SUSTAINABLE USE OF MARINE ECOSYSTEM SERVICES IN INHAMBANE, MOZAMBIQUE

– IDENTIFYING PROBLEMS AND PROPOSING SOLUTIONS

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Alexandra M. Bloecker

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Faculty of Science, Radboud University Nijmegen

Name	Alexandra M. Bloecker
Student Number	4114426
Discipline	M.Sc. Biology
Host Organization	UNU-INWEH, Hamilton, Canada
University coach	Dr. R.J.W. de Nooij
Host Organization Coach	Dr. N. Nagabhatla
Reader	Dr. J.-F. Mercure

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Abstract

Marine and coastal ecosystem services experience declines worldwide. In the Province of Inhambane in Mozambique, tourism and fisheries are among the biggest drivers causing degradation of cultural, regulating and provisioning services. To understand tourism and fishery activities causing these declines, their influencers on marine and coastal habitats and fish were investigated. LMMAs are seen as an approach to halt degradation and to make the use of these services sustainable. The goal was to set up guidelines, categorized into the three dimensions of the Triangle of Sustainability: Ecological demands, policy and socio-economy. In that way, specific guidelines for LMMAs were created.

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Alexandra Michelle Bloecker

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Acronyms

ACIS	Associação Comèrcio e Indústria, Industrial and Commercial Association
ACUDES	Associação Cultural para o Desenvolvimento Sustentáve, Cultural Association for a Sustainable Development
BANP	Bazaruto Archipelago National Park
COAST	The Collaborative Actions for Sustainable Tourism
CORDIO	Coastal Oceans Research and Development – Indian Ocean
CPP	Conselho Comunitários de Pescas, Community fishing council
DPTUR	Direcções Provinciais de Turismo, Provincial Tourism Directorates
EBM	Ecosystem Based Management
Esri	Environmental Systems Research Institute
FAO	Food and Agriculture Organization of the United Nations
FIAS	Foreign Investment Advisory Service
GIS	Geographical Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit, German Corporation for International Cooperation
HDI	Human Development Index
ICZM	Integrated Coastal Zone Management
IIP	Instituto Nacional de Investigação Pesqueira, National Institute of Fisheries Research
INE	Instituto Nacional de Estatística, National Institute of Statistics
IPCC	Intergovernmental Panel on Climate Change
I/T	Inhambane City/Tofo
IUCN	International Union for Conservation of Nature
IUCN CEC	IUCN Commission on Education and Communication
LMMA	Locally Managed Marine Area
MDG	Millennium Development Goal
MPA	Marine Protected Area
MSP	Marine Spatial Planning
NMA	National Maritime Authority
NOAA	National Oceanic and Atmospheric Administration
pc	Personal communication
PoI	Province of Inhambane

RCI	Resilient Coasts Initiative
SDG	Sustainable Development Goal
TAC	Total Allowable Catch
UN	United Nations
UNU-INWEH	United Nations University Institute for Water, Environment and Health
V/B	Vilankulo/Bazaruto
WIO	Western Indian Ocean
WIOFish	Western Indian Ocean Small-scale Fisheries Database
WWF	World Wide Fund

Executive summary

Mozambique has high provisions of coastal and marine ecosystems, which provide supporting, provisioning, regulating and cultural ecosystem services. In the Province of Inhambane (PoI), tourism and fishery influencers cause degradation of provisioning ecosystem services like fish stocks and cultural and regulating services like marine and coastal habitats. Influencers are defined as drivers causing this degradation. To reduce influencers, a collaborative project was set up by UNU-INWEH and partners. The project focuses on the establishment of Locally Managed Marine Areas (LMMAs) in the PoI.

In general, LMMAs are set up in collaboration with stakeholders like fishermen, tourism operators, private and community actors and the government. The aim is to create a locally managed area to support food security and livelihoods of people and conserve the environment by employing resource management tools like Ecosystem Based Management (EBM), Integrated Coastal Zone Management (ICZM) or Marine Spatial Planning (MSP). Successful LMMAs were implemented in Kenya and Fiji, which experienced problems similar to the PoI.

In order to establish LMMAs, tourism and artisanal fishery influencers on fish stocks and marine and coastal habitats had to be analyzed. The goal of this study was to set up guidelines for the fishery and tourism sectors in order to ensure sustainable use of ecosystem services within the context of LMMAs in Inhambane. These guidelines take into account the dimensions of a modified Triangle of Sustainability: ecology, socio-economy and policy. The main research question was therefore as follows: *What guidelines are prerequisite for the fishery and tourism sector for a sustainable management approach for marine ecosystem services in the areas Inhambane City and Tofo, and Vilankulo and Bazaruto, and how can they be tailored to ecology, socio-economic demands and policy regulations for the concept of LMMAs?*

The study areas were the Inhambane city /Tofo (I/T) area and the Vilankulo/Bazaruto area (V/B). I/T is one of the major tourist destinations in the Inhambane Province and V/B contains the only marine conservation area in the province. These areas were chosen to compare a highly touristic and fishery influenced area with a less impacted, conserved area.

Primary and secondary data was gathered for the analysis. Primary data included interviews with experts and tourism operators to obtain information about the tourism and fishery influencers on fish stocks and habitats, the perception of the degradation, people's livelihood and about possible solutions to make the use of marine and coastal ecosystem services more sustainable. Secondary data included reports, articles, data sets and maps. These data were used to find supplement information on livelihoods, to determine policy regulations related to the conservation of the environment and to tourism and fisheries efforts, and to locate coral reefs.

Results from the interviews show that tourism activities like diving and snorkeling mainly have an impact on cultural and regulating services like coral reefs and megafauna. Divers and snorkelers break corals through fin strikes or by holding on to them. Tourism activities like recreational and sport fishing have direct influence on the fish (provisioning ecosystem services) through illegal fishing, time consuming

catch and release efforts (fish are exposed to the air too long) or through unregulated fishing tournaments.

Artisanal fisheries have mainly an impact on provisioning ecosystem services (fish). High fishing efforts, fishing throughout all seasons, unselective gear and incorrect use of selective gear have negative impacts on the fish populations, because too many fish, non-target species and pregnant females are caught.

The results for policy regulations show that tourism operators need to buy licenses for each activity they provide. There are no regulations on the efforts of diving and snorkeling. However, dive centers in the I/T work together to minimize the impact on fish and reefs by limiting the number of tourists they take out. Recreational and sport fishing have regulations on the number of species that are allowed to be taken per person per day.

Detailed regulations exist for artisanal fisheries: licenses are needed for all activities, the areas of operation are defined and minimum mesh sizes for gear are regulated. However, there are no limitations for the sizes of fish. In the fisheries as well as in the tourism sector the enforcement of regulations is lacking due to low financial and human resources by the government.

The socio-economic analyses show that fishermen fully depend on fish and that they have very low incomes. Tourism operators on the other hand have higher incomes and depend mainly on coral reefs and megafauna. This big socio-economic gap between these two sectors makes collaboration difficult.

Based on these results a set of guidelines was outlined, which include for instance:

- A transition from destructive to sustainable gear.
- An increase of financial and human resources by the government to enforce regulations.
- A decrease of the socio-economic gap, by enhancing communication, collaboration and re-allocation of financial and human resources from the government.
- A comprehensive understanding of the LMMA concept by all stakeholders to ensure livelihoods and food security.
- The implementation of resource management tools like EBM, ICZM and MSP to cover all dimensions of the Triangle of Sustainability.

It is anticipated that these guidelines can be of value for other regions with similar problems and can be scaled up to enhance sustainable use of coastal and marine ecosystem services worldwide.

In conclusion, tourism and fisheries are the main influencers causing degradation of ecosystem services in the Province of Inhambane. Based on successful outcomes of LMMAs in Kenya and Fiji, it is likely that the implementation of the guidelines leads to a sustainable LMMA management for Inhambane province. Appropriate resource management tools need to be implemented to manage marine ecosystem services sustainably and to include all local stakeholders for decision making.

1. Introduction

The world's oceans provide a wide variety of coastal and marine ecosystems. An ecosystem is defined as "a biological community of interacting organisms and their physical environment" (Oxford University Press 2016a). The Western Indian Ocean (WIO) and Eastern African countries like Kenya and Mozambique have a big variety of coastal and marine ecosystems due to their climatic conditions. Warm temperatures all year round support marine habitats like coral reefs and seagrass beds, and coastal habitats like sandy and rocky beaches, estuaries, bays or mangrove forests. One of the single-largest mangrove forest areas in Africa for example, can be found in the Zambezi delta in Mozambique. This area represents nearly half of all mangrove forests in Mozambique (SEA-ALARM 2009).

Within these habitats many species of different taxonomic groups can be found. In Kenya for example, 340 species of water birds inhabit one single delta, the Tana River Delta. Furthermore, more than 34 marine mammals and three species of sea turtles are found along the coast. These species are supported by a fringing reef which runs almost along the entire Kenyan coastline (SEA-ALARM 2010). In Mozambique on the other hand, five species of marine turtles and 18 marine mammal species inhabit the coastal and marine area. Islands like the Primeiras and Segundas Archipelago and the Quirimbas support thousands of bird species (SEA-ALARM 2009).

Like most ecosystems around the world, WIO ecosystems experience a steady decline. The human population is increasing steadily which in return increases the needs for natural resources (Hawkins *et al.* 2002). Mangrove forests are chopped for firewood and fish stocks are exploited to maintain food security (Pereira *et al.* 2014). This decline in ecosystems leads to a degradation of ecosystem services, such as provisioning services like seafood or regulating services like coral reefs. Since the East African coast has a wide variety of habitats, the provision of services is also very diverse. Sustainable use and resource management approaches are needed to maintain ecosystems, and herewith marine and coastal habitats, species and services (IUCN *et al.* 2016).

1.1. Sustainable Development Goals

Depletion of natural resources is currently one of the biggest global challenges. Coastal and marine resources are used unsustainably and are impacted by human activities like fishing, tourism or pollution. The United Nations (UN) has set up the Millennium Development Goals (MDGs) in 2000 to maintain the environmental resources and human livelihood. However, the MDGs focused mainly on social and less on environmental aspects. The main goal was to decrease the number of people living in extreme poverty by 2015. Only the seventh MDG included the maintenance of environmental sustainability. However this limited inclusion did not put enough emphasis on marine and coastal ecosystems and the benefits and services derived from them (United Nations 2016). Target 7.B. of goal 7 stated: "*Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss - Protected ecosystems covered 15.2 per cent of land and 8.4 per cent of coastal marine areas worldwide by 2014.*" (United Nations 2016).

In 2015, 17 new goals were established in a post-2015 development agenda where more than 190 UN world leaders committed to. These goals are called Sustainable Development Goals (SDGs) and

highlight the need for conservation and sustainable use of natural resources for a sustainable development (United Nations 2015). The SDGs are detailed and include more targets than the MDGs. A separate SDG was established that pays special attention to seas, oceans and marine and coastal resources: SDG 14 Life below water, which includes ten targets.

Target 14.2 includes the sustainability of marine and coastal ecosystems:

"*By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans*" (United Nations 2015).

Target 14.4 pays special attention to fishing:

"*By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics*" (United Nations 2015).

The other targets pay further attention to the prevention of pollution and ocean acidification, the conservation of coastal and marine areas, the increase of economic benefits for Small Island developing States or the provision of access to markets and marine and coastal resources for small-scale fisheries. SDG 14 is very important for the conservation of marine and coastal ecosystems and their services. If it will be implemented by all member countries, ecosystem degradation can be reduced (United Nations 2015).

1.2. Coastal and marine ecosystem services

Ecosystem services are provisions of benefits to human societies from natural ecosystems (Margaret *et al.* 2004). These services can be divided into four sub-categories according to the service they provide: 1) Supporting services, which include soil formation or primary production; 2) Provisioning services, which include the products that are obtained from ecosystems like food, wood or fresh water; 3) Regulating services like flood regulation or water purification; 4) Cultural services include recreational, educational or aesthetic aspects (Millennium Ecosystem Assessment 2005).

In most developing countries and emerging regions around the tropics, people's livelihoods depend on coastal and marine resources. These resources include community supporting mechanisms like the provision of food through aquatic species and generating income from trade. Cultural services like recreational activities support tourism. Therefore, marine and coastal ecosystem services should be used on a sustainable level, where ecosystems are not harmed and services do not degrade, to enable an indefinite use for future generations (Margaret *et al.* 2004). The focus of this study will be on Mozambique, which is rich in marine and coastal ecosystem services, but experiences great declines.

On the socio-economic side, Mozambique reports low income per capita and high levels of poverty among all developing countries. The United Nations Development Program ranked it as 180 out of 188 countries on the Human Development Index (HDI). The countries with a lower HDI are Sierra

Leone, Guinea, Burkina Faso, Burundi, Chad, Eritrea, Central African Republic and Niger (United Nations Development Programme 2015).

On the ecological side, Mozambique has the longest coastline (2470 km) out of the eight countries with the lowest HDI. This highlights high provisions of coastal and marine ecosystem services. At the cost of ecological sustainability, these provisions are exploited to boost economic growth (IUCN *et al.* 2016). Declines in marine and coastal ecosystem services could eventually lead to loss of livelihood and ecosystem functions.

Therefore, management in a sustainable manner is needed to ensure balance between human needs and ecological demands (Margaret *et al.* 2004). The context of sustainable management of coastal and marine ecosystems and related ecosystems services and benefits closely ties with the targets underlined in SDG 14; especially for developing countries to enhance their economic benefits through the use of marine and coastal ecosystem services (United Nations 2015).

1.3. UNU-INWEH and research topic

The United Nations University Institute for Water, Environment and Health (UNU-INWEH) represents the 'United Nation's Think Tank on Water'. Its vision includes a "world free of water problems where sustainable human development and environmental health and security are assured for all". SDGs are used as underlying goals (UNU-INWEH 2015). UNU-INWEH focuses on two research programs: 1. Water and Human Development and 2. Water and Ecosystems (UNU-INWEH 2016). The present study was associated with the Water and Ecosystems Program area, which among others, improves understanding of coastal and marine ecosystems and the related management approaches, and implements projects that aim at the conservation and protection of ecosystems and their services (UNU-INWEH 2015).

This study was carried out under a collaborative program called 'The Resilient Coasts Initiative' (RCI). The RCI focuses on resilience of coastal and marine ecosystems to support a secure and prosperous future of coastal communities. Partnership-based approaches are implemented to create knowledge, to manage actions in the areas of interest and to enhance policy (IUCN 2016b).

The RCI's national scale project 'Coastal Cities as Sustainable Economic Hubs' was set up by IUCN, IUCN CEC, Deltares, CORDIO, and UNU-INWEH and is funded by the German KfW Bankengruppe. The project focuses on how the Province of Inhambane (PoI) in Mozambique can become an economic hub by 2030, using a sustainable development approach that focuses on the development of the three main economic sectors Agriculture, Fisheries and Tourism. The goal is to secure livelihoods and ensure food security for local people. Locally Managed Marine Areas (LMMAs) are seen as an approach to reach this goal. LMMAs shall be implemented in four municipalities of the PoI: Inhambane (city), Maxixe, Vilankulo and Massinga (IUCN *et al.* 2016).

Several resource management tools will be used to meet the project's goal:1) Integrated Landscape and Seascape Planning as overarching approach, 2) Integrated Coastal Zone Management (ICZM) indicator-based approach, 3) Nature-based solutions approach, 4) Ecosystem based approach, 5) Socially Inclusive Value Chain Development approach, and 6) A Resilience approach (IUCN *et al.* 2016).

UNU-INWEH's tasks within the project focus on spatial planning, socio-economic review and assessment, capacity development and Geographical Information Systems (GIS) (IUCN *et al.* 2016).

The PoI has been chosen for this project because the German government supports municipalities in this province since 2004 and it has been identified to be a potential pilot province. Furthermore, only little research has been conducted in this province, compared to other Mozambican provinces. Therefore this project will increase data, information and knowledge acquisition in unstudied fields (IUCN *et al.* 2016).

The present study is integrated in this umbrella project and focuses on tourism and fishery influences on marine ecosystem services in the PoI. The next section will give a brief overview of the outline of the thesis.

1.4. Outline of the thesis

The first chapter introduces marine and coastal ecosystem services and their relation to Sustainable Development Goals. Mozambique has a rich diversity in marine and coastal ecosystem services, but it is among the poorest countries in the world and thus requires focused and targeted efforts to manage ecosystems services in order to halt degradation of coastal and marine resources.

The second chapter provides background information on the PoI and tourism and fishery influencers on fish stocks and habitats. Also resource management tools to reduce these impacts are discussed in this chapter. The research framework is presented in chapter 3, where the goal and the research questions are described in more detail.

To conduct the study, various data were gathered. Primary data was collected from interviews with experts and tourism and fishery operators. Secondary data was used from existing data bases and literature sources. Spatial and statistical analyses were performed using the programs ArcMap 10.3.1, ArcCatalog 10.3.1 and IBM SPSS Statistics 23, respectively. More information about the methodology used for this research is described in chapter 4.

The results are discussed in chapter 5, focusing on tourism and fishery influencers on marine and coastal ecosystem services, policy regulations and socio-economy. The discussion is described in chapter 6, which includes guidelines, recommendations and ideas for further research. The thesis ends with a conclusion in chapter 7.

2. Background

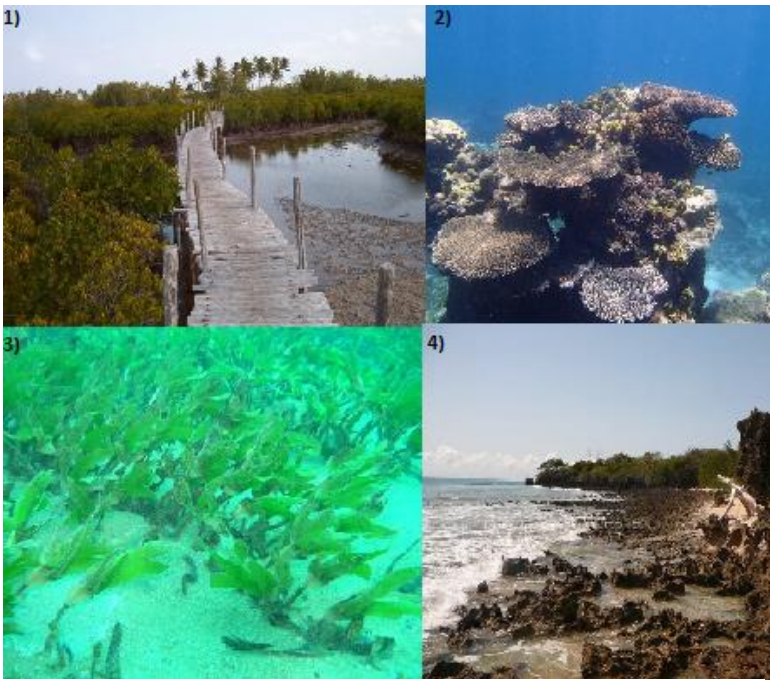
2.1. Province of Inhambane, Mozambique

The PoI is one of Mozambique's eleven provinces and has a coastline at the South Western Indian Ocean (Geohive 2016). The province has an area of 68,775 km^2, includes12 districts and is located in the south of Mozambique. Inhambane City is the capital city of the province (Visit Mozambique 2010b).

Due to unsustainable use, mainly destructive fishing and tourism in fragile ecosystems, a significant decline in marine and coastal resources (fish populations and reef habitats) has been observed in the PoI (Bryceson & Massinga 2002; Fiege *et al.* 2003; Jacquet *et al.* 2010). Management for a sustainable use is required to secure food provision and livelihood (IUCN *et al.* 2016). These habitats and the tourism and fishery influencers are described in the following sections. In this study, influencers are defined as actions that cause degradation of marine and coastal ecosystem services.

2.1.1. Marine and coastal habitats

Mozambique's marine and coastal habitats are diverse and can be divided into three areas: coral coast, swamp and parabolic dune coast (Map 1). Mangroves, coral reefs, seagrass beds, estuaries and bays, and rocky shores belong to these habitats (Picture 1). Coral reefs can be mainly found in the northern part, whereas mangroves and seagrass beds are spread all along the coast. However, the biggest mangrove area is located in the swamp area in central Mozambique (Pereira *et al.* 2014).



Picture 1 Coastal and marine habitats in Mozambique
(Pereira *et al.* 2014)

1) Mangroves at Barra (picture taken by Rodrigo Santos)

2) Coral reef at Northern Quirimbas (picture taken by Marcos Pereira)

3) Seagrass bed at Northern Quirimbas (picture taken by Marcos Pereira)

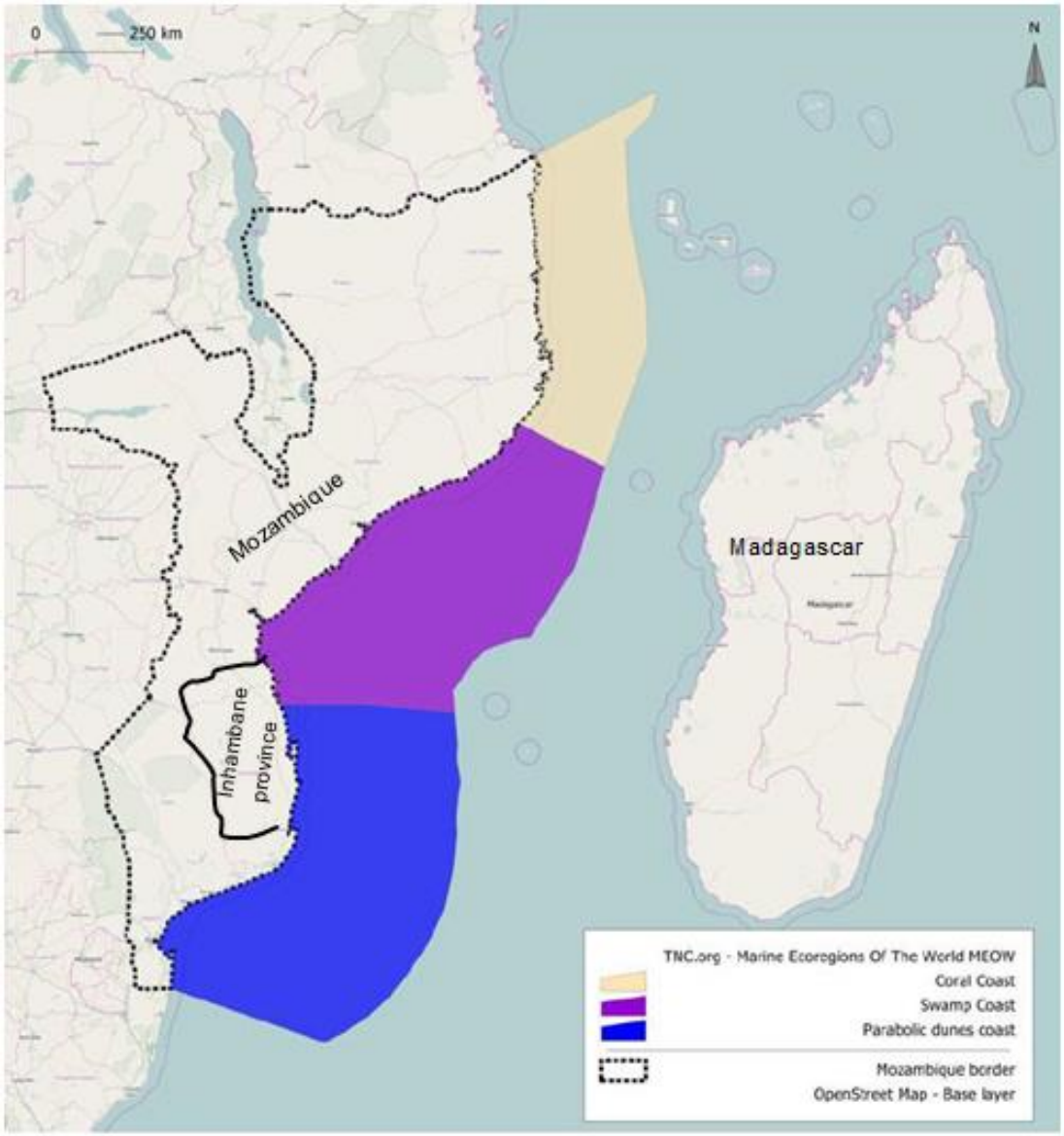
4) Rocky shore at Palma (picture taken by Marcos Pereira)

Estuaries and bays can also be found along the coast with Maputo Bay and the Sofala Bank being the most important bays. These bays belong to the most important fishing areas and therefore are important for the economy of Mozambique (Pereira *et al.* 2014).

Rocky shores are mainly located in the northern and the southern part of the coast. These areas provide shelter to marine species and act as nursery areas (Pereira *et al.* 2014).

Even though these habitats are widely spread along the coast and some of them are more present in the north or in the center of Mozambique, all habitats can be found in the PoI. These marine and coastal habitats experience anthropogenic impacts and are declining. Mangroves, for example, are chopped to be used as fire wood. Estuaries and bays suffer from pollution from industries, which dump their waste into rivers (Pereira *et al.* 2014). Coral reefs show degradation due to destruction through tourism and fishery activities (Toomey 2016).

It is evident that fishing and tourism operators share marine and coastal resources while operating their respective business activities like fishing, recreational and sport fishing, diving and snorkeling. This often leads to competition for the resources and increases pressure on the ecosystem use. Coral reefs which provide a habitat for fish stocks can be seen as the most socio-economically important shared resource for local fisheries and tourism operators (Pereira *et al.* 2014).



Map 1 Mozambique's habitat distribution
(adopted from Pereira *et al.* 2014)

Effective policies and strict regulations are needed to define the resource use and management in a sustainable manner (Ricardo 2004). Current regulations like the Lei do Ambiente (Environment law) include that management for a sustainable use is required and that destruction of natural resources is not permitted (Portal do Governo de Moçambique 2016). As fishing and tourism are among the main influencers impacting fish stocks and marine and coastal habitats, these two sectors and the related influencers will be investigated in detail in this study.

2.1.2. Tourism sector

Tourism had a high economic significance in Mozambique between the 1950s and 1970s (Fiege *et al.* 2003). In 1972, an armed conflict started and decreased the number of international arrivals during its duration of 19 years. After 1992, the tourism sector needed time to recover from this conflict. A growth rate of 8% for tourism has been measured for the period between 1992 and 2002 (COAST 2009; FIAS 2006). This increase is also due to the high effort of the Mozambican government to increase the national economy through tourism activities (Ministério do Turismo 2004).

The tourism sector can be divided into two key markets, namely Business and Leisure. The focus in this thesis will be on leisure activities like diving, snorkeling, and recreational and sport fishing because leisure tourism in the PoI area is highly dependent on biodiversity and other natural assets (Batey 2014).

Inhambane reports environmental problems due to growing marine and coastal tourism establishments (Amiro Motany de Albuquerque Azevedo & de Souza Bias 2011). Almost all the establishments are located in fragile ecosystems (Fiege *et al.* 2003). Whereas tourism activities like quad bikes and motor boats influence the environment indirectly by causing erosion and pollution, fishing, snorkeling and diving directly affect the coastal and marine ecosystems through physical damage (Fiege *et al.* 2003).

The PoI is one of the most famous tourism destinations of the world due to its unique diversity of ecosystems. SCUBA diving increases in terms of number of divers and number of diving facilities (Pereira 2000). Nearly 1 million new divers explore the seas each year, whereas 20,000,000 already exist worldwide (Toomey 2016). Diving is a niche in the Mozambican market (Ministério do Turismo 2004). The coast of the PoI offers many dive and snorkeling spots due to the presence of coral reefs, megafauna and other marine species. The aquatic 'big five' (manta ray, sharks, whale sharks, dolphins and turtles), dugongs and humpback whales can be found frequently. The Tofo region in the PoI is also "the only place in the world where whale sharks can be seen throughout the year." (DPTUR *et al.* 2007). Due to the increasing popularity of diving and snorkeling, especially among young people, it is expected that the number of divers and snorkelers will increase in the PoI (Ministério do Turismo 2015).

Furthermore, the Bazaruto Archipelago National Park is a favorite tourist destination due to its long white beaches and the presence of sea turtles and dugongs. The PoI has also a great potential for ecotourism, which will be further developed by the government according to the Strategic Plan for Development of Tourism (Ministério do Turismo 2015).

The high popularity of the PoI will increase tourism influencers on provisioning, regulating and cultural marine and coastal ecosystem services. Therefore, it is important that management of tourism activities takes place to maintain a balance between the sector's development and marine and coastal ecosystem service use.

2.1.3. Fishing sector

Inhambane's fishing market consists of three sectors: artisanal, semi-industrial, and industrial fisheries. Artisanal fishing represents the largest share (90%) and catches, mainly fish species, are consumed locally. Artisanal fisheries are formed by small groups or individual fishermen who have low economic power. Most of the fishermen own non-motorized boats and use gear like seine and gillnets, hook and line or longline fishing. Only about 3% of all artisanal fishermen boats in Mozambique are equipped with an engine (FAO 2007).

The semi-industrial fisheries focus on domestic shrimp fisheries, where the market is local and goods are also exported. The industrial fisheries use large vessels that target coastal and deep-sea shrimps, tuna and swordfish for export. Mozambique has trade agreements with Europe to allow European countries to fish in their territories. Chinese trawlers and trawlers from other Western Indian Ocean countries fish in Mozambican territories with high efforts to catch as much as possible. This industrial fishing aggravates depletion of marine resources. (Oceanic Développement 2014).

Preliminary review indicates that unsustainable fishing practices and the lack of management structures like marine conservation areas exacerbate depletion of ecosystem services in the PoI. Also the lack of sufficient policy regulations plays an important role. The artisanal fisheries for example have only a few gear limitations, which among others sets a minimum mesh size for seine nets at 2.5 cm (Figure 1) (Pereira *et al.* 2014).

Furthermore, pressure on marine and coastal resources is worsened by an increasing population in coastal areas (Bryceson & Massinga 2002). Fishing efforts have intensified to meet societal and industrial demands (Blythe *et al.* 2014). The high by-catch due to old-fashioned, unselective fishing gear and the lack of registration of the exact amounts of fish caught makes it difficult to estimate the dimensions of depletion (Blythe *et al.* 2014; Jacquet *et al.* 2010). A recent estimation sets the share of overexploited fish stocks in Mozambique at 75% (Pereira *et al.* 2014).

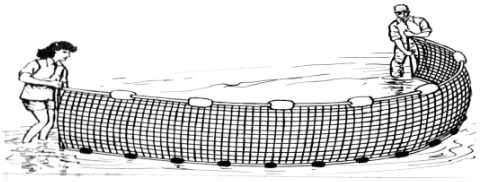


Figure 1 A basic seine net
(Pearson Scott Foresman 2010)

Resource management tools are used worldwide to manage marine and coastal resources sustainably and to diminish influencers from tourism and fisheries. Which tools exist and what they imply is described in the following section.

2.2. Resource management tools

Different tools exist to manage the impact on natural marine and coastal resources and to increase sustainability. In an ecological context sustainability can be defined as the "avoidance of depletion of natural resources in order to maintain an ecological balance" (Oxford University Press 2016b). In this way, sustainability implies the indefinite use of natural resources, which ensures food security and livelihood for current and future generations (IUCN 2016a).

Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP) are tools for sustainable management for coastal and marine areas. Ecosystem Based Management (EBM) is an overarching approach that complements existing resource management tools by facilitating understanding of coastal and marine related ecosystem functioning and human interactions. The use of these approaches enhances the establishment of marine conservation areas like Marine Protected Areas (MPAs) or Locally Managed Marine Areas (LMMAs). The definition of these terms will be given in this section. How these approaches are linked can be seen in Figure 2.

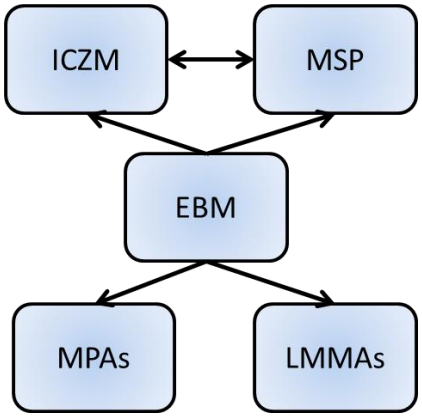


Figure 2 Connection between different sustainable approaches

2.2.1. Integrated Coastal Zone Management and Marine Spatial Planning

The Integrated Coastal Zone Management's (ICZM) aim is to coordinate policies related to "nature protection, aquaculture, fisheries, agriculture, industry, off shore wind energy, shipping, tourism, development of infrastructure and mitigation and adaptation to climate change" to make their use more efficient (European Commission 2016). Various stakeholders from different sectors are included in the ICZM implementation for a high support of the management strategies. The implementation includes the collection of data, planning and decision-making, and management and monitoring (European Commission 2016).

Marine Spatial Planning (MSP) analyzes the temporal and spatial distribution of human activities in the marine space. This analysis helps to allocate human activities to areas and enhances the achievement of social, economic and ecological objectives, without the need of a political process. These objectives allow creating a balance between socio-economic demands and the conservation of the environment (Marine Spatial Planning Initiative 2016).

The above-mentioned definitions of ICZM and MSP show that the approaches complement each other. Furthermore, both ICZM and MSP have Ecosystem Based Management (EBM) as the underlying approach.

2.2.2. Ecosystem Based Management

The Ecosystem Based Management (EBM) approach studies the understanding of interactions and functions between organisms, humans included, and the environment. In this way, knowledge about ecosystem processes and management of these processes can be linked (Palumbi *et al.* 2008). Furthermore, EBM aims at sustainability; an indefinite use of natural resources to benefit present and future generations. Therefore the capacity by ecosystems to provide food or to support livelihoods has to be maintained (IUCN 2016a).

The linkage of these processes is the aim of MSP, where human activities are allocated to marine areas (Marine Spatial Planning Initiative 2016). The ICZM uses EBM to take limitations of natural resources into account, while policy strategies are implemented (European Commission 2016). ICZM, MSP and EBM are used worldwide to establish marine conservation areas like Marine Protected Areas or Locally Managed Marine Areas.

2.2.3. Marine Protected Areas

Marine Protected Areas are used worldwide to protect sensitive species and their habitats. In Kenya, for example, a first MPA was established based on incentives given by the Wildlife Management and Conversation Act (1976) and the Fish Industry Act (1968) (Odote *et al.* 2015). More MPAs were established based on the goals from the first MPA. The establishment took place in collaboration between the government, the local communities and further stakeholders. Mutually agreed goals were set up to enhance the implementation (Odote *et al.* 2015):

- "Preservation and conservation of marine biodiversity for poverty alleviation"
- "Provision of ecologically sustainable use of the marine resources for cultural and economic benefits; and"
- "Promotion of applied research for educational awareness programme, community participation, and capacity building."

Goals and regulations are set up by the collaborative teams for each MPA. MPAs can vary widely in for instance their conservation focus or their level of protection. This means that while fishing is allowed or restricted in some MPAs, a few other MPAs might include no-take fish zones (NOAA 2015).

However, MPAs include a top-down management approach, where the government and higher agencies are in charge of management. This approach is taken from the colonial times, where local communities were seen as unable to manage resources. The exclusion of local communities is an important problem. This was also noticed in Kenya, where the exclusion led to challenges which increased depletion of marine and coastal resources. This experience led to a new concept, where the

management is performed on a local community level: Locally Managed Marine Areas (Odote *et al.* 2015).

2.2.4. Locally Managed Marine Areas

Locally Managed Marine Areas (LMMAs) are gaining recognition globally and many case studies reflect successful implementation of the concept (The Locally-Managed Marine Area Network 2016a). The main difference between MPAs and LMMAs is that Locally Managed Marine Areas are established voluntarily by local communities, and therefore the ownership is local. Different systems of administration are used for the management: "areas administered by individual owners of the land[1]; areas administered by the entire community due to communal ownership of land; and lastly, areas administered by various communities who have rights over the same lands at different times." (Odote *et al.* 2015). This gives communities the opportunity to directly engage and derive benefits from natural resources through conservation. The goals of LMMAs are similar to the MPA goals, but they are developed by the communities (Odote *et al.* 2015).

However, in contrast to MPAs most of the LMMAs have no-take fish areas. Further restrictions in gear, species, or seasonal restrictions are implemented to decrease the pressure on fish stocks (The Locally-Managed Marine Area Network 2016b). This was also noticed in Kenya, where a LMMA with a no-take zone was established in 2006. Fish stocks and coral reefs recovered and fish catch in surrounding areas increased. Also, the revenue through snorkeling increased through ecosystem conservation. This case study shows that the establishment of LMMAs can increase benefits for the economy in different sectors (Odote *et al.* 2015).

The establishments of LMMAs in Kenya show that challenges can be reduced if a clear legal framework is used. Guidelines for the establishment are needed to increase the effectiveness of conservation within the LMMAs. Some examples of legislative guidelines (Appendix V.) are mentioned here (Odote *et al.* 2015):

- The term 'LMMA' has to be defined clearly and refers to a marine and coastal area that is led by local community management initiatives.
- The members of LMMAs have to be from different backgrounds like fishing, trade, private sector, community organizations or farmers.
- The primary goal of the LMMA has to be defined clearly to enhance the collaboration with governmental agencies once the LMMA is established.

To increase the establishments of LMMAs, the Locally-Managed Marine Area Network was created. This network works primarily in the Indo-Pacific region and studies how LMMAs work, why they fail and which conditions are needed to make them work best. A successful project is taking place on Fiji, where tourism operators and fishery operators closely work together to use resources from coral reefs sustainably (The Locally-Managed Marine Area Network 2016a).

[1] In the context of this study, "land" refers to coastal and marine areas and not to inland areas.

All in all, the PoI experiences marine and coastal habitat and fish stock declines due to destructive and unsustainable fishing and tourism. Several approaches and resource management tools exist to set up marine conservation areas to stop marine ecosystems from degradation. The following section will describe in detail the research framework of the present study.

3. Research framework

Tourism and fishery impacts on marine and coastal ecosystem services in the PoI are taking place constantly and will not halt without involving the local community. The problem is that declines in these ecosystem services could eventually lead to loss of livelihood and ecosystem functions.

The project consortium sees the establishment of LMMAs as a possible solution for this problem. However, in order to create LMMAs underlying tourism and fishery influencers causing marine and coastal ecosystem services degradation need to be examined and analyzed.

The present study uses the EBM approach as the guiding concept, as this approach focuses on the interactions between organisms, including humans, and the environment (Palumbi *et al.* 2008). This approach is crucial for the understanding of tourism and fishery influencers on marine and coastal ecosystems. It is important to note that detailed scientific analyses of these influencers have not been conducted earlier for the PoI.

As tourism and fishery influencers are also determined by socio-economic and policy aspects, these aspects need to be examined from the ecological perspective. An analysis of the interaction between these three aspects leads to guidelines, which can be used for the establishment of LMMAs. This interaction is closely linked to the Triangle of Sustainability, which studies the relations between ecology, socio-culture and economy (Figure 3) (Keiner 2016).

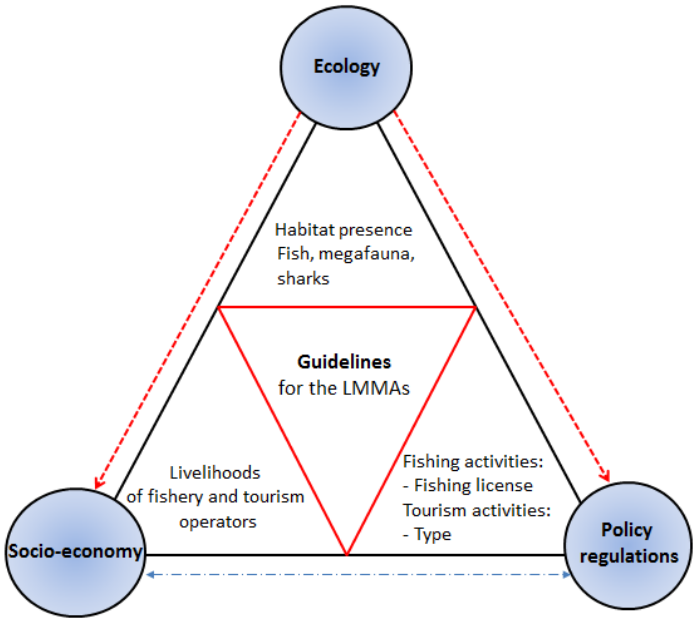


Figure 3 Modified Triangle of Sustainability: interaction between ecology, socio-economy and policy regulations

The selected socio-economic aspects include tourism and fishery operators and their demands for employment, income and food security in relation to marine and coastal ecosystem services.

