. The most devastating of these consequences are on the developing human brain (Mannar & Dunn, 1995). To prevent IDD, humans need around 140 micrograms of iodine a day and it is usually consumed through fish, sea vegetables and other foods of marine origin.

In Tanzania, efforts to combat IDD started in the 1950s, but due to lack expertise were not successful until 1970's when the Tanzania Food and Nutrition Centre (TFNC) was formed. Surveys to determine the prevalence of goitre were conducted nationwide to establish the

magnitude of the problem. The survey report showed that 41% of the population was at risk while 25% (equivalent to 5.6 million people at the time) were already suffering from iodine deficiency. Nowadays, every salt producer is required to mix the mineral with a specified amount of iodine. One kilogramme of potassium iodate costs approximately US$ 44, enough for around 19t. The small-scale salt producers in Tanzania are largely responsible for the non-iodated salt in the market (Leach & Kilama 2009).

In 2013, Pemba salt producers have been receiving year's worth of potassium iodate and a manual sprayer, materials distributed through Zanzibar's Ministry of Health programme that aims for universal salt iodisation on the island, with support from UNICEF. The TDHS 2004/05 also recorded a high coverage of iodated salt; 74% of households had salt which had been iodated. However, the survey revealed a lack of adequately iodated salt in several regions; for example, Zanzibar, Mtwara and Lindi have much lower percentages of households with iodated salt than other parts of the country. To increase coverage, greater monitoring of salt trading is required, as well as stronger measures to support small-scale salt producers, especially in areas identified with low iodation.

Major Issues

The solar salt industry in Zanzibar continues to suffer from inconsistent iodisation. Continued efforts are needed to rectify the situation.

There are grave concerns in the industry on the taxes and levies which salt producers are required to pay, increasing operation costs. In addition, producers are obliged to charge VAT (18%) on the saleable product which makes it more expensive to the consumer. VAT is not charged on other food products. The financial burdens are a disincentive to development of the sector.

Small scale salt producers usually have limited financial means and lack access to technical assistance. As a result, the salt produced is of poor quality. Inputs identified to improve production are improvements to technology and product quality, to health hazards among workers; better organisation of supply chains from small-scale producers to industrial plants and private consumers; and need for training programs and strengthening of the cooperation with public institutions.

Economic Importance

Production Revenues

Trends in the sector suggest that on Zanzibar there has been an increase in production, especially on Pemba where availability of suitable land is not an issue. Nevertheless, the contribution to national GDP is low, based only on taxes and levies.

Overall Exports

In general, the Tanzania solar salt produced is of low quality which is not suitable for export.

Socio-Economic Importance

Due to the relatively small quantities of salt produced in Zanzibar, which is also insufficient for local needs, the importance in terms of national GDP is very low. However, local salt production is more significant with respect to the vital importance of salt for human nutrition.

Employment in the sector is based on a core staff to run the salt works and additional personnel recruited for harvesting. Though employment figures are difficult to find, estimates based on small-scale salt works (UNICEF, 2007), suggest that several hundred people may be employed in the sector along Zanzibar's coasts.

Threats to Coastal Communities Relying On Solar Salt for Livelihoods

No threat exists to the availability of salty seawater, though the following are noted threats that could affect livelihoods of those involved or the wider environment:

- **Lack of suitable habitat** for artisanal (non-pump) and industrial systems into which to expand/adapt, particularly with respect to land and availability of clay to construct dykes.
- **Lack of government support** with infrastructure (e.g. roads) and land ownership.
- **Unplanned urbanisation** in some areas reduces land availability into which to expand.
- **Unsustainable practices** resulting in degradation of mangrove forests for ponds and timber (for boiling salt water), causing losses to the wider environment with respect to shelter from wave action to fisheries production.
- **Sea level rise** threatening infrastructure (dykes and buildings, etc.).
- **Local population hazard from low iodisation of salt** from small-scale producers in Zanzibar **(**iodine deficiency disorders).

CRIAM Ranking of Threats to Local Communities associated with Salt Production

Table 21: Prioritisation of threats to local communities and ecosystems associated with salt production. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_Salt_04	Unsustainable practices resulting in degradation of mangrove forests for ponds and timber (for boiling salt water), causing losses to the wider environment with respect to shelter from wave action to fisheries production.	Salt Production	3	3	3	2	2	63	4					
Z_Salt_07	Solid and liquid wastes from improper disposal	Salt Production	3	3	2	2	2	54	4					
Z_Salt_03	Unplanned urbanization in some areas reduces land availability into which to expand.	Salt Production	3	2	3	2	2	42	4					
Z_Salt_05	Sea level rise threatening infrastructure (dykes and buildings, etc.).	Salt Production	1	2	3	2	3	16	2					
Z_Salt_01	Lack of suitable habitat for artisanal (non-pump) and industrial systems into which to expand/adapt, particularly with respect to land and availability of clay to construct dykes.	Salt Production	1	1	3	2	2	7	1					
Z_Salt_06	Local population hazard from low iodisation of salt from small-scale producers in Zanzibar (iodine deficiency disorders).	Salt Production	1	1	3	2	2	7	1					

Vulnerability to Climate, Climate Variability and Climate Change

Based on assessments made by MACEMP (2009), SMOLE (2010) and GCAP (2012) the specific vulnerabilities can be summarised under the principal climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Unseasonal precipitation affecting evaporation and production.
- Changes in wind pattern causing changes in evaporation rates.

Extreme Weather Events

- Extreme rainfall significantly damages the salt work structure (dykes).

Sea-Level Rise

- The need for salt works to retreat may result in unavailability of adequate space and/or clay soils needed to build salt pan dykes.

Seawater Temperature Rise

- No significant impact, possibly beneficial to evaporation, thus boosting production.

Seawater Acidification

- No impact.

Outlook of the Solar Salt Production Industry

On Zanzibar, based on the information uncovered, it seems that the existing small-scale solar salt industry has very little room for expansion, to the detriment of the small economy and the livelihoods of those involved.

12 NATURAL RESOURCES

Introduction

The coast of Zanzibar stretches over a distance of 370 km, from latitude 4º50′ S at the northernmost tip of Pemba Island close to the Kenya border to latitude 6º53′ S at Latham Island. The coast is exposed to the Southern Indian Ocean and is subject to incoming waves generated by the monsoon winds and local storms, especially on the eastern seaboard. Unguja Island is approximately 95 km long, with Pemba 65 km long, and both lying at a distance of several tens of kilometres off mainland shores. There are also a large number of smaller islands lying almost as fringes close to much of the east coasts of Pemba and Unguja. The most prominent features of the coasts include fringing platforms, limestone cliffs, sandy beaches and mangrove forests in the riverine estuaries and various inlets (Francis et al 2001).

About two thirds of the coastline of both major islands supports fringing coral reefs, often close to the shoreline, broken by creek outlets such as at Chwaka Bay and Fumba Bay on Unguja Island and Chake Chake Bay and Adamson Bay on Pemba Island. Features of interest within the coastal zone include the coastline, continental shelf, corals, mangroves, and seagrass beds. These are characterised by high marine biodiversity and rich marine and coastal resources (Francis and Bryceson, 2001). The few rivers of Pemba, each less than 10 km in length flow to the Indian Ocean and to a certain extent influence the coastal environment through creation of productive brackish water environments in estuaries, tidal flats and shorelines and nourishment of mangroves and seagrass beds (Francis and Bryceson, 2001). These coastal ecosystems subsequently interact with each other and together sustain a tremendous diversity of marine life, which supports the livelihood of coastal communities. A wide range of important and valued species are found along the coast, including an estimated 150 species of corals in 13 families; 8,000 species of invertebrates; 1,000 species of fish; five species of marine turtles, at least 30 species of marine mammal and many seabirds (Francis and Bryceson, 2001).

This section presents in brief an overview of the coastal features of Zanzibar, followed by a description of the mainly non-renewable, marine or coastal resources, grouped as follows: coral reefs, seagrass beds, coastal birds, coastal wildlife (marine mammals, turtles). Mangrove forests are included under the theme on forestry.

Management of the Sector

Institutionally, the Ministry of Agriculture, Natural Resources, Environment and Cooperatives (MANREC) oversee an agricultural sector policy, which includes fisheries. The Department of Fisheries and Marine Products (DFMP), enforces the law, while the Marine Conservation Unit (MCU) manages the Marine Protected Areas (MPA). The Marine Resources Department is responsible for all non-fisheries marine resources, and the Vice President's Office (VPO) and the Department of Environment look after environmental impacts and ICZM. The Marine Control and Surveillance Unit (MCS) is the enforcement part of the Fisheries Department.

The Fishery Policy (1985) objective is to increase the supply of fish, create employment and conserve the marine resources, regulated by the Fisheries Act, 1988 and its Fisheries Regulations (1993). Fisheries development programmes include MKUZA II (Zanzibar Strategy for Growth and Poverty Reduction), which recognises the importance of the marine resource and the Integrated Coastal Zone Management (ICZM) project looking into oyster farming (both meat and pearls), deep-sea fishing and village conservation.

The other principal institution relevant to different aspects of the environment on Zanzibar is the Vice President's Office, and its Department of Environment responsible for environmental law and setting of environmental standards. Sustainable management of the marine environment

falls under the Environmental Management for Sustainable Management Act (the framework environmental law, or "Environment Act") 1996, and conservation of key breeding and feeding sites through the Nature Conservation Areas Management Unit Act, 1999.

The National Environmental Policy 1992 focused on conservation and development of environmental resources with a view to utilising them in a manner that will improve the welfare of the present and future generations of the island. It laid emphasis on the need to ensure that the biological and ecological principles that are important for the development of the lives and resources are complied with. Majamba (2005) notes that the Department of Environment has not been able to effectively commence its mandate which is to give advice on formulation of policies and conduct research on effects on the environment from activities of various sectors. The main hindrance was the failure by authorities to enact enabling regulations, as required by the framework law, though these are now on-going. The new Environmental Policy 2013 addresses fundamental environmental issues which include Environmental and Climate Change Governance; Terrestrial and Marine Resources and Biodiversity; Forest Conservation; Renewable and Efficient Energy; Environmental Pollution; Waste management; Integrated Water Resources Management; Development of Environmental Quality Standards, Environmental and Social Impact Assessment (ESIAs); Environmental Information Systems and Awareness, Climate Change Adaptation and Mitigation, Sustainable Tourism; Gender, HIV/AIDS and Public Health.

The Zanzibar Investment Policy requires investments that are socially and economically beneficial as well as environmentally sound in order to protect Zanzibar's natural heritage.

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

In addition to the marine protected areas and survey information, as well as the general integrated coastal management activities highlighted earlier, there are a number of specific activities targeted at corals. There has been some work looking at sea surface temperature (SST) to assess coral bleaching risk (Shaghude et al). There has also been study on impact of hydrographic parameters and seasonal variation in sediment fluxes on coral status at Chumbe and Bawe reefs on Zanzibar (Muzuka et al (2010). IMS in partnership with the National Oceanography Centre, Southampton have developed a software tool for predicting coral bleaching using Satellite MODIS data broadcasted through the GEONET Cast receivers (as part of the Europe-Africa EO Marine Network (EAMNET) Project). The ISLANDS project is setting up a Coral Reefs facility for the Western Indian Ocean region and has a component for coral monitoring, which has investigated metadata and is building a Coral Reef Information System (CRIS). The recent Zanzibar National Environmental Plan also highlighted the need for collaboration with the private sector in coral reef protection and conservation, and a National Awareness program on protection of coral reefs.

Marine Protected Areas

To ensure the sound management of marine environment, the Government of Zanzibar has created three Marine Conservation Areas (MCAs), the Menai Bay Conservation Area – MBCA (470 km^2), the Mnemba Island Marine Conservation Area – MIMCA (720 km^2) and the Pemba Channel Conservation Area – PECCA (1,000 km^2). Furthermore, Chumbe Coral Park was gazetted in 1995, and two additional MCAs are expected to be gazetted in the near future.

Description of Natural Resources of the Coast and their Use

Coastline types

Based on the shoreline categorisation for Tanzania (and Zanzibar) by Francis et al (2001), Zanzibar's two main shoreline types are as follows:

Cliffed Shorelines

Limestone cliffs predominate on headlands on Unguja and parts of the west and east coasts, as well as large parts of the east coast of Pemba and west coast smaller islands. The limestone (of Pleistocene age or earlier) is characterised by undercut notches and clear vertical zonation of flora and fauna. Indented coves shelter small beaches of calcareous sand made up of coralline particles and shell fragments.

Beach Rock Shorelines

Parts of the coasts of the two main islands are made up of lithified sediments consisting of calcareous sandstone, which are generally coarse and pebbly. The shorelines gently dip seawards and in some parts they are masked by modern beach sand. The latter is finely ground calcareous sand of coral and shell origin mainly, with significant contribution in some bays (e.g. Chwaka) from the calcareous green algae *Halimeda*.

Coral reefs

Zanzibar has major coral reefs, and there are extensive coral reefs around much of the shoreline of both islands (about 60 %) and many islets. These reefs provide important resources for the local economies and communities, and have an important role in coastal protection (against waves, storms and erosion), for fisheries, as well as being important tourism recreational sites on the islands (Thyresson et al, 2013). They provide extremely important ecosystem services and have significant economic value.

The continental shelf (up to a depth of 200 m) is generally narrow, especially around Pemba Island, with the narrowest point being 1 km (east coast) and the widest 20 km (north coast), and slightly wider around Unguja's east coast (5-20 km). The shelf drops sharply after a depth of 60 m. Pemba is separated from the mainland by a deep channel (800 m), while Unguja is separated by a relatively shallow channel whose depth is less than 65 m. Unguja is situated on the continental shelf, while Pemba is located off the continental shelf. There is also a small oceanic island, Latham Island (or Fungu Mubarak) that is under the jurisdiction of Zanzibar.

All these sites, and numerous smaller islands and sand banks that fringe the coasts of Pemba and Unguja, support coral reefs, contributing to varied and rich assemblage of corals and associated reef communities. VPO (2012) estimates coral covers 218,596 km^2 around Zanzibar (around 90 km^2 of living coral) and important sites around Chumbe Island Coral Park, Pange, Bawe, Changuu Island, as well as island sites around the north and northwest of the island (Kichwani, North Mnemba and Kendawi Reef and Pemba).

Zanzibar's reefs support about 150 species of scleractinian corals. The reefs of Pemba are among the healthiest, most diverse and important in East Africa (Grimsditch et al. 2009). Highest hard coral cover (86%) and the coral diversity (42 genera) were recorded in the no-take zone at Misali Island (facing the Pemba Channel), while degraded sites such as Paradise and Fundo Outer had low coral cover (3% and 5% respectively), low coral diversity (23 and 33 genera respectively), dominated instead by rubble and turf algae.

Tanzania's reefs (including those of Zanzibar) are one of the most productive and diverse marine ecosystems in Tanzania waters with over 500 species of commercially important fish and numerous invertebrates (e.g. sea cucumbers, lobsters, octopus), providing fishing grounds to 95% of artisanal fishing (ASCLME, 2012) and supporting 70% of the artisanal fish yield.

The Zanzibar coast also contains numerous small islands; some are raised fossil coral platforms and others sandbanks, mostly fringed by coral reefs. They include Chapwani, Kibandiko, Changuu, Bawi, Chumbe, Misali, Latham and Mnemba off Zanzibar. The west coast of Pemba Island is a unique indented coast fronted by low lying Pleistocene coral islands. Pemba has 50 islets, of which 37 are inhabited, and the ones on the west coast harbour characteristic deep water coral reefs. These islands support some terrestrial vegetation and fauna (including, for instance, the giant coconut crab, *Birgus latro*), but do not support human settlements due to the unavailability of freshwater, though fishermen may visit them for short periods. Some of these islands are critically important for the nesting activities of turtles and birds.

Reef health for Zanzibar is likely to be degraded overall, mainly due to minor but long-lived damage from anchoring and over-fishing, except for the few less accessible and deeper areas i.e. on the west and especially east coasts of Pemba and the core areas of protected reefs (e.g. Chumbe, Misali). Coral cover has diminished by half from 1997 to 2002 (MACEMP, 2009, quoting Obura et al., 2002). The most degraded coral reefs are those found in shallow waters (1-10 m), especially near urban centres of Stone Town, Mkoani, and much of the east coast of Unguja. Over the past few decades, a number of factors have contributed to the degradation of coral reefs. The closeness of the reefs to land make them particularly prone to human impact, either from exploitation or from indirect terrestrial influence such as sedimentation and pollution. Many of the reefs were severely affected by the coral bleaching event of 1997-1998 that reduced the average live coral cover from 52% before bleaching to about 27% after the event (Wells et al., 2004). Follow-up assessments and monitoring indicated that although the impacts were not uniform, generally recovery has been very slow (Mohammed et al., 2002).

Seagrass and algal beds

Zanzibar has extensive sea grass meadows, which provide many ecosystem services, including binding elements for sediments and as fish habitat and substrate provision for nursery, spawning, refugia, food and foraging areas as well as nutrient recycling, dampen strong wave actions and slowing water currents (NEMC, 2009). Through their root base, seagrasses filter and bind sediments and thus prevent sedimentation over coral reefs hence protecting the shoreline from erosion (Saada 2005). They also enhance primary productivity, and a vital food source for turtles and dugong. International studies estimate these meadows have high ecosystem service value (Bjork et al, 2008). At the local level they are important for invertebrate harvesting, which is a source of food security and provision of cash income for women/children on Zanzibar (Nordlund et al, 2010). They have important linkages to corals and mangroves.

Over 300 species of seaweed and 12 species of seagrasses are found in Zanzibar, playing an important ecological role as habitat for micro-organisms and fish. Seaweed farming is important in Zanzibar, but to a lesser extent on the mainland (see Fisheries, page 18). Seagrass in Zanzibar waters are typically found in the coastal fringing reefs and bays. The most extensive seagrass beds are found in sheltered, shallow bays. On Unguja's east coast Chwaka Bay is fed by three main freshwater creeks, fringed by mangrove forest, extending onto vast areas of seagrass and calcareous *Halimeda* algal beds. Chwaka Bay studies have shown the importance of the area as nursery grounds as well as feeding areas for various marine life forms, particularly fish and crustaceans (Gullstrom et al., 2012). The precise areas covered by seagrass beds and the relative species densities for the rest of Zanzibar waters are not well known (Whitney et al. 2003).

Birds life

The avifauna of the whole of Tanzania includes a total of 1,108 species of which 23 are endemic, 4 have been introduced by humans, and 43 are rare or accidental, with 36 species which are globally threatened (http://en.wikipedia.org/wiki/List_of_birds_of_Tanzania). The islands of Zanzibar house far fewer species, mainly because they are very small in surface area and of far

fewer habitats than the mainland. Nevertheless, a wide variety of coastal birds and seabirds are found particularly in mangrove forests, intertidal flats and on rocky cliffs of Zanzibar. Waders and shorebirds visit Zanzibar in large numbers each year between August and May to feed on intertidal flats during low tides. There are five Important Bird Areas (IBAs) designated by Birdlife International on Zanzibar (one on Pemba, three around Unguja and one at Latham Island) (Baker, N.E. and Baker, E.M, 2002). The uninhabited island of Latham, is important internationally as a seabird nesting site for the only major seabirds in East Africa – greater nested tern, masked booby, brown noddy, sooty terns, and others. Coastal villagers occasionally harvest eggs and chicks from shorebirds (e.g. nesting reef herons) though the impact on numbers is very low.

Marine mammals

Whales, dolphins and dugongs are some of the marine mammals that frequently occur in the marine coastal waters of Zanzibar. There are at least 33 species of marine mammals reported from the wider Western Indian Ocean (Berggren, 2009). The following are the species most likely to be present at any time: Sperm whale, Humpback whale, Indo-Pacific bottlenose dolphin, Indo-Pacific humpback dolphin, Spinner dolphin and Spotted dolphin. Humpback whales are regularly observed near the coast during their migration season between July and November.

Dolphins are observed around northern Unguja with the two most commonly observed species being the Bottlenose and Indo-pacific humpback dolphins, either of which is likely to visit the waters of Blocks 9 - 12. A resident population of 200 - 250 bottlenose dolphins lives around the southern end of Unguja Island (Berggren, 2009). Stranding of 600 individual oceanic Bottlenose dolphins occurred in northern Unguja in April 2006, with possible explanations varying from lack of familiarity with shallow, tidal habitats, to echo-location system damage by noise seismic surveys or from tectonic plate movements that produce load sonic releases (Beggren, 2009).

In 2009, a team of scientists from the Institute of Marine Sciences (Zanzibar) and Stockholm University have been photographing tail fluke and estimating populations, with 199 individuals recorded from around southern Unguja Island alone. It is thus likely that several thousand Humpback whales pass through Zanzibar waters each year.

The Pemba-Zanzibar channel in northern Tanzania is also recognised as an important dugong habitat (Bryceson, 1981; Korrubel & Cockcroft, 1997; Howell, 1998; UNEP, 2001), although it is believed dugongs in this area are already locally extinct since the last one was reported in 1990 (Chande *et al.* 1994; Cockcroft & Krohn, 1994; Marshall *et al.* 2001).

Prior to the mid-1970s, dugongs were both abundant and widely distributed along the Tanzania coast. Ray (1968) identified Rufiji and Kilwa as the last remaining refuges for dugongs along the Tanzania coast and until recently, dugongs were thought to have disappeared from northern Tanzania - their former stronghold. Recent studies of dugong distribution and migration along the Tanzania coast show that they are associated with areas of extensive seagrass beds particularly in the Rufiji delta and Mafia-Kilwa area which has a viable dugong population. Dugong is one of the most endangered species on the African continent and is on the IUCN Red list (IUCN 2000). In Tanzania, dugong numbers are estimated to be no more than 100 individuals (Ngusaru *et al.*, 2001) and populations have declined significantly in recent decades possibly to the point where they cannot recover.

Marine turtles

Five species of marine turtles occur in Zanzibar's coastal waters. These are the green, hawksbill, loggerhead, olive ridley and leatherback turtles. The first studies on the status, distribution, uses of and threats to turtles in Tanzania were conducted by Frazier (1976, 1980). However, it was not until the early 1990s that more widespread efforts to conserve turtles began on Zanzibar and

later on the mainland, where recently comprehensive surveys were conducted in Mafia, Saadani, Temeke and Mtwara.

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

The green turtle is the most common nesting species in Zanzibar, with population sise estimates from the mid-1970s putting the total number in the whole of Tanzania at approximately 300 and more recent nesting data from Sea Sense (www.seasense.org) for 2012 nesting, reports 382 Green turtle nests (almost half (163) on Mafia Island), with 120 recorded on Temeke beaches and 98 in Pangani. There is no recent nesting data for Zanzibar. However, it is known that green turtles nest on Zanzibar's beaches all year round usually with a noticeable peak in nesting activity between April and May each year. There is concentrated nesting activity on Misali Island (Pemba), Mnemba and Matemwe Island (Unguja) (Khatib, 1998a, 1998b; Pharaoh et al,. 2003). Evidence from tag returns indicate that some green turtles are probably resident while others are highly migratory, moving to other nesting and feeding grounds in Kenya, Seychelles, Comoros, Mayotte, Europa Island and South Africa.

Hawksbills are also widely distributed but are less abundant, with few records from small remote islands off the mainland coast (Muir, 2005). The main nesting season is during the North East monsoon between December and April. On Misali Island, on the western coast of Pemba Island, 42 hawksbill nests were recorded between 1998 and 2002, peaking during the month of March. Hawksbill is a migratory species and Tanzania and Zanzibar waters harbours both residents and migrants (Muir, 2005).

The three other species are present in far fewer numbers. These include Olive Ridley turtles that used to nest on Maziwe Island south of Tanga in the mid-1970s but after submerged ad no further nesting records for this species have been made (Muir, 2005), though local fishermen note that they are occasionally accidentally caught in gillnets along the Mtwara, and Mnazi Bay Ruvuma Estuary Marine Park. Loggerhead turtles are relatively rare in Tanzania and Zanzibar water, though at least one tagged animals was caught in southern Unguja and released, having been tagged at her nesting grounds in Tongaland and Natal in South Africa. The leatherback turtle used to nest in Zanzibar in the 1970s (Frazier, 1976), but few specimens have been seen since, and those that are present may be migrating to nesting sites in Natal, South Africa.

Zanzibar's inshore waters have extensive seagrass beds and coral reefs which can support considerable numbers of turtles (Howell & Mbindo, 1996), particularly off the southern Rufiji Delta (Kichinja Mbuzi and Toshi) including Mohoro Bay (Fungu ya Kasa) and around Mafia Island. In Mtwara, important turtle foraging habitats exist in Mnazi Bay and off Msimbati (Guard, 1998; Muir, 2003).

Issues

Increasing degradation of the ecosystems due to anthropogenic activities including destructive fishing methods and overexploitation are evident, especially where there has been rapid increase in coastal populations. High pressure on finite coastal natural resources has resulted in degradation of critical coastal ecosystems with the potential to reduce the ecosystem goods and services offered (e.g. from coral reefs and seagrass beds). This has the potential to affect the socio-economic livelihoods of the local communities in Zanzibar.

In addition to intensity of resource extraction, water and coastal pollution are increasing along the Zanzibar shores. Increased economic activities and expanding populations in Zanzibar (especially Unguja Island) have resulted in production of large amount of waste including

sewage and industrial effluent. Domestic wastewater is discharged into septic tanks, after which the overflow combines with storm water and gets finally disposed into the sea. At present (2012) large quantities of sewage, estimated to be more than 2,200m^3/day, are discharged into the marine environment without effective treatment (RGZ 2013). Away from coastal towns, pollution of coastal waters is caused by fertiliser residue contained in run-off from agricultural areas, with evidence of nutrient enrichment (ASCLME, 2012).

Economic importance

The coastal and marine resources of Zanzibar provide an extremely valuable source of food and other commodities to the local populations and those inland. The economic importance of fish, seafood, farmed seaweed, harvested mangrove products and the value of these ecosystems to the tourism sector have been described in other themes.

Less simple to define in economic terms but often clear to envisage are the value of estuaries, fringing corals reefs and seagrass beds, and the presence of marine mammals, turtles and coastal birds. Estuaries are clearly critical to the survival of tens of thousands of birds, mammals and fish. Many different habitat types are found in and around estuaries, including shallow open waters, freshwater and salt marshes, sandy beaches, mud and sand flats, rocky shores, oyster reefs, mangrove forests, river deltas, tidal pools, sea grass beds, and wooded swamps (Muhando, C. and Rumisha, C.K., 2008). Being protected from strong waves and currents, they function as recreational and educational sites. Estuaries serve as nursery grounds for many commercial fish and shellfish. Estuaries are also home to all the main ports of Pemba that support shipping and diverse commercial activities.

Coral reefs and associated seagrass beds support over 70% of the artisanal fish production in Tanzania (Saada, 2005) thus supporting the majority of Zanzibar's full time fishermen, with a sustainable yield estimated at 15 tonnes of fish per km^2 (Munro and Williams, 1985). Coral reefs also provide a natural barrier to waves and storm surges that protect the shores from erosion. Corals have been a source of lime and building rocks for centuries, though the excavation of living coral is now forbidden as it conflicts with the protection of reef for their productivity and shoreline protection services. Zanzibar's coral reefs are of vital importance to the tourism industry (see Tourism, page 39).

The diversity and abundance of coastal bird life, marine mammals and turtles, and rare and iconic fish such as whale sharks and coelacanths, though without direct monetary value are important in focusing international attention of the Zanzibar coast, thus a potential boost to the tourism sector, but also to the role and duty of Zanzibar (and mainland Tanzania) towards international obligations related to biodiversity and endangered species conservation.

Socio-economic importance

The coastal habitats described above (coral reefs, seagrass beds, estuaries, beaches and rocky shores) provide the environment from which diverse resources are harvested by a large number of the coastal population. These have been described in other themes.

Coastal communities have consumed marine mammals for centuries, though they have rarely been the target of any specific fishery. Recently, a more focused fishery for dolphins and turtles has been reported, albeit in low numbers, using gill-nets, mainly for food or bait. Conversely, the resident population of dolphins off the southern shores of Unguja is critical to the livelihoods of those in the "dolphin tourism" sector based at Kizimkazi since the late 1990s.

Thus the coastal habitats is of socio-economic importance for non-consumptive use by the tourism industry in Zanzibar, which on specific reef sites is able to generate considerable value to the local community.

The local trade in turtle meat in Pemba was an important and lucrative business in the past, and despite being a signatory to the CITES, with ceremonial burning of turtle shells in Zanzibar in 1995, and successfully reducing export markets for turtle products, some trade in tortoise shell and other products is likely to continue albeit on a minor scale compared to that of the early 1990s.

Threats to coastal communities relying on sector for livelihoods

The principal threats to those engaged in the exploitation of the coastal resources and to the wider coastal environment are described below:

- **Poor management** of the shores (e.g. coastal developments) and lack of understanding of coastal erosion leading to loss of shoreline.
- **Illegal (destructive) fishing** damaging seaweed, seagrass beds and coral reefs[30].
- **Tourist activities** damaging seagrass beds and coral reefs[31].
- **Poor upstream agriculture on Pemba** affecting seaweed and seagrass productivity[32].
- **Waste disposal**, in solid and liquid form causing harm to seagrass beds and estuaries[33].
- **Coral bleaching** from El Nino sea surface temperature rise damaging coral reefs.
- **Nutrient run off and pollution**, negatively affecting sea grass meadows.
- **Overharvest of invertebrate marine life** negatively affecting sea grass meadows.
- **Pollution through nutrient enrichment**, particularly from sewage disposal, altering the structure of coral reef ecosystems[34].
- **Sedimentation of coral reefs** from river discharges, sewage discharges and dredging.
- **Habitat alteration** form land use changes[35].
- **Introduction of invasive species** can often result in unexpected ecological, economic, and social impacts on the estuarine environment.
- **Invasive Indian house crow** causing loss of bird diversity through ferocious predation on eggs of local bird species thus threatening indigenous populations.
- **Gillnetting** threatening turtles (adults and sub-adults).
- **Gillnetting** threatening whales, especially migrating Humpback whales and dolphins.
- **Seismic surveys** by oil and gas companies deterring whales, especially migrating Humpback whales with calves.

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[30] e.g. beach seining, dynamite fishing

[31] e.g. trampling when wading, boat anchorage

[32] Agriculture practises increase sediment loads, and turbidity thus reducing photosynthesis, especially during the west season.

[33] Debris comes from many sources, including improper disposal of trash on land, storm water runoff and combined sewer overflows to rivers and streams, ships and other vessels.

[34] Through the overgrowth of algae and shading from increased algae production in the water column.

[35] Filling of marshes and tidal flats (e.g. conversion to salt works), and reconstruction of shorelines to accommodate the needs of development, transportation, and agriculture, can degrade estuaries and creeks.

CRIAM Ranking of Threats to Local Communities associated with Natural Resources

Table 22: Prioritisation of threats to local communities and ecosystems associated with natural resources. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_NatRes_02	Illegal (destructive) fishing damaging seaweed, seagrass beds and reefs.	Natural Resources	3	3	3	2	3	72	5					
Z_NatRes_13	Invasive Indian house crow causing loss of bird diversity through predation on eggs of local bird species thus threatening indigenous populations.	Natural Resources	3	3	3	2	3	72	5					
Z_NatRes_01	Poor management of the shores (e.g. coastal developments) and lack of understanding of coastal erosion leading to loss of shoreline.	Natural Resources	3	3	3	2	2	63	4					
Z_NatRes_14	Gillnetting threatening turtles (adults and sub-adults). Gillnetting threatening whales, especially migrating Humpback whales and dolphins.	Natural Resources	3	3	3	2	2	63	4					
Z_NatRes_17	Predation and disturbance of turtle nesting sites	Natural Resources	3	3	3	2	2	63	4					
Z_NatRes_06	Coral bleaching from El Nino, sea surface temperature rise damaging reefs.	Natural Resources	3	3	2	2	1	45	4					
Z_NatRes_09	Pollution through nutrient enrichment, particularly from sewage disposal affecting the structure of coral reef ecosystems.	Natural Resources	2	3	3	2	2	42	4					
Z_NatRes_11	Habitat alteration from land use changes (salt pans in mangrove areas, shoreline alterations and inundation).	Natural Resources	2	3	3	2	2	42	4					
Z_NatRes_05	Waste disposal, in solid and liquid form causing harm to seagrass beds and estuaries and lagoons.	Natural Resources	2	2	3	2	3	32	3					
Z_NatRes_08	Overharvest of invertebrate marine life negatively affecting seagrass habitat.	Natural Resources	3	1	3	2	1	18	2					
Z_NatRes_03	Tourist activities damaging seagrass beds and coral reefs.	Natural Resources	1	2	3	2	3	16	2					
Z_NatRes_16	Seismic surveys by oil and gas companies deterring whales, especially migrating Humpback whales with calves.	Natural Resources	1	3	2	2	1	15	2					
Z_NatRes_10	Sedimentation of coral reefs from river discharges, sewage discharges and dredging.	Natural Resources	1	2	2	2	1	10	2					

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_NatRes_04	Poor upstream land use affecting seaweed and seagrass productivity.	Natural Resources	1	1	2	2	1	5	1					

Vulnerability to Climate, Climate Variability and Climate Change

The Zanzibar economy is very dependent on the climate and a large proportion of GDP, employment and livelihoods are associated with climate sensitive activities such as fishing, and farming. The specific vulnerabilities of the coastal ecosystems and species described above and those that utilise them, can be summarised under the principal climate change areas:

Changes in Weather Patterns (precipitation, and water availability)

- Run-off and river flows affecting salinity and siltation and thus fisheries productivity in coastal ecosystems (coral reefs and seagrass beds), including breeding grounds.
- Unseasonal precipitation affecting various activities[36].
- Changes in wind pattern will thus change fishing behaviour.

Extreme Weather Events

- Fishing effort reduced due to limited access to fishing grounds in small vessels.
- Boats moorings/fisheries infrastructure (landing sites, villages) affected by erosion.

Sea-Level Rise

- Combined with extreme weather events (above) sea level rise will increase beach erosion, threatening coastal infrastructure.
- Erosion of beaches threatening turtle nesting sites.
- Erosion threatening nearshore marine habitats (from smothering from suspended particles in the water column, as well as from reduced light penetration).

Seawater and Air Temperature Rise

- Alteration of marine biodiversity, possibly resulting in extinctions and/or species migration, potentially affecting coastal fisheries.
- Warmer waters can favour plankton transition and enhance fish growth rates.
- Coral bleaching is temperature related.

Seawater Acidification

- Increasingly acidic will have major effects on shell-forming organisms[37].

Outlook

The pragmatic outlook on the coastal ecosystems of Zanzibar is that most areas, especially those close to large urban centres (particularly Stone Town, parts of the east coast of Unguja, close to the main ports of Pemba) are experiencing such a level of degradation from various anthropogenic impacts that the current pressure is damaging their integrity and productivity.

Unfortunately these areas represent a relatively large portion of the total coverage of the coastal ecosystems, some 70-80%. Consequently, at present, the bulk of the natural coastal environment is being over-harvested, damaged by destructive fishing gears, or acutely polluted from riverine, urban or agricultural sources. The focus is to conserve or boost the productive status of much of the coastline, through education and reduced population pressure and impact.

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[36] e.g. seaweed farming and drying (affect quality of the dried product)

[37] CO_2 is absorbed by water to become carbonic acid, causing pH to drop, is expected to have major effects on shell-forming organisms (notable corals and molluscs).

13 FRESHWATER RESOURCES

Introduction

Zanzibar receives a relatively high annual rainwater volume (1,916 mm on Pemba and 1,565 mm on Unguja) (Francis et al. 2001), which exceeds demand, though much of this is lost from run-off to the ocean or through evapotranspiration. Current usage rates are around 1% (RGZ 2007). Despite not significantly different rainfall volumes, marked differences exist between the two islands, with small rivers present on Pemba Island from where water is extracted, to Unguja Island devoid of surface water. On the latter, water resources are derived from seasonal rains that filter through the island's limestone rock and are stored in aquifers comprised of a freshwater lens floating on the underlying seawater (Gossling 2001). Water is therefore extracted from either shallow wells (usually by hand) or pumped from deeper boreholes or caves.

Water resources are critical to Zanzibar's population, its economy (key to the agricultural sector and for the tourism industry). The water in mainland Tanzania's rivers and reservoirs generate over half of the country's grid electricity through hydropower installations, which contribute to the power supply to Zanzibar. Tourism demands for freshwater are high and peak during the dry season. Unlike mainland Tanzania, groundwater (in aquifers) is the major source of drinking water on Zanzibar. Zanzibar is challenged by a high degree of water resource variability both spatially and temporally.

The deep soils on the western parts of Unguja and Pemba have a good structure and precipitation levels are more than double the potential evapotranspiration. These areas are the focus of agricultural productions (e.g. food crops, trees and cash crop) despite seasonal reductions in output due to water scarcity. The water scarcity could be remediated through rainwater harvesting and storage.

Management of the Sector

The Department of Water is entrusted with the responsibility of developing and managing water resources of the country. In 2004, the government published the National Water Policy, a ground-breaking document that changed the approach in the use of water from being available at no cost (though some hotels and guesthouses were charged a monthly tax which was unrelated to level of use). Gossling (2001) quotes an engineer from the Department of Water "Groundwater is an open access resource on Zanzibar, which is provided free to the urban areas and villages by the Department of Water. Usually it is abstracted from suitable locations (springs and caves) and supplied untreated via pipes to public taps and households". In principle the Government holds the formal ownership of water by enacting laws to govern water related affairs.

The National Water Policy makes a number of important declarations, of relevance to management being that water resources shall be allocated to the different users in such a way that benefits to the community are maximised and in a way that both actual and potential users get a fair share, using an integrated approach. The National Water Policy recognised the need to set up the Zanzibar Water Authority (ZAWA) and this body was established in 2006. The Water Act of 2006 details the remit of the authority and requires all water users to register their supply and accept a charge for usage. There are differing charges for usage depending on whether the user is domestic or commercial and there are scaled charges according to level of usage. These details are given in the Water Regulations (Amendment) of 2008. The Water Regulations of 2007 give instruction on all water issues including on the requirement for monitoring of a source, the responsibility for leakages, installation of water meters, definition of small, medium and national water projects, on environmental protection and on conservation of water catchments, water sources and other water facilities, on the selection of appropriate and feasible water supply and

sanitation technologies which are environmentally friendly, and on committee and company registration. The latter regulation (no. 85) is significant in that it allows for the operation of 'an acceptable community water committee' which 'operate and maintain waterworks under special agreements with the Authority'. The Policy recognises that 'involving the community right from the project inception, or even better responding to their needs and planning with them will increase their sense of ownership and responsibility'. It goes on to say that the establishment and consolidation of water committees and other similar community organs at different levels need to be promoted.

Description of Freshwater Resources and their Use

Total water withdrawal by the domestic sector and irrigation in Zanzibar is estimated to be about 42 million m^3. Of this, withdrawal on Unguja Island is 33 million m^3 and on Pemba Island it is 9 million m^3 (Kashaigili, 2010).

Pemba has small surface water streams because the valleys are flat bottomed and filled with eroded silt clays and sand. The island does not have any major aquifers, and the aquifers lack transmissive structures and thus are only suitable for small local supply schemes.

Unguja Island has large underground aquifers, which are the main sources for drinking water, being from natural springs, limestone caves, hand dug wells and boreholes tapping the (shallow) aquifers. The aquifers are recharged by rainfall, and the overflow discharges to the sea preventing saltwater intrusion. There is not much detailed information on the shape and sise of Zanzibar's aquifers (Kashaigili, 2010), though studies carried out in the early 1990's estimated the total annual acceptable yield of the Unguja aquifer is about 50% of the total recharge i.e. 290 Mm^3 per annum (Zanzibar Water Policy, 2006).

Rain harvesting

During the rainy season it is common practice to collect rainwater in all villages. The rainwater is mainly used for dishes and laundry because it is very soft compared to the well water, but can also be as a source of agricultural water and could provide an additional service of storage as a buffer against greater intra-seasonal rainfall variability. In Zanzibar, in particular, rainwater harvesting has been identified as cost effective measure. One study (MDG Centre et al., 2007) estimates the cost at USD 2.4 million for runoff catchment systems and USD 1.2 million for rooftop rainwater catchment. The RGZ collaborative study (2007) assessed the potential for rainwater harvesting on Zanzibar, as part of an Integrated Water Resources Management plan. The Irrigation Master plan (MANREC, November 2006) attaches great importance to harvesting and storing rainwater for irrigation purposes. There are good examples of rainwater harvesting schemes on Pemba. Community Forests International and Community Forests Pemba have built a rainwater harvesting project (250,000 litre water storage tank at a school) on the islet of Kokota off Pemba.

Issues

Despite the potential water availability, the Zanzibar public water system has a supply–demand gap on both islands. Many studies (SMOLE, 2010) highlight the inefficient use of water and losses in the pipeline system are very high (e.g. 35- 40% on Unguja).

Anthropogenic activities related to demand for water for irrigation, livestock, land use changes and tourism needs have contributed to degradation of the groundwater reserves mainly through over extraction. An investigation into the causes and consequences of water abstraction by the tourist industry shows that present levels of withdrawal are not sustainable, and parts of the local populations, especially on the east coast of Unguja, are already experiencing water deficits on a daily basis (Gossling 2010).

As a result of problems of water supply, both conflict and cooperation have been reported between hoteliers and villagers in coastal villages on Unguja, with very severe conflict with demonstrations in Kiwengwa and villagers resorting to cutting pipes in both Nungwi and Kiwengwa, while cave sources in Kiwengwa are guarded 24 hours a day by hoteliers and supply pipes to hotels in Nungwi from private boreholes are also patrolled regularly (Tourism Concern 2011).

One of the key issues in recent years has been the salinisation of shallow water wells (Figure 2), the only source of domestic water supply in many areas (Hansson (2010). The URT NAPA (URTc, 2007) attributed this to rising sea levels, though the ZAPA (SMOLE, 2010) considers the reported lowering of some ground water levels is probably due to more intense abstraction of water (though possible higher rainfall run-off and lower groundwater recharge could be a factor). ZAWA reports declining production in some of its supply wells but this could be attributed to a number of reasons (a number of aquifers are recharged by rainfall and at least one is very responsive to rainfall). The recognition of saltwater intrusion had led to the identification of a priority pilot adaptation project on Unguja Island which constructed a new water pipeline to supply villagers in the Nungwi Peninsula whose traditional sources of fresh water have been affected by salt water intrusion, as well as the localised demand increases from the tourism sector.

