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Analysis of causes and possible methods of dealing with mangrove deforestation in Mozambican coastal areas: a case study of Quelimane District in Zambézia Province

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ANALYSIS OF CAUSES AND POSSIBLE METHODS OF DEALING WITH MANGROVE DEFORESTATION IN MOZAMBICAN COASTAL AREAS:

A case study of Quelimane District in Zambézia Province

By

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Mozambique

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): 

(Date): 2017/09/19

Supervised by: Professor Larry Hildebrand

World Maritime University

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Source: Silvermoz.com (Partial aerial view of deforested mangrove area in Quelimane).

ABSTRACT

Title of Dissertation: **Analysis of Causes and Possible Methods of Dealing with Mangrove Deforestation in Mozambican Coastal Areas: A Case Study of Quelimane District in Zambézia Province.**

Degree: **MSc**

This dissertation addresses to the destruction of mangrove forests and the resulting environmental and social impact, analysing strategies that can be implemented to cease mangrove deforestation along coastal areas.

For the past century, Quelimane coastal area has been widely affected by mangrove deforestation and today it is part of the livelihood of the majority of the coastal communities who face economic difficulties due to unemployment and high poverty rates. As a means of survival, mangrove forests are their last resort, they burn the mangrove wood to make charcoal for commercial use and for the construction of precarious housing of clay and sticks. Furthermore, the practice of agriculture and aquaculture have also contributed to mangrove deforestation.

The Government as a whole and the Quelimane District Environmental Authority face challenges in fighting deforestation. Although there are laws established against deforestation, little is done due to the ever-increasing population living in poverty and the Governments financial limitations to aid the communities. In addition, the socio- political state stands as another drawback to the implementation of the environmental laws, whereby the environmental related institutions are governed by different political parts. Positively, Quelimane City Counsel launched a reforestation campaign, which promotes awareness and involves the participation of the communities.

After having identified the predominant causes of mangrove deforestation, the results of the research pave the way for recommendations and practical methods that can help in the case of law enforcement for the benefit of both the local communities and preservation of mangrove forests. The recommendations in regard to the measures to be enforced not only involve action from the government, but also include the cooperation of the coastal communities.

KEYWORDS: Mangrove deforestation, analysis, socioeconomic, socio-political, environmental impact, reforestation, preservation, communities, poverty.

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List of Abbreviations

ADF	African Development Fund
ADNAP	National Fisheries Administration
AFE	Association of the Environment
ANAC	National Administration of Conservation Areas
CEA	Centre Earth Alive
CEPAM	Research Center of Marine and Coastal Environment
CSO	Civil Society Organization
DPMAIPZ	Zambézian Provincial Direction of Sea, Inland Waters and Fisheries
DPTADRZ	Zambézian Provincial Direction of Land, Environment and Rural Development
DPSZ	Zambézian Provincial Direction of Health
EIA	Environmental Impact Assessment
ESCMC	High School of Marine and Coastal Sciences
FAO	Food and Agriculture Organization
NDF	Forum for Nature in Danger
FRELIMO	The Liberation Front of Mozambique
ha	Hectare
IIP	Fisheries Research Institute
INAMAR	National Maritime Institute
INAQUA	National Institute of Aquaculture Development
INDE	National Institute of Education Development
INE	National Institute of Statistics
KASAMA	Kalibo Save the Mangrove Association
km	Kilometers
LGU	Local Government Units
MDM	Mozambican Democratic Movement
MIMAIP	Ministry of Sea, Inland Waters and Fisheries
MISAU	Ministry of Health

MITADER	Ministry of Land, Environment and Rural Development
NMC	National Mangrove Committee
NOG	Non-Governmental Organisation
PO	People Organisation
SDPI	District Services of Planning and Infrastructure
UEM	Eduardo Mondlane University
UNICEF	United Nations Children's Fund
WHO	World Health Organisation

CHAPTER I

1.0 INTRODUCTION

1.1 Background

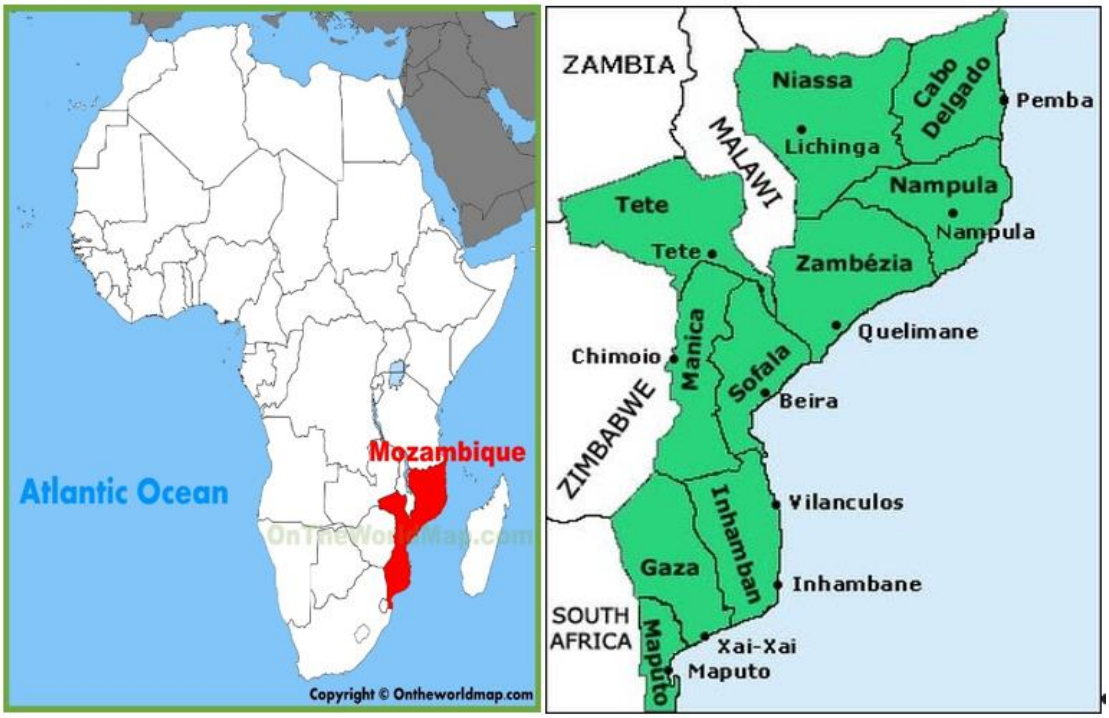
Mozambique is an East African country situated between latitudes 10°20'S and 26°50'S, with a wide diversity of habitats on its 2.770 km of coastline along the Indian Ocean. This includes 'sand beaches, coral reefs, estuarine systems, bays, sea-grass beds and mangroves (Lindén & Lundin, 1997). Mozambique is made up of 10 Provinces divided into three regions, the north, central and south. The Provinces of Cabo Delgado, Niassa and Nampula compose the north region. In the central region, are the Provinces of Tete, Manica, Sofala and Zambézia. In the South region are the Provinces of Gaza, Inhambane and Maputo (**Figure 1**).

Mozambique as a whole has a land area of 80 million hectares, and with a population of about 25 million people. The country's riches are from its natural resources, very fertile lands, vast forests, fisheries, and mineral resources which have greatly contributed to 7.5% of the average economic growth in the last period of ten years (Mercier *et al*, 2016).

Moreover, even with such an increase in productivity, Mozambique continues to face challenges in progression and satisfaction of the populations needs. In addition, due to the ever growing population, which is a barrier to combating poverty, Mozambique is on the list of the world's poorest countries with around 54% of the population living below the minimum level of income for basic necessities and with 70% of the population living in rural districts as displayed by the Human Development Index (INE, 2007; Mercier *et al*, 2016).

According to FAO (n.d), the level of environmental education is directly associated with the numerous reasons for poor preservation of natural resources. Hardly any information in regard to mangroves is circulated to the public and the failure to research and update the current national statistics, are reasons why less value is attributed to mangroves and very little is known about the gravity of deforestation (FAO, n.d). Therefore, better education will guide in the usage of natural resources in a productive and sustainable way.

Figure 1. Location of Mozambique in African Continent and its Territorial Distribution



Source: (ontheworldmap.com)

According to Garschagen *et al*, (2014) cited by Lee *et al*, (2017), Mozambique is ranked as the seventh most vulnerable and the most susceptible country in the world, to natural hazards such as rising sea level, storms, floods and tsunamis. Although this consideration is mainly related to the Mozambican geographic location, the exploitation, lack of improper control and weak preservation of natural resources such as mangroves has its contribution.

1.2 Status of Mozambican Mangrove Conservation

According to Lindén and Lundin (1997), in 1972, just three years before national independence, Mozambique had an estimated area of 408,079 ha of mangroves. Further, the FAO report on the mangrove (2007), considers Mozambique to be the country with the second largest mangrove forest in Africa and the largest of the Eastern part of the continent, estimated on 390,000 ha along its 2,770 km of coastline, bays and estuaries.

However, recent studies revealed that the Mozambican area of mangrove forests is now estimated at only 300,000 ha (Fatoyinbo & Simard, 2013), and others estimate an average of between 290,000 ha and 368,000 ha (Pereira *et al*, 2014), and with greater abundance in the central and northern areas of the country. In addition, according to Giri *et al,* (2011) the Mozambican mangrove area is now in the third place in Africa, after Nigeria and Guinea Bissau.

Moreover, the above data shows that over the years the mangrove ecosystem is gradually reducing in Mozambique (**Table 1)**. The reduction is mainly associated with the demand for wood and firewood, by the local communities (Camara, 2013). It is estimated that of the about 25 million people, more than 60% of the Mozambican population lives in the coastal zone, imposing great pressure and dependence on marine and coastal resources, including mangrove forests (MITADER, 2015; INE, 2007).

Although in Mozambique, there is not any effective monitoring system to know the exact levels of annually and recent mangrove forest decline, it is known that this ecosystem is under threat and in constant reduction due to current frequent unbridled and unregulated modes of exploitation in all coastal communities (MITADER, 2015; Macamo & Sitoe, 2017).

1.3 Aim and Objectives of the Research

Keeping in mind the ultimate objective to coordinate the structure of this research, the aims and objectives are as follows:

1.3.1 Aim of the Research

This research aims to assess the causes of mangrove deforestation in Quelimane and propose some practical methods in dealing with mangrove deforestation to improve their sustainability.

1.3.2 Objectives of the Research

Having identified the current environmental endangerment, the objectives of the dissertation are to:

- Portray the causes of the current environmental crises in regard to mangrove deforestation in Quelimane District;
- Discuss the benefits of having mangrove forests along its coastal and Bons Sinais Riversides;
- Analyse the negative impacts resulting from mangrove deforestation in that particular part of Mozambique;
- Identify the social and political barriers that impede environmental law enforcement;
- Propose strategies and practical solutions based on the analysis in alliance with recommendations for the sustainability of mangrove forests, welfare of the communities, the environment and the economy.

1.4 Methodology

To assemble data used by the author for this research, a study was conducted using geological and environmental information from various sources from the Internet and books, which characterized mangrove importance in maintaining the marine and coastal environment. Therefore, based on the knowledge of local habits and customs on the usage and exploitation of mangrove resources, accompanied by field

observation and present day photographic images, the author was able to estimate the state of mangrove degradation along the coast of Quelimane District, Zambézia Province of Mozambique. Furthermore, to comprehend the sustainability of mangrove forests, an enquiry through a questionnaire was administered with the districts' environmental authority and related institutions to analyse the socioeconomic and political factors that interrupt the phenomenal mangrove ecosystem. In addition, door-to-door interviews were also conducted for a better understanding of the communities' customs, habits, motivations, as well as their economic difficulties that lead to mangrove deforestation.

In conjunction, experiences of the Republic of the Philippines, in the recovery of destroyed mangroves are brought forth for the following reasons:

First, the Philippines is listed as one of the countries with the highest rates of mangrove deforested areas in the world (Strong & Minnemeyer, 2015), and just as in Quelimane District today, the Philippines experienced periods with no governmental sector regarding mangroves. Second, both countries share the same reasons that led to mangrove deforestation, which Quelimane currently faces. Third, the coastal communities in the Philippines that took part in mangrove deforestation dealt with the same social predicament of poverty and the need to meet basic needs as is eventuating in Quelimane.

Indeed, the present research is more objective and based on evidence approach.

1.5 Limitations of the Research

The limitations that caused some barriers during the development of the present research are:

a) The lack of scientific and academic data that analyse the current situation of mangrove deforestation state in Quelimane District.
b) Lack of freedom and support by some institutions to provide details and honest information.

c) Lack of support and willingness of some people to provide necessary personal information in the house-to-house inquiry.

1.6 Structure of the Research

The present research is divided into 7 chapters, each containing subtopics. First, chapter 1 consists of the introduction, background, state of mangrove conservation, aims of research, objectives of research, methodology, limitations and structure of the research. Chapter 2 focuses on the process of data collection and the results from the questionnaire, interviews and study visits conducted for the present research. Chapter 3 consists of the literature review, beginning with the background, followed by the physical structure of mangrove forests along Quelimane coast, the characteristics of mangrove forests and their importance to the marine and coastal environment. Chapter 4 delineates the current state of mangrove deforestation in Quelimane District and then points to the seven main reasons of deforestation which are: rural exodus, land for construction, source for construction material, agriculture, aquaculture, source of energy and socio-political affairs. In addition, this section scrutinizes the national laws and institutions related to mangrove ecosystems, and encourages the government to enforce in effective ways the existing environmental laws and surveillance. Subsequently, chapter 5 presents the current impacts of mangrove deforestation in Quelimane by analysing the environmental, economic and social perspective. Chapter 6 presents the mangrove recovery processes and the Philippines experiences on mangrove recovery that could be applied to recover the Quelimane mangrove areas, by pointing to enforcement and monitoring polices, mangrove reforestation, community involvement and awareness. Ultimately, chapter 7 presents the conclusion of the research, then followed by recommendations to the Mozambican Government as a whole, more specifically to the Government of the Province of Zambézia, the District of Quelimane, the Quelimane City Council in particular and the local communities.