Policy regulation aspects solely include licenses for tourism and fishing operations and ecosystem protection laws. These instruments regulate efforts and locations of operations and activities. Therefore they have direct influence on the strength of impacts marine and coastal ecosystem services.

As the fisheries and tourism sectors highly depend on shared coastal and marine resources, the present study focuses these resources: fish stocks and their habitats. Fishery and tourism influencers on fish stocks and habitats can be linked to these ecological, socio-economical and policy aspects (Figure 4). Fish stocks belong to provisioning and cultural marine and coastal ecosystem services in the PoI; fishing for income and food is provisioning, whereas tourism fishing is cultural.

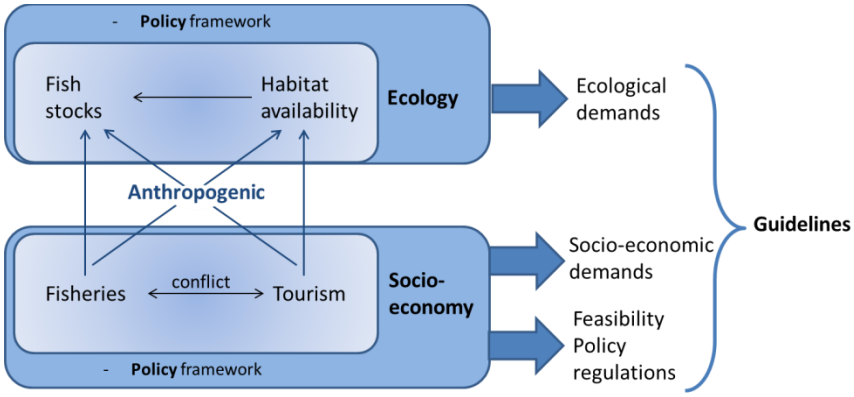


Figure 4 Ecological and anthropogenic interactions

The habitat of focus will be coral reefs, as they are the most socio-economic important shared resource for local fisheries and tourism operators. Coral reefs provide regulating and cultural ecosystem services. Regulating services include that reefs are buffer zones which provide storm shelter by reducing wave action. The use of reefs for tourism purposes are cultural services. Analyses of fish populations, habitat dynamics and ecological demands were not undertaken in this study due to data limitations and time constraints.

Of the three fishing sectors (artisanal, semi-industrial and industrial) in Mozambique, only the artisanal sector was analyzed as most fishermen in Mozambique conduct this type of fishing and it conflicts with the tourism operations. Moreover, target species in this sector are mainly fish species, which is the provisioning ecosystem service of focus in this study.

The semi-industrial sector was excluded because it focuses mainly on shrimp, which are not the target group of this study, and this sector is interfering less with tourism operators. The industrial sector is far off shore and is not directly influencing local people living and conducting their business at the coast (FAO 2007).

Also due to time constraints, two out of the four municipalities were chosen. The focus of this study is on the municipalities Vilankulo and Inhambane city, including their surroundings Bazaruto and Tofo, respectively. More information about the areas can be found in the Methodology section.

3.1. Goal

The aim of this study was to investigate tourism and fishery influencers on fish stocks and fish. The goal was to set up guidelines for the fishery and tourism sector in order to ensure sustainable use of marine and coastal ecosystem services within the context of LMMAs. The guidelines were aligned to the three dimensions of the Triangle of Sustainability to create preconditions, which need to be met to establish LMMAs. These guidelines are boundary conditions, from which guidelines for the LMMA management itself were set up.

These guidelines are part of the overall 'Coastal Cities as Sustainable Economic Hubs' project and can be used for the establishment of LMMAs by the project members, the government of Mozambique, the fishery and tourism sector, and the local society to protect and conserve marine and coastal ecosystems to ensure food security, income and employment. In this way, also coast and marine resilience can be supported. It is expected that the results of this research can be of value for other regions with similar problems and can be scaled up to enhance sustainable use of marine and coastal ecosystem services worldwide.

3.2. Research questions

To set up these guidelines, the following main research question and four sub-questions were used:

What guidelines are prerequisite for the fishery and tourism sector for a sustainable management approach for marine ecosystem services in the areas Inhambane City and Tofo, and Vilankulo and Bazaruto, and how can they be tailored to ecology, socio-economic demands and policy regulations for the concept of LMMAs?

The sub-questions are:

a) What influencers from the tourism and fisheries sector impact fish stocks and marine and coastal habitats and how do these sectors interact?
b) What are current policy regulations concerning fishery and tourism operations and marine ecosystem protection related to marine and coastal ecosystem services use in the Province of Inhambane?
c) What are socio-economic demands in the Province of Inhambane related to the tourism and fishery sector?
d) How can knowledge on influencers, on the interaction between the sectors, on policy regulation and on socio economic demands be implemented into guidelines for fishing and tourism to be used within LMMAs?

The outcome of this research will be a list of guidelines for the tourism and fishery sectors, which can be used while implementing the LMMA concept. These guidelines will cover the three dimensions of the Triangle of Sustainability.

4. Methodology

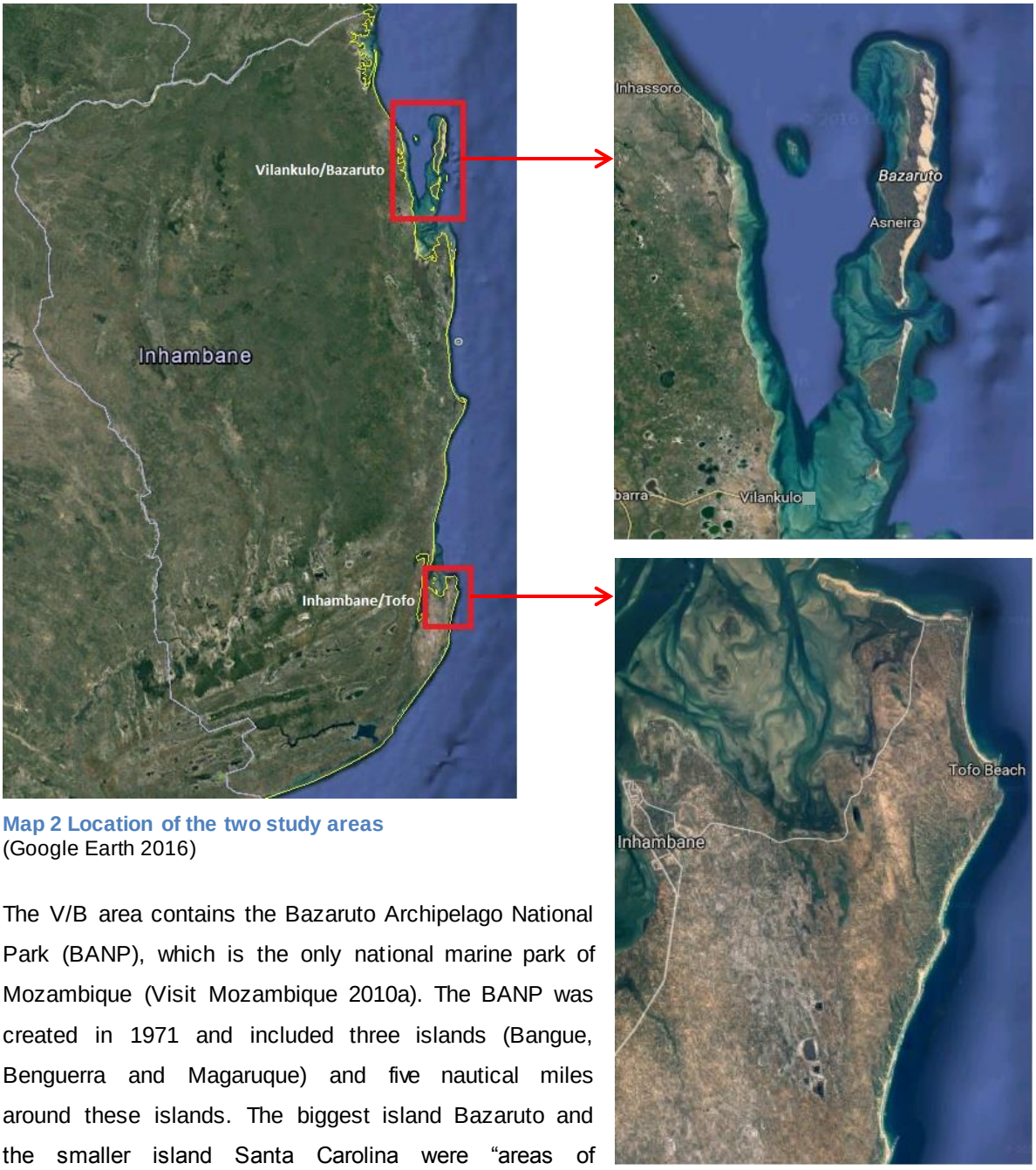
The study is based on one main question and several sub-questions. Different methodological approaches were used to answer these questions and to meet the goal 'setting up guidelines for the tourism and fishery sectors for the establishment of LMMAs' (Table 1). These approaches can be divided into primary data and secondary data collection. Primary data is directly collected by the researcher from subjects of interest and secondary data comprises pre-existing data (Institute for Work & Health 2015). To know where the study areas of interest are located, the areas will be described in this section first.

Table 1 Overview of methods used per research question

Research sub-questions	**Method**
a) What influencers from the tourism and fisheries sector impact fish stocks and marine and coastal habitats and how do these sectors interact?	Primary data: Interviews Secondary data: Literature research Data sets Maps
b) What are current policy regulations concerning fishery and tourism operations and marine ecosystem protection related to marine and coastal ecosystem services use in the Province of Inhambane?	Primary data: Interviews Secondary data: Literature research
c) What are socio-economic demands in the Province of Inhambane related to the tourism and fishery sector?	Primary data: Interviews Secondary data: Literature research
d) How can knowledge on influencers, on the interaction between the sectors, on policy regulation and on socio economic demands be implemented into guidelines for fishing and tourism to be used within LMMAs?	Primary data: Interviews Secondary data: Data sets Maps
Main research question	**All methods combined**
What guidelines are prerequisite for the fishery and tourism sector for a sustainable management approach for marine and coastal ecosystem services in the areas Inhambane City and Tofo, and Vilankulo and Bazaruto, and how can they be tailored to ecology, socio-economic demands and policy regulations for the concept of LMMAs?	Primary and secondary data

4.1. Study areas

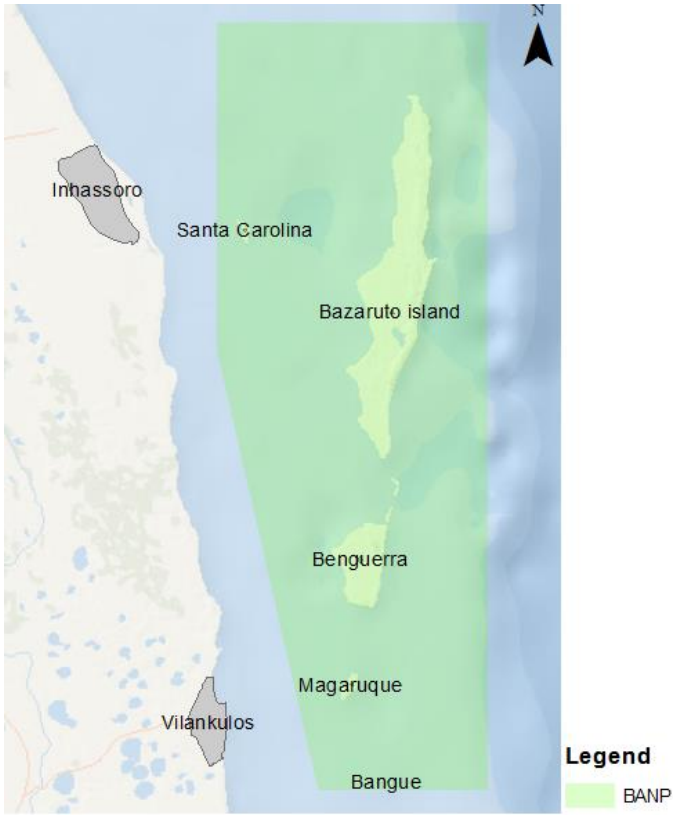
Two of the four municipalities from the umbrella project and their surroundings were chosen due to time constraints. The two study areas of interest were Inhambane City/Tofo and Vilankulo/Bazaruto (Map 2). Both areas are tourist hotspots in the Province of Inhambane, I/T being the bigger tourist attraction (Visit Mozambique 2010b).



Map 2 Location of the two study areas
(Google Earth 2016)

The V/B area contains the Bazaruto Archipelago National Park (BANP), which is the only national marine park of Mozambique (Visit Mozambique 2010a). The BANP was created in 1971 and included three islands (Bangue, Benguerra and Magaruque) and five nautical miles around these islands. The biggest island Bazaruto and the smaller island Santa Carolina were "areas of viligance" at that time (WWF 2005). In 2001, Bazaruto and Santa Carolina were included as well (Mclean *et al.* 2014). Now, the BANP encompasses five islands and has a total cover area of 1.430 km^2 (Map 3) (República de Moçambique 2001).

The two study areas differ regarding the amount of tourism taking place, which is higher in the I/T area, and the nature conservation aspect, which is higher in the V/B area (Visit Mozambique 2010b).



Map 3 Area of the Bazaruto Archipelago National Park

4.2. Primary data

The collection of primary data was necessary to obtain information about people's livelihoods, their areas of operation and their opinions on how to make the use of fish and marine and coastal habitats more sustainable. Primary data was collected through qualitative research. Qualitative research gives insight into attitudes, experiences and behavior of interviewees (Dawson 2009). In-depth opinions were obtained from interviewees. Semi-structured interviews were held, recorded and transcribed verbatim.

The interviews were used to find answers to the sub-research questions. Interviewees' opinions could be used to outline guidelines that match the demands of the local community. Also, insight into policy regulations was given, which could align the guidelines to the Mozambican policy. In this way, the EBM approach was implemented to understand the interaction between humans, organisms and the environment.

Interviewees of interest were experts, tourism operators and fishery operators. The sampling method used was a quota sample, which belongs to purposive sampling. In contrast to probability sampling where interviewees are chosen randomly, purposive samples are not random. The researcher selects the interviewees to find answers for particular questions (Dawson 2009).

For a quota sample, the sample size and interviewee requirements are determined beforehand to make sure that all important groups are represented (Dawson 2009). For the present study the following requirements were used:

1) At least ten people per group (experts, tourism operators and fishery operators) had to be interviewed to receive a good sample size within the given time frame.
2) Five fishery and tourism interviewees had to be from the I/T area and five from the V/B area to have a balance between these two areas.
3) Experts must have been involved in projects or research that involved marine and coastal ecosystem services in Mozambique. In this way, it was made sure that experts knew about the situation in the PoI.

To find interviewees, local and global organizations and local tourism offices were contacted. Interviews with experts and tourism operators were held via Skype or land line phone calls, because the time constraint did not allow a field visit. Liaisons with project partners in the field helped to set up connections to conduct interviews with fishermen. Fishermen were interviewed by Joaquim Macassa, a professional technician of fish, employed at the Administração Nacional das Pesca (National Fishing Administration). During the conduction of interviews, it was noticed that a total number of ten interviewees per group was sufficient, as interviewees repeated answers which have been given by another interviewee. Hence, more interviews would not have led to more information. Details about the three different groups can be found in the following sections.

4.2.1. Experts

Interviewees were considered as experts when they had been conducting or still conduct research in the areas of interest, or when they helped implementing projects that enhance the livelihood of local communities and their interactions with marine and coastal ecosystems. Almost all experts belonged to local or global research institutes operating in the two study sites of interest.

In total, ten experts were interviewed. The interview consisted of five parts and about 20 main questions, followed by several sub-questions. The topics of the interview were as followed:

1) The background of the interviewee
2) Marine and coastal ecosystem services in the Inhambane Province, particular fish and their habitats
3) Fisheries and their influencers on fish stocks and habitats
4) Tourism and its influencers on fish stocks and habitats
5) Policy regulations in the fisheries and tourism sector
6) Interaction between fishery and tourism and possible solutions for a sustainable use of fish and marine and coastal habitats.

All interviews lasted about 30 minutes. The interview guide for experts is listed in Appendix I.

4.2.2. Tourism operators

Tourism operators were either owners of diving centers, diving center employees or owners of tourism activity centers. Most of the diving centers also provide other tourism activities next to diving. These activities are for example snorkeling, whale and dolphin watching or game fishing.

For tourism operators, an interview guide was compiled, as well as a survey. The interview consisted of five parts, containing about 16 main questions and several sub-questions. Topics of the interview were as followed:

1) The background of the interviewee
2) Information on the tourism center and its activities and their influencers on fish stocks and habitats
3) The livelihood of the interviewee (income, diversification of livelihood)
4) Policy regulations in the tourism sector
5) Fisheries, their interaction with these and possible solutions for a sustainable use of fish stocks and marine and coastal habitats.

The interviews lasted about 25 minutes. The interview guide for tourism operators can be found in Appendix I. A total of 6 tourism operators were interviewed. Some of them wanted their information to be handled anonymously.

The survey was sent via email to tourism operators who did not want to be interviewed or who had no time for an interview. The survey consisted of five parts including questions about the tourism operators, their livelihoods and tourism licenses. A total of four tourism operators filled in the survey. The survey can be found in Appendix II. In total, ten tourism operators took part in this research, from which five were from the I/T area and five from the V/B area.

4.2.3. Fishery operators

As mentioned earlier, fishery operators were interviewed in the field by Joaquim Macassa.

An interview guide and a survey were compiled for them too. Both had to be translated to Portuguese, Mozambique's national language. The interview guide consisted of five parts and about 20 questions. These five parts had the following topics:

1) The background of the interviewee
2) Information on the fishery, fishing efforts, fishing gear, fish species and influencers on fish stocks and habitats
3) The livelihood of the interviewee (income, diversification of livelihood)
4) Policy regulations concerning their fishing activities
5) Tourism, their interaction with tourist operators and possible solutions for a sustainable use of fish stocks and marine and coastal habitats.

The interview guide for fishery operators can be found in the Appendix I.

The survey consisted of the same 5 parts and was distributed among fishermen (Appendix II).

However, it was very time consuming to find a person who could help with the interviews in the field. Therefore, fishermen interviews were held at a very late stage of this study. Since this study was time limited to only five months, the results of fishermen interviews could not be included in this thesis; the execution and translation of the interviews is still taking place. Nevertheless, the results of these interviews will be included in a report for the umbrella project 'Coastal Cities as Sustainable Economic Hubs'.

4.2.4. Analysis

To analyze the information from the interviews, all interviews were transcribed verbatim. A content analysis was used to extract the most important information from the transcripts. The content analysis implies an initial coding framework, where at least two researchers read through the transcripts and assign codes (words or numbers) to major characteristic themes. Also new categories can emerge from transcripts and can be used to improve interview questions for further interviews. This analysis gives an overview of all categories of importance that can be used to answer research questions in the proposed research (Burnard *et al.* 2008; Dawson 2002).

A table with the most important parts per code was made for each group. Codes are words representing the most important categories for this research. Codes from the expert group were 'Marine and coastal ecosystem services', 'Role habitats', 'Fish stock changes', 'Economy', 'Influence fisheries', 'Influence tourism', 'policy of tourism/fisheries' and 'Possible solutions'.

'Where from', 'Activities', 'Used most', 'Influence on fish stocks', 'Livelihood', 'Licenses', 'Regulations/laws', 'Fisheries', 'Conflict/ Collaboration' and 'Possible solutions' were codes from the tourism operators' interviews.

Codes from the fishery operator interviews were 'Where from', 'Fishery location', 'Fishing activities', 'Gear and species caught', 'Influence on fish stocks/habitats', 'Livelihood', Licenses', 'Regulations/laws', 'Conflict/Collaboration' and 'Possible solutions'.

By assigning codes, the most important information was already sorted per topic. In this way, the information could be analyzed easily.

4.3. Secondary data

Secondary data can be divided into literature research, data sets and map collection. Literature research was conducted to find information on the current situation and policies. Data on the amount of fish caught and maps with the distribution of marine and coastal habitats and different threats were collected to analyze the amount of catch and the location of habitats. This section will give more details about the different secondary data approaches.

4.3.1. Literature research

A literature study was performed to gather background information on the topic. This information was used to understand whether a problem of overfishing exists and how the present study fits into the

umbrella project. The literature research was necessary to answer sub-research questions a), c), d), e) and f) (Table 1).

Furthermore, the literature research included laws on fishery and tourism policy regulations in Mozambique. As these laws were in Portuguese, they were translated into English using an online translation web page called online-translator.com (PROMT 2016). This information on regulations was crucial to align the guidelines to current policy legislation. Also, literature was found about the type of gear that is used by fishermen, about human population growth, and about tourism development in the I/T and V/B areas. In this way, gear restrictions and socio-economic demands could be determined. Population growth and tourism development information also showed in how far human development can become a threat for fish stocks and marine and coastal habitats.

To find literature, several online search engines were used. Scientific articles and reports could be found on Google Scholar and the Web of Knowledge. Google's search engine was used to find more information. Policy documents on fisheries could be found on the FAOLEX- legislative database of the FAO Legal Office (FAO 2016). Policy information on tourism was sourced from the Google web interface.

4.3.2. Data sets and maps

Data sets and maps layers were collected with the help from participants of the umbrella project and from Mozambican institutes. These data were used to analyze the impacts on fish stocks and on marine habitats, especially coral reefs. Maps were also used to show the location of marine and coastal habitats, the BANP and fishing restriction zones in the BANP. By gathering these data sub-questions a) and b) (Table 1) could be answered. Which datasets and maps were found through which organization will be described in this section.

Data sets

Data about artisanal fisheries were obtained from the Instituto Nacional de Investigação Pesqueira (IIP, National Institute of Fisheries Research). IIP databases showed information about the amount of catch of fish and the gear used for each month from 2004 to 2015. Four types of fishing and gear were distinguished: 1) Arrasto (trawling), 2) Emalhe de superfície (surface gillnets), 3) Linha (hook and line fishing), and 4) Gamboa (beach seine nets) (Figure 5). Data for the years 2007 and 2010 were lacking. Also, there were measurements lacking for many months. The data were divided into four areas: 1. Inhambane city, 2. Tofo, 3. Vilankulo, and 4. Bazaruto Island.

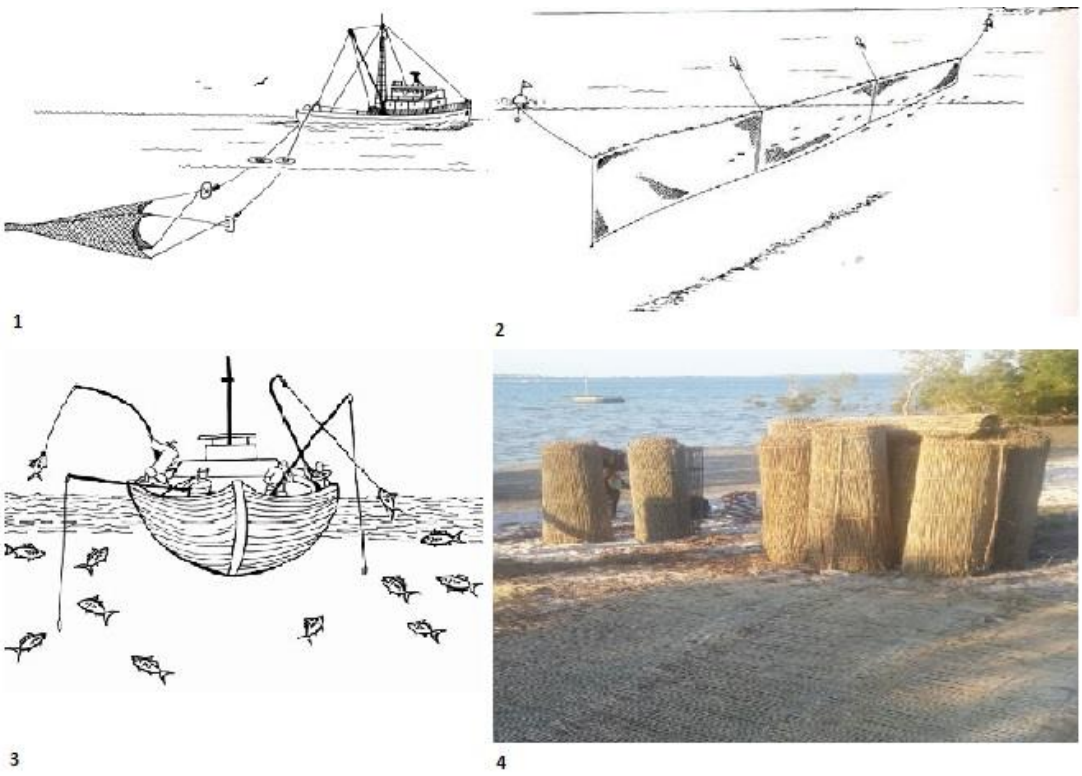


Figure 5 Different fishing types in the Province of Inhambane
1) Arrasto (trawling) (Alaska Seafood 2010);
2) Emalhe de superfície (surface gillnets) (Prefeitura de ANGRA Tempo de mudanças 2013);
3) Linha (hook and line fishing) (WWF 2009);
4) Gamboas rolled up at the beach (beach seine nets) (picture taken by Joaquim Macassa, 21.06.2016)

To analyze whether the absolute number of gear has influence on the amount of catch of fish, correlation analyses (Pearson's correlation) were performed with IBM SPSS Statistics 23. For trawling, surface gillnets and beach seine nets the absolute number of nets was used. For hook and line fishing, the absolute number of boats was used. Trend lines in scatter plots were drawn to show whether there is a positive or negative relation between the number of gear and the amount of fish. This could also be confirmed by looking at the Pearson correlation. The statistical procedure was discussed with and validated by experts. Correlation analyses were performed for the four areas independently. Significant outliers were removed from the dataset due to Pearson's r high sensitivity to outliers.

Data about human population growth and population projections were derived from the Instituto Nacional de Estatistica (INE, National Institute of Statistics). Microsoft Excel 2010 was used to sort the data and to make graphs.

Maps

The maps used in this report were compiled from different already existing map layers with ArcGIS and ArcCatalog 10.3.1. Firstly, ecosystem services maps were made on a national level, where differences between the provinces of Mozambique could be seen. Ecosystem services were divided into tourism,

fisheries landed values, coastal protection and recreation. It has to be noticed that the fisheries landed values include all aquatic species that were caught. There is no distinction between species like fish or crustaceans. Tourism and recreation seem to be similar, but have to be distinguished. Tourism values were derived from international and domestic tourism flows like the tourism arrivals and the revenues. Recreation was derived from activities that can be performed at the coast like diving or surfing (Nunes & Ghermandi 2015). The maps were used to determine the current situation of Inhambane compared to other provinces in Mozambique. It could be determined which ecosystems services need to be supported to increase socio-economic advantages for Inhambane.

Secondly, local maps for the areas Inhambane City/Tofo and Vilankulo/Bazaruto were created to indicate habitat distributions and different threats on coral reefs. Threats were already classified into over- and destructive fishing and coastal development and projections for integrated threats for 2030 and 2050. This pre-existing classification was adapted for this study. Also, the location of the Bazaruto Archipelago National Park (BANP) was displayed. These local maps were used to determine differences in threats between the two study areas.

Map layers about ecosystem services and habitat distribution were sourced from CORDIO. The coral reef map layer did not include all coral reefs in Tofo. Therefore, reefs were added to the layer. As a base layer, a map from the Mozambique Travel Service was used (Mozambique Travel Service 2010). Geoprocessing was performed in ArcGIS to match this base layer map with the coral reef distribution layer. In this way, the Tofo coral reefs could be added at the correct location. This performance included the assumption that the locations of the Tofo beach reefs were accurate. The ocean base map layer and the different provinces in Mozambique were obtained from the Environmental Systems Research Institute (Esri) ArcGIS Map Gallery (Esri 2016).

To display changes in the level of different threats on coral reefs, information was used from ReefBase (ReefBase 2016). Information on fishing and coastal development threats was from 2011. Even though this information is five years old, it is the most recent information that could be found for the two study areas. ReefBase displays information on a global level, which is why information on a local level for the areas I/T and V/B could have been less accurate. Also, the Tofo coral reefs were not included in ReefBase. Therefore, the level of threats was estimated based on the surrounding reefs in the north and south, which always had the same level of threat. Therefore, it was assumed that the Tofo reefs in the center have the same level of threat.

To show the location of the BANP and the restricted fishing zones within the BANP, information was used from a map on the internet published by the Cashew-Bay Lodge (Cashew-Bay Lodge 2010). All maps in this thesis were adapted from map layers from CORDIO, including supplement information from other sources.

Analyses of visible habitat changes were not included in this study, because no data was available to study and analyze these changes. Landsat images from the Millennium Coral Reefs Landsat

Archive for example were only available for 2002 for V/B and 2001 for I/T (USF Millennium Global Reef Mapping Project *et al.* 2007). In this way it was not possible to analyze visible changes of coral reefs.

4.3.3. Link between primary and secondary data

The primary data formed the core of this study. It was used to analyze the situation and to determine solutions. Secondary data was used as supplement information to determine underlying developments like the tourism and fisheries economy. Even though interview guides included questions on all relevant topics for this study, interviewees were sometimes not sure or did not know an answer. Further information which was not obtained from the interviews, like the income of fishermen and tourism operators, the current policy regulations, the type of gear that is used and the amount of fish that is caught, could be gathered through secondary data. Secondary data was also very important to find information about the fishing sector, since data from interviews with fishermen could not be included in this study.

By linking primary and secondary a more complete picture of the current situation could be analyzed. Based on both types different results could be obtained. The following chapter will focus on these outcomes.

5. Results

This section presents the results that were obtained through the primary and secondary data collection. First, more general results about ecosystem services in the PoI will be given, followed by the results per sub-question.

5.1. Ecosystem services in the Province of Inhambane

The Province of Inhambane has a wide variety of ecosystem services through coastal and marine ecosystems like tourism, fisheries, coastal protection and recreation. In terms of these four ecosystem services, Inhambane is put in comparison to other coastal provinces of Mozambique; Cabo Delgado, Nampula, Zambezia, Sofala, Gaza and Maputo. All services are expressed in monetary values (million $US per year) to make a comparison possible.

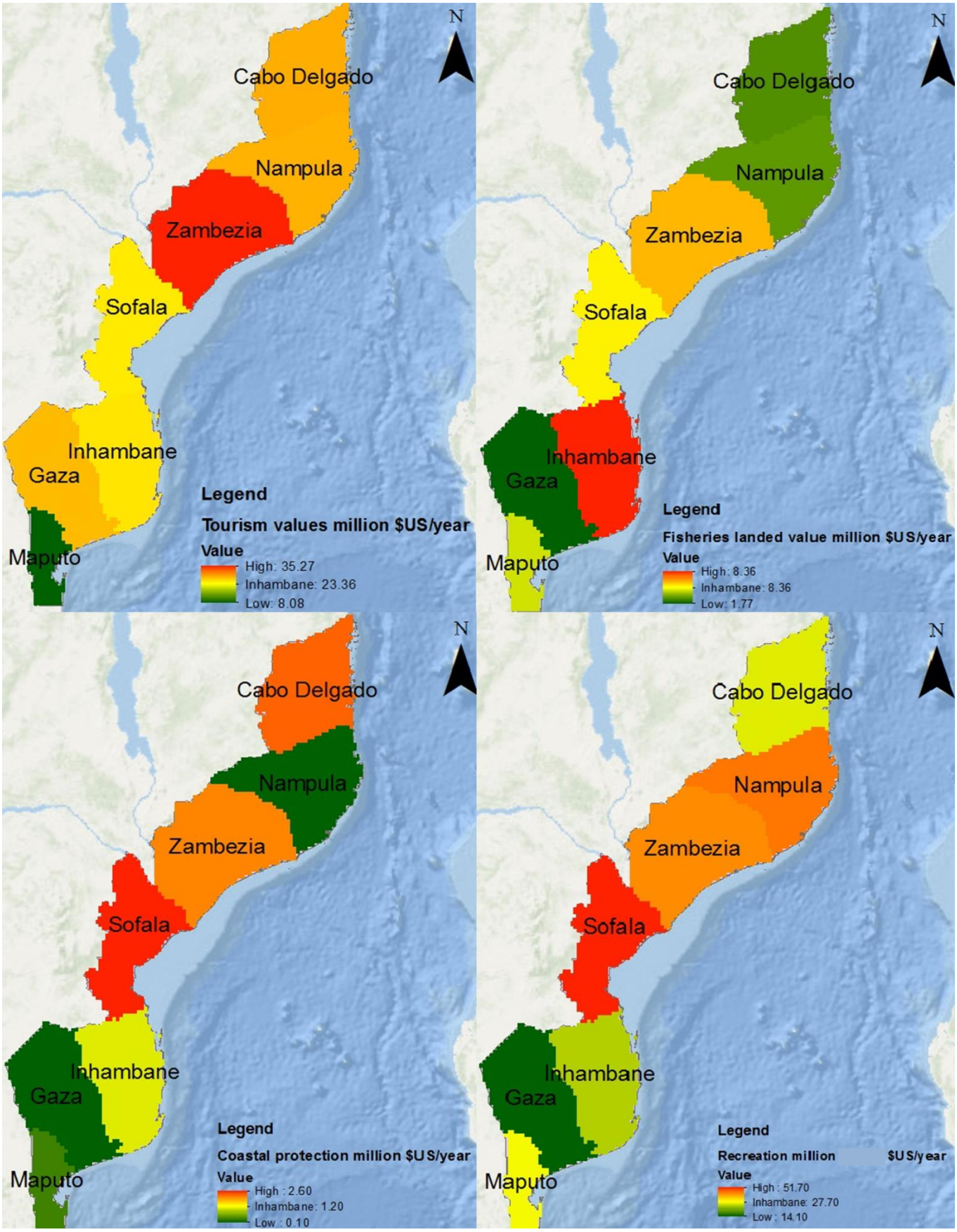
Looking at tourism, a recreational service, the PoI has high values (23.36 million $US/year) compared to Maputo (8.08 million $US/year) (Map 4). However, the PoI has low values compared to all other provinces. The highest tourism values can be found in Zambezia with 35.27 million $US/year (Nunes & Ghermandi 2015).

The provision of food like fish is an important marine ecosystem service for people's survival and livelihoods. Comparing all coastal provinces in Mozambique, one can see that the PoI has the highest fisheries landed values per year (8.36 million $US/year) and that Gaza has the lowest fisheries landed values (1.77 million $US/year) (Map 4). Zambezia and Sofala are the second highest, followed by Maputo, Nampula and Cabo Delgado (Nunes & Ghermandi 2015).

An important service that is provided by ecosystems is coastal protection, a regulating service. When looking at the different provinces, Inhambane's coastal protection value (1.2 million $US/year) is between the highest (2.6 million $US/year for Sofala) and the lowest (0.1 million $US/year for Nampula) values (Map 4) (Nunes & Ghermandi 2015).

Recreation is also an important cultural ecosystem service and is closely related to tourism. Sofala has the highest recreation values (51.70 million $US/year) and Gaza the lowest (14.10 million $US/year) (Map 4). The PoI recreation value is more than twice as high as the value from Gaza. However, when looking at all the provinces, the PoI has the second lowest recreation value with 27.70 million $US/year (Nunes & Ghermandi 2015).

From these results it can be seen that the PoI has high values for the fisheries landed values. When looking at other benefits of marine and coastal ecosystems, the PoI has average values compared to the other provinces. However, the values for the recreational and tourism services are going to increase due to the development of the tourism sector in the PoI. The PoI is one of the main destinations for diving and snorkel tourism, which are increasing sectors and which will increased the values. In return, the pressure on cultural ecosystem services is going to increase too. Conservation of marine and coastal habitats is needed to increase the values for coastal protection through the protection of cultural and regulating services.



Map 4 Ecosystem services values for tourism, fisheries, coastal protection and recreation
(Nunes & Ghermandi 2015)

5.2. Influencers on fish stocks and marine and coastal habitats

In the PoI there are several influencers that effect fish stocks and the habitats. The fishery and the tourism sectors are the main among those. This section shows the results for the first research sub-question:

a) What influencers from the tourism and fisheries sector impact fish stocks and marine and coastal habitats and how do these sectors interact?

An overview of influencers on coral reefs and fish stocks can be found at the end of this section (Figures 6 to 9). The results for this section were obtained from the analysis of primary data.

5.2.1. Marine and coastal habitats and fish stocks

Marine and coastal ecosystem services in the I/T and V/B are experiencing a decline. This has been recognized by almost all interviewees. Mangrove forests are an exception. They are stable due to successful conservation campaigns (Zacarias, pc[2], 2016).

Anecdotal evidence shows that coral reefs (cultural and regulating services) have decreased over the past years (Flam; Zacarias, pc, 2016). There are no successful campaigns set up to protect coral reefs (Zacarias, pc, 2016). Species richness also declined due to the catch of grazers like fish and crustaceans. The presence of grazers limits algae growth, which takes over corals if grazers are removed from the food chain (Lundin; Zacarias, pc, 2016). Influencers through tourism such as diving and snorkeling decreased the abundance of soft coral (Levack, pc, 2016). However, the lack of data and information to establish evidence for coral reef degradation was mentioned (Flam; Interviewee A; Interviewee C pc, 2016; Adamo; Bateman, survey, 2016).

There is also anecdotal evidence that fish stocks (provisioning and cultural services) declined (Mclean *et al.* 2014). Fishermen noticed that their catch of fish and sharks has decreased over the past five to ten years (Allen; Zacarias, pc, 2016). In I/T it occurs that fishermen go fishing for five hours and catch nothing (Hof, pc, 2016). Examples of declining species are grouper species, kingfish species, jobfish, croaker species and sharks. The abundance of Marlin on the other hand might have increased, based on the observation of increased catch (Interviewee C, pc, 2016).

Megafauna are also an important aspect for the PoI since the diving tourism is highly dependent on whale sharks and manta rays. Between 2003 and 2011, declines have been noticed for manta rays (88%) and for whale sharks (79%) (Rohner *et al.* 2013). This has also been observed by interviewee B (2016) who stated that sightings of megafauna decreased by 80% in the past ten years. According to Rohner et al. (2013), this decline takes place due to increasing numbers of tourism activities and destructive fishing by local fishermen. Moreover, ocean currents are an important food source for whale shark. Changes in currents occurred due to climatic changes and whale sharks adapted to the new routes (Levack, pc, 2016).

[2] pc = personal communication, and refers to the personal communication through interviews

5.2.2. Tourism

In 2004, the PoI had the highest number of leisure activities establishments and most of Mozambique's total leisure tourists (Ministério do Turismo 2004). In the past years, other provinces like Zambezia and Cabo Delgado increased their investment in tourism and therefore increased their tourism values. Nevertheless, the PoI is still one of the major tourism destinations in Mozambique (section 2.1.2) (Ministério do Turismo 2015). Within the PoI, the two study areas experience the biggest tourism developments (Ministério do Turismo 2004). The I/T region provides key products like water sports, bird watching, culture, sun, sea and sand. Market segments can be divided into domestic, regional and international, and into leisure, special interests and backpackers. The V/B area provides sun, sea and sand as well, as well as coastal eco-tourism and water sports. The market segment here is both international and regional leisure (ACIS *et al.* 2014).