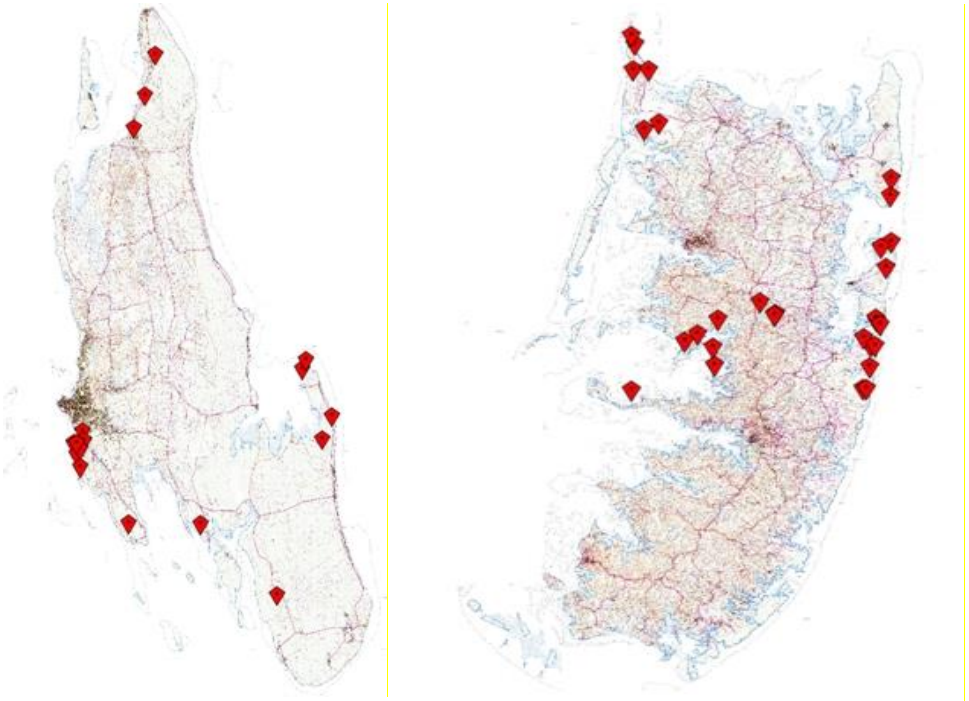

Figure 2: Documented saltwater intrusion sites on Unguja (left) and Pemba (right) (DoE/SMOLE 2013, cited VPO, 2012).

Economic importance

The importance of Zanzibar's freshwater resources cannot be underestimated. In monetary terms it is difficult to quantify, yet it provides drinking water for the entire population, for industrial production, for the tourism sector and is critical for agriculture. Adequate water flows support Pemba's forests, and coastal resources, which provide provisioning services (such as food, fodder, fuelwood, timber and other products) and other services (water purification, climate regulation, cultural and supporting services). Water flows in national parks and protected areas support the tourism sector, a key foreign exchange earner.

Socio-economic importance

The freshwater supplies of Zanzibar are possibly the single most valuable resource to the population, the economy and agriculture. Several hundred jobs are related to the management of the water, typically in the water authority and in NGOs engaged in water conservation.

Threats to coastal communities relying on freshwater for livelihoods

The principal threats to those reliant on freshwater systems and to the wider wetland environment are described below:

- **Inefficient management of piped water supply** leading to leaks and loss of water.
- **Increased demand from tourism sector** exceeding supply.
- **Inefficient management of water bodies on Pemba,** leading to removal of riverine vegetation, erosion of riverbanks, pollution of water bodies from municipal waste dumping, agricultural practices or mining (minerals and river sand) or abstraction for water for agriculture (or livestock).
- **Corruption within management** wasting water or revenues from water usage.
- **Degradation of catchments** due to land use changes and livestock keeping.
- **Population and economic growth** leading to increasing demand for freshwater.
- **Pesticide and waste water pollution of aquifers** on Pemba and Unguja from poor agricultural practices, or pollution from municipal waste dumping or inadequate sewage systems.
- **Lack of information** on climate change and its impacts on Zanzibar's aquifers.
- **Lack of updated data on current river discharges on Pemba and aquifer recharges on both islands** leading to failure to comprehensively control water supplies.

CRIAM Ranking of Threats to Local Communities associated with Freshwater Resources

Table 23: Prioritisation of threats to local communities and ecosystems associated with freshwater resources. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_Fresh_06	Population and economic growth leading to increasing demand for freshwater.	Freshwater Resources	3	3	3	2	2	63	4					
Z_Fresh_05	Degradation of catchments due to land use changes and livestock keeping.	Freshwater Resources	3	2	3	2	2	42	4					
Z_Fresh_09	Lack of updated data on current river discharges on Pemba and aquifer recharges on both islands leading to failure to comprehensively control water supplies.	Freshwater Resources	3	2	3	2	2	42	4					
Z_Fresh_08	Lack of information on climate change and its impacts on Zanzibar's aquifers.	Freshwater Resources	3	2	3	2	1	36	4					
Z_Fresh_02	Increased demand from tourism sector exceeding supply.	Freshwater Resources	2	2	3	2	2	28	3					
Z_Fresh_03	Inefficient management of water bodies on Pemba, leading to removal of riverine vegetation, erosion of riverbanks, pollution of water bodies from municipal waste dumping, agricultural practices or mining (minerals and river sand) or abstraction for water for agriculture (or livestock).	Freshwater Resources	2	2	2	2	2	24	3					
Z_Fresh_01	Inefficient management of piped water supply leading to leaks and loss of water.	Freshwater Resources	3	1	3	2	2	21	3					
Z_Fresh_07	Pesticide and waste water pollution of aquifers on Pemba and Unguja from poor agricultural practices, or pollution from municipal waste dumping or inadequate sewage systems.	Freshwater Resources	2	1	2	2	2	12	2					

Vulnerability to Climate, Climate Variability and Climate Change

The analysis of impacts is challenging due to the high uncertainty from the climate models in terms of average, seasonal and daily trends of future precipitation. Rainfall patterns and water flows projection vary widely, including both spatially and temporally within seasons. The potential future impacts of climate change include:

Changes in Weather Patterns (precipitation, and water availability)

- Unpredictable rainfall affecting water supply and water balance, thus affecting surface water and groundwater recharge and likely to exacerbate water supply problems.
- Increased pressure on water resources due to the potential decreases in rainfall during the dry season, when tourist demand is highest.
- Changes in flows affecting water quality and wastewater treatment.
- Unpredictable rainfall affecting water supply and water balance, thus affecting surface water and estuarine discharges and ecological and sediment processes.

Extreme Weather Events

- Affecting surface water on Pemba, estuarine discharges, ecological and sediment processes, potentially exacerbating catchments erosion, riverbanks, estuaries and shores.

Sea-Level Rise

- More extreme saltwater intrusion of wells and aquifers.

Seawater and Air Temperature Rise

- Household and tourism water demand increases with higher temperatures.[38]
- Agricultural water demand increases with higher temperatures, due to the combination of evaporation and plant transpiration rates.

Seawater Acidification

- No impact.

Outlook

In the future, if the expected increase in tourist numbers on Zanzibar occurs, the pressure on the aquifers will correspondingly increase. The results could be that tourism on the east coast of Unguja becomes unsustainable, which could have an adverse effect on the national economy and also on the local population and environment. The future outlook is clearly one of insufficient water to meet the needs of the population, particularly the large urban centres on the coast (Stone Town, Mkoani and Chake Chake) as well as in the drier eastern coral rag areas where local water supplies are least abundant and tourism resorts more dense than elsewhere.

A new climate-future-proof water supply system has been designed for Stone Town, and provided funding will materialise as expected from AfDB the supply system will be upgraded in 2013-2015. JICA is also supporting the water sector in Zanzibar (ZAWA), with TA support and investment funds. The two AfDB projects also include some additional borehole drilling, a monitoring system, and integrated water management. There are also some early pilots on rainwater harvesting, as well as studies of price structuring which could encourage water efficiency. There are also a number of small desalination plants on Zanzibar in some tourist hotels for supply of drinking water. Two solar desalination units are being piloted for remote communities, one of them on a small island of the Pemba coasts.

[38] Higher consumption, use in shower, garden irrigation, evaporation from swimming pools, etc.

14 MANAGEMENT FRAMEWORK FOR COASTAL ZONE MANAGMENT

Introduction

This overview provides a summary of the institutions, principle laws and technical/research facilities charged with the responsibility for management of the coastal zone of mainland Tanzania. The present population on Zanzibar is approximately 1 million and there are myriad ways in which these citizens interact with the marine environment – the challenge is the means to manage these interactions so as to promote sustainability and prosperity.

Management of the Sector

There are over twenty national legislation documents with particular relevance to coastal and marine resources and environment management. As described in the preceding thematic sections, these, relate to natural resources, maritime transport, waste management and pollution, water resources, forestry and agriculture, urbanisation, infrastructure, industry and others. An additional ten to twenty international conventions to which Zanzibar is signatory (either independently or though the Union) are also relevant to the coastal zone. Financial and human resources have constrained the effective implementation of the diverse legislative mechanisms from operating at their full capacity, and some of the legislation is in need of update.

It is hoped that in the long run the implementing agents of these laws and policies will be allocated sufficient funds to enable them to improve enforcement operations. Zanzibar is still in the process of implementing reforms in its legal sector; old and outdated laws are repealed and replaced by new ones, while the current trend in the enactment of new laws indicates a great likelihood that there will eventually be a strong enforcement machinery (ASCLME, 2012).

The implementation of the legal instruments related to the regions begins with central government authorities, directed to regional authorities and in some cases devolved to the district authorities for implementation. At various stages along this process, additional stakeholders may become involved, from international funding agencies interacting with central government ministries, and security services, to local non-governmental organisations and private sector groups working on the ground with local authorities.

Description of Management Framework

The National Assembly of the United Republic of Tanzania, which includes members from Zanzibar, legislates on all 'Union matters' set out in the Constitution. All matters not listed, referred to as 'non-Union matters', such as environmental protection and management are within the exclusive jurisdiction of the Zanzibar Government and its legislative body, the House of Representatives. Thus Zanzibar and mainland Tanzania have different legal regimes regulating environment management.

Unguja has three administrative regions: Zanzibar Central/South, Zanzibar North and Zanzibar Urban/West. Pemba has two: Pemba North and Pemba South. On Zanzibar urban authorities are made up of town councils and municipalities, while rural authorities comprise of district councils.

There are ten districts and 236 shehias, Each region is run from a regional council and each region is divided into two districts; i.e., there are six districts in Unguja and four districts in Pemba.

At the head of each district administration is a District Commissioner appointed by the President and there is also a District Administrative Officer in charge of the district administration. In

addition, every district has a planning officer, a community development officer, as well as officers from sectoral ministries assigned to the district. District councils have autonomy in their geographic area, their councils coordinate the activities of the village councils, which are accountable to the district for all revenues received for day to day administration. The village and township councils have the responsibility for formulating plans for their areas.

The National Assembly of the Union, which includes members from Zanzibar, legislates on all 'Union matters' set out in the Constitution. In contrast, all matters not listed in this Schedule (i.e. referred to as 'non-Union matters') concerning Zanzibar are within the exclusive jurisdiction of the Zanzibar Government and its legislative body, the House of Representatives. Since matters relating to environmental protection and management are not listed as 'Union matters', Zanzibar and mainland Tanzania have different legal regimes regulating environment management at a domestic level.

The main piece of legislation regulating environmental issues is the Environmental Management for Sustainable Development Act (No. 2 of 1996). It was developed with the objective of protecting and managing the country's environmental assets, such that their capacity to sustain development is unimpaired and Zanzibar's rich environmental endowment is available for present and future generations to use and enjoy. The EMSD Act also places a duty on each and every person to promote the purposes of the Act, which includes inter alia, maintaining basic ecological processes of land, water and air, ensuring an environmentally sound and healthy quality of life for Zanzibar residents and strengthening institutional capabilities for protecting the environment.

In addition, the Act provides for the establishment of three institutions tasked with the implementation of environmental provisions set out in terms of the Act, namely, the Ministry of Agriculture, Natural Resources, Environment and Cooperatives (MANREC), the Committee of the Revolutionary Council on Environment; and the Department of Environment. Further details on the roles and responsibilities of the above-mentioned environmental institutions are provided below (Table 24).

National and sector plans and strategies

There a numerous plans and strategies within Zanzibar's ministries that are directly relevant to the livelihoods and environment of the coastal zone, most of which are described in the individual sectoral overviews.

Natural Resource Research and Non-Governmental Organisations

A diverse range of institutions plays important parts in the preservation of the coastal environment on which hundreds of thousands of Zanzibar livelihoods depend. A brief description of competent bodies involved in development control and environmental management is provided, together with their roles and responsibilities.

State University of Zanzibar (SUZA)

The SUZA was established by Act No. 8 of 1999. It now has now runs undergraduate and postgraduate programmes. The University scores highly for degree completion rates, and for students achieving good honours degrees (Firsts or Upper Second). The University is the largest provider of professionals to meet the country's growing demands for teachers.

Institute of Marine Sciences, University of Dar es Salaam

The Institute of Marine Sciences is a research and education department of the University of Dar es Salaam, with the mandate to conduct research and offer postgraduate and undergraduate training and consultancy services in all aspects of marine sciences. The IMS vision is to become a centre of excellence in the advancement of knowledge in marine science. The Institute is also

the National Oceanographic Data Centre and holds various coastal and ocean data and information.

Table 24: Institutional arrangement, roles and responsibilities relevant to coastal zone management.

Institution	Roles and Responsibilities
Department of Lands (Ministry of Lands, Housing, Water & Energy)	• Land management • Administration and control
Department of Urban Planning and Surveying	• Urban planning, land use planning, development controland physical standards.
Department of Local Government (Ministry of State for Regional Administration)	• Co-ordination of all aspects related to regional and district administration and local government (village leader (sheha), municipal/village councils) • Special departments: e.g. the Navy
Department of Fisheries and Marine Resources (MANREC)	• Environmental policy, EIA, environmental education, • Research co-ordination for sustainable development.
Department of Environment (MANREC)	• Coordination of all matters related to regional and international conventions and protocols associated with environmental affairs; • Assessing and monitoring the quality of the Environment; • Providing technical arbitration in the course of significant environmental impacts to the society through enforcing the environmental legislation; • Manage and regulate environmental impact assessment requirements and procedures and to facilitate public participation in attaining the objectives of the Act by empowering and encouraging people to protect their environment. • Approval or rejection of EIAs in Zanzibar; • Administer environmental matters, which is connected to other institutional arrangements concerned with Fisheries, Forestry, Lands, Energy, and the Local Government and Regional Administration Authority.
Zanzibar Maritime Authority (Ministry of Infrastructure and Communication)	• Shipping activities, navigation safety and the marine environment.
District Councils	• Formulate, coordinate and supervise the implementation of plans for economic, commercial, industrial and social development; • Ensure the collection of proper utilization of revenue of Council; • Make by-laws applicable throughout its area of jurisdiction; and • Consider, regulate and co-ordinate development plans, projects and programs of villages and township councils within area of jurisdiction.
Shehia; regional and district development committees	• Oversee general development plans for the Shehia • Provide information on local situation extension services • Provide technical support and advice to supervise implementation of government policies, to identify problems, and advise government on ways to solve problems and promote development in their areas; • Monitor and assist in the formulation of policies for local government authorities in their areas and advise on best implementation strategies; • Mobilize people to participate and contribute in all ways to assist in the efficient uses of resources and the protection of environment for sustainable development and in all activities of national development; • Ensure that implementation strategies correspond to relevant policies and to create awareness among the people in their areas on the importance of both; • Ensure and establish understanding, cooperation and coordination among government agencies, local government, NGOs and the people in creating an enabling environment for sustainable development.
Assorted leaders (religious, teachers, traditional chiefs, elders etc); communities groups (farmers, fishers, women, youth, etc).	• Provide information on local social, economic, environmental situation • View on socio-economic value of proposed drilling operations • Acting as watchdog for the environment, ensure well-being of residents and participate in development activities.
WWF, WCS and Care International Local NGO/CBO	• Support, monitoring and management of the conservation area • Mangrove Forest/environment conservation • Socio-economic development in the area • Safeguard of natural environment

WWF Tanzania

WWF, one of the world's largest independent conservation organizations has been actively involved in conservation work in eastern Africa since 1962. As part of an ongoing global structuring, the geographical concentration will be in coastal East Africa focusing at the coast from Kenya to Mozambique. This programme has recently combined conservation and climate change issues, including coastal zone management. On Zanzibar, the focus area has been the Mnazi Bay Conservation Area.

CARE International

The Misali Island Conservation Association (MICA), a local fisher's association, is charged with assisting communities to protect the island and enhance livelihoods. Since 1998, the project has been funded by CARE International.

Wildlife Conservation Society

The WCS Zanzibar Forests Project began as a research initiative focusing on the ecology of the Zanzibar red colobus. It has since evolved into a broad conservation programme that works closely with the Zanzibar government to implement sustainable development and natural forest conservation. Since its inception, and following lobbying by WCS, the Zanzibar government installed speed breaks on the main road adjacent to Jozani-Chwaka Bay Conservation Area.

In 2004, WCS established the first long-term ecological monitoring programmes in two of Zanzibar's most important protected areas, Jozani-Chwaka Bay National Park (JCBNP), Zanzibar's first National Park, and Kiwengwa-Pongwe Forest Reserve (K-PFR), and on the unprotected Islands of Uzi and Vundwe. These programs continue to monitor key flora and faunal species, and human disturbances. In 2006 and in collaboration with communities adjacent to JCBNP, WCS established long-term ecological monitoring programmes in eight village-managed forests under the Zanzibar Forests Project. Nine additional villages were assisted to establish programmes in 2007. Data from these monitoring programmes are now being collected jointly by WCS team members and village volunteers and used to determine scientifically the success of village conservation efforts.

Western Indian Ocean Marine Science Association (WIOMSA)

WIOMSA is a regional professional, non-governmental, non-profit, membership organization, registered in Zanzibar, Tanzania. The organization is dedicated to promoting the educational, scientific and technological development of all aspects of marine sciences throughout the region of Western Indian Ocean (Somalia, Kenya, Tanzania, Mozambique, South Africa, Comoros, Madagascar, Seychelles, Mauritius, Reunion (France)), with a view toward sustaining the use and conservation of its marine resources. The Association has about 1,000 individual members as well as about 50 institutional members from within and outside the region.

The organization's inter-disciplinary membership consists of marine scientists, coastal practitioners, and institutions involved in the advancement of marine science research and development. The Association: (1) provides a forum for communication and exchange of information amongst it members that promotes and fosters inter-institutional linkages within and beyond the region; (2) supports marine research by offering research grants; (3) implements programs to build the capacity of marine scientists and coastal management practitioners; and (4) works to promote policy dialogue on key topics by organizing meetings and seminars on the findings and policy implications of science.

Zanzibar Coastal Conservation or High Biodiversity Areas

Zanzibar's coastline presently includes six marine protected areas (MPAs), managed under Zanzibar Government jurisdiction through the Department of Environment, three Important Bird Areas (IBAs). Zanzibar's MPAs are:

- Misali Island Marine Conservation Area (MIMCA) established 1997
- Pemba Island Conservation Area (PECCA) in 2005
- Mnemba Island Marine Conservation Project under development since 2010.
- Jozani-Chwaka Bay National Park (previously Conservation Area)
- Menai Bay Conservation Area
- Chumbe Island Coral Park

Issues

One clear link between the sectors is the constraint of governance and capacity. In the small-scale fisheries, the lack of institutional infrastructure to monitor the sector has led to destructive fishing practices going unchecked. In agriculture and forestry, community capacity is too weak to sustainably manage their resources, while government ownership in ports and shipping sector continues to weaken capacity and service delivery. Likewise, in the energy sector, capacity to manage and enforce laws has been highlighted as a weakness, particularly at lower-levels of government. Despite these constrictions, progress is being seen (ACLME 2012).

Economic Importance

The cost of implementing coastal zone management initiatives are built in to the budgets of the relevant ministries, and/or district authorities, in many cases with support from international NGOs or donors, as described above for WWF and CARE. The management framework for conservation of the coastal resources and preservation of the associated livelihoods cannot be achieved without cost. However, the incomes obtained from licensing legal businesses related to mangroves, coastal tourism, deep sea fishery, marine transport, etc., to a large extent are all and always directed to the central government with less or non to the local government or community directly. It is important if the distribution of these incomes can be adjusted to enable the local governments to cope with rising management challenges at local level (ASCLME 2012). The importance of balancing the budgets for implementing management efforts and income generated from the resource needs to be undertaken in an open and transparent form.

Socio-Economic Importance

Without a management framework for conservation of the coastal resources the livelihoods of the hundreds of thousands of people that rely directly on these resources would be more threatened and unreliable than they are at present. Hence the importance of management is vital.

Threats to coastal communities relying on Management Framework for livelihoods

In a situation where an ever-increasing extractive effort is failing to yield greater returns, the need for management cannot be over-stated. The principle threats to those relying on the management framework and to the wider coastal environment are described below:

- **Poor coordination and monitoring** between different sectors leading to ineffective governance and failing of enforcement in coastal and marine areas.
- **Poor capacity and motivation** at local district authority level to implement legal mandates

governing natural resource use, resulting in continued deterioration of productive resources.

- **Absence of financial capacity** to address management issues related to coastal and marine resources.
- **Poor coordination** to address solid waste disposal leading to pollution of beaches and coastal waters.
- **Poor sewage treatment** facilities in the Stone Town leading to pollution of beaches and coastal waters.

CRIAM Ranking of Threats to Local Communities associated with Management Framework for Coastal Zone Management

Table 25: Prioritisation of threats to local communities and ecosystems associated with management framework for coastal zone management. The assessment used the Coastal Rapid Impact Assessment Matrix (CRIAM) approach, described in detail in Annex 3.

ThemeID	Threat as stated in Coastal Profile	Themes	A1 : Extent of issue	A2 : Seriousness of issue	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative character	Evaluation Score (ES)	Range Value (RV)	Light problem	Problem	Important problem	Very important problem	Major problem
Z_MFCZM_03	Absence of financial capacity to address management issues related to coastal and marine resources.	Management Framework for CZM	3	3	3	2	2	63	4					
Z_MFCZM_06	Increasing demand of water for irrigation	Management Framework for CZM	3	3	3	2	2	63	4					
Z_MFCZM_02	Poor capacity and motivation at local district authority level to implement legal mandates governing natural resource use, resulting in continued deterioration of productive resources.	Management Framework for CZM	3	3	3	2	1	54	4					
Z_MFCZM_01	Poor coordination and monitoring between different sectors leading to ineffective governance and failing of enforcement in coastal and marine areas.	Management Framework for CZM	3	2	3	2	1	36	4					
Z_MFCZM_04	Poor coordination to address solid waste disposal leading to pollution of beaches and coastal waters.	Management Framework for CZM	2	2	3	2	2	28	3					
Z_MFCZM_05	Lack of sewage treatment facilities in the Stone Town leading to pollution of beaches and coastal waters.	Management Framework for CZM	1	3	3	2	2	21	3					

Outlook

There are positive signs that Zanzibar is improving management on natural coastal resource in general, especially with respect to climate change issues (Hepworth 2010), and has consistently increased the area of the coast that is governed by some form of management system, there remains much to do. The historic ownership of fishing grounds by certain villages bodes well for marine conservation in general. Reconciling that with the other users that now have an increasing presence in the coastal marine environment (e.g. tourism, sea weed farming) remains a challenge.

However, with population growth and increases in tourism numbers there is a need for strong government coordination on marine resource management. Currently it suffers from a lack of authority, capacity and ability to influence across government. The reach and efficacy of government in supporting the most vulnerable communities is weak, and there are systemic problems with governance, public sector functionality and the efficacy of aid which must be negotiated and learnt from within efforts to prepare Tanzania for the increasing and more complex challenges of coastal zone management.

15 CLIMATE CHANGE IN COASTAL TANZANIA

Introduction

The oceans are under multiple and often interconnected threats unprecedented in modern human history. Sea levels are rising, the water is warming and the pH is dropping and the oxygen is consumed by degrading processes in many areas. Particularly the shallow seas are being polluted and fishing is far too intensive, which leads not only to decreasing stocks of many species but also to effects on the ecosystem level. To be able to deal with the problems of ocean degradation in order to secure the goods and services provided by the sea, it is necessary to develop a holistic view of how anthropogenic actions impact the ocean environment. As humans are the dominant drivers of ocean change a framework for management is needed. Although much research has been carried out on the different issues affecting the oceans little knowledge exists on the extent to which the different threats interact with and feedback on each other. Questions that largely remain unanswered at this stage are, what are the possible feedback processes of these different individual threats? Do any of the problems amplify or are reduced by other issues? How do local, regional, and global stressors interact? What sort of policy and management strategies do we need to account for multiple, interacting stressors?

Developments in climate science research are regularly reviewed and assessed by the Intergovernmental Panel on Climate Change (IPCC). The IPCC Working Group 1 published the most recent report about the physical science in September 2013 (IPCC., 2013). In 2014 further reports from IPCC will follow: in end of March 2014 on impacts, adaptation and vulnerabilities, and in April 2014 on mitigation of climate change. The recent report about the physical science is based on many independent scientific analyses from observations of the climate system, investigations of paleo-climate archives, and of theoretical studies of climate processes including simulations using various climate models.

In East Africa several national reviews of the state of climate change and discussions of the possible future development have been carried out recently. In Tanzania the GCAP studies are examples of this (The Economics of Climate Change in Tanzania (mainland) (2011), The Implications of Climate Change and Sea-Level Rise in Tanzania, (2011), and The Economics of Climate Change in Zanzibar – Vulnerability, Impacts and Adaptation (2012). These reports provide an analysis of the present situation, forecasts for the future and discuss vulnerability and adaptation as well as economic impacts.

The Increasing Temperature of the Atmosphere and Oceans

Global warming is caused by the increased emissions of greenhouse gases (GHG) (carbon dioxide CO_2, methane CH_4, nitrous oxides N_20). The concentrations of all these gases have increased in the atmosphere since 1750 due to human activities. In December 2013 the carbon dioxide levels were 396.8 ppm, in 2011 methane concentrations 1803 ppb, and nitrous oxide 324 ppb, meaning an increase from pre-industrial concentrations by about 40%, 150% and 20% respectively. The concentrations of these gases are now higher than in at least 800,000 years (IPCC., 2013).

The effects of the increasing emissions on the earth's atmospheric and oceanic temperatures are projected using models that currently are valid primarily on the global level. The global climate models are the only information available for decisions about the response at the local level, which is a major problem as local conditions may very significantly affect the degrees of impacts at local and regional levels. On a global level the IPCC (2013) concludes that the global surface temperature (land and sea) has increased during the last 60 years by 0.5-0.84°C. Furthermore

IPCC (2013) forecasts, based on the available models that the average global temperature by 2100 will be more than 1.5°C higher than today and probably more than 2.0°C.

As the atmosphere warms so will the oceans. Warming of the world oceans due to increasing GHGs was first identified in a report by Revelle et al. (1965). Estimates for the increasing heat content for the upper 300 and 700 m layers and pentadal estimates for the upper 3000 m of the world ocean are shown in Figure 3 (after Levitus S., J. Antonov, and T. Boyer, 2005). For the world ocean the linear trend of heat content (0-3000 m layer for 1955-1998) is 0.33×10^{22} J/year representing an increase in the heat content of 14.5×10^{22} J corresponding to a mean temperature increase of 0.037°C. From the surface down to 700 m the ocean temperature has increased by 0.2°C during the last 50 years (Bindoff N.L. et al., 2007). For the Atlantic, Pacific and Indian Ocean the increases of heat content (linear trends) are 7.7, 3.3, and 3.5×10^{22} J respectively (Figure 4) (Levitus S., J. Antonov, and T. Boyer, 2005).

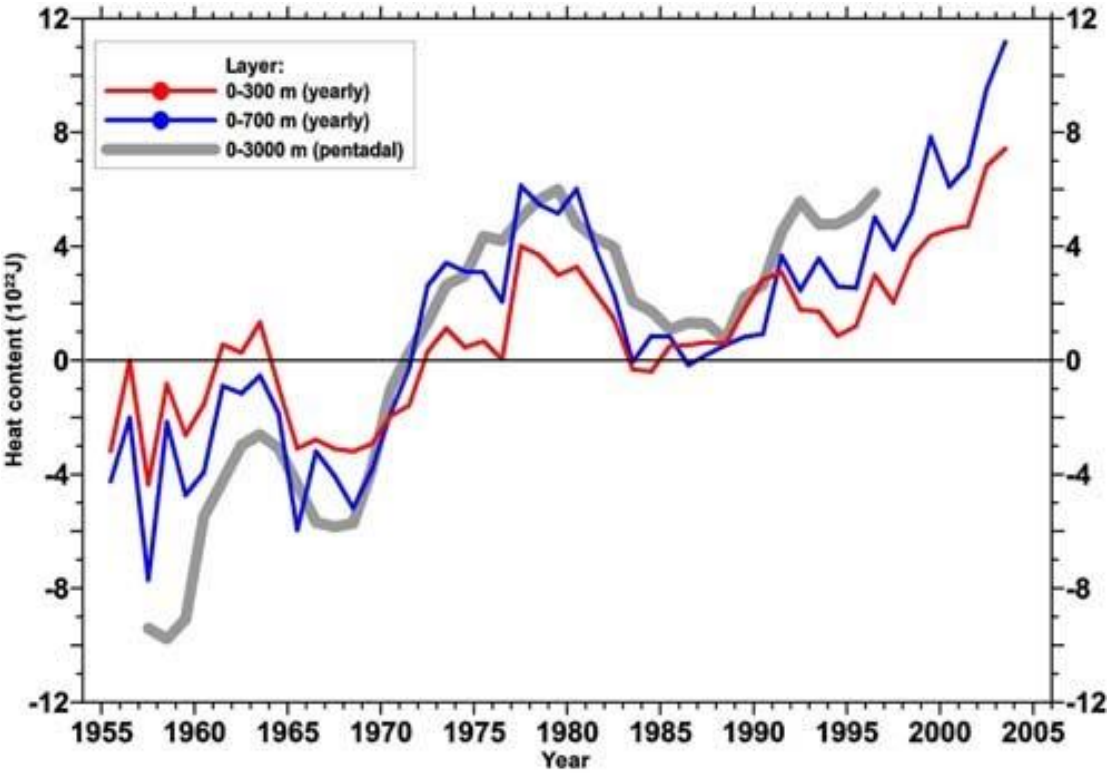

Figure 3: The heat content of the global ocean for the layers 0-300, 0-700 and 0-3000 m. From Levitus S., J. Antonov, and T. Boyer, 2005. For further information see the text above.

As the oceans warm, the amount of water vapour in the atmosphere at a given relative humidity increases. The increase is exponential and as the temperature increases the amount of water vapour at a given relative humidity increases very rapidly. Such changes in the amount of water vapour will affect the hydrological cycle and result in increases in the intensity of precipitation both over the oceans and over terrestrial areas.

The warming of the atmosphere and particularly the oceans has resulted in changes in extreme weather and climate events. Hence, on global scale IPCC states that it is very likely that the number of warm days and nights has increased and that the number of cold days and nights has decreased. Overall the frequency of heat waves has increased over large parts of the world, and there are more land areas where the number of heavy rainfalls has increased than where such rains have decreased in numbers.

On a global scale sea surface water temperature (down to 75 m) has increased by more than 0.1 degrees in the last 40 years. Also deeper waters have warmed, and it is likely that the ocean warmed from 3000m to the bottom, with the largest warming observed in the Southern Ocean (IPCC., 2013). In addition, during the last 40 years, more than 60% of the net energy increase in the climate system is stored in the upper ocean (0-700 m) and about 30% is stored in deeper waters. As a consequence the increase in upper ocean heat content during this period is likely to be in the range of 15 to 19 x 10^{22} J. Other general ocean observations related to climate change show that it is very likely that regions of high salinity where evaporation dominates have become fresher since 1950s.

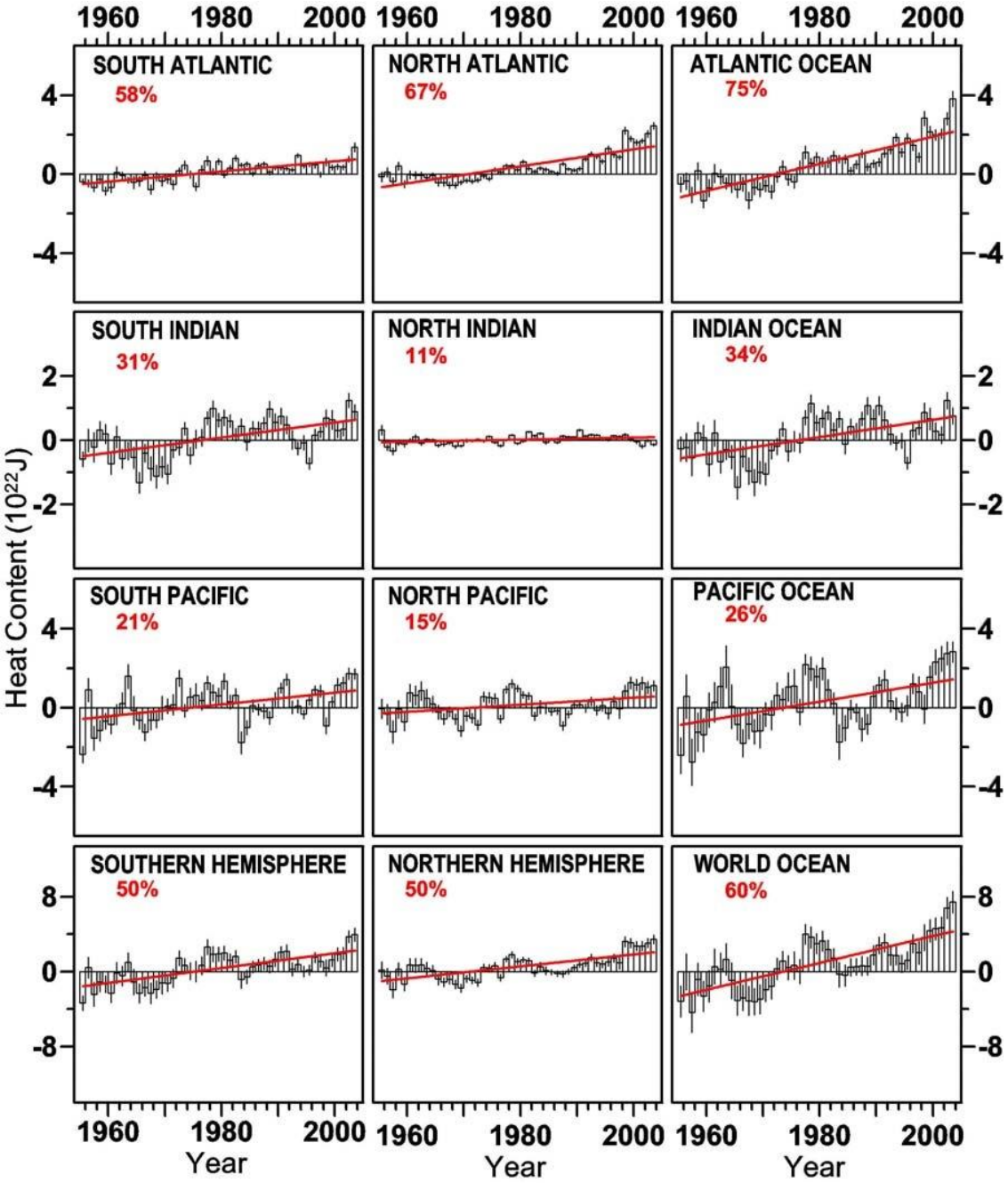

Figure 4: Time series of the yearly increase in the heat content for the 0-300 m layer of the world ocean and individual ocean basins. Vertical lines through each yearly estimate represent plus and minus one standard error of the estimate of heat content. The linear trend is plotted as a red line. The percent variance accounted for by this trend is given on the upper left corner of each diagram (from Levitus S., J. Antonov, and T. Boyer, 2005).

Sea level rise will impact all coastal areas, but to differing extents. Small islands may disappear entirely even with very modest increases in the sea levels. It has been estimated that about 145 million people would be directly affected by a 1 m sea level rise, 268 and 397 million by 5 and 10 m rise respectively (Anthoff D., R. Nicholls, R.S.J. Toi and A. Vafeidis, 2006).

Changes of the sea level at any given location are due to a combination of a number of different factors and processes and may be very different from the global average. Several hundred-year-old records of sea level fluctuations are available for many sites around the world. However, the quality of data that was collected 400 years ago may be questioned. Observations from different locations show different degrees of variability and different overall trends. Most sites around the world show clear upward trends (Boon, J.D., 2012), (Sallenger A.H., K.S. Doran and P.A. Howd, 2012), (Permanent Service for Mean Sea Level, 2014), but many sites show a fair amount of inter-annual variability. Global causes of sea level rise are the warming of the ocean which causes thermal expansion, and the melting of the glaciers and ice caps. However, at the regional and local levels a number of local phenomena play important roles, such as changes in the ocean and atmospheric circulations, uplift or subsidence due to tectonic movements or the abstraction of ground water or oil.

According to the IPCC (2013), the sea level rise during the last 60 years has been larger than the mean rate of change in sea levels, during the previous 2 million years. Globally the mean sea level has increased by 0.17 to 0.21 m between 1900 and 2010. Since 1970 global mean sea level rose by about 1.8 mm/year, which doubled to 3.1 mm/year in the 1990's and was 2.5mm/y since 2000.

Table 26: Summary of the sources of Sea Level Rise (mm/year) for three different time periods (modified after Noone K.J., 2013).

Source	42 years (1961-2003)	10 years (1993-2003)	4 years (2003-2007)
Observed Change	1.8	3.1	2.5
Thermal expansion	0.4	1.6	0.35
Melting glaciers	0.5	0.8	1.1
Melting ice sheets	0.2	0.4	1
Land storage (liquid water)	-	0	-
Residual	0.7	0.3	0.1

As can be seen from Table 26 most of the rise in sea levels has been caused by the combination of warming of seawater (thermal expansion) and as a result of adding water to the oceans from continents through melting, or transport of ice from glaciers. The residual fraction is the difference between the actual (observed) sea level rise and the sum of the different identified sources. This "unexplained" fraction is believed to originate from melting of ice sheets in Greenland and Antarctica (Steffen et al. 2010). It is important to observe that the relative contribution from the different sources vary with time, and also that the residual fraction has decreased as the techniques of quantifying the different contributions has improved. Thermal expansion (warming) of the upper 700 meters of the oceans shows clear variability on 5-10 year time scales, and can also be linked to volcanic eruptions. The contribution from water from terrestrial sources (groundwater, lakes and wetlands) is variable but averages out to be roughly zero over the period in question (1960-2010). Glaciers and icecaps have been the dominant source of sea level rise since about the late 1970's. However, as pointed out earlier, at the local level changes in mean sea level are a combination of a number of global processes and natural or human-induced subsidence due to tectonic movements or related to removal of ground water.

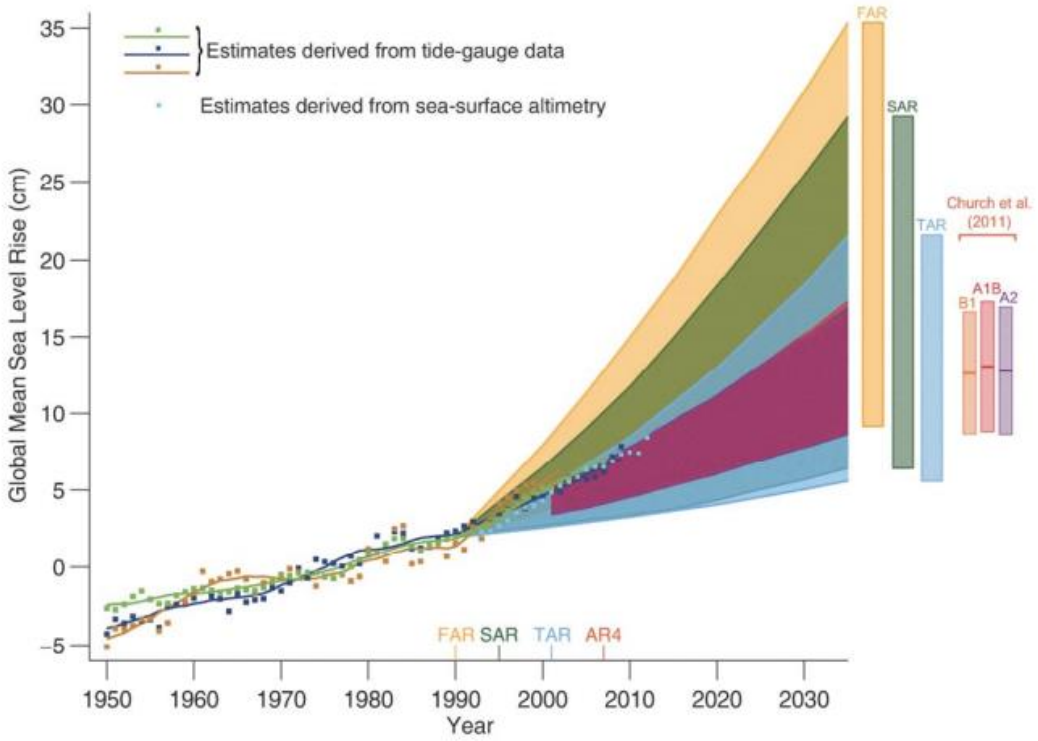

Figure 5: Sea level rise since 1950 and prediction for the future according to the different scenarios (from IPCC 2013).

Ocean Acidification

As atmospheric carbon dioxide is taken up by ocean water and transformed into carbonic acid the acidity of the water will increase. The oceans presently have taken up about 25% of the CO_2 emitted from human activities. Without ocean uptake the atmospheric concentrations of CO_2 would be about 460 ppm (instead of about 395 at present). The carbonic acid increases the ocean acidity, shifting the partitioning of inorganic carbon species towards increased CO_2 and dissolved inorganic carbon, and decreased concentration of carbonate ion. As a result the pH is decreasing (Figure 6). The degree of future ocean acidification will depend on carbon dioxide emission concentrations and rates, and if these are known, the corresponding degree of acidification is highly predictable. According to model projections burning of fossil fuels at similar rates as during the last 100 years, will result in a decline of the pH in ocean surface waters of 0.77 from preindustrial levels of 8.2, with a pH decline of 0.3-0.4 occurring during this century (Caldeira, K. and M.E. Wickett, 2003); (Orr J.C., V.J. Fabry, O. Aumont and 24 others, 2005); (Royal Society., 2005). The solubility of $CaCO_3$ depends on its crystalline form and varies with temperature and pressure, being more soluble in cold water than in warm water.