CHAPTER II

2.0 DATA COLLECTION AND RESULTS

2.1 Data Collection

The process of collecting data for the present research work involved three important phases:

The first phase was carried out by the author in the district of the present study from December 2016 to January 2017. The author directly contacted environmental and other relevant institutions to collect necessary information and carried out door-to-door interviews in three of the most affected neighbourhoods by mangrove deforestation, namely Icidua, Mirazane and Chuabo Dembe. The interview guide is listed in Appendix 1.

In this same period, the author made several visits to different mangrove areas currently deforested, and to the markets where mangroves sticks, together with charcoal made from mangrove trees, are sold. Photographs of these areas and markets are included throughout Chapters V and VI.

The second phase was carried out in a different location, namely Malmö, Sweden, and basically consisted of research and selection of scientific and academic information relevant to the mangrove ecosystems from the Internet and library of the World Maritime University.

The last phase involved correspondence through emails and telephone calls with the institutions with whom the questionnaire was administered and other companies such as AQUAPESCA and Krustamoz Limited Quelimane, for the request and receipt of

relevant information in regard to how their sectors could be somehow affected by mangrove deforestation in Quelimane. See Appendix 4 for the requested information.

2.1.1 Questionnaire Guide

The questionnaire guide of the present research was directed to three main governmental institutions which are responsible for the environment fisheries and urbanization, namely the Provincial Direction of Land, Environment and Rural Development of Zambézia - DPTADERZ, Provincial Direction of the Sea, Inland Waters and Fisheries of Zambézia- DPMAIPZ and Quelimane City Council. However, each institution reacted differently according to their level of freedom and confidence in providing the requested information. See Appendices 2 and 3 for the questionnaire guide and Appendix 4 for the requested data.

2.1.2 Interview Guide

The target group of the interviews conducted for the present research were the communities living in the above-mentioned neighbourhoods, created on mangrove lands with greater dependence on mangrove resources, implying deforestation of several areas for the building of residences.

It should be noted that initially it was intended to interview 100 people. However, the freedom, willingness and availability of the head of the family, associated with a limited time factor, resulted in the interview of only 84 adults whose ages range between 25 to 55 years. Thus, from the 84 people interviewed, 40.5% are residents of Icidua, 31% of Chuabo Dembe and 28.5% of Mirazane.

Nevertheless, the data collected through the questionnaire, interviews and visits to the locations in focus, allowed the author to reach the following results presented below.

2.2 Summary Results of the Research

2.2.1 Questionnaire Results

Based on the information obtained through the questionnaire, it is clear that the DPTADRZ and DPMAIPZ, institutions that responded favourably are aware of the severity of mangrove deforestation state in Quelimane.

The DPTADRZ recognises that the predominant species of mangrove in Quelimane, the Avicennia marina (salgueiro), is the primary source of food and reproduction for marine species. However, the DPTADRZ, as an environmental authority, is aware that the current mangrove destruction can be related to the lack of environmental education and poverty in the local communities. Furthermore, the DPTADRZ stated that in order to minimize the situation, awareness campaigns in the communities about the consequences of mangrove deforestation are required.

Another important detail recognised by the DPTADRZ is that the mangrove deforestation phenomena in Quelimane is of a political nature. This is because it began during the 16 years civil war that took place from 1977 to 1992, whereby many people from other parts of the Province sought refuge in Quelimane, and opted for mangrove resources as their main and only source for survival. However, even with the end of the war, the scenario continued to grow in an alarming proportion, which could be associated with low family income and the high level of illiteracy that characterizes the poor population.

Finally yet importantly, Quelimane's environmental authorities are aware of the current impact of coastal erosion and reduction of biodiversity that could be related to the mangrove deforestation in the District.

On the other hand, the DPMAIPZ highlighted the importance of the mangrove ecosystem to biodiversity, since during the life cycle of the fishery resources most of them spend the larval, juvenile and sub-adult stages in the estuaries making use of the shelter and food provided by the mangroves (DPMAIPZ questionnaire). It was

recognized that the deforestation and destruction of the mangrove ecosystem directly or indirectly affects the reproduction of marine resources, and eventually, the economy of the country.

In addition, the DPMAIPZ also emphasized the decreasing annual productivity of fish catch in the last 4 years in Quelimane District. However, the DPMAIPZ suggests and feels that only a deep and specific study can determine the extent to which the phenomenon of mangrove deforestation is linked and contributes to the low productivity of fish catch in Quelimane.

Indeed, the environmental and other related authorities are very much aware of what is happening to the mangrove ecosystem in Quelimane District. However, promoting awareness campaigns without introducing solutions or alternatives to the local poor communities, especially to those whose means of income and energy source depends on the mangrove resources, will not make them cease cutting mangroves.

2.2.2 Interview Results

From the interviews conducted in the three-targeted neighbourhoods mentioned above and visits made, the author was able to reach the following results:

- The neighbourhoods that have emerged on mangrove lands are almost entirely inhabited by poor people.

- Fishing, agriculture, trade, mangrove cutting and sale of their resources are some of the main activities performed by residents of the targeted neighbourhoods in the present study.

- In Quelimane District, the mangrove ecosystem is primarily destroyed by local communities to build precarious houses using mangrove sticks, production of charcoal, firewood and transformation of mangrove lands into farms and building of houses.

- Residents of neighbourhoods that have emerged from the destruction of the mangrove point to reasons such as lack of space, expensive land sale prices in safe areas and proximity to the river, as the main reasons for building their homes on mangrove lands.

- In general, residents and practitioners of mangrove deforestation have little knowledge of the importance and relationship of mangroves to biodiversity and coastal protection in relation to natural phenomena such as floods and cyclones.

- The Quelimane District now faces serious problems of coastal erosion, floods caused by the seas, epidemics such as cholera, among others, which may be associated with the deforestation of the mangrove ecosystem.

CHAPTER III

3.0 LITERATURE REVIEW

3.1 Background

Zambézia is a coastal Province with more than 400 km of coastline and is located in the eastern part of the country, between Sofala Province at southern part and Nampula Province at northern part. It is the second most populated Province in Mozambique with 3.645.630 inhabitants on a total area of 103.127 km2 (INE, 2007).

Zambézia Province is divided into 23 districts. The capital city of the Province is Quelimane, which possess the same name of the district where it is located. Further, Quelimane district is virtually surrounded by mangrove forests along its coastal areas. As shown in Table 1 and according to other sources, more than 155,757 hectares of Mozambicans mangrove are located in Zambézia Province (Camara, 2013; Lindén & Lundin, 1997).

3.2 Mozambican Mangrove Distribution

According to Lindén and Lundin (1997), Mozambican mangrove ecosystems are located and discontinuously distributed along the coastal areas. The table below presents the seven coastal Provinces of Mozambique and where basically occurs predominance of mangrove ecosystem. The mangroves cover an area of 32,834 ha in the southern region, corresponding to 8.0% of the total area of mangroves in the country, 281,074 ha equivalent to 70% in the central region and 87,172 ha corresponding to 22%, in the northern region (Lindén & Lundin; Macamo & Sitoe, 2017) (**Table 1)**.

Table 1. Mangrove Distribution in Mozambique

Province	Mangrove area (ha) 1972	Mangrove area (ha) 1990	Area degraded (ha)	New mangrove area (ha)	Change (%)
Maputo	14 605	12 599	2 217	211	15.2
Gaza	387	387	0	0	0
Inhambane	20 094	19 848	246	0	1.2
Sofala	129 997	125 317	6 334	1 654	4.9
Zambézia	159 417	155 757	3 766	106	2.4
Nampula	55 849	54 336	2 006	493	3.6
Cabo Delgado	27 730	27 836	0	106	0
Total	**408 079**	**396 080**	**14 569**	**2 570**	**3.9**

Source: Saket & Matusse (1994) cited by Lundin & Lindén (1997).

The central provinces of Zambézia and Sofala have the most extensive areas and diversity of mangrove forests, where their coast is classified as delta coast (Lindén & Lundin, 1997).

On the other hand, Saket and Matusse (1994) cited by Hoguane (2007) and Lindén & Lundin (1997), estimated that Mozambican mangrove forests have been reducing at an average of 3.9% every year from 1972. This means, in general that Mozambique loses an average of 15,000 ha of mangrove annually to deforestation and coastal erosion among other factors, and based on this estimation, from 1972 until present, the country has already lost 660,000 ha of mangrove. However, if we take into account the current pressure and exploitation rates due to population growth, dependence on coastal resources and occupation by habitations in coastal areas, it can be said that the actual estimated annual mangrove areas destroyed are much larger than in the 1970s.

Mozambique is known to have nine species of mangroves denominating; *Avicennia marina Bruguiera gymnorrhiza*, *Ceriops tagal*, *Rhizophora mucronata*, *Sonneratia alba Heritiera littoralis*, *Lumnitzera racemosa*, *Xylocarpus granatum* and *Pemphis acidula* (Camara, 2013; MITADER, 2015). Unfortunately, these species are currently

under threat and constant reduction, as annually Mozambique loses thousands of hectares of mangrove to deforestation.

3.3 Physical Aspects of Quelimane Coast

According to Muchangos (1999), the coastal area of Quelimane has a humid tropical climate as a result of the influence of the warm current of the Mozambique Channel. The tropical nature is guaranteed by the existence of two different seasons of the year: rainy and dry. The rainy season lasts for about six months starting in November and ending in April. In the dry and cool season, the spacing of the inner equatorial low pressure and the approach of the equatorial Anticyclones continental origin determines the occurrence of mild and fresh low temperatures during the night (Muchangos, 1999).

The Quelimane District is surrounded by several rivers of which the main river network of the District is the Bons Sinais River that spans the coast of the city of Quelimane and is more than 20km distant from the Indian Ocean (The World Bank, 2014). Groundwater is distributed along the coastal area whose depth varies depending on geological characteristics. Most of the water table is presented with salubrious waters (Muchangos, 1999). As can be noted, the watercourse is a remarkable hydrological phenomenon, representing both a landscape element surrounded by mangrove, (Muchangos, 1999).

The geology of Quelimane District is characterized by sedimentary rocks and sand dunes which were formed by floods as a result of ongoing accumulation in the recent centuries. Its soils are very sandy and are formed from sand stones. The coastal soils are where the mangroves originate, which are clay like and rich in sodium and salt (The World Bank, 2014).

Because of its geographic configuration, the coastal area of Quelimane has a relief fluvio-marine plains, caused by accumulation and erosion of sediments swept away by the force of the water (Muchangos 1999).

3.4 Mangrove Forest

According to FAO (1994: 5),

> The mangrove are characteristic formations of coastal plants that occur throughout the tropical and subtropical, inhabiting an area subject to tidal regime in coastal planes and marking a slow transition between the shelf and the sea. They are very often described as "coastal forest", tidal forests "and" forests of mangroves".

Oceana (n.d),

> Refers to the mangrove or mangrove forest as a term to describe a variety of tropical plants found on coastal zones located between the mainland and the sea, that grow in regions with high salinity water.

However, according to the concepts presented above, both the authors agreed that mangrove forests are formed of coastal plants of tropical and subtropical areas subject to tidal regime and marks a transition between oceanic and continental shelf. In short, mangroves can be regarded as being a special ecosystem that grows in tropical coastal areas, associated with low land, planes and estuarine areas with tides marking a transition between the continental shelf and the sea.

In addition, the heights of the mangrove trees in Quelimane district vary from 25-30 meters due to extensive estuaries and deltas found in that part of the country, such as the deltas of the Zambezi River and Messalo, the most extensive and diverse mangrove forests in South Eastern Africa (FAO, 2007; Macamo & Sitoe, 2017).

The important factor in the formation of mangrove and its sustenance is the wet and warm temperatures in tropical areas and they survive in salty waters with the lower trunk in water and the upper trunk in air (Oceana, n.d). Further, the variation of the salt in the seawater influences the developments of various species of mangroves.

Therefore, constant supply of water as well from rain will increase more sediments and nutrients (Lighthouse Foundation, n.d). Thus, it can be said that mangroves adapt to any reduction or increase in the average sea level and salinity in waters, preventing the extinction of the ecosystem (MangroveWatch Australia, 2013).

3.5 Importance of Mangroves in Maintaining the Marine and Coastal Environment

According to a recent report, the high-yield resulting from the mangrove forests is evaluated at around US$186 million annually (WWF, n.d), as they are vital for the maintenance and productivity of the coastal ecosystems that in turn benefits both the marine environment and humanity.