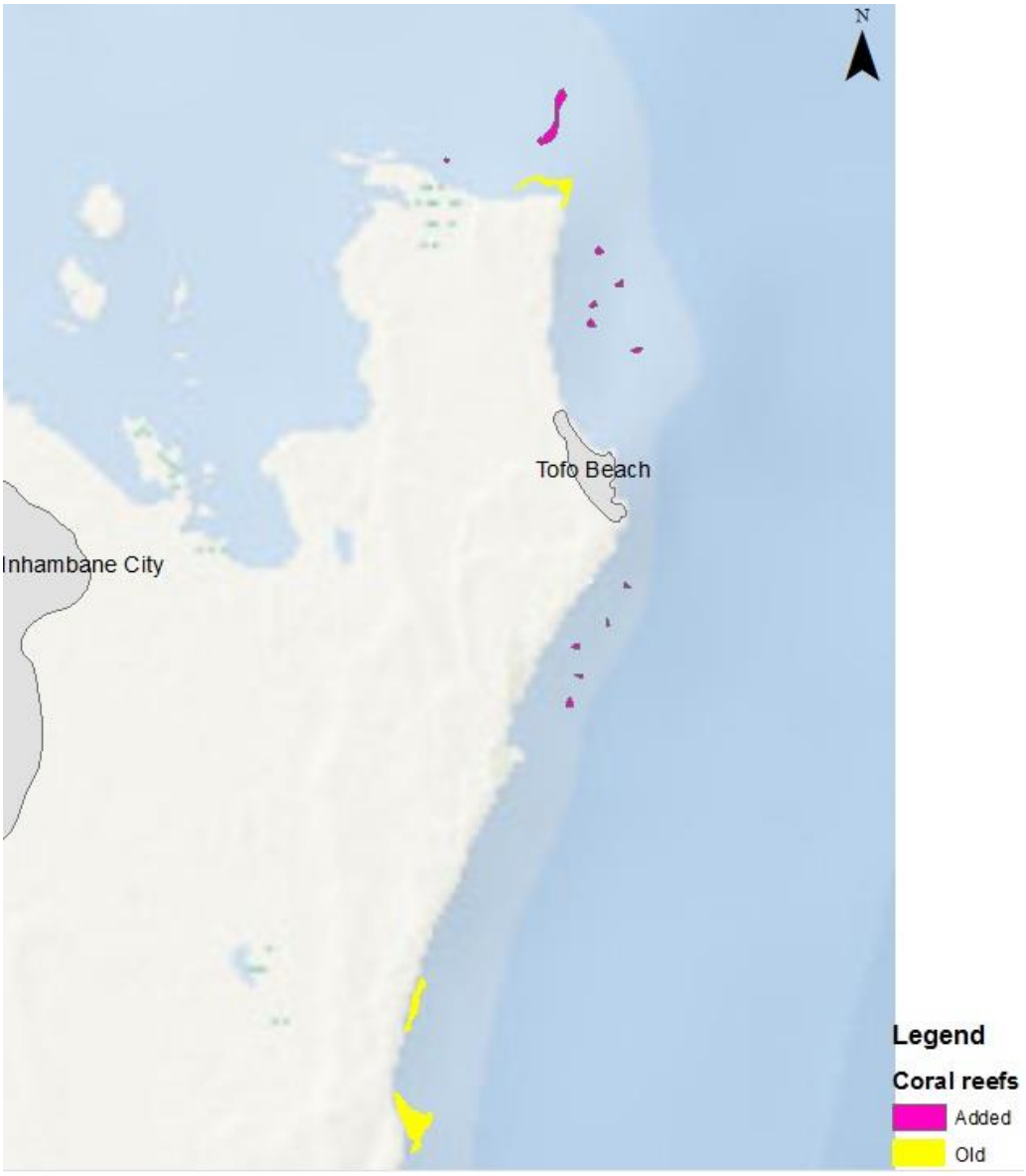
For both study areas diving and fishing are the main activities conducted by tourists (DPTUR *et al.* 2007). In Inhambane City, 67% of all tourism establishments offer aquatic sports and diving, and another 10% are interested in offering these activities. Also, 29% of the establishments offer sport fishing, whereas another 38% are interesting in offering it (DPTUR *et al.* 2007). The impact on provisioning services (fish stocks), cultural and regulating services (marine habitats) is mainly induced through diving, snorkeling and recreational and sport fishing activities and will be explained in more detail in the following sub-sections.

Diving and snorkeling

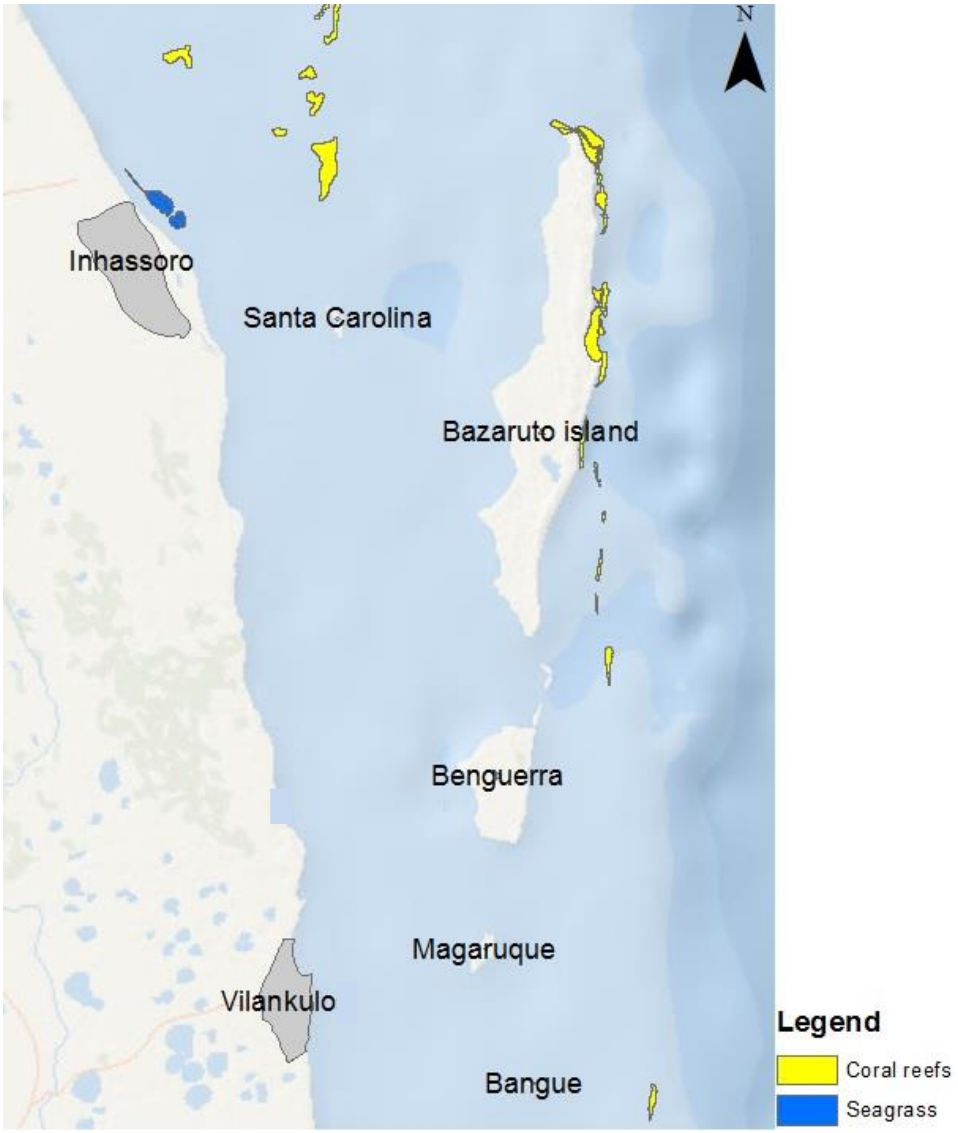
In the two study areas, coral reefs are found along the coast (Map 5 and Map 6). Dive centers go out for dives and snorkeling at all reefs in the I/T and V/B regions. The numbers of dives and snorkeling varies and depends on the number of tourists. One dive center in Vilankulo has about 900 to 1000 snorkelers per year (Rocco, pc, 2016). Usually about one to four boats are sent out per day and two dives are done per boat, but occasionally also four take place (Allen; Levack; Rocco; Interviewee B, pc, 2016). It has been observed that at some reefs, diving does not take place every day which lowers the impact because rotation takes place (Allen, pc, 2016).

The number of people on the boat is limited by the diving centers. One dive center in Tofo takes a maximum of 12 people out, of which two are staff (Levack, pc, 2016). Another dive center in the V/B area has on average six to eight divers per boat (Interviewee D, pc, 2016).

From the interviews it became clear that in both areas coral reefs are seen as important dive spots (Interviewee D, pc, 2016). Since the diving sector is growing rapidly, it can be expected that the influencers of diving and snorkeling on fish stocks and coral reefs will increase (Ministério do Turismo 2004).



Map 5 Location of coral reefs in the Inhambane City/Tofo area
Old reefs were in the CORDIO base layer, 'added reefs' were added to this layer (see section 4.2.)



Map 6 Location of coral reefs in the Vilankulo/Bazaruto area

Coral reefs

Coastal tourism is an important part of coastal development. The threats of coastal development on coral reefs are differ in the two areas. All reefs in the I/T area are reported to show a medium level of threat in 2011 (Map 7). Most reefs in the V/B reported a low level of threat in 2011, with an exception of one reef in the north with a medium level (Map 8).

Even though there are several coral reefs in both study areas, some reefs are visited more often than others due to access, travel time or the probability of encountering marine megafauna (Mclean *et al.* 2014). In this way, pressure on specific coral reefs is increased, while others have more time to recover from damage (Mclean *et al.* 2014). In Tofo, shallow reefs nearby the coast are affected as the site serves as a diving learning location (Hof, pc, 2016).

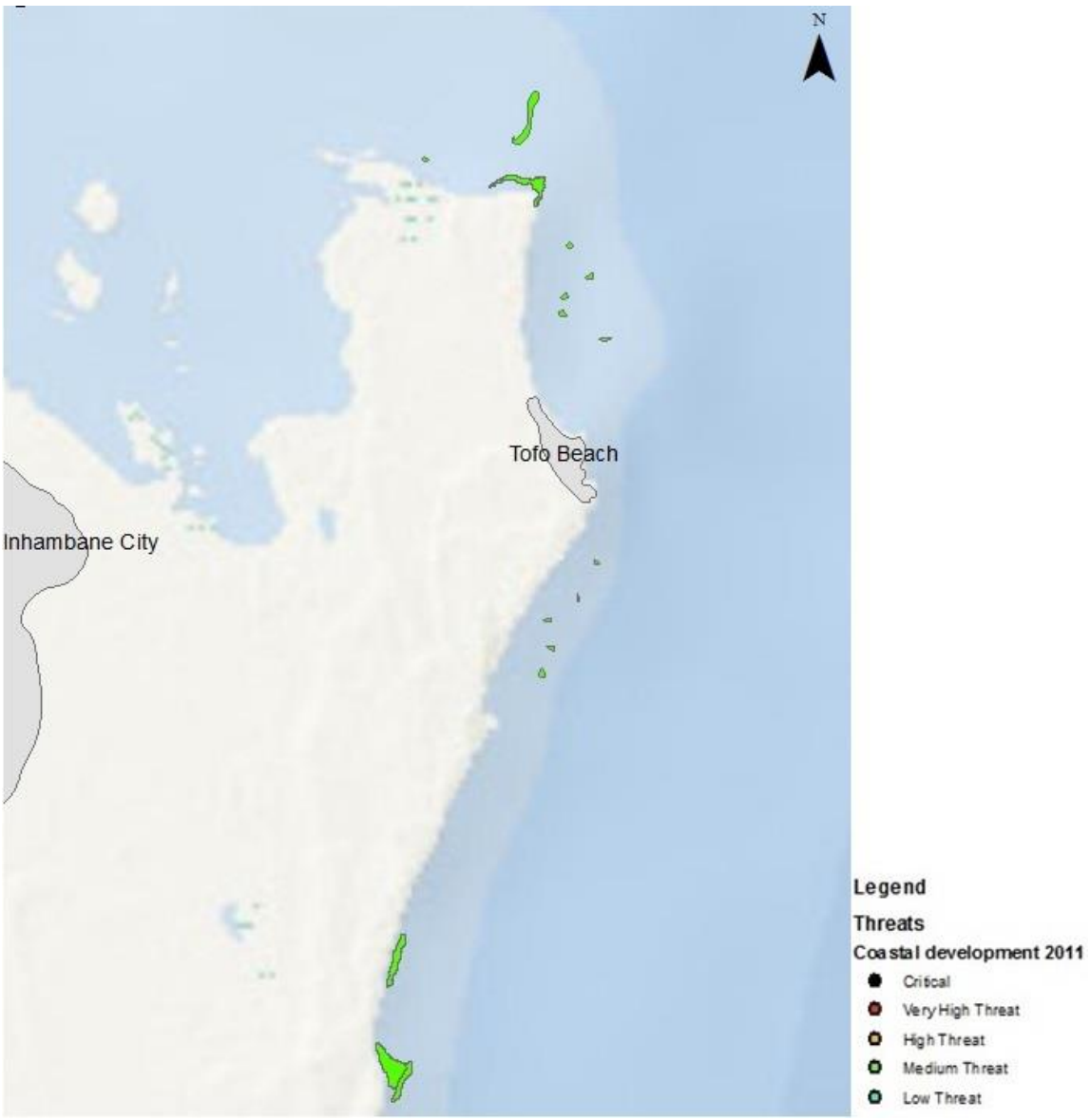
Diving and snorkeling have more direct influence on the coral reefs than on fish and can change the reef structure through inadvertent physical damage (Allen; Flam; Levack, pc, 2016). Divers and

snorkelers hold on to reefs and break off coral pieces by hitting the coral with their fins (Hof; Levack, Reeve-Arnold; Interviewee A, pc, 2016). Before the dives, tourism operators inform tourists to be aware of the environment and to not kick the coral. However, it still happens (Interviewee D, pc, 2016).

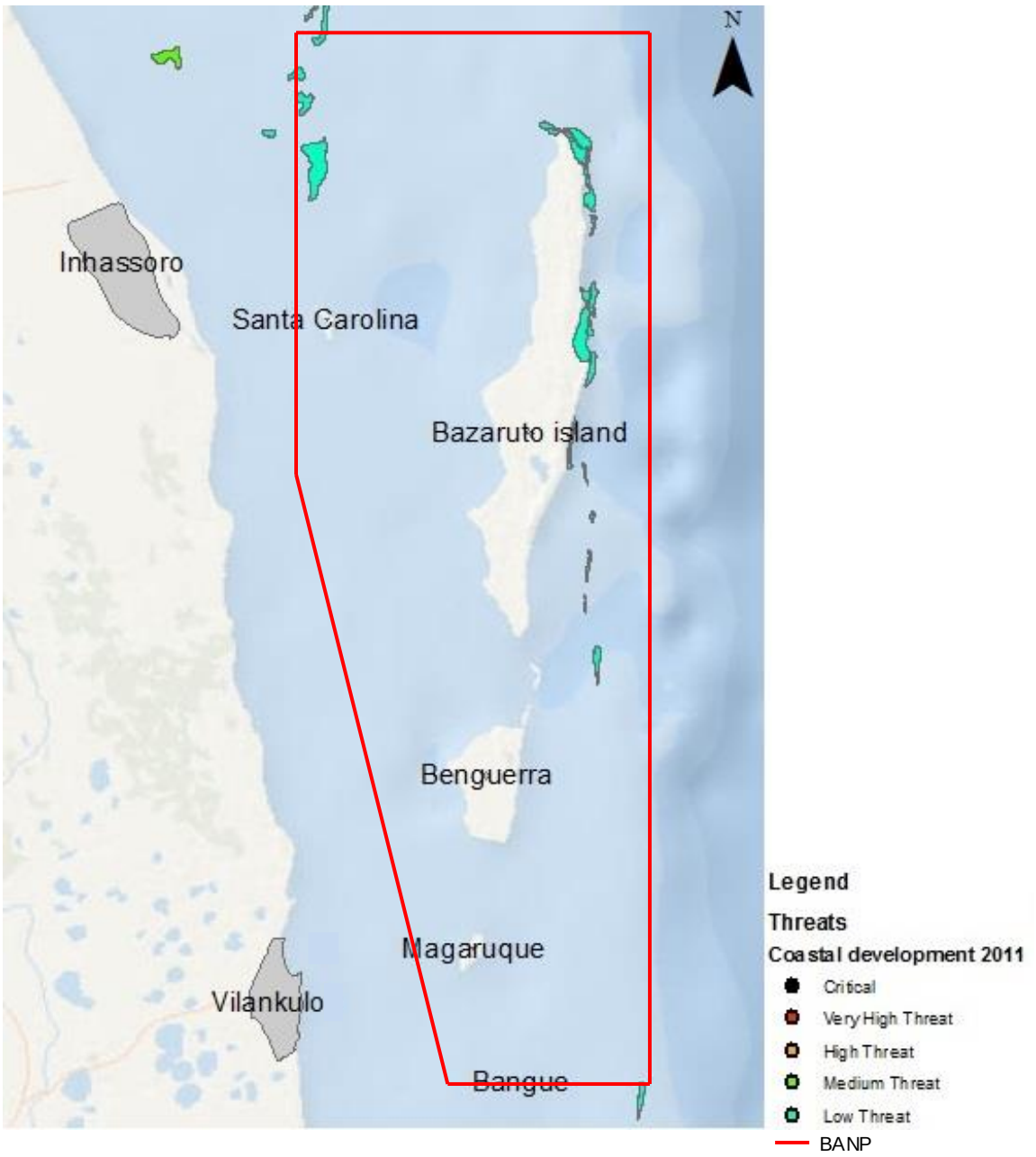
The level of the diving license reflects different tourism behavior (Lundin, pc, 2016). It can be expected that inexperienced divers create more damage on coral reefs than experienced divers. Dive students need to learn to control their buoyancy to keep a certain distance between them and the environment. The correct use of wet suits and weight belts is required to help divers to gain a horizontal swimming posture. This is already implemented in dive centers in the I/T and V/B areas (Everett *et al.* 2008). Furthermore, damage on corals is caused through anchoring of boats on reefs, which causes coral break off (Allen; Retzlaff; Interviewee D, pc, 2016).

Even though the results show that the threat on coral reefs through diving exists in both areas, some interviewees do not see diving as the major underlying tourism activity causing coral reef degradation. Diving has rather a small impact, compared to other influencers like snorkeling, fishing or human population increase (Allen; Rocco; Silva, pc, 2016). Snorkeling is easy to learn, which is why snorkelers might not be briefed about accurate behavior in the ocean. Furthermore, in contrast to divers, snorkelers swim above the reef in shallow water, which increases the chance of a fin strike (Rocco, pc, 2016).

The magnitude of the impact on coral reefs in general depends on the management of tourism activities (Allen; Lundin, pc, 2016). Well managed operations "*don't really need to have much of an influence on the actual coral*" (Lundin, pc, 2016). The diving and snorkeling sector is predicted to expand in the future. Currently, the impact of influencers on fish stocks and marine and coastal habitats may not be that significant or worrisome, but it can be expected that the impact will increase (Fiege *et al.* 2003). Therefore, adequate management is needed to conserve reefs to maintain their cultural and regulating services.



Map 7 Coastal development threat on coral reefs in Inhambane city/Tofo
(ReefBase 2016)



Map 8 Coastal development threat on coral reefs in Vilankulo/Bazaruto
(ReefBase 2016)

Megafauna and fish

In the I/T area it has been noticed that diving has an impact on megafauna (Flam; Reeve-Arnold; Zacarias, pc, 2016). Physical damage can be caused through touching megafauna which can lead to skin infections (Fiege *et al.* 2003).

Next to touching animals, solely the presence of divers on the reefs can create disturbances in the megafauna's behavior (Interviewee A, pc, 2016). Manta rays at cleaning stations[3] leave these places and move on when divers arrive. Megafauna will only return to these stations when the divers are gone

[3] Cleaning stations are reef sections which are homes to cleaner fish that clean megafauna.

(Levack, pc, 2016). Divers can also scare off manta rays in general, which start avoiding the dive sites (Allen, pc, 2016).

Changes in shark behavior were also recognized. Sharks tend also to swim away from divers or snorkelers (Interviewee D, pc, 2016). The noise of the dive boats can also have influence on megafauna and sharks and scare them (Allen, pc, 2016).

When looking at the impact on reef fish, interviewees agreed that diving has no impact on fish species at the moment (Zacarias; Retzlaff; Interviewee A; Interviewee D, pc, 2016).

Recreational and sport fishing

Fishing in the tourism sector has less influence on marine and coastal habitats, but more impact on the fish itself. Anglers contribute to the exploitation of fish (Fiege *et al.* 2003). Fishing in the tourism sector can be divided into recreational fishing and sport fishing:

The definition of recreational fishing is "fishing by an amateur fisherman out of sport fishing contests" (República de Moçambique 2013). Sport fishing on the other hand "[…] is performed by amateur fisherman, in sport competition, according to international rules and regulations formulated by the contest organizers and competitions with a view to obtaining sport marks, including training and learning" (República de Moçambique 2013). Sport fishing also includes the deep-sea game fishing, where the target species include marlin, sailfish and tuna. Deep-sea fishing is seen as a key activity for regional, island and resort markets (Ministério do Turismo 2004). The influence on fish through recreational and sport fishing will be described in the following section.

Influencers on fish

According to Interviewee C (2006), 20% of the fish kill taking place in the V/B area is due to recreational and sport fishing. Species caught are for example black, blue and striped marlin, sailfish, wahoo, dorado, king mackerel or yellow fin tuna (Interviewee C, pc, 2016). Competition for catching the big species exists. In the I/T area for instance, a fishing event takes place once a year (Reeve-Arnold, Siniquinha; Interviewee A, pc, 2016).

One tourism operators takes out four people per day, ten days a month on average (Interviewee C, pc, 2016). During the peak season between September and December, another tourism operator takes tourists out six to seven days in the week (Rato, survey, 2016).

The gear used is rod and reels with different sizes (Interviewee C, pc, 2016). This gear is selective and targets specific species of fish (Allen, pc, 2016). Sport fishermen in the two study areas conduct catch and release, where fish are caught and released back to the sea as soon as possible (Interviewee A; Interviewee C, pc, 2016). King mackerel, yellow fin tuna, wahoo or dorado are taken for private consumption or for lodges (Interviewee C, pc; Rato, survey, 2016). One tourism establishment in the BANP releases demersal fish like billfish and kingfish species, barracuda, and jobfish for 100% (Rato, survey, 2016).

Instead of simple 'catch and release' more and more fishermen implement the method 'tag and release' (Allen, pc, 2016). Fish that are released to the sea are tagged so they can be followed and their information can be collected in databases for research (Flam, pc, 2016). Even though releasing of the fish takes place most of the times, fish die during the catch/tag and release procedure (Allen, pc, 2016). It occurs that swim bladders of small fish blow up when they are fished from the deeper ocean due to pressure differences (Interviewee C, pc, 2016). The following factors cause stress and physical injuries (Ricardo 2004):

- Physical injuries: Damage is caused with the hooks and during the handling of the fish.
- Stress: Stress is caused through the exertion from tagging or the fight when the fish is caught.
- Differences in temperature between external and water temperature can lead to death.
- The time fish is exposed to the air is prolonged when anglers remove the hooks slowly, take pictures and tag the fish.

When looking at the use of marine space, sport fishing activities take place in other marine areas than local fishing activities. Sport fishermen fish further off shore because transportation by motorized boats allows bigger distances (Allen, pc, 2016). If fishing takes place at coral reefs, an important statement concerning game fishing was made by Interviewee C (2016): "*I find a new reef and you catch for freaking two years on it and then they will just disappear and then we pretty much wiped them out*". This statement shows that the abundance of fish stocks can be diminished within a short time period.

However, recreational and sport fishing are, like diving, not seen as a major reason for fish decline (Allen, pc, 2016). The major reason for fish and habitat degradation is fishing by local fishermen, which will be described in the next section.

5.2.3. Fisheries

Most of the local fishermen conduct artisanal fishing, which will be the main focus of this section. Artisanal fishing is an important aspect for the survival of local people, who highly depend on marine and coastal ecosystem services (Allen, pc, 2016). Fishermen go out every single day and try to catch as much as possible. However, their fishing activities highly depend on the weather. Many of the fishermen cannot swim and do not go fishing during rough weather conditions (Allen, pc, 2016)

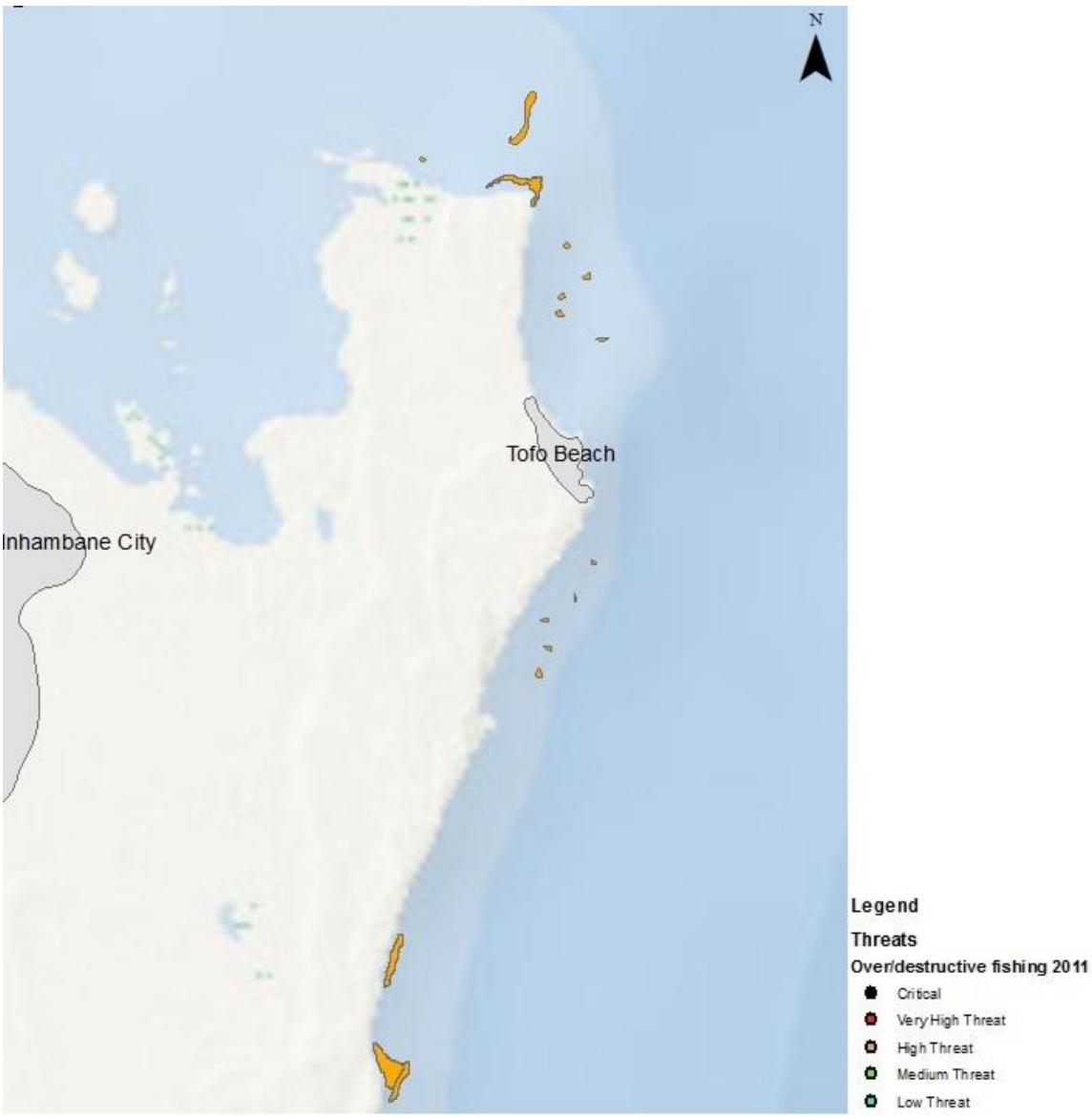
According to many interviewees, fishing, and especially artisanal fishing, has the biggest impact on fish stocks and marine and coastal habitats in various ways (Hof; Lundin, pc, 2016). The pressure of fisheries has increased in the past years and local fishermen create more damage than all tourism activities combined (Allen; Interviewee B, pc, 2016). Influencers on coral reefs, fish, megafauna and sharks and the influencer commercial fishing will be discussed to show impacts on provisioning, regulating and cultural ecosystem services.

Coral reefs

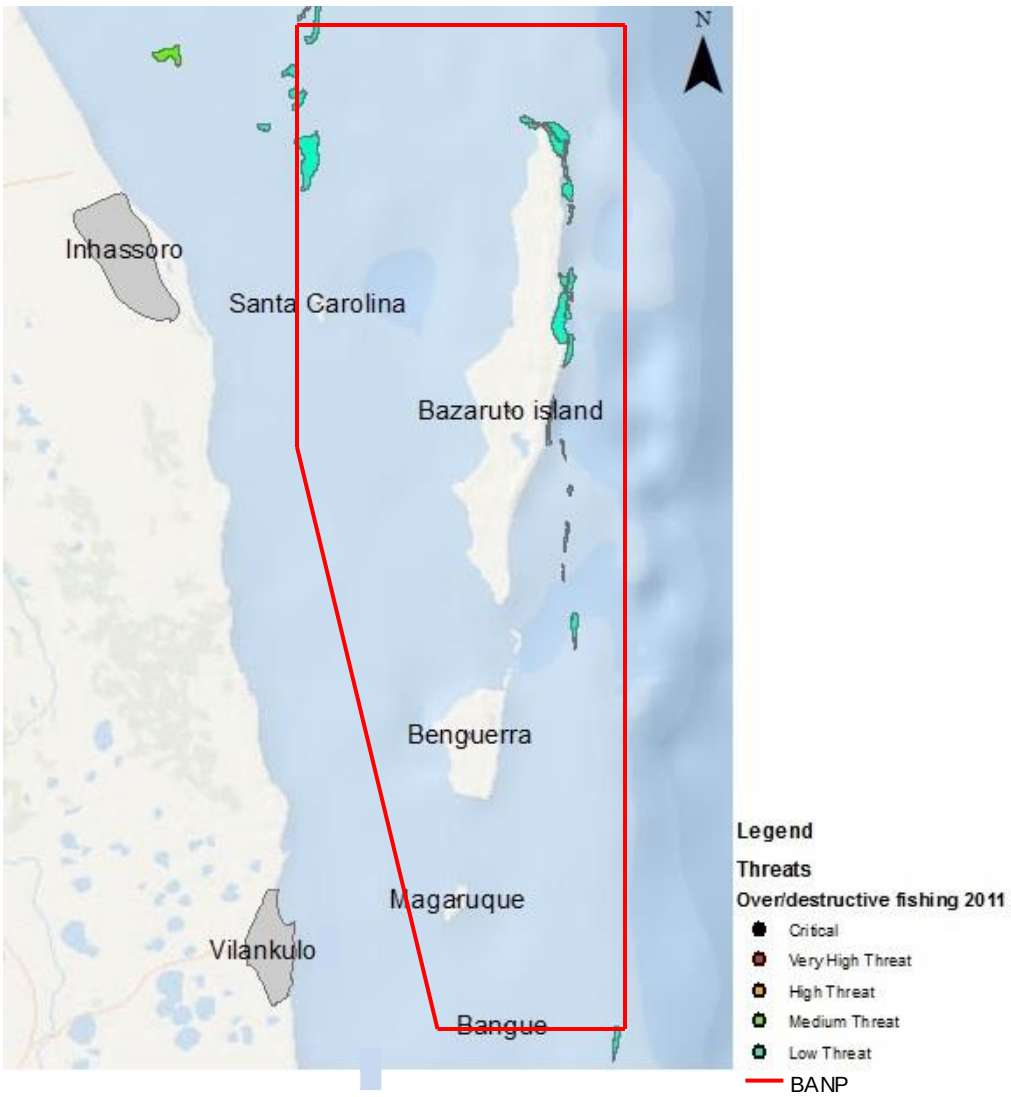
Over- and destructive fishing are influencers on coral reefs in the two study areas. In I/T, all coral reefs were at a high level of threat due to over and destructive fishing in 2011 (Map 9). The influence of fishing was less on coral reefs in the V/B area, where almost all coral reefs were at a low threat in 2011 (Map 10). Only one reef in the north was at medium threat level.

Corals reefs are an important habitat for various fish. Therefore they are also an important and easy fish source for fishermen (Allen, pc, 2016). The impact on inshore reefs increases due to an increased fishing effort. Fishermen cannot find fish in others areas of the marine space anymore and need to fish close to corals (Lundin, pc, 2016). Lines, seine and gillnets that are used on the reef happen to end up tangled on corals or flow around as ghost nets which can lead to coral die off (Allen; Lundin; Reeve-Arnold, pc, 2016). Also, when gillnets above corals are hauled, pieces of corals break off by accident and are taken on board with small animals that live in these pieces (Interviewee A, pc, 2016).

Another important aspect is the fact that fishermen often cannot afford a motorized boat and stay close to the coast, where reefs are located (Zacarias; Interviewee A, pc, 2016). However, a change is taking place. More and more fishermen switch from canoes to motorized boats to increase their areas of operation (Zacarias, pc, 2016). Trainings about boat construction were given for fishermen so they can build and use more boats (Patrocinio, pc, 2016). The World Bank and other investors provided money to fishermen to support motorized boats. In this way, also pelagic species can be targeted (Levack, pc, 2016). However, the use of boats increases physical coral reefs damage through anchoring (Allen; Interviewee B, pc, 2016).



Map 9 Over- and destructive fishing threat in Inhambane city/ Tofo
(ReefBase 2016)



Map 10 Over- and destructive fishing threat in Vilankulo/Bazaruto
(ReefBase 2016)

Fishing gear

The impact on fish is mainly determined by the type of gear that is used by artisanal fishermen. Many fishermen do not have a lot of money and use whatever gear that can be found (Silva; Interviewee B, pc, 2016). Gear that is used are seine nets, gillnets, spears, hook and line from boats and shore, fish traps and long lines (Allen; Hof; Lundin; Interviewee A; Interviewee B; Interviewee D, pc, 2016).

A change from hook and line to gillnetting has occurred in the past because fishermen could not catch enough fish anymore (Hof, pc, 2016). The decline in catch also forced fishermen to use mosquito nets for fishing, which have a small mesh size and catch a lot of fish at once (Hof; Silva, pc, 2016). Also, small mesh sizes lead to the catch of juveniles (Silva, pc, 2016). Because mosquito nets are forbidden according to regulations, fishermen fish at night when the probability of patrolling by the government is smaller (Hof, Silva, pc, 2016).

Which type of gear is used also depends on whether fishermen can afford a boat or not (Allen, pc, 2016). Fishermen that cannot afford a boat use mosquito nets to increase their catch (Zacarias, pc, 2016). Furthermore, the government provides gillnets to local fishermen so they can increase their catch and the price for seine nets has become more affordable (Allen; Interviewee A, pc, 2016).

Due to their unselective character and their high use, seine and gillnets are seen as the most destructive and devastating gear impacting provisioning ecosystem services (Allen; Hof; Interviewee D, pc, 2016). Nets can be up to 500 meters long, which makes the catch of many fish possible, and are left in the sea for a few days to increase the catch (Zacarias, Interviewee A; Interviewee B, pc, 2016). The unselective fishing methods also have a high bycatch, but according to Silva (2016) all bycatch is eaten and no fish is wasted in the northern part of Mozambique. Based on the data gathered for this study, it is unknown whether this also occurs in all areas of the PoI.

In both study areas, the orientation of gillnets also creates a problem. Often nets are oriented perpendicular to the coast, which restricts transient animals from moving along the shore. If nets would be oriented parallel to the coast transient animals could move and fishermen would catch fish that comes in and out with the tides (Reeve-Arnold, pc, 2016).

In the BANP the influence of seine netting is very high in the west of the park. Sand banks are located between the islands and the coast, which makes it a suitable netting spot for fishermen who stand on these banks. Especially at low tide the sand banks are convenient fishing grounds. Also hand lining is taking place from the sand banks (Allen, pc, 2016).

Next to seine and gillnets, long lines (lines with many hooks) have an impact as they are not very selective and flow around in the ocean, which creates danger for any aquatic animal. Often these lines are constructed like clothes lines where one line is above the other (Reeve-Arnold, pc, 2016).

Experience shows that selective gear like fish traps can also have a very negative impact. Fish traps can smash the environment and just catch only specific species. The removal of certain species in high numbers has influence on the ecosystem equilibrium, for example the food chain. When using selective gear, one has to make sure which species are caught so that the equilibrium can be maintained (Lundin, pc, 2016).

Megafauna and sharks

Whale sharks and mantas have declined "*a lot*" in the last 13 years in the I/T area (Flam, pc, 2016). Megafauna are caught by fishermen for food and for sale or end up as bycatch in nets (Flam; Hof, pc, 2016). Gills nets are the most influencing type of gear for megafauna because these nets are unselective (Hof; Interviewee A, pc, 2016). Also sharks and turtles are caught as bycatch. Due to the use of gillnets around coral reefs, the probability of megafauna in bycatch is increased (Hof, pc, 2016).

Sharks are not only caught as bycatch. Illegal shark finning takes place in the I/T area (Bateman; Siniquinha; Reeve-Arnold; Interviewee A, pc, 2016). Protected species like sharks, manta and other rays, parrot fish, potato and brindle bass can be seen slaughtered on the beaches or sold on the streets or the markets on a daily basis in the V/B area (Rato, survey, 2016).

Temporary fishing closures can also have a negative impact on megafauna. During the closure period the fish stocks recover and more fish becomes available. However, after the closure ends fishermen start fishing as much as they can and reduce the amount and sizes of fish quickly. To maintain their livelihood and food security they start fishing megafauna and sharks when fish is not sufficiently available anymore (Rocco, pc, 2016).

Commercial fishing

Next to artisanal fishing, commercial fishing was mentioned as an influencing factor on fish stocks. Interviewee C (2016) mentioned that fishermen with commercial doughs are the major problem of decreasing fish stocks in the V/B area. Rato (2016) observed that numerous commercial vessels move into the BANP at night and start illegal fishing in the park.

Commercial fishing takes place in deeper waters and is a major reason for the decline of fish stocks in the Mozambican channel and the Western Indian Ocean in general (Hof; Levack; Zacarias; Interviewee B, pc, 2016). Every country that has a fishing fleet conducts fishing activities in the Indian Ocean (Levack, pc, 2016).

The use of unselective gear increases the decline in fish (Interviewee C, pc, 2016). Trawlers use mosquito nets in the last parts of nets to increase their catch. Furthermore, trawling destroys the ocean bottom and smashes coral reefs (Silva, pc, 2016). This is a bigger problem in Maputo where more trawling is taking place than in the northern parts of Mozambique (Interviewee A, pc, 2016).

5.2.4. Interaction between tourism and fishing

It is known that artisanal fishermen and tourism operators share the same marine space, which leads to competition for natural resources (Pereira *et al.* 2014). One dive operator said that there is no interference with fishermen and therefore no disturbance by fishermen during the dive and snorkeling activities (Adamo, survey, 2016). Levack (2016) states that fishermen fish at dive sites, but that is not considered as a problem.

However, most interviewees agreed that there is a conflict between these two sectors (Allen; Bateman; Levack; Patrocinio; Reeve-Arnold; Rocco; Zacarias, pc, 2016). Zacarias (2016) categorizes this conflict as "*terrible*" and Revee-Arnold (2016) sees the conflict as "*underlying*". Underlying means that the conflict is always present. Both sectors blame each other for fish and coral reef declines and hardly communicate, which makes collaboration difficult. But they also depend on each other through the local seafood market, since tourism operators buy fish from fishermen for their guests (Revee-Arnold, pc, 2016). The conflict evolved because both sectors blame each other for the degradation of provisioning, cultural and regulating ecosystem services.

Fishermen's view

Flam (2016) made the experience that fishermen say "*well it's not our fault that there is no fish, it's all the divers fault because of this and this*". Fishermen see divers as a threat and disruptive to corals. They scare off fish by chasing them and destroy the reefs (Flam; Hof; Reeve-Arnold, pc, 2016).