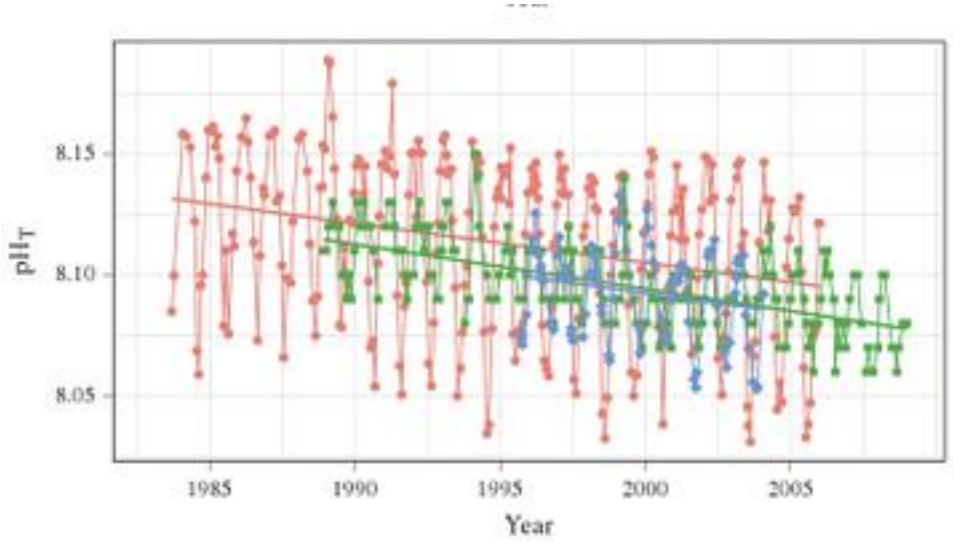

Figure 6: The diagram showing time series of pH at three ocean stations (from Orr J.C., 2011).

Climate Change and the Indian Ocean – the Larger Picture

Oceans are determining and moderating the climate on the planet. Ocean phenomena such as sea surface temperatures, surface and vertical currents, and salinities are all drivers influencing the climate as well as shorter time scale changes. Through increasing emissions of GHGs, human activities are causing increasing atmospheric temperatures which increase the sea surface temperatures. In order to comprehend how climate change will affect Zanzibar, Pemba and the coastal regions of Tanzania, it is necessary to understand the basic oceanic features of the western Indian Ocean.

Oceanographic Phenomena Influence the Local Scene

The major driving force influencing the weather and climate in Tanzania and along the East African coast is the Equatorial Current flowing from eastern Indian Ocean towards the west. Particularly the South Equatorial Current (SEC), which is a broad and shallow current that flows at a speed of 2 to 5 knots, 10 – 15 degrees south of the equator, is of importance to coastal East Africa. This current is feed by water from the South Indian Tropical Gyre. Some of its water comes from the Pacific via the Indonesian Seas. The flow through the Indonesian Seas is affected by the El Nino/La Ninja phenomena (see below). The SEC reaches the coast of East Africa at the latitude of southern Tanzania. A part of the SEC bends off to the north forming the East African Coastal Current and the South Indian Ocean Tropical Gyre (see Figure 7). During the North-East Monsoon (November-March) the East African Coastal Current/Somali Current is pushed to the east at the latitude of southern Somalia, in a clockwise movement and is starting to flow east along the equator forming the Equatorial Counter Current (see Figure 8). During June to September the South East Monsoon usually dominates and during this period the East African Coastal Current continues northward along the Somali coast to the Gulf of Aden.

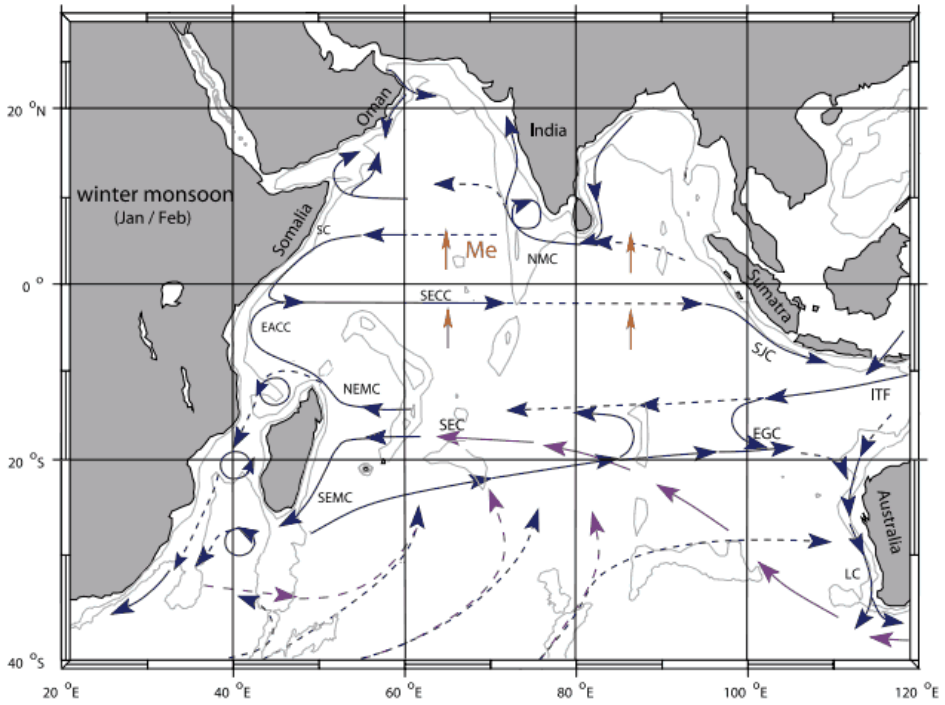

Figure 7: Major currents and branches of currents in the Indian Ocean during the winter monsoon (above) and summer monsoon (below). SEC = South Equatorial Current, SECC = South Equatorial Counter current, NEMC and SEMC = Northeast and Southeast Madagascar Current, EACC = East African Coastal Current, SC = Somali Current, SG = Southern Gyre, GW = Great Whirl, ITF = Indonesian Through flow. From Schott F.A., S.-P. Xie, and J.P. McCreary Jr., 2009.

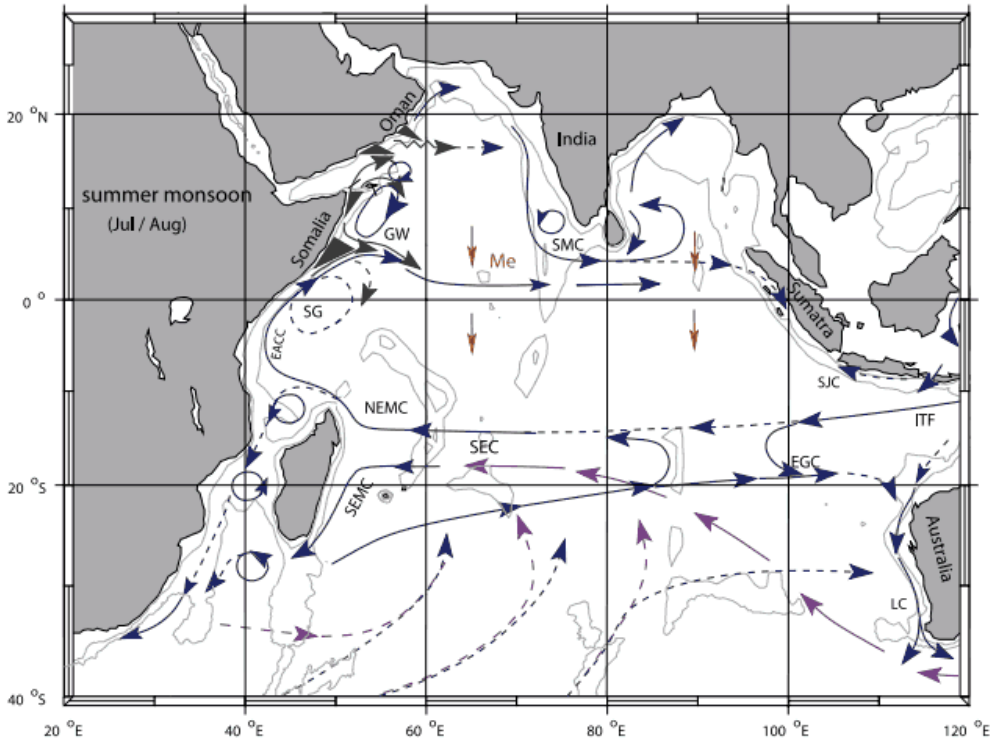

Figure 8: Major currents and branches of currents in the Indian Ocean during the summer monsoon. For further explanation and conditions during the winter monsoon see Figure 5. From Schott F.A., S.-P. Xie, and J.P. McCreary Jr., 2009.

A major portion of the Equatorial Counter Current bends off to the south, forming the Madagascar Current along the eastern Madagascar and the Mozambique Current along the Mozambique coast. These two south flowing currents merge between southern Madagascar and Mozambique roughly at the latitude of Inhambane, to form eddies and the western boundary current of Indian Ocean Subtropical Gyre (the Agulhas). The Agulhas runs south along the east coast of southern Africa and due to wind stress it does not usually form a complete gyre back into the Indian Ocean but rather shrinks as it moves poleward and westward or eastward.

Certain intra-annual global ocean phenomena exert at times very pronounced influence on the local conditions in the western Indian Ocean. Examples of such phenomena are the Indian Ocean Dipole (IOD) and the El Nino and connected La Nina modes. The Indian Ocean Dipole or the Zonal Mode is an indicator of the east-west temperature gradient across the tropical Indian Ocean. Years of extreme September-November rainfalls in tropical East Africa are associated with this phenomenon (Black E., J. Slingo and K.R. Sperber., 2003). During positive Indian Ocean Dipole mode (+IOD) strong easterly winds push warm surface water towards the western Indian Ocean resulting in unusually high sea surface temperature (SST) along the East African coast (see also Figure 9 and Figure 10 below). Hence under +IOD conditions the water in the eastern tropical Indian Ocean is cooler than normal. On the other hand, during negative Indian Ocean Dipole mode (–IOD), surface waters warms in the eastern tropical Indian Ocean while a corresponding cooling occurs along East Africa.

El Nino and La Nina modes are closely correlated to the Pacific Ocean Southern Oscillation. Even though these events are Pacific Ocean phenomena, their influence on surface water and the climate/weather in the western Indian Ocean through the Indonesian Seas is very significant, which was noted for example in 1983 and 1998. Even though El Nino/La Nina and IOD are largely natural phenomena, observations related to these phenomena must be carefully assessed in relation to increasing GHG concentrations. El Nino and La Nina events are related to changes in the coupled atmosphere-ocean system over the tropical Pacific. During El Nino conditions air pressure anomalies measured as the air pressure difference between eastern and western Pacific show below normal pressure over Tahiti and above normal over Darwin. This results in weak easterlies (trade winds) which result in the transport of warm surface water towards the east along the equator from the western Pacific to the east. On the other hand strong easterly equatorial winds over the eastern tropical Pacific Ocean results in shallow thermoclines in this region causing La Nina events. These events impact the ocean and land climate in all major ocean basins.

The relationship between the intensities of the different currents in the western Indian Ocean is intimately linked to the intensity of the South Equatorial Current (SEC). Several hypotheses exist related to these linkages (Palastranga V., P.J. van Leeuwen and W.P.M. de Ruijter, 2006); (Gordon A.L., 2005); (Schott F.A., S.-P. Xie, and J.P. McCreary Jr., 2009); (Ridderinkhof, H., P.M. van der Werf, J.E. Ullgren, H.M. van Aken, P.J. van Leeuwen, and W.P.M. De Ruijter., 2010). During El Nino conditions, the transport of water through the Indonesian Seas weakens and the SEC is reduced as a consequence. The Sea Surface Temperature anomalies over the Indonesian Seas and the Eastern Indian Ocean are negative during El Nino conditions. This causes high pressures, cools the air and generates easterly wind, which gives rise to planetary waves propagating towards the South Western Indian Ocean. Down-welling waves in the region of northern Madagascar deepens the thermocline of the sea water, leading to SST going up and the formation of a pressure difference between east and west. An extreme such event happened in 1998 when SST increased 3 to 5°C over large parts of the south and central western Indian Ocean (Wilkinson C., O. Linden, H. Cesar, G. Hodgson, J. Rubens & A. Strong., 1999).

During La Nina conditions in the Pacific Ocean, the low pressure conditions over the tropical western Pacific induce a stronger flux through the Indonesian Seas, creating conditions in the Indian Ocean that leads to a relatively stronger Southern Equatorial Current, a southward

displacement of the current and the intensification of the Tropical Gyre (dr Ruijter, W.P.M., H.M. van Aken, E.J. Beier, J.R.E. Lutjeharms, R.P. Matano and M.W., 2004); (Gordon A.L., 2005), (Ridderinkhof, H., P.M. van der Werf, J.E. Ullgren, H.M. van Aken, P.J. van Leeuwen, and W.P.M. De Ruijter., 2010); (Palastranga V., P.J. van Leeuwen and W.P.M. de Ruijter, 2006). The more intensive than normal Tropical Gyre induces upwelling of cooler deep water along the East African coast, with cooler sea surface temperatures as a result (Schott F.A., S.-P. Xie, and J.P. McCreary Jr., 2009).

Observed Climate Changes in Coastal Tanzania

Air Temperatures

The climate of coastal Tanzania is characterised by a tropical hot and humid climate driven by two distinct seasonal monsoon winds. Over the last 50+ years air temperatures typically has ranged between 22 and 30°C. The Northeast Monsoon ("kaskazi") (November-March) is the hottest period. This traditionally has been considered the mild season with calmer seas and gentle winds typically 1-8 m/s. In contrast the Southeast Monsoon ("kusi") (May-October) typically is characterised by stronger winds, 5-15 m/s and rougher seas. During the inter-monsoon, the winds are variable but calm. The rainy seasons coincide with the end of the Southeast Monsoon (March-May), and a shorter rainy season during November-December. Annual rainfall in coastal Tanzania averages 800-1000 mm/year with the highest levels recorded in Pemba (1500 mm/year) and lowest in Mtwara (<500 mm/year).

The description above reflects the normal situation as it has been experienced during the last 5 to 10 decades. However, during the last couple of decades temperatures, rainfall and humidity show tendencies to change. Particularly the air temperatures have changed. Metrological data from the Metrological Office in Dar es Salaam and from the Zanzibar Weather Service has been analysed (see Annex 4 and Annex 5). Data on maximum and minimum average monthly temperatures are shown for coastal sites in Tanzania including Zanzibar and Pemba. The data show significant changes in the air temperatures over the last 25 years in coastal Tanzania. Hence monthly average maximum and minimum temperatures in Dar es Salaam have increased 0.5 to 1.5 °C during the 25 year period from1985 to 2012 (Annex 5). A detailed analysis of the data from Dar es Salaam show an average decadal increase of 0.24°C. The ERAInterim values are about 50% of these figures (Annex 4). The reason for the lower values is that ERAInterim data refers to monthly means of the full diurnal cycle and gives less weight to extreme values.

In other coastal locations such as Mtwara there is no significant increase in average maximum temperature. However there is a clear tendency for increased minimum temperatures. In Pemba there is a very pronounced increase in the average minimum temperatures for the period 1985 to 2012. The corresponding figures for Zanzibar shows an increase of about 1 °C for average minimum temperatures and 0.5-1.5 °C increase in the average maximum monthly temperatures.

As mentioned above, the global average decadal temperature increase during the last 60 years is 0.08-0.14 °C (IPCC., 2013). This is the average land and sea surface temperature increase and the increase over land is significantly higher. Compared to the global average the figures reported here for Dar es Salaam and Zanzibar are significantly higher. However, IPCC points out that short record series such as those presented here are very sensitive to beginning and end dates and may therefore not reflect long-term climate trends.

Ocean Temperature

Even though there is a distinct warming trend for the Indian Ocean as a whole (see above), the warming of the ocean basin is not homogenous. The warming exhibits geographical differences with quite different patterns of warming and even cooling in some areas. The cooling is important to discuss as it is particularly relevant to Tanzania. The explanation for the trends of warming and cooling in the Indian Ocean are due to atmospheric and oceanographic processes primarily in the Southern Hemisphere and the understanding of these processes has gained much ground in the last decade based on large amounts of data and modeling (Schott F.A., S.-P. Xie, and J.P. McCreary Jr., 2009); (Ridderinkhof, H., P.M. van der Werf, J.E. Ullgren, H.M. van Aken, P.J. van Leeuwen, and W.P.M. De Ruijter., 2010); (Ridgway K.R. and R.J. Dunn., 2007); (Speich S., B. Blanke and W. Cai., 2007). During normal conditions the South Equatorial Current is bringing water from the eastern Indian Ocean towards East Africa. The current reaches the African continent at the level of north-eastern Madagascar where it bifurcates into a northern branch which becomes the East African Coastal Current flowing north along the coast of Tanzania (Figure 9). During El Nino mode the flow of warm Pacific water through the Indonesian Seas decreases in intensity and the South Equatorial Current moves southward as it is flowing across the Indian Ocean. When it reaches East Africa at the level of central Madagascar it bifurcates into a northern and a southern branch (Figure 9). The northern branch of warm water is flowing along the Tanzanian coast.

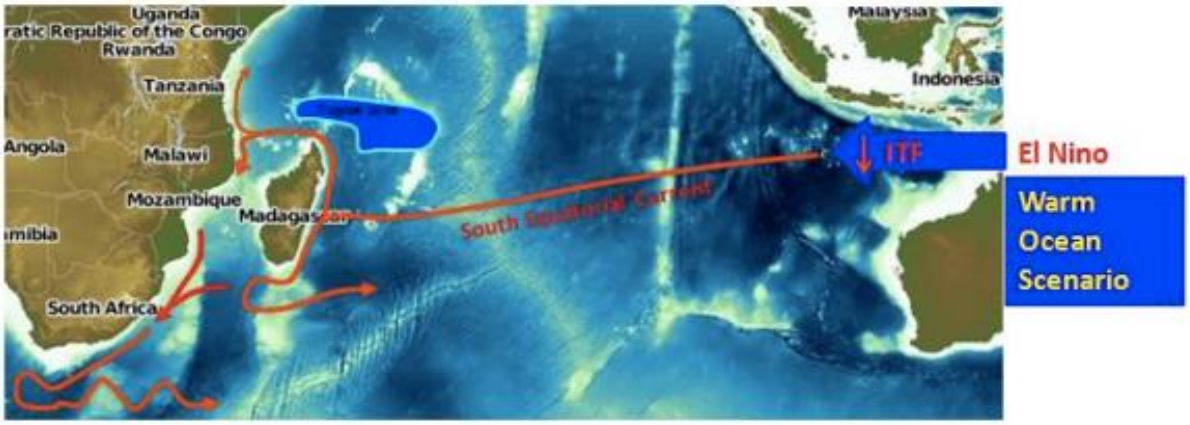

Figure 9. The warm water scenario is based on the South Equatorial Current bringing warm subtropical waters from east to west where on arrival to Madagascar it divides into two currents, one flowing north and one to the south. See also Figure 10. From "Responding to climate change in Mozambique" Synthesis Report (2012).

However, during La Nina modes the flow of the current through the Indonesian Seas intensifies and is displaced to the south by the Indian Ocean Tropical Gyre. This leads to extensive but temporary upwelling in the Mozambique Channel and along the Tanzanian coast (Figure 10)

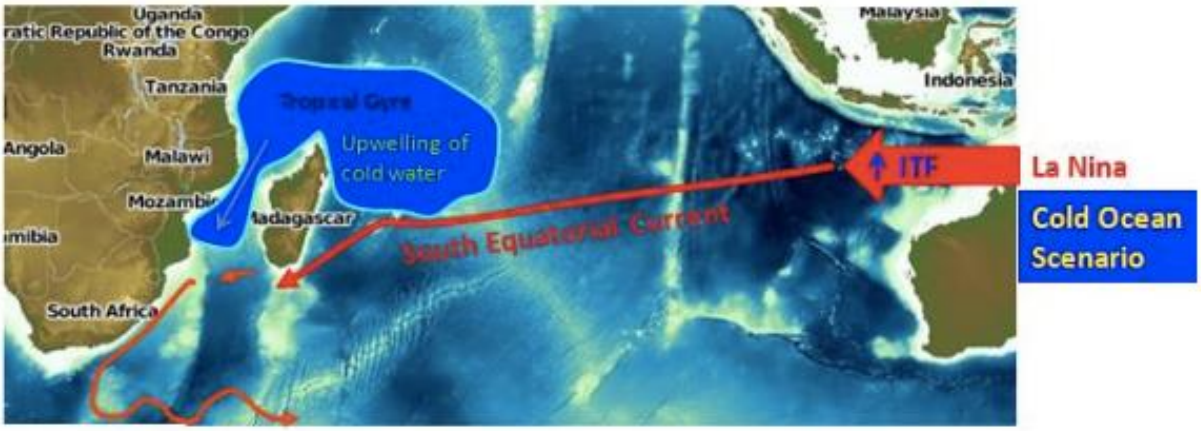

Figure 10: The cool water scenario (figure above) is based on a southward displacement of the South Equatorial Current, pushed down by a large south Indian Ocean tropical gyre. This situation results in large upwelling of deep cold water along the coast of Tanzania. From "Responding to climate change in Mozambique" Synthesis Report (2012).

Wind Speed / Intensity and Frequency of Storms

The available data on wind speeds from coastal Tanzania seem to indicate that wind speeds and the frequency and intensity of tropical storms has generally been increasing during the last three decades for four coastal stations (Tanga, Zanzibar, Dar es Salaam, and Mtwara (Mahongo S., and Y. Shaghude, 2013)(see Figure 11 and Figure 12). The authors also found a clear relation between past erosion events along the coast and the intensity of winds and occurrence of extreme wind speeds and tropical storms. These observations are in accordance of what would be expected as in warmer and moister conditions with higher sea surface temperatures changes in tropical storm and cyclone characteristics should be expected (Anthes, R. A., Corell, R. W., Holland, G., Hurrell, J. W., MacCracken, M. C., & Trenberth, K. E., 2006); (IPCC, 2007). There is a growing understanding of the correlations between anthropogenic warming, sea surface temperatures, and high wind/cyclone/hurricane intensity (Emanuel, K., 2005); (Emanuel, K., Sundararajan, R., & Williams, J., 2008). However, this does not necessarily mean that the frequency of events will increase, but rather that the intensity will.

Traditionally experts have been of the opinion that there is a functional relationship between storm intensity and the impacts on human infrastructure. Based on physical principles the power exerted by strong winds and the damage it causes should be proportional to the cube of maximum wind speed. However, with more real world cases of such events, experts now are of the opinion that the relationship is non-linear, since coastal structures typically survive up to a breaking point at which there are abrupt large losses. Also, experts generally agrees that impacts of climate change on coastal communities as a result of storm surges will be the most significant threat in the short term. It is the combination of increasing human populations and infrastructures along the coastlines with extreme winds (related to climate change) and spring-tides where the water table is superimposed by increasing sea levels (climate change) that will cause the greatest damage. This is discussed further below.

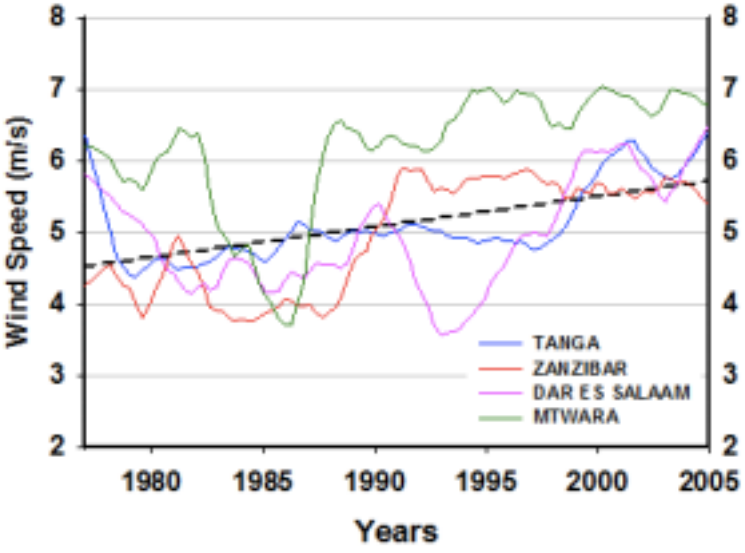

Figure 11: Monthly mean wind speeds (in the morning). The dotted line represents the combined linear regression line for all the four stations.

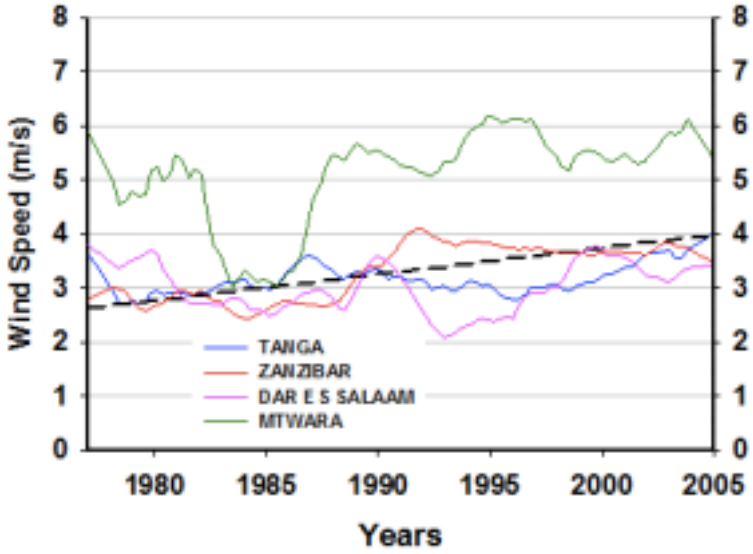

Figure 12: Monthly mean wind speeds (in the afternoon). The dotted line represents the combined linear regression line for all the four stations.

Rainfall and humidity

Data on rainfall over coastal Tanzania has been assessed in order to find out if any trends can be identified. Rainfall data are available from almost 20 sites, most of them along the coast (see Table 27 and Annex 5)

. Records of monthly average rainfall data are available from 1970's and 1980's. It should be pointed out that this is rather short period for assessing trends. The patterns of rainfall are complex and it is difficult to detect any single trend from the data available although there seems to be a general trend towards dryer conditions. However from a few sites a clear downward trend seems to be present. One of these sites are Mafia Island during the period 1989 – 2013 where a downward trend seems to be present during the rainy season towards the end of the year. Also in Muheza (inland from Tanga) there is a clear downward trend during both the rainy seasons recorded from 1981 to 2010. Also from Utete in the Rufiji Delta there seem to be a downward trend during the rainy season since 1981.

Table 27: Trends in total monthly rainfall in coastal Tanzania. See also Annex

Location	Period of recording	Observation
Lindi Boma	1971 – 2011	No trend
Dar es Salaam	1989 – 2013	No trend
Chakechake	1998 - 2012	No trend
Utete (Rufiji)	1981 – 2010	Downward (rainy season)
Tanga	1987 - 2012	No trend
Muheza (inland Tanga)	1981 - 2010	Downward (rainy season)
Pangani	1980 - 2011	No trend
Mtwara	1987 - 2012	No trend
Zanzibar	1971 - 2011	No trend
Karume (Pemba)	1974 - 2011	No trend
Kizimbani (Kilwa)	1970 - 2011	Downward (dry season)

Similar results of variations in rainfall have been reported by (Francis J. and S.B. Mahongo, 2012). They report a general downward trend in the precipitation although the trends are not significant. When studying data from the last 50 years the authors saw a significant influence of the El-Nino Southern Oscillation, and less influence by the Pacific Decadal Oscillation and the Indian Ocean Dipole. In the seasonal timescale the effects of the large scale climatic phenomena are relatively smaller during the rains and the Northeast Monsoon seasons, but are significantly larger during the Southeast Monsoon.

Data for precipitation is available from Zanzibar for the period since 1975 (Annex 5) and these recordings seem to indicate a consistent trend towards increasing humidity. It seems logical that the humidity should increase as the temperature increases.

The Sea Level

As mentioned above the global sea level has risen during the past decades as a result of thermal expansion of the warming ocean water and due to addition of water from the melting glaciers. However, the sea level has not risen uniformly everywhere. Regionally the sea level is also affected by subsidence and uplift and of changes in atmospheric or oceanic circulation. Furthermore as the gravitation pull from the poles decrease due to the melting of the ice, there are indications this might lead to increased water levels elsewhere, particularly around the equator. In addition there are inter-annual and decadal fluctuations that makes interpretation difficult unless data are available for very long periods of time. Long-term observational records are scarce in the Indian Ocean and hence regional changes in sea level are poorly known.

Han et al. (2010) studied the spatial pattern of sea-level rise since 1960's in the Indian Ocean. The authors combine *in situ* and satellite observations of Indian Ocean sea level with climate-model simulations. The investigation indicates that the sea level has decreased substantially in the south tropical Indian Ocean whereas it has increased elsewhere (see Figure 13). This pattern is driven by changing surface winds associated with a combined invigoration of the Indian Ocean Hadley and Walker cells, patterns of atmospheric overturning circulation in the north-south and east-west direction, respectively, which is partly attributable to rising levels of atmospheric greenhouse gases (Han, W., Meehl, G. A., Rajagopalan, B., Fasullo, J. T., Hu, A., Lin, J., ... & Yeager, S., 2010). The authors conclude that—if ongoing anthropogenic warming dominates

natural variability—the pattern detected is likely to persist and to increase the environmental stress on the tropical East African coast and islands such as Zanzibar.

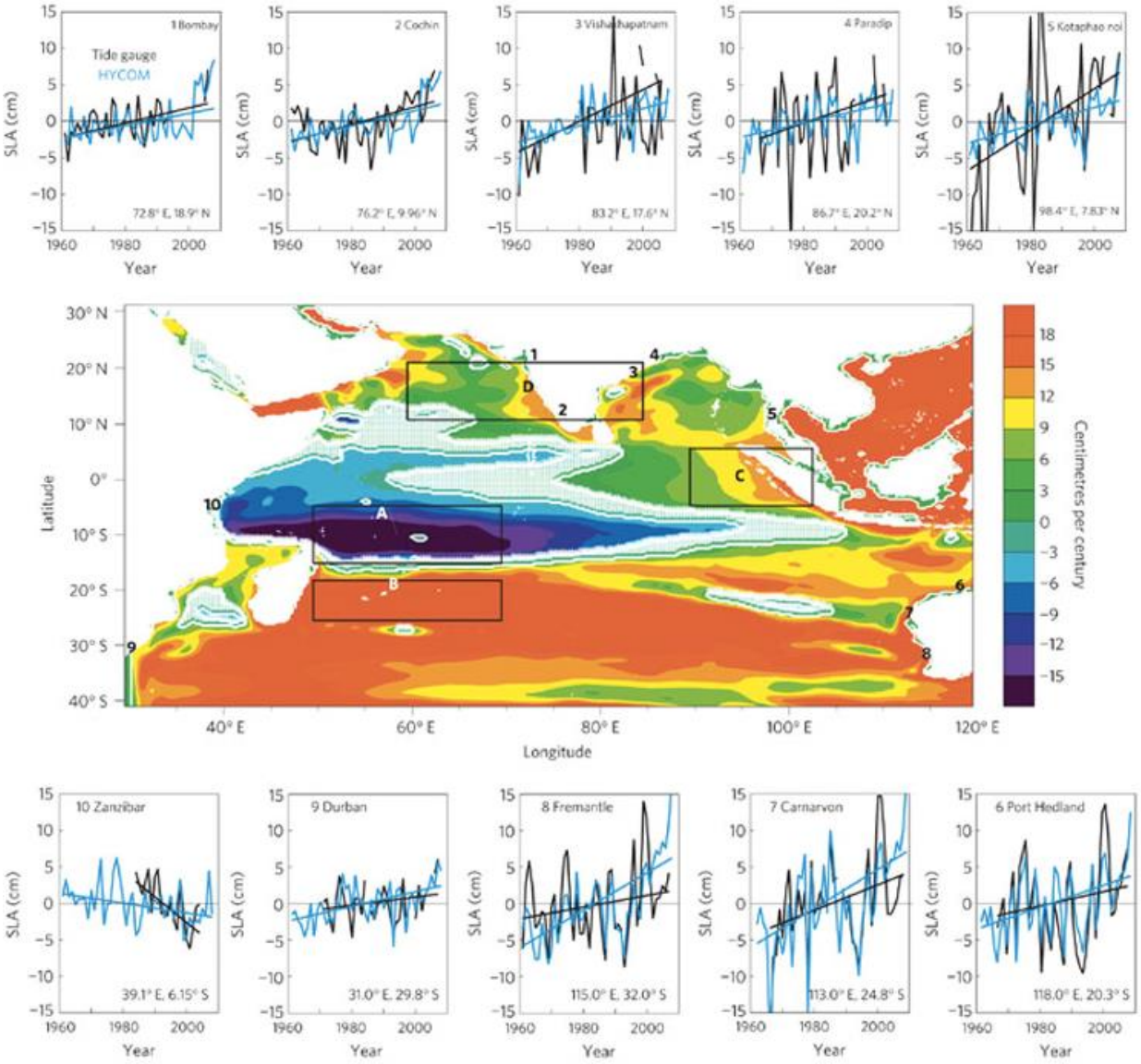

Figure 13: In situ (tide gauge) observed and model experiments (HYCOM) of mean sea level anomalies and their Kendall Theil trends during 1961 – 2008 in the Indian Ocean. The 10 tide gauge stations with records longer than 30 years (20 years for Zanzibar) are shown. The coloured map shows the Kendall Theil trend of HYCOM sea level anomaly for the same period. The blue/green regions are below and the rest are above 95% significance.

Historic regional data reconstructed and reviewed by Mohongo, S., (2009) indicates that sea levels in Tanga 1962-1966 and Dar es Salaam 1986 to 1990, and from Zanzibar 1984 – 2004, were falling. Furthermore Mohongo reports that about 60% of the 34 tide gauge stations in the Western Indian Ocean region with at least 4 years and up to 41 years of data, show rising sea levels, while 40% show falling trends. Data from the Sea Level Center (University of Hawaii) (Figure 14) show a downward trend from 1986 to 2000, but after that period a significant increase.

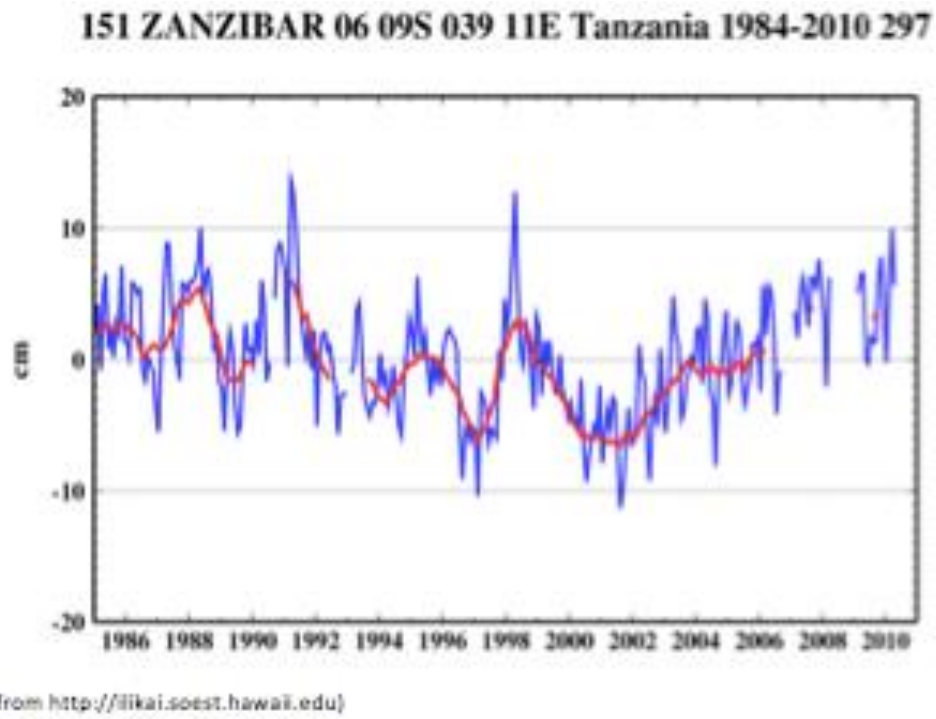

Figure 14: Sea level data from Zanzibar from 1985. A downward trend is apparent until about the year 2000 after which the sea level is rising. From Gloss/Clivar/NOAA Climate and Clobal Change Program, University of Hawaii Sea Level Center.

Impacts of Climate Change on Coastal Areas

Impacts of changing water levels: The physical impacts due to sea level rise include the disappearance of low-lying islands and coasts, erosion of coastal land, increasing incidents of flooding of coastal areas, saltwater intrusion of groundwater as well as surface water, and impacts in habitats such as reef ecosystems, marshes and mangroves as well as sandy beaches. The effects, interacting factors and possible adaptation approaches to these impacts have been summarised by Nicholls (2011) and are shown in the Table 28 below – modified to tropical East African conditions.

Table 28: Effects, interacting factors and possible adaptation approaches to physical impacts have been summarised by Nicholls (2011), but modified here to African conditions.

Natural system effect	Possible interacting factors	Possible adaptation approaches
Erosion of low-lying sand/mud beaches	Sediment supply/ Dam construction, construction in coastal areas	Nourishment, land-use planning, managed realignment
Wetland/mangrove loss	Sediment supply, Filling, construction in coastal zone	Nourishment, land-use planning, managed realignment, replantation of wetland vegetation
Inundation/flooding	Waves/storms, sediment supply	Dikes, surge barriers, closure of dams, dune management, building codes, set-back lines
Saltwater intrusion	Runoff/rainfall, catchment/water extraction management	Salt water intrusion barriers, change water extraction, freshwater injection
Coral reef loss	Destructive fishing methods, bleaching, sedimentation	Managed fishing, coral replantation, provision of hard substrates for natural coral recruitment

Impacts of increasing temperatures: Increasing temperatures of the ocean and coastal waters will affect the availability of dissolved oxygen which will impact temperature dependent respiration and metabolism. These factors will have a number of impacts on the local marine and shallow water ecosystem. As part of US National Climate Assessment, Howard et al. (2013) summarised the impacts of increasing water temperatures that have been observed and will be increasing even more so in the future. Observed impacts include shifts in species distributions and ranges, effects (primarily negative) on survival, growth, reproduction, health, and alterations in species interactions. Impacts are occurring across a wide diversity of taxa and in all ocean regions. However, high latitude and tropical areas appear to be particularly affected. There is high variability in the vulnerability and responses of marine organisms to climate change, leading to "winners" (i.e. species positively impacted) and "losers" (i.e. species negatively affected). Species with high tolerance for changes in temperature and other environmental conditions will likely experience fewer climate-related impacts and may therefore outcompete less tolerant species. Corals and other calcifying organisms as well as other species that are highly vulnerable to climate change will continue to suffer and the diversity and abundance of these organisms will drop in tropical regions such as East Africa. Climate change effects on local ecosystems interacts with, and can exacerbate, the impacts of non-climate stressors such as pollution, the impacts of overfishing or the use of destructive fishing methods and the consequences of introductions of invasive species. Opportunities exist for ameliorating some of the impacts of climate change by reducing non-climate stressors at local and regional scales. The combined impacts of multiple stressors are difficult to predict considering the complexity in the physiological response and the ecological interactions among species. Past and current responses of marine organisms to climate variability and change are informative but extrapolations to future responses are difficult considering that future environmental conditions are likely to be unprecedented. It is clear however, that observed responses vary in magnitude across space and time. Phenomena such as threshold responses or tipping points resulting in rapid and more or less irrevocable ecosystem change are issues of great concern.

Impacts on fishing: Temperature is a very critical environmental factor in the embryonic development and growth of fish. Only a few degrees difference from the optimal will lead to declined growth and increased sensitivity to stress. Most research on these aspects has been carried out in the North Atlantic and few studies have been carried out in the Indian Ocean. What most studies seem to indicate is that it is not sufficient to study the impacts of the annual mean temperature on fish survival and growth. The seasonal pattern of temperatures and the food supply are also highly critical. Climate change is very likely to already have affected fisheries in the Indian Ocean. Following the massive coral bleaching and subsequent mortality of corals in 1998, many reefs in East Africa changed from being reefs dominated by corals to reefs dominated by algae. Typical coralivorous fish species disappeared and were replaced by herbivorous species (Linden, O., D. Souter, D. Wilhelmsson & D. Obura (Eds), 2002); (Souter, D. & O. Linden (Eds.), 2005). The IPCC (2007) considers that climate change is likely to have a greater impact on coastal than on pelagic species, but believes that the levels of fishing pressure are more likely to dominate reproductive success and abundance. Climate change is considered primarily as an additional pressure on fish stocks whose resilience may already be low due to anthropogenic impacts on stock and habitats.

Summary: Climate Changes in Coastal Tanzania

- The air temperatures in coastal Tanzania are increasing rapidly and there are indications the increase is accelerating.
- The temperature increase is particularly pronounced in Dar es Salaam, Zanzibar and Pemba.
- Increasing air temperatures are likely to affect patterns and intensity of precipitation. However, rainfall data from Tanzania does not indicate wetter conditions as might be

expected from the increasing temperatures. In a few places along the coast a trend towards drier conditions can be seen.

- The ocean water off the coast is highly influenced by atmospheric processes including El Nino and La Nina phenomena which results in periods of very high temperatures interrupted by periods of relatively cold surface temperatures.
- Changes in wind speeds/directions and intensity of storm events have not yet been noticed in the area but increasing air and sea surface temperatures should be expected to result in higher wind/cyclone/hurricane intensities.
- Data on the changing sea levels that are available from the region show both rising and falling trends from up to 41 years. Data from Zanzibar since 1986 indicate an initial decrease in the water levels followed by an increase since about 2000.