NatureWorks (2017) describes ecosystem as:

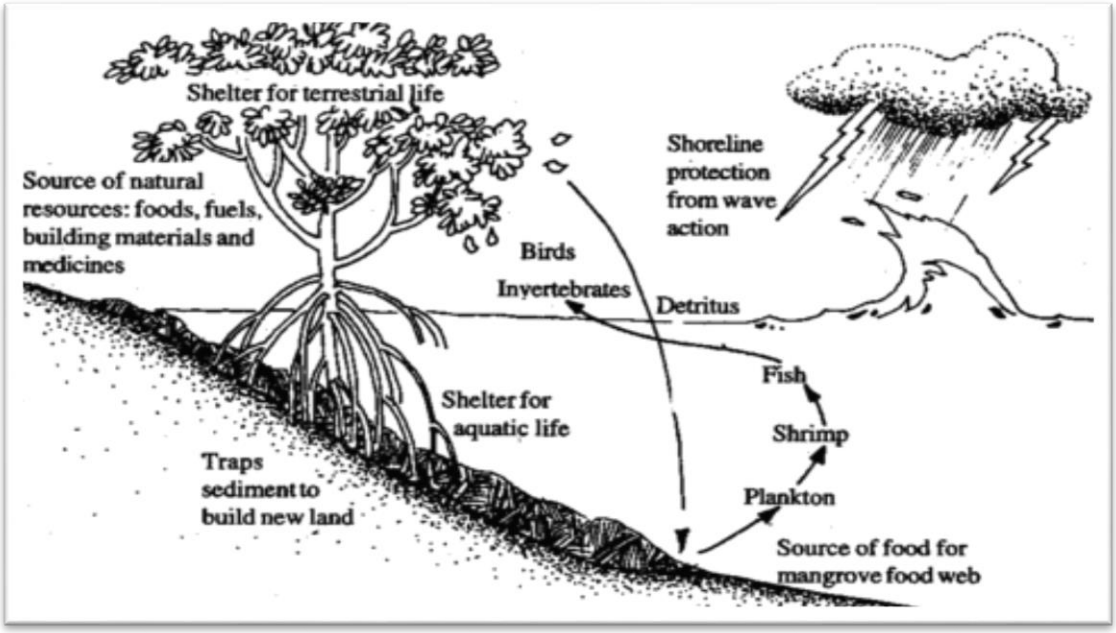
> A dynamic complex of both non-living and living organisms, animals and microorganisms interacting together. However, an ecosystem also involves the contribution from the light, atmosphere, soil and temperature for its function (NatureWorks, 2017).

The article "Ecosystems": What is (2017), consider an ecosystem as:

> A group of living organisms in a common habitat where the pH, temperature and sunlight are the abiotic influences, the environment in which they interact.

With the concepts presented, we can say that ecosystem refers to a set of living organisms interacting with each other, and these with the physical environment that surrounds it. Thus, it can be said that ecosystems are dynamic entities as the distribution and composition where the living beings and the environment function as a whole (**Figure 2**).

Figure 2. Schematic representation of the benefits of mangroves



Source: (CoastvsErosion, 2013)

In summary, the mangrove is an essential element in maintaining biodiversity of the marine and coastal environment at global and local level. As stated by Chong (2005), the mangrove ecosystem has several natural functions of great ecological and economic importance, among which are highlight the following:

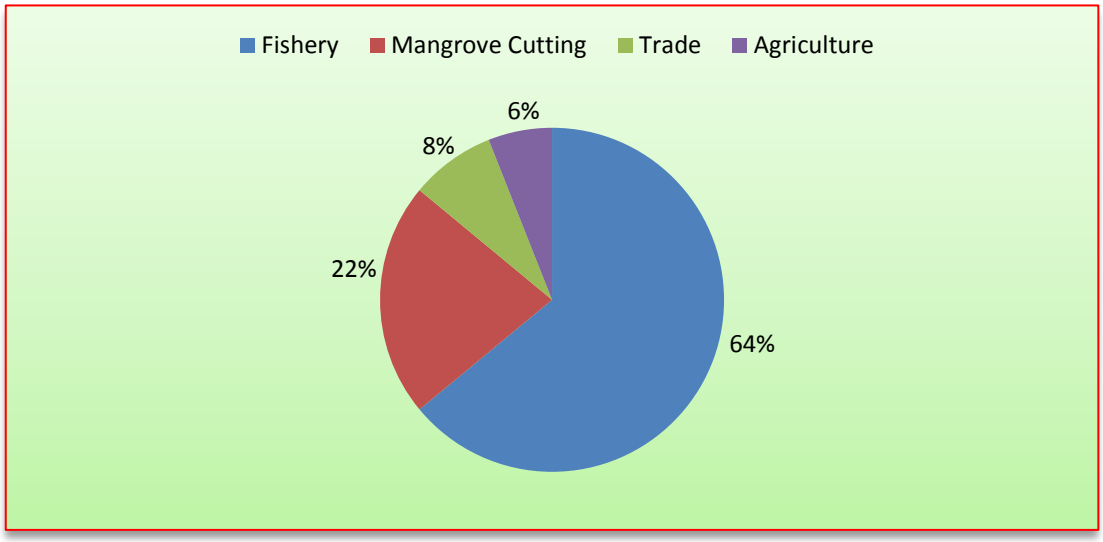
3.5.1 Fisheries

Mangrove forests accommodate large varieties of shrimps, crabs, fish and mollusc species, which are the source of financial gain and food for thousands of coastal communities around the world (WWF, n.d). However, according to African Wetlands International (2017) and Lindén & Jernelöv (1980), the mangrove roots and leaves that decay produce a significant amount of organic matter in this environment which is released in the coastal waters in the form of debris, providing nourishment to plankton which is the vital food needed for the survival of all marine species that live among the mangrove roots.

To cite an example, research conducted on the Mesoamerican reef proved that there are as many as 25 times more fish on reefs near to mangrove forests in comparison to the areas where mangrove deforestation has occurred (WWF, n.d). In addition, roughly 80% of global fisheries come directly or indirectly from mangroves (Ellison, 2008). This shows how vital mangrove forests are to the coral reefs and their production and for the benefit of production and commercial fisheries. According to the USAID (2001) and ADF (2001), more than 40% of the protein consumed by the Mozambican population is attained from fish. The same applies to Quelimane District, where part of the local communities resort to fishing as part of their means of survival.

For example, Icidua, one of Quelimane's neighbourhoods created entirely on mangrove lands, today has more than 9,084 habitants (MuniSAM - Concern Universal, 2013). Furthermore, from the survey conducted with 84 of the habitants of the three neighbourhoods selected for the present research, namely Icidua, Chuabo Dembe and Mirazane, 64% affirmed fishery in Quelimane as their daily principal activities (**Figure 3**).

Figure 3. Main activities of the Population living on mangrove lands in Quelimane



Source: The author

3.5.2 Shoreline Protection

Mangrove forests provide coastal resilience, protecting shorelines from erosion caused by natural events, such as storms, tsunamis, floods, hurricanes, winds and waves from the ocean (CoastvsErosion, 2013; Wetlands International Africa (2012). Their thick roots grow in an entangled form thus stabilizing sediments, which in turn averts soil erosion.

Furthermore, the mangrove roots trap sediments from ashore and act as a filter from harmful substances and maintaining the water clear and clean (Florida Museum, n.d). In addition, as stated by Wetlands International Africa (2012), "a mangrove stand of 30 trees per 0.01 hectare with a depth of 100 m can reduce the destructive force of a tsunami by up to 90%, and reduce wave height by as much as 66% over 100 m of forest." This means that having the mangrove ecosystem is synonymous with great protection against many of the destructive natural phenomena.

3.5.3 Shelter to Biodiversity

The estuaries are the areas with high amounts of nutrients and these nutrients are supplied to the mangroves by water from rivers and the sea. Allied to this favoured location, the mangrove vegetation has high productivity and is considered as the main carbon source ecosystem (FAO, 1994; Lindén & Lundin, 1997). Therefore, these areas of mangroves, rich in nutrients, become feeding grounds and shelter to wildlife and marine species that occur in this environment, where mangroves act as important maintainers of biological diversity (Lindén & Lundin, 1997; WWF n.d). Further, according to Dugan (1993) cited by CoastvsErosion (2013; pp.1) "within the mangrove forests, wildlife is abundant as at least 35 species of reptiles, 270 bird species and 42 mammal species are native".

In summary, it can be said that the mangrove forests are an essential element in maintaining biodiversity and protection of the marine and coastal environment at global and local level. However, the destruction of this important ecosystem results in negative and compromising consequences affecting the survival of human beings,

the environment, the economy and social well-being, as will be further developed in the exemplification of Quelimane District.

CHAPTER IV

4.0 MANGROVE DEFORESTATION IN QUELIMANE DISTRICT

4.1 Current State of Mangrove Deforestation

There is little information recorded on the current status of mangrove deforestation in Quelimane as no scientific study has been carried out to determine the estimated amount of mangrove lost in this particular district. Therefore, current images display the affected areas in Quelimane, especially the targeted areas Chuabo Dembe, Icidua, and Mirazane.

4.2 Causes of Mangrove Deforestation in Quelimane

4.2.1 Rural Exodus

The Mozambican civil war, which began in 1977 and ended in 1992, immensely affected the population's sustainability, leaving long-lasting effects, especially in the rural areas (DPTADER interview). According to local sources, the coastal areas referenced above for this study initially were not inhabited. However, from the 1990s onwards, mangrove lands were occupied by fishermen and shortly after began to emerge settlements attracted by better survival conditions. Evidence shows a strong relationship between poverty and the environment (Satterthwaite, 2003). The ever-increasing population living under poverty in Quelimane District contributes a lot to more accelerated environmental degradation, it being the main reason of the population shifting from rural areas to urban areas along the coast.

4.2.2 Land for House Construction

The lands in Quelimane urban areas are costly, forcing new poor people and migrants to invade the mangrove area to establish their dwellings. The massive occupation of these spaces was done in a disorderly manner, culminating in the destruction of mangroves and their biodiversity (**Figure 4-8**).

Figure 4. Part of Mangrove Areas Deforested for House Construction at Liberdade

Source: Picture taken by the author

Figure 5. Houses Built on Mangrove Lands at Mirazane

Source: Picture taken by the author

Figure 6. Houses on Mangrove land at Mirazane

Source: Picture taken by the author

Figure 7. Vast Areas of mangrove Deforested at Icidua

Source: Picture taken by the author

Figure 8. Houses on Mangrove Land at Chuabo- Dembe

Source: Picture taken by the author

The above images give us a qualitative impression of the current status of mangrove land occupied by people from rural areas.

A survey was carried out with the local communities as part of this research, to determine the initial period of mangrove devastation and the causes of resettlement into mangrove land (**Table 2**).

Table 2. Period of mangrove Land Occupation in Quelimane

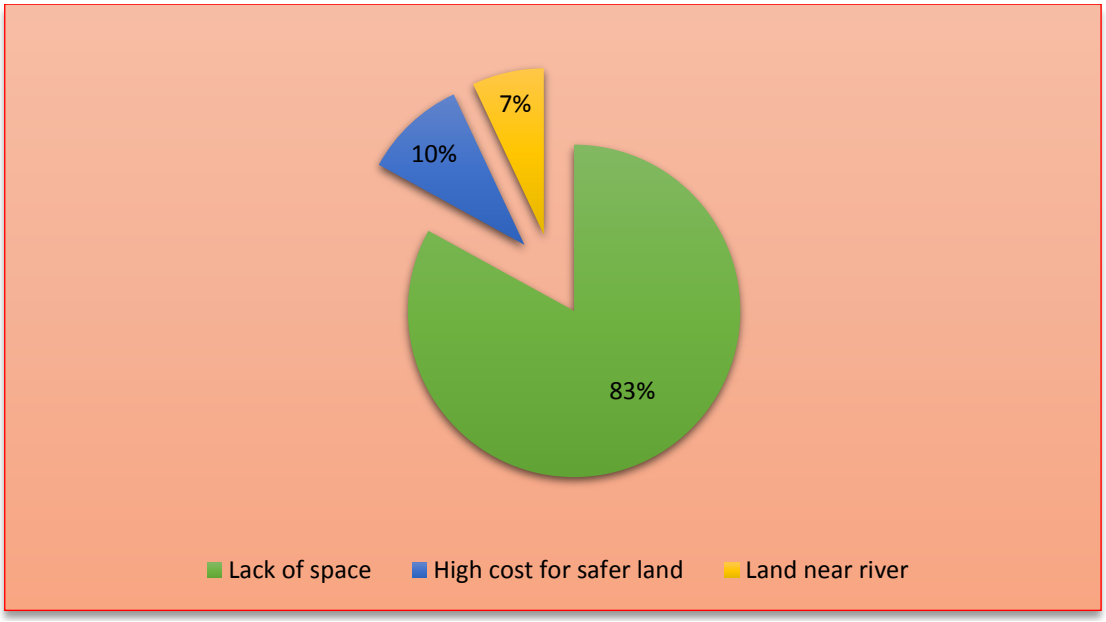
Period	Nº of surveyed	Percentage (%)
1990 – 1997	14	16%
1998 – 2005	20	24%
2006 – 2016	50	60%

Source: The author (based on the survey made for this research).

The results of the survey show a significant increase in destruction of mangrove areas for various purposes over the last 25 years. Residents of Quelimane District point to factors such as available land to build new houses and easy access to the sea resources.

Looking at the current situation that characterizes the main urban centers in Quelimane, it is clear that the ecosystem of mangroves has been sacrificed to house a large number of people. In addition to the above factors, as can be seen in Figure 9 below, the population inquired affirms that the main reasons of living on mangrove land is due to lack of space, high cost for safer land and the need of living close to the river.

Figure 9. Reasons for Mangrove Land Habitation



Source: The author

4.2.3 Source of Construction Material

The main product from mangrove trees is its wood which in Quelimane is mainly used as construction material. Studies show that 70.5% of the population in Zambezia Province live in poverty of which 93% are in the rural areas (Mercier, *et al*, 2016). However, with such economic conditions and the high cost of construction

materials, such as cement, concrete brick, sand and stones, the arriving and poor populations resort to cutting mangrove trees and using its wood with clay sand to build precarious houses for accommodation (**Figure 10-14**).

Figure 10. Construction of Precarious Houses at Liberdade Neighbourhood

Source: Miramar Notícias (2016)

Figure 11. Construction of Precarious House at Chuabo Dembe

Source: Picture taken by the author

Figure 12. Mangrove Sticks in a Precarious House Construction at Mirazane

Source: Picture takem by the author

Figure 13. Houses Made with Mangrove Sticks and Clay Sand on Mangrove Lands

Source: Picture taken by the author at Icidua

Figure 14. Various Houses on Mangrove Lands at Icidua

Source: Image taken by the author.