Next to diving, game fishing is influencing fish stocks and fishermen. Some game fishers target species that local fishermen target as well, which increases competition for the same resource. Next to this competition, the livelihood of fishermen is influenced. Fishermen highly depend on fish as a food source, since they have to feed their families. Game fishing reduces the chance of catching enough fish (Interviewee A; Interviewee B, pc, 2016). Fishermen also accuse the tourism sector of spilling oil in the water, which comes from motorized boats (Flam, pc, 2016).

Furthermore, fishermen accuse the government of unfair treatment. The government wants to set up MPAs to, among other reasons, reduce this conflict. These areas have no-fish zones where tourism is allowed. In the BANP, the government cares a lot about tourism because it is a source of money. Therefore dive sites and snorkeling areas are more supported than fishing areas and fishermen are not involved in decision making (Interviewee D, pc, 2016). Therefore fishermen question whether conservation areas are meant to protect the fish for the environment or for tourism (Zacarias, pc, 2016). They also ask for compensation for their lost catch, because fishing areas are minimized without that alternatives are provided (Patrocinio, pc, 2016).

Another problem from the fishermen's perspective is corruption. Lodges and hotels are impacting villages and fishermen through bribery. Tourist operators bribe villages to implement no-fish areas close to their establishments, because nets are pulled in front of the establishments and bycatch is thrown on the beaches, which creates a bad smell (Allen, pc, 2016). Therefore, private arrangements exist between tourism establishments and villages (Silva, pc, 2016). If villages deny the claim of no-fish areas, tourism operators threaten to stop payments for schools, hospitals and other facilities (Silva, pc, 2016).

Tourism operator's view

Tourism operators accuse fishermen of frightening divers by surrounding them with their nets or lines at coral reefs (Zacarias, pc, 2016). There are situations were fishermen fish above divers (Levack; Silva, pc, 2016). It also occurs that fishermen wait close to the reefs for the divers to leave so they can start fishing directly (Rocco, pc, 2016).

Furthermore, in the tourism operators' opinions fishermen take the fish out of the water directly and destroy the environment with their gear. In this way they have a direct impact on degrading provisioning, regulating and cultural ecosystem services (Allen; Reeve-Arnold, pc, 2016). Efforts are made by Interviewee B (2016), who tries to educate local fishermen about fishing in nursery areas like coral reefs. Fishing in these areas will decrease fish stocks fast and will lead to reduced catch for future generations. However, most of the fishermen continue fishing according to their habits (Interviewee B, pc, 2016).

The lack of communication, knowledge and data is a major problem and increases the conflict between the sectors. Some tourism operators, tourists and fishermen do not understand the complexity

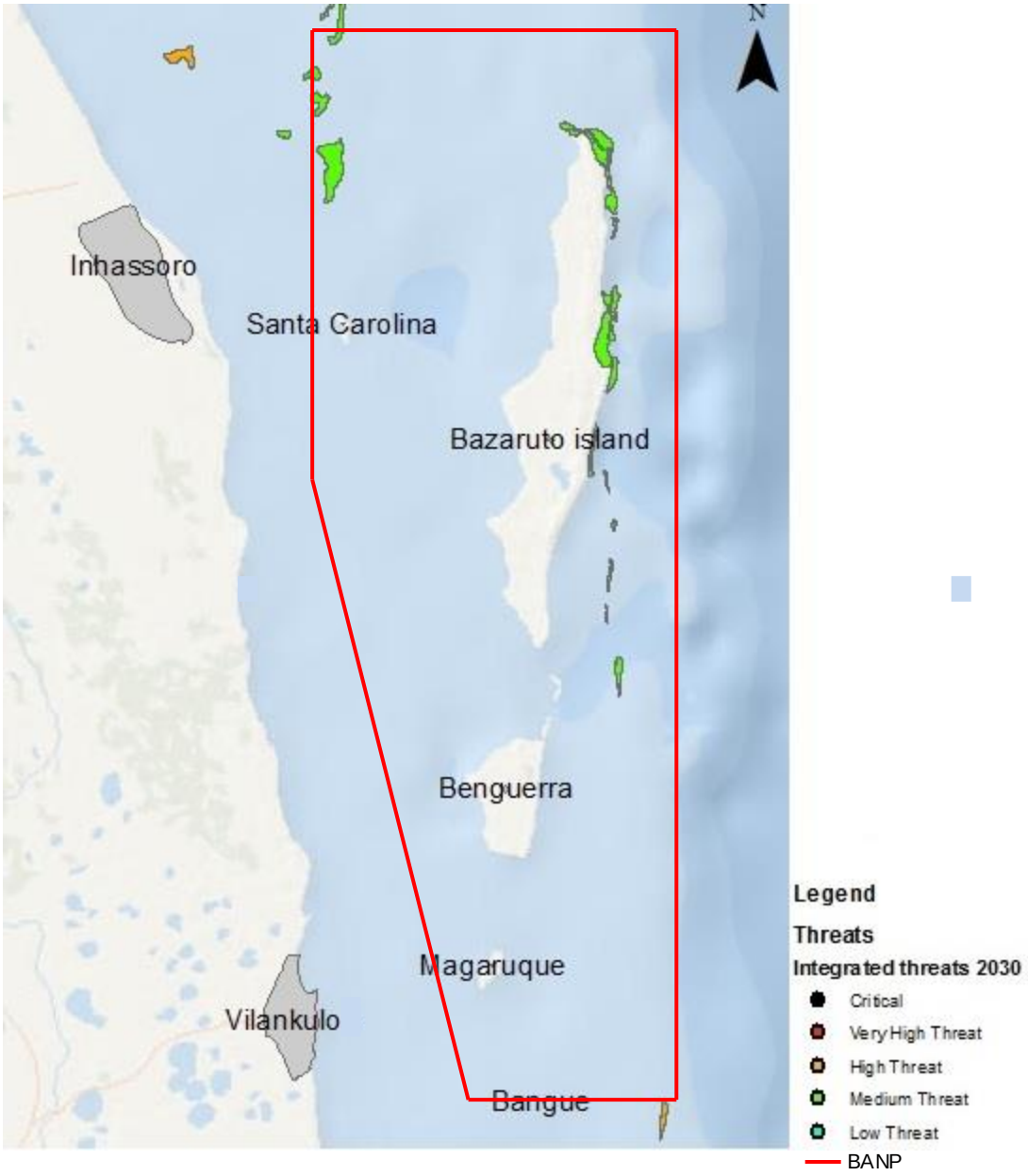
and the connections between tourism, fisheries and the environment (Hof; Zacarias, pc, 2016). Some tourism operators said that they do not know anything or not too much about fisheries (Retzlaff; Rocco, pc, 2016). Interviewee A (2016) experienced a situation where fishermen caught a shark and tourists were shouting at them because tourists do not understand that fishermen fished these animals for ages and that they have not been taught how to it differently (Interviewee A, pc, 2016).

Tourism operators and fishermen do not understand that they depend on each other and the ecosystem services. The presence of tourists creates a new market for seafood, but the market asks for high value fish, which can have a negative impact on the coral reefs (Allen; Lundin, pc, 2016).This market can only be maintained if fishermen do not catch too many fish or megafauna because a decline in biodiversity would lead to a decrease of tourists (Reeve-Arnold, pc, 2016).

Even though both sectors accuse each other, fishing has a greater impact on reefs and fish stocks than tourism activities according to the interviewees. There might be local influencers on ecosystems through tourism, but these are far smaller than the ones from the fishing industry. This is due to the fact that the fishing industry is "*actually now following their own rules*" (Lundin, pc, 2016). On the other hand, artisanal fishermen are not well educated and do not know how to fish in a sustainable way (Interviewee A, pc, 2016).

The interaction of all threats is expected to increase the influence on fish stocks and coral reefs. Projections for coral reefs show that integrated threats lead to very high level of threats for the I/T area in 2030 and 2050 (Map 11). Projections for V/B show that most of the coral reefs will be at medium level of threat in 2030 and 2050 (Map 12). Two reefs, one in the north and one in the south, are expected to be at a high threat in 2030 and 2050.

Map 11 Integrated threats projections for 2030 and 2050 in Inhambane city/ Tofo
There are not differences between 2030 and 2050 (ReefBase 2016)



Map 12 Integrated threats projections for 2030 and 2050 in Vilankulo/Bazaruto
There are not differences between 2030 and 2050 (ReefBase 2016)

5.2.5. Overview

The following figures show a summarized overview of the influencers. Influencers are distinguished between tourism (Figures 6 & 7) and fisheries on coral reefs and megafauna, sharks and fish (Figures 8 & 9).

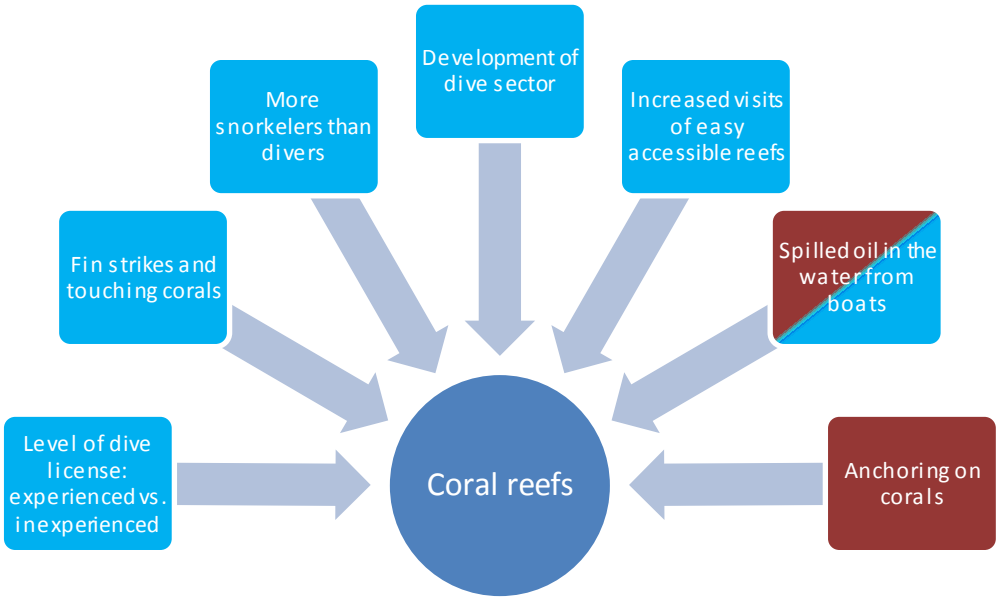


Figure 6 Tourism influencers on coral reefs
Blue: diving and snorkeling; red: recreational and sport fishing

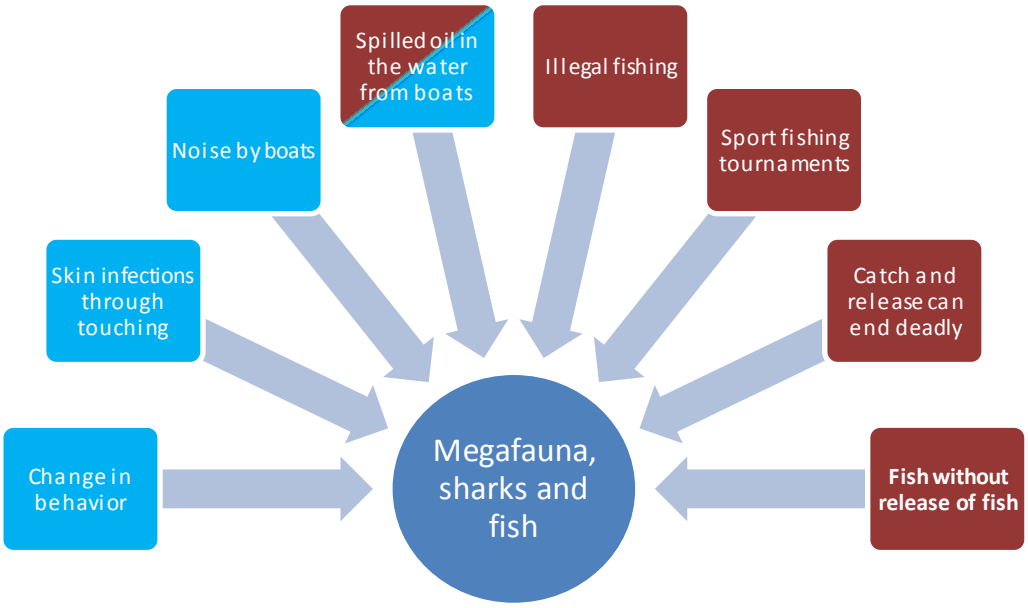


Figure 7 Tourism influencers on megafauna, sharks and fish
Blue: diving and snorkeling; red: recreational and sport fishing

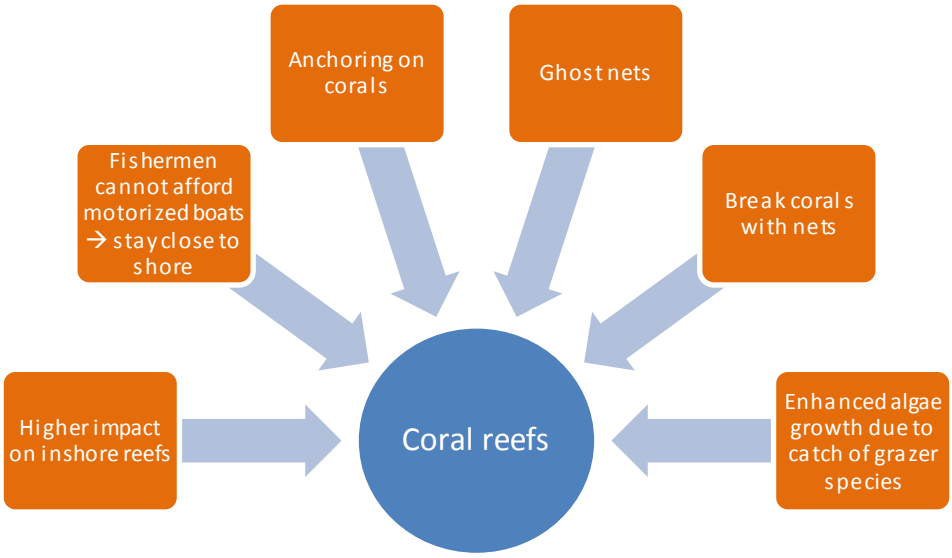


Figure 8 Fisheries influencers on coral reefs

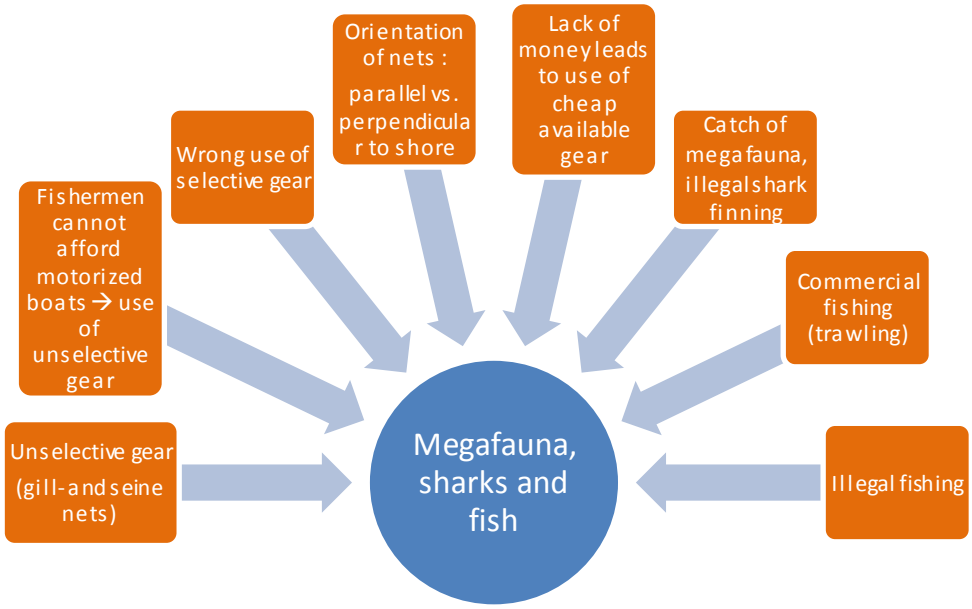


Figure 9 Fisheries influencers on megafauna, sharks and fish

To answer sub-question a) one can say that tourism and fisheries have different ways and dimensions of impact on fish stocks and coral reefs. While dive and snorkeling tourism has more direct influence on the coral reefs, and therefore on cultural and regulating ecosystem services, recreational, sport and artisanal fishing has more direct impact on the fish stocks, the provisioning service. The tourism and fishery sector blame each other for the degradation of these services. The influencers put coral reefs and fish stocks at high risk nowadays and the integration of influencers will increase the level of threat in the future.

5.3. Policy regulations

The goal of this thesis is to set up guidelines, which need to be aligned to existing policy regulations. Guidelines that are not aligned to policy cannot be implemented. With this understanding, the analysis in this section answers the third sub-question:

b) What are current policy regulations concerning fishery and tourism operations and marine ecosystem protection related to marine and coastal ecosystem services use in the Province of Inhambane?

As mentioned earlier, this study will only highlight policy regulations that solely include licenses and laws for tourism and fishing operations and marine and coastal ecosystem protection laws. These instruments regulate efforts and locations of operations and activities. Therefore they have direct influence on the strength of impacts on fish stocks and habitats. The results are divided into policy regulations for the environment, tourism and fisheries. All regulations are on a national basis and apply to both study areas.

5.3.1. Environment

According to the constitution of the republic, it is the state's responsibility to preserve the environment and to create an ecological balance (Fiege *et al.* 2003). Environmental policy is not concerned as a major priority on the Mozambican development and economic agenda. The focus is more on socio-economic aspects, where ecological dimensions are not accounted to satisfaction (Fiege *et al.* 2003). Main laws which are important for the conservation of nature are the Lei do Ambiente (Environmental law), the Lei de Terras (Land law), the Lei de Pescas (Fisheries law). Conservation areas also play an important role in the protection of the environment and regulations and rules are set up per conservation area individually.

Environmental law

The environmental law includes how natural resources should be used and considers duties and rights of citizens (Fiege *et al.* 2003). The participation of the public is used as a basis for environmental management. According to the law, the government creates mechanisms to involve different sectors of the society to prepare legislation and policies concerning natural resource management. It is the duty of each citizen to use natural resources sustainably and to encourage others to do so too. In this context it does not matter where the resource has been found or what the purpose of the use is (República de Moçambique 1997b). Also, the government ensures that measures are taken to conserve animal species, to create new habitats and to regenerate destroyed ones. The environmental law sets the goal to create a sustainable development in the country and to support an "ecologically balanced environment" for Mozambicans (República de Moçambique 1997b).

Activities that impact the quality, quantity, reproduction or conservation of natural resources are not allowed. Especially activities which may lead to the extinction of species are strictly prohibited. If people act against the environmental law and cause damage to the environment, Damage and actions against the Environmental law will be evaluated by the government and compensation in monetary values will be assessed (República de Moçambique 1997b).

Land law

The land law considers all norms, principles, restrictions and possibilities of land use. The law defines that all land is property of the state and cannot be sold, pledged or alienated in any way (República de Moçambique 1997a). Furthermore, new businesses need to be legal, have a proper license and need to have performed an evaluation of possible impacts through their business on the environment. In this way, businesses cannot be establishment everywhere (República de Moçambique 1997a).

Fisheries law

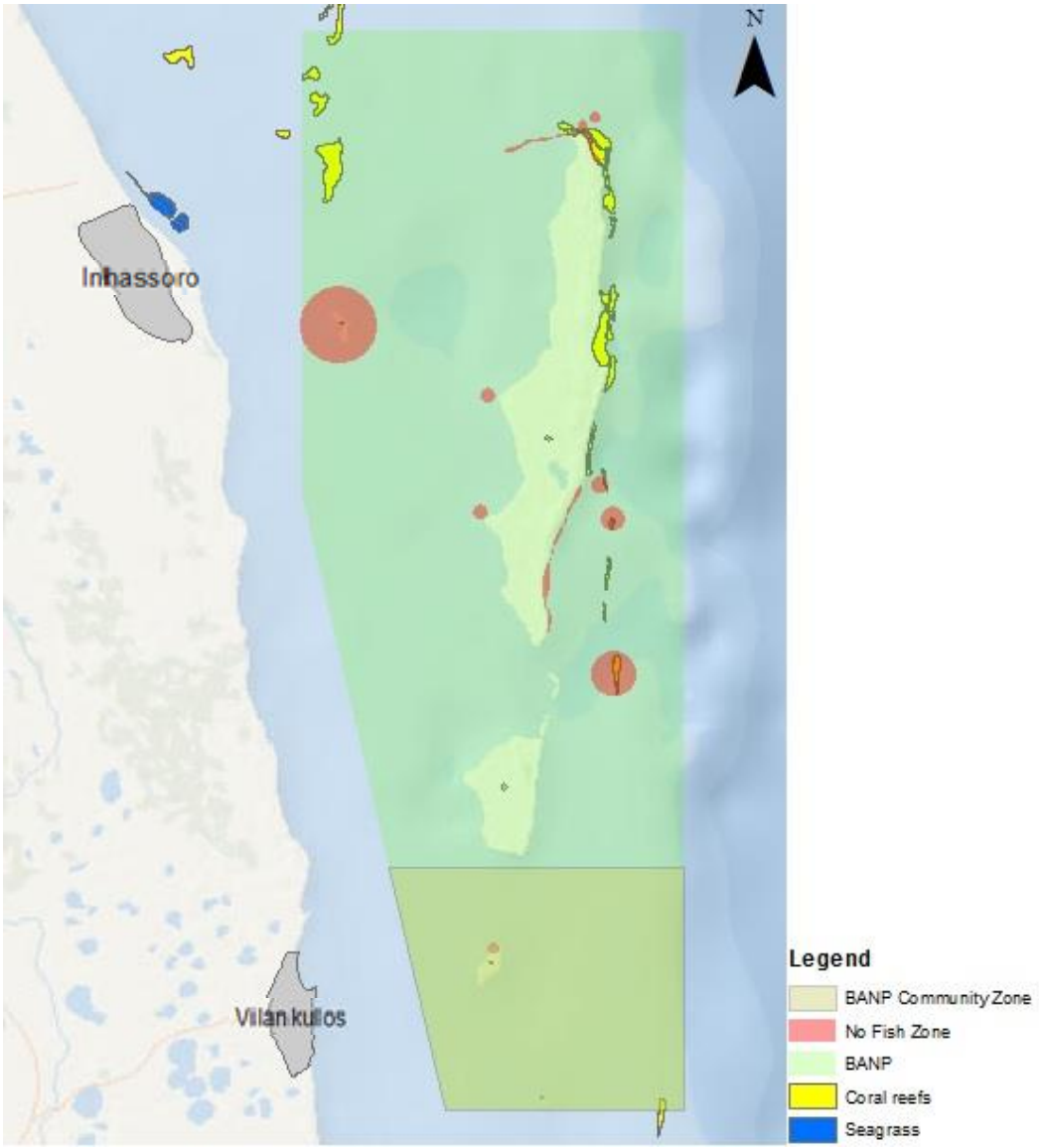
The fisheries law also includes articles on how the environment has to be preserved. Like in the environmental law, people are obligated to repair damage that has been created through fishing and compensate the state (República de Moçambique 2013). The fisheries law also concerns research; the state of exploitation of fish stocks, the sustainable use of aquatic ecosystems and biological resources have to be assessed to evaluate the dimension of the current situation. Impacts through climate, economy, society, and ecology have to be studied to obtain knowledge about how they influence coastal and marine ecosystems and fish stocks (República de Moçambique 2013).

Conservation areas

In Mozambique, conservation areas were first built to conserve habitats, biological biodiversity, ecosystems and natural resources. Animals' genes and species are meant to be maintained through protection and conservation. Later, a second purpose was noticed: the benefit of future and present generations. These areas should support the socio-economic development and citizens' welfare through national and international tourism. Products of interests are wildlife and natural resources for consumption, which create new businesses and create employment opportunities for the local population (Ministério do Turismo 2004).

Conservation areas are managed by the government of Mozambique. Cooperation with other actors for decision making is a requirement in this process. In that way management takes place through governmental and non-governmental organizations (Ministério do Turismo 2004).

An important conservation area in the Province of Inhambane is the Bazaruto Archipelago National Park (BANP) in the V/B area (Map 13). The BANP is the only marine park in Mozambique and was also created to support the environment (Santos 2008). It was assigned as a MPA in 1971 and is seen as a successful conservation area which supports the great diversity of megafauna, fish, dugongs and sea turtles (Everett *et al.* 2008). The park includes several coral reefs located around the islands. The park itself is a restriction zone (green highlighted part in Map 13), where park fees have to be paid by every vessel or visitor entering the zone; daily visits to the islands are not excluded. The southern part of the park is designated as the BANP Community Zone. Local fishermen are allowed to harvest aquatic species restrictedly in this zone (Map 13) (Cashew-Bay Lodge 2010). Restrictions include for example the type of gear they are allowed to use. Gillnetting and spear fishing are strictly illegal in the BANP (Rato 2016). The park also includes no fish zones, where fishing is forbidden (Cashew-Bay Lodge 2010). Diving and snorkeling are permitted in these areas (Allen, pc, 2016).



Map 13 Regulation areas of the BANP
(Cashew-Bay Lodge 2010)

To reduce illegal activities two control boats are used in the BANP. However, the frequency of patrolling is very low; about once a month. Budget for fuel is an underlying constraint. In 2003, five marine managers were assigned to monitor illegal commercial fishing by foreign vessels increased within the park. After this intervention, the problem was controlled and the human resources were reduced to three marine managers. In addition, the park has 17 park rangers who are responsible to perform patrols on land and sea (WWF 2005). WWF (2015) reports a need for a chief law enforcement officer to oversee all activities.

Due to the location in a conservation area, impact on coral reefs is low. To increase the protection of reefs special attention is paid to corals in the Beach regulation framework that includes prohibitions of physical damage to coral reefs. Physical damage can be induced through fin strikes or breaking of coral

by holding on to them. It is also prohibited to collect corals, reef fish or invertebrates for trade, to anchor on the reefs, or to fish within 100 meters off reefs. Actions against these prohibitions can lead to heavy fines. So far, coral restoration has not been incorporated into current policy due to low capacity and high costs (Pereira *et al.* 2010).

Temporary closures are set by the government around the coral reefs to enhance regeneration of the system. In the V/B area closures take place in the summer months January, February and March. Fishing starts again in April (Rocco, pc, 2016). However, these closures also apply only to fishermen (Hof, pc, 2016).

In conclusion one can say that regulations exist that take into account the conservation of marine and coastal ecosystem services. However, the incentive structure is not clearly defined. Fines need to be enforced by the government if people act against the laws and destroy nature. This money could be used to increase the enforcement of laws through the development of human resources.

5.3.2. Tourism

Tourism is regulated on different levels where the main focus is on sustainable tourism activities. Sustainable tourism is defined as "tourism based on environmental management that meets the needs of present generations without compromising the environmental balance and the ability of future generations to meet their needs as well" (República de Moçambique 2004). Ecotourism plays an important for sustainability.

Licenses are requires for every activity within the tourism sector (ACIS & GIZ 2008). The underlying regulation for the tourism sector is the Lei do Turismo (Tourism law), which incorporates the following objectives (República de Moçambique 2004):

- Create jobs, to reduce poverty and contribute to economic growth; where economic growth through tourism development has to be sustainable and take into account the environment.
- Promote the conservation of marine and land ecosystems and the biological diversity.
- The improvement of the local communities' life and encourage their involvement in the tourism sector.

The tourism law also includes the duties of tourists and tourism operators, which have to comply with the tourism law, have to respect the environment in general and in particular natural heritage (República de Moçambique 2004).

To conduct tourism entertainment activities a general license is needed according to the Regulamento de Animação Turística (Tourism entertainment regulation). This license allows the tourism operator to provide tourism activities and is valid for five years. After five years the license is renewable, but not transferable to other parties. If the license is not renewed within 15 days, it expires (República de Moçambique 2007). Licenses and regulations are enforced for aquatic tourism activities like diving and recreational and sport fishing and for ecotourism.

Diving

Diving is regulated generally by the tourism entertainment regulation, but also has an own regulation called Regulamento de Mergulhador Amador (the Amateur diving regulation).

Before a dive school can be set up, the owner has to comply with several steps which need to be approved by the National Maritime Authority (NMA). First of all, the purpose of the business has to be proved (for example diving instructions and guiding objectives of the business). Then, a detailed program of the offered courses has to be set up and the qualifications and certifications of the staff have to be approved. A list of the equipment has to be provided, where a boat, vehicle and oxygen tanks are seen as minimum requirements. An important factor is the approval of the location of the dive center. A map with coordinates of the dive sites needs to be provided to the authority. A written approval from the Ministry of Environment and Defense is the last step. Furthermore, diving operators are obligated to check if there is any activity taking place against the law like ignorance of permanent or temporary closures or prohibitions (República de Moçambique 2006).

For a diving business, licenses for every aspect of the business are required. Most often diving centers offer activities like snorkeling or ocean safaris next to diving. Therefore licenses are needed for example for the diving activity, the snorkeling activity, the teaching of diving, ocean safari activity, licenses for the boats, a license to be allowed to launch the boat, and a transportation license for the passengers (Interviewee B; Levack, pc, 2016). The license of the boats also includes that no fishing gear is allowed on dive boats (Rocco, pc, 2016). Each license explains in detail the operational procedures (Retzlaff, pc, 2016).

Licenses for the diving activity are granted by the NMA under the amateur diving regulation. Two different licenses exist: 1) The license for the exercise of activities of dive centers and 2) the license for the exploration of the environment through diving (República de Moçambique 2006). Taxes on licenses have to be paid to the municipality (Levack; Retzlaff, pc, 2016). The taxes are divided into a share of 40% which goes to the state and a share of 60% which is for the entity of licensing (República de Moçambique 2006).

Licenses last for five years, but each diving center is inspected by the maritime department yearly where every aspect of the diving center is evaluated. The conditions of boats or the diving gear are important aspects of the evaluation. If all aspects are according to the regulations, the license is renewed for another year (Rocco; Interviewee B, pc, 2016).

There are no regulations in any of the two study areas on how often a diving center can conduct dives, snorkeling or ocean safaris. There are also no regulations that determine the area of operation, which means that coral reefs can be visited wherever and whenever (Flam; Levack; Rocco; Interviewee D, pc, 2016).

Recreational and sport fishing

The Ministério of Mar Aguas Interiores e Pesca (Ministry of Sea, Inland Waters and Fisheries) is responsible for the inspection of recreational and sport fishing. The recreational and sport fishing sector has its own law, which is the Regulamento da Pesca Recreativa e Desportiva (Regulation for recreational

and sport fishing). This regulation distinguished two types of fishing: surface and underwarter fishing, both having their own regulations (República de Moçambique 1999):

Surface fishing:

Surface fishing is allowed during night and day, limited to the use of a fishing hook. A fishing rod with or without a wheel can be used, but is not mandatory. However, no more than three hooks are allowed. Casting nets is only permited for the catch of bait which is exclusivly for recreational and sport fishing. When fishing on shore, fishermen need to keep a distance of 10 meters between each other (República de Moçambique 1999).

Underwater fishing:

Underwater fishing can only be performed during the day (from sunrise to sunset). Only a few types of gear are permitted: knives, spears and weapons that provide compressed air to shoot spears are allowed. Only one spear is permitted, which can have one or two points (República de Moçambique 1999).

It is forbidden to use other breathing devices than a snorkel to stay underwater. Also, weapons with detonation of chemicals are not allowed. The same goes for harpoons that have explosive tips. A minimum distance of 20 meters needs to be kept between fishermen (República de Moçambique 1999).

Both types of fishing are allowed in all areas in Mozambique, except for ports and areas where fishing is prohibited due to legislation. Further restricted areas for the preservation of resources, public hygiene or scientific investigation can be chosen by the Minister of Agriculture and Fisheries and the Commission of Fishery Administration (República de Moçambique 1999).

The recreational and sport fishing regulation also includes a number of species that are not allowed to be fished due to their protection status: *Epinephelus lanceolatus* (Brindle bass), *Polysteganus undulosus* (Seventy four seabream), *Epinephelus tukula* (Potato bass), *Petrus rupestris* (Red steenbrass), and *Carcharodon carcharias* (Great white shark) (República de Moçambique 1999).

Furthermore, only a certain number of species is allowed to be caught per person (Allen, pc, 2016). Remaining fish has to be thrown back to water. Maximum 10 demersal species are allowed to be brought to land per fishermen per day. During fishing contests the catch of demersal species is forbidden. Maximum 10 fish per species of non-demersal fish are allowed in total, regardless of how long the contest lasts. The Minister of Agriculture and Fisheries and the Commission for Fishery Administration can set more limits per boat, as well as fish sizes and weights (República de Moçambique 1999).

To make fishing licenses accessible to tourists, the government provides sport associations, national nautical clubs and tourism agents with a license quota. This quota enables the organizations to purchase licenses for their tourists. Monthly, quarterly and annual licenses can be obtained (República de Moçambique 1999). These licenses are mandatory to perform fishing. Tourists can buy these from the sport associations, clubs or tourism agents directly. A license for a month costs 420 Meticais per person per month (6.36 USD) (Interviewee C, pc, 2016).

Tourism agents also have to obtain licenses to be allowed to run their business. The maritime department of the government inspects boats and fishing gear yearly (Interviewee C, pc, 2016). Licenses for the boats and operation of the boats are paid after the yearly renewal. There are no restrictions in terms of number of trips. Recreational and sport fishing can take place as often as provided by tourism operators (Rato, survey, 2016).

Any transgression of the law will be punished. The use of prohibited fishing gear or the possession of this gear on board is not allowed. It is also not prohibited to have explosives or toxic substances on board. An overview of penalties can be found in Table 2 (República de Moçambique 1999).

Table 2 Transgressions of the law and fines for recreational and sport fishing
(República de Moçambique 1999)

Transgressions	Fines
a) The attempt to or actual fishing without a license;	Fifty to one hundred million Meticais (0.75-1.51 million USD)
b) The performance of fishing contests that have not been previously notified to the relevant authority or that have been forbidden;	Fifty to one hundred million Meticais (0.75-1.51 million USD)
c) Transport, use of or attempt to use explosives or toxic substances or even electrocution fishing gear	Thirty to forty million Meticais (0.45-0.60 million USD)
d) The use of or attempt to artificial breathing equipment;	Thirty to forty million Meticais (0.45-0.60 million USD)
e) Fishing in forbidden areas;	Thirty to forty million Meticais (0.45-0.60 million USD)
f) Flight or attempt to flee upon interpellation by relevant authority;	Thirty to forty million Meticais (0.45-0.60 million USD)
g) The use of unauthorized fishing gear;	Fifteen to twenty million Meticais (0.22-0.30 million USD)
h) Capture or possession of protected species;	Eight to ten million Meticais per piece (0.12-0.15million USD)
i) Capture and possession of number of pieces exceeding the authorized limit;	Fifty to one hundred million Meticais per Kilogram (0.75-1.51 million USD)
j) Capture and possession of a number of pieces sizes and weights below the established limits;	Fifty to one hundred million Meticais per Kilogram (0.75-1.51 million USD)
k) Sale of the catch	Fifty to one hundred million Meticais per Kilogram (0.75-1.51 million USD)

In general, any performance of water sport (e.g. diving, snorkeling, recreational and sport fishing) without a valid license or outside the validity of the license will be fined with 20,000 Meticais (303.03 USD) (ACIS

& GIZ 2008). Transgressions of the tourism law follow a strict procedure: "warning, fine, temporary suspension of the establishment from business, closure of the establishments, license revocation, administrative prohibition, and demolition" (República de Moçambique 2004).

Ecotourism

According to the tourism law, ecotourism "means a set of tourism activities developed in natural areas, ensuring conservation of the environment and the well-being of local communities, with the involvement of tourists and consumers of tourism products and services" (República de Moçambique 2004). Ecotourism is regulated through the Regulamento do Ecoturismo (Ecotourism regulation). It can be carried out in conservation areas like national parks, national reserves, zones of historical and cultural use and value, and other zones with appropriate characteristics. However, the conduction of ecotourism in these areas has to be aligned to current management plans in these areas (República de Moçambique 2004; 2009b).

Activities that are covered by this regulation are sport in nature like paragliding, mountain biking, rafting and other activities that do not harm nature and the conservation of nature. A license has to be obtained by tourism operators to conduct ecotourism. This license is valid for five years and can be renewed for the same period of time (República de Moçambique 2009b).

5.3.3. Fisheries

Fisheries in Mozambique need to obey many regulations. The most important regulations that concern the dimension of impact on fish stocks and habitats will be mentioned in this section: the Regulamento Geral da Pesca Marítima (General regulation of sea fishing), Lei das Pescas (Fisheries law), the Decisão do dia 20 de julho de 1971 estabelecendo tamanho mínimo de peixes e outros animais marítimos (Decision of 20 July 1971 establishing minimum size for fishes and other marine animals), the Regulamento da Pesca Marítima (Regulation of sea fishing).

The government is responsible for the supervision of regulations and licenses for fishing activities. According to the fisheries law, every local fishery has to register before they can obtain a license. Only subsistence fishing is excluded from licensing, but the registration of the fishing gear is still compulsory. Foreign persons are allowed to operate in the territorial sea, but no longer than a year. A new application is needed after expiry (República de Moçambique 2013).

Licenses for local fishermen are granted by local fishery councils. These councils surveil how many licenses are granted and to who. Officers from the Ministry of fisheries help fishermen with the application process (Lundin, pc, 2016).

Different types of licenses exist for the different fishing sectors and purposes (República de Moçambique 2003):

a) License of artisanal fishing without fishing vessel;
b) License of artisanal fishing with fishing vessel;
c) License of semi-industrial fishing;
d) License of industrial fishing;

e) License of fishing of scientific investigation;
f) License of experimental fishing;
g) License of connected operations of fishing;
h) License of recreational and sport fishing.

A license is valid for 12 months, but expires on the 31st of December of the year it has been granted (República de Moçambique 2003). The small-scale fishery licenses cost about 653 Meticais (9.89 USD) (198 Meticais per fishermen and 385 Meticais per boat) (DPTUR *et al.* 2007). These licenses are only granted to national people and each fishery receives criteria, periods for granting fishing rights and agreements from the government. If a fishery has conducted illegal (e.g. unreported or unregulated) fishing and is registered on an international list, the application for a new license can be denied. To decrease illegal fishing, the government has set up a vessel monitoring system (República de Moçambique 2013).

Next to these licenses, regulations exist for the types of gear. Fishing in Mozambican waters is not allowed with gear that is not regulated. The government defines which type of gear can be used, what the technical characteristics have to be, which type of species are allowed to be caught with the gear and what the gear's impact on the environment can be (República de Moçambique 2013). For sharks for example, the minimum mesh size for nets is 120 millimeter (mm). Gillnets on the other hand, need to have a minimum mesh size of 38 mm regardless of the species that is caught (República de Moçambique 2003). For artisanal fisheries, the minimum mesh size for seine nets is 25 mm (Pereira *et al.* 2014).

Minimum sizes for marine species were set for the bivalve *Mytilus perna* (5 cm in diameter), the giant mud crab *Scylla serrata* (10 cm in diameter) and the spiny lobster family *Panulirus spp* (5 cm between eyes and cephalothorax). For fish species, the decision of 20 July prohibits the take of immature fish or tiny fish which cannot be sold as food on the markets (República de Moçambique 1971a). The government also induces restricted fishing when fish are in their reproduction season to reduce the probability of catching pregnant females (Retzlaff; Siniquinha, pc, 2016).

The processing of fish for the artisanal sector is addressed in the regulation of sea fishing. After fish has been caught it has to be packed in boxes with crushed ice immediately to make the fish transportable for the markets. After delivery, the boxes have to cleaned with water and detergent to guarantee hygiene (República de Moçambique 1971b).

Fishing areas

The government also regulates the fishing zones. In general, small-scale fisheries are allowed to practice fishing activities up to three nautical miles from the coast. This area is exclusively reserved for this type of fisheries (República de Moçambique 2013). Artisanal fishers with drag nets and boats need to be at least half a mile off the shore. If there are estuaries or bays located at the coast the minimum distance increases to one mile. Semi-industrial and industrial fishing with seine nets is not allowed with vessels in any estuaries or bays (República de Moçambique 2003).