Future Climate Change in Tanzania

Introduction

The report above presents the current state of the science regarding the causes and consequences of climate change as it has been recorded until now and from an Indian Ocean and Tanzania perspective. Several of the changes that have occurred may appear to have been gradual and relatively predictable. Year after year the air and ocean grow warmer, sea levels are rising, ocean water is acidifying and anoxic zones are spreading. The question is if the changes will continue to be gradual and predictable. If they are the most likely outcomes will be rather easy to forecast. However, gradual changes are not the whole story. Abrupt changes involving less likely and less predictable impacts are likely to occur. Many natural systems reach thresholds or tipping points after which the behaviour of the systems suddenly changes. In fact tipping points have been observed in numerous situations in the ocean before. Fisheries have collapsed as a result of warming waters in the northern Atlantic. Corals in the tropics live close to their maximum temperature tolerance limit and an increase of only a few degrees will cause bleaching and mortality. Ocean acidification will eventually lead to under-saturation of aragonite, at which point the oceans will become corrosive to calcifying organisms such as molluscs, crustaceans and many plankton species. When it comes to sea level rise science indicates that the melting of the ice sheets and glaciers on the planet are much faster than predicted in the earlier scenarios of the IPCC. The general opinion among climatologists today seems to be that there are two stable states for the planet: one with and one without ice sheets and glaciers. About 40 to 65 million years ago no major ice existed on Antarctica and Greenland. Concentrations of CO_2 in the atmosphere at that time were around 500 ppm. Today the CO_2 concentrations have increased to 400 ppm from 320 before industrialisation. Stable ice on Greenland was formed only 8 million years ago when the CO_2 concentrations were below 300 ppm. Most climatologists seem to agree that a complete loss of the Greenland ice sheet with a resulting sea level rise of 7 m is very likely with the development today.

Preparing for the impacts of future climate change is extremely difficult as the uncertainties are significant. Prediction of impacts and tipping points is difficult, in part because individual threats interact in complex and non-linear fashions. If coral reefs disappear because of warming of the ocean, fisheries will suffer and islands and low-lying coastal areas will be impacted by increasing erosion as the protective properties offered by the coral reefs will disappear. At the same time fisheries are generally suffering from overfishing and pollution. The combined impacts on the coastal livelihoods can be expected to be worse than the sum of the parts as feedbacks among the threats are frequent and inescapable. What this also means, and what a number of scientific studies have illustrated is that the management of local stressors has the potential of reducing the impacts of global stressor.

Below an attempt is made to forecast the future climate change impacts in coastal Tanzania. However, due to our limited understanding of feedbacks and interactions, forecasts are difficult and surprises should be expected.

Temperature

Based on the available climate data for Zanzibar and coastal Tanzania, feed into the global climate models which use the forecasted greenhouse gas emissions, it is possible to make predictions of the future development of the temperature in the air and coastal waters. As pointed out earlier, Regional Climate Models are not sufficiently developed at this stage to be useful in predicting local and regional weather and climate patterns. However, by downscaling empirical or statistical data from coastal Tanzania including the islands it is possible to approximate the regional temperatures over the near future. Such downscaled data were presented for Zanzibar based on CMIP3 archive GCMs using nine different simulations (done by University of Cape Town). The results were presented in the Zanzibar Climate Change Strategy presented early in 2014. The strategy considers future climate projections for the medium-long (2040-2060) and long-term (2080-2100). It uses meteorological data from the islands based on a baseline climate simulation of data from 1961 to 2000 and observed greenhouse gas concentrations. The Zanzibar Climate Strategy predicts a medium term (2040-2060) temperature increase of 1.5 to 2°C by 2050 (2045-2065) and 2 to 4°C by 2090 (2081-2100) (Figure 15). The prediction is for a fairly similar increase across the months of the year. Considering the close resemblance between the trends in temperature between Zanzibar, Pemba and the mainland coastal sites (see Annex 2), the predictions for Zanzibar are likely to be valid also for these other sites.

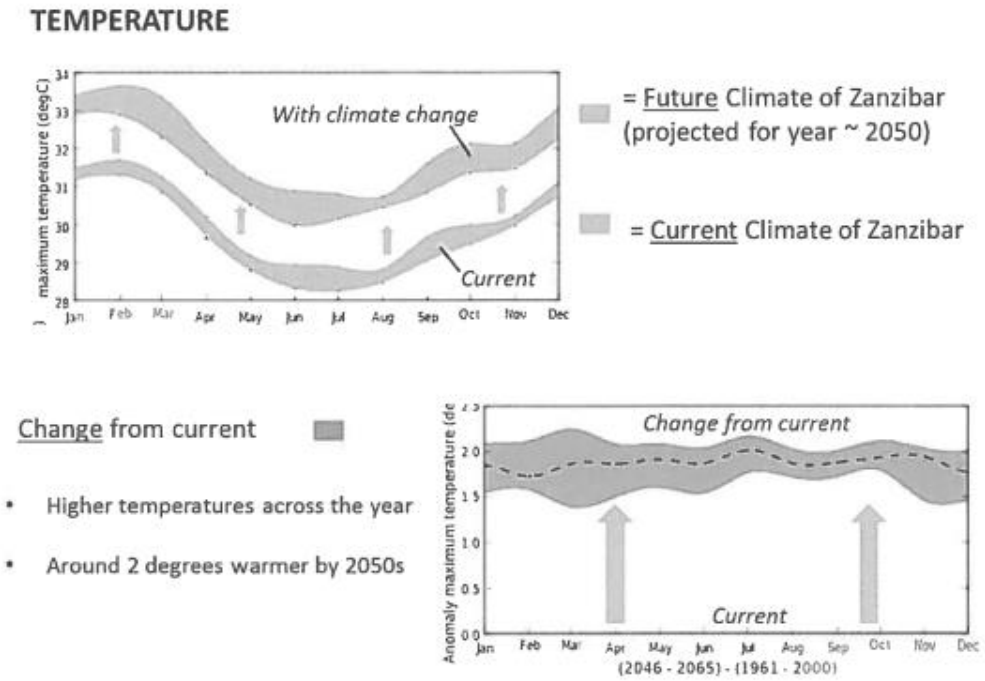

Figure 15: Forecast for future monthly daily maximum temperature (2045-2065) compared to the current situation in Zanzibar. From Zanzibar Climate Change Strategy/CSAG, Univ. Cape Town, SA (Figure 12 from the Zanzibar Climate Change Strategy).

Rainfall and Humidity

The future rainfall and humidity is more complex and difficult to predict. Increasing air temperatures could mean increasing humidity and indeed the data received from Zanzibar (see above) indicates that the humidity has increased significantly during the last decades. Whether

this translates into more rainfall is questionable. In Zanzibar there was no corresponding increase in rainfall during the period in question.

The Zanzibar Climate Change Strategy forecasts increasing precipitation during the wet seasons and lower rainfall during the dry seasons (Zanzibar Climate Change Strategy). The sise of the changes during the year varies dramatically across the models used (represented by the column height in the bottom panel), hence firm conclusions cannot be drawn.

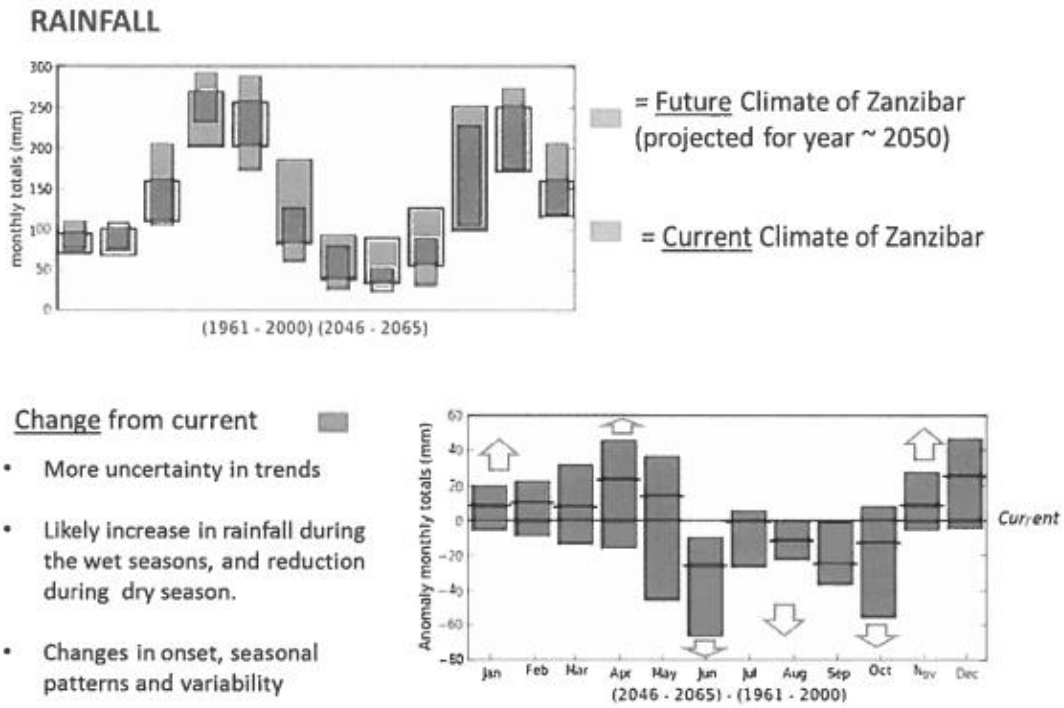

Figure 16: Forecast for future monthly rainfall (2045-2065) compared to the current situations in Zanzibar. From Zanzibar Climate Change Strategy/CSAG, Univ. Cape Town, SA.

The results of a modeling of the future monthly rainfall in Dar es Salaam was carried out by Besa (2013) based on CMIP5, a new set of climate model experiments coordinated between 20 modeling groups around the world. Also these results are rather inconclusive (Figure 17). The results indicate a decrease in the length of the long rainy season for the period 2020-2040 and 2040-2060 compared to 1958-2000. There are also indications that the short rainy season may change in its pattern (decrease in November, increase in January). As can be seen from the diagram there are few consistent trends. Additional projections were made as for the future number of heavy rains in Dar es Salaam for the period 2020-2040 (Figure 18). The results here are also not conclusive but the number of wet days (>20mm/day) from January to April may increase. Most models suggest increasing number of wet days in October – December. In the longer-term (2040-2060) there are no conclusive patterns.

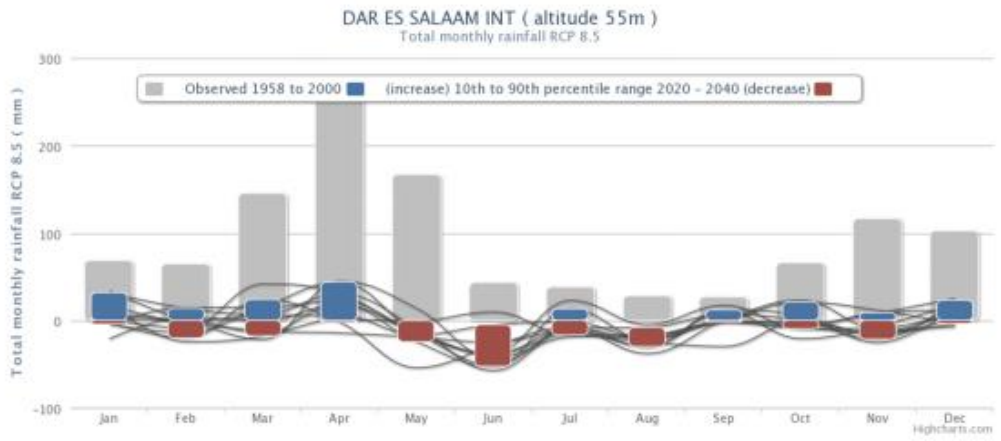

Figure 17: Projected changes in total monthly rainfall in Dar es Salaam (airport) 2020-2040, using the sing RCP8.5 scenario (high emission) (CMIP5). From Besa (2013).

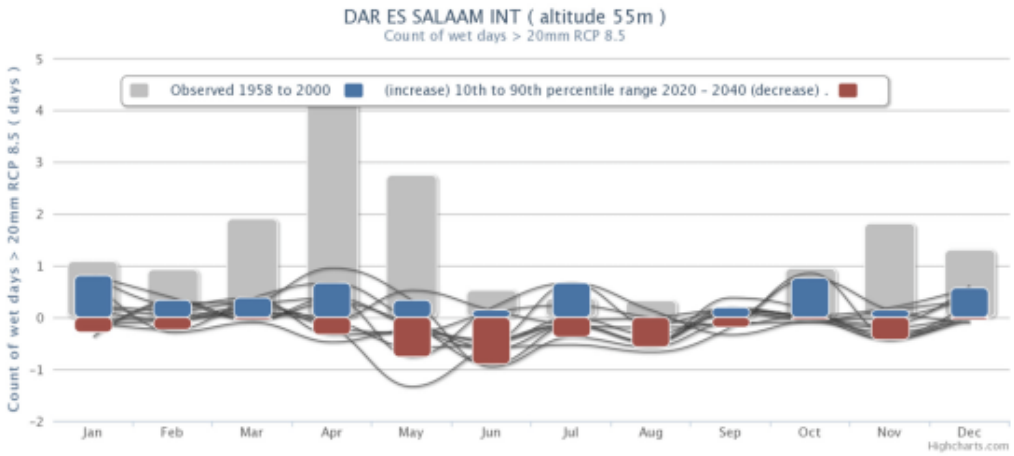

Figure 18: Projected changes in number of heavy rains in Dar es Salaam (airport) 2020-2040, using the sing RCP8.5 scenario (high emission) (CMIP5). From Besa (2013).

Besa (2013) further reported future forecasts regarding dry spells in Dar es Salaam based on CMIP5 (20 modeling groups around the world). Also here the models show mixed results (Figure 19). There is some agreement between several models that in the near to medium term there will be some decreases in the length of dry spells in the late and early parts of the year and a risk for increased length of dry spells in the middle of the year. However, in the longer term there are no conclusive picture and the models show different outcomes.

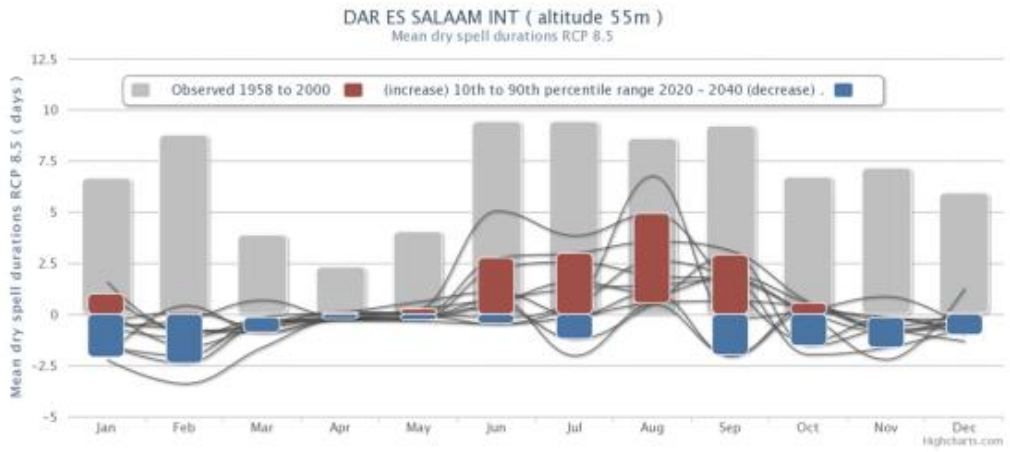

Figure 19: Projected changes in number of dry spells in Dar es Salaam (airport) 2020-2040 and 2040-2060, using the sing RCP8.5 scenario (high emission) (CMIP5). From Besa (2013).

Increasing Wind Speeds, Extreme Events and Multiple Stressors

Increasing intensity of winds in coastal Tanzania will affect coastal livelihoods in a number of ways. Coastal infrastructures will be affected, erosion is likely to increase, and traditional activities like fishing will be negatively affected.

Low-lying parts of Zanzibar and coastal Tanzania will be affected by extreme climate related events, most likely a combination of strong winds coinciding with spring tides and against a backdrop of sea level rise. A quite likely scenario is also changes in current and wind patterns as the air temperatures continue to increase. The result will be flooding of low laying areas, destruction of coastal infrastructures, salt-water intrusion into soils and groundwater, and erosion of the coastline. This kind of impacts has occurred with increasing impacts in parts of Zanzibar, Bagamoyo, Pangani, and Rufiji. In the near to medium term future such kind of impacts can only be expected to increase.

If our understanding of the impacts of the different aspects of climate change is limited, we have even less understanding of the extent of impacts of the climate change related stressors (of global origin) in combinations with other anthropogenic stressors of local origin. There are different types of responses from additive, antagonistic to synergistic. The additive response occurs when the impact of the multiple stressors is a direct addition of the stressors acting alone. An antagonistic is when the response is less than the addition of the stressors acting alone, and synergistic when the impact of the multiple stressors is greater than the additive impact. However, recent research (reviewed by Hall et al. 2013) seems to indicate that additive and synergistic reactions are far more common than antagonistic effects. This should indicate that improved coastal management at the local level would improve the situation in coastal Tanzania. Hence better management of reefs and mangroves and improved fisheries management would mean that the coastal environment would be in a better position as the climate is gradually changing.

Acidification

The problems with acidification of the coastal and ocean waters of Tanzania will depend on which CO_2 mitigation scenarios area is followed on a global level. There is a very clear and direct correlation with CO_2 emissions, the atmospheric concentrations of CO_2 and the uptake of CO_2 by the sea. However, it is important to consider the local variations across the oceans. Lower pH and carbonate ion concentrations will first affect high-latitude oceans, upwelling areas and the deep ocean. Cold waters absorb more CO_2 than warm water and the pH and the saturation of

carbon ions, aragonite and calcite are lower in polar seas than in tropical waters. Hence coastal East Africa is not expected to experience negative effects as a result of acidification during this century.

Summary: Changes that can be Expected in the Future

Our understanding of the likely future development of the climate is based on models that to a largely base their assumptions on historic events. It should be remembered that we know very little about feedbacks, additive, antagonistic and synergistic effects as well as thresholds above which the trends change. With this in mind, based on current knowledge and the different models that are used to predict the future climate we can say the following:

- All models show that temperatures are likely to increase in air and water. The average yearly temperatures at the end of the century is likely to be 2 to 2.5°C higher than today. Temperature increases of such magnitudes will have drastic effects on the ecosystem and very likely eliminate certain species almost totally (for example scleractinan corals);
- The models forecasting precipitation in future scenarios are not conclusive but could indicate dryer conditions during the non-rainy seasons and wetter during the wet seasons. There are also indications that we may expect changes in the pattern of the seasons, indicating possibly longer dry seasons and shorter but wetter rainy seasons;
- The models forecasting dry spells are not totally conclusive but there are indications that in the short to medium term dry spells during the beginning of the year and end of the year are decreasing and the mid-year dry spells increase in length;
- Models for the future wind speeds and intensity and frequency of strong winds/hurricanes indicates increasing trends. We can assume increasing problems related to incidences of extreme winds and that these will affect coastal areas with significant impacts on coastal infrastructures, agriculture biodiversity, and ground water;
- The issues related to acidification of the tropical Indian Ocean waters are not likely to seriously affect the conditions in Tanzania until towards the end of the century.

16 COASTAL EROSION CONDITIONS

Introduction

The coast of Tanzania stretches over a distance of 650 km. It has an orientation approximately north-south from latitude 4.7^0 south to 10.5^0 south. The coast is exposed to the Southern Indian Ocean and is subject to incoming waves generated by the monsoon winds and local storms. There are a large number of islands that shelters the mainland from the waves, some of these islands are very large (notably Zanzibar, Pemba and Mafia) with length of 50-100 km and lies at a distance of several tens of kilometres offshore. There are also a large number of smaller islands lying almost as fringes close to the mainland.

With its major islands the coastline of Tanzania has a total length of about 1,424 km (ASCLME, 2012).

Forcing

Coastal sediment transport and erosion is driven by waves, currents and tide. The waves are wind generated by local and regional wind fields, or they may be swell waves coming from storms at far distance.

Wind

The climate at the coast of Tanzania and in the entire Western Indian Ocean is dominated by the monsoons. The northeast monsoon season is from November to March and the southeast monsoon season is from April to October, see sketch in Figure 20.

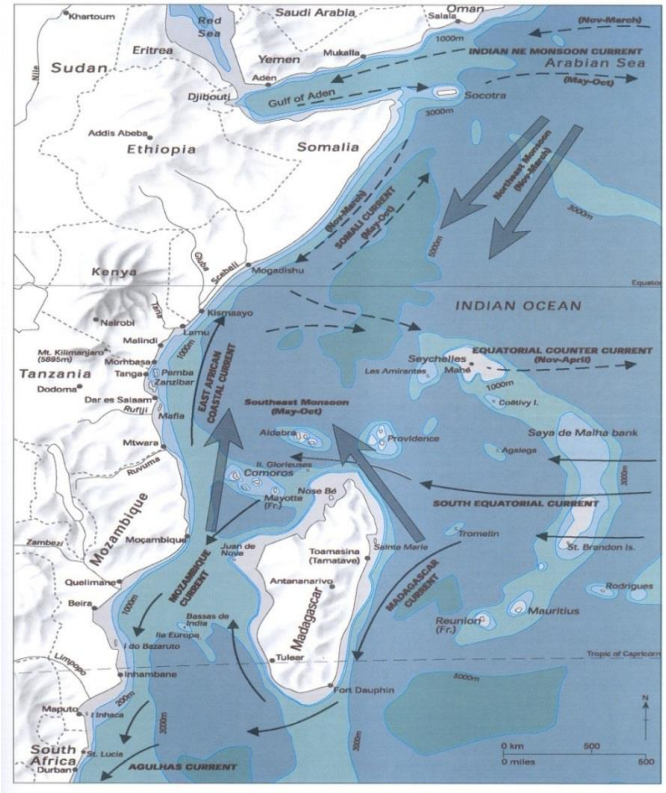

Figure 2. Ocean currents, monsoon winds and water depths.
For greater detail on coastline features and water depth, see charts at the end of the introduction, pages 56–58.

13

Figure 20: Monsoon winds and ocean currents, Western Indian Ocean (from Richmond, 2007).

In addition to the monsoon winds, sea breezes may also affect the coast (ASCLME, 2012).

Tanzania is located in an area where cyclones and tropical storms are uncommon. Most heavy depressions that come from the Indian Ocean do not fall on land in Tanzania, and if it does happen the storms will have decayed and hardly ever have the strength of a tropical storm. Even though the south-eastern part of Tanzania may get hit by a cyclone the chances are very small. Figure 21 shows historical cyclone tracks in the western Indian Ocean. The cyclone season is from November till May.

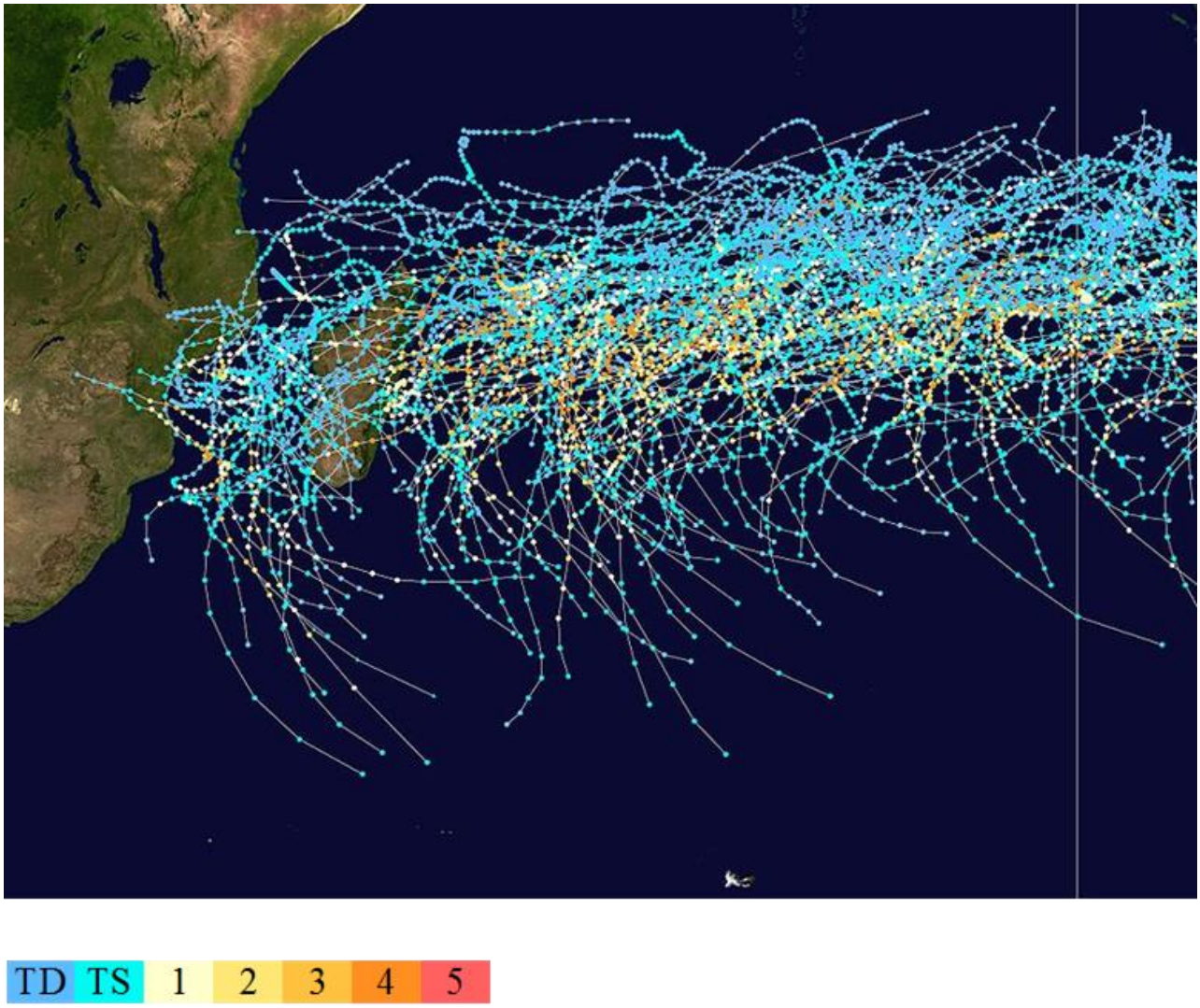

Figure 21: Tracks of all tropical cyclones in the South-western Indian Ocean between 1980 and 2005, Wikipedia, (Wikipedia, 2014). TD: Tropical Depression, TS: Tropical storm, 1-5: SSHS hurricane wind scale.

Waves

The offshore wave climate is to a large degree determined by the monsoon winds. There are no thorough studies of the wave conditions available, but the overall pattern is known. During the northeast monsoon the waves approach the coast from the northern sectors, with a wave height of approximately 0.9 m. During the southeast monsoon the waves approach from south-easterly directions and have heights of about 1.2 to 1.5 m, (ASCLME, 2012).

Almström, B. and L. Larsson (2008) present a wave statistics for the western Indian Ocean obtained from the KNMI/ERA-40 Wave Atlas, (Caires, S., A. Sterl, G. Komen and V. Swail, 2004). Statistics are given for waves coming from the four easterly directions between north and south, Table 29. It is seen that waves coming from east to south are much more frequent (84%) than waves coming from north to east (15%), and that the mean wave height of the former is also higher.

Table 29: Percentage of waves with a given wave height, Hs, and period Tm, coming from different directions in Western Indian Ocean, (Almström, B. and L. Larsson, 2008).

	Direction N - NE				Direction NE - E			
	H_s(m)							
T_m(s)	**0 -1**	**1 - 2**	**2 - 3**	**3 - 4**	**0-1**	**1 - 2**	**2 - 3**	**3 - 4**
3 – 4	0.00	0.01	0.00		0.12	0.08	0.00	
4 – 5	0.01	**0.76**	0.03		1.64	**5.66**	0.02	
5 – 6	0.00	0.15	0.05		1.85	2.59	0.05	
6 – 7	0.00	0.00	0.00		0.81	0.88	0.01	
7 – 8	0.00	0.00	0.00		0.11	0.16	0.00	
8 - 9	0.00	0.00	0.00		0.00	0.01	0.00	
All periods	0.01	0.92	0.07		4.53	9.38	0.08	
total		1.0				13.99		

	Direction E - SE				Direction SE - S			
	H_s(m)							
T_m(s)	**0 -1**	**1 - 2**	**2 - 3**	**3 - 4**	**0-1**	**1 - 2**	**2 - 3**	**3 - 4**
3 – 4	0.08	0.05	0.00	0.00	0.02	0.01	0.00	0.00
4 – 5	1.88	3.89	0.01	0.00	0.19	3.98	0.27	0.00
5 – 6	5.51	**12.25**	2.26	0.01	0.53	**8.79**	9.61	0.11
6 – 7	8.30	9.20	1.19	0.03	1.10	3.34	2.30	0.21
7 - 8	2.35	3.05	0.08	0.01	0.54	1.37	0.15	0.01
8 - 9	0.28	0.50	0.00	0.00	0.06	0.23	0.01	0.00
9 - 10	0.02	0.07	0.00	0.00	0.00	0.06	0.00	0.00
All periods	18.42	29.00	3.54	0.04	2.54	17.79	12.34	0.33
Total		51				33		

Tide

The tide at the coast of Tanzania is semidiurnal with a mean spring tidal range of approximately 3.5 m (Figure 22). This tidal range is large, especially when considering the offshore wave climate. The tide is therefore expected to important for the coastal morphology and the coast is characterised as 'macrotidal'.

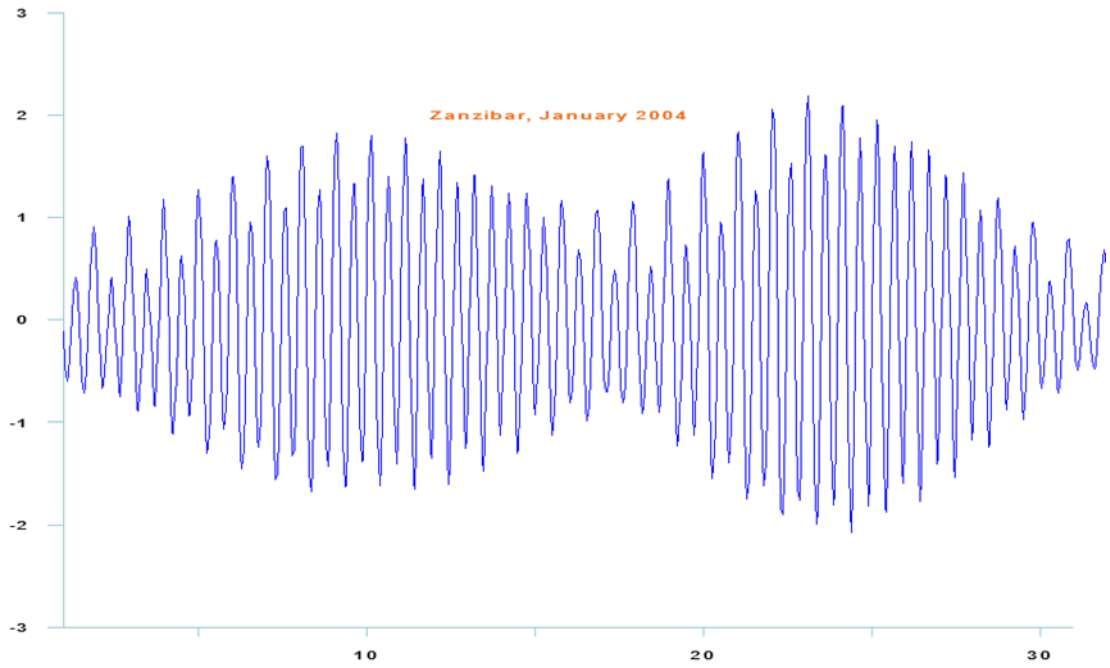

Figure 22: Example of predicted tide, Zanzibar, (Mahongo, 2006).

Currents

Tidal currents in creeks and estuaries can be important for the coastal erosion, but on the open coast tidal currents will often play a minor role compared to the wave action.

Ocean currents do not have sufficient velocity in the shallow coastal waters near the shoreline to play any role for the coastal erosion.

Characteristics of the Coastline

The morphology of a coastline is often dominated by longshore transport, littoral drift. The longshore transport is caused by waves approaching the coast at an angle, when breaking the waves will drive a current along the coast in the surf zone, and sand agitated by the breaking waves and the wave-driven current will transported along the coast. The transport direction changes with the direction of the wave incidence, and the coast will be characterised by the net transport, which is the mean transport on a long time scale of years, and the gross transport, which is the total of the transport going in both directions. The net transport thus represent the net drift of sand in one direction along the coastline, while the gross transport is a measure of the strength of the wave climate and how effective the waves are in distribution sand delivered to the coastline, for example by a river, on the coast.

The littoral drift thus depends on the direction of the wave incidence relative to the coastline and vice versa. The orientation of the coastline will change if the littoral drift is changed, for example if it is reduced by coastal protection structures or if the supply of sand from a river is changed due to mining of aggregates from the river or due to river regulation. Often it will be important to determine the 'equilibrium orientation' of a coastline, which is the local orientation of the shoreline for which the littoral transport is zero. The difference between the actual coastline orientation and the equilibrium orientation is an indication of how strongly the coastline will be affected by interference with the littoral drift.

An important concept is the littoral cells, which are coastal units for which well-defined sediment budgets can be established, and which either are isolated from the neighbouring cells, for example by headlands, or have a well-defined exchange of sand with the neighbouring cells.

It is characteristic for the coastline of Tanzania, that it is highly irregular with a large variation in the coastline orientation even over short distances. There are no large systems or littoral cells where the coastline is defined by the incoming waves and transport or redistribution of sand along the coast.

The reason for the absence of large littoral cells is to a large degree the presence of extensive coral reefs and the many islands along the coast. The coral reefs shelter the coast from the incoming waves except at high water, and the islands near the shoreline, which in some case are also parts of the coral reefs, give an effective local protection of the coastline and prevent any significant transport of sand in the lee zones.

The three large islands will also create lee for the waves coming in from the Indian Ocean. Taking a typical wave height of 1.5 m, this will be generated by winds with a speed of 7.5 m/s blowing over the sea over very large distances, Figure 23. In the lee of an island it would require a fetch of about 170 km to re-establish this wave height, and over a distance of 30-60 km, which is typical for the distance between the large islands and the mainland, it would only have regained 50-60 % of this height.

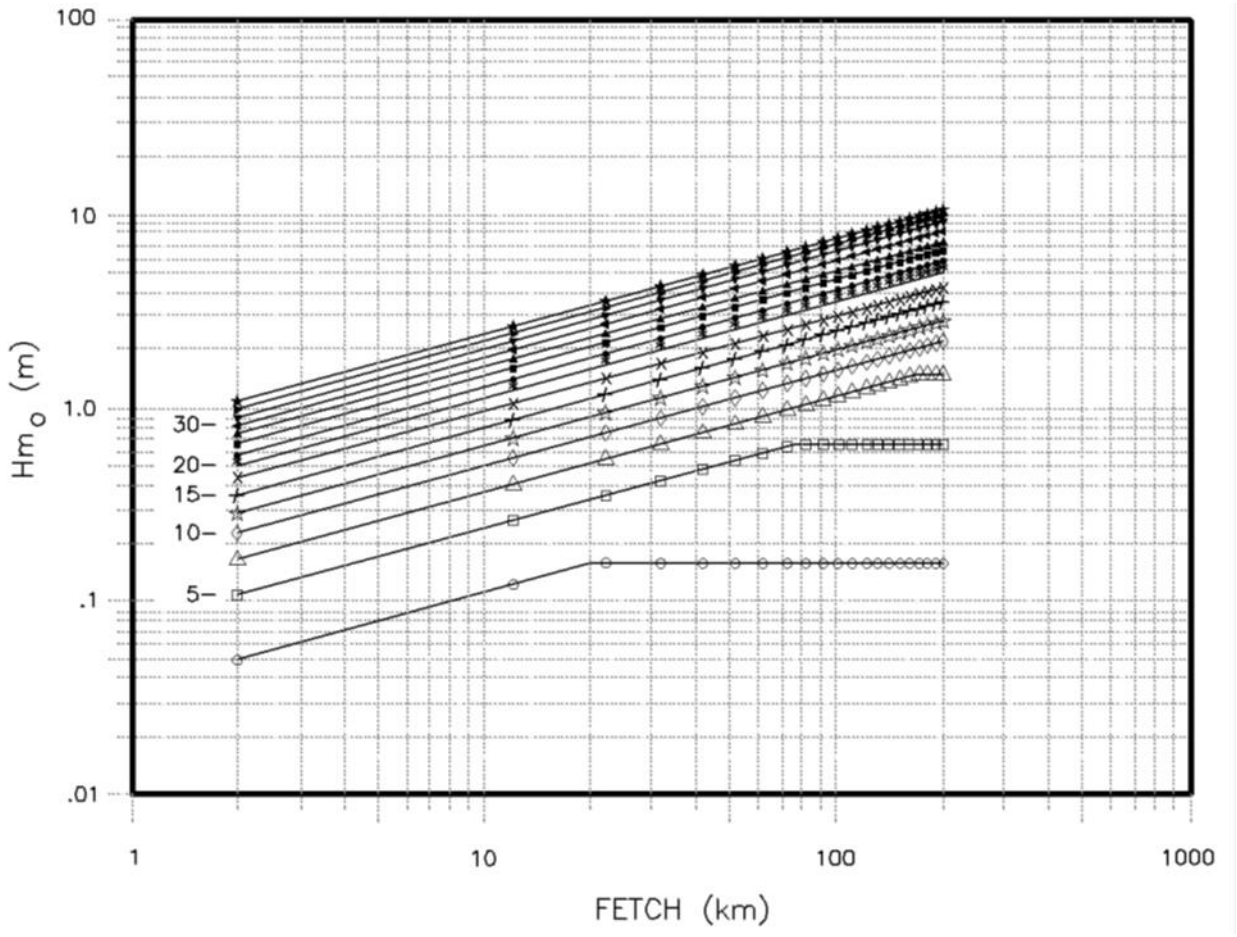

Figure 23: The relation between Wave height (Hm0), the distance the wind is blowing over (FETCH) and wind speed given next to the different curves (5 to 30 m/s).

At many locations the irregular coastline is also fixed by hard erosion resistant points. The hard point may be fossil reef terraces, (ASCLME, 2012). An example of an island formed as a reef terrace is shown in Figure 24.

Figure 24: Lighthouse on Bird Island, north of Tanga, Photo from Google Earth

Coral Reefs

As mentioned coral reefs play an important role for the coastal morphology. ASCLME (2012) estimates that coral reefs cover about two thirds of Tanzania's continental shelf. And fringing reefs forming margins along the edge of the mainland or the islands and patch reefs dominate the coastal waters of Tanzania.

ASCLME (2012) presents a classification of coastal types found along Tanzania's coast. The main types are Fringe reef coasts, patchy reef coasts and exposed low lying coasts, Figure 25.

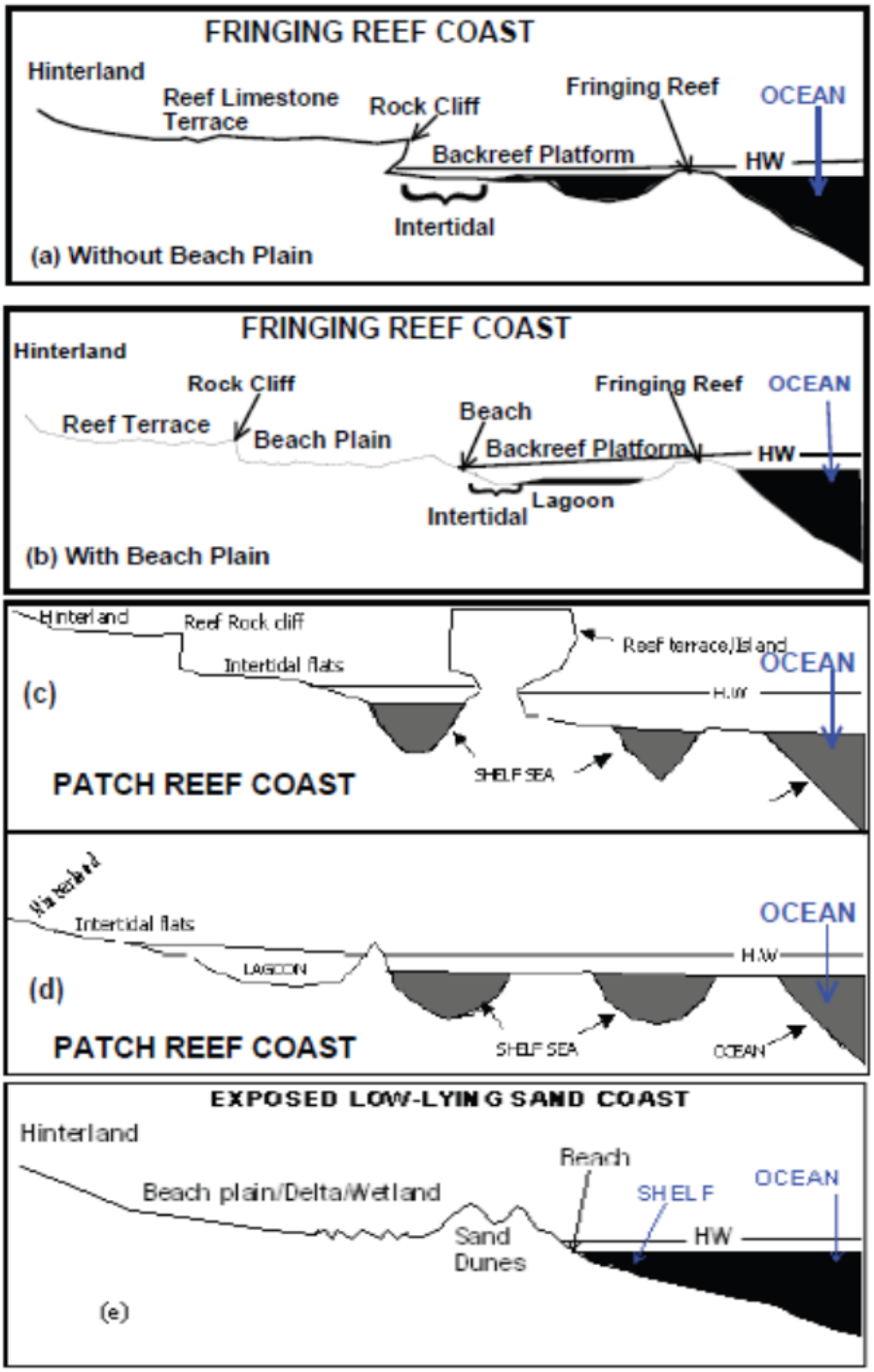

Figure 25: Cross sections of the most prominent coastal types in Tanzania, (ASCLME, 2012).