A study was conducted in 2007 by the National Statistical Institute - INE, to determine the types of habitations and materials used for house construction in Quelimane District. The results are shown in the table below **(Table 3)**.

Table 3. Number of Houses in Quelimane According to Material Used

Type of Material	Quelimane District	
	Number of houses	%
Concrete bricks	4,390	10.5
Ceramic bricks	1,110	2.7
Wood/Zinc	579	1.4
Clay bricks	379	0.9
Bamboo/palm sticks	8,528	20.04
Mangrove sticks and clay	26,379	63.1
Paper/plastic/sack/Tins	110	0.3
Others	329	0.8
Total	**41,804**	**100**

Source: Adapted from INE (2007)

The above table presents the highest number of houses constructed, 26,379, which is 63.1% to be of sticks derived from mangrove and clay from mangrove lands. This condition is observed along Quelimane coastline communities.

4.2.4 The Practice of Agriculture

Quelimane District has an estimated population of 475,000, where more than 60% are uneducated and unemployed (INE, 2007). Therefore, the survey shows that the majority of families practice annual subsistence farming of rice, sweet potatoes, vegetables, cassava, beans and pumpkin among other types of crops. The agriculture practiced by the communities has very little economic significance as most of the produce is obtained for personal consumption and partly for commercial benefit.

However, some of the families residing in mangrove areas without fertile lands to practice agriculture opt to cut mangrove trees or shrubs to clear an area and create artificial barriers in the form of dunes around the land to impede the flowing of salt sea water in the crop fields. With this technique, only rain waters the land, eventually modifying its natural salinity in two or three rain seasons and making the land more and more acceptable to growing some of the crops mentioned above (**Image 15-17**).

Figure 15. Mangrove Lands Converted Into Rice Field at Mirazane

Source: Picture taken by the author

Figure 16. Mangrove Lands Converted Into Rice Field at Chuabo Dembe

Source: Picture taken by the author

Figure 17. Part of Sweet Potatoes Field on Mangrove Land at Chuabo Dembe

Source: Picture taken by the author

4.2.5 Commercial and Energy Source

Since mangrove trees have various uses in the community of Quelimane district, large areas of mangroves are cut for commercial purpose. Many cut mangrove trees to sell the sticks as a means of income (**Image 18-21**).

Figure 18. Mangrove Sticks on Sale at Mirazane Market

Source: Image taken by the author

Figure 19. Mangrove Sticks on Sale at Mirazane

Source: Image taken by the author

Figure 20. Mangrove Sticks on Sale at Icidua Market

Source: Picture taken by the author

Figure 21. Mangrove Sticks on Sale at Icidua

Source: Picture taken by the author

Furthermore, Mozambicans in general, depend on biomass energy for domestic consumption. Apart from selling sticks, it is observed in Quelimane's coastal communities that mangrove trees are burned to produce charcoal both for domestic and commercial use (**Figure 22, 23**). Even in urban areas, it is noted that charcoal from wood remains the main source of energy for most of the population living in the cities, as the cost of electricity is high.

Figure 22. Charcoal from the Burning of Mangrove Trees on Sale at Mirazane

Source: Picture taken by the author

Figure 23. Charcoal from the Burning of Mangrove Trees on Sale at Manjante

Source: Picture taken by the author

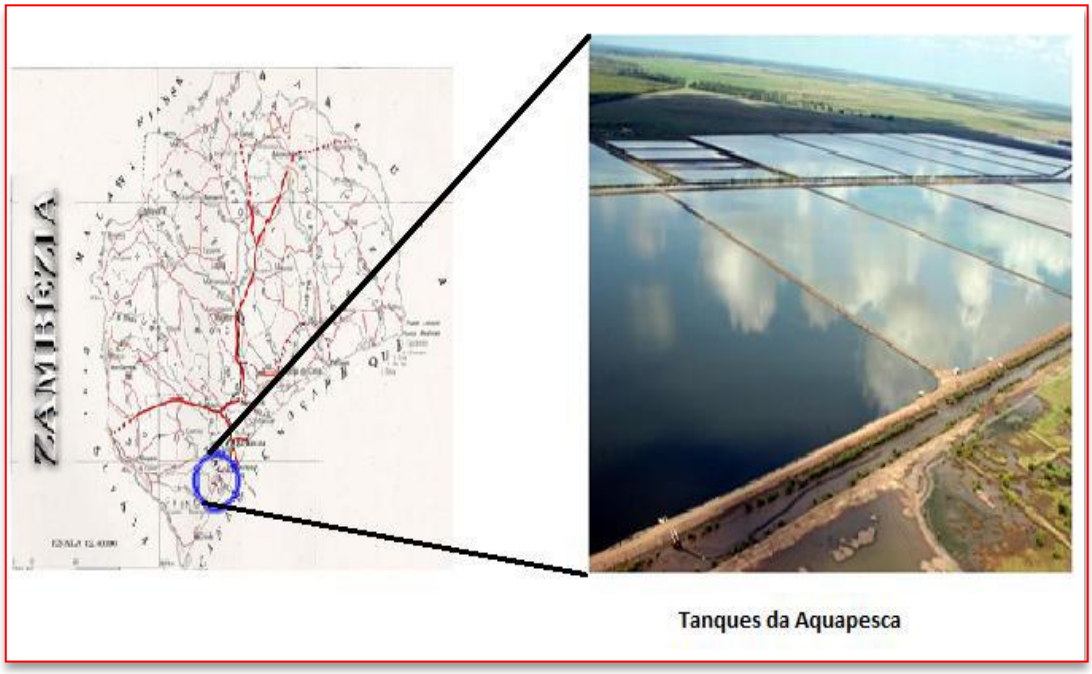
4.2.6 Land for Aquaculture

The practice of coastal aquaculture has been increasing throughout the years worldwide and the ever-expanding aquaculture farms have led to the destruction of mangroves in a large scale all over the world (Pattanaik & Prasad, 2011).

Speaking of Mozambique, Lindén and Lundin (1997, pp 54), stated that "with the development of shrimp aquaculture, a new threat to mangrove ecosystems may arise when large areas are cleared for aquaculture ponds". This situation is clearly noted in Quelimane District whereby part of the mangrove ecosystem has been converted into aquaculture tanks, in which is practiced mainly for the production of Tilapia fish, various species of prawns and clams.

According to AQUAPESCA, the only aquaculture company in Quelimane, their farming tanks covers an area of 350 ha (AQUAPESCA, received by email). The aquaculture tanks, as seen in pictures below, were built on mangrove lands, thus meaning the destruction of vast areas of mangroves ecosystem (**Figure 24-27**).

Figure 24. Location of AQUAPESCA Company and its Tanks



Source: AQUAPESCA Company (Received by email)

Figure 25. Aquaculture Ponds on Mangrove Land

Source: AQUAPESCA Company (Received by email)

Figure 26. Aquaculture Ponds of AQUAPESCA on Deforested Mangrove Areas

Source: Picture taken by the author

Figure 27. AQUAPESCA Ponds for Aquaculture on Mangrove lands

Source: Picture taken by the author

As evidenced by the above images, the aquatic tanks were situated on mangrove lands, thus meaning the destruction of a vast area of mangroves.

Indeed, although no studies have been performed to determine the exact amount of area of mangrove deforested annually or in its entirety by the practices described above, the reality as seen, is that large areas of mangrove in Quelimane District have been destroyed and continues to be reduced by the day, with the knowledge of the local authorities (DPTADERZ questionnaire; DPMAIPZ questionnaire).

However, to the detriment of the benefits mangroves bestow on the global and local environment, the precarious constructions, disordered in an unclean environment, carry with them risks and damage the lives of hundreds of citizens each year. The author's knowledge about the district and his visits to the neighbourhoods that emerged on mangrove lands helped him to relate the occupation and use of mangrove resources to the poor. This means that the neighbourhoods on mangrove lands in the district of Quelimane are the poorest, and the most prone to diseases such as malaria, cholera among others.

The Mozambican Government has, however, already taken important steps in the creation and implementation of national laws and institutions aimed at the environment, which in part focus on the preservation and rational management of the mangrove, as explained below:

4.3 Implementation and Enforcement of National Environmental Laws Related to Mangrove Ecosystem

4.3.1 Implementation - Political and Strategic Framework

In Mozambique, the management and conservation of mangrove forests is regulated by a set of legal provisions as shown below in the tables 4 and 5, whereby it is listed the main political strategies that guide the institutions and establish their legal responsibilities of mangrove forests sustainable management.

The Policy and Strategy of Forestry and Wildlife Development, establishes the manner of conservation and the types of management plans for the sustenance and utilization of natural resources with regular and permanent involvement of communities (Resolution 8/1997 of 1 April).

Table 4. Political and Strategic Framework Applicable to the Management of Mangrove Ecosystem

Policy / Strategy	Incidence on Mangroves
National Policy of Environment (Resolution n° 5/1995, of 3 August).	The policy recognizes the need to harmonize sustainable economic development by reducing the impact on the environment. Among the various strategies and priorities for actions that contribute to this vision. is to emphasize the need to strengthen institutional capacity for environmental management, decentralization, coordination, documentation, information and environmental research in regard to fisheries, the environment and conservation areas.
National Land Policy (Resolution n° 10/1995, of 17 October).	The policy acknowledges the need to promote economic and human development by ensuring the rights to usage and ownership of land by the population as investors, and also the preservation and management of important ecological areas (e.g. coastal areas with high biodiversity)
Policy and Strategy Development for Forests and Fauna Bravia (Resolution 8/1997 of 17 October.	The policy focuses on the monitoring and establishment of management plans and conservation; defining roles for the local NGOs, communities state for the proper management of mangrove forest resources.
Policy and conservation Strategy for Implementation (Resolution 63/2009 2 November.	The policy aims to promote the technical and financial capacity for conservation by establishing a network of representative areas and appropriate conservation needs and creating instruments to reinforce fundraising strategies and improve local benefits.
Policy monitoring, Control and supervision and strategy Implementation (Resolution 36/2008, 17 September).	The policy aims to improve monitoring, controlling and surveillance of fishing (e.g. industrial fishing, semi-industrial fishing, subsistence fishing, recreational and exploratory fishing and research) and environmental protection of marine and coastal species.

Source: Macamo & Sitoe (2017)

4.3.2 Implementation - Legal Framework

The Mozambican legislation related to mangrove forests management was adapted from regional and international procedures and adopted into national laws and regulations (Pereira *et al*, 2014). Table 5 below presents the foremost laws and regulations for the sustainable management, protection and conservation of mangrove forests implemented at national level.

Table 5. National Legal Framework for Mangrove Ecosystem Management

Legal Instruments	Incidence on Mangroves
Constitution of the Republic of Mozambique (BR I serie-n^{0} 51, 22 December, 2004).	All citizens have the duty to defend and preserve the environment. They have the right to live in a balanced environment, whereby the state is the one that ensures the ecological balance and conservation of the environment through policies, environmental education and awareness to the sustainability and utilization of natural resources.
Environment Law (Law 20/1997, of 1 October.	Prohibits pollution and all activities that accelerate erosion, deforestation or any form of environmental degradation, especially that endanger species. It also prohibits the implantation of infrastructures with negative impact on the coastal environment and requires the completion of Environmental Impact Assessment-EIA, for environmental licensing purposes. The law defines the coastal zone and wetlands, in this case the mangrove forests as sensitive areas.
Regulation of the Environmental Impact Assessment Process (Decree 54/2015, of December 31 repeals Decree 45/2004 of 29 September).	Defines the criteria and procedures to be respected when carrying out the environmental impact assessment. As should be noted that the category A and A + activities require the performance of EIAs. Category A + activities are those that take place in significant habitats for critically endangered species, endemic or protected species by law, highly threatened ecosystems and areas associated with key processes, such as

	mangroves. The A category of activities are activities that take place in ecosystems with special protected status, such as mangrove areas, small islands and erosion zones.
Prevention of Pollution Regulation and Protection of the Marine and Coastal Environment (Decree 45/2006, of 30 November).	This regulation prohibits environmental pollution by chemicals or waste, especially in fragile ecosystems. It also establishes legal standards for the protection and conservation of such areas, specifically addressing wetlands, prohibiting the discharge of untreated effluent, introduction of exotic species, uncontrolled burning and forest exploitation.
Law of Land (Law 19/1997 of 1 October)	Considers mangroves areas as partial protected zone (the strip of coastline and outline of islands, bays and estuaries, the measured line of high tides maximum up to 100 meters into the territory). Further, it establishes that in the partial protected zones, there are no rights to usage, otherwise for any type of activity on the land and City Council or Provincial Governments require special permission. This law protects forms of customary utilization of resources by the communities.
Law of Forestry and Wildlife (Law 10/1999, of July 7).	Guarantees the customary use of resources by communities, and promotes the recovery of degraded areas through tree plantations, including in degraded fragile ecosystems. It also prohibits the transformation of degraded fragile ecosystems, stating that it should regain its former condition. Promotes participatory management through the creation of local councils with representatives of the local community. Establishes fines to be applied and charged to unauthorized exploitation of forest resources, and aggravating it if the offense is in a sensitive and protected area, such as mangroves forests.