Next to areas where fishing is allowed, restricted areas like sea parks, sea reserves or protected areas exist. Fishing in sea parks is completely forbidden. Also subsistence, recreational or sport fishing are not permitted. In sea reserves subsistence fishing can be practiced as long as protected species are not harmed. Protected areas can contain a total or a partial closure of all fishing activities. Partial closures can be in terms of species that are allowed or not allowed to be caught, seasons in the year where fishing is prohibited, or minimum sizes of fish or fish quantities (República de Moçambique 2003).

Fishing rights can be suspended if there is a proven threat of extinction of a species in the fishing areas. Also if there is proven damage to the environment or human health, fishing rights can be suspended (República de Moçambique 2013).

Illegal fishing

Illegal fishing is a big problem in Mozambique. National rules exist, but some are ignored regularly (Lundin, pc, 2016). The government has set up 85 measures in the appendix of the fisheries law to reduce illegal fishing. Some of these measures will be mentioned here briefly (República de Moçambique 2009a):

- Measure 9: Categorize three fishing offenses: simple, severe and very severe. Sort damage of the environment and resources and the effort of management according to these categories.
- Measure 10: Create a new sanction system: 1) Limit the wide range of sanctions and create a minimum and maximum. 2) Monetary sanctions should be set as a multiple of the license fee. 3) Also, it should be clear which cases are included in monetary measures.
- Measure 21: Develop multi-sectoral mechanisms between the Ministry of Fisheries, the Navy and the Marine Police to increase the development of navigation capabilities and management of vessels.
- Measure 30: Set up a plan to train new staff and recruitment and give old inspectors with low level of training service access to an early retirement.
- Measure 41: Every three to five years, management plans need to be monitored and adjusted. Human resources are required to fulfill this task.

Tourism might have a positive influence on illegal fishing. Tourism operators will look at regulations and will make sure that they are in place and followed by fishermen. In a jointly policed area in Mozambique for example, illegal fishing activities take place when tourism operators are not present in this area (Lundin, pc, 2016).

The government also supports the investigation of the state of species exploitation, the sustainable use of biological resources and aquatic systems. Planes are used additionally to track illegal fishing activities (Patrocinio, pc, 2016). Furthermore, the state has the sole responsibility to surveillance all fishery activities in the Mozambican waters, which also includes setting effort limitations like the Total Allowable Catch (TAC) (República de Moçambique 2013).

5.3.4. Challenges in implementation

According to most of the interviewees, the existing regulations are sufficient to control tourism and fishery activities in the I/T and V/B areas. The problem is the enforcement of all regulations, which is why illegal activities take place (Patrocinio; Silva; Interviewee C, pc, 2016). Interviewee D (2016) agrees that there is no sustainable fishing and that quotas for the catch are not existent in the V/B area. The government lacks the resources for correct and sufficient licensing (Mclean *et al.* 2014). Santos (2008) summarizes: "*The sole purpose of licensing today is as the legitimization of the fisheries administration, and the imparting of a professional and moral legitimization to the fisherman who voluntarily pays the fee*".

For recreational and sport fishing it has been observed that minimum sizes or limited numbers are ignored (Rocco; Silva, pc, 2016). Sport fishermen fish aggressively for demersal fish and keep all the fish they catch (Allen; Hof; Interviewee B, pc, 2016). Species targeted are marlin, sailfish and groupers, and juveniles of any kinds of species. Tourists from South Africa bring freezers and fill these with fish to take back home, which has an impact on demersal and pelagic species (Allen; Interviewee B, pc, 2016).

Local fishermen go out fishing without holding licenses, without taking into account no-fish areas or ignore regulated mesh sizes (Rocco; Siniquinha; Zacarias; Interviewee D, pc, 2016). They fish in restricted areas in the BANP regularly, using forbidden gear like spears (Rato, survey, 2016). Fishermen are not monitored and their catch is not inspected frequently by the government (Zacarias, Interviewee A, pc, 2016). Therefore catch is sold on markets illegally, which creates a competition between the legal and illegal market (Rato, survey, 2016).

Another problem is corruption (Lundin; Silva; Interviewee C, pc, 2016). It happens that agents and governmental administrations selling licenses end up taking more money and sell more licenses than allowed. The sale of more licenses may lead to a higher fishing impact than originally planned. Therefore, licenses do not have the power to regulate fishing anymore (Lundin, pc, 2016).

Moreover, Mozambique is one of the poorest countries and lacks monetary and human resources (Patrocinio, pc, 2016). According to Flam (2016), the government stated that a protection of the entire environment of the PoI will not be realized. Next to lacking resources, it appears that the lack of knowledge is also a problem. Fishermen have difficulties in understanding regulations, which leads to different interpretations in different regions of the PoI (Santos 2008).

Misunderstanding is also increased through the lack of communication (Interviewee A, pc, 2016). According to the experience with fishermen of Interviewee A, the Ministry of Fisheries does not inform fishermen about regulations. This problem is experienced around the world, where the interaction with small-scale fisheries is limited. The only interaction between small-scale fishermen and the government takes place during the yearly inspection of the fisheries (Santos 2008). Therefore, artisanal fishermen do not know what is allowed or prohibited. This is also a problem for tourism operators. One tourism agent in the recreational and sport fishing sector does not know what he can and cannot catch: "*To be honest, in Mozambique I can do pretty much what I want*" (Interviewee C, pc, 2016).

To answer research sub-question c), one can conclude that several regulations exist for the tourism and the fishery sector. The protection of the marine and coastal environment, in particular fish stocks and habitats, is mentioned in regulations to increase the conservation of coastal and marine ecosystem services. Even though there are enough regulations, they are not enforced sufficiently. The lack of enforcement, knowledge and communication leads to illegal activities and the exploitation of ecosystem services. Human resources and money are needed to increase the enforcement of legislations and regulations.

5.4. Socio-economy

LMMAs are managed by the local community. Therefore it is very important that the people's social and economic demands are accounted while establishing LMMAs. This section will therefore focus on the following research sub-question:

c) What are socio-economic demands in the Province of Inhambane related to the tourism and fishery sector?

5.4.1. Tourism

Economy

Mozambique's economy is driven by three main sectors: agriculture, fisheries and tourism (Zacarias, pc, 2016). The tourism sector in Mozambique is increasing since the end of the civil war (COAST 2009; FIAS 2006). Especially in the south of Mozambique, coastal tourism is well developed (COAST 2009). The provinces Maputo, Maputo city, Gaza and Inhambane have a total share of 50% of all registered establishments and a share of 65% of all beds in Mozambique (Ministério do Turismo 2004). The tourism sector is the biggest tax paying sector in the PoI and delivers a *"significant contribution to the Mozambican economy*" (Lundin, pc, 2016).

Mozambique's tourism businesses are mainly run by foreign nationals, mainly from South Africa. Especially for dive centers, Mozambique is a better location than South Africa due to the competitive South African market (Interviewee D, pc, 2016). Furthermore, Mozambique is seen as an "*unspoiled dive spot*" with all ecosystem services needed for dive businesses (Rocco, pc, 2016).

International arrivals come to Mozambique for different reasons, where spending leisure time and holidays is the main reason (Figure 10) (Instituto Nacional de Estatística 2015).

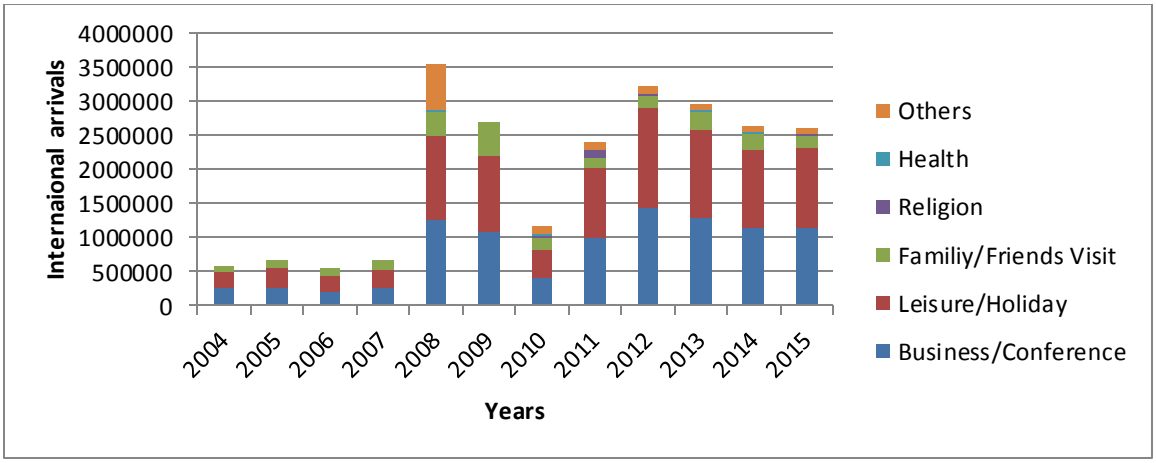


Figure 10 International arrivals in Mozambique
No data was available for religion, health and others for 2004-2007 and 2009 (Instituto Nacional de Estatística 2015)

When looking at the number of guests, it can be seen that the PoI has a very little share of the total number of foreign and national guests in Mozambique (Figure 11). The share of visitors in the PoI has decreased from 4.89% in 2011 to 1.62% in 2015.[4]

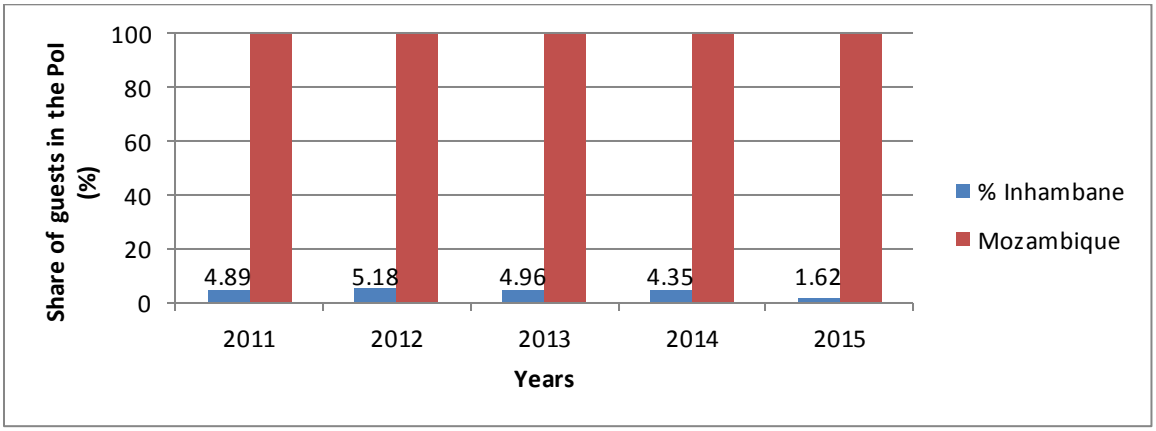


Figure 11 Guests in the Province of Inhambane
See Appendix III, table 6 for absolute numbers (Instituto Nacional de Estatística 2015)

Even though the numbers show declines in arrivals and guests, the PoI is seen as a major Mozambican tourist destination (see section 2.1.2.) (Ministério do Turismo 2015). Also, according to Rocco (2016) the sector has been stable in the past 7 years for the V/B region.

Anecdotal evidence shows that more and more tourists are spending their holidays in the province (Siniquinha, pc, 2016). Diving and recreational and sport fishing bring in a lot of money for the economy in both study areas (Flam; Interviewee A, pc, 2016). Next to increasing financial resources, recreational and sport fishing can increase the research sector through tag and release. Fish could be monitored and data about fish population dynamics could be gathered. Research will also help to reduce impacts on marine and coastal resources, because influencers could be determined and studied in more detail (Interviewee A, pc, 2016).

[4] A reason for this decline could not be found within the study time. This topic requires more research.

The government supports marine tourism through no-fish areas, where tourism is allowed to increase the profit (Interviewee D, pc, 2016). However, the government is not investing high amounts into the tourism sector, even though Mozambique has a big tourism and ecotourism potential given its pristine biodiversity and its marine and coastal habitats (Interviewee A, pc, 2016). Still, ecotourism is increasing in both areas, which makes tourism more sustainable (Interviewee A, pc, 2016).

Social demands

The tourism sector employs large numbers of people (Lundin; Reeve-Arnold, pc, 2016). In 2014, travel and tourism sustained 262,500 jobs in Mozambique, which is 2.2 % of the total employment. For 2025 it is expected that travel and tourism will account for 940,000 jobs, which is 5.9% of the total employment (World Travel and Tourism Council 2011). In 2011, 130,000 people were employed in the marine tourism sub-sector (Ocean Revolution 2011).

Two dive center operators that were interviewed confirmed that 100% of their income is from tourism (Interviewee D, pc, 2016; Bateman, survey, 2016). Most tourism operators on the other hand have a diverse source of income. Operators make money by fixing or running guest houses, car rental companies, web pages, writing for magazines, and photography. The share from tourism contributing to the income varies between 80% and 100% (Levack; Rato; Retzlaff; Rocco, pc, 2016). Rocco (2016) said that their lodge brings 45% of the income and the dive center 55%. Interviewee D's (2016) income is composed of 25-30% from game fishing.

Information about the income in the PoI was scarce. Around five months of a year are considered as low income months with an average wage of 151,076 Meticais per month (2289.03 USD) and about four months of the year are seen as good months with an average monthly income of 608,628 Meticais (9221.63 USD) (Perene Consulting 2014).

However, some interviewees confirmed that the income varies with the seasons, hence limiting income to solely manage survival (Levack; Retzlaff; Interviewee B, pc, 2016; Rato, survey, 2016). Data was provided by Rocco (2016) who has a turnover of 90-95,000 Meticais per month (1363.63-1439.93 USD), Interviewee C (2016) who has a monthly profit of 40,000 Meticais (606.06 USD) and Adamo (2016) who has a monthly income of 10,000 Meticais (151.51 USD).

Fish stock and habitat degradation

In both study areas, tourism is highly dependent on the marine biodiversity. It can be argued that decline of provisioning services like fish stocks will impact the number of sport fishing tourists, whereas the decline of regulating and cultural services like coral reefs and megafauna has negative influence on dive and snorkeling tourists (Flam, pc, 2016). Without megafauna, tourist arrivals would decline significantly and employment in the tourism sector would decrease. This is especially a problem for families that solely depend on tourism (Interviewee B, pc, 2016). Rocco (2016) said: "*without fish we would die*", which highlights the importance of marine species clear for the tourism sector.

5.4.2. Fisheries

Economy

Fishing is one of the major industries in Mozambique (Lundin; Zacarias, pc, 2016). Many people concentrated at the coast because of the civil war, which increased the fishing sector (Lundin, pc, 2016). The ability of just going to the sea and take out as much food as possible had also a positive effect on the population (Reeve-Arnold, pc, 2016). The per capita consumption of fish per year increased from 2005 to 2012 from 4.2 Kg to 10.4 Kg (Ministério das Pescas 2013).

In 2007, 90,000 people were involved in the Mozambican fishing sector, which includes processing and marketing, fishing and gathering. Around 70,000 people were employed in the marine sector and 20,000 people in the freshwater fisheries (FAO 2007). When all fishing sectors are compared, the largest increase can be seen in the artisanal fishing sector (Figure 12). It accounts for 84% in the Mozambican fishing industry (Revista de Marinha 2010). Observation shows that fishermen were using three to four nets a day in the past, which increased to more than 20 bigger nets per day to increase catch (Rato, survey, 2016).

Even though there is an increased effort, the amount of fish that was caught between 2004 and 2015 decreased in Inhambane city (Figure 13). An increased catch on the other hand was noticed in the Tofo (Figure 14), Vilankulo (Figure 15) and Bazaruto areas (Figure 16). When comparing the catch between the different areas, Vilankulo has the highest increase of catch over the past years and the highest catch in general. The catch in Tofo went up in November 2014, but was low in the years before. The catch in Bazaruto oscillated less and shows an increase in July 2014.

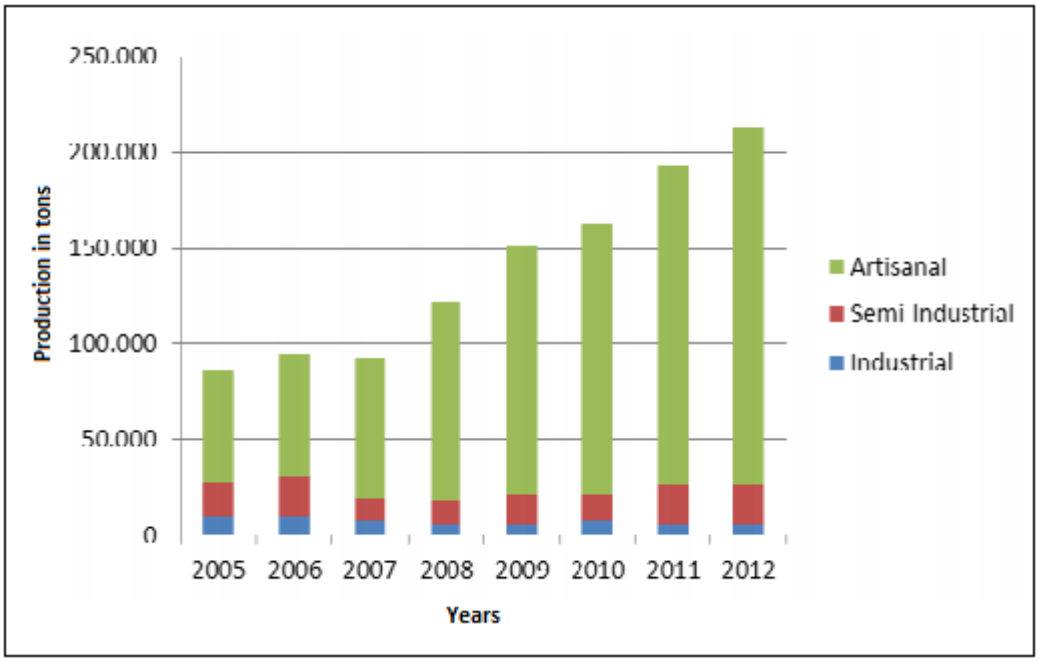


Figure 12 Production of the three different fisheries sectors in Mozambique
(Pereira *et al.* 2014)

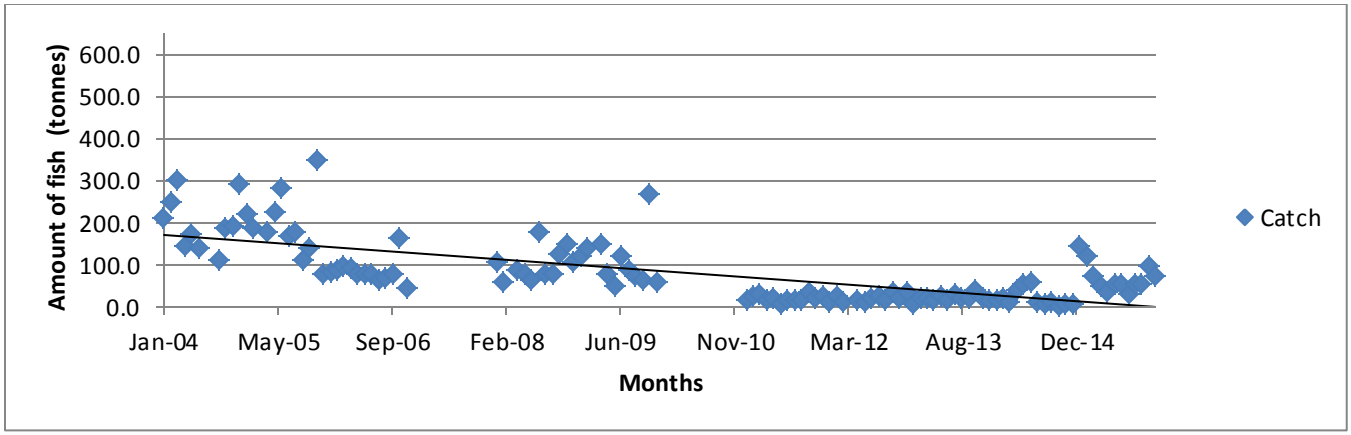


Figure 13 Fish catch in Inhambane city from January 2004 to December 2015

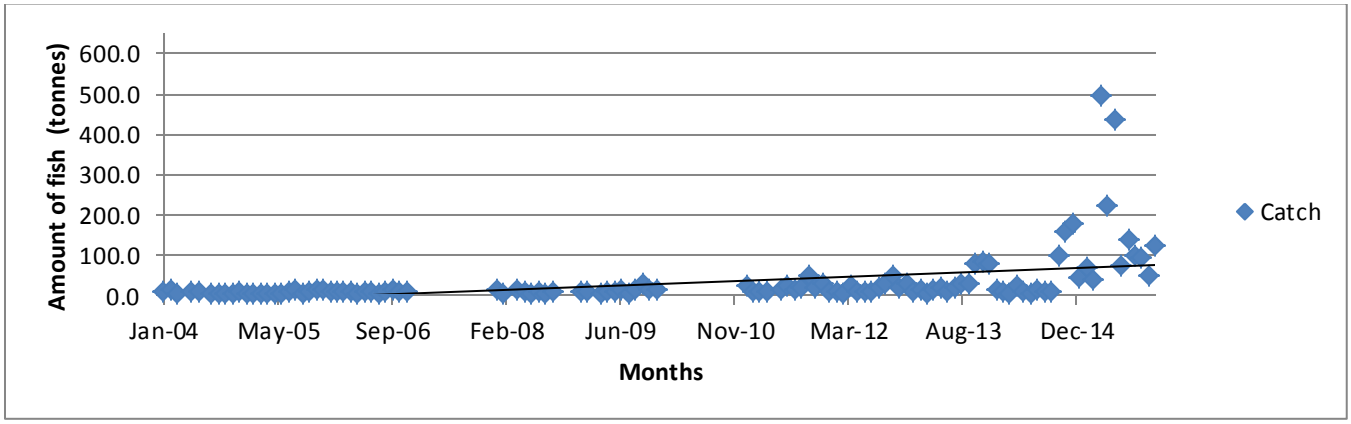


Figure 14 Fish catch in Tofo from January 2004 to December 2015

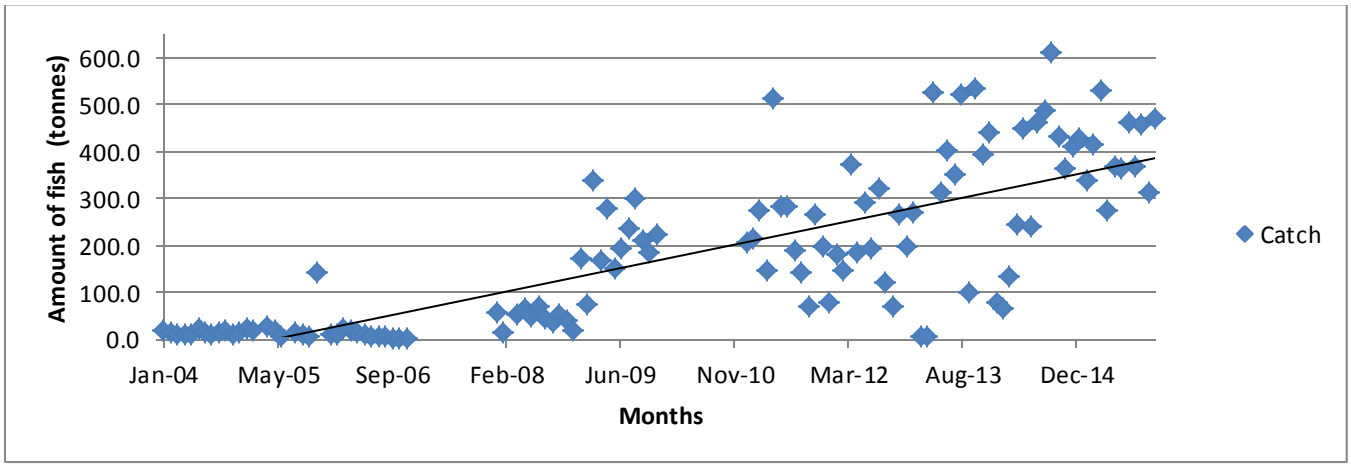


Figure 15 Fish catch in Vilankulo from January 2004 to December 2015

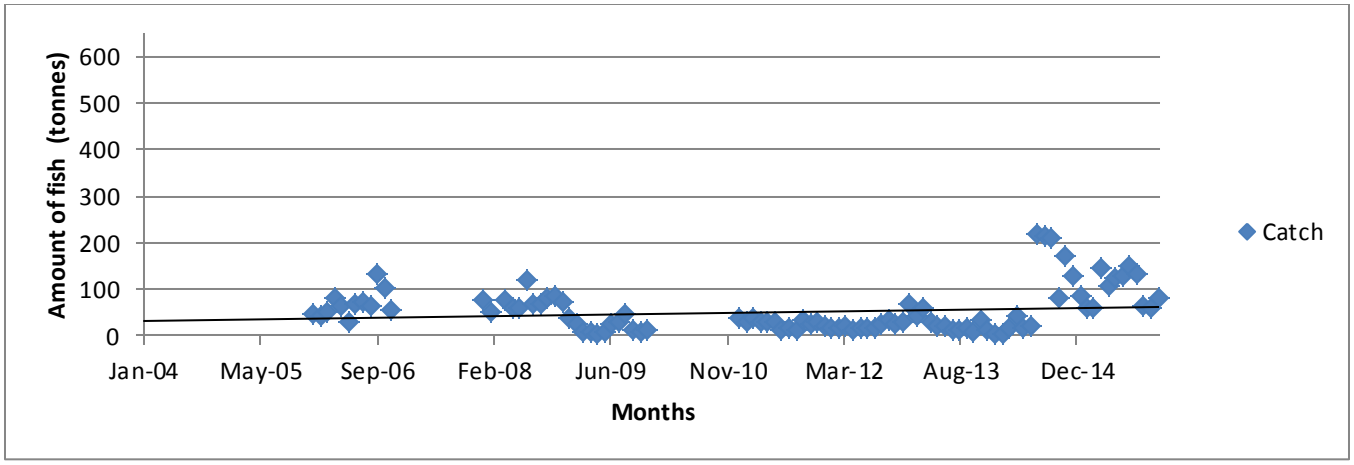


Figure 16 Fish catch in Bazaruto from January 2004 to December 2015

The effort (number of nets and number of boats for line fishing) was increased to increase the catch. In Inhambane city the increased use of trawling and beach seine nets increases the number of fish caught (Figure 17). It can be seen that high catches are obtained by using trawling and beach seine nets. Also, a few high catches are due to surface gillnets even though the number of surface gillnets is low.

In Tofo, the highest catch is obtained by using hook and line fishing and surface gillnets (Figure 18). Fewer surfaces gillnets than hook and line fishing boats are needed to obtain a higher catch. However, in the area Tofo data was lacking to deduce the trend with certainty. Only one measurement was taken for trawling and none for beach seine nets.

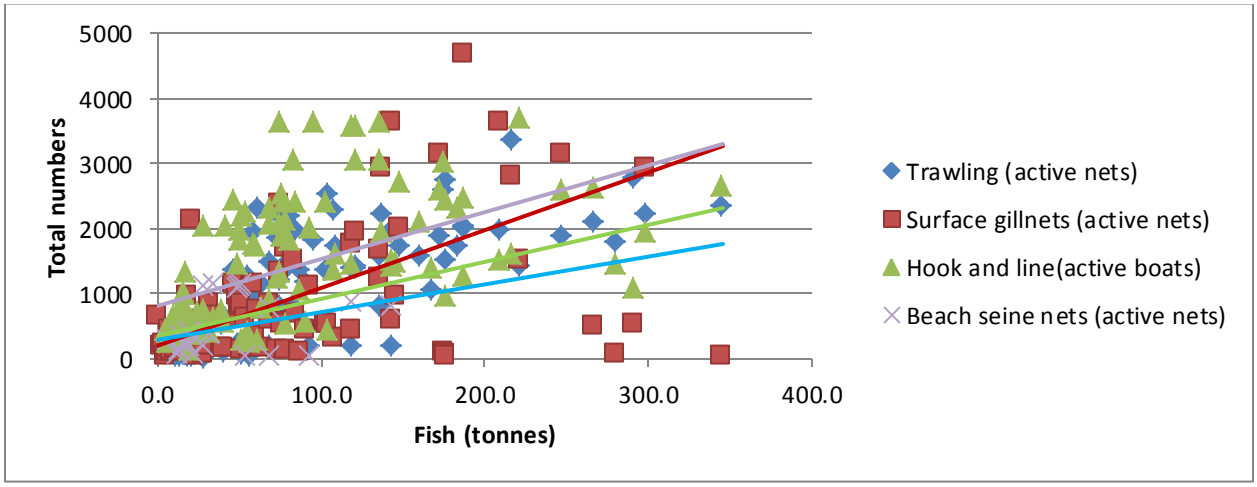


Figure 17 Number of gear related to fish catch in Inhambane city

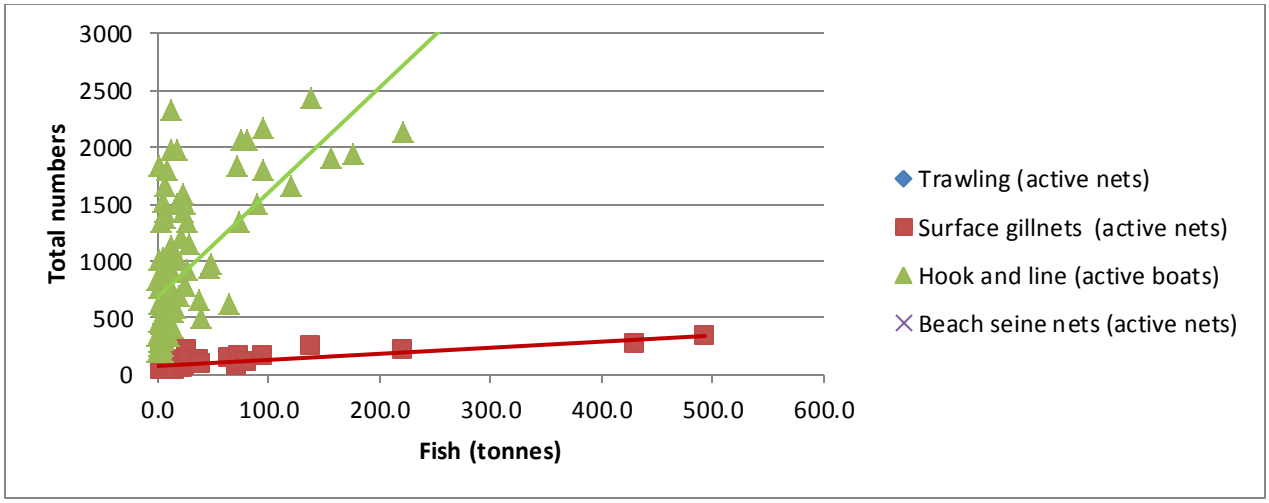


Figure 18 Number of gear related to fish catch in Tofo

In Vilankulo, the highest catches are made with trawling (Figure 19). Nearly 8000 trawling nets were used, whereby the use of about 6000 led to the highest catch. The negative trend line for beach seine nets shows that fewer nets lead to higher yields.

When looking at Bazaruto (Figure 20), high catches are obtained with trawling, hook and line fishing and beach seine nets. When these three types are compared, only a few beach seine nets are needed to obtain similar catches to a lot hook and line fishing boats and trawling nets. Also less surface gillnets are needed to catch high amounts of fish.

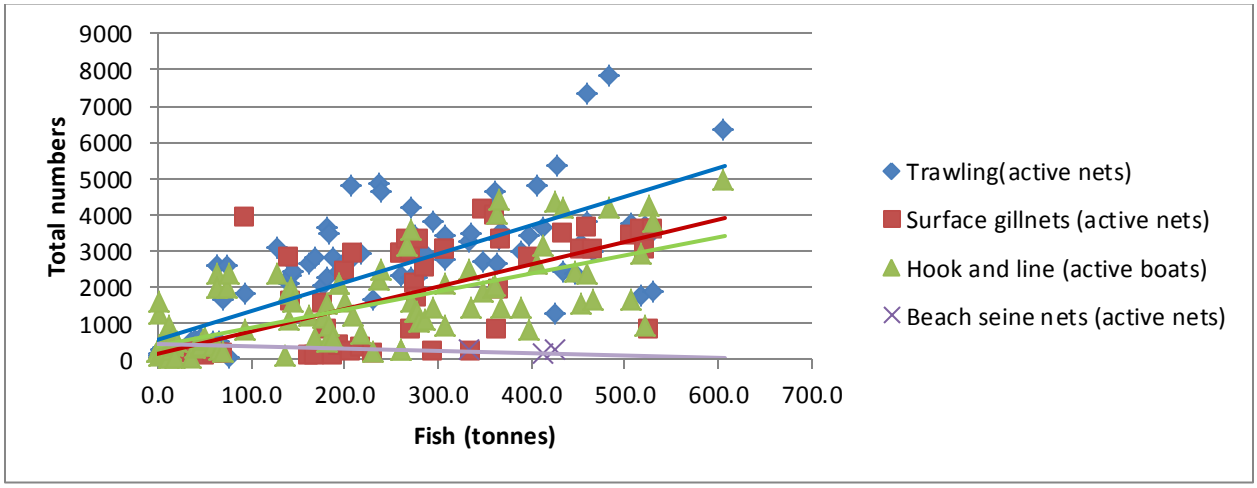


Figure 19 Number of gear related to fish catch in Vilankulo

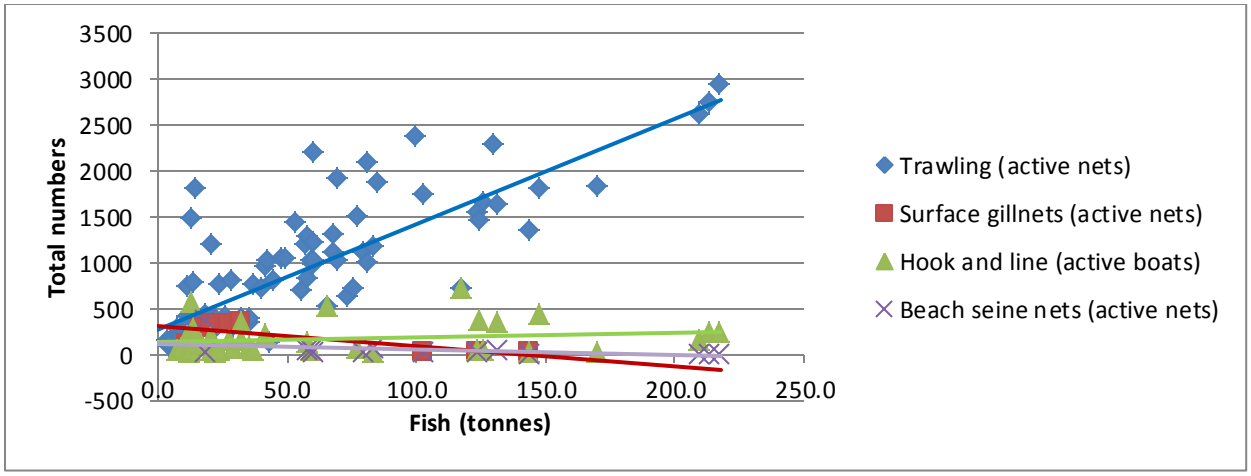


Figure 20 Number of gear related to fish catch in Bazaruto

While comparing the data one has to be careful and consider the number of data points. In some cases the use of less gear leads to a higher catch, but there are many cases wherein more gear equals less catch. Summing the data up, it appears that more gear still leads to higher catches. Therefore, trend lines are only indicative and statistical analyses were performed. Whether trends between gear types and the amount of fish caught are significant was analyzed with a Pearson's correlation (Appendix III, table 7). Table 3 shows which relation between the amount of catch and gear is significant. A positive Pearson correlation number indicates a positive relation and a negative number a negative relation.

Table 3 Outcomes of Pearson correlation analysis (2-sided) between the amount of catch and the amount of gear used for Inhambane, Tofo, Vilankulo and Bazaruto*

Area	Type of gear	Significance with amount of catch
Inhambane	Trawling	Pearson correlation = .763, p= .000
	Surface gillnets	Pearson correlation = .473, p= .000
	Hook and line	Pearson correlation = .558, p= .000
	Beach seine nets	Pearson correlation = .345, p= .091
Tofo	Trawling	-
	Surface gillnets	Pearson correlation = .847, p= .000
	Hook and line	Pearson correlation = .623, p= .000
	Beach seine nets	-
Vilankulo	Trawling	Pearson correlation = .788, p= .000
	Surface gillnets	Pearson correlation = .636, p= .000
	Hook and line	Pearson correlation = .709, p= .000
	Beach seine nets	Pearson correlation = -.430, p= .717
Bazaruto	Trawling	Pearson correlation = .820, p= .000
	Surface gillnets	Pearson correlation = -.693, p= .018
	Hook and line	Pearson correlation = .194, p= .225
	Beach seine nets	Pearson correlation = -.464, p= .095

* When p≤0.05, relations are significant. The data set for trawling and beach seine nets in Tofo only included one data point for trawling and none for beach seine nets. Therefore, no correlation test could be performed for these two gear types.

It can be seen that all relations between the amount of catch and gear are significant, except for Inhambane: Beach seine nets (p=.091), Vilankulo: Beach seine nets (p= .717) and Bazaruto: Hook and line (p= .225) and Beach seine nets (p=.095).

Artisanal fishing is not only important for subsistence, but also for trade. Fishermen sell their fish on the local market or to tourism establishments (Allen; Lundin, pc, 2016). Tourists consume high-value species such as lobsters, crabs or groupers, which increases the value of the local market (Lundin; Siniquinha, pc, 2016). Two important markets for seafood exist in Mozambique, namely in the Province of Gaza and in the Province of Inhambane. These provinces were identified by the government. The market in the PoI is located in Maxixe and has improved hygiene standards. Maxixe was chosen due to a good infrastructure, which enables an easier transport of products (Patrocinio, pc, 2016).

Hygiene is a big problem in processing fish. Artisanal fishermen only have ice in boxes on board to cool the catch (Patrocinio, pc, 2016). Due to high temperatures, the ice melts and fish starts degrading on the boat already. After a long fishing day the value of the fish has decreased and fishermen need to offer their catch at lower prices. In this way, the value of the market is decreased (Lundin, pc, 2016).

Social demands

In Mozambique, about 500,000 people depend directly on the provisioning ecosystem service fish (FAO 2007). Also in both study areas local people highly depend on these ecosystem service (Reeve-Arnold, pc, 2016). The civil war pushed many people into dependency on marine and coastal resources (Lundin, pc, 2016). Citizens who stayed inland need to buy dried fish from the coast to get enough proteins (Silva, pc, 2016). People are poor and hungry and fishing is their only option to get enough proteins (Flam; Interviewee A, pc, 2016). For coastal citizens fish ensures their food security, their employment, and their livelihoods. Around 75% to 80% of the people living in Mozambique either depend on it through fishing or as a food or income source (Hof, pc, 2016). In the BANP, 80% depend on fish (Allen, pc, 2016).

The income depends on the status of a fisherman and the district. The following list presents an average of fishermen's monthly net incomes in Inhambane Province in USD (SAL – Consultoria em desenvolvimento Social Lda. 2006).

1 USD = 66.00 Meticais (XE 2016):

- Boat/gear owners: 1500-5100 USD
- Independent fishers: 115-2900 USD
- Divers/collectors: 2800-6800 USD
- Crew (employees): 50-160 USD
- Informal traders: 380-1380 USD

Fishermen can sell their fish for about 50 Meticais per Kg (0.75 USD), which is resold by local buyers to customers for around 65 Meticais (0.98 USD) (DPTUR *et al.* 2007).

Another factor that increases dependency on fish is the low education level in Mozambique. Many people do not know how to read and write. Fishermen learn fishing from their ancestors and fish in the

same way. Changes to sustainable fishing do not occur because no one teaches fishermen about alternatives (Interviewee A, pc, 2016).