Tidal Inlets

The large tidal range have also caused the formation of numerous tidal inlets estuaries and creeks, which can be found in connection with all of the three major coastal types.

Mangrove

Extensive mangrove forests are found in the tidal inlets, estuaries and creeks, including where such locations are associated with urban and port development. Due to the gentle wave conditions sheltered by coral reefs mangroves can even be found on the open coast.

Rivers

Several rivers discharge to Indian Ocean on the Tanzanian coast, Figure 26. The river mouths are forming estuaries and deltas with extensive mangrove forests. The rivers are often significant as sediment sources for the coastline, especially for the low lying sandy shores. The rivers carry fine sediments, which are important for the sediment balance of estuaries end the formation of mangroves, but may also cause high turbidity in the coastal waters and have a negative effect on the corals.

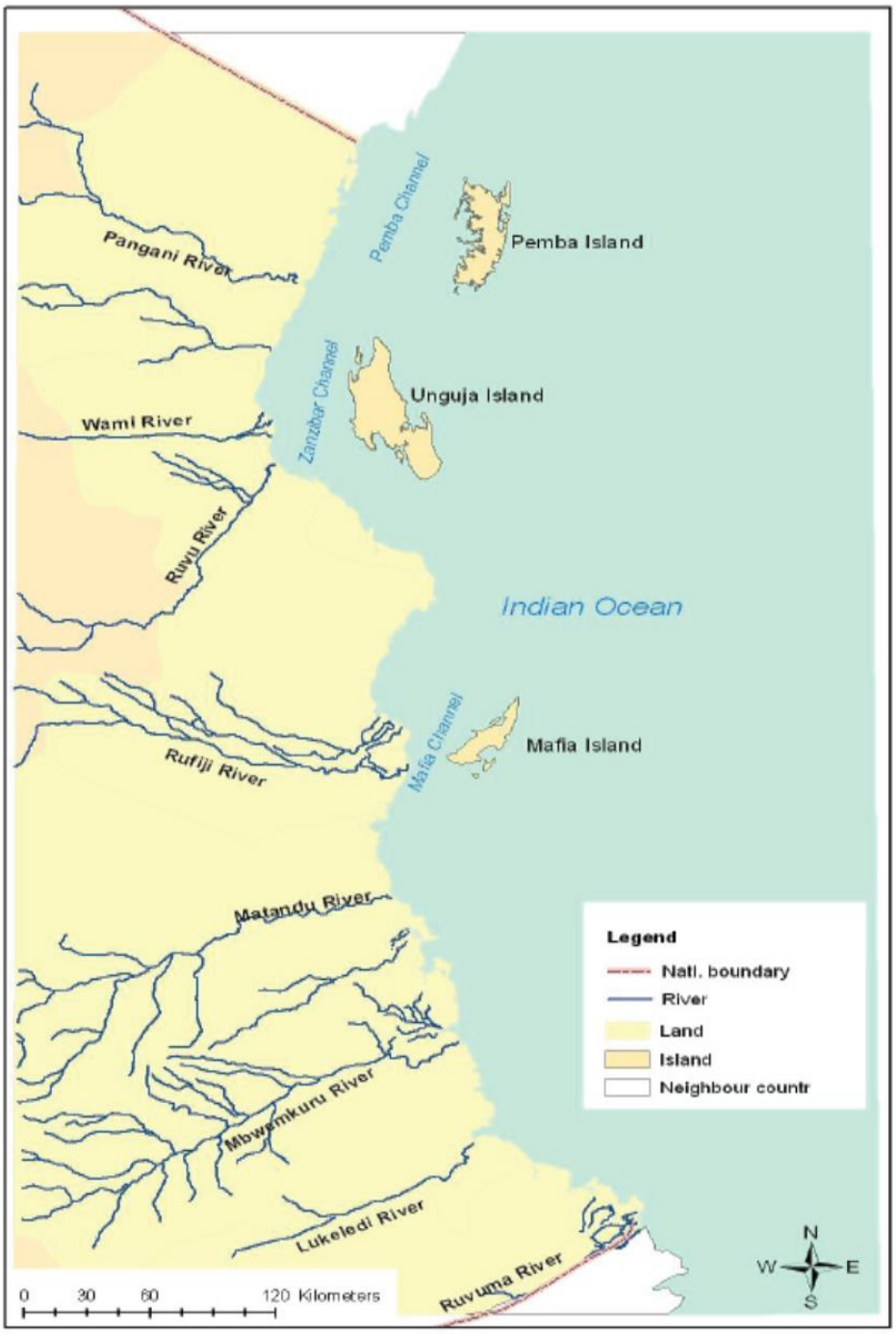

Figure 26: Rivers draining to the Tanzanian coast (ASCLME, 2012).

Coastal Erosion Problems

The severity of coastal erosion problems depends of course on the persistence of the erosion, whether it is continuing year after year or whether it occurs in connection with single events and the beach is restored during the following more gentle wave and weather conditions. It is also important how developed the coastal front is: if the erosion threatens infrastructure such as roads or railways, of built up areas with hotels or houses.

The coastal types described above will often have a high resilience against erosion, and erosion problems will often be in the form of removal or shifting of an often sparse pool of sand lying in front of a more erosion-resistant backshore.

There are only few studied or reported examples of coastal erosion. Kairu, K. and N. Nyandwi, (2000) describes historical incidences of coastal erosion at locations from Pangani River and southward. The Mazewi Island and Kunduchi Beach are given as reference sites and is described in more detail in the thematic volume covering mainland Tanzania. Examples of damage to historical buildings are also given. An example, Kilwa Kisiwani, is illustrated in Figure 27 and Figure 28. In this case as in others, the erosion is not due to severe wave action, but rather shifting tidal channels.

Figure 29 and **Error! Reference source not found.** show a site in Lindi, which is not very exposed to waves from offshore, but where erosion seems to occur due to deterioration of a dead coral reef.

Figure 27: The location at Kilwa Kisiwani

Figure 28: Historical buildings damaged by erosion at Kilwa Kisiwani. Left: location 1. Center and Right: location 2.

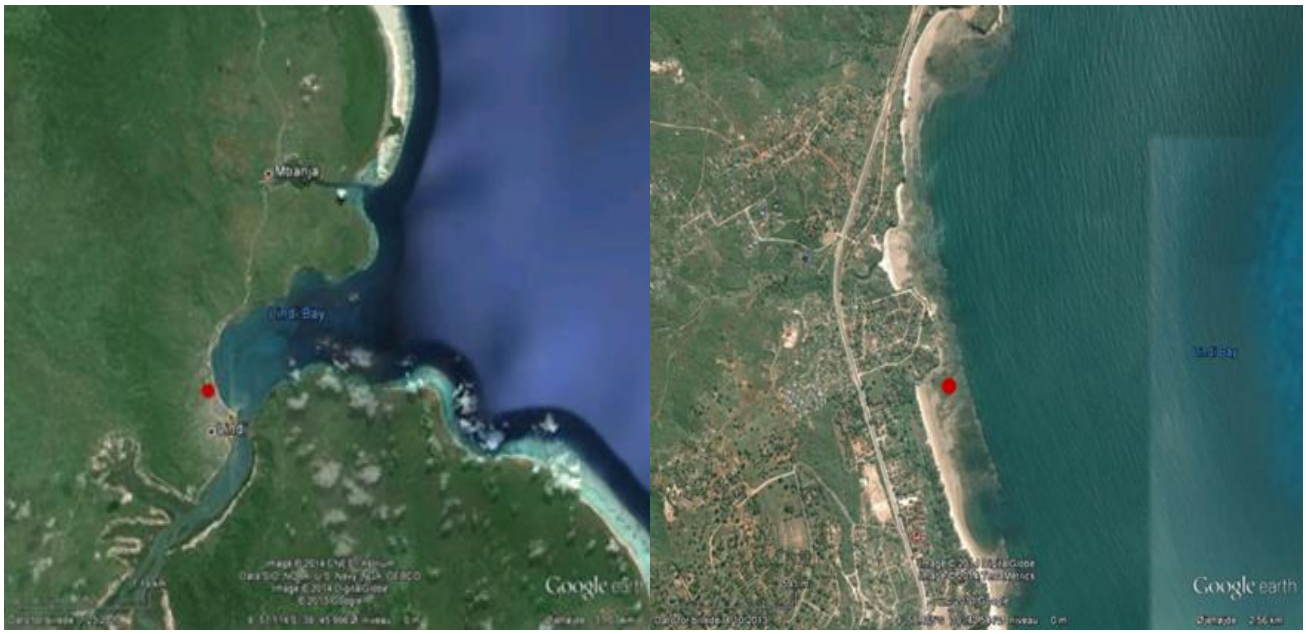

Figure 29: The location at Lindi.

Figure 30: Coastal erosion at Lindi.

Coastal Erosion Conditions at Selected Locations

The two cases, Maziwe Island and Kunduchi Beach, and the coasts at the coastal cities of Dar es Salaam and Tanga are treated in more detail in the thematic volume covering mainland Tanzania, whereas Stone Town on Zanzibar is briefly commented below. The cities are of interest because the high level development makes the consequences of coastal erosion more severe, and makes it realistic to introduce costal protection measures.

Stone Town

The city of Stone Town is situated on the west coast of Zanzibar, and is therefore not attacked by waves coming from the Indian Ocean. The coast around the city shows very few signs of any erosive pressure. The only location that shows changes in the shoreline and some structures is at the promontory at Shangani, Figure 31. Even here the coastline variation is weak and not systematic and the structures have probably been found to be necessary because the buildings are placed too close to the beach.

Figure 31: Shangani Promontory, Stone Town.

Future Erosion Pressures

The coastal erosion problems of Tanzania are manageable, but future conditions may cause more severe erosion problems and a deterioration of the quality of beaches used for fishing or recreation and water sports. The good beach conditions are to a high degree caused by the presence of coral reefs, which over large stretches protect the coastline against severe wave action but allow sufficient wave energy to propagate to the beaches to maintain a sandy beach of good quality without deposition of fine sediments, which would make the beach soft and wet.

Effects of Climate Change

The coral reefs may be affected by climate change. An increase in temperature may be detrimental to the corals.

The coastlines of Tanzania are also particularly sensitive to rapid variations in the sea level, if the coral reefs cannot keep up with the rising sea level the coasts will – in addition to the higher sea level – be exposed to a harsher wave climate with higher maximum waves and a higher frequency of severe waves reaching the coastlines, which today are protected by corals.

Changing wind conditions will be reflected in a change in the wave conditions which will affect the coastal erosion.

Changes in the precipitation will affect the water and sediment discharge of rivers. An increase in the fine sediment load can result in an increase in the turbidity of the coastal waters, which may affect the coral reefs.

A change in the sand load delivered to the coast will affect the sediment budget for the coast. A decrease will increase the tendency for coastal erosion, while an increase will provide more sand to the coastal system.

Anthropogenic Effects

Sand mining directly from the coast, in the nearshore or in rivers discharging to the coast will deprive the coast of the sediment and promote coastal erosion.

Coral reefs can be directly damaged by human action, which as described above can increase the coastal erosion. Coral reefs may be damaged or destroyed by collection of coral specimens, by mining of corals for construction material and by fishing by use of heavy equipment, by dynamite or by use of poison.

Cutting of mangroves can expose the coast and cause increased erosion.

River regulation, irrigation or changes in the land use in the drainage area may change the regime of the rivers discharging to the coast. The result may be changes in the load of fine sediments or sand with the consequences discussed above.

Coastal structures such as harbours will interfere with the coastal sediment transport and can cause coastal erosion. This should be taken into account when planning a project and is necessary remedial measures, as for example artificial bypass of sand past a harbour, should be considered (ZHTI, 2006).

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ZCT (2010) Zanzibar Commission for Tourism - Tourism Policy 2002, cited in Ussi, M.U. (2013). The Viability of Community Tourism in Least Developed Countries: The Case of Zanzibar. PhD Thesis. University of Central Lancashire. 397 pp.

ZHTI (2006). *Zanzibar Ecotourism Study NUFFIC support facilitated by MMA Ltd.: 55p.*

Annex 1: List of Documents

Table 30: Document Database at SAMAKI compiled for the Prioritisation Study

Title	Source	Year
Feasibility Study for New Port Project in Zanzibar -Phase I	REVOLUTIONARY GOVERNMENT OF ZANZIBAR, TANZANIA	2014
Perceptions of Rule-Breaking Related to Marine Ecosystem Health	Matthew J. Slater1, Yunus D. Mgaya, Selina M. Stead	2014
Alleviating Poverty & Countering Environmentally Unsustainable Practices.	Smallholder Empowerment and Economic Growth through Agribusiness & Association Development (SEEGAAD)	2014
Shipping Traffic At major Ports	Annual Statistics 2012-2013 TPA	2013
Economic Impacts of Dynamic Fishing in Tanzania	Wilson and Associates	2013
Marine and Coastal Environment Management Project (MACEMP): Implementation Completion and Results Report	World Bank	2013
Zanzibar Climate Change Strategy	THE REVOLUTIONARY GOVERNMENT OF ZANZIBAR THE FIRST VICE PRESIDENT'S OFFICE	2013
Zanzibar Environmental Policy	Department of Environment Zanzibar	2013
Management Plan For the Tanzanian Artisanal Fishery for Small and Medium Pelagic Fish Species	Ministry Of Livestock and Fisheries Development.	2013
Tanzania Tuna Fishery Management Strategy		2013
The Proposed Transboundary Conservation Area (TCA)	UNEP	2013
Tanzania Economic Update How the ports of Dar es salaam can transform	www.Worldbank.org/tanzania/economicupdste	2013
$200 - $350 bn a year needed for Africa-UN	wwwnewsdaily.com	2013
2012 Population and Housing census	National Bureau of Statistics	2013
Coastal and Marine Ecosystems in Changing Climate.	Prof. Pius Z. Yanda	2013
The Earth Security Index	Alejandro Litovsky, Founder & CEO, Earth Security Initiative	2013
Future habitat suitability for coral reef ecosystems under global warming and ocean acidification	Elena Couce,Andy Rdgwell and Erica J Hend	2013
Distribution and Marketing Networks within Dynamite Fishing in Tanzania.	Winfried Venant Haule	2013
Tanzania: marching toward sustainable IDD elimination	Idd Newsletter	2013
Anthropogenic Impacts On Coral Reefs and Their Effect on Fishery of Kilwa District ,Tanzania	Mbije ,N.E and Rinkevich,B.	2013
The Economic Impacts Of Dynamite Fishing in Tanzania	MANCEMP	2013
National Gas policy Of Tanzania	URT	2013
Report urges modern farming	www.theeastafrican.co.ke	2013
Situation analysis for Mangroves for the Future: Understanding the resilience of coastal systems	Melita Samoilys, George Waweru Maina, Julie Church, Brigid Mibei, Marta Mo njane, Abdulla Shah, Doris Mutta and Mine Pabari	2013
Action on Nutrition in Tanzania	WHO & URT	2013
Tanzania Initiatives on Coastal Ecosystem Management in The Context of Adaptation and Mitigation	Zainabu Shabani	2013
The Deloitte Guide to Oil and Gas in East Africa	Deloitte	2013
The Ecosystem, Livelihoods and Future Status of Mbegani	USAID/PWANI Project & http://www.crc.uri.edu	2013

Title	Source	Year
The Description of Ecologically or Biologically significant of Marine Areas.	UNEP/CBD/RW/EBSA/SIO/1/4	2013
Agriculture Lab Tanzania Development Vision 2025	URT	2013
Education NKRALab Report Tanzania Development Vision 2025	URT	2013
EnergyLab Final Report Tanzania Development Vision 2025		2013
Resources mobilization(NKRA)Report Tanzania Development Vision 2025		2013
Transport Lab (NKRA)Report Tanzania Development Vision 2025		2013
National Key Result Area (NKRA) Water Tanzania Development Vision 2025		2013
Environmental factors influencing whale shark occurrence & movements at Mafia Island, Tanzania	Christoph A. Rohner & Simon J. Pierce ,Michael Berumen,Jesse Cochran3 & Fernando Cagua, Mathias Igulu& Baraka Kuguru Jason Rubens6	2013
Economics of Climate Change in Zanzibar - Vulnerability, Impacts and Adaptation	Global Climate Adaptation Partnership	2012
Marine Legacy Funds of Tanzania	Meyers, D.	2012
Socio-economic Impact Assessment of MACEMP Supported Subprojects	Health and Environmental Concerns (HEC) Limited	2012
People, Nature and Research in Chwaka Bay, Zanzibar, Tanzania	de la Torre-Castro M. and Lyimo T.J. (eds)	2012
National Marine Ecosystem Diagnostic Analysis. Tanzania. Contribution to the Agulhas and Somali Current Large Marine Ecosystems Project	ASCLME	2012
The Economics of Climate Change in Zanzibar	Global Climate Adaptation Partnership	2012
Marine and Coastal Environment Management Project (MACEMP): The Marine Legacy Funds of Tanzania	MACEMP	2012
Implementation of Concrete Adaptation Measures to Reduce Vulnerability of Livelihoods and Economy of Coastal Communities of Tanzania	UNEP	2012
Rising tides threaten Tanzania's coastal towns	Kizito Makoye	2012
A Study of Working Conditions in the Zanzibar Seaweed Farming Industry	Flower E. Msuya	2012
The Revolutionary Government of Zanzibar NATIONAL SAMPLE CENSUS OF AGRICULTURE 2007/2008		2012
Chumbe_Island__Coral_Park__Governance_Analysis	Lina M.Nordlund,Ulrike Kloiber,Eleanor Carter and Sibylle Riedmiller.	2012
Coastal and Marine Tourism Development Plan for the Menai Bay Conservation Area (MBCA), Mnemba Island Marine Conservation Area (MIMCA), and the Pemba Channel Conservation Area (PECCA).	Enviro-Fish Africa (Pty) Ltd	2012
Octopus Fishery Management Plan		2012
Prawn Fishery Management Plan		2012
National Marine Ecosystem Diagnostic Analysis	ASCLME	2012
Deep Sea Coral Research and Technology	NOAA	2012
NATIONAL SAMPLE CENSUS OF AGRICULTURE 2007/2008		2012
2007/2008National Sample Census of Agriculture	URT	2012
Vulnerability, Impacts and Adaptation	SMZ	2012
Legal and Institutional Framework for Effective Management of Marine Managed Areas in Tanzania	Mwita M. Mangora Mwanahija S. Shalli Bernice McLean	2012

Title	Source	Year
Socio-Economic Profiles of Communities Adjacent to Tanga Marine Reserve Systems, Tanzania	Mwita M. Mangora and Mwanahija. S. Shalli Institute of Marine Sciences, University of Dar es Salaam, P.O. Box 668, Mizingani Rd., Zanzibar, Tanzania	2012
National Sample Census Of Agriculture 2007/2008 -Mtwara Region	URT	2012
Human induced changes, biodiversity loss, livelihood implications and management in the Western Indian Ocean	Lina Mtwana Nordlund	2012
Pwani Region Report	URT	2012
Sea Sense Annual report	www.seasense.org	2012
Tanzania Environmental Threats and Opportunities Assessment	USAID	2012
Tanzania Ports Authority	TPA	2012
Impact Assessment (SESIA) for the Oil & Natural Gas Subsector	NEMC	2012
Legal and Institutional Framework for Effective Management of Marine Managed Areas in Tanzania	EcoAfrica Environmental Consultants	2012
Water Perfromance Report	ewura	2011
Economics of Climate Change in Tanzania (mainland) - The Implications of Climate Change and Sea Level Rise in Tanzania	Global Climate Adaptation Partnership	2011
Community-based Vulnerability Assessment and Adaptation Options in Coastal Villages: Bgamoyo District, Tanzania	TCMP (Tanzania Coastal Management Partnership)	2011
The Tanzania Five Year Development Plan 2011/2012 - 2015/2016	GOT: President's Office. Planning Commission	2011
The Economics of Climate Change in the United Republic of Tanzania	Global Climate Adaptation Partnership and partners	2011
Developing Core Capacity to Address Adaptation to Climate Change in Productive Coastal Zones of Tanzania	UNEP	2011
Sea Level Rise and Impacts in Africa 2000 - 2100	Sally Brown, Abiy S. Kebede and Robert J. Nicholls School of Civil Engineering and the Environment University of Southampton Southampton SO17 1BJ, UK	2011
Population and Assets Exposure to Coastal Flooding in Dar es Salaam (Tanzania) Vulnerability to Climate Extremes	Abiy S. Kebede and Robert J. Nicholls University of Southampton School of Civil Engineering and the Environment and Tyndall Centre for Climate Change Research Southampton, Highfield, SO17 1BJ United Kingdom	2011
Preparation of a Zoning Plan for Tanga Coelacanth Marine Park	Christopher A. Muhando	2011
Proceeding Of The Tanga Coelacanth Marine Park Zoning Workshop,Veta Tanga,20th April 2011 and The TCMP Zoning Plan	Christopher A. Muhando	2011
Ministry of Livestock Development and Fisheries - Achievents and Lessons Learnt	MACEMP	2011
Environmental and Social Impact Statement for the proposed Fish Market and landing site at Tumbe, Micheweni District, Pemba	MK Business Consultants Ltd	2011
Poverty Eradication through Aquaculture	A Leverhulme Trust Research Grant Project	2011
Impacts Of Climate Change In Zanzibar	Care International	2011
Local Economic Development Plan Kilwa Kisiwani, Kilwa, Tanzania	Eco Africa	2011

Title	Source	Year
To connect or not to connect? Floods, fisheries and livelihoods in the Lower Rufiji floodplain lakes, Tanzania	http://www.tandfonline.com/loi/thsj20	2011
International Social and Environmental Performance Standards	BG Group Workshop Dar esSalaam, Tanzania 14 September 2011	2011
Integrated Industrial Development Strategy	URT	2011
State of Knowledge of Coastal and Marine Biodiversity of Indian Ocean Countries	Mohideen Wafar, Krishnamurthy Venkataraman, Baban Ingole, Syed Ajmal Khan, Ponnapakkam LokaBharathi	2011
The Formation and Establishment of the Jozani-Chwaka Bay National Park, Zanzibar, Tanzania	Fred Saunders School of Life Sciences, Södertörn University, Huddinge, Sweden	2011
Health Sector and Social Wlfare public Private Partnerships Policy Guidelines	Ministry of Health and Social Walfare	2011
The organisation Structure of the Ministry of Lands ,Housing and Human Settlements Development		2011
Tanzanian Food and Water Security Outlook	Aida Mliga	2011
Tourism Guide for the Tanga Region, Tanzania 2nd edition	Tanga City Council	2011
2011 TanSEA layers delivered	TanSea	2011
National Nutrition Strategy	URT	2011
WIOMSA Annual Report	WIOMSA	2011
Preparation of an Adaptation Programme of Action for Zanzibar (Zanzibar NAPA)	SMOLE	2010
The Implications of Climate Change and Sea-Level Rise in Tanzania – The Coastal Zones	Kebede, Brown, and Nicholls. University of Southampton School of Civil Engineering and the Environment and Tyndall Centre for Climate Change Research Southampton, Highfield, SO17 1BJ United Kingdom	2010
News of the Coast no 14	RECOMAP (Regional Programme for the Sustainable Management of the Coastal Zones of the Indian Ocean Countries)	2010
Annexes to Zanzibar NAPA	SMOLE	2010
Mapping of Mangroves in Jasini, Ndumbani, Mahandakini, Moa, Boma Kichakamiba and Boma Subutuni villages, Mkinga District, Tanga	Christopher A. Muhando	2010
Intergrated Social and Ecological Report For Non - Node and Node Sites	T. Campson R. Pomeroy C. Dahlgren S. Gopal L. Kaufman H. Patel B. Shank J.F. Bertrand	2010
Sustainable Management of Land and Environment II	Mr. Lars Møller	2010
Calibration of Community-based Coral Reef Monitoring Protocols	Christopher A Muhando	2010
Mapping of Mangroves in Jasini, Ndumbani, Mahandakini, Moa, Boma Kichakamiba and Boma Subutuni villages, Mkinga District, Tanga	Dr. Christopher A. Muhando	2010
SMOLE II - Environmental Impact Assessment	KRISTINE KARPF, EIA Advisor, Environmental consultant with NIRAS	2010
SMOLE II - Final Report from International IT and Database Advisor		2010
SMOLE II - Final Report of GIS and Data Sharing Advisor	Mr. Arto Vuorela	2010
SMOLE II - Functional Analyse and Capacity Assessment	SMOLL II	2010
Policy misfits,climate change and cross scale vulnerability in Coastal Africa;How development projects undermine resilience	Matthew Brunce,Katrina Brown and Sergio Rosendo	2010
Calibration of Community-based Coral Reef Monitoring Protocols: Tanzanian Case Study	Christopher A. Muhando	2010

Title	Source	Year
Impact of hydrographic parameters and seasonal variation in sediment fluxes on coral status at Chumbe and Bawe reefs, Zanzibar, Tanzania	Alfred N.N. Muzuka, Alfonse M. Dubi, Christopher A. Muhando, Yohanna W. Shaghude	2010
Synthesis Report The Implications of Climate Change and Sea-Level Rise in Tanzania	Abiy S. Kebede, Sally Brown and Robert J. Nicholls	2010
The Mining Act	The United Republic Of Tanzania	2010
Policy misfits,climate change and cross scale vulnerability in coastal Africa	Matthew Brunce,Katrina Brown and Sergio Rosendo	2010
Ecosystem-based Adaptation in Tanzania	Tahia Devisscher	2010
Marine Fisheries Frame Survey Result.doc	URT,MACEMP & WWF	2010
Mnemba Island-Chwaka Bay Marine Conservation Area (MIMCA)	SMZ & MACEMP	2010
Zanzibar Strategy for Growth and Reduction of Poverty 2010-2015 (MKUZA II)	RGoZ	2010
Strengthening Co-Management (SccaFcoM) in Rufiji,Mafia,and Kilwa Districts	Dr Robert M. Otsyina Monitoring and Evaluation Expert Team Leader Development Associates Ltd Dr Benaiah L. Benno Expert in Fisheries Management University of Dar es Salaam Dr Jumanne M. Abdallah Socio-economist & Community Based Management Sokoine University of Agriculture	2010
An update on research on migratory routes and feeding destinations of Southwest Atlantic humpback whales	Alexandre N.Zerbini,Artur Andriolo,Daniel Danilewicz,Mads Peter Heide-Jorgensen,Nick Gales and Phillip J Clapham.	2010
State of the Coast Report - Tanzania Mainland	National Environmental Management Council	2009
Marine and Coastal Environment Management Project (MACEMP): The Status of Zanzibar Coastal Resources	Zanzibar Revolutionairy Government - Department of Environment	2009
Habitats and Ecological Zone in Kicamp Area	Christopher A. Muhando, Mwanahija S. Shalli, Rukia A. Kitula ,Mwita M. Mangora	2009
Coral Reef Baseline Survey in Tumbatu Conservation Area	Christopher A. Muhando	2009
The Status of Zanzibar Coastal Resources Towards the Development of Integrated Coastal Management Strategies and Action Plan	Department of Environment	2009
The Status of Zanzibar Coastal Resources	Department of Environment through support from Marine and Coastal Enviromental Project (MACEMP)	2009
Coral reef monitoring in Tanzania: an analysis of the last 20 years	Christopher A. Muhando	2009
Solar Saltworks'wetland Function	Global NEST Journal, Vol 11, No 1, pp 49-57, 2009	2009
Improved Salt Iodation Methods for Small scale Salt produces in Law resource setting in Tanzania.	www.biomedcentral.com/1471-2458/9/187	2009
Documenting the global impacts of beach sand mining	R. Young and A. Griffith	2009
The Extractive Resource Industry in Tanzania	Society for International Development Regional Office for Eastern Africa P O Box 2404 – 00100 Nairobi Kenya Telephone: +254 - 20 - 2737991 Fax: +254 - 20 - 273 7992 Email: sidea@sidint.org Website: http://www.sidint.org	2009
Tanzania Ports Master Plan	TPA	2009
Consultancy Study On The Needs assessment For Implementation Of The Prevention Of Marine Pollution From Ships (MARPOL 73/78) and Oil Spill Response Contingency Plan For The United Republic Of Tanzania.	Gorton Consultancy	2009
Coral Reef Resilience Assessment of the Pemba Channel Conservation Area, Tanzania	G. Grimsditch, J. Tamelander, J. Mwaura, M. Zavagli, Y. Takata, T. Gomez	2009

Title	Source	Year
Institutional Analysis of Nutrition in Tanzania	Valerie Leach and Blandina Kilama	2009
Tanzanian water policy reforms between principles and practical applications	Haakon Lein and Mattias Tagseth	2009
Country Wildlife Response Profiles	Sea Alarm	2009
Integrated Coastal Management Action Plan Bagamoyo District Council	The District Executive Director P.O. BOX 59 BAGAMOYO	2009
Integrated Coastal Management Action Plan ilala District Council	www.ilalamunicipal-tz.org	2009
Mpango Kazi wa Usimamizi Kamilifu wa Mazingira ya Pwani Kilwa Masoko	Mkurugenzi Mtendaji wa Wilaya P. O. Box 160 Simu Na. Nukushi. Kilwa Masoko	2009
Integrated Coastal Management Action Plan Kinondoni District Council		2009
Mpangokazi wa Usimamizi Kamilifu wa Mazingira ya Pwani Wilaya ya Lindi.	Mkurugenzi Mtendaji Halmashauri ya Wilaya ya Lindi S.L.P. 328 LINDI Simu : 023-2202325/2261 Nukushi: 023-2202472 Baruapepe: dedlindi@yahoo.co.uk	2009
Integrated Coastal Management Action Plan Lindi District Council	Town Director Lindi Town Council P.O. Box 1070 LINDI Tel. 023 – 2202164 Fax: 023 – 2202116 E-mail: linditc@pmoralg.go.tz	2009
Integrated Coastal Management Action Plan Mkuranga District Council	District Executive Director Mkuranga District Council P.O. Box 10 Mkuranga Coastal Region	2009
2009 Integrated Coastal Management Action Plan Mtwara District Council	Municipal Director Mtwara-Mikindani Municipal Council P.O. Box 92, Mtwara. Te:+255 23 3333941 Fax: + 255 23 2334256 E-mail: Mtwaramikindani@yaoo.com	2009
2009 Mtwara District Council ICM Action Plan	District Executive Director Mtwara District Council P.O Box 528 MTWARA. Tel: 023-2333928 Fax: 023-2333293 Email: Mtwara rural@gmail.com	2009
2009 Integrated Coastal Management Action Plan Muheza District Council	District Executive Director Muheza District Council P.O.Box 20 Muheza TANGA	2009
Integrated Coastal Management Action Plan Pangani District Council.	District Executive Director Pangani District Council P.O. Box 89 Pangani Tanga Tel: 0272630058 Fax: 0272630315	2009
Mpango kazi wa Usimamizi Kamilifu wa Mazingira ya Pwani (ICM) Halmashauri jiji la Tanga	Mkurugenzi Halmashauri ya Jiji la Tanga S.L.P 178 TANGA Simu: 0272644530 Barua pepe: tmc@kaributanga.com	2009
Mpango kazi wa Usimamizi Kamilifu wa Mazingira ya Pwani Halmashauri ya Jiji la Temeke	HALMASHAURI YA MANISPAA YATEMEKE S.L.P. 46343, FAX NO. 2850640 SIMU: 2851054 TEMEKE DAR ES SALAAM	2009
Integrated Coastal Management Action Plan Mkinga District Council		2009
Tanzania Coral Reefs Status Report	Muhando, C.A. and Mwaipopo, R.	2008
The Social Dimensions of Marine Protected Areas: A Case Study of the Mafi a Island Marine Park in Tanzania	Rosemarie Nyigulila Mwaipopo	2008
Distribution and Status of Coastal Habitats and Resources in Tanzania	Dr. Christopher A. Muhando, Institute of Marine Sciences and Mr. Chikambi K. Rumisha Ministry of Natural Resources and Tourism	2008
Local community perceptions, Tanga Coastal Resources Centre and Socio-economics considerations for Coelacanth MPA: An overview	Dr. Christopher A. Muhando & Hassan W.J. Kalombo	2008
Biophysical Survey in The Newly Gazetted Inner & Outer Sinda,inner and outer Makatumbe and Kendwa Islands Marine Reserves in Temeke District,Dar es salaam.	Christopher A. Muhando	2008

Title	Source	Year
Distribution and Status of Coastal Habitats And Resources in Tanzania	Christopher A. Muhando and Chikambi K. Rumisha	2008
Tanzania Mainland and Zanzibar Island Socio - Economic and Environment Study	Festo Maro	2008
Mapping research systems in developing countries	http://www.state.gov/r/pa/ei/bgn/2843.htm	2008
Ecological Effects of the Crown-of-Thorns Starfish Removal Programme on Chumbe Island Coral Park, Zanzibar, Tanzania	C.A. Muhando and F. Lanshammar	2008
Preparation Of Surveying and Mapping Policy for Tanzania	Topo-Carto Consultants Limited, Consultant	2008
Approaches to Coral Reef Monitoring in Tanzania	Christopher A. Muhando	2008
Interactive Governance Approach in Mariculture Activities In Tanzania	Mutatina Alieth	2008
A study of perceptions and impacts from different types of tourism in Mafia Island Marine Park, Tanzania.	Noragric Department of International Environment and Development Studies Norwegian University of Life Science (UMB) P.O. Box 5003 N-1432 Ås Norway Tel.: +47 64 96 52 00 Fax: +47 64 96 52 01 Internet: http://www.umb.no/noragric	2008
Natural resource dependence, livelihoods and development Perceptions from Tanga, Tanzania	Melita A. Samoilys and Nyaga W. Kanyange	2008
Method for calculating brine evaporation rates during salt production	D. Glen Arkridge	2008
Microfinance and environmental sustainability at selected sites in Tanzania and Kenya	Robert Wild, Altemius Millinga and James Robinson	2008
National and Regional Networks of Marine Protected Areas	UNEP World Conservation Monitoring Centre	2008
The Social Dimensions of Marine Protected Areas	Rosemarie Nyigulila Mwaipopo	2008
SongoSongo Social Services and Economic Survey.	Dr. Oswald Mashindano Deus Kibamba Prosper Charle Festo Maro	2008
Optimisation of Production and Quality of Solar Salt from New and Existing Solar Saltfields using Brine Mass Balance Computer Modelling.	Roland Mottershead: CGV Pty. Ltd. Perth, Western Australia & Kevin Wellisch: K F Wellisch & Associates Pty. Ltd. Perth, Western Australia.	2008
Status of Coral reefs in East Africa : Kenya , Tanzania , Mozambique and South Africa	Nyawira Muthiga , Alice Costa , Helena Motta , Christopher Mu H ando , Rose Mwaipopo and Michael Scheleyer	2008
Tanga Regional Socio -Economic Profile.	NBS and Tanga Regional Commissioner's office	2008
Coast Region Socio-economic Profile	National Bureau of Statistics	2007
Tanzania National Adaptation Program for Action (NAPA)	VPO-Division of Environment	2007
East Africa Exploration Map		2007
National Report of the United Republic of Tanzania on Sea Level Measurements	Ignatious K. Nhnyete TANZANIA PORTS AUTHORITY and Shigalla B. Mahongo TANZANIA FISHERIES RESEARCH INSTITUTE	2007
Development of a Geographic Information System for Tanga; supporting expedition planning for the Tanga Coast, Tanzania		2007
Coast Region Socio-Economic Survey	URT	2007
The Status Report On The Impact Of Dynamite Fishing In KICAMP Localities	Chikambi K. Rumisha and Christopher A. Muhando	2007
Effects Of Climate and Seawaters Variation on Coral Bleaching and Mortality.	TIMOTHY R. MCCLANAHAN,1,2,5 MEBRAHTU ATEWEBERHAN,2 CHRISTOPHER A. MUHANDO,3 JOSEPH MAINA,2 AND MOHAMMED S. MOHAMMED4	2007
Zanzibar Fisheries Frame Survey	Department of Fisheries and Marine Resources,Ministry of Agriculture,Livestock and environment,Zanzibar Institute of Marine Sciences ,University of Dar es salaam	2007
Sustainable universal salt iodization in low-income countries – time to re-think strategies?	VD Assey S Peterson and T Greiner	2007
Coast Region Socio Economic Profile	National Bureau of Statistics and Coast Regional Commissioner's Office	2007

Title	Source	Year
Land Suitability Mapping Lindi Rural	Steve Ball & Anne-Marie Gregory	2007
National Sample Census Of Agriculture 2002/2003	URT	2007
Report on Eviction And Resettlement Of Pastoralist From Ihefu and Usangu Mbarali District To Kilwa and Lindi Districts	PINGOs Forum, Hakiardhi, HIMWA, LHRC, ITV and Majira	2007
Mtwara Region Socio - Economic Profile	The Planning Commission Dar es salaam and Regional Commissioner's Office Mtwara	2007
Tanga Region Agriculture Sample Census Report	URT	2007
National Adaptation Programme Of Action (NAPA)	URT,UNEP & GEF	2007
Mpango Kazi wa Usimamizi Kamilifu wa Mazingira ya Pwani Wilaya ya Rufiji	Mkurugenzi Mtendaji wa Wilaya, P.O Box 28 Tel. 0232010304 Fax. no.0232010317 Utete/Rufiji	2007
Zanzibar Ecotourism Study	ZHTI	2006
Ecological Monitory of Coral reefs in Marine No -Take and Fished zones off Bagamoyo Coast	Christopher A. Muhando	2006
Trends in Reef Benthos in Mafia Island Marine Park, Tanzania: 1999-2005 coral reef monitoring results	Muhando, C.A.	2006
Menai Bay Governance Baseline.	Elin Torell, Aviti Mmochi, and Karen Palmigiano	2006
Discussion Paper · Fisheries	The Development Partners Group .www.tzdac.or.tz	2006
Discussion Paper · Forests	The Development Partners Group.www.tzdac.or.tz	2006
Impacts of Salt Production on Pemba	http://digitalcollections.sit.edu/isp_collection/329?utm_source=digitalcollections.sit.edu%2Fisp_collection%2F329&utm_medium=PDF&utm_campaign=PDFCoverPages	2006
The trial of deepwater Fish Aggregation Devices (FADs) in Tanzania	Richmond, M.D. & Mohamed, A.	2006
Smallholder fisheries enterprises trials, Rufiji District, Tanzania	Richmond, M.D., Mohamed, A., de Villiers, A. K., Esseen, M. & LeVay, L.	2006
Collaborative & Coastal Resources Management &Livelihoods Development in Rufiji,Mafia & Kilwa Distrits,Tanzania.	J.Rubens,M.Medarard &Khamis Juma.	2006
Zanzibar Ecotourism Study	Study initiated as part of NUFFIC Support program to ZHTI and facilitated by MMA Ltd	2006
Wildlife (hunting)	Tanzania Development Partners Group	2006
Blueprint 2050: Sustaining the Marine Environment in Mainland Tanzania and Zanzibar	World Bank (Jack Ruitenbeek, Indumathie Hewawasam and Magnus Ngoile (eds.))	2005
Marine and Coastal Environment Management Project (MACEMP): Environmental and Social Assessment	Jacques Whitford Environment Limited 3 Spectacle Lake Drive Dartmouth, NS B3B 1W8 CANADA	2005
Marine and Coastal Environment Management Project (MACEMP): Pemba Channel Conservation Area (PECCA)		2005
Mnemba Island and Chwaka Bay Conservation Areas: A Preliminary Situational Assessment	EcoAfrica Environmental Consultants	2005
Ngezi - Vumawimbi Forest Reserves Biodiversity Inventory	C. L. Nahonyo, L. B. Mwasumbi, C. A. Msuya, C.A. Masao, T. B. Suya and C. Shing'wenda	2005