Regulation of the Forestry and Wildlife Law (Decree 12/2002 of 6 June.	List species of mangrove as 3rd class wood producers, namely: *Avicennia, Barringtonia recemosa, Bruguiera gymnorhiza, Ceriops tagal, Heritiera littoralis and Rhyzophora mucronata* (which should be protected and managed in a sustainable way).
Law of Fisheries (Law 22/2013, of November 01).	Applied for management and administration of the various fishing practices, including small-scale fishing, subsistence fishing, and aquaculture, among others. The Law of Fisheries, article 63 prohibits the destruction of mangroves for the establishment of aquaculture infrastructures. It allows only the construction of water pumping stations, water intake channels for fixed installations on land and anchorages for crop species whose habitat is mangrove, and require replacement of mangroves destroyed during the technical and EIAs studies.
General Regulations for Aquaculture (Decree 35/2001, of 13 November).	Prohibits the transformation of mangrove lands for the installation of aquaculture facilities; or obligation to compensate by replacing in another area.
Law of Territorial Planning (Law 18/1997, of 18 July).	This law aims to the organization of the national territory and the sustainable use of natural resources, including also, among other objectives the preservation of ecological balance between the needs of the community and the protection of fragile ecosystems, such mangrove forests, coastal areas and the seafront.
Law of Conservation (Law 16/2014, of 18 July).	The Law aims to the application of principles and rules for the management, protection, conservation, restoration and sustainable use of biodiversity within conservation areas, including the requirements for a participative management, financing mechanisms, and categorization of protected areas.

Source: Macamo & Sitoe (2017)

4.3.3 Implementation - National Institutions Related to Mangroves

4.3.3.1 Ministry of Land, Environment and Rural Development

In Mozambique, the administration, conservation and protection of mangrove forests is in the care of the Ministry of Land, Environment and Rural Development - MITADER. The ministry monitors, plans and coordinates environmental issues including the implementation of polices and laws for conservation, sustainable use and rural development (Presidential Decree n° 13/2015, of March 16; Resolution n° 5/2015, of 26 June).

The MITADER, through the National Forestry Directorate, is responsible for the issuing of licenses, protection, supervision, conservation and management of forests and the monitoring of consumption by communities (Presidential Decree n° 13/2015, of 16 March). The MITADER has its provincial branches, which, among other tasks, are responsible for issues related to management, protection and conservation of mangrove forests. Therefore, for each district, the responsibility is in the care of the District Services of Planning and Infrastructure - SDPI, while in municipal areas, the responsibility lies in the hands of the local municipality. In addition, for the areas beyond the urban lands, the management strategy consists of both the participation of authorities and the local communities (Resolution n° 8/97, of 1 April).

4.3.3.2 National Administration of Conservative Areas

The administration and conservation of mangroves is the responsibility of the National Administration of Conservation Areas – ANAC, because the Mozambican law of lands and decree n° 45/2006, of November 30, considers mangrove ecosystems as a zone of partial protection and fragile ecosystem. ANAC works under the supervision of MITADER (MITADER, 2015). ANAC aims for the conservation of biodiversity and its sustainability thus ensuring the well functioning of ecosystems, monitoring and research on the natural resources (Decree n° 9/2013, of 10 April).

4.3.3.3 Ministry of Transport and Communication

The National Maritime Institute - INAMAR works under the Ministry of Transport and Communication. One of its responsibilities includes the preservation of the marine environment and halting sea pollution (Resolution n° 9/2012, of 15 March). Although the INAMAR is represented at provincial level by the Provincial Maritime Administrations, its districts Maritime Delegations and Maritime Inspections Posts, they also partake in the preservation and the occupation of mangrove lands. However, INAMAR do not exercise authority on the exploitation of mangrove resources; instead is just responsible for its occupation. The articles 69 of the decree n° 45/2006, of November 30, establishes that the occupation of the mangrove areas shall be done only under the authorization of the Provincial Governor with knowledge of the Maritime Administration and DPTADER.

4.3.3.4 Ministry of the Sea, Inland Waters and Fisheries

The Ministry of the Sea, Inland Waters and Fisheries - MIMAIP, works in relation to coastal ecosystems management, which include mangrove forests (Macamo & Sitoe, 2017). Their role is to prevent and minimize pollution, coastal erosion, conduct research, planning and authorization to issues concerning the ocean and inland waters. (Presidential Decree n° 17/2015, of 25 March). Furthermore, the Ministry aims to administrate and monitor fisheries management with the participation of communities (Resolution n° 12/2015, of 1 July).

The MIMAIP has under its subordination the following institutions:

- National Fisheries Administration - ADNAP, which is responsible for ensuring the implementation of polices and laws as well as the management and promotion of fishing activities and conservation of fishing breeding areas, such as mangroves ecosystem (Ministerial Diploma n° 188/2011, of 27 July).

- National Institute of Aquaculture Development – INAQUA, has the duty to monitor, evaluate, aiding aquaculture projects, ensure management of aquatic

species and promote developments concerning fisheries and aquaculture by national minor fisheries producers with the participation of fishing communities (Decree n° 28/2008, of 3 July).

- The Fisheries Research Institute - IIP and INAQUA work in harmony under the subordination of the MIMAIP, whereby the IIP develops research and monitoring programs of fisheries resources and complementary environmental studies that includes mangrove ecosystem for the management, conservation and optimization of their exploitation (Ministerial Diploma n° 251/2011, of 7 November).

4.3.3.5 Civil Society Organizations

The Civil Society Organizations – CSO's objectives are to train and promote coastal awareness in the communities for the better use and management of natural resources, by certifying that the customary and legal rights of the communities are satisfactorily respected (Macamo & Sitoe, 2017). Furthermore, the CSO's are very vital to the government for they work directly with the local communities and this strategy has resulted in a more effective management of other natural resources and needs to be implemented to the management of mangrove ecosystem (DPTADERZ questionnaire).

In Mozambique, the CSOs are currently working with the government for research and implementation of monitoring programs. Some of the local conservation projects that promote awareness on the need of mangrove protection are:

a) Forum for Nature in Danger (FNP)
b) World Wide Fund for Nature (WWF)
c) Association for the Environment (AFE)
d) Centre Earth Alive (CEA)

Source: (Macamo & Sitoe, 2017).

4.3.3.6 Research Institutions

The two main research institutions in Mozambique in General and Quelimane in particular are: The Research Centre of Marine and Coastal Environment- CEPAM and the High School of Marine and Coastal Sciences - ESCMC, a branch of the Mozambican major university, Eduardo Mondlane - UE, established in Quelimane (MITADER, 2015). The results from the scientific research conducted by these institutions serve as the base for the creation of environmental policies, decisions and management (MITADER, 2015).

4.3.4 Enforcement of the Domestic Laws Related to Mangrove Ecosystem Management

The national legal framework objective is to define and ensure the appropriate management and usage of mangrove forests. Although Pereira *et al,* (2014), stated that Mozambique has already a well-defined and comprehensive environmental legal framework which they considered to be widely recognized and more than satisfactory, as shown above, the legal and institutional legal framework in Mozambique related to the management, conservation and protection of the mangrove ecosystem and its resources is complex. The aspects related to the mangrove ecosystem are incorporated in several laws such as the forest laws, environmental law, maritime pollution laws, fisheries laws, among others. However, despite having such laws, very little is carried out and superficial treatment is given to the mangroves (DPTADERZ questionnaire).

On the other hand, despite such grand efforts from the government on the setting up of domestic laws and institutions as described above, the enforcement of these laws and policies is deficient in Quelimane District (DPTADERZ questionnaire). Indeed, the reality is that it is a great challenge for the environmental authorities and the City Council to stop, protect and prevent mangrove deforestation in Quelimane District, thus very few concrete actions are being done to recover the destroyed areas of mangrove forests in that particular part of the country.

To cite an example, the National Law of Fisheries (Law n° 22/2013, of 1 November) prohibits fishing within mangrove areas, and the destruction of the same for the practice of aquaculture or any other activity. However, despite such restriction, as shown through the survey, fishing in the mangrove areas using prohibited mechanisms such as mosquito nets and the destruction of mangrove forests is common and is daily activity for most of the poor and fisherman people in the Quelimane District.

Therefore, this implies that the actual major and main challenge is not the creation of institutions and laws, instead, institutional capacity building in experts, resources, enforcement and compliance of the existing environmental laws related to mangrove protection and conservation (Pereira *et al*, 2014; MITADER, 2015).

4.4 Socio-Political Issues that Might Lead to Quelimane Mangrove Deforestation

With all the laws, regulations and institutions created to guarantee the sustainable use and management of mangrove forests and its ecosystem in Mozambique, the question that arises is: Why are the environmental laws and regulations related to mangrove forest not enforced in Quelimane district even with the current degraded state of deforestation?

The answer to this question is given by the results of the survey conducted by the author for the present research, which points to 3 main factors: The actual socio-political state of Quelimane, poverty and financial limitations.

4.4.1 Socio-Political State

The Front for Libertation of Mozambique – FRELIMO, has been the ruling party since Mozambique won independence in 1975. However, since the municipal elections that took place in 2011, Quelimane is governed locally by the Mozambican

Democratic Movement - MDM, which is the second largest opposition party. Further, since 2011 there have been constant frictions and political disputes between the two parties to gain the support of the population, especially from the economically disadvantaged, the social stratum in which most of the residents of the mangrove lands belong.

However, with such a situation, the removal of population from the mangrove lands and the prohibition of the usage of mangrove forests and land could result in retaliation of the population to both the ruling party, which is directly responsible for the organization and law making and enforcement, and opposition party in Quelimane who is responsible for the urbanization. Such a conflict may result in loss of supporters from one party to another and thus amounting to another reason why no concrete actions carried out for the enforcement of the environmental laws related to mangrove forests in Quelimane District.

To site one example, the article 1 of the decree n° 45/2006, of 30 November, characterize mangrove forests as part of fragile ecosystems and the Mozambican law of lands (Law n° 19/97, of 1 October), in its article 22 considers mangrove lands as areas that should not be covered by urbanization plans. This means that the city council should not give permission and allow the construction of houses in the mangrove areas.

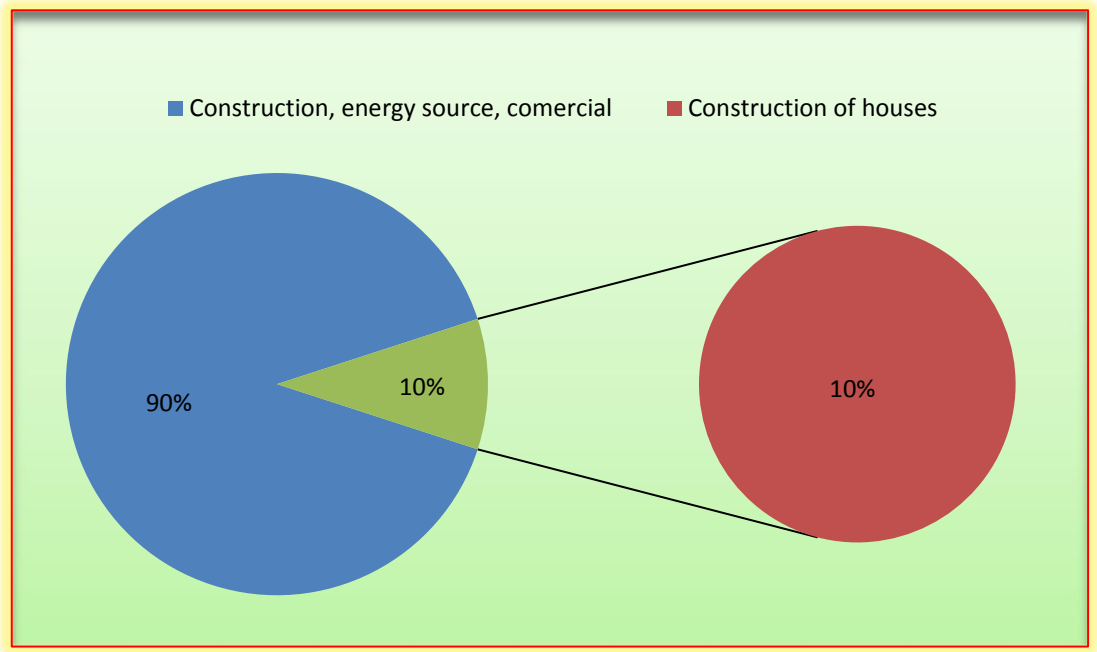
4.4.2 Poverty

As statistics show, around 70% of the population living in Quelimane district are living under poverty (INE, 2007). Part of the population seeks to find new homes and a means of survival from mangrove lands and produce. Before them, there are no other alternatives as many are illiterate and cannot find employment for their sustenance. In addition, as presented in the Figure 3, the activities practiced by the local communities reveal a total dependence on the direct and indirect resources of the mangrove ecosystem.

According to the news report Verdade, Icidua is one of the areas in Quelimane where poverty is aggravated and whereby 8000 of the 8523 population in that particular neighbourhood are committed to fishing and cut mangrove trees for survival means (Verdade, 2014).

Indeed, in poor regions with access to mangroves such as Quelimane District, mangrove destruction is one of the inevitable impacts due to human needs of wood consumption, charcoal, firewood and salt production (Janeiro, 2014).

Figure 28. Purpose of Cutting Mangrove by the Local Communities



Source: The author

From the survey, the author was able to identify the main activities performed by the coastal communities in Quelimane and the purpose of cutting mangrove trees in order to examine to what extent they may jeopardize the ecological balance of marine and coastal biodiversity. As shown, 90% of those surveyed cut mangroves for all activities including use for construction, use as energy source and for commercial use, whilst 10% cut mangroves only for construction of houses. Moreover, it can be

said from the 84 local people surveyed, that financial difficulties and lack of other means of survival are the major influences towards mangrove deforestation; it is not a situation of choice.

4.4.3 Financial Limitations

The challenge faced by the government to support and aid the ever-increasing poor population might be due to the country's financial state. According to Jonathan Gregson's article published on 13 February 2017, Mozambique is in the 7th position on the list of poorest countries in the world. In addition, as concluded by the International Transparency (2016) cited by the national journal O País (2017), the corruption rates in Mozambique are quite high, involving people from every social stratum and the country is today in the 144th place of the international transparency ranking about corruption. To site an example, according to Mozambican corruption central office cited by the Journal O País (2017), just in 2015 Mozambique lost USD 80 million through corruption, of which only USD 14 million were recovered. It was noted that since 2016, Mozambique has faced a financial setback which is said to be related to corruption and has highly increased the cost of living and the depreciation of the local currency, metical (The World Bank, 2016).