Fish stocks and habitat degradation

Fish stock and habitat degradation impacts the fishermen community. Without access to the resources, the community will struggle with their food security and livelihoods. Due to the decline of these resources, more and more people shift from the fishery sector to the tourism sector to solve their "*problem with surviving*" (Zacarias, pc, 2016).

The increase of the population in the province and the two study areas will also have a negative impact (Figure 21). It is projected that in 2040 there will be 2,217,002 people in the PoI, 122,668 in Inhambane city and 235,354 in the whole Vilankulo district (Instituto Nacional de Estatística 2015). Demand for fish is expected to rise by 2.6% annually to meet the population growth (FAO 2007). The availability of fish may not be sufficient to meet this demand (Reeve-Arnold, pc, 2016).

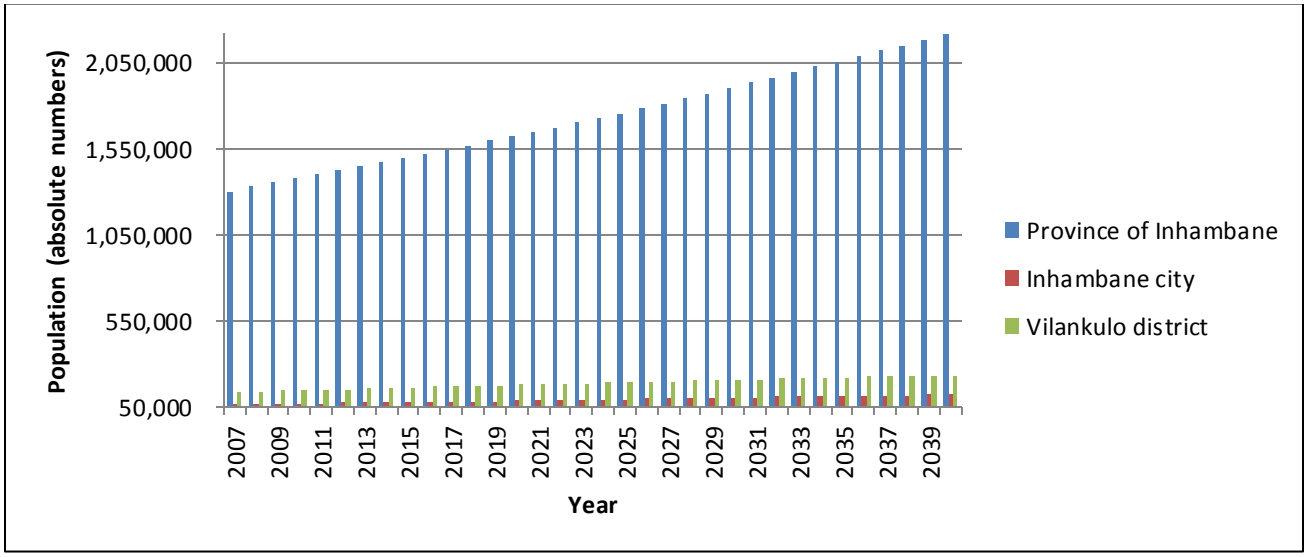


Figure 21 Population projections in Inhambane Province and the two study areas
(Instituto Nacional de Estatística 2015)

The fishing and the tourism sectors are among the three biggest economic sectors of Mozambique. To answer sub-question c) one can say that the socio-economic demands include the maintenance of marine and coastal ecosystem services. Livelihoods and food security depend on provisioning, regulating and cultural services. The decline of resources will have a significant impact on both sectors, but especially on fishermen with lower income and without alternative livelihoods. It is anticipated that the rapid development of the tourism sector and human demographics in the PoI will further stress coastal and marine ecosystem services.

5.5. Implementation into guidelines

The current knowledge of influencers of tourism and fisheries on fish stocks and coastal and marine habitats can be implemented into new guidelines. This section will focus on the fourth sub-question:

d) How can knowledge on influencers, on the interaction between the sectors, on policy regulation and on socio economic demands be implemented into guidelines for fishing and tourism to be used within LMMAs?

To know how the knowledge gathered can be implemented it is important to understand possible solutions to challenges. Interviewees mentioned possible solutions for the different problems. Based on that information and empirical analysis, the solutions are split in two sections: the tourism and the fishery sector and second, information that concern both sectors. An overview of the existing influencers, solutions and challenges is summarized in Tables 4 and 5.

5.5.1. Tourism

Solutions for the tourism sector were proposed on the following levels: socio-economy, policy regulations and tourism activities.

Socio-economy

Tourism operators' livelihoods depend on the number of tourists they take out for recreational and sport fishing, and diving and snorkeling. They sometimes go closer to megafauna and whales and launch more boats than they should. Therefore, regulations could limit the number of boats that are allowed at specific sites. However a balance is needed between regulations and the maintenance of livelihoods (Reeve-Arnold, pc, 2016).

New tourism markets have to be defined to have a better distribution of tourism sub-sectors. Mozambique has a great potential for ecotourism based on its rich ecosystem services. Existing sectors could be made more sustainable to support ecotourism. A certain share of earnings from this sector could be given to fishermen to maintain their livelihoods (Reeve-Arnold, pc, 2016).

Policy regulations

Diving

For diving, regulations on efforts do not exist. To decrease the influence of diving on coral reefs, diving centers in the I/T area work already together (Flam; Levack; Reeve-Arnold, pc, 2016). In the V/B area the need for changes of policy regulations for diving activities is less relevant because of the protection status. Reefs and other habitats are protected in the BANP, which reduces the impact on the environment (Rocco, pc, 2016).

Dive center also minimize the impact on reefs by taking out small groups of tourists. Especially when students are taken to reefs, the number is small because the impact through inexperienced divers is higher (Levack, pc, 2016).Through the implementation of policy regulations, tourism activities can be more regulated and impacts on fish stocks and coral reefs can be reduced (Flam, pc, 2016).

Recreational and sport fishing

Recreational and sport fishermen pay high fees for their licenses. Rato (2016) recommends sport fishing regulations should be enforced at a national level. More control is needed for sport fishing tournaments and the earnings from these tournaments should in return be used to support management of this sub-sector: "*We pay extreme high fees to operate, but see very little done to nothing done on the sport fishing side*." (Rato, survey, 2016).The share between donations for the BANP, entrance fees paid by tourists and the fees for licenses are not equally distributed. Licenses bring in the highest amount of money at the moment. A more equal distribution is needed to ensure equality between every user of the environment (Rato, survey, 2016).

To enforce regulations for the recreational and sport fishing sectors it is important that communication is enhanced. Hof (2016) proposed to talk to tourism fishermen to educate them about the impacts they have on fish stocks. However, it can be expected that they might be skeptical since they do not seem to care a lot (Hof, pc, 2016). Furthermore, the implementation of a check points would decrease illegal fishing. The catch could be checked at the return of recreational and sport fishermen (Interviewee B, pc, 2016).

A regulation that allows the removal of certain species could support equilibrium between species. Frequent assessments are needed to determine which species can be removed and which cannot (Levack, pc, 2016). In the same context, a regulation that determines the release for only slow growing species (e.g. all species of jobfish, kingfish queenfish or barracuda) could be implemented (Rato, survey, 2016). For recreational fishing in particular limits for bag sizes, species and fish sizes should be implemented (Rato, survey, 2016).

Tourism activities

An initiative called 'Green Fins' concerns the issues around diving and marine threats. Currently it is implemented in Indonesia, Malaysia, Maldives, Philippines, Thailand and Vietnam (The Reef-World Foundation 2016b). The missions is "To protect and conserve coral reefs by establishing and implementing environmentally friendly guidelines to promote a sustainable diving and snorkeling tourism industry" (The Reef-World Foundation 2016a). Green Fins promotes a code of conduct which is adapted by the private sector (Appendix IV). To establish Green Fins stakeholders from the government, diving centers, snorkelers and the local community work together. Hands books exist for businesses, organizations, governments and individuals (The Reef-World Foundation 2016a). To minimize influencers through diving activities on the environment, Green Fins could also be established in the PoI.

5.5.2. Fisheries

The analysis of the interviews revealed solutions for the fishery sector on different levels: socio-economy, regulations or the fishing activities.

Socio-economy

Interviewees proposed alternative livelihoods for fishermen (Reeve-Arnold, pc, 2016). Fishermen could be integrated in the tourism sector to reduce their dependency on fishing. For example, tourism operators can hire fishermen for tourism expeditions on doughs, where fishermen can inform tourists about the aquatic diversity and marine and coastal ecosystems. This integration has two advantages: first, the fish stocks would be less influenced because fishermen are working in the tourism sectors, and second, fishermen would make more money with tourism activities than with fishing (Flam, pc, 2016).

Another alternative would be the implementation of aquaculture. Next to fishing, fishermen could conduct aquaculture with seaweed or crustaceans (Allen, pc, 2016). Fish farming could also be conducted in the lakes which are in the PoI (Interviewee B, pc, 2016). In this way, they could have two sources of income; aquaculture would be a supplement when fishing cannot be conducted due to bad weather conditions or closures (Silva, pc, 2016). The government should support these activities which reduce the pressure on the marine and coastal provisioning services (Interviewee B, pc, 2016).

Besides aquaculture, fishermen could also farm rabbits or chicken. Terrestrial alternatives could help to reduce the impact on marine and coastal resources. However, these alternatives have to be explained to fishermen so they understand why they are necessary and why they cannot continue with their business as usual (Rocco, pc, 2016).

Fishermen have to sell their fish as low value fish due to bad storage capacities on board. By improving storage capabilities the value of fish would increase and fishermen would have a higher income. A better transport of fish would also decrease the fishing effort. Less fish is needed to be caught to meet the same financial demands (Lundin, pc, 2016).

A change in target species would also be an alternative to meet financial demands. Megafauna for example are three times more worth in monetary values in the ocean than megafauna on the fish market (Flam, pc, 2016).

Policy regulations

According to most interviewees, the fishery sector has sufficient policy regulations to implement sustainable fishing. However, it was proposed that regulations focus more on specific species. It should be included which species can and cannot be caught. Furthermore, more details about the trade of marine megafauna should be included in regulations to reduce the impact (Hof; Interviewee A, pc, 2016).

To reduce illegal fishing activities the government needs to improve patrolling. Allocation of funds for financial and human resources is needed to implement a good monitoring system (Siniquinha; Zacarias, pc, 2016). Fines could be used for example to reduce the catch of mature and pregnant females (Interviewee A; Interviewee D, pc, 2016). Revenues obtained through fines can be used to support local communities (Interviewee B, pc, 2016).

A good way to involve fishermen in the decision of policy regulations are Conselhos Comunitários de Pescas (CCPs, Community fishing councils). In many Mozambican communities the government has set up CCPs, which are organized locally and apply a bottom-up management approach (Flam, pc, 2016). CCPs are a good alternative since the government lack human resources to support resource management implementation plans (Hof, pc, 2016).

Fishermen elect members for a board and register with the government. After the registration, the CCP is in charge of the area where fishing activities take place. Regulations for all fishing activities are set up by the CCP (Hof, pc, 2016). These regulations include rules like the type of gear that fishermen can use, the period fishing is allowed (closures), or which species are allowed to be caught (Flam, pc, 2016).

CCPs could also implement rotated site closures in policy regulations to have an even distribution of fishing activities. This means that a certain part of the reef is closed on a rotation basis. Since current site closures still allow diving and snorkeling, one could implement a dive fee which is paid by each divers. This money could be given to fishermen to supplement their loss of income due to closures (Flam, pc, 2016).

To help with the setup of CCPs and regulations, the MMF works together with fishermen and provides scientific recommendations. Information is provided about sustainable fishing methods and planning (Flam, pc, 2016). CCPs heads can use this and their own knowledge to educate local fishermen (Patrocinio; Reeve-Arnold, pc, 2016).

It is important that CCPs are empowered with financial support by the government to increase capacity and attention (Patrocinio, pc, 2016). CPPs could spend money on boats for patrolling and pay members that are good at policing. Even though CCPs are established in cooperation with the government, it occurs that the government leaves CCPs alone after the establishment (Silva, pc, 2016).

Fishing activities

To help fishermen to implement sustainable fishing activities, they need to be educated. Education can include information about sustainable gear and the importance of fish and megafauna for the ecosystem, Mozambique's economy, the fishery sector and the tourism sector (Hof: Interviewee D, pc, 2016; Rato, survey, 2016). Education would increase the sustainability of fishing activities, which in return would increase food security (Interviewee D, pc, 2016).

Changes in gear would have a direct positive effect on fish stocks. Gear restrictions could for instance include the number and sizes of hooks on a long line (Interviewee A, pc, 2016). Also, a "*transition from seine netting to hand line fishing*" would be possible (Allen, pc, 2016). According to Allen (2016), the use of hand lines would increase the catch per capita because catch is not shared between crew members. Catch obtained through nets on the other hand is shared (Allen, pc, 2016). A transition to line fishing would also decrease the number of ghost nets, which need to be prohibited by legislation to decrease the impact on reefs and aquatic species (Interviewee B, pc, 2016).

Interviewee C (2016) sees the reduction of beach seining as a solution, because on the one hand it reduces the impact on fish and on the other hand this type of fishing has the greatest impact on his tourism fishing activities. Moreover, fishermen could be educated in how to determine pregnant females like sharks so they can be released back to the sea (Flam, pc, 2016).

Education would also help fishermen to understand existing regulations to know what they are not allowed to do (Patrocinio; Siniquinha, pc, 2016). Anchoring on coral for example is prohibited, but this could be diminished by implementing mooring buoys (Revee-Arnold, pc, 2016). Tourism operators could also help educate fishermen about coral reefs and the importance of fish and megafauna (Interviewee A, pc, 2016).

The fishery sector interacts with the tourism sector, but communication and collaboration between these sectors is limited. How the interaction between these sectors can be enhanced is described in the following section.

5.5.3. Tourism and Fisheries

Collaboration between the different sectors is important. Currently, communication between tourism operators and fishermen is minimal. The MMF organizes meetings with tourism operators and fishermen to discuss their issues and visions. The goal is to find mutual agreements to enhance self-regulation of these sectors in their areas of operation (Flam, pc, 2016). Experiences show that both tourism operators and fishermen are very communicative (Hof, pc, 2016). Also the communication between scientists and public businesses needs to be enhanced so that all knowledge about nature conservation is provided (Reeve-Arnold, pc, 2016).

Another idea that concerns both sectors are MPAs. The establishment of MPAs in the I/T area to reduce impacts was mentioned by several interviewees (Siniquinha; Zacarias, pc, 2016; Bateman, survey, 2016). These MPAs could be associated with tourism operations and include no-take zones for fishermen (Lundin, pc, 2016). No-take zones should also account for recreational and sport fishermen. In other areas of the MPA, tourism fishing should be licensed with catch and release (Levack, pc, 2016).

The idea of closures or no-take zones is seen critically by fishermen, because they cannot fish in these areas. A further idea concerns permanent sanctuaries, in which natural resources can recover. Fishermen could fish at the borders of sanctuaries, since fish can leave these areas (Zacarias, pc, 2016).

However, Zacarias (2016) highlights that there is currently not enough data for the establishment of conservation areas for a sustainable management of marine and coastal ecosystem services. A base line study could identify all fishermen and divers, determine what and how much is fished, where fishermen fish in the marine space and why and find the exact location of coral reefs (Siniquinha; Zacarias, pc, 2016). Furthermore, more research is needed on an ecological level to determine which species exist in the I/T and V/B areas and how abundant they are (Interviewee A, pc, 2016).

The MMF is currently conducting a pilot study in a shallow reef in the I/T area that has been closed for 6 months. Neither fishing nor tourism activities are allowed during this period. The goal is to determine if differences on the coral reef and related species occur when the status before and after the

closure is compared. Taking this approach one could determine which steps are needed to conserve aquatic species and marine habitats, and therefore marine and coastal ecosystem services (Levack, pc, 2016).

Further general solutions concern the government and the national level. A general aspect on the national is population growth. By implementing population limitations, the impact on natural resources would decrease. The development of the inland like agriculture could be increased so people are more distributed among the country (Lundin, pc, 2016).

A top-down management approach by the government can decrease corruption, but management is needed on all levels of governance and in local areas (Lundin; Interviewee B, pc, 2016). It is important that regulations apply for everyone and that everyone has the same regulations to follow (Rato, survey, 2016).

To provide good governance, the government needs to be educated too. Currently it supports the use of gillnets, but it needs to be clarified which gear is sustainable and why (Interviewee A, pc, 2016). Furthermore, the government needs to understand that action is necessary before ecosystems are at a stage which can hardly be turned back. The concept of resilience is very important (Levack, pc, 2016).

5.5.4. Overview

The following tables show a summarized overview of the existing influencers on, proposed solutions and challenges for coral reefs and fish stocks. A detailed description of the influencers is available in section 5.3.

In the tourism sector for example an influencer is the fin striking and touching of corals (Table 4). Solutions to this influencer are education of tourists about the environment, organizing small groups of tourists and enhancing diver's buoyancy control through implementing more dive classes. This solution comes with the challenge that some tourists do not care about the environment and will strike reefs and hold on to corals anyways. More of these influencers, solutions and challenges are described for tourism in Table 4 and fisheries in Table 5.

For each solution that is given per influencer, new challenges have to be faced. The lack of financial and human resources from the government is the most important challenge that counts of several solutions. To diminish this challenge, the government of Mozambique needs to reallocate their monetary sources. The increase of financial resources needs to take place before human resources can be increased. Money from other sectors like agriculture and industry can be used for the development of the fisheries sector. To increase the financial resources in the tourism sector, taxes from licenses can be used. The implementation of visitor's taxes would also be an option to directly increase these resources.

The increase of financial and human resources would also diminish the ignorance of regulations. The government could invest in new monitoring systems to decrease illegal activities. Moreover, human resources can be used to implement education programs to raise awareness of the interaction between humans and the environment. Resource management tools like the ICZM, MSP and EBM can be used as underlying concepts to explain how management can take place within LMMAs and how livelihoods can

be aligned to a sustainable use of marine and coastal ecosystem services. Common knowledge about these concepts among local people would also enhance communication and therefore support collaboration between different sectors; in this case especially between the tourism and the fishery sector.

Table 4 Influencers, solutions and challenges for tourism
Blue: diving and snorkeling; red: recreational and sport fishing

Influencers	Solutions	Challenges
Development of diving and snorkeling sector	Education, Green Fins, small diving groups, ecotourism	Livelihood of tourism operators depend on number of tourists, low knowledge about ecotourism
Fin strikes and touching corals	Education, small diving groups, buoyancy control	Some tourists do not care about the environment
Experienced vs. inexperienced divers	Education, buoyancy control	Make tourists aware of the environment
Increased visits of easy accessible reefs	Rotated site closures	Find agreements between tourism operators and fishermen
Change in megafauna behavior	Education, rotated site closures, include minimum distances in regulations	Ignorance of regulations → the more tourists the higher the income
Noise by boats	Include minimum distances in regulations, minimize number of boats	Ignorance of regulations to satisfy tourists and to maintain livelihood
Illegal fishing	Enforcement of regulations, patrolling	No financial and human resources from the government
Spots fishing tournaments	Enforcement of regulations, species specific regulations, Use fees from licenses as monetary resource	No financial and human resources from the government, government focuses on other financial issues
Catch and release can end deadly	Prevention of unnecessary action like taking pictures, implement tag and release	No financial and human resources from the government
Fishing without release of fish	Enforcement of regulations, check points in the harbor	No financial and human resources from the government
Anchoring on corals	Enforcement of regulations, patrolling, mooring buoys	No financial and human resources from the government

Table 5 Influencers, solutions and challenges for fisheries

Influencers	Solutions	Challenges
High impact on inshore reefs	Support motorized boats, rotated closures	No financial and human resources from the government, explain the need of closures to fishermen
Fishermen cannot afford boats: Unselective gear, stay close to corals	Financial support through World Bank, private investors, government , alternative livelihoods	No financial and human resources from the government, fishermen stick to what they have done forever
Anchoring of corals	Enforcement of regulations, rotated closures, mooring buoys	No financial and human resources from the government, explain the need of closures to fishermen
Ghost nets	Regulations against ghost nets	No financial and human resources from the government
Break corals with nets	Education, rotated closures	No financial and human resources from the government, explain the need of closures to fishermen
Enhanced algae growth due to catch of grazers	Research which species can be caught at a specific time	No knowledge about ecosystem, no financial resources from the government
Unselective gear	Transitions to more sustainable gear	Collaboration between stakeholders, no financial resources from the government
Wrong use of selective gear	Education	Collaboration between stakeholders, no financial resources from the government
Orientation of nets in the sea	Education and research	Collaboration between stakeholders, no financial resources from the government
Lack of money leads to use of cheap available gear	Financial support through World Bank, private investors, government, fees from tourism and fishing sector, education, alternative livelihoods	No financial and human resources from the government, fishermen stick to what they have done forever

Catch of megafauna, illegal shark finning	Education, enforcement of regulations, patrolling, fines	Collaboration between stakeholders, no financial and human resources from the government
Commercial fishing	Enforcement of regulations, patrolling	No financial and human resources from the government

To summarize, based on the knowledge about the current situation several solutions were proposed to challenge influencers induced through fishing and tourism activities. To answer sub-question d) one can say that knowledge on influencers, on sector interactions, policy regulations and socio-economic demands can be implemented into guidelines by incorporating the proposed solutions. These solutions show what is demanded by the local society, what they want to have changed. Through the implementation of these solutions it is expected that influencers on marine and coastal ecosystem services are reduced and that their use becomes sustainable.

6. Discussion

The goal of this study was to set up guidelines for the tourism and fishery sectors, which are divided into ecology, socio-economic demands, policy regulations and LMMAs. Results show that the tourism and the fishery sector induce several different influencers on provisioning (fish stocks), regulating and recreational (coral reefs) ecosystem services. Solutions were proposed to reduce these influencers, which are associated with challenges. Before guidelines can be set up, the results have to be interpreted and analyzed. This analysis is given below for the ecosystem services that exist in the PoI and the associated influencers. Based on this analysis guidelines are presented. Furthermore, this section highlights how the results of this study are relevant for UNU-INWEH and the umbrella project. The representativeness of the data, limits of this research and further research are described to understand which recommendations can be adopted by the host organization.

6.1. Results discussion

6.1.1. Ecosystem services in Inhambane Province

The results show that the PoI is rich in ecosystem services like fishing, tourism, recreation and protection. Especially provisioning services are high, as can be seen through high fisheries landed values. Values for tourism and recreation are higher than average and coastal protection shows low values. The explanation for these scores is given here:

The high fisheries landed values come from rich fishing sources in the PoI like the Sofala Bank, which is a main destination for shrimp fishing (Nunes & Ghermandi 2015). Furthermore, Maputo bay is a main destination for fishing for fish species and belongs to the most important bays of Mozambique (Nunes & Ghermandi 2015). These two areas contribute mainly to the high fishing values in the PoI.

When looking at tourism for the countries in the Northern Mozambique Channel, Mozambique has the lowest tourism values compared to Madagascar, Seychelles, Comoros and Tanzania. (Nunes & Ghermandi 2015). Mozambique's tourism mainly depends on investment capacity from outside. South Africa is the main trade partner and has the highest share of direct foreign investment. Local operators have problems to meet the demands of the tourism industry and many local businesses are not registered officially. The development of local tourism is also limited due to the lack of policy decisions(Sarmento 2007).

The reason for the PoI being in the top half of the tourism values is that income and employment for many households are generated. Inhambane city, Vilankulo and the Bazaruto Archipelago are major tourism destinations and provide high employment opportunities for locals (Turpie & Wilson 2011). Only Zambezia, Nampula and Cabo Delgado have higher tourism values than Inhambane due to higher investments in the sector. In order to promote the PoI, more up-market lodges and resorts were built in the V/B area (Turpie & Wilson 2011).

The Ministry of Tourism (2004) included the following vision for Mozambique's tourism sector in the Strategic Plan for Development of Tourism: "*By 2020, Mozambique is Africa's most vibrant, dynamic*

and exotic tourism destination, famous for its outstanding beaches and coastal attractions, exciting eco-tourism products and intriguing culture, welcoming over 4 million tourists a year. Conservation areas are an integral part of tourism and the combined benefits constitute a significant contribution to National GDP, bringing wealth and prosperity to communities across the Country." (Ministério do Turismo 2004). Especially marine and coastal ecosystem services play a relevant role for this development, as they are the basis for Mozambique's tourism. It is important that their current status is assessed to determine how much development is possible based on the current capacity.

Coastal recreation supports cultural ecosystem services. In Mozambique, coastal recreation depends highly on the condition of marine animals and coral reefs. The PoI is experiencing a decline in these resources, which leads to a decline in coastal recreation and therefore low values (Nunes & Ghermandi 2015). Destructive and overfishing, unsustainable tourism and the lack of governmental authority increase the decline. Key challenges for a sustainable management as identified by COAST (2009):

- Awareness by visitors, user groups and decision makers about the importance of healthy marine and coastal ecosystems is lacking
- The adequate management of coastal tourism is lacking
- The adequate protection of marine and coastal ecosystems and species is lacking
- Unsustainable tourism activities taking place
- Collaboration, communication and coordination between all stakeholders is missing

These challenges need to be overcome to increase coastal recreation values. Increasing human and financial resources by the government would help to increase adequate management and to create information programs to raise awareness of the environment.

Coastal protection is enhanced through coral reefs, mangroves and rocky shores. The PoI is not very rich in these ecosystems compared to the other Mozambican provinces, which leads to low scores. The highest abundance of coral reefs can be found in the northern part of Mozambique and the biggest mangrove forests are found in the central coast area. Rocky shores on the other hand are also found in the southern region (Pereira *et al.* 2014). However, when adding values up, the central and the northern provinces have a higher protection due to combinations of mangroves, coral reefs and rocky shores (Turpie & Wilson 2011).

The interpretation if these results show that the PoI is rich in provisioning ecosystem services like seafood. However, the PoI scores lower for supporting, regulating and cultural services. Still, there is potential to increase the values of these services. The development of tourism is included in the strategic plan and an increase can be expected. Potential also exists for recreation because the increase of financial and human resources can help to overcome challenges. Management needs to be supported to make the most out of the existing ecosystem services. The low values of coastal protection show that conservation of coral reefs, mangroves and rocky shores is important to pretend further decrease of regulating and cultural ecosystem services.

6.1.2. Influencers on marine and coastal habitats and fish stocks

The results show that the tourism and the fishery sector induce several influencers on marine and coastal habitats and fish stocks. Several solutions exist to mitigate the influencers and to facilitate habitats and fish conservation. These solutions concern marine conservation areas, socio-economy, alternatives for fishermen and regulations for diving and snorkeling. These categories are described in this chapter.

Marine conservation areas - LMMAs

When looking at coral reefs in particular, it can be seen that the level of threats on reefs within the BANP are and will be lower than threats on reefs in the I/T area. Small patches in the north and in the south in the V/B area are expected to have higher levels of threat than other reefs because they lie outside of the BANP. The establishment of a marine park has a positive influence on the conservation of coral reefs and therefore on regulating and cultural ecosystem services. To receive similar conservation results, it is recommended to establish a conservation area like a LMMA in the I/T area.

From the interviews it became clear that many interviewees have not heard about the concept of LMMAs, but MPAs were known. Due to the benefits of LMMAs over MPAs, LMMAs are a better management tool. MPAs consider a top-down management approach, where the government is in charge of decision making. In this way local stakeholders are not always involved and their opinions could be neglected. LMMAs on the other hand promote a bottom-up approach, where local stakeholders are in charge of decision making and the government has an advisory role. A LMMA would also benefit locals and the environment in the V/B area, because currently the BANP is regulated by a top-down management approach. Additional LMMAs would take into account demands and visions of the locals and they would have the authority. For both study areas it is important that the LMMAs cover the whole area to reduce the impact on all fish stocks and coral reefs.

The implementation of rotated closures in LMMAs would decrease the impact on marine and coastal habitats and fish stocks. These closures need to regulate that neither tourism nor fishing activities are allowed during the period. The results of this study show that tourism activities have an impact on especially coral reefs. Comprehensive closures would conserve the environment on the levels of fish stocks and coral reefs. By prohibiting activities of both sectors, also the conflict between fishermen and tourism operators is reduced.

The lack of communication between the involved stakeholders is a challenge that needs to be faced when setting up LMMAs. In order to establish LMMAs it is necessary that the concept is comprehended in the same way by each stakeholder. Meetings with all stakeholders are needed to define the terms of each LMMA and to set up a project management plan, which also includes an agenda for the management after the establishment. This will ensure a sustainable management of natural resources within the LMMAs. Main stakeholders that are involved are the government, tourism and (artisanal) fishery operators and experts who provide guidance and education.

Next to the LMMA concept, stakeholders need to be aware of available resource management tools like MSP, ICZM and EBM. MSP should be taken into account to understand which and where

anthropogenic activities take place in the coastal and marine areas. The information that tourism activities and artisanal fishing take place at all coral reefs in the two study areas is valuable for MSP. ICZM can be used to determine existing policies and how they regulate activities in the environment. The analysis of policy regulations in this study feeds into the ICZM approach. The underlying EBM approach is needed to understand the interaction between humans and the environment. The analysis of influencers on provisioning (fish), cultural and regulating (coral reef) marine and coastal ecosystem services can be used as a basis to understand this interaction. A combination of these tools would support the management of LMMAs because all important topics from the Triangle of Sustainability are covered.

However, additional research needs to be performed. Currently, little is known about tourism, fisheries and the condition of the ecosystems in this area. Data on the number of fishermen and tourism operators and their exact areas of operations are needed.

CCPs need to play an important role in communication and research. They are already existent and can be used to obtain local data, information and knowledge about fisheries. They regulate fishing activities on a local scale, which is also a goal of LMMAs. Also the already existing collaboration between dive centers is important and can be used as a basis to support collaboration. If the collaboration and communication between CCPs, tourism operators and the government would be enhanced, the basis for a LMMA would be set:

CCP + Tourism + Government = LMMA

The implementation of LMMAs in other countries like Kenya and Fiji can function as a guideline. Advantages and disadvantages from these projects can be compared to the situation in the PoI to predict similar outcomes. Due to the success of LMMAs in these regions with similar problems as the PoI, it can be expected that LMMAs in the PoI will also become a success.

To conclude one can say that the establishment of LMMAs would increase the sustainable use of marine and coastal ecosystem services in the PoI. Especially provisioning, cultural and protecting services would be supported. Resource management tools need to be used to cover all dimensions of sustainability and to involve all stakeholders. Existing collaborations like CCPs and between dive centers should be used as a basis for collaboration between sectors.

Socio-economy

The analysis of the socio-economic demands shows that there is a social-economic gap between artisanal fishermen and tourism operators. Fishermen do not have realizable alternatives to increase their income and to decrease their dependency on fish.

Tourism operators on the other hand have a higher income than fishermen and depend less on fish, but more on coral reefs and megafauna. Degradation of these services might decrease the number of tourists that dive or snorkel. But in order to maintain the income, tourism operators can offer alternatives like ocean safaris for dolphin or whale watching.

Next to the higher income and the possibilities of alternatives, tourism operators are more supported by the government. An example concerns the closures which are implemented only for

fishermen. Tourist activities like diving and snorkeling are still permitted. This is done because the government sees the tourism sector as an important developing money sector. The development of modern concepts like ecotourism enhances the investments into the tourism sector. Artisanal fishing on the other hand is seen as an old, ever-existing sector which is executed by poor people.

The pilot study conducted by the MMF will show in 6 months what the outcomes of a fully closed area are. Based on these results, the government can evaluate how to decrease the gap between the two social classes. This socio-economic gap has not been discussed in any of the papers that were used for this study.

All in all, it is recommended that either the government directly invests more in the fishing sector, or that money from the tourism sector is utilized to support fisher communities. If this socio-economic gap is not decreased, fishermen will probably not be willing to cooperate as they feel treated as not being important. This will make the establishment of LMMAs more difficult.

Alternatives for fishermen

From the results it becomes clear that diverse livelihoods would help fishermen to increase their income and to reduce their dependency on fish. To offer alternatives to fishermen, it has to be ensured that they will be used by fishermen. In-depth meetings with fishermen are needed to discuss what their demands are and how they see alternatives.

To introduce fishermen to alternatives, education is needed. Local experts, tourism operators and members of the CCPs can help with providing information about successful projects where alternatives were implemented. Since members of the sectors are very cooperative, meetings are a good approach.

Also, fishermen need to understand the concept of closures. This study shows that the catch decreased over the past years in Inhambane city, but increased in Tofo, Vilankulo and Bazaruto. The continuous decrease in catch could mean that in the Inhambane city area overfishing takes place at high levels. Catch in Tofo might be low because the Tofo area itself is not very big. In this way, fewer fisheries are taken into account for data collection. The low catch in Bazaruto can be explained by the BANP that restricts fishing. The increase in catch in the Vilankulo area might be due the sanctuary effect, which was mentioned by Zacarias (2016). Fish move from the ‘safer’ BANP into the ‘unsafe’ area outside the BANP. As Vilankulo lies directly next to the BANP, the catch increases. The increase in catch starts in May 2005 and the park was established in 2001. This shows that a few years are needed for the recovery of fish stocks. A closure in the Inhambane city area would increase the chance of recovery of fish stocks. Fishing could take place close to the closures to use the sanctuary-effect.

Education is also needed for a transition from destructive to more sustainable gear. The results show that the use of more gear leads in general to higher catches. However, it depends on the region and the type of gear and how much gear is used to catch the same amount of fish and whether the amount of catch indeed depends on the amount of gear used. From the correlation analysis it became clear that the number of beach seine nets does not have significant relation to the amount of catch. Also, in Bazaruto the number of hook and line fishing boats does not relate to the amount of catch significantly. Information

from these analyses can be used to help fishermen to determine how many and which type of gear is really needed to increase the catch. In Tofo for example, the use of surface gillnets is more efficient than hook and line fishing, but in Vilankulo the use of hook and line fishing is more efficient than the use of trawling or surface gillnets. If hook and line fishing is more efficient, a transition from unselective to more selective gear would be easier.

In order to increase the catch but to fish in a sustainable way, a balance is needed between the amount and the type of gear. Furthermore, one needs to take into account that the data set which this information is based on was lacking a lot of data points. Due to lack of data it is unknown why certain gear is used more in one area than in another. Therefore, more detailed research is needed to create a complete and reliable data set.

In conclusion, it is certain that solely the provision of alternative livelihoods will not solve the problem for fishermen. Collaboration between the government, experts and the fishermen is needed to identify their needs and to align alternatives to their livelihoods.

Regulations for diving and snorkeling

The tourism sector has no limitations on the effort or the locations of dives, snorkeling and fishing. The implementation of closures that would include tourism as well could provide a short-term solution. It is only short-term because the increasing number of tourists will have an increased impact on the not-closed reefs. Therefore, the implementation of a regulation which would limit the dive and snorkeling effort will be needed for a long-term conservation. Regulations could include the number of dives per center per day, the number of diving and snorkeling tourists per boat and the number of visits of reefs. In the I/T area, dive centers already work together to limit the above mentioned factors. This cooperation can be used to implement this self-regulation into legislative regulations.

To conclude, regulations are needed for the effort of diving in snorkeling tourism to make a long-term conservation of coral reefs possible. Due to the development of the sector, action is needed as soon as possible to maintain coral reef's ecosystem services.

6.2. Guidelines

Based on the interpretation of the results, guidelines can be set up for the establishments of LMMAs in the I/T and V/B areas. This section will show the results for the main question:

What guidelines are prerequisite for the fishery and tourism sector for a sustainable management approach for marine and coastal ecosystem services in the areas Inhambane City and Tofo, and Vilankulo and Bazaruto, and how can they be tailored to ecology, socio-economic demands and policy regulations for the concept of LMMAs?

Legislative guidelines for LMMAs were already created by Odote *et al.* (2015) in the report 'Legislative Guidelines for the establishment and operation of Locally Managed Marine Areas in Kenya' (Appendix V). The following guidelines are additional to these guidelines. Some are more general and set preconditions.

These preconditioned guidelines are needed to create a basis from which LMMAs can be established. They are divided into the three dimensions (ecology, socio-economy, policy) of the Triangle of Sustainability (Figure 3). Ecological guidelines aim at diminishing influencers on fish and coral reefs. Socio-economical guidelines aim at the improvement of livelihoods of fishermen and tourism operators and to enhance collaboration between sectors. Policy related guidelines aim at changes of fish that is caught and at changes of fishing and tourism efforts. Guidelines from these three dimensions can be divided into process and management oriented guidelines.

Next to these boundary conditions, guidelines for LMMAs themselves were set up. These guidelines aim a successful implementation of LMMAs. A common understanding of the concept and collaboration are main points. The guidelines for LMMAs are all process oriented.

6.2.1. Ecology related guidelines

Management oriented:

1. Implement a transition from destructive gear to sustainable gear. The number and type of gear needs to be determined for each fishing area.
2. Use Green Fins in Mozambique to decrease the impact of diving and snorkeling.
3. Include species specific limitations in the regulations of the recreational and sport fishing and artisanal fishing.
4. Include minimum fish sizes in the regulations of the recreational and sport fishing and artisanal fishing.
5. Implement temporary closures for the fishing and the tourism sector to keep the level of conservation high.

6.2.2. Socio-economic guidelines

Fishermen

Management oriented:

6. Improve storage capabilities for catch on board to increase the value of fish. This leads to higher sales for the fishermen
7. Provide alternative livelihoods to fishermen to reduce their dependency on fish and to increase their income.

Process oriented:

8. Raise awareness, through information provision, about the relationship between ecosystems and humans by engaging those involved in the fishing sector.
9. Diminish the socio-economic gap between fishermen and tourism operators to enhance collaboration between sectors and to support fishermen's livelihoods.

Tourism operators

Management oriented:

10. Set up a balance between the livelihood of tourism operators and the number of tourists. This is crucial to maintain livelihoods and the environment at the same time.
11. Investment from the tourism sector into the artisanal fishing sector; either by involving them in tourism activities or by spending a certain amount of the license fees.
12. Use tag and release instead of catch and release. This change increases data collection for research to gather information on fish population dynamics.

Process oriented:

13. Raise awareness, through information provision, about the relationship between ecosystems and humans by engaging those involved in the tourism sector.

6.2.3. Policy related guidelines

Management oriented:

14. Increase human and financial resources and reallocation of these resources by the government.
15. Check points and patrolling boats should be used to reduce illegal fishing.
16. Enforce the regulations in the recreational and sport fishing sector.
17. Enforce the regulations in the artisanal, semi-industrial and industrial fishing sectors.

6.2.4. Guidelines for LMMAs

Process oriented:

18. Distribute knowledge about LMMAs in Mozambique to make people familiar with this concept. It will also explain why LMMAs are more convenient than MPAs.
19. Use resource management tools like ICZM, MSP and EBM as tools to facilitate management and to make management sustainable.
20. The integration of CCPs, the tourism sector and the government in the LMMA establishment will set a basis for communication.
21. Conduct research to determine the current condition of marine and coastal ecosystems and their interaction with humans.
22. Discuss demands of each stakeholder in detail and include these demands in the management of the LMMAs.
23. Set a priority for areas without conservation areas for the establishment of a LMMA.

The guidelines are based on the solutions for a sustainable use of ecosystem services discussed in section 5.5. They need to be implemented to create successful LMMAs. From an ecological perspective, the guidelines will be sufficient to manage marine and coastal ecosystem services sustainably. Ecological sustainability is defined as the "avoidance of depletion of natural resources in order to maintain an

ecological balance" to sustain livelihoods and food security for present and future generations (Oxford University Press 2016b).

The guidelines cover the three dimensions of the Triangle of Sustainability based on the EBM approach (ecology, socio-economy and policy). For the ecological dimension, they provide solutions to diminish direct tourism and fishery influencers on coral reefs and fish stocks. The implementation of these guidelines will decrease and eventually avoid the impact on these marine and coastal resources, which is aligned to the definition of sustainability. More data, information and knowledge on fish population and habitat dynamics would be necessary to receive a full analysis of the ecology dimension (section 6.4.).