Title	Source	Year
Assessment of marine biodiversity, ecosystem health and resource status of intertidal (non-mangrove) and sub-tidal (non-coral) habitats in MBREMP	M. D. Richmond and A. Mohamed	2005
Rufiji District Residents and Adaptation to Environmental Changes over Time.	Abdallah Ramadhani Mkindi And Hubert E. Meena(ENVIROCARE).	2005
Offshore and Transition zone Seismic Acquisation in Songo Songo Archipelago.	PanAfrica Energy limited Dar es salaam,Tanzania	2005
Development of Mnazi Bay-Ruvuma Estuary Marine Park	Christopher Muhando	2004
BiophysicaI Assessment Of The Dar es salaam Marine Reserve System	Christopher A. Muhando	2004
Study on the Ecological Basis for Establishing a System of MPAs and Marine Management Areas in the United Republic of Tanzania	S.Wells, S. Juma, C. Muhando, V. Makota and T. Agardy	2004
Assessment of Marine Biodiversity, Ecosystem Health, and Resource Status in Mangrove Forests in Mnazi Bay Ruvuma Estuary Marine Park	G.M. Wagner, F.D. Akwilapo, S. Mrosso, S. Ulomi and R. Masinde	2004
City Profile for Dar es salaam	Document Prepared By Dar es Salaam City Council,City Director Dar es Salaam City Council Morogoro/Sokoine Drive P.O. Box 9084 DAR ES SALAAM TEL.:255-22-2123551/6 FAX: 255-22-2125589 E-mail: cd@dcc.go.tz Website: www.dcc.go.tz	2004
Five Year Meteorological Development Plan And Investment Strategy	East Africa Community	2004
Fisheries Act 2003	URT	2004
The Implementation of the convention on biological diversity	URT	2004
Coral Reefs and Their Management in Tanzania	Greg M. Wagner Western Indian Ocean ,J.Mar .Sci Vol 3,No ,pp 227 -243 2004	2004
Eastern African Marine Ecoregion Programme 2004. Eastern African Marine Ecoregion Conservation Plan (2005 - 2009)		2004
Marine research methodologies: Pemba Island, Zanzibar Archipelago	Frontier Tanzania	2004
National Integrated Coastal Environment Management Strategy	URT	2003
Sustainable Financing of Marine Protected Areas in Tanzania	Hurd, A.	2003
Sustainable Financing of Marine Protected Areas in Zanzibar	Lindhjem, H.	2003
Report on the Cetacean Bycatch in Artisanal Drift Gillnet Fishery off Zanzibar, Tanzania	RES/0571/7294	2003
2003 Intitial National Communication Under The United Nations Framework convetion on climate change	United Republic of Tanzania(URT),Vice President's office	2003
Coral and fish distribution patterns in Mafia Island Marine Park, Tanzania: fish–habitat interactions	Kajsa C. Garpe & Marcus C. Öhman Department of Zoology, Stockholm University, 10691 Stockholm, Sweden Tel: +46 8164002. Fax: +46 8167715. E-mail: kajsa.garpe@zoologi.su.se	2003
Mangroves Of East Africa	Michelle Taylor, Corinna Ravilious, Edmund P. Green	2003
National Trade Policy	URT	2003
Local Governance in Zanzibar	(Edited Version of chapter by Per Tidemand in "Zanzibar Good Governance Strategy" A Report by the Consultants Prof. Othman, Prof Mukandala, Robert Makaramba and Per Tidemand, for Revolutionary Government of Zanzibar	2003
Managing Tanzania's Coast through Integrated Planning - Reflections upon the first five years of District ICM Action Planning	TCMP (Tanzania Coastal Management Partnership)	2002
Estimating Fishery Statistics in the Artisanal Fishery of Zanzibar, Tanzania: How Big a Sample Size is Required?	Narriman S. Jiddawi1, Richard D. Stanley2 and Allen R. Kronlund2	2002
Coral Reef Benthos and Fisheries in Tanzania Before and After the 1998 Bleaching and Mortality Event	Christopher A. Muhando and Mohammed S. Mohammed	2002

Title	Source	Year
Coastal Erosion and Its Social and Environmental Aspects in Tanzania	Desiderius C. P. Masalu	2002
Environmental Management and Biodiversity Conservation of Forests,Woodlands, and Wetlands of Rufiji Delta and Floodplain.	Richmond,M.D,Wilson,J.D.K.,Mgaya,Y.D & Le Vay ,L.	2002
National Land Planning Approach	Government of Zanzibar & UNICEF	2002
The Mineral Industry Of Tanzania	Thomas R. Yager	2002
Coastal Resources and their Use	Muhando, C., Mgaya, Y. and Daffa, J.	2001
Eastern Africa Atlas of Coastal Resources - Tanzania	UNEP	2001
Tanzania State of the Coast 2001: People and the Environment	TCMP (Tanzania Coastal Management Partnership)	2001
The Voyage from Seychelles to Maputo - Successes and failures of Integrated Coastal Zone Management in Eastaern Africa and island states, 1996 - 2001	The Secretariat for Eastern African Coastal Area Management (SEACAM)	2001
Forest Landscape Restoration	Tanzania Specialist Organisation on Community Natural Resources and Biodiversity Conservation (TASONABI)	2001
The Maximum Sustainable Yield of Artisanal Fishery in Zanzibar: A Cointegration Approach	Adolf F Mkenda and Henk Folmer	2001
Restoration and management of mangrove systems — a lesson for and from the East African region	JG Kairo, F Dahdouh-Guebas, J Bosire1, and N Koedam	2001
The Economics of Climate Change in the United Republic of Tanzania	URT & UKAid	2001
A review of the fisheries of the Misali Island Marine Conservation Area (MIMCA), Pemba, with recommendations for monitoring	Matthew D. Richmond and Mohammed S. Mohammed	2001
Guidelines & Procedures For Undertaking Environmental Impact Assessment In Marine Parks and Reverses in Tanzania		2001
The Eastern African Marine Ecoregion Vision Report	WWF	2001
Progress in Integrated Coastal Management for Sustainable Development of Zanzibar's Coast Unguja Island Coastal Profile and Management Strategy	Protection and Management of the Marine and Coastal Areas in the Eastern African Region - EAF/5-II	2000
Tanzania Coastal Management Partnership and the Science and Technical Working Group	TCMP (Tanzania Coastal Management Partnership)	2000
Survey of the extent of human-induced beach erosion problems in Tanzania	Nyandwi, N. Institute of Marine Sciences	1999
A situational&Status Analysis of the Misali Island Project, Pemba,Zanzibar.	Li Ching Lim	1999
Towards Strategic Planning In Tanzania	Tumsifu Jonas Nnkya Department of Urban and Rural Planning University College Of Lands and Architectural Studies Dar es salaam ,Tanzania	1999
Nutrition Improvement Projects in Tanzania	Zentrum für Entwicklungsforschung (ZEF) Center for Development Research Walter-Flex-Strasse 3 D – 53113 Bonn Germany Phone: +49-228-73-1861 Fax: +49-228-73-1869 E-Mail: zef@uni-bonn.de http://www.zef.de	1999
Coastal Resources and Their Use	Muhando, C., Mgaya, Y. and Daffa, J.	1999
Advances in Marine Science in Eastern Africa: Application of Scientific Knowledge in Marine and Coastal Resources Management.	WIOMSA (Ngoile, M.A.K., Farancis, J. and Mtolera, M.)	1997
National Fisheries Sector Policy and Strategy Statement	Ministry of Natural Resources and Tourism	1997
National Land Policy	The Ministry of Lands and human settlements	1997
Dynamite Fishing in Southern Tanzania ,Geographical Variation,Intensity of us and Possible Solutions.	Martin Guard and Mwajuma Masaiganah	1997

Title	Source	Year
Review of Salt Iodation East central and Southern Africa.ACSA	Food and Nutrition Program Commonwealth Regional Hearth Community Secretariat for East Central and Southern Africa.	1997
Mineral Policy Of Tanzania	URT	1997
Mtwara Region Socio-Economic Profile.	URT	1997
Coastal r esources of B agamoyo District, Tanzania	A.K. Semesi, Y. Mgaya, M. Muruke, J. Francis, A. Julius, C. Lugomela, M. Mtolera, B. Kuguru, D. Kivia, J. Lilungulu, D. Magege, A. Mposo, D. Kaijunga4 N. Mwinoki4, G. Msumi and B. Kalangahe	1997
The Environmental Management for Sustainable Development Act NO 2 of 1996.	House of Representatives of Zanzibar.	1996
Sustainable Industries Development Policy	URT	1996
Integrated Coastal Zone Management in Tanzania	World Bank Land Water and Natural Habitats Division, Environment Department	1995
Salt Iodization for the Elimination of Iodine Deficiency	M. G. Venkatesh Mannar and John T. Dunn	1994
Land Use Planning and Resource Assessment in Tanzania	A.S.Kauzeni, I.S.Kikula, S.A.Mohamed & & J.G.Lyimo andD.B.Dalal-Clayton	1993
National Enviromental Policy For Zanzibar.	Commission For Lands and Environment.Ministry of Water,Construction,Energy,Lands and Environment Zanzibar.	1992
DSM Small Pegalic Fishery Paper	L.B Nhwani & E.D Makwaia,Tanzania Fisheries Research Institute.	1986
Design And Layout of Solar Salt Works	M.J Mehta	1981
The Elopoid and Clupeoid Fishes of East African Coastal Waters.	G.F Losse	1968
The Status Of Coral Reefs In Dar es salaam Marine Reserves System and The State of Reefs in Other Marine Protected Areas of Tanzania	Christopher A. Muhando and J. Francis	
Physical Alteration and Destruction of Habitats in the Eastern African Region	Christopher A. Muhando, Harrison Ong'anda and Lieven Bydekeke	
Menai Bay Governance	Elin Torell, Aviti Mmochi, and Karen Palmigiano	
Marine Fisheries in Tanzania	Narriman S. Jiddawi and Marcus C. Ohman	
Seawater Temperature on Shallow Reefs Off Zanzibar Town, Tanzania	Christopher A. Muhando	
Coral Reefs in Chwaka Bay and Adjacent Areas	Christopher A. Muhando and Mohammed S. Mohammed	
Coastal Tanzania ,A New Home To The Living Coelacanth An Oceanographic Analysis	N. Nyandwi Institute of Marine Sciences, University of Dar es Salaam P.O. Box 668 Zanzibar, Dar es Salaam, Tanzania	
Water Use Standard - Offshore Aqueous Discharges		
Sustaining the Marine Environment in Mainland Tanzania and Zanzibar	www.worldbank.org	
Survey of the extent of human-induced beach erosion problems in Tanzania	N. NyandwiInstitute of Marine Sciences, University of Dar es Salaam P.O. Box 668 Zanzibar, Dar es Salaam, Tanzania	
Draft National Land Surveying and Mapping Policy.		
Frequency and long-term distribution of coastal winds of Tanzania	A.M. Dubi	
A review of Climate Dynamics and Climate Variability in Eastern Africa.	S.E Nicholson,Department of Meteorology, Florida State University.	
Extending the Coastal Forest Protected Area Subsystem in Tanzania	United Nations Development Programme	
Botanical Assessment Of Ngezi Forest ,Pemba	H.J. Beentje	
Mangrove diversity Maps	NA	
Information Outline for Tanzania Coastal and Marine Atlas.		
Marine Science country profiles Tanzania	Julius Fransis/IOCINCWIO-IV/Inf. 8	

Title	Source	Year
Implications for sustainable coastal management	Huruma Sigalla,Richard Sambaiga, Godwin A. Lema, Emmanuel Shemaghembe, Vendelin Simon, Richard Abila, Jacob Ochiewo, Andrew Wamukota	
Mangrove diversity Maps		

Annex 3: Coastal Rapid Impact Assessment Matrix (CRIAM)

Introduction

Background

The coastal zone in Tanzania is under development pressure induced by population growth and economic activities and the area is experiencing a range of management problems giving rise to increased concern, including ecosystem encroachment, pollution, salinisation of soils, estuaries and aquifers, degradation of resources, shoreline erosion and conflicts of interest among stakeholders depending on the coast for their livelihood. Climate change will further aggravate this situation due to sea level rise and more frequent extreme weather.

In order to address these management challenges the Government of Tanzania with World Bank assistance has through the project "Investment Prioritisation for Resilient Livelihoods and Ecosystems in Coastal Zones of Tanzania" embarked on identifying and prioritising threats with the view of developing fundable adaptation measures to address the most pertinent threats.

The complex situation in the coastal area requires a holistic approach to managing development addressing amongst others the problems linked to insufficient coordination between sectors and integration of knowledge, experience and resources in the management processes. For this purpose a rapid but comprehensive coastal profile has been produced based on as recent information as readily available. The profile has been organised to describe threats to coastal communities and ecosystems thematically (sector and other themes as presented in this Volume I of the coastal profile) and geographically by coastal district (as presented in Volume II of the coastal profile) and there is a need to analyse these threats in a coordinated manner to identify linkages and overlaps prior to embarking on developing recommendations for adaptation measures.

Given the extent of the area under concern and the multitude and complexity of activities therein the study as a first step adopts a bird's eye approach to identifying and ranking the most pertinent areas of concern and impacting issues and to relating these to the main development sectors. This approach does not initially produce detailed recommendations for specific locations of individual development projects and activities but rather offers directions to where efforts should be focused to alleviate the main pressures on the coast.

To accomplish the bird's eye overview we are suggesting a matrix approach allowing for a structured consideration of the main impact areas of concern along the coast of Tanzania, the impacting issues and the sectors involved (thematic origin).

The matrix approach apart from offering a tool for structured consideration of conditions in a complex management environment also provides means of transparently communicating the basis for the assessment. The Excel application described further in this appendix can therefore be used in validating the assessment at various levels of management.

This technical annex describes the methodology proposed.

Coastal Rapid Impact Assessment Matrix

The matrix presented in detail below is intended to systematically and in a structured way examine impact areas of concern in the coastal zone and the impacting issues. While the analysis also targets to establish an overview of which main economic and other sectors are concerned it is important to differentiate between the physical situation in the coastal areas and the management arrangements that are available to plan and control the development on

the ground. The matrix approach serves to establish an understanding and overview of the situation as it is on the ground. The result of the matrix analyses can identify deficiencies and shortcomings in the current management arrangements the most pertinent of which may be addressed in the subsequent phase of the study through identification of fundable actions. Management arrangements in this contexts cover policy, legal and institutional aspects, and management tools such as information and communication framework, institutional and human resources and financial aspects.

The Coastal Rapid Impact Assessment Matrix Method

The Coastal Rapid Impact Assessment Matrix method[39] is proposed to allow the attribution of reasonably qualified quantitative values to more or less subjective judgments[40], thus, offering at the same time an evaluation of a given impact and a recordable figure which can be used later, either for re-evaluation or for comparison with other impacts.

The method is based on a standard definition of the important assessment criteria as well as the means by which semi-quantitative values for each of these criteria can be assigned, with the aim to give a precise and independent score to each condition relevant to areas of concern in the coastal zone.

The impacts of issues considered are evaluated against the various components of the studied problem and, for each component, a score (using the defined criteria) is determined giving a measurement of the impact or importance for the component considered.

The assessment criteria fall into two groups:

A: Criteria that are of importance to the condition, and which can individually change the score obtained considerably;

B: Criteria that are of value to the given situation, but individually have a little effect on the score obtained.

For group A, the overall scoring system is based on multiplying the scores allocated each criterion. The principle of the multiplication is important since it assures that the weight of each criterion intervenes directly, whereas a sum of the scores could give identical results for groups of different scores.

For group B, the scoring system consists in summing up the scores allotted to each criterion. This ensures that an individual score cannot influence the overall result disproportionally. On the other hand, the sum assures that the combined importance of all values in group B is taken into account.

The scoring system is simple as there are only two criteria in group A (A_1 and A_2) and three criteria in group B (B_1, B_2 and B_3).

[39] The method proposed for Tanzania has been adapted from the WRIAM method (Water Resources Impact Assessment Matrix) which again was derived from the RIAM (Rapid Impact Assessment Matrix) method used for complex project impact assessments.

[40] A comprehensive and detailed description of the situation in the coastal areas of Tanzania based on acquired information is difficult to make in a uniform manner as the level of documentation varies significantly in terms of resolution, accuracy, detail and updatedness. The matrix assessment method described in this technical note offers an opportunity to establish a rapid and uniform assessment of the situation at bird's eye level which again can guide in-depths efforts to address key problems at local and project level.

Calculation of the overall score for a given condition is also simple.

A_1 and A_2 represent individual criteria scores for group A;

B_1, B_2 and B_3 represent individual criteria scores for group B;

For each condition the following calculation is done:

$$A_T = A_1 \times A_2$$

$$B_T = B_1 + B_2 + B_3$$

$$ES = A_T \times B_T$$

where:

A_T is the result of multiplication of all A scores

B_T is the result of summation of all B scores

ES is the overall score of importance for the condition considered.

For a traditional environmental impact assessment, the criteria of group A can be determined by using scales that pass from negative to positive values through zero, thus reflecting both positive and negative impacts. However, in the present situation, the target is to quantify and compare negative impacts by only applying a one-way scale (from 0-4 and 0-3 for A_1 and A_2, respectively)[41]. In group B it has to be ensured that the sum of values cannot become zero as this in all cases would lead to an overall score of zero, which is against the required goal. For this reason the values of the criteria in group B is 1, 2 or 3, where 1 represents a neutral situation.

Compared to the RIAM method, the WRIAM method introduced a scoring system for the level of documentation as well as scores for the evolutionary character of each identified impact.

In the Coastal Rapid Impact Assessment Matrix (CRIAM) for Tanzania we have kept these scorings and in addition added three fields allowing for:

- Comments important for additional qualification related to the scoring which should be given only if required.
- Reference to the documentation database compiled by the project. This information may be useful for decision makers and managers in subsequent steps to address the areas of concern highlighted in the matrix.
- Reference to resources that are considered relevant for addressing the area of concern in more detail in later steps.

These three fields are not part of the structured impact assessment. The capture of documentation and competent resources at this point can however be useful for subsequent in-depth and localised analyses.

[41] This impact assessment for the coastal zone of Tanzania is a first step macro analysis of the threats identified to coastal communities and ecosystems. It is intended to assess the degree of impact from various issues in these areas of concern, while at the same time providing an indication of impacting sector or sectors if more are involved. Following such a "bird's eye" ranking decision makers and managers can prioritize efforts in addressing these areas of concern through individual and local interventions applying more detailed assessments that would allow a balanced capture of both positive and negative project impacts.

Assessment criteria for the coastal rapid impact assessment matrix method

The criteria should be defined for the two groups A and B, and should be based on fundamental conditions that may be affected by change introduced by the activities considered. It is theoretically possible to define a number of criteria, but those should always satisfy two principles:

- The universality and importance of the criterion;
- The nature of the criterion, which determines whether it should be treated as a group A or B condition.

For the purpose of ranking the coastal impacts of concern in Tanzania the method operates with 5 criteria in this first phase of the impact analysis (2 in group A and 3 in group B). These 5 criteria represent the most important fundamental assessment conditions and comply with the principles stated above.

These criteria, and their scales of scores, are defined in the following:

Group A criteria

Criterion A_1 - Importance of condition

A measure of the importance of the condition, which is assessed against the spatial boundaries or human interests it will affect:

A1 = 4: Important to national/international interests

A1 = 3: Important to regional/national interests

A1 = 2: Important to areas immediately outside local condition

A1 = 1: Important only to local condition

A1 = 0: No importance

Criterion A_2 - Magnitude of change / effect

Magnitude is defined as a measure of the scale of benefit / dis-benefit of an impact or a condition:

A2 = 0: No change / status quo

A2 = 1: Negative change to status quo

A2 = 2: Significant negative dis-benefit or change

A2 = 3: Major dis-benefit or change

Group B criteria

Criterion B_1 - Permanence

This criterion defines whether a condition is temporary or permanent:

B1 = 1: No change / not applicable

B1 = 2: Temporary

B1 = 3: Permanent

Criterion B_1 - Reversibility

This criterion defines whether the condition can be changed and is a measure of the control over the effect of the condition:

B2 = 1: No change / not applicable

B2 = 2: Reversible

B2 = 3: Irreversible

Criterion B_1 – Cumulative character

This criterion is a measure whether the effect will have a single direct impact or whether there will be a cumulative effect over time, or a synergistic effect with other conditions:

B3 = 1: No change / not applicable

B3 = 2: Non-cumulative / single

B3 = 3: Cumulative / synergistic

The overall evaluation score (ES) may reach values ranging from 0 to 108. The achieved score is translated into 5 levels describing the problem using range bands as shown in **Error! Reference source not found. Error! Reference source not found.**.

Table 31: Translation of EV into Range Values and their significance.

Score (ES)	Range value (RV)	Description
0	0	No importance / Not applicable
1 to 9	1	Importance / slight negative impact
10 to 18	2	Importance / negative impact
19 to 35	3	Importance / moderate negative impact
36 to 71	4	Importance / significant negative impact
72 to 108	5	Importance / major negative impacts

To substantiate the assessment and support further analyses the matrix includes a field where the level of documentation relevant to the assessed condition can be indicated using a score between 0 and 3 as shown in Table 32 below.

Table 32: Scoring the level of documentation relevant to the assessed condition

Documentation Score (DS)	Description
0	No information / documentation
1	Slight actual information / documentation
2	Existing information / documentation, but insufficient
3	Good documentation / information

The speed with which the condition is developing is not captured in the EV and we have the matrix therefore also includes a field where the evolutionary character of the condition can be assessed using a score between 0 and 3 as shown in Table 33 below. The sensitivity to climate change may have implications on the speed with which the condition is developing. Such a sensitivity assessment however will be pursued after the CRIAM has prioritised impacts.

Table 33: Scoring the speed of development of the condition

Evolutionary Score (ES)	Description
0	No evolutionary character
1	Light evolutionary character
2	Moderate evolutionary character
3	Strong evolutionary character

The scores for level of documentation and development speed of the condition at present do not enter into the calculation of the EV, but serves rather to assist at the subsequent decision making process.

Excel application to support the matrix analysis

To support the matrix analysis of impacts in the coastal zone of Tanzania we have developed an Excel application, which allows for structured input into the matrix, while providing the basis for semi-automatic queries.

The matrix itself is a database with the following fields (**Error! Reference source not found.**, **Error! Reference source not found.**):

Districts to specify which of the Tanzania's coastal districts are considered, thus determining the bird's eye scope of the analysis. Districts should not be keyed into the matrix itself but are selectable from drop down menus. When the impacts are derived from a thematic threat (Volume II of the Coastal Profile), and therefore lack in geographical reference the matrix provides under Districts for selecting MAINLAND for mainland Tanzania or ZANZIBAR for Zanzibar.

Impact area of concern to specify which physical area or physical resource of concern is considered for the conditional assessment. Examples could be a habitat, an ecosystem or another physical feature a water body or resource, a shoreline, an area vulnerable to flooding, etc. Impact areas of concern should not be keyed into the matrix itself but are selectable from drop down menus. This drop down list can be expanded should new impact areas emerge.

Nature of issue which serves to specify which impact issue is being considered. Examples could be pollution, encroachment, erosion, flooding, degradation, biodiversity degradation, etc. If there are several issues relevant to a problem area of concern these would emerge in separate records in the matrix. Nature of issues should not be keyed into the matrix itself but are selectable from drop down menus. This drop down list can be expanded should new natures of issue emerge.

Theme, which serves to specify which main development sector, can be identified as contributing to the impacting issue. Examples of main development sectors could be agriculture, fisheries, forestry, industry, infrastructure etc. If there are several sectors contributing these would emerge in separate records in the matrix. Theme should not be keyed into the matrix itself but are selectable from drop down menus, which initially contain the themes covered in Volume I of the Coastal Profile. Should new themes emerge from the drop down menu can be expanded.

Sub-sector, allowing for a finer level consideration of sector contribution to the impacting issue if this is required. Examples of sub-sectors could be transportation, water supply, sanitation, etc. under infrastructure, and aquaculture, processing and coastal fisheries under fisheries. If there are several sub-sectors contributing these would emerge in separate records

in the matrix. Sub-sector should not be keyed into the matrix itself but are selectable from drop down menus.

Criteria fields: These are fields for each of the five assessment criteria A_1, A_2, B_1, B_2 and B_3. The assessment consists of inputting values for these criteria for each of the conditions examined for a given area of concern. The values can be entered directly from the keyboard or using drop down menus. Values outside the respective ranges for these criteria are not allowed and will be rejected by the application.

EV field containing the evaluation score based on the values allocated to the criteria. The field will automatically calculate the EV based on the criteria input.

RV field which contains the range value corresponding to the EV. The field will automatically calculate and display the RV value based on the calculated EV.

Speed of evolution field, where the speed of the condition's development can be entered as a value between 0 and 3.

Documentation level, where the availability of documentation considered relevant for the condition can be entered as a value between 0 and 3.

Degree of problem field which provide a graphical display of the severity of the problem area of concern. These will appear as a bar display automatically generated based on the EV and RV.

Documentation (DOCBase) field, where references can be made to the database of documents compiled through the study.

Resources (Government, NGO, Academia, Individuals), allows references to be entered that may be useful in subsequent work, including the development of adaptation measures.

Comment field. Providing for any brief comment on the assessment made for the condition if relevant.

In the presentation above it was explained that selection of entries for a number of fields should be made using drop down menus. If a choice is not displayed in the dropdown menu a separate spread sheet in the Excel application provides for adding additional choices.

At the present state of development the application includes the following choices which serve as examples:

Districts

Only the 26 coastal districts are relevant for the present analysis. The application however could be used for assessments in other regions and districts, addressing concerns that go beyond the coastal zone.

Table 34: Table of administrative areas considered in the CRIAM, including Districts, Regions, Mainland Tanzania (MAINLAND) and Zanzibar (ZANZIBAR).

Districts	Super-Region	Region
Bagamoyo	Mainland	Pwani
Ilala	Mainland	Dar es Salaam
Kilwa	Mainland	Lindi
Kinondoni	Mainland	Dar es Salaam
Lindi Rural	Mainland	Lindi
Lindi Urban	Mainland	Lindi
Mafia	Mainland	Pwani
MAINLAND	**MAINLAND**	**MAINLAND**

Districts	Super-Region	Region
Mkinga	Mainland	Tanga
Mkuranga	Mainland	Pwani
Mtwara Rural	Mainland	Mtwara
Mtwara Urban	Mainland	Mtwara
Muheza	Mainland	Tanga
Pangani	Mainland	Tanga
Rujifi	Mainland	Pwani
Tanga	Mainland	Tanga
Temeke	Mainland	Dar es Salaam
Chakechake	Zanzibar	Kusini Pemba
Kaskazini A	Zanzibar	Kaskazini Unguja
Kaskazini B	Zanzibar	Kaskazini Unguja
Kati	Zanzibar	Kusini Unguja
Kusini	Zanzibar	Kusini Unguja
Magharibi	Zanzibar	Mjini Mhagaribi
Micheweni	Zanzibar	Kaskazini Pemba
Mjini	Zanzibar	Mjini Mhagaribi
Mkoani	Zanzibar	Kusini Pemba
Wete	Zanzibar	Kaskazini Pemba
ZANZIBAR	**ZANZIBAR**	**ZANZIBAR**

Impact area of concern

Table 35: Drop down list of Impact Areas of Concern emerging from the updated Coastal Profile

Impact Area of Concern	
Bird Sanctuary	The drop down list of impact areas of concern has been based on impact areas identified through the preparation of the updated Coastal Profile. In discussions with stakeholders this list can be considered the point of departure based on the rapidly collected information contained in the coastal profiles, but should be expanded as and if these discussions identify additional areas of concern.
Coastal Vegetation	
Coastal Villages	
Coastal Zone	
Coral Reefs	
Estuaries/Backwater	
Fishing Grounds	
Islands	
Lagoons	
Mangroves	
Mussel/Oyster Beds	
Pearl Banks	
Ponds and Lakes	
Ramsar Sites	
Rivers	
Rocky Shores	
Salt Marsh	
Sand Bar/Dunes	
Sandy Beach	
Sea Grass Beds	
Shoreline	
Tidal Flats	
Wetlands	
Wildlife Sanctuary	

Nature of Issue

Nature of Issues
Accretion
Biodiversity Degradation
Conflict
Destructive Fisheries
Encroachment
Erosion
Flooding
Over Exploitation
Physical Degradation
Pollution
Sedimentation

Here again the discussions in the assessment group of experts will determine which main issues are relevant to take into account impacting on the problem area of concern. Any new main impacts should be added to this list.

Theme

Themes
Agriculture
Climate Change
Coastal Communities
Coastal Information Management
Fisheries
Forestry
Freshwater Resources
Hydrocarbons
Industry
Infrastructure
Management Framework for CZM
Natural Resources
Non-renewable Extractive Industry
Ports and Harbours
Salt Production
Shoreline Management
Tourism
Urbanisation

The main development sectors presently considered in the intersector impact assessment study are listed here.

It is not expected at present that additional sectors will be included but should it be required the list can be expanded.

Source of Concern

Source of Concern
Catchment Management
Fisheries Resources Management
Fishing Practices
Mangrove Management
Mining
Waste Management

A list of possible subsectors for consideration. The list is an example there are many more sub-sectors under the different sectors that may be included in the analysis. At this level of analysis however, care should be taken not to differentiate too much.

COASTAL THREATS IMPACT ASSESSMENT — Tanzania Coast

IMPACT RANKING — TABLE FOR CALCULATIONS

Super Region	Region	District	Themes	Source of Concern	Problem Area of Concern	Issue	A1 : Extent of issue	A2 : Seriousness of	B1 : Permanence	B2 : Irreversibility	B3 : Cumulative	ES	RV	Speed of evolution	Level of	Light problem	Problem	Important problem	Very important	Major problem	Documentation (DOCBase)	Resources (Government, NGO, Academia, Individuals)	Remarks
MAINLAND	MAINLAND	MAINLAND	Fisheries	Fishing Practices	Coastal Villages	Conflict	2	1	3	2	3	16	2										
MAINLAND	MAINLAND	MAINLAND	Fisheries	Fisheries Resources Management	Fishing Grounds	Conflict	4	3	3	3	3	108	5										
MAINLAND	MAINLAND	MAINLAND	Fisheries	Fishing Practices	Coral Reefs	Destructive Fisheries						0	0										
MAINLAND	MAINLAND	MAINLAND	Fisheries	Fishing Practices	Sea Grass Beds	Destructive Fisheries						0	0										
MAINLAND	MAINLAND	MAINLAND	Fisheries	Fishing Practices	Fishing Grounds	Destructive Fisheries						0	0										
MAINLAND	MAINLAND	MAINLAND	Fisheries	Fisheries Resources Management		Conflict						0	0										

Figure 32: Coastal Rapid Impact Assessment Matrix for Tanzania

Additional steps

Constraint analysis

In a later step, constraints analyses may be performed on the identified and ranked coastal zone issues in order to specify the types of constraints related to a specific coastal zone issue. The constraints used in the analysis could be divided into issues of technical, institutional, economic, sociological and legal character. The constraint analyses would involve an evaluation and identification of the existing technical level, responsible institutions, existing legal framework, sociological structure and the economic situation with respect to each coastal zone issue. Examples of different types of constraints are given below.

Constraints

Examples of technical constraints connected to a given coastal zone issue are lack of information/monitoring programs concerning pollution, encroachment, degradation and erosion, limited availability of water, technical difficulties in mobilising the water resources, constraints with rehabilitation of an ecosystem, a habitat, an aquifer or a reservoir, insufficient laboratory capacity/quality, few or no adequate sites for various desired development.

Institutional constraints can typically include subjects as lack of or dispersed co-operation and co-ordination between involved institutions, insufficient human resources, lack of capacity/expertise regarding a given issue, no clear operational framework between the involved parties, e.g. clear guidelines regarding responsibilities etc.

Types of economic constraints includes inadequate economic resources to; carry out monitoring of the quality and quantity of the resource, mobilise the resource, water purification treatment, establishment of reservoirs and hydropower installations, purchase of equipment etc.

Sociological constraints could be that the population ignores the risks connected to a given issue, lack of awareness and/or education concerning imposing issues.

Legal constraints could be that the existing legal framework is not fully covering a specific issue, that there are enforcement problems with respect to the existing legal framework, lacking or insufficient regulations and absence of required policies.

Management level

In a further step of the analysis each of the listed constraints can be evaluated with respect to the management level. In this context whether the management level can be characterised as international, national, regional, and local or a combination of these levels and both considering the government, non-government and civil society dimensions.

Identification of the responsible institutions

Furthermore an identification of the existing public and private institutions such as authorities, laboratories and industries involved with the types of constraints are conducted.

Policy option analysis

At this point relevant facts and the importance of a given coastal zone issue are established forming the first part of a Policy Option Analysis. The elements in a Policy Option Analysis can be summaries as:

- Observation and Description. Description of the key facts about the issue, process issues and policy context.

- Analysis. Identification of major issues, interests, costs and benefits.
- Option Identification. Identification of the most optimal solutions.
- Advice. Succinct and clear advice to the decision maker providing the basis for the policy choice.
- Action plans. Finally detailed action plans addressing high prioritised coastal zone issues can be prepared and implemented.

Annex 4: ERA Interim Reanalyses for Temperature, Wind Speed and Precipitation

Time series climate data for Pemba, Dar es Salaam, Zanzibar, and Mtwara, for the climatological period 1979 - 2010. As the software predominantly calculates area averages, the area average cover 6.5S-7.1S, 39E-39.6E. This area is broadly consistent with the grid length of ERA-Interim. Only land points are used. The anomalies are relative to the 1989-2001 climatology.

For temperature (2m) the linear trend is 0.24K/decade = 0.24°C/decade. Ascii and netCDF time series files are available if they are required. Annex 2 show monthly means of max and min temperatures registered once every day and measure the extremes of the diurnal cycle. The ERAInterim averages refer to monthly means of the full diurnal cycle, thus giving less weight to the extreme values. This is also clear from the variances of the time series, hence the R^2 in Annex 4 are about twice the value of the variance in the ERAInterim series.

The ERA-Interim data are computed using information about surface properties, upper air temperatures and surface observations in a full data assimilation system. The 2m temperature product is calculated through a vertical interpolation procedure. The interpolation as well as the coarse spatial resolution of reanalysis data decreases the variance compared to that of the localised observations.

Estimating a trend from highly variable data is sensitive to start/end points and temporal resolution. One should also calculate uncertainty estimates for the trend and compare two trends using the uncertainty bounds. The R^2 of around 0.5 K^2 (Annex 2) implies a standard deviation of around 0.7 K for the temperature series. This implies a fairly large uncertainty interval for the trend.

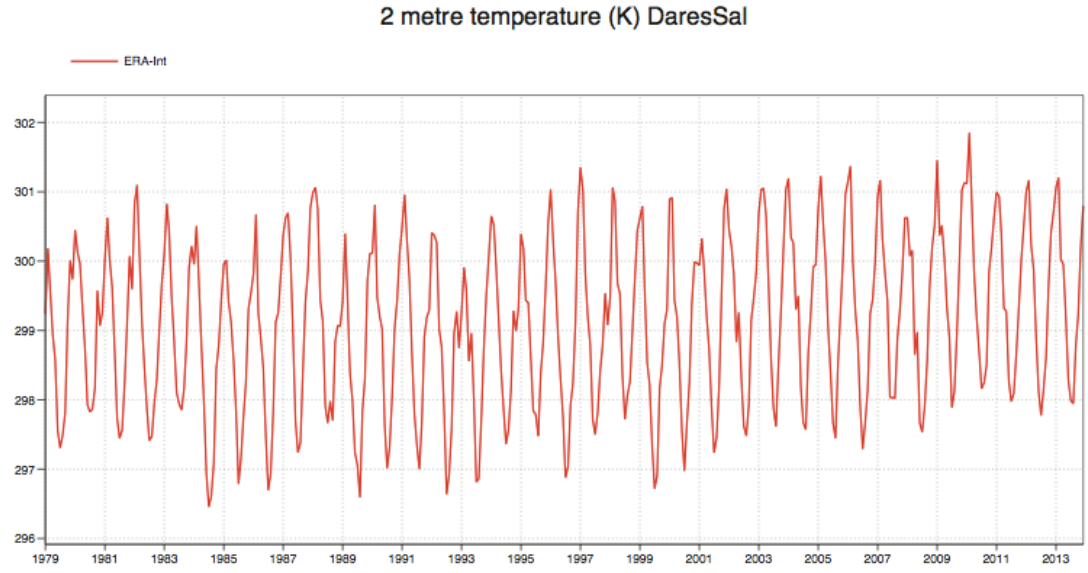

Figure 33: Dar es Salaam temperature variation in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

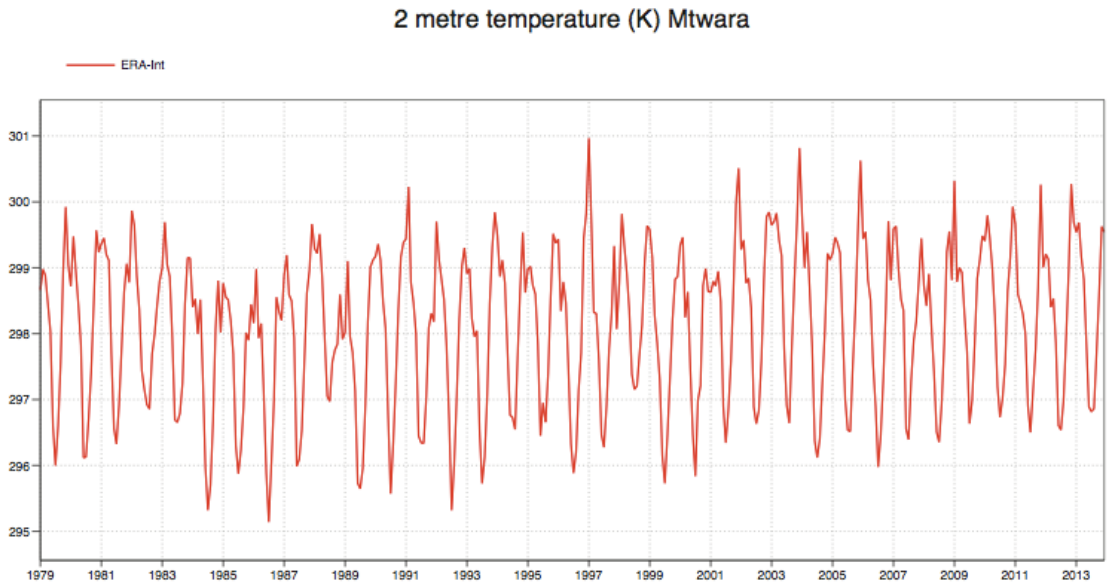

Figure 34: Mtwara temperature variation in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

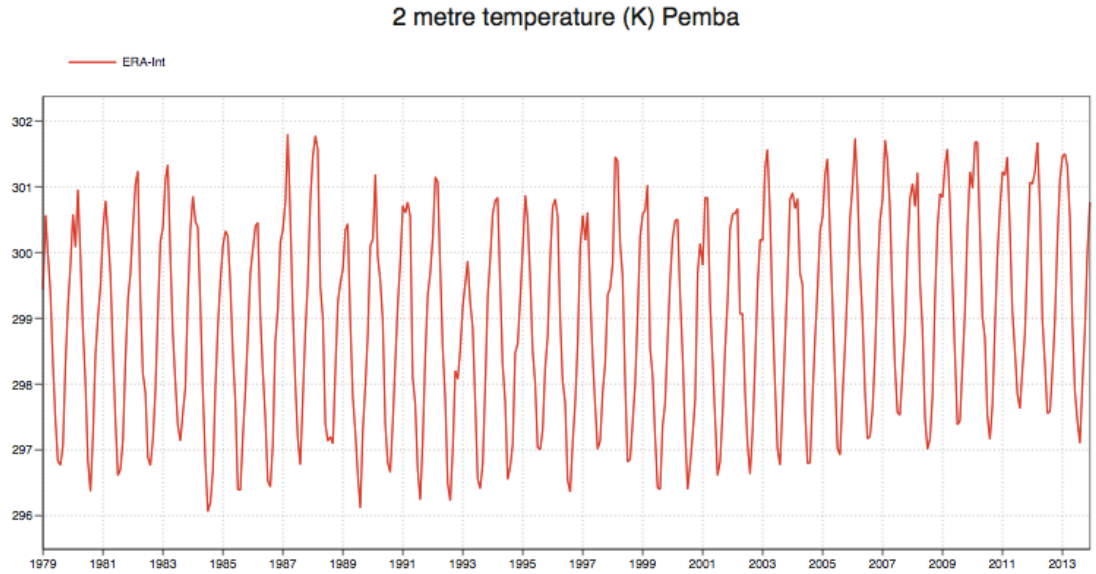

Figure 35: Pemba temperature variation in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

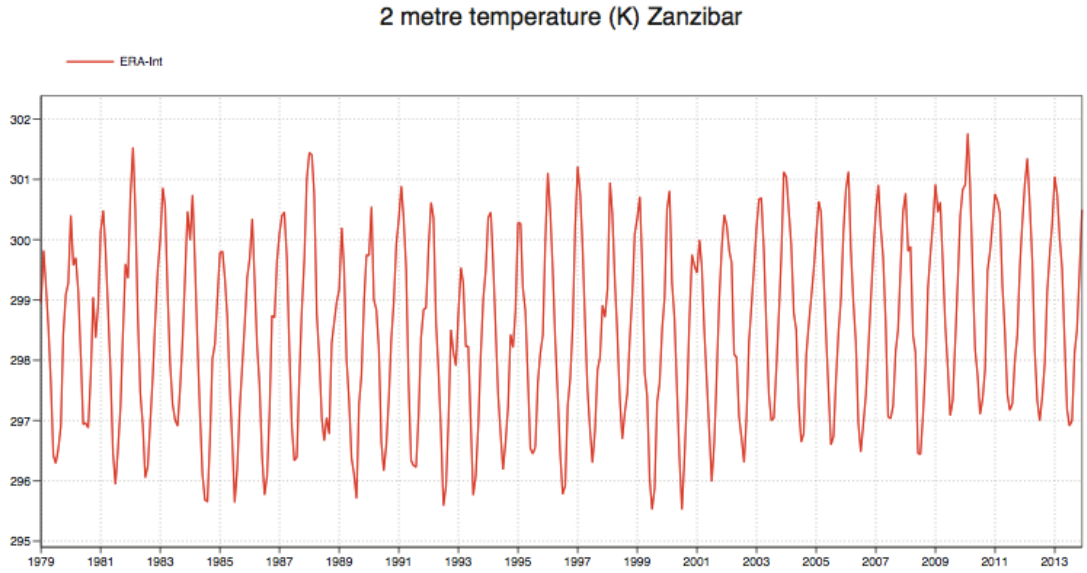

Figure 36: Zanzibar temperature variation in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

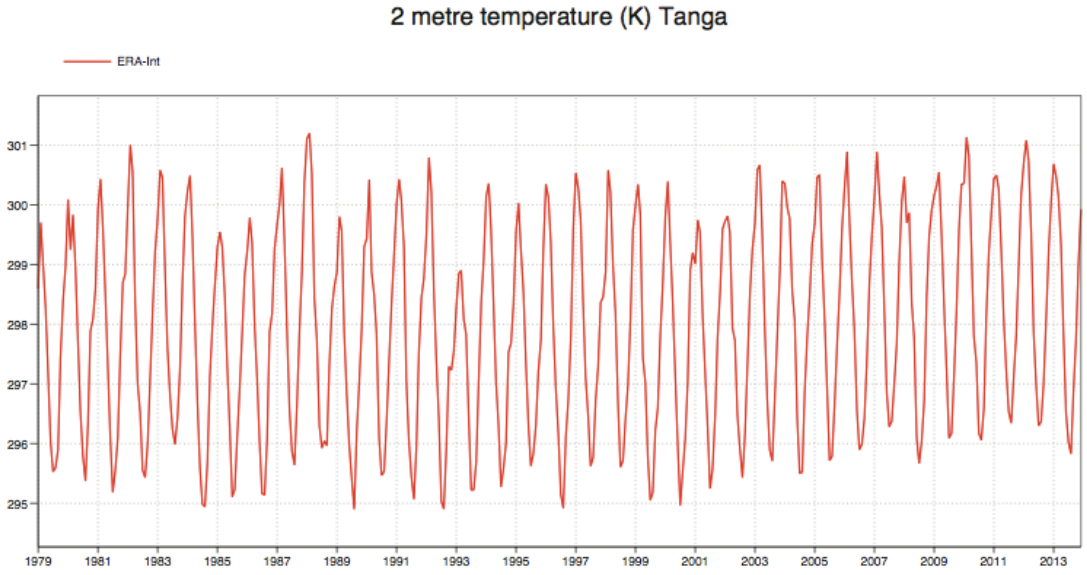

Figure 37: Tanga temperature variation in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