The economic state of the country serves partially as another cause for no enforcement of laws related to mangroves. For instance, if the government and local authorities were to enforce all environmental laws and regulations related to mangrove preservation and management, that would mean the termination of cutting of mangroves trees, habitation on mangrove lands, fishing in mangroves areas and the subsistence farming on mangrove lands.

However, given such a situation, another delicate question arises; how will the coastal communities that live on mangrove lands in Quelimane survive and earn an income? Where will those poor people build their houses and how will they get the lands?

Therefore, the reflection to the questions above has left no doubt to the author that the government's financial limitations contributes to the weak enforcement of environmental laws related to mangrove ecosystems and to create alternative solutions for the coastal communities to cease mangrove deforestation, but it is not something that is impossible. In addition, it seems like the government is aware of its responsibilities to provide social welfare to its people through employment and decent housing. Moreover, as these basic necessities are not being provided, the environmental authorities may find it difficult to impede or question the current deforestation of the mangrove, for it supports and shelters thousands of families in Quelimane District.

CHAPTER V

5.0 IMPACTS OF MANGROVE DEFORESTATION IN QUELIMANE

According to Dilip Ganguly (n.d),

> The environmental impact can be defined as any alteration of the "physical, chemical and biological environment," it can be negative or positive which can benefit or destroy the environment.

Environmental impact can be caused by "human activities which directly or indirectly affect the health, safety and well - being of the population as well as social and economic activities" (NOVA, 2015).

In the optical MELP (2000),

> Consider environmental impacts as the change of a value or an environmental parameter in quantitative or qualitative terms caused by human action. As it is known, many of the human activities cause impacts that may be social, economic or environmental in nature.

Although the concepts presented above by both authors bring a common vision about environmental impacts, considering it as any change to the natural ecosystem caused by human activities, in the MELP's viewpoint, environmental impact needs to be qualified or quantified in order to make a value judgment in the same way that one cannot speak of behaviour without qualifying it. Indeed, environmental impact is the

negative or positive change resulting from any activity affecting the ecosystem and causing modification in the original structure and function. Thus, we say that the impact is imminent or that the risk is high for something that seems right or with big chances of happening.

In fact, there are many and varied types of human activities that alter the ecosystem and the relationship between natural systems and dynamics, some of them with long lasting effects (NOVA, 2015), which are highly expressed in Quelimane's coastal ecosystem. From the observations, analysis and survey carried out in Quelimane District, the author concludes that the consequences of mangrove deforestation are as follows:

5.1 Coastal Erosion

Coastal erosion is the wearing away of land due to natural agents such as strong wind, water and high waves or human involvement (FAO, 2007; Hoguane, 2007). As show in chapter 2, one of the important functions of mangrove ecosystems is to inhibit coastal erosion, for they protect and stabilize coastlines from erosion with their thick and entangled roots, which trap sediments.

However, due to human intervention, mangrove areas have become one of the most vulnerable ecosystems (FAO, 1994). The coasts are losing their natural barrier of protection, thus accelerated soil erosion which in turn leads to soil impoverishment, as a result of the top soil being washed away (Lindén & Lundin, 1997) (**Figure 29-32**). In addition, the mangrove-deforested areas are much more susceptible to floods with greater impacts during hurricanes (Parenti, 2015; FAO, 2007).

In Quelimane, areas are noted where erosion has occurred due to mangrove cutting, namely: Madal, Icidua, Supinho, Mugogoda and Sangariveira as can be seen in the images presented below.

Figure 29. Part of Coastal Erosion at Madal

Source: ASU (2017)

Figure 30. Coastal Erosion at Icidua

Source: Picture taken by the author

Figure 31. Coastal Erosion at Supinho

Source: Picture taken by the author

Figure 32. Coastal Erosion at Mugogoda

Source: Picture taken by the author

As seen, a substantial area of mangrove land has been eroded away and erosion continues gradually with the rise and fall of tides and heavy rains.

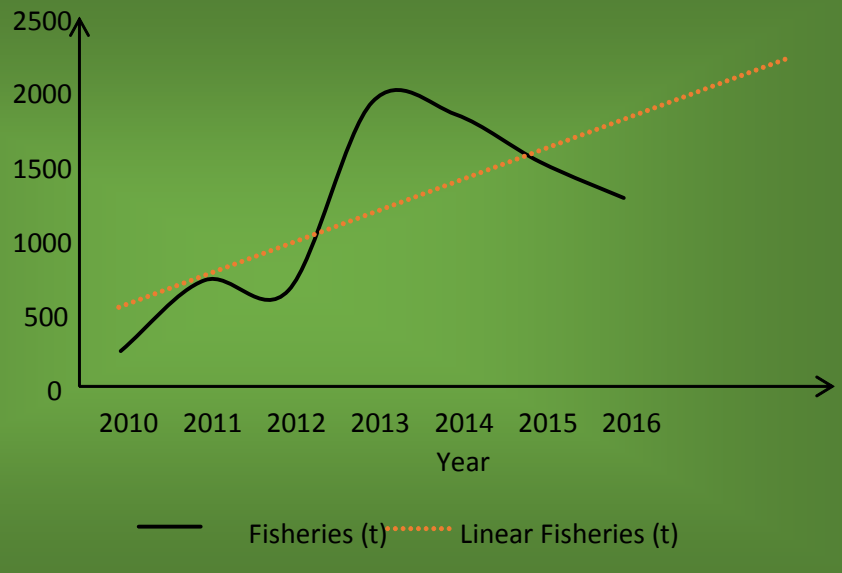
5.2 Reduction of Biodiversity

Another important function of mangroves stated in Chapter III was that they are home to various species of marine and terrestrial creatures; in other words, it is home to 90% of all marine species (WWF, n.d). Henceforth, with mangrove destruction, this implies the destruction of the ecosystem and its production.

Quelimane currently faces a reduction in biodiversity to which the consequences are reflected by the ever-reducing amount of fisheries caught annually (DPMAIPZ questionnaire). According to the responses to the questionnaire sent do the DPMAIPZ, Quelimane has been registering notable reduction in fisheries from the last 4 years in contrast to the years back whereby the average annual scale of fisheries had been increasing **(Figure 33).**

Figure 33. Variation of Fisheries Caught in the Last 7 Years in Quelimane District

Year	Fisheries
2010	238.5
2011	716
2012	647.4
2013	1917.6
2014	1832.3
2015	1513.6
2016	1270.7
Total	8136.1



Source: IIP, provided by DPMAIPZ (Questionnaire).

No study has been conducted that determines and relates the reduction of annual fisheries in Quelimane district to the current index of mangrove deforestation. However, according to the DPMAIPZ, it might be related to the combination of

factors such as the increase of the population, the type of fishing gear used, the climate changes, hydrometeorological factors and the deforestation of mangroves (DPMAIPZ questionnaire). Therefore, such a reduction in productivity directly affects the economy of the country and of Quelimane in particular.

An example to cite is of a well-known fishing company that has been operating for more than three decades in Quelimane. In a brief interview, it was noted that for the past years, lesser amounts of fisheries were being caught at the same period of time. The company was obliged to extend its fishing timetable so as to catch a reasonable amount of fisheries but still not as much as years before and this means more financial investment so as to yield better results (**Table 6**).

Table 6. Annual Fisheries Production Balance (2002-2012)

	year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
SEMANA		C. TOTAL	C. TOTAL	C. TOTAL	C. TOTAL	C. TOTAL	C. TOTAL	C. TOTAL	C. TOTAL	C. TOTAL	C. TOTAL	C. TOTAL
8									54646	39894		36920
9					50252	51100	53620	30946	73348	38094		5096
10					75526	63968	9968	40730	61766	58568		41370
11		35660	17878		55666	60674	64018	59836	51768	43576	77500	40480
12		109444	118516	120142	65740	59410	54228	35162	48922	62534	86408	26590
13		100082	73022	102640	48524	47138	50860	38836	58442	50110	56506	23272
14		70374	51930	85502	21370	36630	44032	30622	55678	39052	40834	12206
15		45674	43700	43768	45148	30620	37668	41754	28910	38144	36436	14936
16		54782	18822	48562	45044	37270	39430	31548	55850	25686	50482	22344
17		49782	43364	36498	34450	35738	29544	29480	39448	25918	47110	21716
18		54838	46620	22816	32086	42708	35180	24900	61010	47490	25712	26598
19		29388	35674	35104	33812	33058	31782	23748	47652	39924	42996	23080
20		42358	29032	29326	30364	36360	32428	20504	34174	34304	34736	21338
21		46774	32850	30946	28092	29602	26570	19622	41070	44238	29580	18232
22		20042	35934	28434	55736	27862	25528	23134	40178	31126	38128	18988
23		20988	25878	13470	20916	23884	26864	21392	25560	39048	37724	19610
24		25604	21496	25934	25708	27248	21728	16390		28082	12344	11788
25		28412	21144	3400	18118	27550	19304	19996		30588	21032	20304
26		29132	29132	21402	18656	20242	21174	21690		32712	23168	
27		27554	21148	11056	17952	25654	14272	20574		32026	8036	
28		29064	25286	12252	20480	17296	17260	18626		26412	22888	
29		24756	19884	13858	17986	21718	20486	18124		26586	29308	
30		8374	18786	18124	18442	24000	21206	24468		564	23260	
31		17812	18276	11728	17772	21566	17620	24502		7884	22434	
32		15816	22330	17170	17284	21564	18450	22304		4824	22368	
33		18204	20382	17184	16080	19838	10436	14910		9244	10440	
34		16440	15730	16516	13666	10896	13458	14208		8336	26376	
35		12488	16964	14720	10838	16640	18294	18266		7726	13482	
36		11828	12398	16308	10296	16772	21080	9144		6264	19076	
37		8856	6652	18560	11808	18152	15556			7328	19004	
38		13228	9676	15626	16786	17708	18268			6772	15398	
39		4522	16558	19852	12638	16864	13056			6926	3230	
40		6508	13690	12538	17382	15064	16116			3670		
41		3500	11416	22832	14858	13936	1492					
42		6322	15562	12430	17734	16372						
43		5476	16914	21578	15664	10018						
44		3702	17284	20548	18482	4278						
45		2216	16740	18578	8570							
46			15620	15854								
47			21586									
48			1942									
49												
50												
TOTAL		**1000000**	**999816**	**975256**	**999926**	**999398**	**860976**	**715416**	**778422**	**903650**	**895996**	**404868**

Source: Krustamoz Limited Quelimane (Received by email).

As shown in the table above, the quantity of fisheries continues to reduce over the years. The causes of this drastic reduction need a detailed scientific study, so it should not be exclusively associated with the deforestation of mangrove ecosystem in the district.

5.3 Health Problems

Flooding has immeasurable effects on human health, which include outbreaks of infectious diseases (WHO, 2017). According to the analysis of Water and Sanitation by UNICEF (n.d), in Mozambique, only around 44% of the population in urban areas and 11% in rural areas have adequate sanitation systems, which is one of the main causes of disease outbreaks that claim many lives, principally of infants in the country. Most of the population use unhealthy sanitation methods with severe impacts. The news report comments on one of the common habits of most the population in Quelimane to be defecating in open air on mangrove lands as they lack sanitation systems in their homes (Verdade, 2011).

Images (**Figure 34-36**) show a perilous toilet whereby human excretion is discarded, constructed upon a drainage canal with waters connecting the Bons Sinais River and the Indian Ocean. The level of water falls and rises depending on the tides and covers areas including houses. In fact, the reality is that the majority of residents of mangrove lands do not build basic latrines; they rely and defecate in the nearby shrubs.

Figure 34. Precarious Toilet under a ditch at Icidua

Source: Picture taken by the author

Figure 35. Precarious Toilets along a Ditch at Icidua

Source: Picture taken by the author

Figure 36. Precarious Toilet used for Shower only at Icidua

Source: Picture taken by the author

However, the above images give evidence to the vulnerability of the coastal residents in Quelimane to sickness such as cholera and infections. In addition, the swampy areas resulted from floods and cyclones are a breeding home for anopheles' mosquito which are the carriers of the main malaria parasites called Plasmodium falciparum, which are the cause of almost 30% of the deaths occurring in hospitals (MISAU, 2011). For example, just in the first six months of this year, 10 people died with malaria and about 33,169 were infected in Quelimane District (DPSZ report, received by email).

In summary, the improper and unsustainable manners of usage of resources generated by mangrove ecosystems implies the compromising of the hydrological state, increment of soil erosion and lesser sedimentation, leaving the coastlines without protection (CoastalCare, 2017). Furthermore, the reduction and extinction of fish species are one of the direct impacts of mangrove destruction and is noted clearly in Mozambique (Club of Mozambique, 2016). Further, in the case of Quelimane, the destruction of mangrove forests, associated with local practices and

customs in the form of use of this ecosystem, not only has environmental and economic effects, but above all, lives are lost annually. This compromises a whole system of sustainable management today and for the future generations.

CHAPTER VI

6.0 MANGROVE RECOVERY PROCESS AND THE PHILIPPINES EXPERIENCE

6.1 Recovery of mangrove degraded areas

According to Almeida (2006), degraded areas are classified as areas in which disturbance and subsequent imbalance has resulted in the elimination or reduction of vegetation with its biotic regeneration means, reduction in biodiversity, and the goods and services they provide. Human action is critically needed for the recovery of mangrove ecosystems as they present low resilience, thus its return to the initial state may not occur or be extremely slow (Almeida, 2006).