The socio-economic guidelines are needed to create a balance between the stakeholders. Stakeholders need to perceive the degradation of marine and coastal ecosystem services in the same way to create common understanding of the situation and to support communication and collaboration between sectors. No stakeholders should be left behind while others are supported more by authorities. In this way, ecosystem services are divided among stakeholders to enhance sustainable use and to decrease depletion. More data about detailed income of fishermen and tourism operators and their dependency on these resources would increase full understanding of the socio-economy dimension (section 6.4.).

Policy related guidelines are important to create and enforce regulations which apply to all stakeholders. These guidelines directly diminish the impact on fish stocks (provisioning services) through decreasing illegal activities. The size of fish stocks remains larger and provides food security for present and future generations. Data, information and knowledge about policy regulation which determine other fisheries efforts like the total allowable catch would be needed to strengthen the understanding of sustainability of the policy dimension.

The implementation of LMMA guidelines will support sustainability by implementing resource management tools and determining the interaction between the ecosystem services and humans. It is expected that the implementation of all guidelines makes a sustainable management of marine and coastal ecosystem services possible. If the implementation of LMMAs in the PoI is successful, the guidelines can be used for LMMA projects in other PoI areas and also in countries with similar problems of marine and coastal ecosystem services decline.

These guidelines were set up based on an EBM approach, an ecological definition of sustainability and therefore from an ecological perspective. To obtain a full picture and to sustain marine and coastal ecosystem services, it is important that guidelines are also set up from the other dimensions: socio-economy and policy. Odote *et al.* (2015) provide guidelines from a legislative perspective, but an analysis from a socio-economic perspective is still missing. A combination of guidelines based on all three dimensions of the Triangle of Sustainability would increase the sustainable use of marine and coastal ecosystem services and increase the chance of success of LMMAs.

6.3. Relevance for UNU-INWEH

The guidelines from this study are relevant to the topic of this research, UNU-INWEH, and especially for the project partners. It is anticipated that the implementation of these guidelines could help in sustaining coastal and marine ecosystem services in the PoI.

The guidelines could also support SDG 14, because sustainable management of marine and coastal ecosystems (target 14.2.) and the regulation of over fishing and illegal fishing (target 14.4) are included in the guidelines (United Nations 2015).

UNU-INWEH can integrate these guidelines in the water and ecosystems research program for projects which focus on sustainable management of marine and coastal ecosystem services. Guidelines about socio-economy and policy should be kept in mind for every project that is implemented in a developing country, because they are major points for successful management. Ecology related guidelines are important for all countries with fishing and marine tourism sectors.

The outcome of this study is also relevant of the umbrella project 'Coastal Cities as Sustainable Economic Hubs'. UNU-INWEH's tasks within this project focus on spatial planning, socio-economic review and assessment, capacity development and GIS (IUCN *et al.* 2016). Especially the tasks spatial planning, socio-economic review and assessment and GIS are met with this study. It is expected that the results of this research can be used in other regions to enhance sustainable use of marine and coastal ecosystem services worldwide.

6.4. Representativeness of data and further research

The study was conducted by using quantitative and qualitative data. The conclusions and guidelines in this discussion section are mainly based on the results from the interviews (qualitative data), which are the core of the study. These conclusions and guidelines are representative at a high level of certainty; answers from interviewees were reliable, which was shown by the many repetitions. The method of in-depth interviewees was successful. The implementation of conclusions like the use of management resource tools, the decrease of the socio-economic gap, the provision of alternative livelihoods, and the implementation of effort regulations is needed to establish a successful LMMA and to conserve especially provisioning, regulating and cultural ecosystem services.

Less certain are conclusions that are derived from quantitative data, which will be highlighted in the following section.

6.4.1. Limitations

During the implementation of this study, limitations had to be accepted. Based on these limitations, recommendations for further research can be given. Limitations will be distinguished into data, information and knowledge gaps (Jetz *et al.* 2016):

- "Data represent raw observations or measurements of states or drivers, which may be qualitative or quantitative."

- "Information includes "processed data" and quantitatively "aggregated knowledge", which might be metrics, indicators, trends or model parameter estimates or other types of variables derived from aggregating, integrating and analysing other data or analysis results."
- "Knowledge refers to understanding gained through analysis and interpretation, experience, reasoning, perception, intuition and learning, which is developed as result of using and processing data and information. It empowers people to take action and supports decision-making."

6.4.2. Data

The data set that was used included measurements of the amount of catch and the amount of gear that was used. However, the lack of measurements in the data set made an analysis with this data set difficult. These missing data points indicate that no measurements were taken in a certain month for the amount of gear or for catch in a certain area. Also, the relation between type of gear and amount of catch is influenced by further parameters like the areas where fishermen fish (close to reefs catch might be higher), the fish stock sizes, the size of nets, or the material the nets are made of. The lack of measurements and supplement data on the fishing activities and the gear made a full analysis of the relation between gear types and the amount of catch impossible. The outcomes of the correlation analysis need to be handled carefully.

Furthermore, data was missing on a species level. No data was available that showed how many animals of a certain species where caught over the past decade. Data on fish populations or the state of coral reefs was also lacking.

Another limitation is that this study only focused on two of the four municipalities that are mentioned in the umbrella project. This choice was made based on time limitation. Therefore, this study needs to be carried out in the municipalities Maxixe and Massinga as well to make comparisons possible. Therefore the same data is needed for these two municipalities.

An important aspect is the lacking data of fishermen that would have been obtained with the interviews. Due to time constraints, it was not possible to conduct interviews with fishermen and include their data in this study.

When looking at the socio-economic aspect of this study, detailed data on the income of tourism operators and fishermen was lacking. For tourism operators, only one income, one profit and one number for sales are known. For fishermen, only averages for different occupations could be found.

6.4.3. Information

Through the lack of the above mentioned data, information that is based on these data was missing too. The incomplete data set did not show any information on the relation between beach seine nets and trawling and the catch for the Tofo area. Also, due to the high lack of measurements the dataset might be biased and might have provided misleading information. A complete dataset is needed to perform a reliable and good quality analysis. All parameters that determine the catch need to be included.

A data set on species level would have shown which species are caught most and with which type of gear. Trends could have been derived from these data and could have shown which type of species is caught less or more nowadays than ten years ago. Data on fish populations and habitats states would have shown trends and dynamics. The fish populations or the habitats could have increased, decreased or stayed stable. It could not be determined which fish or coral species is impacted most through tourism and fishery activities.

Data on the other two municipalities would have provided information on Massinga's and Maxixe's tourism and fishery sectors and on tourism operators and fishermen livelihood's in these two municipalities.

Interviews with fishermen would have provided information about their livelihoods, their employment and their incomes, and about the location of their fishing grounds. Also their demands could have been discussed and taken into account for the setup of the guidelines. Furthermore, their view on the conflict with tourism operators would have been important to incorporate to define solutions. More information on tourism operators' and fishermen's incomes would have made an assessment of the current situation of each sector and the difference between these sectors better. Furthermore, the dynamic on the incomes could have revealed if tourism or fisheries are performing better or worse over the past decades.

6.4.4. Knowledge

The lack of data and information lead to a lack of knowledge. Due to the missing detailed analyses of the relation between type of gear and catch it cannot be determined which type of gear indeed leads to higher catches when less numbers of this gear are used. This is a problem when assessing which type of gear would make fishing most sustainable in a certain area.

Lack of information on species level, fish and habitat dynamics also lead to a lack of knowledge. It is unknown how these parameters have changed over the past years, which also makes an assessment of the influencers impossible. In that way it cannot be determined which species and which habitats need priority for conservation measures.

The guidelines of this study cannot be used for Massinga and Maxixe. It is unknown what the current situation is in these areas and what the expected development of the tourism and fishery sector is. The whole study only concerns the Inhambane city/Tofo and Vilankulo/Bazaruto area.

The lack of interviews with fishermen induces a big lack of knowledge concerning the artisanal fishery sector and fishermen. It remains unknown how the fishery sector perceived the idea of the implementation of LMMAs in their area of operation. Knowledge on the income of the tourism and fishery sectors could have helped to determine the people's livelihood better. Now it is unknown in how far tourism operators and fishermen depend on fish stocks and marine and coastal habitats in monetary values. Moreover, the relation between fishing grounds and habitats remains unknown.

To conclude one can say that this study had several limitations due to time constraints, but also due to incomplete and lacking data. Results derived from the database which provided information about the number of gear types and the amount of catch are therefore not very reliable. The study is also biased because opinions of fishermen could not be included in the analysis. The results are solely based on qualitative data from tourism operators and experts. Further research needs to be conducted to fill gaps.

6.4.5. Further research

The analyses of the limitations give incentives for further research. First of all, more detailed research about the number of gear and the amount of catch is needed. The already existing data set needs to be complemented with measurements to receive a full data set. It is important that the measurements are all collected in the same way, so they stay comparable. Data on net sizes, the location of fishing grounds and the material of nets needs to be gathered. Research would also include measurements on a species level. Species need to be allocated to the type of gear to get to know which type of gear is catching which species most or less.

There is also more research needed on fish population and habitat levels. So far, nothing is known about the dynamics of these two parameters. The real magnitude of over and destructive fishing and unsustainable tourism activities is still unknown.

Further research also includes obtaining data, information and knowledge from fishermen. Fishermen need to be fully incorporated into the establishment of LMMAs. Therefore it is important that research focuses on their demands and their view on LMMAs. Also it is important to know where the exact location of their fishing grounds is to relate habitats and type of fishing to each other.

To meet the goals of the umbrella project, the same study needs to be conducted in Massinga and Maxixe. It is important that the exact same interview guides and questionnaires are used to make the data comparable. Also the way of processing interview data needs to stay the same.

Further research should also include a pilot study where a LMMA is set up in one of the two study areas for a limited period. This LMMA should take into account the above mentioned guidelines to see whether these guidelines work in reality and to find challenges which need to be faced.

6.5. Recommendations for UNU-INWEH

Based on the results of this study recommendations within the concept of LMMAs can be provided to the UNU-INWEH. These recommendations are also based on challenges that had to be faced during the execution of this study. Furthermore, these recommendations can also apply for the establishment of LMMAs in countries other than Mozambique.

1. *Take the abovementioned guidelines into account for further LMMA projects.*
2. *Implement a pilot LMMA to determine the feasibility of such an area.* This should also show which challenges need to be taken into account when a LMMA is established, for example where regulations need to be improved to make the use of marine and coastal ecosystem services more sustainable.

3. *Establish partnerships with local research institutes and with the Ministries of Fisheries, Tourism and Agriculture.* Partnership will simplify the exchange of data, information and knowledge. This would also cross language boundaries (the national language in Mozambique is Portuguese) because local project members can interact with main stakeholders for LMMAs. Also time constraints would be diminished as the project would be carried out in the field.
4. *Data and information from local stakeholders are as important as data from research institutes and ministries.* Local stakeholders need to be taken seriously and their opinions need to be taken into account. They will be in charge of the management of LMMAs; therefore it is important that they have the voice in how LMMAs are designed.
5. *One organization should take the lead in the project for the establishments of LMMAs.* In this way, the organization in charge keeps track that everyone is working according to the agenda and that everyone is involved equally.
6. *Involve all important stakeholders in the decision making for the establishments and the management of LMMAs.* Fishermen, tourism operators and the government are among the main stakeholders. In this way the bottom-up approach of LMMAs could effectively be implemented.
7. *Experts should be consulted.* Experts from social sciences should be consulted to understand the local people's livelihoods and their demands. Furthermore, experts from natural sciences can assist to analyze marine species population dynamics in detail.

7. Conclusion

The Province of Inhambane in Mozambique is rich in ecosystem services which support fisheries in tourism. Tourism and fisheries are both major influencers on fish stocks and marine habitats (coral reefs) and therefore on regulating, cultural and provisioning marine and coastal ecosystem services. The urgency of sustainable management approaches are also recognized by the local people, for example Interviewee C (2016) summarized:

> "I am just glad that I can still do some fishing while it's not all fucked up."

To ensure sustainable management of marine and coastal ecosystem services the guidelines outlined in this study will be useful. Resource management tools like ICZM, MSP and EBM could be implemented to guarantee adequate and sustainable management in all dimensions of the Triangle of Sustainability (ecology, socio-economy, policy). These tools form the basis to create LMMAs.

It can be expected that the implementation of the guidelines will diminish the influencers on provisioning services (fish stocks), and cultural and regulating ecosystem services (marine and coastal habitats). This includes for example more rigorous enforcement of existing regulations or stringent monitoring of use of destructive gear to incentive structure in using sustainable gear to reduce the impact on ecosystem services. Furthermore, these guidelines help local people to ensure livelihoods and food security.

However, these ecological based guidelines need to be combined with policy and socio-economy based guidelines. This increases the chance of a successful, sustainable implementation LMMA because all dimensions from the Triangle of Sustainability are fully covered.

The successful implementation of LMMA projects in regions with similar problems like Kenya and Fiji, increase the likelihood that the LMMA approach makes a good case for sustainable management in the PoI region. The guidelines can be of value for other regions with similar problems and can be scaled up to enhance sustainable use of marine and coastal ecosystem services worldwide.

Further research is needed to fill data and information gaps. In addition, a case study can help to determine the perception of LMMAs by locals, to define challenges and to investigate the feasibility of this concept in the Province of Inhambane.

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Appendix

I. Interview guides

Interview guides were compiled for experts, tourism operators and fishery operators. The fishery guide is shown in English and in Portuguese. All guides can be found in this section.

Experts

Name Interviewee:

Background interviewee:

Location interview:

Date:

Length of interview:

Anonymity in report (yes/no):

Introduction

I am Alexandra, a Biology student from the Radboud University in Nijmegen, the Netherlands and I am currently doing my internship at the UNU-INWEH (United Nations University Institute for Water, Environment and Health) in the water and ecosystems program in Hamilton, Canada. For my research I am interested in marine ecosystem services in the Inhambane region. Inhambane experiences great declines in marine ecosystem services and there are several reasons like tourism and fishery influencers. My goal is to understand the bigger picture of these influencers on fish stocks and fish habitats. To get an overview from different perspectives of the current situation in Inhambane, I will interview tourism and fishery operators and experts.

I would like to interview you as an expert to understand the underlying reasons for declining marine ecosystem services in Inhambane from a scientific perspective. The interview results will be used to set up guidelines for a sustainable use of fish stocks to ensure food security and livelihood for future generations.

The interview consists of five parts: starting with more general questions, followed by questions about the current situation in Inhambane. I will ask about 20 questions, which will take about 30 minutes. The information you give will solely be used for my research.

- Am I allowed to record the interview?
- Do you have any questions or remarks before we start?

Interview questions

Part 1:

The first part is about who you are and includes general questions about marine ecosystem services.

Main questions	**Follow-up questions**	*Why asking these questions*
Could you tell me about yourself?	- What is your background? - What is your current position? - Has your work included/Does your work include marine ecosystems?	*Get to know the interviewee and whether he has been involved with the services earlier. Gives me a picture of how detailed his knowledge would be.*
How would you define marine ecosystem services?		*It is important to know how interviewees frame these services to understand their answers. Also, it shows in how far the definition of these services is the same among experts.*

Part 2:

So, about marine ecosystem services in Inhambane:

Which marine ecosystem services exist in the Province of Inhambane?	- Have you recognized a change in the services? (becoming more or less)	*Understand the bigger picture of the existing services. Also, understand their changes over time. Some might have changed more than others.*
What role do fish stocks play in marine ecosystem services?	- Have you recognized any fish stock changes?	*Understand the importance of fish stocks compared to other marine services and what relevant changes are. These changes will be used determine on what the guidelines have to focus on.*
What role do marine habitats play?	- What kinds of marine habitats exist? - Have you recognized any changes in habitats?	*These questions make sure which marine habitats exist in Inhambane, how*

	Which changes? Why?	*important they are and how they have changed. I found general habitats in literature, but I could not find anything specific information about their changes or influences on them.*
How important are fish stock as marine services for the - economy in Mozambique? - local citizens in Mozambique?		*Link fish stocks to economy and local citizens to understand what the fish stocks are used for and in how far Inhambane depends on these resources. From the answers can be derived what might happen if fish stocks become totally depleted.*
Could you tell me something about the degradation of fish stocks and habitats in Inhambane?	- What are possible causes? - What are anthropogenic influences on these services? Which influences are the most important?	*There are several causes for the degradation of fish stocks and habitats and it is known that tourism and fishery play important roles. However, it might be that the experts see other impacts as being more relevant.*

Part 3:

Next, I would like to focus a bit more on fisheries and their influences related to marine ecosystem services

How do fisheries influence the marine services? - On fish stocks? - On habitats?	- Are there any positive influences? - Are there any negative influences? Possible influences:	*It is known that fishing influences the services in terms of taking too many fish or destruction by using special nets. However, literature only briefly*

	- Type of fishery (artisanal, semi-industrial, industrial) - Use of gear (nets (seine/gill), speargun, hook&line, traps) - Fishing effort (amount of trips, length of trips) - Pollution through ships - Depletion of stocks due to too high catch - By-catch problems	*describes these influences. I want to understand what influences exist and how they influence the services. Influences on marine habitats include the destruction of habitats. In literature, only negative aspects were mentioned. Maybe there are also some positive aspects.*
Which influences would you determine as having the biggest impact on fish stocks?	- Why?	*It is important to understand the details about fisheries influencing fish stocks to make a good analysis of the problem possible. For the guidelines it is necessary to know the most important impacts. Measures are then especially necessary for these influences.*
Which influences would you determine as having the biggest impact on marine habitats?	- Why?	*It is important how these influences impact the habitats, e.g. breaking corals reefs, or destroying sea grass beds, how that happens and which fishing operations causes these influences. For the guidelines it is necessary to know the most important impacts. Measures are then especially necessary for these influences.*
What are policy regulations or	- What policies exist for different fishing operations	*Different licenses and*

laws concerning fishing?	(effort, gear)? - What kind of licenses exist? - Are these regulations fully implemented? If yes: Why are there still problems? If no: What are obstacles?	*policies exist for the various fisheries (artisanal, semi- and industrial). However, I do not know specific details about these licenses and policies, e.g. do they include the allowed number of fishing trips per day or do they restrict the areas of fishing grounds?*

Part 4:

Now, I would like to focus on tourism related to marine ecosystem services

How does tourism influence the marine services? - fish stocks? - habitats?	- Are there any positive influences? - Are there any negative influences? Possible influences: - Diving (breaking corals) - Snorkeling (breaking corals) - Game fishing	*It is necessary to understand which tourism operations take place in the marine space and how they influence the fish stocks and the habitats. From literature it is known which activities take place, but their detailed influence on fish stocks and habitats is not known in Inhambane.*
Which influences would you determine as having the biggest impact on fish stocks?	- Why?	*It is relevant to understand which influences have the biggest impact and why. This will be useful for the guidelines.*
Which influences would you determine as having the biggest impact on marine habitats?	- Why?	*It is relevant to understand which influences have the biggest impact and why. This will be useful for the guidelines.*
What are policy regulations or laws concerning tourism?	- What policies exist for different tourism operations (effort, gear)?	*Different licenses and policies exist for tourism.*

	- What kind of licenses exist? - Are these regulations fully implemented? If yes: Why are there still problems? If no: What are obstacles?	*However, I do not know specific details about these licenses and policies, e.g. do they include the allowed number of trips per day or do they restrict the areas where tourism takes place? It is relevant to know this to align the guidelines according to policy regulations.*

Part 5: This is the last part of the interview

Do you know anything about the conflict between fishery and tourism operators sharing the same marine resources?	- What does that mean for fish stocks? - What does that mean for marine habitats?	*This question is relevant to understand the conflict between stakeholders sharing the same marine space. Answers might reflect how big this conflict is and what that means for stocks and habitats. The answers are also relevant to set up the correct guidelines, which suit both, tourism and fishery stakeholders. For the guidelines it is necessary to know the most important impacts. Measures are then especially necessary for these influences.*
Could you think of possible solutions to make the use of fish stocks and habitats sustainable?	- LMMAs or MPAs? - Could you think of changes in regulation for fishery and tourism? - What measures are needed? - What is possible and what is not possible?	*This question analyzes what solutions are possible. If interviewees were/are involved in projects with marine ecosystem services, they*

		might mention answers related to these earlier projects. Also, there are possibilities of building LMMAs. It can be asked if they think if LMMAs are sufficient on their own, or if more involvement is needed. This will show what guidelines will be necessary.

Last comments

These were all my questions. Thank you very much.

- Is there anything you would like to add?

- May I mention your name in the report?

- Would you like to have a copy of the report when it is finished?
- May I contact you again, if something important comes into my mind?

Tourism operators

Name Interviewee:

Background interviewee:

Location interview:

Date:

Length of interview:

Anonymity in report (yes/no):

Introduction

I am Alexandra, a Biology student from the Radboud University in Nijmegen, the Netherlands and I am currently doing my internship at the UNU-INWEH (United Nations University Institute for Water, Environment and Health) in the water and ecosystems program in Hamilton, Canada. For my research I am interested in marine resources in the Inhambane region. Inhambane experiences great declines in marine ecosystem services and there are several reasons like tourism and fishery influencers. My goal is to understand the bigger picture of these influencers on fish stocks and fish habitats. To get an overview from different perspectives of the current situation in Inhambane, I will interview tourism and fishery operators and experts.

I would like to interview you to understand the underlying reasons for declining marine resources in Inhambane. As a tourist operator you are directly involved and you can show how this issue is perceived by the tourism sector. The interview results will be used to set up guidelines for a sustainable use of fish stocks to ensure food security and livelihood for future generations for the fishery and the tourism sector.

The interview consists of five parts: starting with more general questions, followed by questions about the current situation in Inhambane. I will ask about 16 questions, which will take about 30 minutes. The information you give will solely be used for my research.

- Am I allowed to record the interview?
- Do you have any questions or remarks before we start?

Interview questions

Part 1: The first part is about who you are

Main questions	**Follow-up questions**	*Why asking these questions*
Could you tell me about yourself?	- Where do you live? - Since when? - Where are you from? - If immigrated from a different region of Mozambique or country: When? Why?	*It is important to know the interviewee. Also, knowing for how long he lives here gives an indication of how many of the interviewed fishermen are locals or have immigrated. From literature became clear that most tourism operators are from South-Africa. This might show that pressure on ecosystems increase because of 'foreign' people moving to Mozambique.*

Part 2: So, about tourism in Inhambane:

Where is the location of your tourist office?	- How many employees do you have?	*By knowing the location, tourism activities can be clustered for further analyses. They can be compared according to their size.*
Which tourism activities do you offer?	- Which ones are used most by tourists?	*It is important to know which tourism activities are offered, and which are used most by tourists. This has influence on the guidelines, whether certain activities need to be taken into account or not.*
How often do you conduct these activities per day?	- How long do the activities last? - Are there any changes in the number of fishing trips and lengths per day over the past decade?	*To determine the tourism effort it is necessary to know how often and how long these trips are. Also, changes in these efforts indicate whether tourism*

		became more important or not. (leave the option to not record and handle information anonymously)
Where do you conduct the activities? (provide a map)	- Have the areas changed over the past decades/years?	*At this moment, it is unknown where exactly the activities take place. It is important to know that to relate the activities to habitats, which are related to fish species.*
Are fish involved in the activities?	- E.g. watching them by tourists during dives or catching them for game fishing	*It is known that fish are important for divers, snorkeling and game fishing. It is also important to know if they are involved in any other activities and how they are involved like directly (through catching) or indirectly (through watching)*
Do the activities have influence on fish stocks?	- How? (posive/negative) - And on fish habitats? How? (posive/negative) - To keep in mind: Divers breaking coral reefs, e.g.	*It is known from literature that tourism influences fish stocks and habitats. However, it is unknown whether tourism operators recognize that as well. This can be included in the guidelines, for example providing training or information programs about influences.*

Part 3: About employment, income and food security

Is tourism the only source for your income?	- What are other sources? - What is share of tourism contributing to your income?	*From literature is known that some fishermen have a diverse livelihood to earn*

		enough money. Maybe some tourist operators do the same because tourism is not sufficient (maybe dependence on seasons)
What is your income?	- What is your employees' income?	*It makes clear, how much money a tourism operator has for living and how dependent he is on his activities. However, if they do not want to answer the questions that is fine.*
In how far are fish stocks important for your tourism operations?	- And for your income?	*As tourism offer many activities, it is important to know that role fish stocks paly in this activities. It is unknown for how important tourism operators see fish for their tourism efficiency.*

Part 4: About policy regulations

What kinds of licenses exist for tourism activities?	- Which license do you have? - For how long is the license/are the licenses valid?	*Gives an overview of what the licenses imply and if they are really used or not.*
What policies regulate tourism, next to licenses? - In terms of effort (trip per day, lengths of trips, areas) - Gear	- What kind of restrictions exist for tourism?	*These restrictions are necessary for a sustainable use of fish resources.*
Which laws determine your area of operation?	- Are there areas where tourism activities are restricted?	*It is known that marine parks exist. However, game fishing and other tourism may still be conducted in these areas because they are seen as not threatening to fish stock and habitats. This question show whether there are*

		indeed areas where fish can develop without being disturbed.

Part 5: About fisheries

What do you think about fisheries?	- Why?	*Fisheries and tourism share the same resources, namely fish. Either through catching or watching it (e.g. diving). It is important to know how fishermen perceive tourism, whether as a good or bad sector and why.*
Do you have to share your marine space with fishermen?	- How do you think about that? - Which fishing takes place in your area?	*From literature, it is unclear which fishery types interfere with which tourism activities.*
What would you like to happen to make the use of fish stocks more sustainable?	- What do you expect from the government? - What do you think is possible given the current situation? - Do you can think of any obstacles?	*It is unknown what tourism operators think about this topic. Therefore, their opinions about changes are also not known. It is important to include them in the decision process because they play a major role in influencing fish stocks. It is necessary to find guidelines that suit both, tourism and fishery operators.*

Last comments

These were all my questions. Thank you very much.

- Is there anything you would like to add?

- May I mention your name in the report?

- May I contact you again, if something important comes into my mind?

Fishery operators – English version

Name Interviewee:

Background interviewee:

Location interview:

Date:

Length of interview:

Anonymity in report (yes/no):

Introduction

I am Alexandra, a Biology student from the Radboud University in Nijmegen, the Netherlands and I am currently doing my internship at the UNU-INWEH (United Nations University Institute for Water, Environment and Health) in the water and ecosystems program in Hamilton, Canada. For my research I am interested in marine resources in the Inhambane region. Inhambane experiences great declines in marine ecosystem services and there are several reasons like tourism and fishery influencers. My goal is to understand the bigger picture of these influencers on fish stocks and fish habitats. To get an overview from different perspectives of the current situation in Inhambane, I will interview tourism and fishery operators and experts.

I would like to interview you to understand the underlying reasons for declining marine resources in Inhambane. As a fishermen you are directly involved and you can show how this issue is perceived by the fishery sector. The interview results will be used to set up guidelines for a sustainable use of fish stocks to ensure food security and livelihood for future generations for the fishery and the tourism sector.

The interview consists of five parts: starting with more general questions, followed by questions about the current situation in Inhambane. I will ask about 20 questions, which will take about 30 minutes. The information you give will solely be used for my research.

- Am I allowed to record the interview?
- Do you have any questions or remarks before we start?

Interview questions

Part 1: The first part is about who you are.

Main questions	**Follow-up questions**	*Why asking these questions*
Could you tell me about yourself?	- Where do you live? - Since when? - Where are you from? - If immigrated from a different region of Mozambique or country: When? Why?	*It is important to know the interviewee. Also, knowing for how long he lives here gives an indication of how many of the interviewed fishermen are locals or have immigrated. This might explain changes in fishermen numbers. From literature it is known that pressure on fish stocks increased because many people moved to the coast (civil war) and became fishermen.*

Part 2: So, about fishing in Inhambane:

Where is the location of your fishery?	- How many vessels has this fishery? - How many fishermen has this fishery?	*By knowing the location, fisheries can be clustered for further analyses. They can be compared according to their size. Also, different sized fisheries focus on different fish species and use different gear types.*
Where do you catch the fish? (provide a map)	- Have the fishing grounds changes over past decades/years?	*At this moment, it is unknown where exactly the fishermen fish. It is important to know that to relate the fishing grounds to habitats, which are related to fish species.*
What type of fishing do you	- Artisanal, semi-artisanal, industrial	*The different types of*

conduct?		*fishing use different gear, vessels and also process the fish differently. Industrial fishing for example includes export of fish.*
What type of fishing gear do you use?	If several gears are used: - Which gear do you use most? - Why?	*The type of gear is necessary to relate habitats and fish species to this gear. Different gear is used for different types of fish in different habitats.*
How often do you go fishing per day?	- How long are you fishing trips? - Are there any changes in the number of fishing trips and lengths per day over the past decade?	*To determine the fishing effort it is necessary to know how often fishermen go fishing and how long these trips take. Also, changes in these efforts indicate whether fishing became more important. (leave the option to not record and handle information anonymously)*
What type of fish do you catch?	- Have you noticed changes in the fish composition in the last years/decades? ➔ Which? - Have you noticed changes in fish abundance? - Have you noticed changes in fish size? ➔ Which?	*The type of fish is important to relate fish stocks to fishery types. I could show that high numbers of a certain fishery type causes a strong decline in a certain fish type.*
Do you have bycatch? (in general, includes all species)	- Which type of fish? - How much? - What do you do with it?	*Fisheries often have bycatch. It is important to know what fish is*

		bycatch and how much it is (the focus of my study is solely on fish species). In that way guidelines according to changes in for example gear can be formulated.
Do the activities have influence on fish stocks?	- How? (positive/negative) - And on fish habitats? How? (positive/negative) - To keep in mind: Fishing too many fish Bycatch too high Destroying habitats through certain gear	*It is known from literature that fishing influences fish stocks and habitats. However, it is unknown whether fishermen recognize that as well. This can be included in the guidelines, for example providing training or information programs to fishermen about influences.*

Part 3: About livelihood and food security

Do you sell the fish?	If Yes: - For what? (local consumption, export) - How much of each type of fish? (Kg/day) - What is the price for the fish? (per Kg)	*Different fishery types process their fish in different ways: local or national selling or export. It can be assumed that different amounts of fish are needed to satisfy the different market needs. This has influence on fish stocks.*
Is fishing your only source for income?	- What are other sources? - What is share of fishing contributing to your income?	*From literature is known that some fishermen have a diverse livelihood to earn enough money.*
What is your income?	- What is your employees' income?	*It makes clear, how much money a fishermen has for living and how dependent he*

		is on fish. However, if they do not want to answer the questions that is fine.
In how far is fish a source of food for you?		*This question highlights if the fish caught is also used for personal consumption. Also, it shows how fishermen are personally dependent on fish stocks.*

Part 4: About policy regulations

What kinds of fishery licenses exist?	- Which license do you have? - For how long is the license/are the licenses valid?	*Gives an overview of what the licenses imply and if they are really used or not.*
What policies regulate fishing, next to licenses? - In terms of effort (trip per day, lengths of trips, fishing areas) - Gear	- What kind of restrictions exist for fishing?	*These restrictions are necessary for a sustainable use of fish resources.*
Which laws determine your fishing area?	- Are there areas where fishing is restricted?	*It is known that marine parks exist, where commercial fishing is prohibited. Maybe next to these parks there are other areas (or water depths) where they are not allowed to fish. This would give fish and habitats more space to develop.*

Part 5: About tourism

What do you think about tourism?	- Why?	*Fisheries and tourism share the same resources, namely fish. Either through catching or watching it (e.g. diving). It is important to know how fishermen*

		perceive tourism, whether as a good or bad sector and why.
Do you have to share your marine space with tourism operators?	- How do you think about that? - What tourism activities take place in your fishing area?	*From literature, it is unclear which fishery types interfere with which tourism activities.*
What would you like to happen to make the use of fish stocks more sustainable?	- What do you expect from the government? - What do you think is possible given the current situation? - Do you can think of any obstacles?	*It is unknown what fishermen think about this topic. Therefore, their opinions about changes are also not known. It is important to include them in the decision process because they play a major role in influencing fish stocks. It is necessary to find guidelines that suit both, tourism and fishery operators.*

Last comments

These were all my questions. Thank you very much.

- Is there anything you would like to add?

- May I mention your name in the report?

- May I contact you again, if something important comes into my mind?

Fishery operators – Portuguese version

The column 'why asking these questions' was not translated because this was simply information for the person conducting the interviews.

Ficha de inquérito operadores de pesca

Nome do entrevistado:

Nível de escolaridade do entrevistado:

Local da entrvista:

Data:

Duração da entrvista:

Anonimato no relatório (sim / não):

Introdução

Eu sou Alexandra, estudante de Biologia da Universidade Radboud em Nijmegen, Holanda e actualmente estou fazendo o meu estágio na Universidade das Nações Unidas, Instituto de Água, Meio Ambiente e Saúde (UNU-INWEH) em Hamilton, Canadá. A minha pesquisa centra-se nos recursos marinhos na província de Inhambane. Inhambane vem registando declínios nos serviços dos ecossistemas marinhos e há várias razões nomeadamente as influências do turismo e da pesca. O meu objetivo é ter um retrato dessas influências sobre o pescado e e seu habitats. Para obter uma visão geral de diferentes perspectivas sobre a situação atual em Inhambane, vou entrevistar operadores turísticos e da pesca, incluindo especialistas.

Eu gostaria de entrevistá-lo para compreender as razões subjacentes do declíneo dos recursos marinhos em Inhambane. Estando directamente envolvido como pescador, pode nos ajudar a entender como esta questão é percebida pelo sector pesqueiro. Os resultados serão utilizados para produzir guiões sobre o uso sustentável dos recursos pesqueiros para garantir a segurança alimentar e meios de subsistência para as futuras gerações e para os sectores da pesca e turismo.pesca eo sector do turismo.

A entrevista consiste em cinco partes: começando com questões mais gerais, seguida por perguntas sobre a situação atual em Inhambane. Vou lhe fazer cerca de 20 perguntas, com duração de cerca de 30 minutos. A informação que você vai dar será exclusivamente usada para a minha pesquisa.

- Posso gravar a entrevista?
- Você tem alguma pergunta ou observações antes de começarmos?

Questões do inquérito

Parte 1: A primeira parte é sobre sí.

Principais questões	**Perguntas de seguimento**	*Why asking these questions*
Pode falar me sobre sí?	- Onde vives? - Desde quando? - De onde és? - Se emigrou de outras regiões do país: Quando? Porquê?	*It is important to know the interviewee. Also, knowing for how long he lives here gives an indication of how many of the interviewed fishermen are locals or have immigrated. This might explain changes in fishermen numbers. From literature it is known that pressure on fish stocks increased because many people moved to the coast (civil war) and became fishermen.*

Parte 2: Acerca da pesca em Inhambane:

Onde se localiza a sua área de pesca?	- Quantas embarcações existem? - Quantos pescadores existem?	*By knowing the location, fisheries can be clustered for further analyses. They can be compared according to their size. Also, different sized fisheries focus on different fish species and use different gear types.*
Onde apanhas o peixe? (mostre o mapa)	- Houve mudança de locais de pesca nas últimas décadas/anos	*At this moment, it is unknown where exactly the fishermen fish. It is important to know that to relate the fishing grounds to habitats, which are related to fish species.*
Que tipo de pesca realiza?	- Artesanal, semi-artisanal, industrial	*The different types of fishing use different gear, vessels and also process the fish differently. Industrial fishing for example includes export of fish.*
Que tipo de arte de pesca usa?	Se usa várias artes de pesca: - Qual é a mais usada? - Porquê?	*The type of gear is necessary to relate habitats and fish species to this gear. Different gear is used for different types of fish in different habitats.*
Quantas vezes vai a pesca por dia?	- Quanto tempo leva a sua viagem para a pesca?	*To determine the fishing effort it is necessary to know how*

	- Há alguma mudança no número de viagens e distância para a pesca por dia durante a última década?	*often fishermen go fishing and how long these trips take. Also, changes in these efforts indicate whether fishing became more important. (leave the option to not record and handle information anonymously)*
Que tipo de peixe captura?	- Tem notado alguma mudança na composição/tipo do peixe nos últimos anos ou décadas? ➔ Qual? - Tem notado alguma mudança na abundância do peixe? - Tem notado alguma mudança no tamanho do peixe? ➔ Qual?	*The type of fish is important to relate fish stocks to fishery types. I could show that high numbers of a certain fishery type causes a strong decline in a certain fish type.*
Você tem as capturas acidentais? (Em geral, inclui todas as espécies)	- Que tipo de peixe? - Quanto? - O que você faz com isso?	*Fisheries often have bycatch. It is important to know what fish is bycatch and how much it is (the focus of my study is solely on fish species). In that way guidelines according to changes in for example gear can be formulated.*
Será que a actividade têm influência sobre o stock de peixe?	- Como? (posetiva/negativa) - E no habitat de peixe? Como? (posetiva/negativa) - Para manter em mente: Pescar muito peixe Captura acidental demasiado elevada Destruindo habitats através de determinadas artes de pesca	*It is known from literature that fishing influences fish stocks and habitats. However, it is unknown whether fishermen recognize that as well. This can be included in the guidelines, for example providing training or information programs to fishermen about influences.*

Parte 3: Meios de subsistência e segurança alimentar

Você vende o peixe?	Se sim: - Para quê? (Consumo local, exportação) - Quanto de cada tipo de peixe? (Kg / dia) - Qual é o preço para o peixe? (Por kg)	*Different fishery types process their fish in different ways: local or national selling or export. It can be assumed that different amounts of fish are needed to satisfy the different market needs. This has influence on fish stocks.*

A pesca é a sua única fonte de renda?	- Quais são as outras fontes? - Qual é a contribuição da pesca para o seu rendimento?	*From literature is known that some fishermen have a diverse livelihood to earn enough money.*
Qual é a sua renda?	- Qual é o rendimento dos seus funcionários?	*It makes clear, how much money a fishermen has for living and how dependent he is on fish. However, if they do not want to answer the questions that is fine.*
Em que medida o peixe constitui uma fonte de alimento para você?		*This question highlights if the fish caught is also used for personal consumption. Also, it shows how fishermen are personally dependent on fish stocks.*

Part 4: Políticas e regulamentos

Que tipo de licenças de pesca existem?	- Qual licença que você tem? - Por quanto tempo é a licença / as licenças são válidas?	*Gives an overview of what the licenses imply and if they are really used or not.*
Que políticas regulam a pesca, juntamente com as licenças? - Em termos de esforço (viagens por dia, distância, áreas de pesca) - Artes de pesca	- Que restrições existem para a pesca?	*These restrictions are necessary for a sustainable use of fish resources.*
Que leis regulam a sua área de pesca?	- Existem áreas onde a pesca é restrita?	*It is known that marine parks exist, where commercial fishing is prohibited. Maybe next to these parks there are other areas (or water depths) where they are not allowed to fish. This would give fish and habitats more space to develop.*

Parte 5: Turismo

O que achas sobre o turismo?	- Porquê?	*Fisheries and tourism share the same resources, namely fish. Either through catching or watching it (e.g. diving). It is important to know how fishermen perceive tourism, whether as a good or bad sector and why.*
Partilhas o seu espaço marinho	- O que achas acerca disso?	*From literature, it is unclear*

com os operadores turísticos?	- Que tipo de actividades turísticas ocorrem na sua área de pesca?	*which fishery types interfere with which tourism activities.*
O que gostaria que fosse feito para que o uso do stock de peixe seja mais sustentável?	- O que espera do Governo? - O que acha possível tendo em conta a situação actual? - Achas que tem algum obstáculo?	*It is unknown what fishermen think about this topic. Therefore, their opinions about changes are also not known. It is important to include them in the decision process because they play a major role in influencing fish stocks. It is necessary to find guidelines that suit both, tourism and fishery operators.*

Últimos comentários

As minhas perguntas terminam por aquí. Muito obrigado.

- Tens algo que gostaria de acrescentar?

- Posso mencionar o seu nome no relatório?

- Posso lhe contactar novamente se me recordar de algo importante?

II. Surveys

The maps in the surveys were adjusted according to the tourism and fishery operator's location in the Province of Inhambane. In this way, they had more detailed maps to show their areas of operation.