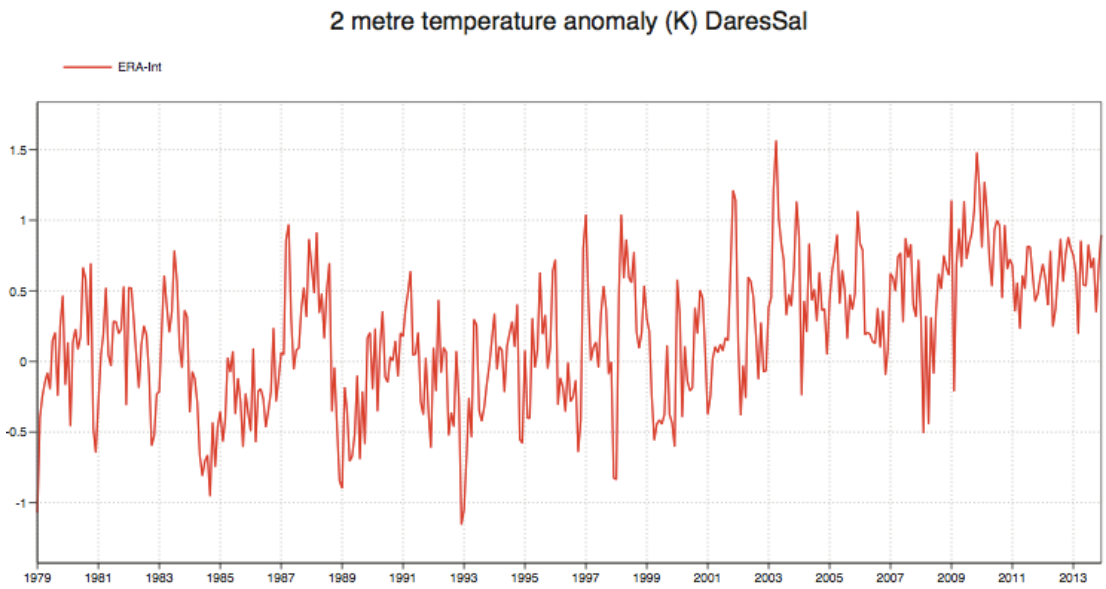

Figure 38: Dar es Salaam temperature anomaly assessment in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

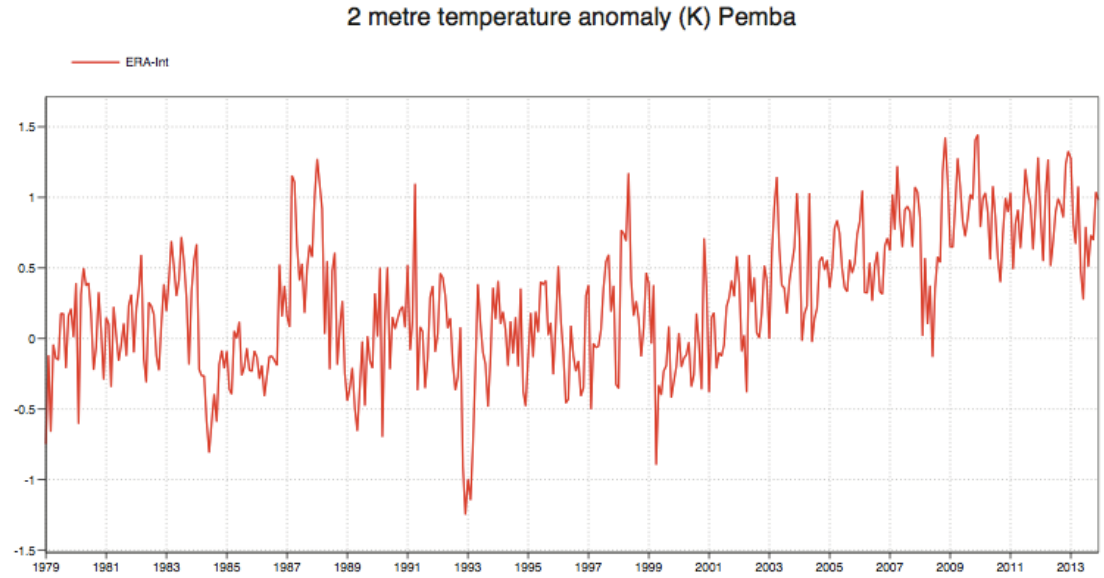

Figure 39: Pemba temperature anomaly assessment in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

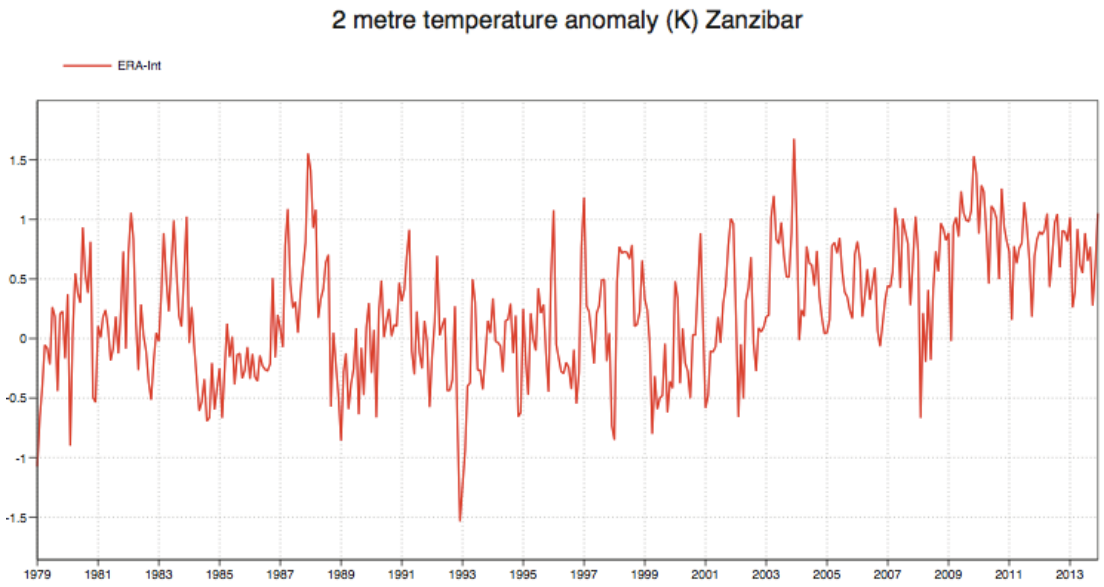

Figure 40: Zanzibar temperature anomaly assessment in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

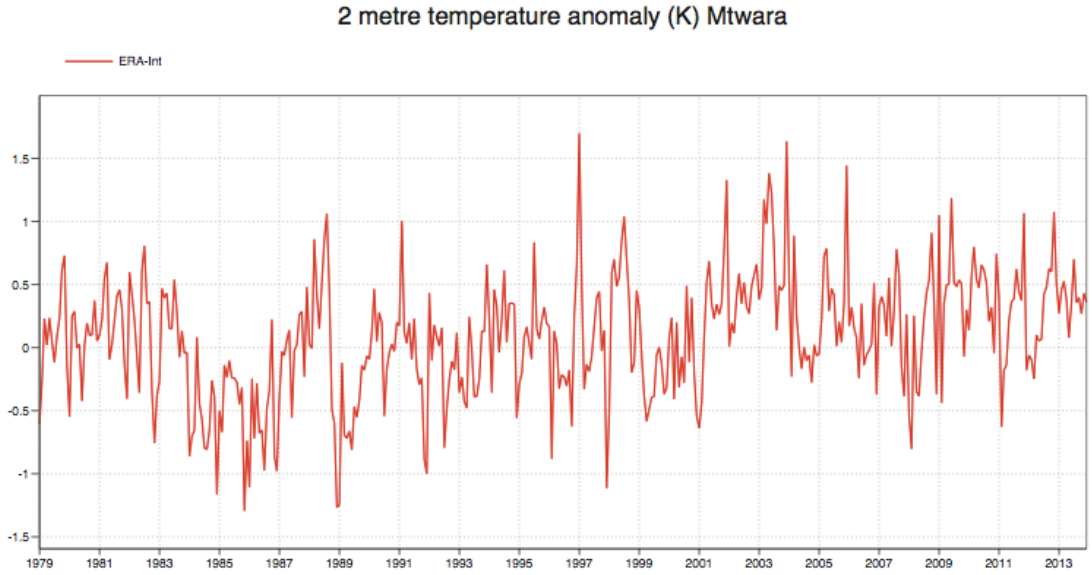

Figure 41: Mtwara temperature anomaly assessment in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

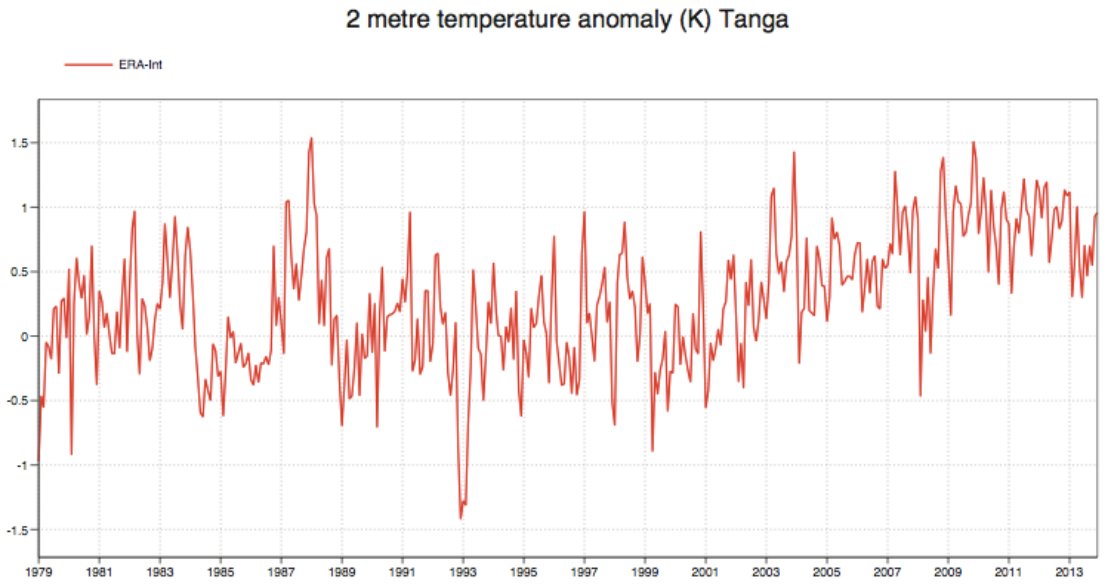

Figure 42: Tanga temperature anomaly assessment in °K from 1979 to 2013 using ERA-Interim Software for reanalysis.

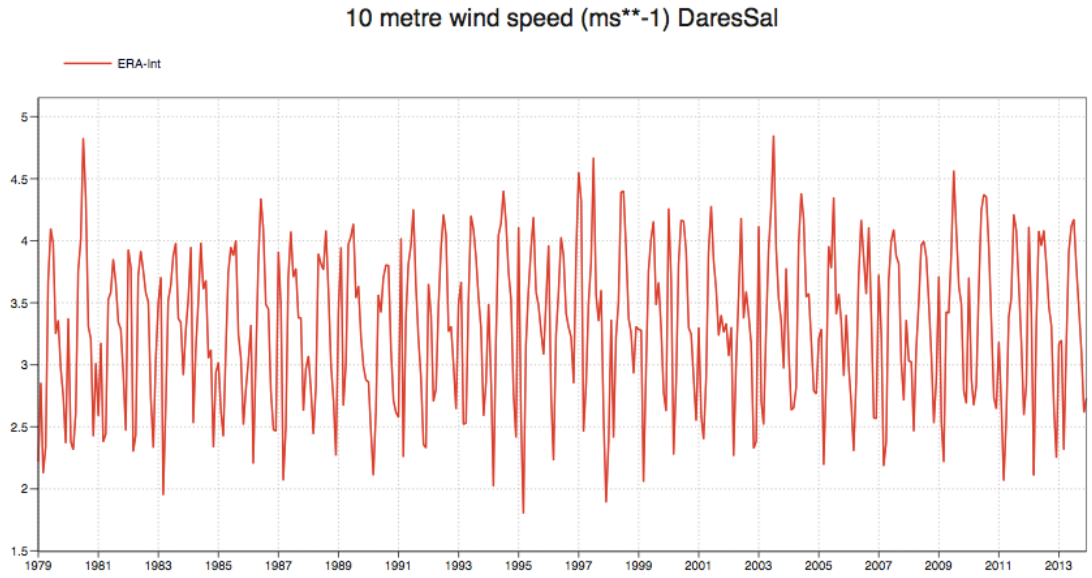

Figure 43: Dar es Salaam average wind speeds variation in m/s from 1979 to 2013 using ERA-Interim Software for reanalysis.

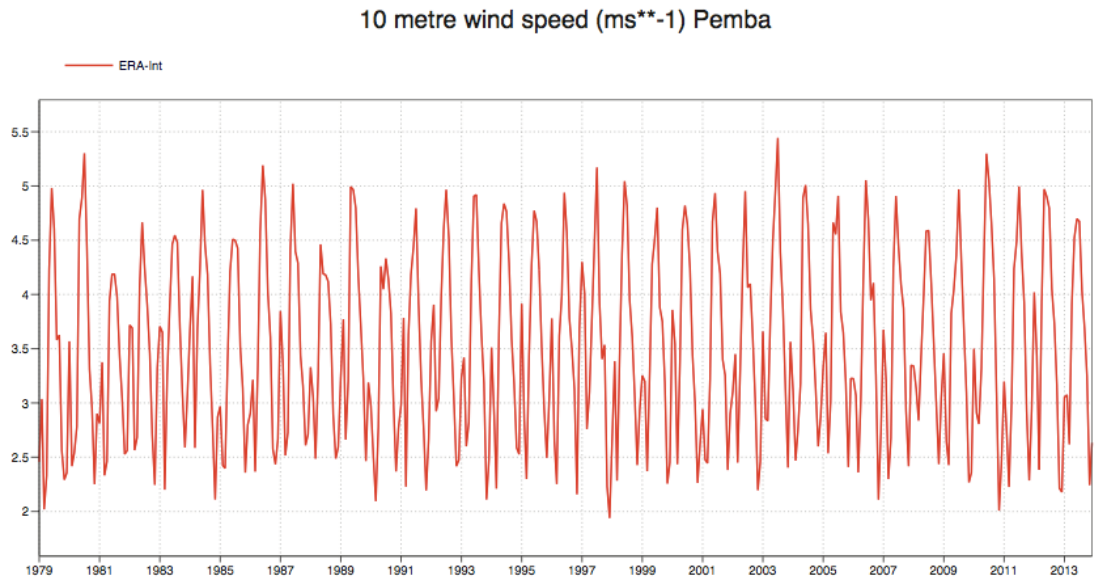

Figure 44: Pemba average wind speeds variation in m/s from 1979 to 2013 using ERA-Interim Software for reanalysis.

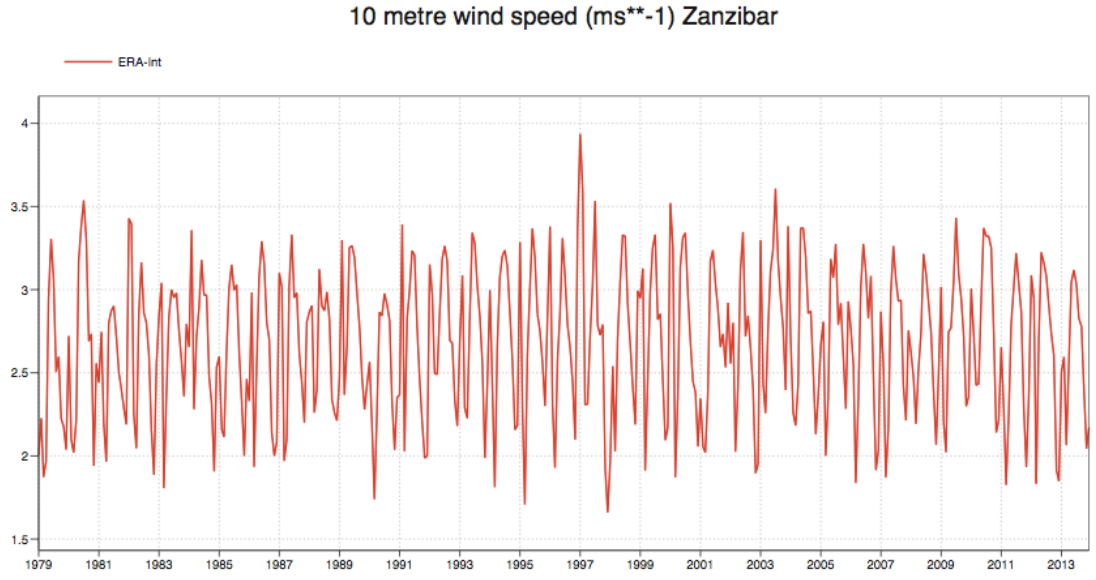

Figure 45: Zanzibar average wind speeds variation in m/s from 1979 to 2013 using ERA-Interim Software for reanalysis.

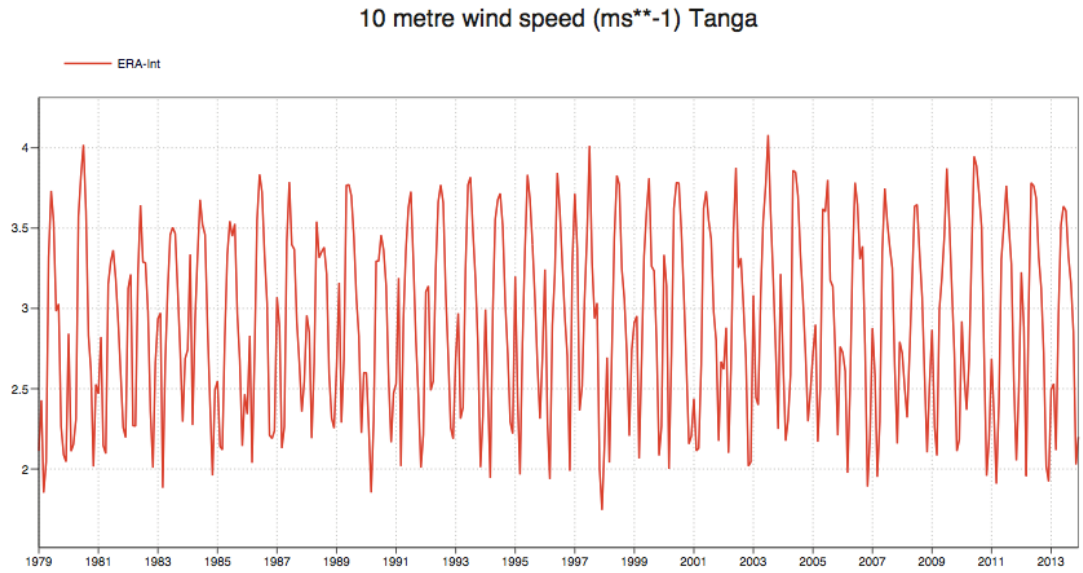

Figure 46: Tanga average wind speeds variation in m/s from 1979 to 2013 using ERA-Interim Software for reanalysis.

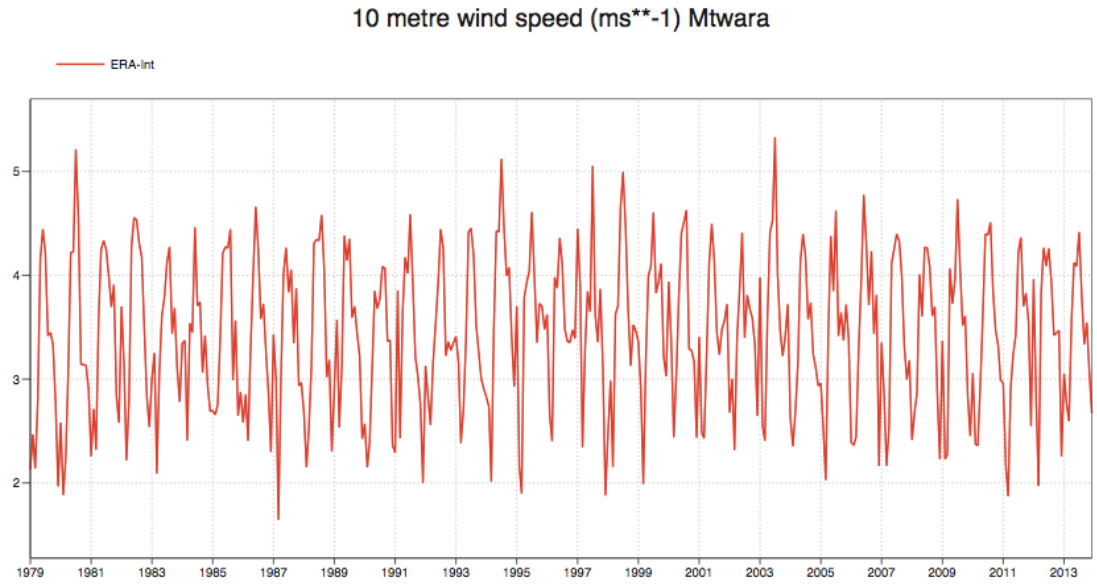

Figure 47: Mtwara average wind speeds variation in m/s from 1979 to 2013 using ERA-Interim Software for reanalysis.

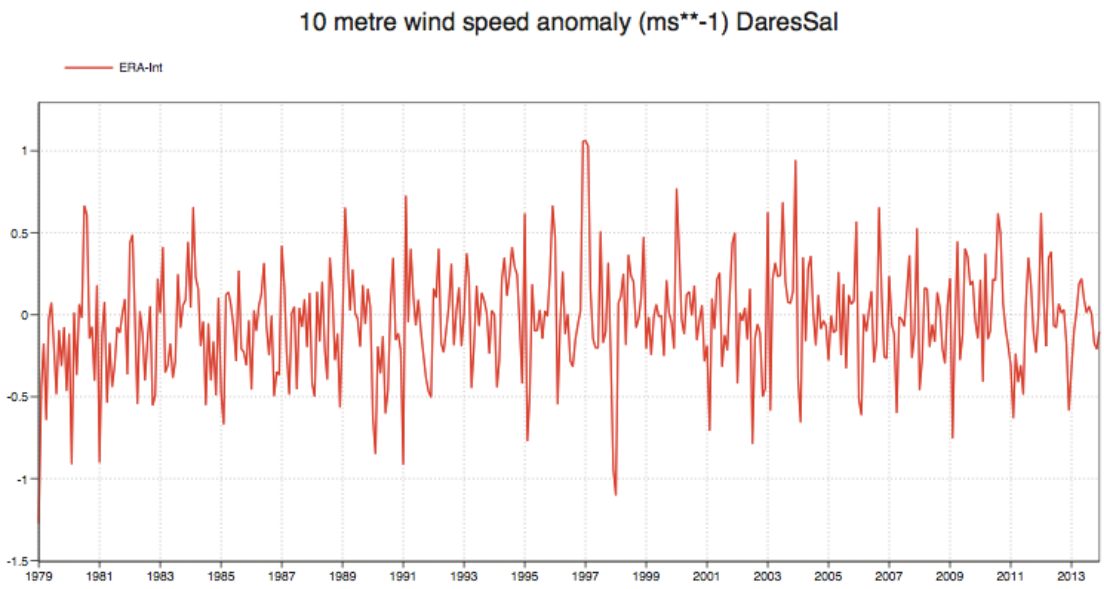

Figure 48: Dar es Salaam wind speed anomaly assessment in m/s (10 m above ground) from 1979 to 2013 using ERA-Interim Software for reanalysis.

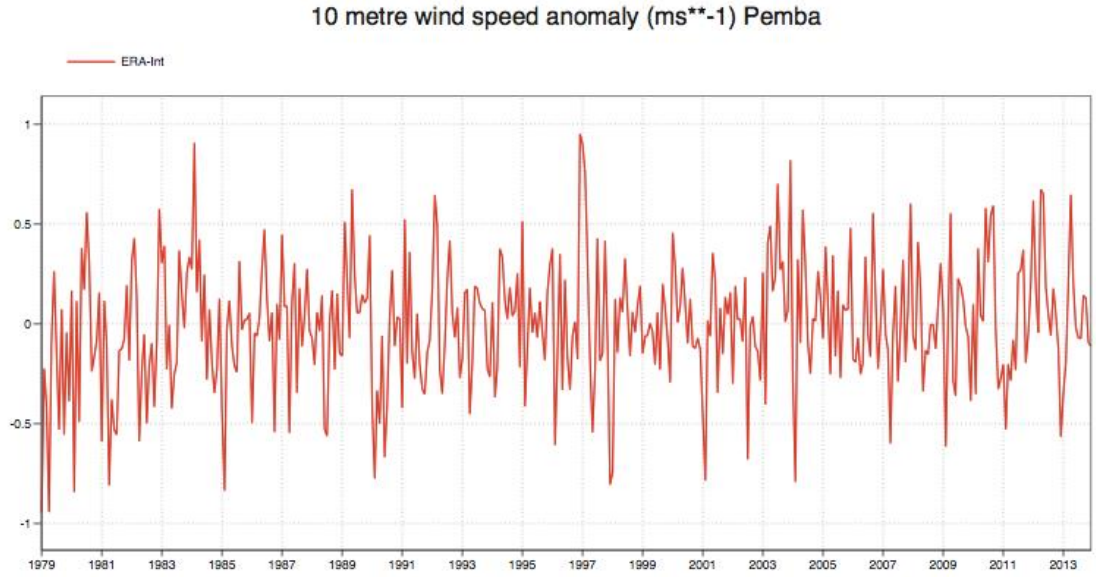

Figure 49: Pemba wind speed anomaly assessment in m/s (10 m above ground) from 1979 to 2013 using ERA-Interim Software for reanalysis.

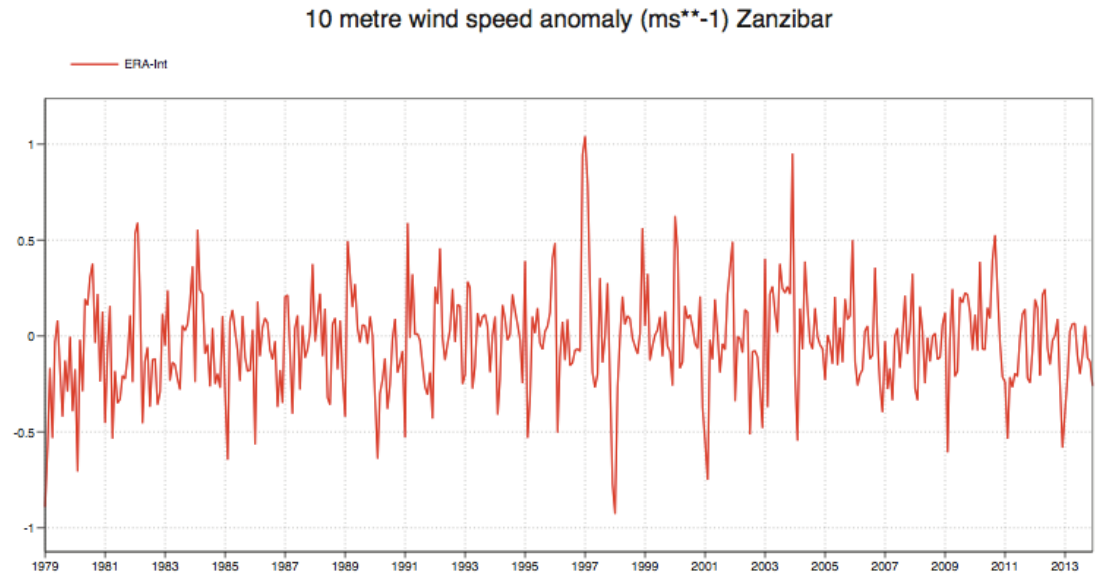

Figure 50: Zanzibar wind speed anomaly assessment in m/s (10 m above ground) from 1979 to 2013 using ERA-Interim Software for reanalysis.

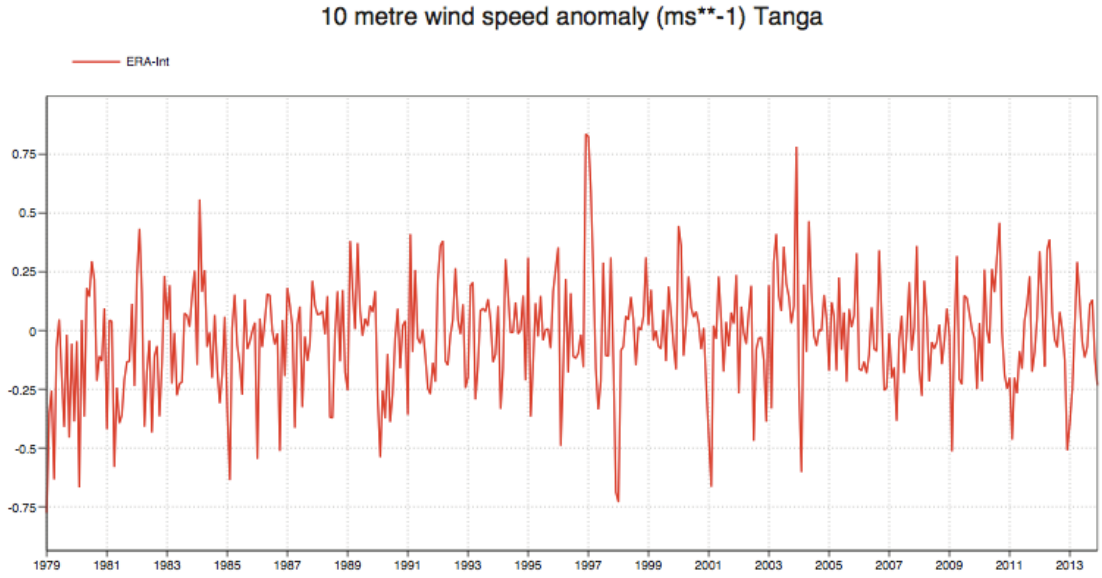

Figure 51: Tanga wind speed anomaly assessment in m/s (10 m above ground) from 1979 to 2013 using ERA-Interim Software for reanalysis.

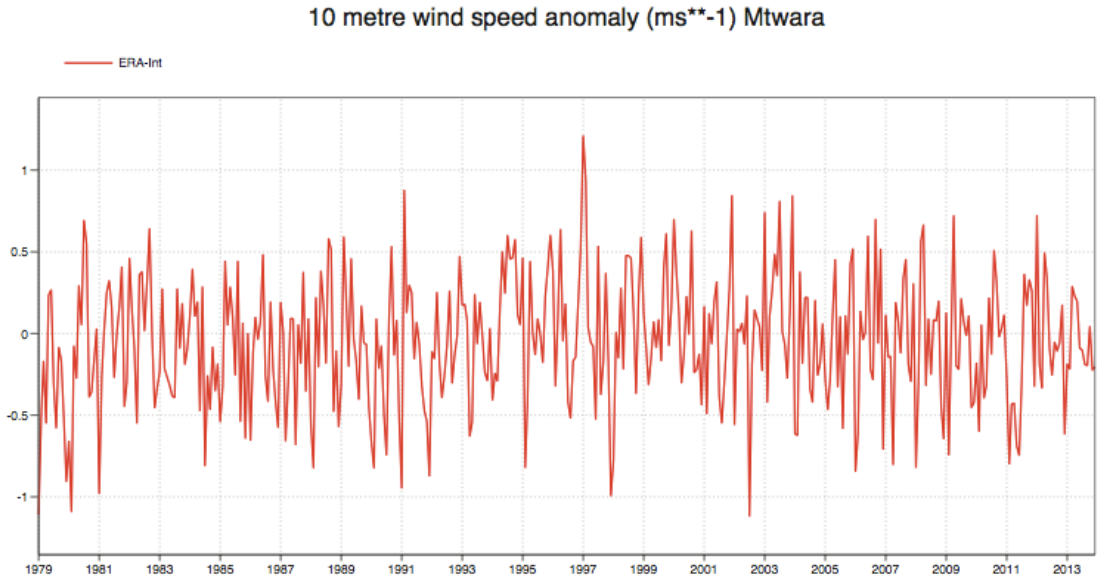

Figure 52: Mtwara wind speed anomaly assessment in m/s (10 m above ground) from 1979 to 2013 using ERA-Interim Software for reanalysis.

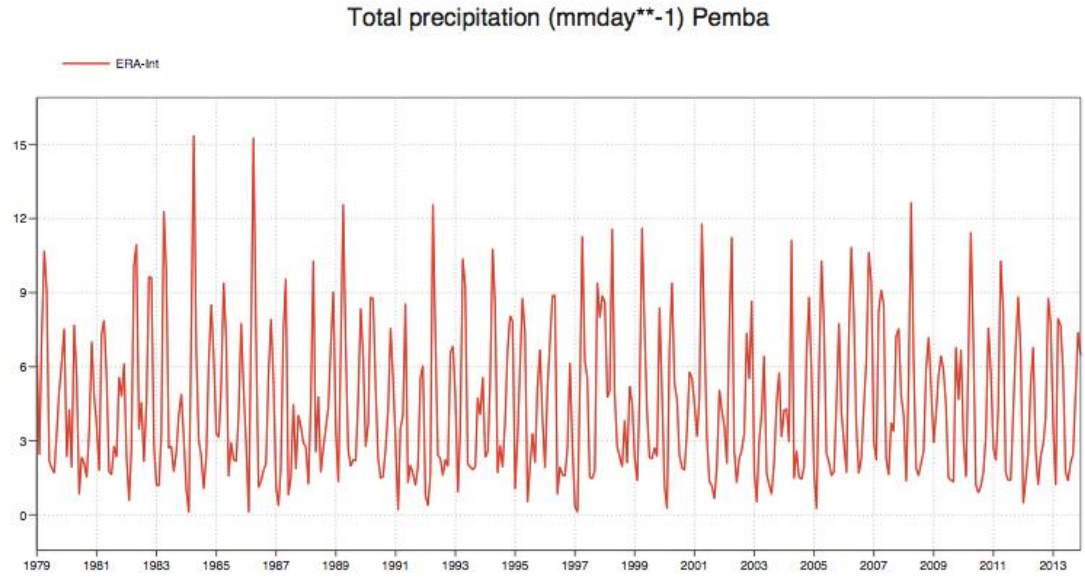

Figure 53: Dar es Salaam total precipitation variation in mm/day from 1979 to 2013 using ERA-Interim Software for reanalysis.

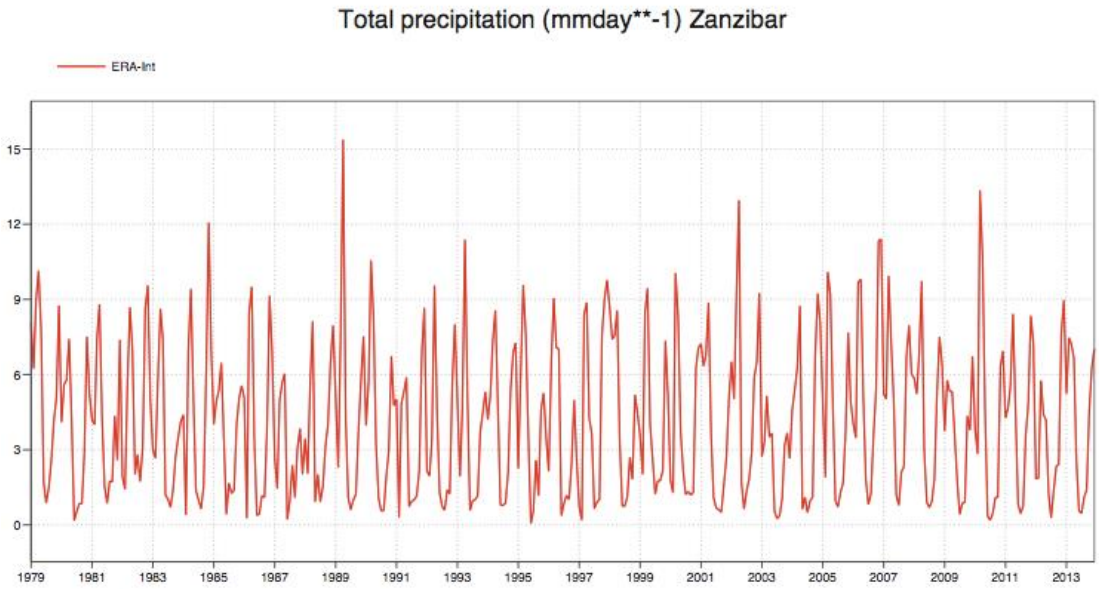

Figure 54: Zanzibar total precipitation variation in mm/day from 1979 to 2013 using ERA-Interim Software for reanalysis.

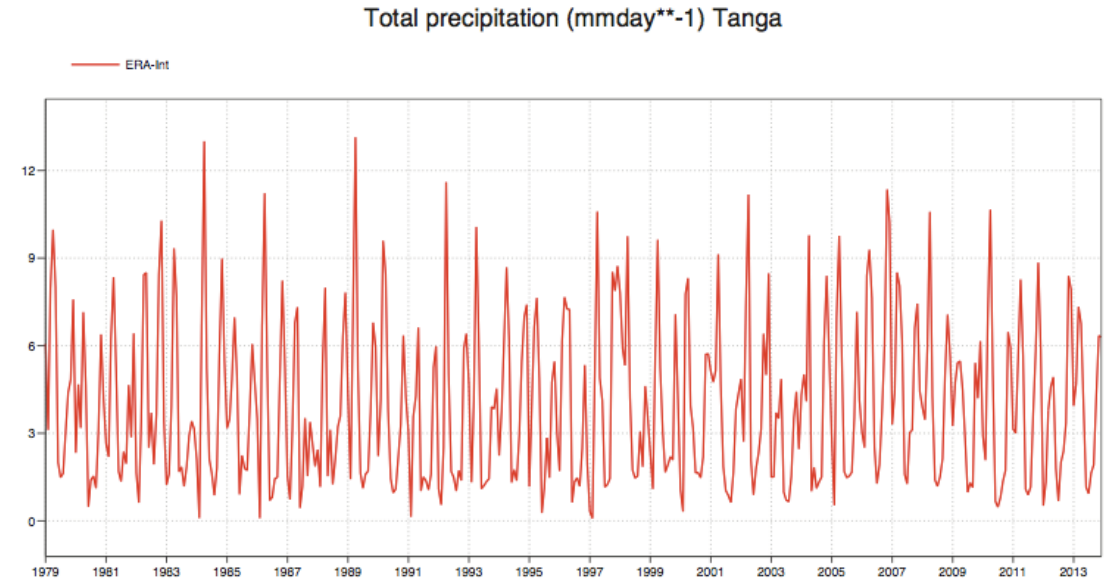

Figure 55: Tanga total precipitation variation in mm/day from 1979 to 2013 using ERA-Interim Software for reanalysis.

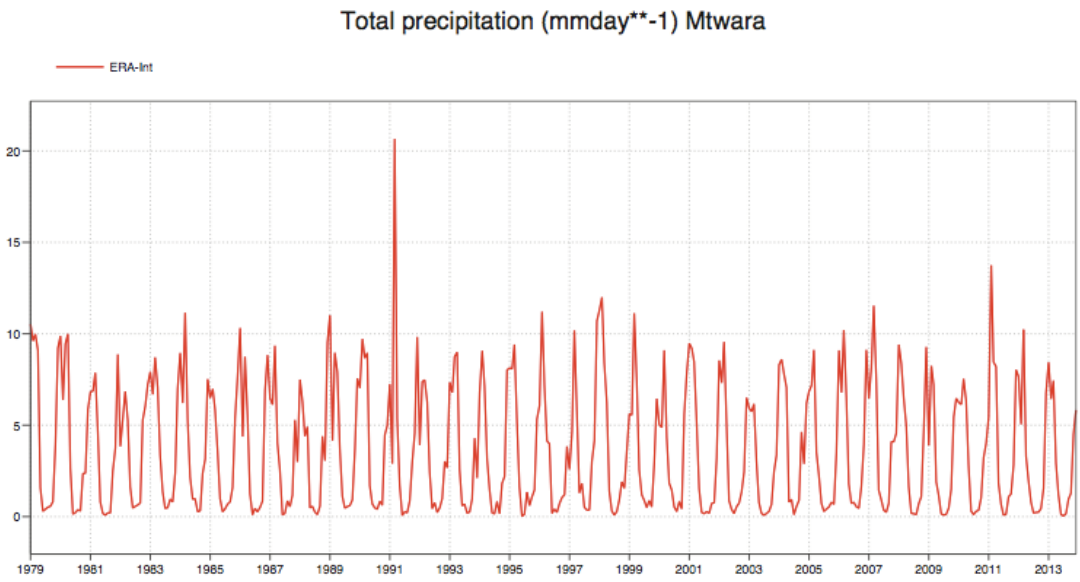

Figure 56: Mtwara total precipitation variation in mm/day from 1979 to 2013 using ERA-Interim Software for reanalysis.