The term recovery refers to regeneration of the damaged area and consequent return to its initial or similar state, so that sustainable plans of its management can be defined. It implies that the degraded site will have minimum conditions to establish a new dynamic equilibrium, developing a new ground and a new landscape (Ibama, 1990; Almeida, 2006). The term recovery can be distinguished among the following:

6.1.1 Rehabilitation

This procedure refers to the set of treatments that seek the recovery of one or more ecosystem functions that can be basically economic and/or environmental (Viana 1990), whose environmental degradation is attributed to unsustainable forms of human use. This includes planting actions, definition of policies and other legal approaches that may protect the improper use and destruction of the ecosystem.

6.1.2 Restoration

Refers to the treatments aimed at recovering the original shape of the ecosystem, its original structure, dynamics and biological interactions (Viana, 1990). However, given the impossibility of remaking an ecosystem with all its original biodiversity, in practice, only rehabilitation of the ecosystem is possible (FAO, 2010; Viana, 1990).

The restoration being an intentional process to restore an ecosystem in order to mimic its structure, function, unique diversity and dynamics, should involve the creation or formation of a new ecosystem, focusing on the recovery of the forest functions such as its entire biodiversity. However, this recovery occurs by the following processes:

- **Reforestation** - is the opposite process of deforestation, characterized by planting of nurseries of forest plants - in the case of the present research, young mangrove plants are able to survive and evolve in areas considered forest, however, which was temporarily non-forested (FAO, 2010).
- **Forestry** - is the planting of forests in areas not classified as forest, which implies the landscape transformation of non-forest to forest (FAO, 2010).

The recovery act of a forest, namely the mangrove, can be carried out in order to regenerate its form or its function:

- **Recovery of the form** - in which operations are carried out in a degraded area, in order to recover the original features of the ecosystem, such as species composition, species diversity, structure and natural dynamics (FAO, 2010).
- **Recovery of function** - characterized by activities aimed at recovering the ecosystem services such as reproduction, nursery and shelter species, soil conservation, etc. (FAO, 2010).

6.2 Aspects to Consider in Relation to Recovery of Mangrove Ecosystem

In the environmental recovery of a degraded mangrove area, the planning should always be associated to the natural process of succession (Almeida, 2006), through the seeds of the species that are germinating and forming seedlings of new mangrove plants. Nevertheless, one should promote the succession of all the elements (soil, microflora, flora and fauna), which will cause the area to gain new ability to return to a steady state (Viana & Pinheiro, 1998).

6.2.1 Selection of Species

One of the basic points to the success of the degraded areas recovery process is the correct selection of species to be planted, which is carried out depending on the climatic conditions, relief, soils and local biodiversity (Galvão & Medeiros, 2002).

Knowledge of the biological level of the degraded area is essential for the selection process, and the interplay between flora and fauna in the area will enable the accurate selection of the species, knowing that it is vital to use only the typical species of the specific environments in the recovery process (Galvão & Medeiros, 2002). However, the measure of details of the flora and fauna obtained through surveys, and the knowledge of the species will vary depending on the size of the area intended to recovered (Almeida, 2006). Henceforth, the best approach to regain the original composition and structure of a degraded ecosystem is to carry out the process of selection of species based on detailed knowledge of forest composition environment similar to what is intended to be reforested.

6.2.2 Recovery Strategies of Degraded Mangrove Forests

In the face of concerns about the degradation of mangroves, since this ecosystem is of utmost importance, as already mentioned in this research, several strategies aimed at recovery have been developed for the restoration and protection of this ecosystem. However, these strategies, involve all the restoration work of the original vegetation, comprising the following steps:

- Definition of biological methods of recovery;

- Selection of the species to be used;
- Definition of recovery models to be employed;
- Preparation techniques of the area and maintenance.

(Source: Almeida, 2006)

Nevertheless, as stated by Almeida (2006), to maximize the benefits and speed up the recovery process of mangrove-deforested areas, it requires the combination of various methods.

In the following sections, initiatives will be addressed with a view to the recovery of mangrove forests, including the results and factors behind the failures and successes in the Republic of the Philippines, which might be applied in Quelimane case.

6.3 The Philippines Experiences on Mangrove Recovery

The Republic of the Philippines is comprised of about 7,100 islands with seaweeds, coral reefs and mangrove ecosystem along 36,300 kilometres of coast. More than half of the 1,500 towns and 42,000 villages in the country depend on the production of the marine environment to sustain them with food, goods and resources (DENR, 2001; Primavera, 2000). Mangroves in that geographical area, in particular, contribute to a variety of fishing products (seaweed, fish, crabs, shrimp, clams and other invertebrates) and forestry (timber, firewood, etc.) (DENR, 2001). Furthermore, mangrove ecosystems give coastal protection from the occurrence of typhoons, storms waves, erosion, flood and make possible the trapping of sediments, the interchange of inorganic and organic substances and give home to wildlife (DENR, 2001).

Moreover, in the twentieth century, the mangrove forests in the Philippines were reduced from about half a million hectares in 1918 to less than 120 000 hectares in 2000 (DENR, 2001). The cause of such tremendous reduction was the uncontrolled usages of mangrove lands for salt production, new settlements, construction of industry's and farming. (Primavera, 2000). Notably, from 279,000 ha of mangrove

forests destroyed from 1951 to 1988, 139,500 ha destroyed were for the creation of tanks for the practice of aquaculture, being one of the principal causes of mangrove deforestation in the Philippines (Primavera, 2000).

However, to mitigate or reverse the situation of extreme vulnerability, several mangrove-planting campaigns were developed with the communities' initiative from 1930 to 1950, projects sponsored by the government in 1970s and international aid programs for international development from 1980 (Primavera, 2000).

6.3.1 Planting and Rehabilitation of Mangrove Forests

According to Walters (2003), during the years 1930 to 1940 and 1950 to 1960, the local communities of Negros and Bohol respectively, planted mangroves with the main purpose of providing wood and typhoon protection. However, it was observed during these periods, that broader political guidelines for the rehabilitation of mangrove forests were introduced (Walters, 2003). As an example, in 1976, the Philippines Government created the National Mangroves Committee - NMC, whose duty was to create a balanced program which is understandable and to simplify the strategies for the organization and proper administration of mangroves and the issuing of timber licenses (Walters, 2003).

In addition, the mangrove-planting program sponsored by the Philippines Government on the National Forestry Program commenced in the year 1980 with its initial assignment covering 4,560 hectares in Marungas islands (Agaloos, 1994). Further, the first project of mangrove reforestation with international aid was the Regional Central Visayas Project funded by the World Bank in 1984 in order to improve coastal protection due to the high vulnerability of the islands to typhoons. (Agaloos, 1994). Since then, various recovery projects of mangrove forests assisted externally were founded and enforced locally by the local Government Units - LGU, Non-Governmental Organizations - NGOs and by the People's Organizations - POs made up from the local associations (Agaloos, 1994).

6.3.2 Community and Local Government Initiatives

6.3.2.1 Pagangan Island, Bohol

In this small island, access to the mainland by the city of Calape was only possible during low tides, for that, in 1950s, the villagers built a 4.5 km sidewalk with a limestone structure that was only half a meter above sea level during high tides, which caused it to be damaged by typhoons (Agaloos, 1994). Therefore, in 1956, Felix Ytac the school director together with primary and secondary students campaigned in planting mangrove plants along the sidewalk, which was later joined by school employees, turning the activity into a yearly occasion. (Agaloos 1994). This valuable lesson of Pagangan serves as an example of self-help, preservation and enhancement of the environment that local communities can give in planting and reforestation of mangrove areas without any government assistance.

6.3.2.2 Bani, Pangasinan

After many decades of converting mangrove forests into fishponds, Bani had devastated much of the mangrove forests in 13 coastal villages (Walters, 2003). However, to reverse this negative situation, the district members and the local appointee appealed to the officials of the segment of Environment and Natural Resources Department – DENR, to disburse about 21,500 USD for the purchase of propagules[1] for the expansion of the remaining area of mangrove. In turn, they provided labour for planting, monitoring and maintenance without charging, which had a favourable response (Walters, 2003).

6.3.2.3 New Buswang, Kalibo, Aklan

The Economic Cooperation Fund for Overseas - OECF from Japan credited 23.100 USD for the restoration of mangroves called project Kalibo Aklan together with

[1] Propagules are vegetative structures that break off and may give rise to new individuals of the same species and therefore enable the establishment of a new population (Biology Online Dictionary).

LGUs, in which technical assistance was provided by the DENR and assistance in community organization was carried out by Uswag NGOs (Primavera, 2000). According to Primavera and Esteban (2008) and Walters (2003), the KASAMA (Kalibo Save the Mangroves Association) reforested an area of 45 hectares of mangroves which therefore protected the coast from typhoons, contributed to food security and the improvement of families income through direct wages.

6.3.3 International Assistance: Government Projects of Large Scale

6.3.3.1 Central Visayas Regional Project

The program covered four provinces in central Visayas, and its approach was adopted based on community organizations, qualified in legal cases and administration. (Walters, 2003). About 10% of the total funding of 35 million USD was intended for projects of coastal fishing projects and the planting of new mangroves which led to an increment of catches, meaning more income of fishermen (Walters, 2003). The funding indicates the government's awareness of the importance of mangroves in increasing the productivity of the food sector.

6.3.3.2 The Forestry Sector Program

The program aimed to reconstruct the degraded mangrove forests and highlands and to ensure its everlasting sustenance and its management with the ongoing development of communities and to create better strategies of consuming natural resources in a sustainable manner and for economical use (Walters, 2003). The project activities focused on 12 locations of sub-projects and aimed at the recovery of 11,175 hectares of a total of 68,748 hectares of all mangroves (Walters, 2003).

6.3.3.3 Fisheries Sector Program

Although there were other governmental projects related to mangrove recovery as described above, the fisheries program is considered to be the first applicable program as it pointed to the difficulties faced by the fishers through the creation of four principal policies. The strategies encouraged marketing incentives and funded activities in environmental assessments, Coastal Resource Management -CRM and activities in the 12 main catch locations (Walters 2003). The CRM, being the principal mangrove recovery program, worked on employing NGOs to work in conjunction with the communities.

6.3.3.4 Project of Community Based

The management programme focuses on the destruction of natural resources and the coastal environment, the poverty faced by the communities and enables the communities together with the government in the implementation of management programs for the development of the communities, which was supported by the finance department. (Primavera & Esteban, 2008). This project had a more realistic approach because it addressed the poverty of the rural communities, which in many cases, such as in the District of Quelimane, are the backbone of the degradation of the mangrove ecosystem.

6.3.3.5 Pew Project in Iloilo 2006

Two of the mangrove recovery projects were started on the river of Iloilo province and covered 5 hectares on the coast of Dumangas (Primavera & Esteban, 2008). Both projects included inquiry to the local communities and an agreement was done by paper, between the LGUs and the POs, and they planted Avicennia created by a research group of biology students, instead of favorite species of Rhizophora (Primavera & Esteban, 2008). The students planted the incubator-created seeds on parallel forms on the riverbank.

Indeed, the conversion of mangrove forest areas in aquaculture ponds has been the major cause of the reduction and degradation of mangroves in the Philippines. Mangrove reforestation began in the 1930s and by the 1950s, communities in Negros, Bohol and Visayas joined in the campaigns. Thereafter, in 1970 onwards, projects founded by the government and in the 1980s international programs partook in aid financially. However, with time, the development of projects initiated by the community, were financed internationally. Over the past two decades, millions of dollars were funded for mangrove reforestation.

Despite such efforts to recover mangrove-deforested areas, only about 10-20% reforested plants survived and today, "conservation organisations and mangrove specialists worldwide highlight the multifunctional multiple benefits of the practice of 'natural regeneration' of mangroves. Compared to planting efforts, 'natural regeneration' of mangroves leads to higher survival rates, and results in a more biodiverse, resilient and productive mangrove forest, enhancing community livelihoods and reducing disaster risk" (Primavera & Esteban, 2008; Wetlands International, 2017). However, projects such as the New Buswang mangrove recovery were somewhat more satisfactory when compared to the other projects and the factors behind this result, included the close coordination between the LGU, communities and the Philippines DENR (Primavera & Esteban, 2008).

CHAPTER VII

7.0 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

Despite the important role played by mangrove ecosystems in the maintenance and increase of marine biodiversity and fauna, carbon capture, protection and prevention of coastal erosion, reduction of risks and impacts of tsunamis and strong winds, little knowledge about their function and value is attributed to these by Mozambican coastal communities, especially those of the District of Quelimane.

The unsustainable forms and modes of exploitation of mangrove resources in the Quelimane District is associated to four basic aspects: Firstly, the lack of knowledge about mangrove ecosystem's contribution to human survival as a result of poor interaction between environmental authorities and local coastal communities with the intention of disseminating and promoting awareness campaigns. Secondly, the weak and negligent application of the laws that regulate the mangrove ecosystem as well as its management, preservation and exploration, being left to the discretion of the communities. Thirdly, the high illiteracy rates and poverty in which the coastal communities who are residents of mangrove lands live in Quelimane, associated with lack of alternatives and job opportunities as source of honest income. The poor coastal populace is more reliant on the mangrove ecosystem resources for satisfaction of their needs. Lastly, the divided political state of institutions that are liable to care for the environment and urbanization in Quelimane District contribute greatly to the lack of application of the laws directed to the protection of mangroves.

The Quelimane mangrove ecosystem is destroyed primarily by the poor local community, whereby mangrove trees are locally used for the construction of precarious houses and the production of charcoal as a source of energy for personal consumption and commercial use. The mangrove forests of Quelimane were largely destroyed for habitation, the practice of agriculture, aquaculture and the construction of precarious houses, which created new poor neighbourhoods, disorganized and unclean due to lack of sanitation, making them vulnerable to natural catastrophes such as floods, cyclones and diseases such as malaria and cholera.