Tourism operators

Survey tourism

I am Alexandra, a Biology student from the Radboud University in Nijmegen, the Netherlands and I am currently doing my internship at the UNU-INWEH (United Nations University Institute for Water, Environment and Health) in Hamilton, Canada. For my research I am interested in marine resources in the Province of Inhambane. Inhambane experiences great declines in fish stocks and there are several underlying reasons. To analyze these reasons in more detail I am conducting interviews and surveys with tourism operators, fishermen and ecologists.

The survey consists of 4 parts. At the end you have some free space to add comments or remarks. Your information will solely be used for my research and will be handled anonymously; you don't have to mention your name.

Filling in the survey will take about 10-15 minutes. Thank you!

Name Click here to enter text.

Occupation What: Click here to enter text.

Since: Click here to enter text.

City of birth Click here to enter text.

Part 1: Tourism effort

- Where is the location of your tourist office? (Please drag the red point onto the map)

Red point:

- Which water tourism activities do you offer? (Please tick boxes below)

- How often do you perform these activities per day?
(Please indicate that behind the respective activity)

☐ Diving Click here to enter text.

☐ Water-skiing Click here to enter text.

☐ Ocean safaris Click here to enter text.

☐ Game fishing Click here to enter text.

☐ Snorkeling Click here to enter text.

☐ Other: Click here to enter text.

Click here to enter text.

- Which activity/ies is/are performed most by tourists? Click here to enter text.

- Where do you conduct the tourism activities?

(Please use the colored points from below to indicate activities at a certain position, drag points onto the map)

1 = Diving

2 = Snorkeling

3 = Ocean safaris

4 = Water-skiing

5 = Game fishing

6 = Other

- What type of fish do you encounter during tourism activities? (Please tick boxes)

☐ Albacore
☐ Bartail flathead
☐ Beautiful fusilier
☐ Bigeye tuna
☐ Black marlin
☐ Black-barred halfbeak
☐ Blacktip sea catfish
☐ Blue trevally
☐ Blueskin seabream
☐ Common dolphinfish
☐ Common pike conger
☐ Common ponyfish
☐ Cresent-tail bigeye
☐ Crimson jobfish
☐ Dorab wolf-herring
☐ Dot dash rockcod
☐ Dusky spinefoot
☐ European barracuda
☐ Flame goatfish
☐ Flathead grey mullet
☐ Goldstripe sardinella
☐ Green jobfish
☐ Humpback red snapper
☐ Indian anchovy
☐ Indian goatfish
☐ Indian mackerel
☐ Indian pellona
☐ Indian scad
☐ Javelin grunt
☐ Kawakawa
☐ Kelee shad
☐ Largehead hairtail
☐ Largespotted dart
☐ Marbled parrotfish
☐ Narrow-barred Spanish mackerel
☐ Orangemouth anchovy
☐ Pompano dolphinfish
☐ Rainbow runner
☐ Redspot goatfish
☐ Saddle grunt
☐ Santer seabream
☐ Sharptooth jobfish
☐ Shoemaker spinefoot
☐ Silver sillago
☐ Sin croaker
☐ Skipjack tuna
☐ Sky emperor
☐ Slinger seabream
☐ Smallscale pursemouth
☐ Spotcheek emperor
☐ Spotted sardinella
☐ Swallow-tail
☐ Swordfish
☐ Talang queenfish
☐ Tigertooth croaker
☐ Wahoo
☐ White sardinella
☐ White-edged grouper
☐ Yellowfin tuna
☐ Yellowlip emperor
☐ Other:

Click here to enter text.

- Have you recognized changes in abundance, size and composition in the species over the past 10 years?

Abundance: Click here to enter text.

Size: Click here to enter text.

Composition: Click here to enter text.

Part 2: Livelihood

- Is tourism your only source of income? (Please tick box) ☐Yes ☐No

IF NO: What are other sources? Click here to enter text.

- What is the share (%) of tourism contributing to your income? Click here to enter text. %

- What is your income per month? Click here to enter text. Metical

Part 3: Licenses

- What tourism license/s do you have?

Click here to enter text.

- For how long is this license valid in total?

Click here to enter text.

- What does the license allow you to do? (E.g. which activities you can perform)

Click here to enter text.

- What are restrictions you have due to the license? (E.g. numbers of trips per day)

Click here to enter text.

- Which laws determine your activity area?

Click here to enter text.

Part 4: Fisheries Klicken Sie hier, um Text einzugeben.

- Do you share your marine space with fishery operators? ☐ Yes ☐No

-Are you disturbed during your tourism business through fishery? ☐Yes ☐ No

-IF YES: How? Click here to enter text.

- What would you like to happen to stop the fish stocks from declining?

Click here to enter text.

Last comments

- Please feel free to leave any comment or remark

Click here to enter text.

Fishery operators – English version

Survey fishermen

I am Alexandra, a Biology student from the Radboud University in Nijmegen, the Netherlands and I am currently doing my internship at the UNU-INWEH (United Nations University Institute for Water, Environment and Health) in Hamilton, Canada. For my research I am interested in marine resources in the Province of Inhambane. Inhambane experiences great declines in fish stocks and there are several underlying reasons like tourism and fishing. To analyze these reasons in more detail I am conducting interviews and surveys with tourists, fishermen and ecologists. The results will be used to set up guidelines for a sustainable use of fish stocks to ensure food security and livelihood for future generations for the fishery and the tourism sector.

The survey consists of 4 parts. At the end you have some free space to add comments or remarks. Your information will solely be used for my research and will be handled anonymously; you don't have to mention your name.

Filling in the survey will take about 10-15 minutes. Thank you!

Name _____

Occupation What:_____ Since:_____

City of birth_____

Part 1: Fishing effort

- Where is the location of your fishery? (Please make a cross on the map)

- How often do you go fishing per day? _____

- How long are the trips? _____

- What kind of fishing do you conduct? (Please circle)

Artisanal Semi-industrial Industrial

- What type of gear do you use? (Please tick box)

- ☐ Small nets, shark net, sharks/rays/fish
- ☐ Hook & line, longline, tuna
- ☐ Traps, commercial, fish
- ☐ Hook & line, longline, artisanal
- ☐ Diving, Seagrass, Fish & Octopus
- ☐ Traps, staked (gamboa)
- ☐ Industrial nets, purse seine, tuna
- ☐ Small nets, bottom gillnet, artisanal
- ☐ Hook & line, large vessel, commercial
- ☐ Hook & line, small motorboat, recreational
- ☐ Hook & line, artisanal
- ☐ Hook & line, small motorboat, sports
- ☐ Small nets, Chicocota, Artisanal
- ☐ Small nets, estuarine seine net
- ☐ Small nets, beach seine, fish
- ☐ Small nets, gillnet, small pelagic
- ☐ Diving, speargun, recreational
- ☐ Shore gathering, clams
- ☐ Hook & line, shore angling
- ☐ Small nets, gillnet, small pelagic
- ☐ Traps, basket (gaiola)
- ☐ Other: _____

- What type of fish do you catch? (Please tick boxes)

- ☐ Albacore
- ☐ Bartail flathead
- ☐ Beautiful fusilier
- ☐ Bigeye tuna
- ☐ Black marlin
- ☐ Black-barred halfbeak
- ☐ Blacktip sea catfish
- ☐ Blue trevally
- ☐ Blueskin seabream
- ☐ Common dolphinfish
- ☐ Common pike conger
- ☐ Common ponyfish
- ☐ Cresent-tail bigeye
- ☐ Crimson jobfish
- ☐ Dorab wolf-herring
- ☐ Dot dash rockcod
- ☐ Dusky spinefoot
- ☐ European barracuda
- ☐ Flame goatfish
- ☐ Flathead grey mullet
- ☐ Goldstripe sardinella
- ☐ Green jobfish
- ☐ Humpback red snapper
- ☐ Indian anchovy
- ☐ Indian goatfish
- ☐ Indian mackerel
- ☐ Indian pellona
- ☐ Indian scad
- ☐ Javelin grunt
- ☐ Kawakawa
- ☐ Kelee shad
- ☐ Largehead hairtail
- ☐ Largespotted dart
- ☐ Marbled parrotfish
- ☐ Narrow-barred Spanish mackerel
- ☐ Orangemouth anchovy
- ☐ Pompano dolphinfish
- ☐ Rainbow runner
- ☐ Redspot goatfish
- ☐ Saddle grunt
- ☐ Santer seabream
- ☐ Sharptooth jobfish
- ☐ Shoemaker spinefoot
- ☐ Silver sillago
- ☐ Sin croaker
- ☐ Skipjack tuna
- ☐ Sky emperor
- ☐ Slinger seabream
- ☐ Smallscale pursemouth
- ☐ Spotcheek emperor
- ☐ Spotted sardinella
- ☐ Swallow-tail
- ☐ Swordfish
- ☐ Talang queenfish
- ☐ Tigertooth croaker
- ☐ Wahoo
- ☐ White sardinella
- ☐ White-edged grouper
- ☐ Yellowfin tuna
- ☐ Yellowlip emperor
- ☐ Other: _____

_____

_____

- Have you recognized changes in abundance, size and composition in the species over the past 10 years?

Abundance: _____

_____

_____

Size: _____

_____

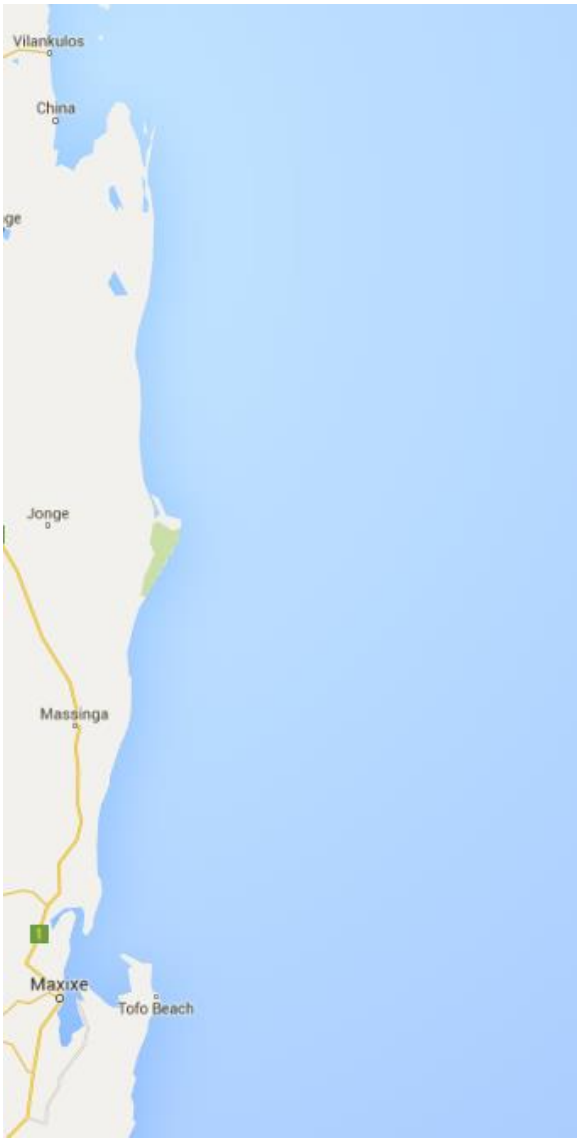
_____

Composition: _____

_____

_____

- Where are your fishing areas? (Please make crosses on the map)



Part 2: Livelihood

- Is fish your only source of income? (Please circle) Yes No

IF NO: What are other sources? _____

- What is the share (%) of fishing contributing to your income? _____%

- What is your income per month? _____Metical

- What do you do with the fish you caught? (Please circle, more answers possible)

Sale (to who? _____) Home consumption

- IF SALE: What is the price of the fish? Between _____ and_____ Metical/Kg

Part 3: Licenses

- What fishing license/s do you have? _____

- For how long is this license valid in total? _____

- What does the license allow you to do? (E.g. which vessel you can use)

_____

_____

_____

_____

_____

- What are restrictions you have due to the license? (E.g. numbers of trips per day)

_____

_____

_____

- Which laws determine your fishing area? _____

_____

_____

_____

Part 4: Tourism

- Do you share your marine space with tourism operators? Yes No
- Are you disturbed during your fishing business through tourism? Yes No
    - IF YES: How? _____
    _____
    _____
    _____
- What would you like to happen to stop the fish stocks from declining?

_____

_____

_____

_____

_____

Last comments

- Please feel free to leave any comment or remark

_____

_____

_____

_____

_____

_____

Fishery operators – Portuguese version

Inquérito para pescadores

Eu sou Alexandra, estudante de Biologia da Universidade Radboud em Nijmegen, Holanda e actualmente estou fazendo o meu estágio na Universidade das Nações Unidas, Instituto de Água, Meio Ambiente e Saúde (UNU-INWEH) em Hamilton, Canadá. A minha pesquisa centra-se nos recursos marinhos na província de Inhambane. Esta província vem registando declínios no volume do pescado e há várias razões subjacentes, como turismo e pesca. Para analisar estes factos com mais detalhes, estou fazendo entrevistas e inquéritos aos turistas, pescadores e ecologistas. Os resultados desta entrevista serão usados para produzir guiões sobre o uso sustentável dos recursos pesqueiros para garantir a segurança alimentar e meios de subsistência para as futuras gerações, incluindo para os sectores da pesca e turismo.

O inquérito consiste em 4 partes. No final você tem algum espaço livre para incluir comentários ou observações. A sua informação apenas será usada para a presente pesquisa e será anónima; não sendo necessário para tal mencionar o seu nome.

O preenchimento do inquérito terá a duração aproximada de 10-15 minutos. Obrigado!

Nome _____

Ocupação _____ A quanto tempo: _____

Local de nascimento _____

Parte 1: Esforço de pesca

- Onde se localiza a sua área de pesca? (Por favor, marque um X no mapa)

- Quantas vezes vai a pescar por dia? _____

- Quanto tempo leva para a zona de pesca? _____

- Que tipo de pesca realiza? (Por favor marque um X)

Artesanal Semi-industrial Industrial

- Que arte de pesca usa? (Por favor marque no quadradinho)

☐ Pequenas redes, rede de tubarão, tubarões / raias / p☐ke☐Anzol & linha, longline, atum

- ☐ Armadilhas, comercial, peixe
- ☐ Anzol & linha, longline, artesanal
- ☐ Mergulho, ervas marinhas, peixe & polvo
- ☐ Anzol & linha, pequenas embarcações, sports
- ☐ Pequenas redes, Chicocota, Artesanal
- ☐ Pequenas redes, arrasto no estuario
- ☐ Pequenas redes, arrasto a praia, peixe
- ☐ Pequenas redes, rede de emalhar, pequenos pelágico
- ☐ Armadilhas, staked (gamboa)
- ☐ Redes industriais, de cerco, atum
- ☐ Pequenas redes, redes de emalhar de fundo, artesanal
- ☐ Anzol & linha, grande embarcaçã, comercial
- ☐ Anzol & linha, pequenas embarcações a motor, recreação
- ☐ Anzol & linha, artesanal
- ☐ Mergulho, arpão, recreativos
- ☐ Shore gathering, clams
- ☐ Anzol & linha, pesca à linha na costa
- ☐ Pequenas redes, redes de emalhar, pequenos pelágicos
- ☐ Armadilha, basket (gaiola)
- ☐ Outros:_____

- Que tipo de peixe capturas? (Por favor marque no quadradinho)

- ☐ Atum voador
- ☐ Sapateiro do índico
- ☐ Fuzileiro bonito
- ☐ Atum Patudo
- ☐ Espadim negro
- ☐ Peixe agulha
- ☐ Bagre
- ☐ Xaréu azul
- ☐ Cachucho
- ☐ Dourado comum
- ☐ Enguia
- ☐ Patana comum
- ☐ Peixe encarnado
- ☐ Sardinha
- ☐ Machope espada
- ☐ Garoupa ponto e linha
- ☐ Coelho nebuloso
- ☐ European barracuda
- ☐ Barracuda-europeia
- ☐ Salmonete de Vanicolo
- ☐ Tainha cabeça achatada
- ☐ Pargo verde
- ☐ Vermelhao / Pargo curvado
- ☐ Anchoveta do Indico
- ☐ Salmonete do Indico
- ☐ Cavala
- ☐ Sardinia de Indico
- ☐ Carapau do índico
- ☐ Peixe pedra
- ☐ Atum
- ☐ Magumba
- ☐ Peixe-fita
- ☐ Pâmpano manchado
- ☐ Papagaio
- ☐ Serra
- ☐ Ocares
- ☐ Dourado
- ☐ Salmão
- ☐ Salmonete cinabar
- ☐ Gonguri
- ☐ Robalo / Ximangwa
- ☐ Pargo dentuçao
- ☐ Coelho sapateiro
- ☐ Pescadinha branca
- ☐ Macujana de barba
- ☐ Gaiado or atum bonito
- ☐ Ladrão masena
- ☐ Marreco / Ximangwa
- ☐ Melanúria timoneira
- ☐ Ladrão maquilhado
- ☐ Sardinha manchada
- ☐ Garoupa bordo branco
- ☐ Espadarte
- ☐ Machope saltador
- ☐ Corvina
- ☐ Wahoo
- ☐ Cavala gigante
- ☐ Sardinha branca
- ☐ Albacora
- ☐ Ladrão de boca amarela
- ☐ Outros: _____

_____

_____

- Notas alguma mudança na abundância, tamanho e composição de espécies nos últimos 10 anos?

Abundância: _____

_____

_____

Tamanho: _____

_____

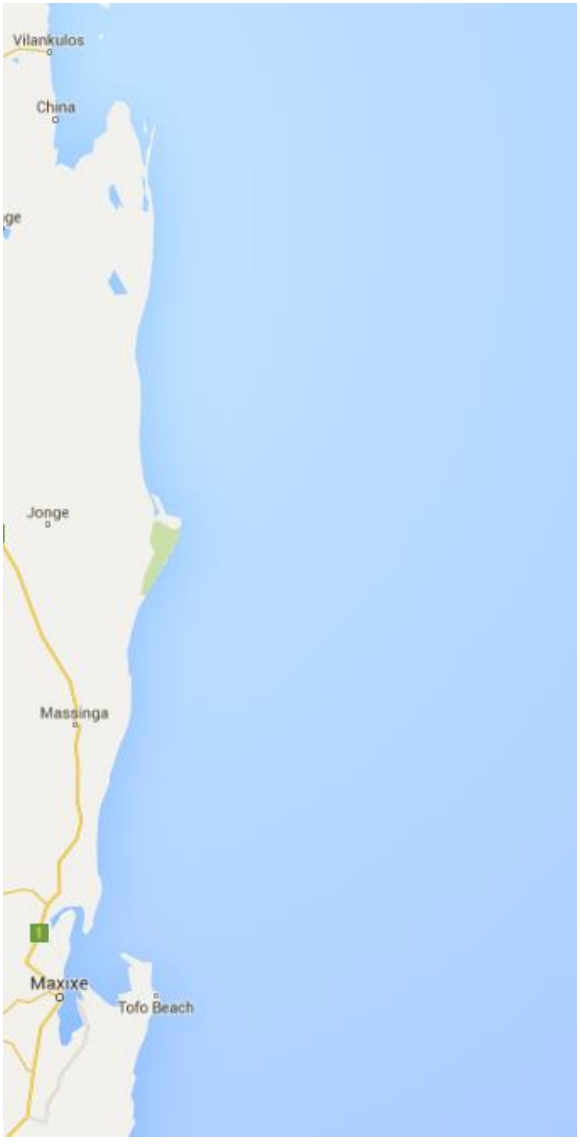
_____

Composição: _____

_____

_____

- Onde se localizam as suas áreas de pesca? (Por favor, marque um X no mapa)



Parte 2: Meios de subsitência

- O peixe é a sua única fonte de renda? (Por favor, marque um X) Sim Não

Se NÃO: Quais são as outras fontes? _____

- Qual é apercentagem (%) de contribuição da pesca para o seu rendimento? _____%

- Qual é o seu rendimento mensal? _____Meticais

- O que fazes com o peixe capturado? (Por favor, marque um X, pode ser mais que uma opção)

Venda (a quem? _____) Consumo doméstico

- Se for para a VENDA: Qual é o preço do peixe? Entre _____ e _____ Meticais/Kg

Parte 3: Licenças

- Que tipo de licença de pesca possuis? _____

- Qual é o tempo de validade da licença? _____

- O que a licença te permite fazer? (Exemplo: que embarcação podes usar)

_____

_____

_____

_____

- Que restrições tens devido a sua licença? (Ex. Número de pescas diárias)

_____

_____

_____

_____

- Que leis regulam a sua área de pesca? _____

_____

_____

_____

Parte 4: Turismo

- Você compartilha o seu espaço de pesca com operadores turísticos? Sim Não

- Há alguma perturbação durante a sua actividade de pesca pelo turismo? Sim Não

  - SE SIM: Como? _____

  _____

  _____

  _____

- O que gostaria que fosse feito para parar com o declíneo do pescado?

_____

_____

_____

_____

_____

Últimos comentários

- Por favor, sinta-se livre para deixar qualquer comentário ou observação

_____

_____

_____

_____

_____

_____

III. Supplement data

This appendix shows the supplement data that belong to the data presented in the results section.

Table 6 Number of guests in the Province of Inhambane and Mozambique
(Instituto Nacional de Estatística 2015)*

Total Guests	**2011**	**2012**	**2013**	**2014**	**2015**	**Var. % (15/14)**
Inhambane	27203	25981	25329	26022	8316	-0.319575744
Total Mozambique	555990	501751	511114	598093	513108	-0.857906714

*A reason for this decline could not be found within the study time. This requires more research.

Table 7 Results of Pearson's correlation analysis
The fish catch from a certain area was always related to the number of gear from that area. Fish_1 = Inhambane, Fish_2 = Tofo, Fish_3 = Vilankulo and Fish_4 = Bazaruto

Correlations

		Fish_1	Arrasto (active nets)	Emalhes (active nets)	Linha (active boats)	Gamboas (active Gamboas)
Fish_1	Pearson Correlation	1	,763**	,473**	,558**	,345
	Sig. (2-tailed)		,000	,000	,000	,091
	N	114	104	101	108	25
Fish_2	Pearson Correlation	1	.a	,847**	,623**	.a
	Sig. (2-tailed)			,000	,000	
	N	112	1	41	103	0
Fish_3	Pearson Correlation	1	,788**	,636**	,709**	-,430
	Sig. (2-tailed)		,000	,000	,000	,717
	N	116	103	53	101	3
Fish_4	Pearson Correlation	1	,820**	-,693*	,194	-,464
	Sig. (2-tailed)		,000	,018	,225	,095
	N	95	91	11	41	14

**. Correlation is significnat at the 0.01 level (2-tailed)
". Correlation is significnat at the 0.05 level (2-tailed)
a.&c. Cannot be computed because at least one of the variables is constant

IV. Green Fins Code of Conduct

This appendix shows the code of conduct created by Green Fins (The Reef-World Foundation 2016b).

Code of Conduct

As a Green Fins Member, you are expected to:

1. Adopt the Green Fins mission statement
2. Display the adopted Green Fins agreement for the public to see
3. Adhere to the 'Green Fins' Friendly Diving and Snorkelling Guidelines and act as a responsible role model for guests
4. Participate in regular underwater cleanups at dive operator selected sites
5. Participate in the development and implementation of a mooring buoy program and actively use moorings, drift or hand place anchors for boats
6. Prohibit the sales of corals and other marine life at the dive operation
7. Participate in regular coral reef monitoring and report coral reef monitoring data to a regional coral reef database
8. Provide adequate garbage facilities on board facility's vessel and deal with responsibly
9. Operate under a 'minimum discharge' policy
10. Abide by all local, regional, national and international environmental laws, regulations and customs
11. Provide guests with an explanation of Green Fins' Friendly Diving and Snorkelling Guidelines in pre dive briefings
12. Provide training, briefing or literature for employees and guests regarding good environmental practices for snorkeling, diving, boating, marine wildlife interaction and other marine recreational activities
13. Provide staff and guests with public awareness and environmental materials (ID books, pamphlets etc)
14. Provide guests with information on local Marine Protected Areas, environmental rules and regulations
15. Promote a strict 'No Touch' policy for all reef diving and snorkelling.

UNEP

www.greenfins.net

GreenFins Green_Fins

V. Legislative guidelines for LMMAs

This section presents legislative guidelines that were set up by CORDIO for the establishment and operation of LMMAs (Odote *et al.* 2015).

i	As used in the Kenyan context, while there is no single legislation defining marine community conservation areas, they are the equivalent of the internationally recognised Locally Managed Marine Areas (LMMAs). They are a generic term and refer to an area set aside in coastal waters for conservation and management activities by local communities in collaboration with relevant government agencies. This clarifies that LMMAs are not an institution but an approach that involves setting aside an area in coastal waters for purposes of marine conservation. By these guidelines, the term Locally Managed Marine Area is adopted as the operational term to refer to areas of the sea set aside for local-community led management initiatives.
ii	While legal registration is not a prerequisite for commencing the process of establishment of LMMAs by communities, the finalisation of the process should involve determining the legal form under which the Community will operate. The option of what form or legal status a Community can be registered for the purpose of operating a LMMA will be left entirely to the discretion of the community members and based on the anchoring legislation. As this legal review has demonstrated, there are several legal forms ranging from associations, BMUs, CFAs and Community Wildlife Associations that can be considered as options.
iii	Groups of people who have constituted themselves for purposes of using and/or conserving the sea, land and any component of the marine environment including fishers communities, traders, farmers, local community organisations can be recognised for purposes of operating a LMMA. Current examples exist in the form of BMUs.
iv	Membership to groups establishing and operating a LMMA should be inclusive of

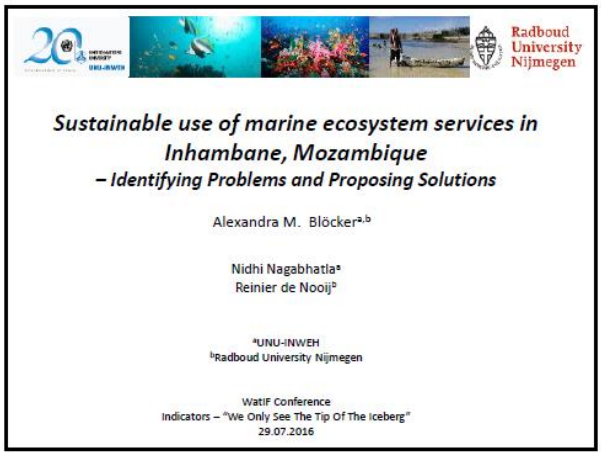
	different interest and stakeholders within the local community including fisher folk, traders, farmers, private sector, environmental groups and community based organisations.
v	The coverage of the LMMAs shall include a designated part of the sea and may extend as high as sixty meters (60) above the Mean High Water Spring mark (MHWS) on the beach. The delineation process will be undertaken through a consultative process involving local communities and government agencies responsible for the conservation of the marine environment. Further the delineation process should be based on scientific research information and advice.
vi	There exists numerous government agencies and legislation that have relevance for conservation of the marine environment and creation of LMMAs. While the Fisheries Act and the State Department of Fisheries (SDF) have been at the forefront in establishing LMMAs at the coast, the reliance on that legislation and approach is mainly relevant if the focus is fisheries management. The experience with LMMAs point to the relevance of several pieces of legislation including the Wildlife Conservation and Management Act, The Fisheries Act, The Environmental Management and Conservation Act and the Forest Act. Consequently the operations of LMMAs could draw from the provisions of any these four pieces of legislation. It is recommended that they be anchored on one depending on the main objective sought to be pursued by the LMMA.
vii	The Community should at their initial consultations processes clarify what is the primary objective of the LMMA, and this will help determine the Government agencies to collaborate with in the operations of the LMMA once established.
viii	In establishing LMMAs communities should consult and receive recognition from relevant government agencies in the process of establishing the LMMA.
ix	Based on clearly set objectives and in consultation with relevant agencies the community should develop a management plan, including no-take zones for conserving the marine environment within the LMMA. Broad objectives of LMMAs should capture sustainable resource use; promotion of alternative sources of revenue; improvements of livelihoods; and conservation of marine resources.
x	Government agencies should establish inter-agency committees at the coast and sign MoUs to clearly stipulate a coordinating mechanism to support communities in the establishment and operations of LMMAs.
xi	The coordinating mechanism should designate the focal government agency that the local community desirous of establishing a LMMA should approach and which will have the duty of bringing on board the other relevant government agencies.
xii	The process of establishing LMMAs should also involve consultations with NEMA as the legislative body charged with Integrated Coastal Zone Management. NEMA should then ensure that where the objectives to be pursued are beyond the mandate of one lead agency, then all relevant agencies are brought on board so as to collaborate with and support the community in achieving the objectives it has set for the LMMA.

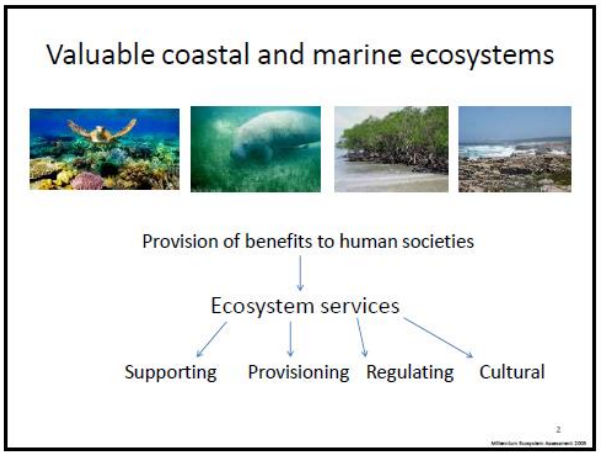
xiii	County governments, through the relevant County Executive Committee should be consulted in the process of establishing LMMAs to ensure their involvement and support to the LMMA once operational. This should culminate in the recognition of LMMAs by the County Government.
xiv	County Governments should factor LMMAs and their operations into their integrated development plan and budgeting process. Function 14 of the Fourth Schedule of the Constitution mandates County Governments to ensure and coordinate the participation of local communities in governance. LMMAs are a critical tool in actualising these frameworks.
xv	The formation of LMMAs should seek to involve and represent the different stakeholders within the local communities including fisher folk, traders, farmers, private sector, environmental groups and community based organszations. It should not, however, be about formation of new rival institutions. Wide and objective consultation is at the heart of success of LMMAs. In addition efforts should be geared towards linking with and building on existing local community institutions.
xvi	Every community should develop regulations to govern the operations of the LMMA, and set out management objectives, relevant procedures and rights and obligations of the community members and the larger public.
xvii	Every LMMA should put in place internal mechanisms for resolving any disputes that may arise in the operations of the LMMA. Formal methods of dispute resolution should be relied on only after exhaustion of internal mechanisms.
xviii	LMMAs should enter into partnerships with the private sector and civil society for capacity building, training and financial support for operations and sustainability purposes.

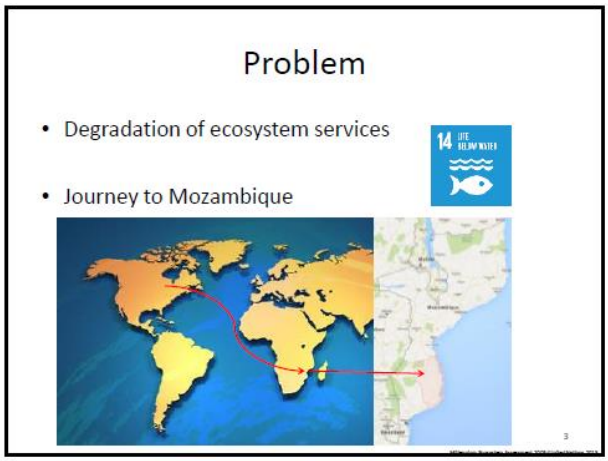
VI. Presentation at WatIF 2016 conference

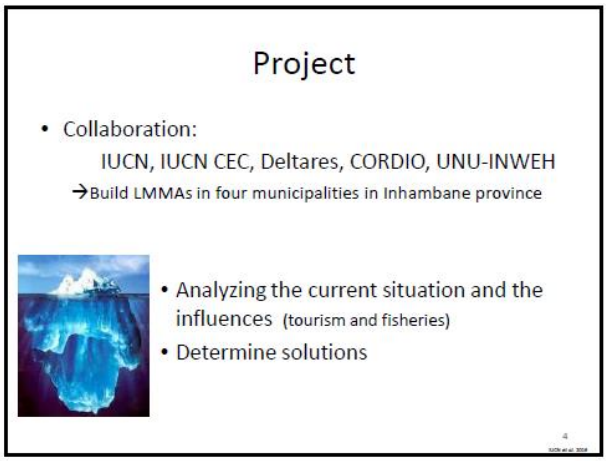
This study was presented at the Water Initiative for the Future (WatIF) 2016 conference in Kingston, Ontario, Canada (http://www.waterinitiativeforthefuture.org/). The WatIF conference is organized by graduate and PhD students for graduate and PhD students, who get the opportunity to present their study to an international audience. Feedback from the audience was used to improve the thesis. Therefore there are slight deviations between the presentation and the thesis.

A more elaborated version of this presentation was presented at the host organization UNU-INWEH on the 3rd of August to a multidisciplinary audience.

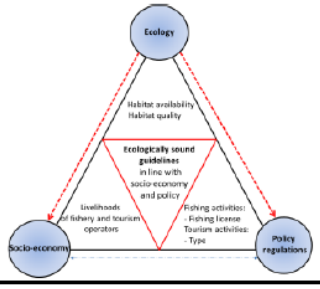








What ecological guidelines for the fishery and tourism sector are prerequisite for a sustainable management approach for marine ecosystems of Inhambane (Inhambane (city) and Vilankulo, and how can they be tailored to socio-economic demands and policy regulations?



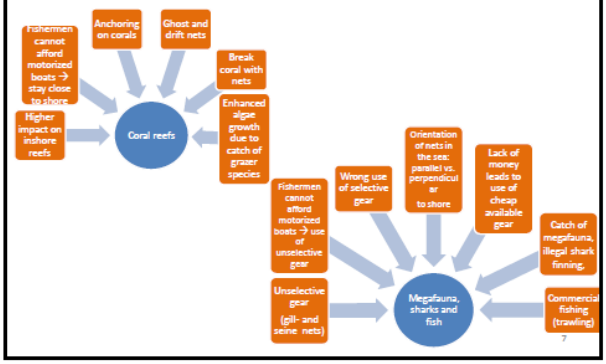
5

Methodology

- Ecosystem Based Management Approach (EBM)
- Primary data: Interviews and Surveys
  - Tourism and fishery operators, experts
- Secondary data:
  papers, reports, databases, maps
  - Tourism and fishery efforts
  - Policy regulations, Licenses

6

Results I. Influences - Fisheries



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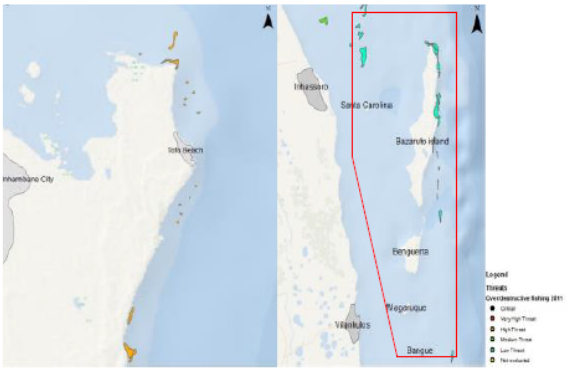
Study areas



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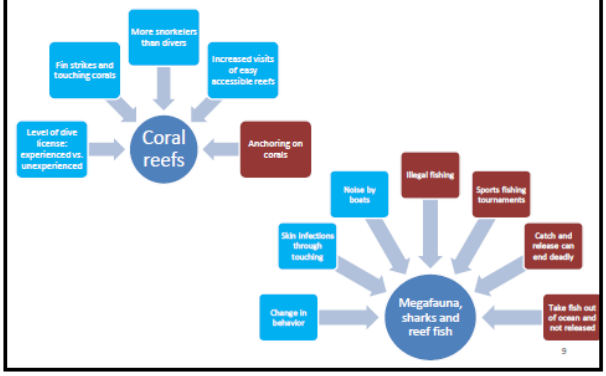
Results I. Influences - Tourism



9

Results II. Socio-economy

- Fishermen:
  - Fully depend on fish for income and food
  - Low income
  - Low prices for low value fish
    - Poor storage capabilities on board
- Tourism operators
  - Diving and Snorkeling are main sectors
    - Increasing
  - Dependence on mainly coral reefs and megafauna
- Large socio-economic gap between sectors

10

Results III. Policy regulations & Licenses

- Tourism activities
  - Licenses for all activities (e.g. diving, launch boats)
  - No regulations for effort or area of operation
- Fishery activities
  - Licenses for all activities (e.g. gear, boat)
  - Minimum mesh sizes for gear
  - No minimum sizes for fish
- Enforcement
  - Reduce illegal fishing
  - Fines

11

Guidelines I

- Diminish influences
  - Transition of gear

- Socio-economic
  - Alternative livelihoods for fishermen and improve existing livelihoods
  - Raise awareness about the relationship between ecosystems and humans
  - Decrease socio-economic gap

12

Guidelines II

- Policy related
  - Increase human and financial resources by government
  - Enforce regulations in tourism and fishery sectors
- LMMAs
  - Distribute knowledge about LMMAs
  - Integration of all stakeholders

13

Conclusion

Understand the full picture with research, communication and collaboration

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Sustainable use of marine ecosystem services in Inhambane, Mozambique

Identifying Problems and Proposing Solutions

Alexandra M. Bloecker

UNU-INWEH Canada & Radboud University, Nijmegen, The Netherlands

August 3rd

12:00 - 1:00 pm
UNU-INWEH boardroom

Abstract:

Coastal and marine ecosystems constitute world's plushest biodiversity regions and provide various ecosystem services. However, unsustainable use of these services leads to degradation. Mozambique is one country that has rich provisions of coastal and marine ecosystem services, but is experiencing great declines. The country has eight provinces that are located at the coast; Inhambane is one of them. Tourism and fisheries are the main impacts on services like fish stocks and marine habitats in this province. Around 90% of the local fishermen conduct artisanal fishing, where all catch is consumed locally. To study and synthesize the drivers and impacts of ecosystems services loss, UNU-INWEH partnered in a collaborative project with IUCN, IUCN CEC, Deltares, CORDIO. To increase the sustainable use of marine ecosystem services, this project focuses on the establishment of Locally Managed Marine Areas (LMMAs) in the Inhambane province.

To establish LMMAs, the current situation needs to be analyzed in detail to determine the drivers that are degrading ecosystem services and to find solutions. The present study analyzes tourism and artisanal fishery influences on fish stocks and marine habitats, with a focus on coral reefs. The goal is to set up ecologically sound guidelines for the fishery and tourism sector in order to ensure sustainable use of ecosystem services within the context of LMMAs in Inhambane.

The methodology included gathering of primary and secondary data. Primary data were interviews with tourism operators and experts to obtain information about the tourism and fishery influences on fish stocks and coral reefs, the perception of the drivers causing degradation, livelihoods and possible solutions to make the use of ecosystem services more sustainable. Secondary data was used to supplement the outcomes from the interviews.

The results highlight guidelines that include: integrating all stakeholders in decision making, enforcing policy regulations, inducing a transition from destructive to sustainable gear, creating alternative livelihoods for fishermen and diminishing the socio-economic gap between tourism operators and fishermen.

The implementation of the guidelines can facilitate sustainable management within the concept of LMMAs. These guidelines can be of value for other regions with similar problems and can be scaled up to enhance sustainable use of marine ecosystem services worldwide.

About the Speaker

Originally from Germany, Alexandra is a Master student in Biology at the Radboud University in Nijmegen, the Netherlands. Within her studies she focuses on the track Science, Management and Innovation, where students can apply their science-based background to a policy or business question. For her Master graduation project, she joined the UNU-INWEH to deepen the link between her interests water, environment and management. Within UNU-INWEH, she is associated with the Water and Ecosystems Program. Her research is about fishery and tourism influences on declining fish stocks and fish habitats in the Province of Inhambane, in Mozambique.

Follow the presentation by the author at the WatIF Conference 2016 in Kingston on the 29th of July. The WatIF conference is an international conference, where graduate students from different disciplines have the opportunity to present their research (http://www.waterinitiativeforthefuture.org/).