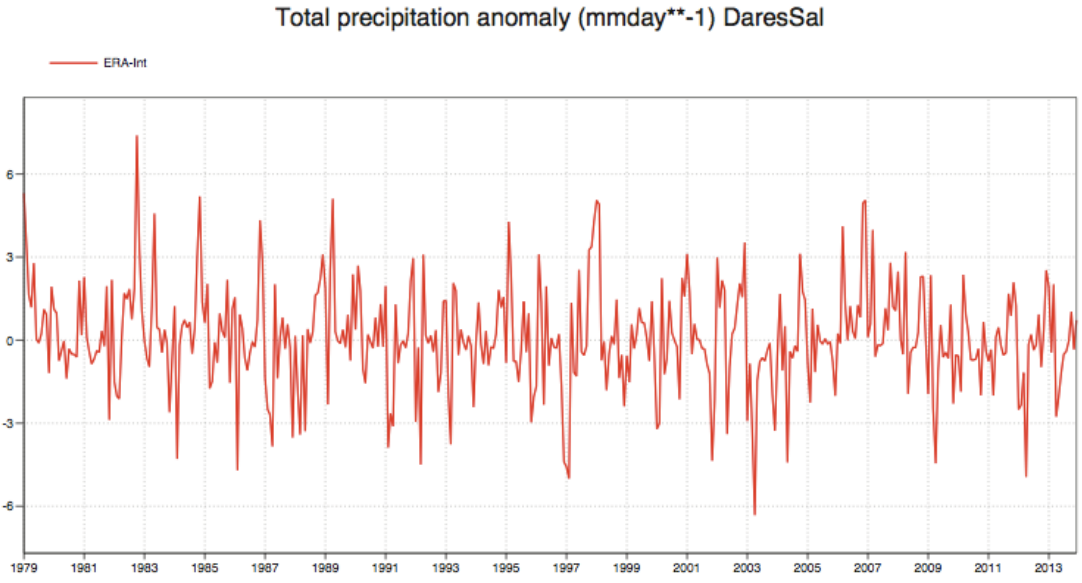

Figure 57: Dar es Salaam total precipitation anomaly assessment in mm/day from 1979 to 2013 using ERA-Interim Software for reanalysis.

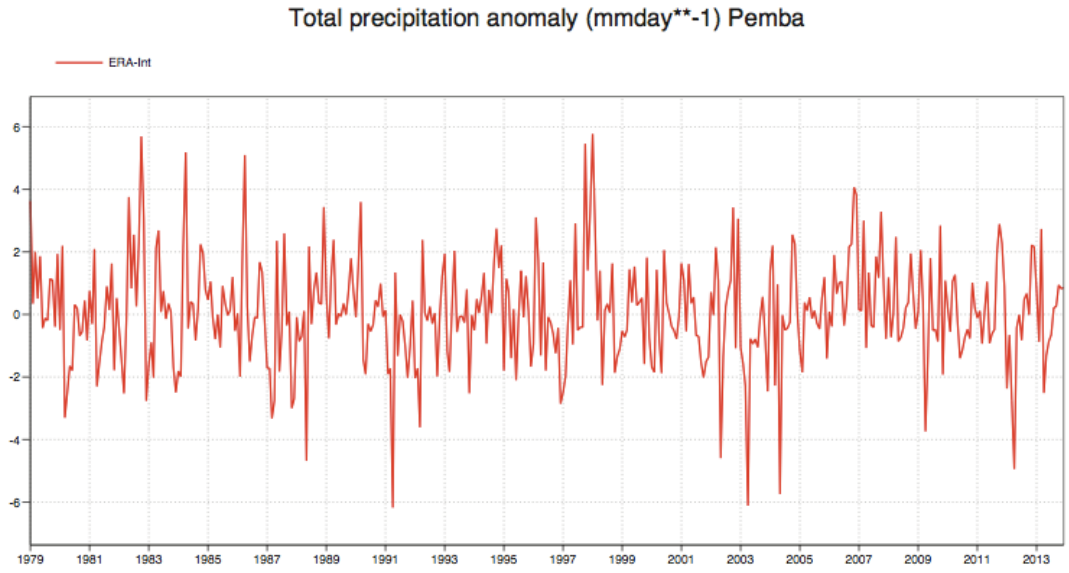

Figure 58: Pemba total precipitation anomaly assessment in mm/day from 1979 to 2013 using ERA-Interim Software for reanalysis.

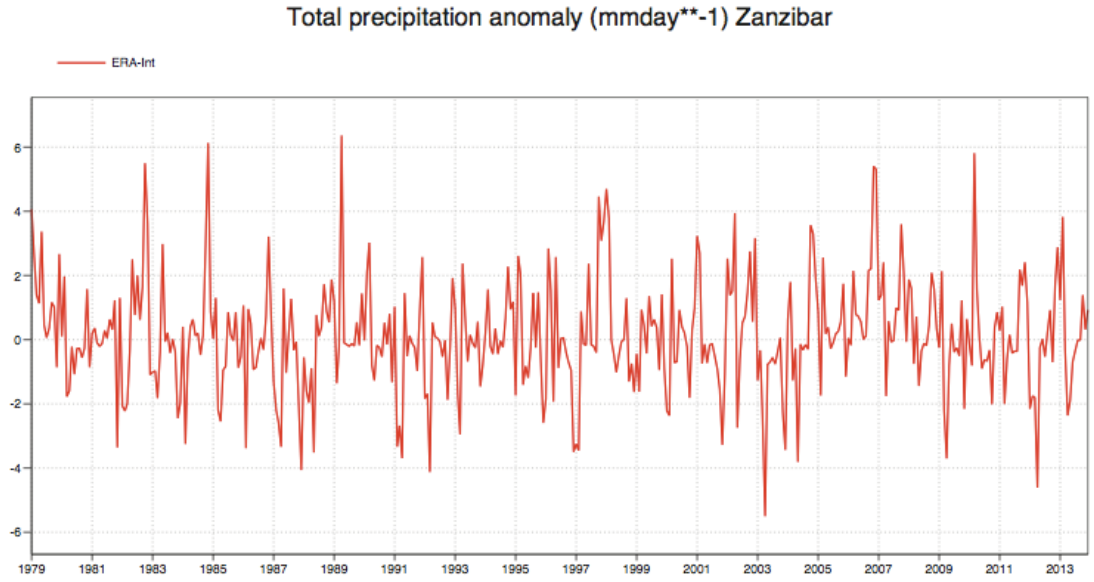

Figure 59: Zanzibar total precipitation anomaly assessment in mm/day from 1979 to 2013 using ERA-Interim Software for reanalysis.

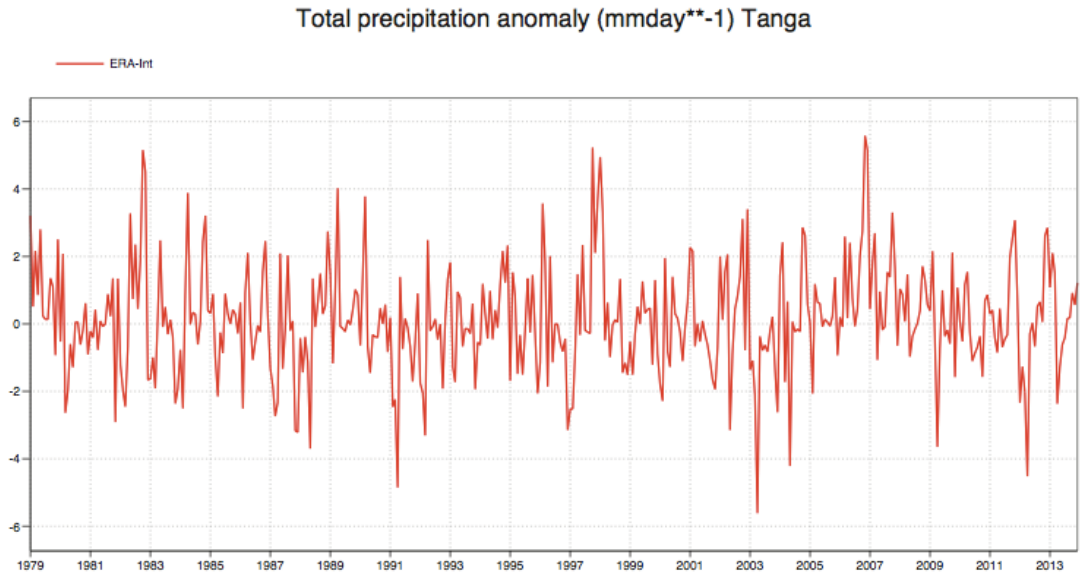

Figure 60: Tanga total precipitation anomaly assessment in mm/day from 1979 to 2013 using ERA-Interim Software for reanalysis.

Annex 5: Trend Assessment of Historical Temperature Data from National Bureau of Statistics

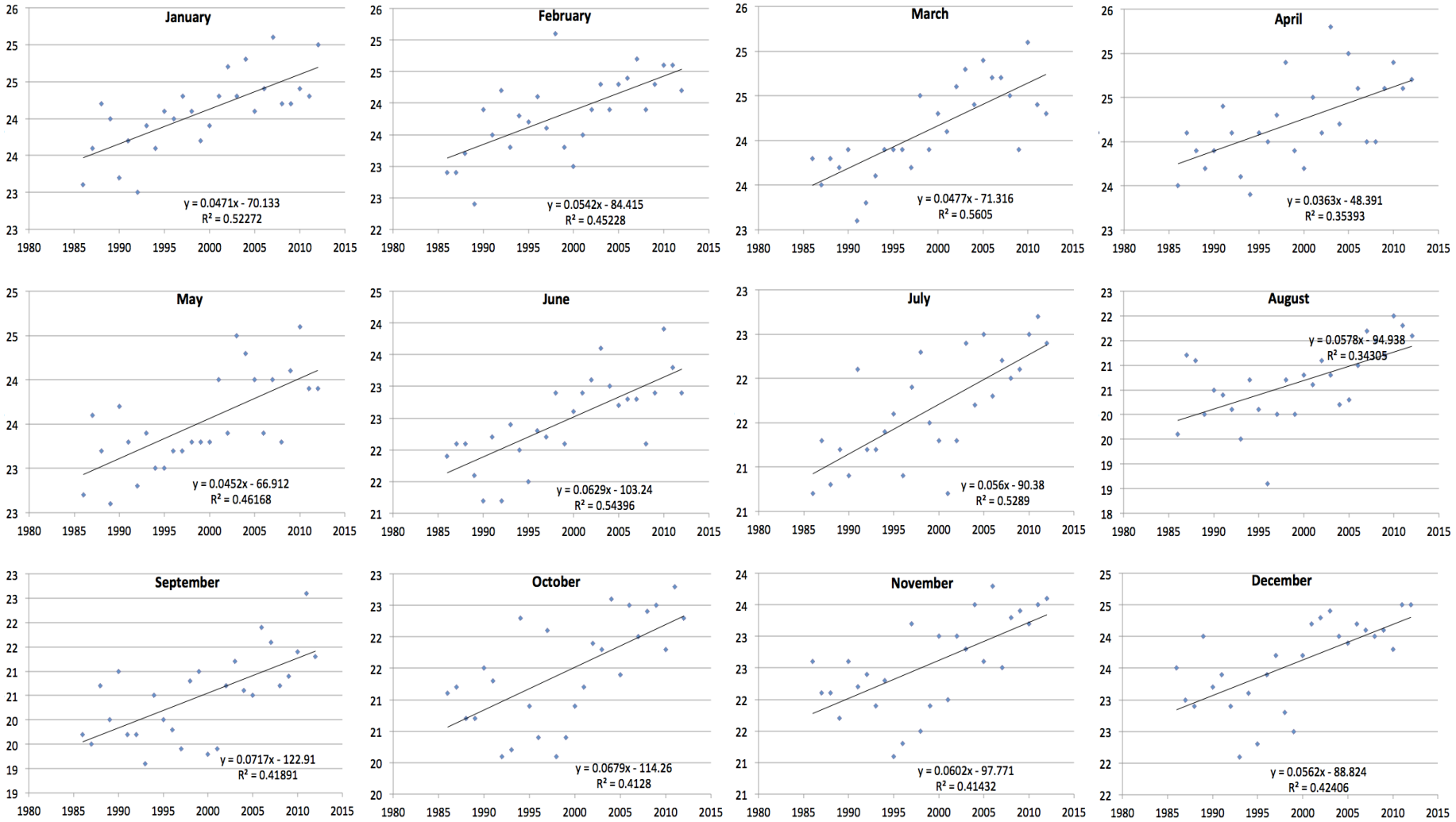

Figure 61: Zanzibar, monthly average minimum temperatures, 1985 – 2012 (National Bureau of Statistics).

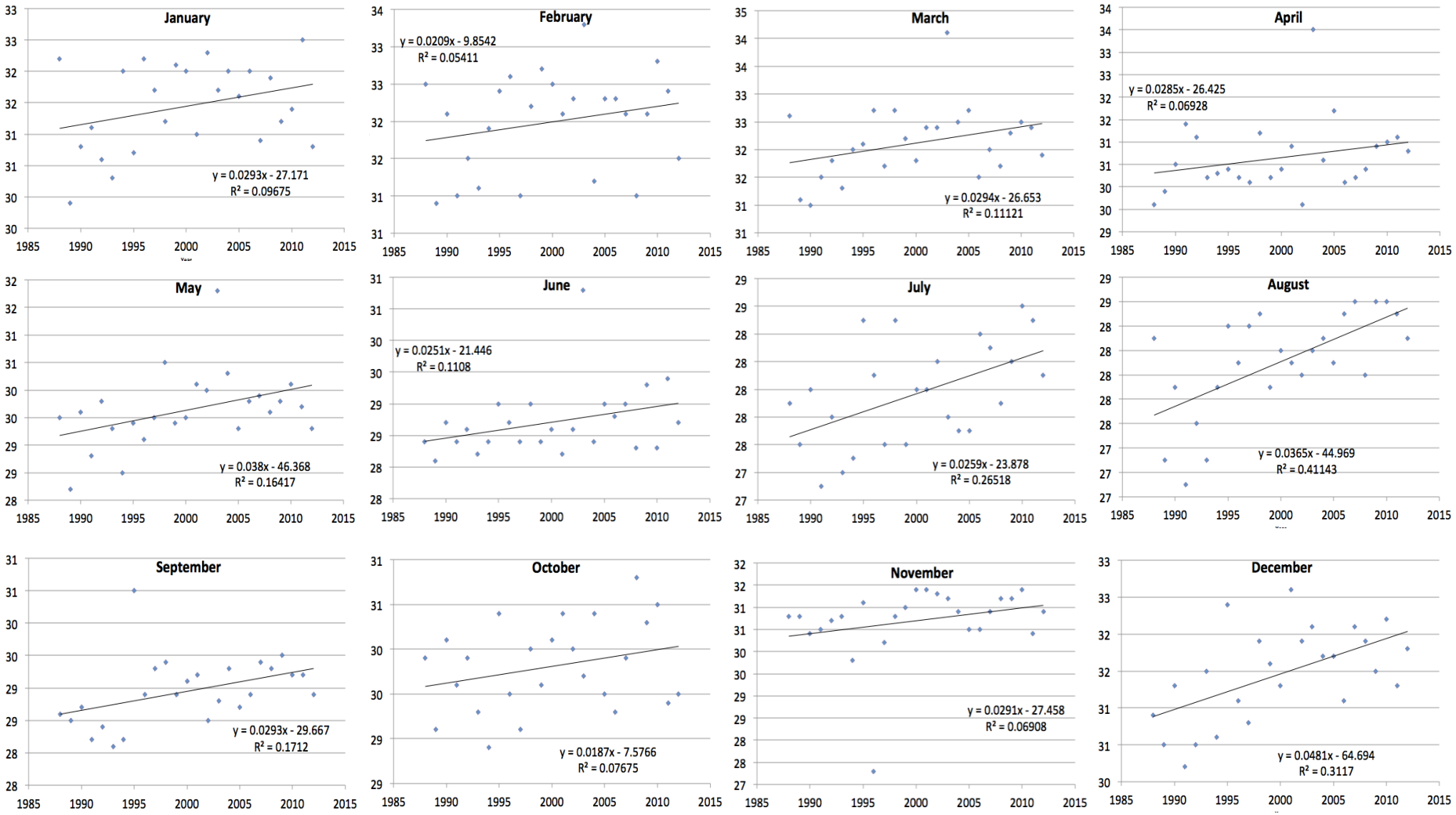

Figure 62: Pemba, monthly average maximum temperature, 1985-2012 (National Bureau of Statistics).

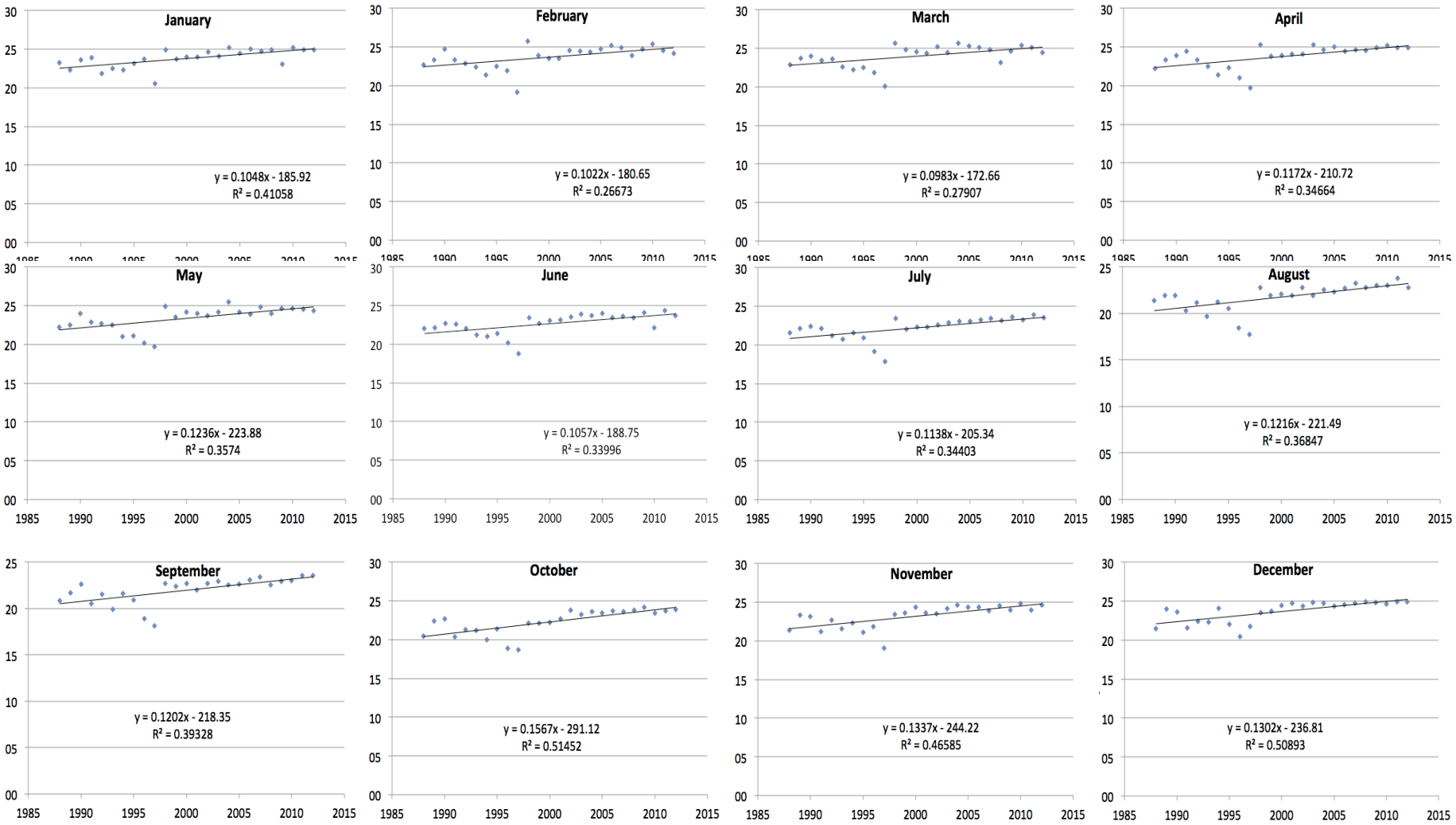

Figure 63: Pemba, monthly average minimum temperature, 1985-2012 (National Bureau of Statistics).

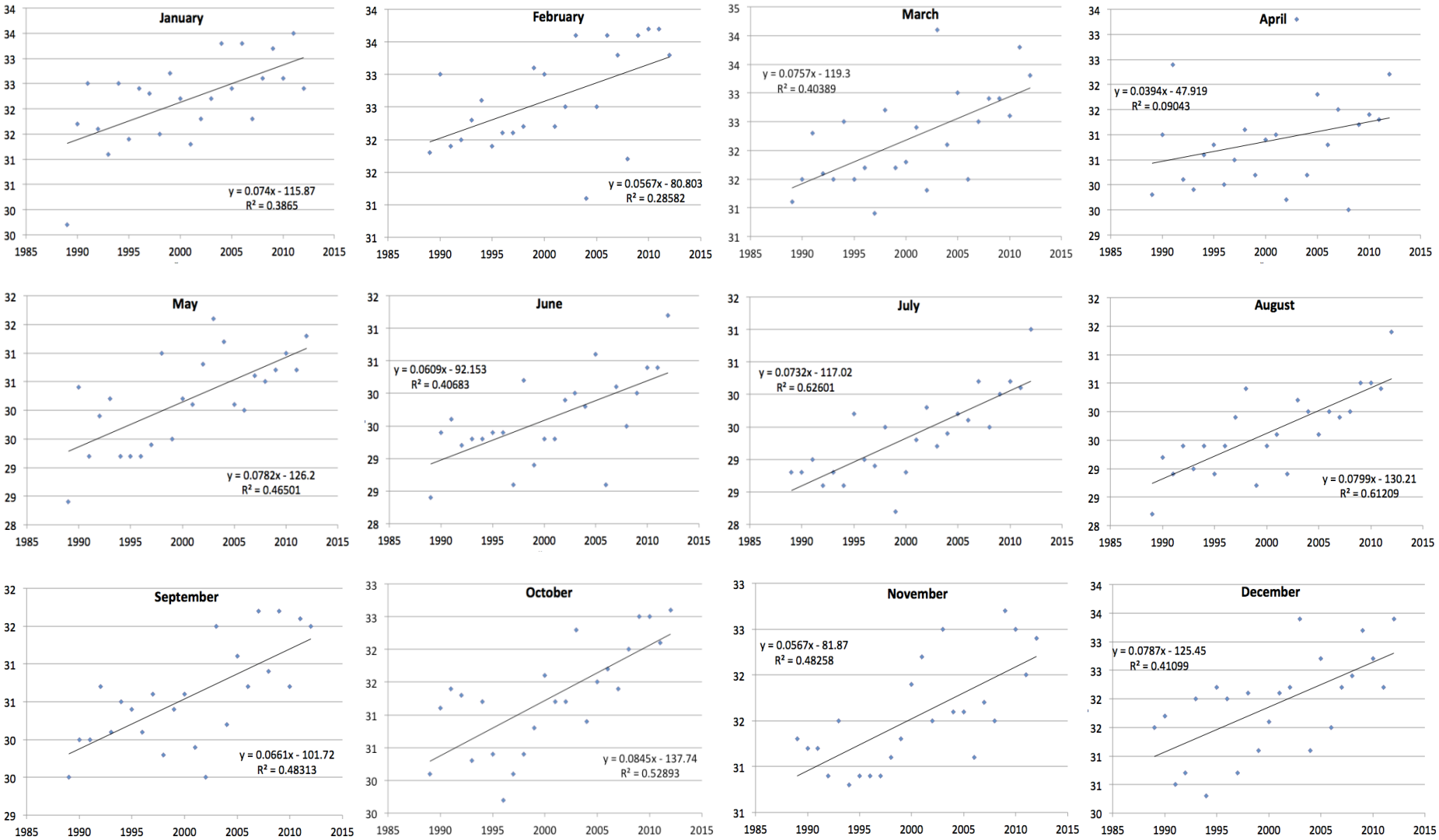

Figure 64: Dar es Salaam, monthly average maximum temperatures, 1985-2012 (National Bureau of Statistics).

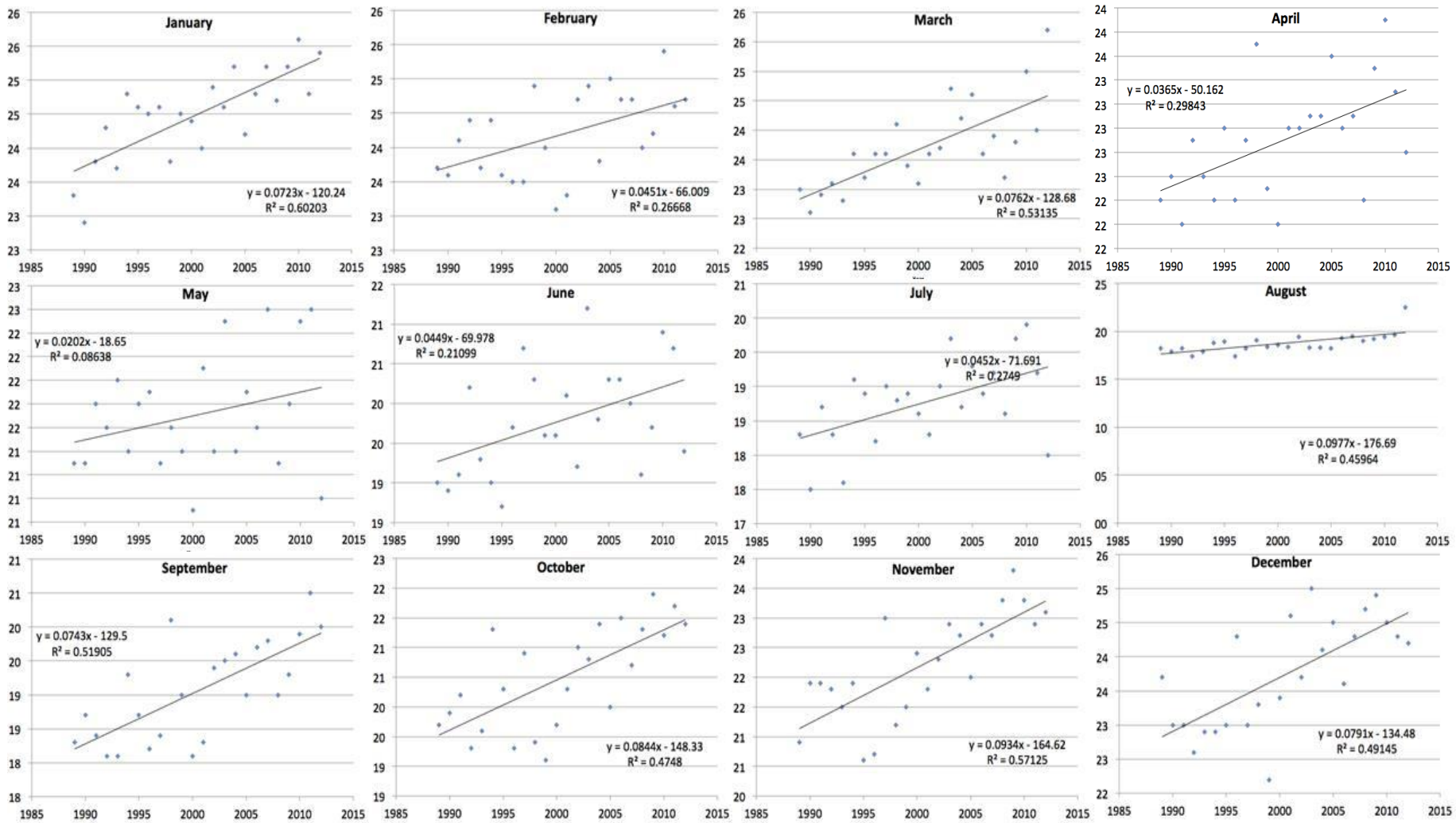

Figure 65: Dar es Salaam, average monthly minimum temperature, 1985-2012 (National Bureau of Statistics)..

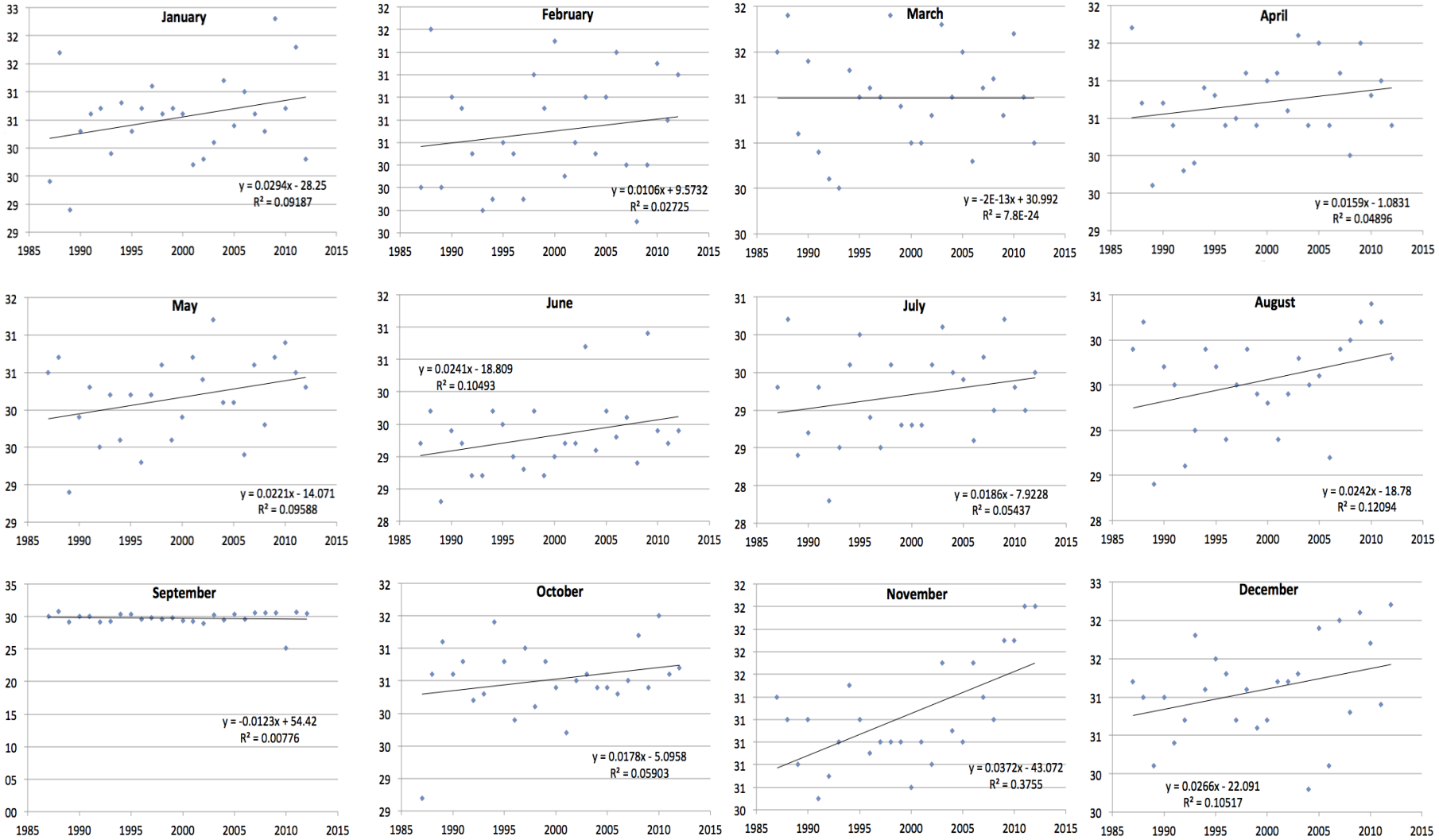

Figure 66: Mtwara, average monthly maximum temperatures, 1985-2012 (National Bureau of Statistics)..

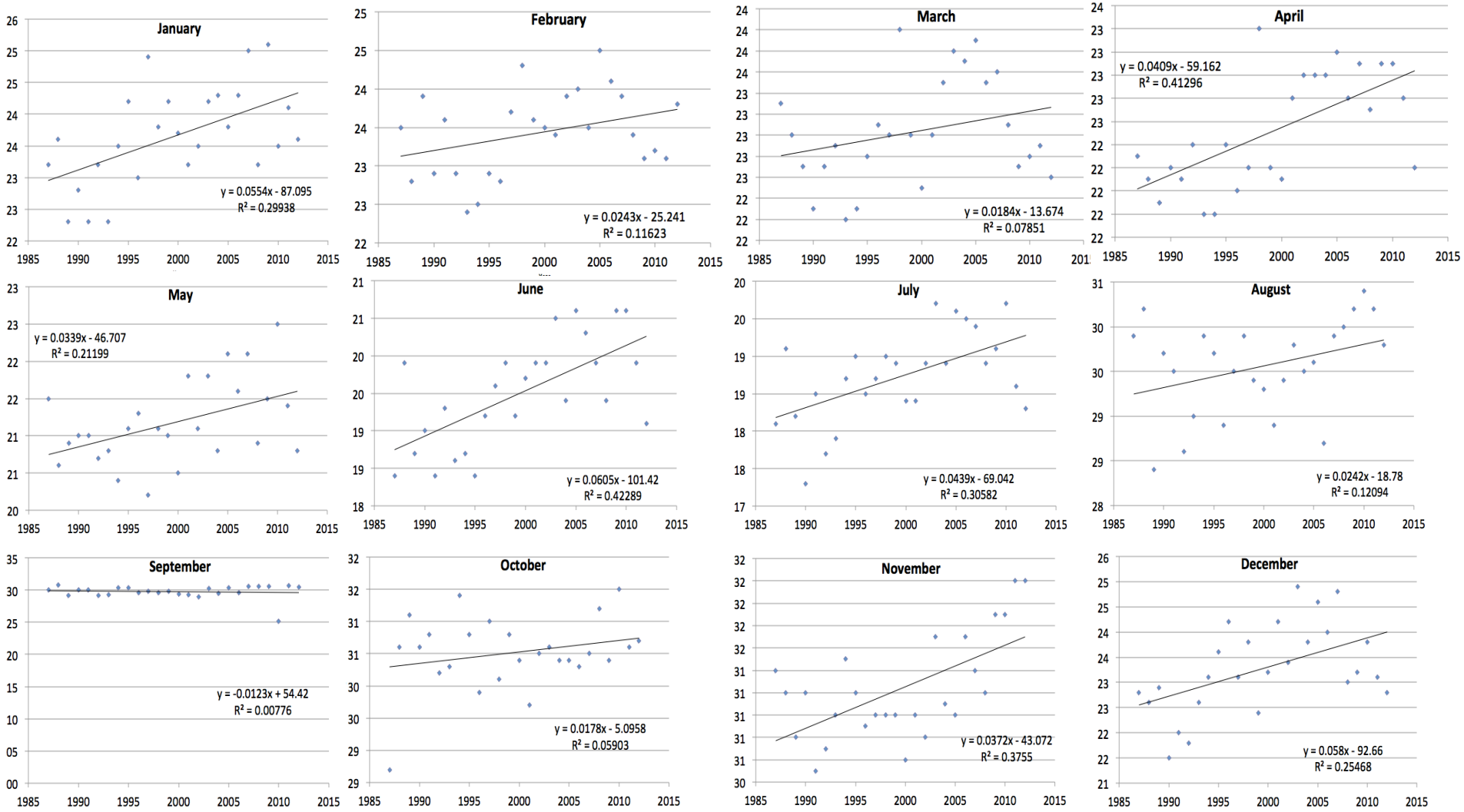

Figure 67: Mtwara, average monthly minimum temperatures, 1985-2012 (National Bureau of Statistics).

Annex 6: Inception Workshops – Participants

Dar es Salaam 8 April 2014

Table 36: List of Participants – Inception Workshop 8 April 2014, Dar es Salaam

Name	Organisation	Name	Organisation
Benaih Benno	UDSM-DASF	Shadrack Stephen	National Land Use Planning
Mathias Igulu	TAFIRI	Philbert Luhunga	TMA
Bupe. E. Mwansasu	Kinondoni	Magdalena Banasiall	DFID
Upendo Hamidu	MLFD (head quarter)	Jason Rubens	Sound Ocean Ltd
Mwanaidi R. Mlolwa	MLFD-FDD	J. M Daffa	WWF
Matthew Richmond	Samaki Consoltants Ltd	Doyi Mzenzele	IUCN TZ
Kimasa Bugomba	MLFD	Titus Mwisomba	NBS
Baraka S. M. Mngulwi	MLFD	Violaine Lepoosez	French Embassy
Magese . E. Bulayi	MLFD	Hannes Potgietel	SEE BREEZE MARINE
Dr. E. J. Mosha	MLFD	Alexander Riefer	SEA BREEZE MARINE
Jovice Mkuchu	MLFD	Ambakisye Simtoe	Fisheries Education Training
Ezra E. Mutagwaba	MLFD	Ramadhani H. Mwigah	UWAWADA-Katibu mkuu
Dr. Simon J. Kangwe	TAFIRI	Abdulkarim Salum	UWAWADA-Mwenyekiti
Flora Akwilapo	NEMC	Christopher Muhando	IMS
Theddy P. Chuwa	Temeke Municipal Council	Rosemarie N. Mwaipopo	UDSM
Juma Msangi	Ilala Municipal Council	Gorm Jeppesen	DHI
Rashidi Tamatamah	UDSM	B.E Mapunda	DAFIE
Rikard Liden	World Bank	Fadhila Ruzika	MLFD-AQUACULTURE DEPT
Jairos Mahenge	Marine Parks	Abdallah Mohamed	Samaki Consultants Ltd

Figure 68: Inception Workshop groups sessions examining threats from thematic sectors and considering prioritization and mitigation alternatives, Dar es Salaam, 8 April 2014

Figure 69: Dar es Salaam Inception Workshop participants, 8th April 2014

Zanzibar 10 April 2014

Table 37: List of Participants – Inception Workshop 10 April 2014, Zanzibar

Name	Organization	Name	Organization
Hamad S. Khatib	MLF-Department of Marine	Ali Kassim Mohamed	PECCA
Ali Ameir Ali	MLF-Fisheries Department	Saleh K. Kina	SMOLE
Othman Maulid	ZIPA	Miza S. Khamis	DFNR
Ali S. Mchenga	Mkoa Kusini (U)	Thani R. Said	SUZA
Dr. Mabau A. Usa	Mkoa Kaskazini (U)	Tammy Holter	SCUBA DO/ZATI/Ocean
Saleh Mohamed Juma	MANR	Rikard Liden	World Bank
Martin McDonald	Chumbe	Tamriri Ali Said	Forestry Zanzibar
Matthew Richmond	Samaki Consultants Ltd	Dr. N.S.Jiddawi	IMS
Gorm Jeppesen DHI	DHI	Amas M Othman	MBCA
Ramla Talik Omar	SWIOFish Coordinator	Omar Hakim Foum	MCU
Salum Rehan	Urban West Region	Ali S. Mkarafuu	DFD
Mohamed. M. Nur	Samaki Consultants	Makame Khamis Makame	Rc's Office Pemba North
Rosemarie Mwaipopo	Samaki Consultants	Sheha Mjaja Juma	DOE- FVPO
Rukia Kitula	Institute of Marine Science	Mwalim KH.Mwalim	DOE- FVPO Pemba
Omar Mohamed Ali	Kojani Fishermen Dev. Organization	Masoud S. Said	Zari-Kizimbani
Juvinaries M. Nyandoto	Deep Sea Fishing Authority	Othman Mohamed	Director KATI-Kizimbani
Asma Othman	Ministry of Livestock and Fisheries	Casper Loursen	Smole Project
Ummi Molid	SWIOFish	Makame Salum	C-Weed Corp Ltd
Amour Mlenge	Ministry of Livestock and Fisheries	Ramla Fadhil	Aquaculture
Abdulrahman Ali	ACRA-ZNZ	Batuli M. Yahaya	C-Weed section
Mohammed Chum	Department of Fisheries	Jadidi Abdulla	Zanea Seewed Co Ltd
Hussein M. Mohamed	ZFSE	Arif Mazrui	Zanqur Aqua Farms Ltd
Jaala Sumba	Department of Fisheries	Christian Mchloll	ZATI-Scuba Do Zanzibar
Mohamed Habib	Dept of Urban and Rural Planning	Issa Yussup	Daily News
Thani R. Said	SUZA	Hinja Haji	ZBC Radio
Hashim Runehielun	GIM SEA CO .Ltd	Salama Mohamed	Mwandishi Wizara
Amour Kassim	Dept of land and Registration	Madina Issa	Zanzibar Leo
Sihaba H. Vuai	Dept of Environment	Beatrice George	ZBZ Tv
Munira A. Arahman	Dept of Fisheries	Makame Ame Ussi	ZBZ Tv
Semeni Mohamed Salum	Dept of Fisheries	Chalid Abdallah	Ministry of Livestock and
Hamad Masoud	DPPR-MLF	Ngwali M. Haji	Forestry Department
Khatib Juma	ZARI	Dr. Ahmada H. Panda	ZCT
Lars Moller	SMOLE	Daud H. Pandu	DFA
Mwadidni Haji	DPF	Maryam Ali Mohamed	Fisheries
Radhiya R. Haroub	PORASD	Bahati Ameiri Khamis	Fisheries
Khamis Khalfan	CHICOP LTD		

Figure 70: Inception Workshop participants attending a presentation by Dr. Rosemarie Mwaipopo on the preliminary social and economic assessment of the coast as it relates to threats to livelihoods and the environment, prior to groups work considering prioritization and mitigation alternatives of thematic threats identified thus far, Zanzibar, 10 April 2014

Figure 71: Zanzibar Inception Workshop participants, 10 April 2014

Annex 7: Members of Working Groups

Tanzania Mainland Working Group

Table 38: Members of the Working Group for Mainland Tanzania

Name	Institution
Dr. Rashid Tamatamah	University of Dar es Salaam (USDM)
Jeremiah Daffa	Tanzania Coastal Zone Management Project (TCZMP) – National Environmental Management Council (NEMC)
Magese E. Bulayi	Ministry of Livestock and Fisheries Development MLFD
Shadrack Stephen	National Land Use Planning Commission
Deogratius Paul	Vice President's Office (VPO), Division of Environment
Abdallh Said Shah	International Union for Conservation of Nature (IUCN)
Lewis Nzali	National Environmental Management Council (NEMC)

Zanzibar Working Group

Table 39: Members of the Working Group for Zanzibar

Name	Institution
Sihaba Vuai	Department of Environment
Hamad Khatibu	Ministry of Livestock and Fisheries (MLF) -Department of Marine Resources
Rune Hashim	GIM SEA CO .Ltd
Daudi Pandu	DFA
Christian Zati	SCUBA DO/ZATI/Ocean watch
Bakari Asseid	Deputy PS, Ministry Natural Resources
Makame Kitwana	Institute of Marine Sciences, UDSM
Nariman Jiddawi	Institute of Marine Sciences, UDSM