Further, the end results of the mangrove deforestation have caused the district of Quelimane to face consequences such as epidemics of cholera and malaria, disorderly occupation on mangrove lands, coastal erosion and reduction of biodiversity evidenced by the sharp reduction of catches of fish, which affects the economy locally and nationwide.

Subsequently, if urgent measures are not taken to stop and reverse the current deforestation, Quelimane District, at this vulnerable state, is susceptible to a catastrophic disaster caused by natural phenomena and/or climate change.

However, the involvement of all is indispensable, from government agencies, civil society, educational institutions at all levels and the coastal community itself. Together, willing and committed to the environment, we can make the difference and gradually restore and save the indispensable mangrove ecosystem of the land of Bons Sinais River.

7.2 Recommendations

To recover, better manage, and protect the Quelimane mangrove areas that are already deforested and areas occupied by the local communities, the following recommendations should be taken into consideration for the better results:

- The local environmental authorities and the city council should look to the Quelimane's environmental problem of mangrove deforestation as part of their responsibility to manage and protect this ecosystem and be committed, work together and be willing to apply the law, despite political party differences. They should not approach mangrove deforestation in the political view, instead, as a threat to the environment, well-being of the population and the country's economy. There is a need for an integrated and multisectorial approach to effectively plan and enforce mangrove laws, and not be dispersed, as it is today.

- Mozambique does not need to keep creating new institutions for mangrove management. Instead, the existing institutions linked to mangroves should be limited, clarified, and defined what really is expected from them in the management and protection of mangrove ecosystem, for it will help them to know how and when to act in favour of the mangrove ecosystem when the law is being violated. Further, the institutions should be strengthened with experts and resources for the better environmental phenomena understanding.

- The country should remove the attributions and responsibilities for the management and conservation of the mangroves, which are scattered in many laws that highlights other issues and combine them into one unique, specific, strict and clear law that regulates all matters related to mangroves and its resources, prioritising its enforcement to prevent violations of unsustainable usage of mangrove ecosystem. The suggested law should be realistic and reflect the reality of the country's state in relation to the need to stop the phenomenon of mangrove deforestation.

- The local coastal communities in Quelimane District should be made aware of the value, importance and necessity of preserving the mangrove ecosystem through campaigns, lectures, radio and television programs, accompanied by promotions of sustainable ways of using and exploiting the mangrove resources.

- Just as families affected by floods in recent years have been relocated to safe places, central and local government authorities should define a model of homes to be built in phases in new areas for the resettlement of residents living on the mangrove lands. To this end, the following actions should be taken into consideration:

  a) The government should carry out an updated, objective and specific survey to find out how many families actually live on mangrove lands in order to have an estimated budget plan to facilitate the possible resettlement project for the affected communities.

  b) Identify new areas not inhabited, such as the thousands of hectares of palm orchard lands of the company Madal, in which due to coconut yellowing disease, the lands are currently underutilized.

  c) Areas to be identified for resettlement should be provided with basic infrastructure such as energy, piped water supply, markets, hospitals, schools, transportation system and other facilities, in order to attract and retain resettled people so that they do not feel tempted to leave.

  d) In order to facilitate the resettlement process, families should be phased in, mapping the areas and grouping the houses currently on mangrove land into enumerated lots, then followed the transfer phase. It should not be spread as a project for future resettlement, as this would attract opportunists who from day to night can erect precarious houses with the aim of being contemplated. On the contrary, it can be as a survey of houses that are illegal in reserved areas and prohibited by the law.

e) As the houses are being vacated, they must be destroyed immediately and the land controlled to avoid further occupations. Some members of the families who will be resettled can be used as volunteers or workers in mangrove reforestation projects.

f) Provisions should be made for alternative sources of income for the survival of families whose source of income today is the sale of mangrove resources such as sticks and charcoal derived from carbonizing mangrove wood. This could include the creation of small associations for the production of honey in the mangrove forests, association of artisanal fisherman, associations of animal breeding such as chickens, duck, pigs and small farmer's association for vegetables and fruits. However, for the success of such initiatives, it will require members of the associations to be trained in how to contribute, manage, maintain and distribute incomes.

g) The government should conduct a specific, objective and detailed study to determine to what extent the deforestation of the Quelimane mangrove adversely affects the economy of the country and the district. The study should be based on the abrupt decline of annual fish, coastal erosion and health problems in the affected areas and experts in the field should be used for this purpose. The results can be used by the government as a future basis for decision-making for an effective management system, taking into account the sustainability of its resources and economic benefits in short and long term.

h) As part of the deforested mangrove lands are occupied, it requires a specialized study of the area, taking into account the local characteristics of the environment, to define between planting and natural regeneration of the mangrove, and which process to be used for reforestation. However, mangrove experts worldwide highly do not recommend planting, because the survival rates and results are higher in the natural regeneration of mangroves.

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Appendices

Appendix 1

Interview guide to the Quelimane residents on mangrove lands

Inquest Number: _____ Date: ___ / _____ / _____

Gender: Male ( ) Female ( )

1. Age of residents
   a) Under 25 ( ) b) 35-45 years ( )
   c) 25-35 years ( ) d) 45-55 years ( )
   e) 55-65 years ( ) e) Above 65 ( )

2. Level of education
   a) Elementary School ( ) b) Graduate ( )
   c) No formal education ( ) d) High school ( )

3. Which is the district of your origen?

   _____

4. Why have you chosen this area for the installation of your dwelling?
   a) Lack of space in other areas ( )
   a) Safe spaces are expensive for acquisition ( )
   b) It is closer to the river ( )
   c) Other ( ) state: _____

5. In what activity are you engaged?
   a) Agriculture ( ) b) Fishing ( )
   c) Cutting mangrove ( ) d) Trade ( )
   e) Other ( ) state: _____

6. Can you confirm if mangrove cutting occurs in this neighbourhood?
   a) Yes ( ) b) No ( )

7. If so, for what purpose?
   a) Construction of their houses ( )
   b) Production of charcoal for commercial ( )
   c) Construction of artificial boats ( )
   d) For sale ( )

8. Do you think that the floods occurring in the area is related to cutting of mangrove?
   a) Yes ( ) b) No ( )
   d) Maybe ( ) d) Do not know

9. Do you think that the cutting of mangrove is related to the low production of fisheries?
   a) Yes ( ) b) No ( )
   d) Maybe ( ) d) I do not know

10. Do you understand the importance of mangroves to the coastal environment?
    a) Yes ( ) b) No ( )
    If yes, briefly explain:
    _____

11. Any additional information?
    _____
    _____
    _____

Thank you for your cooperation

Appendix 2

Questionnaire guide directed to the DPTADERZ

Position occupied: _____ Date: ___ / _____ / _____

Academic level: _____ Age: _____

Gender: Male ( ) Female ( )

1. What mangrove species are found in Quelimane?

2. What is the importance of mangroves in maintaining the biodiversity of the marine and terrestrial environment?

3. In the DPMAIP point of view, how serious is the degradation of mangroves in Quelimane?

4. What are the environmental laws in regard to mangrove deforestation along Quelimane coast?

5. What mechanisms are being carried out to minimize mangrove deforestation in Quelimane?

6. What are the challenges faced when it comes to the implementation of environmental laws related to mangrove ecosystem?

7. In your opinion, do you think that the permission for cutting mangrove is a socio-political issue? If so, can you briefly explain?

8. What risks do the population face by living on mangrove lands?

Any additional information?

Thank you for cooperation

Appendix 3

Questionnaire guide directed to the DPMAIPZ

Position occupied: _____ Date: ___ / _____ / _____

Academic level: _____ Age: _____

Gender: Male ( ) Female ( )

1. How has this sector been affected by mangal deforestation in Quelimane District?
2. Can you evaluate if there is reduction in fisheries caught on annual productivity?
3. If there is a reduction in productivity, how can it be related to mangrove deforestation in Quelimane?
4. If you permit, I would like to request data of annual fish catches of the last 5 to 10 years.
5. Any additional information?

_____
_____
_____
_____

Thank you for cooperation

Appendix 4

Data collection table

INSTITUTION	QUESTION	ANSWER	PERSON CONTACTED
DPTADERZ (Questionnaire)	1. What mangrove species are found in Quelimane?	1. No study has been carried out to evaluate the abundance of the mangrove species in the district. However, the Salgueiro, scientifically known by Avicennia Marina is the most predominant specie of mangrove in Quelimane District.	Respondent 1
	2. What is the importance of mangroves in maintaining the biodiversity of the marine and terrestrial environment?	2. The mangroves are very important because they are used as a breeding place, shelter and food source for marine species and some terrestrial species.	
	3. In the DPTADERZ's point of view, how serious is the degradation of mangroves in Quelimane?	3. In fact, the situation is quite worrying, measuring by the size that the scenario of mangal destruction is today. Nevertheless, there is still a prevalence of lack of awareness and environmental education on the part of the population of Quelimane, especially those involved in this harmful practice to the environment.	
	4. What are the environmental laws in regard to mangrove deforestation along Quelimane coast?	4. In Mozambique, the mangrove ecosystem is regulated under a combination of several legal instruments. However, the most noteworthy are Decree n° 45/2006, of 30 November (Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment), Decree n° 54/2015 (Regulation on Environmental	

		Impact Assessment Processes - EIA) and Law n° 19/97 (Land Law).	
	5. What mechanisms are being carried out to minimize mangrove deforestation in Quelimane?	5. Application of fines and embargo of activities in mangrove areas without authorization of the Governor of the Province. However, the occupation by the local communities is a very complex and sensitive social issue. On the other hand, DPTADERZ has lectured in some communities about the importance and consequences of mangrove cutting. In addition, small funding to small associations for mangrove planting and other actions aimed to minimize mangrove deforestation have been carried out, but with very few results.	
DPTADERZ (Questionnaire)	6. What are the challenges faced when it comes to the implementation of environmental laws related to mangrove ecosystem?	6. The main challenges have to do with the assimilation and development of environmental culture by the local communities.	Respondent 1
	7. In your opinion, do you think that the permission for cutting mangrove is a socio-political issue? If so, can you briefly explain?	7. In fact, the problem of "permitting" the uncontrolled cutting of mangrove in Quelimane is of a political nature. I say this because the uncontrolled cutting and occupation of the mangrove began with population displaced during the civil war (1977 to 1992), from various parts of the province who took refuge in Quelimane. Consequently, they saw mangal as the main and only	

DPTADERZ (Questionnaire)		source of survival (housing construction, food preparation and sale for the satisfaction of various needs (buying clothes, food and schoolbooks for their children, etc.). However, even after the war ceased, the cutting and occupation of mangrove lands still prevails and is becoming alarming, and to this end, the practice is also associated to low family income and illiteracy that characterizes the population in these neighborhoods.	Respondent 1
	8. What risks do the population face by living on mangrove lands?	8. In these areas, the population is widely exposed and vulnerable to floods, strong winds and epidemic diseases given the lack of sanitation and urbanization.	
DPMAIPZ (Questionnaire)	1. How has this sector been affected by mangal deforestation in Quelimane District?	1. Mangrove is an ecosystem that plays an important role in fishery resources that are subject to our sector. In the life cycle of fishery resources most of them pass the larval stage, juvenile and sub-adults in the estuaries taking advantage of the shelter and food provided by the mangroves. As we know, the first two stages (larval and juvenile) are quite sensitive and vulnerable to biotic factors, especially predation. In this sense, the deforestation of mangrove ecosystem could directly or indirectly affect the fishery resources and thereby this sector and the country's economy.	Respondent 2
	2. Can you evaluate if there is reduction in fisheries caught on annual productivity?	2. A brief assessment of annual catches shows that there has been a reduction in the last four years, although before this period the trend was increasing (See **Figure 33**).	

DPMAIPZ (Questionnaire)	3. If there is a reduction in productivity, how can it be related to mangrove deforestation in Quelimane?	3. Studies have not yet been done that relate the decrease in annual catches to the deforestation of mangrove ecosystem in Quelimane District. It is therefore difficult to say that the current rates of fish catches are directly related to mangrove deforestation. On the other hand, it has to be considered that there are many factors that should be analyzed when assessing the reduction of fish catches, factors such as excessive fishing due to increase of population, types of gear used in fishing, degradation of coastal and marine habitats, climate changes and hydrometeorological factors, among others. These factors can cause reduction of fish stocks, each with its magnitude. Therefore, in the case of the Quelimane District it is difficult, without a directed and specific study to affirm that one of these factors is determinant in the reduction of the catches.	Respondent 2
	4. If you permit, I would like to request data of annual fish catches of the last 5 to 10 years.	4. See **Figure 33**.	
AQUAPESCA (Contacted by email and telephone calls).	1. A request for information of the total mangrove area occupied by the Company, from offices to the breeding ponds.	1. AQUAPESCA Company covers an area of about 350 ha.	Respondent 3

AQUAPESCA (Contacted by email and telephone calls).	2. The species of fish and shellfish produced in their aquaculture ponds.	2. AQUAPESCA Company produces Tilapia fish, different species of prawns and clams.	Respondent 3
	3. Please include some pictures of aquaculture ponds.	3. See **Figures 24** and **25**.	
KRUSTAMOZ Limited Quelimane (Contacted by email).	1. A request for the annual average of fisheries catch of the last 10 years.	1. See **Table 6**.	Respondent 4
DPSZ (Contacted by telephone call)	1. Requested data of malaria cases in Quelimane for the first 6 months of 2017.	1. Received a report, whereby the information needed was used and cited in the present research.	Respondent 5

NB: It should be noted that all the above participants were guaranteed by the author that the information obtained by the questionnaire, email and telephone calls, would be used exclusively as supporting data in the dissertation work for the Master's degree at the World Maritime University - Malmö/Sweden.