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Climate Vulnerability Background Review
for
The Primeiras and Segundas Environmental Protection Area
Mozambique

Final Report

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Climate Vulnerability Background Review for the Primeiras and Segundas Environmental Protection Area, Mozambique

Final Report

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EXECUTIVE SUMMARY

Mozambique is recognized as one of the most vulnerable countries in Africa to climate change impacts due to its geographic location. Mozambique has a coastline of about 2470 km with more than 60% of the population (approximately 20.5 million) living in coastal areas. The northern coast of Mozambique is susceptible to seawater rise and a marked reduction in water availability on the mainland, as well as a substantial reduction of available agricultural land and the increase of forest fires risk. Marine and coastal conservation areas, like the Primeiras & Segundas Environmental Protected Area (PSEPA) in Nampula and Zembezia Provinces is prone to be affected by climate change negative impacts. Both people and PSEPA ecosystems and species, are vulnerable to climate change impacts, namely extreme events like floods and sea level raise.

This review is included in the WWF CEAGI Climate change adaptation programme and intends to summarize the relevant available information and references to assess climate vulnerability in the PSEPA. From all the available references for this review, 120 were considered relevant and analysed and relevant stakeholders, including the Provincial Directorates and Delegations were contacted. The main results obtained are:

- The numbers of fishermen, fishing gear, fishing vessels and fishing centres have been increasing since 2002 to 2012 in both provinces (with increases ranging from 14% to 63%). Globally there is a positive trend in terms of total catches, especially in Zambezia province that presented an increase in almost all type of fishing gears and an overall increase of 63%. Nampula showed a global increase of 27%, with positive results for the following fishing gears: beach seine, gillnet and hand line, and a great decrease in longline, purse seine and others types. Beach seine is the fishing gear with the higher catches in the 3 fishing districts of PSEPA (Angoche, Moma and Pebane). Most of the families that were caught by those fishing gears are increasing in terms of % of occurrence (34% in Nampula and 41% in Zambezia) against 24% and 13% that are decreasing, respectively. Currently there are at least two approved processing units and one fish farm in Pebane district (accordingly with the Zambezia's Provincial Delegation of DPCA). However, there may be more, since so far it was not received data from Nampula Provincial Directorate of DPCA nor from Zambezia and Nampulas's Provincial Directorate for Fisheries.

- It was not possible to analyse trends relatively to agricultural land, crops & livestock. Subsistence agriculture dominates the regions, and the three most practised subsistence crops (in order) are: cassava, groundnuts and rice. The three most produced cash crops are cashews, sesame and peanuts. Cattle raising is generally an activity beyond the reach of the rural farmer. However animal husbandry also contributes to livelihoods, with small stock (chickens, goats, pigs and ducks). The majority of farmers practice slash and burn agricultural practices that often leads to wild fires, poor soils, destruction of ecosystems and desertification. Large scale irrigated agriculture was not identify in PSEPA.

- Coral reefs are estimated to cover 22 km^2 in the PSEPA. No regular reef monitoring has been conducted in the PSEPA. Apart from storms, the reef benthos does not seem to be under high stress from anthropogenic action, although fishing (hand-lining, spearfishing and traps) is a common practice.

- Despite the socio-economic importance of seagrass beds, no monitoring has been conducted on the species abundance, distribution and total area, therefore trends and current status is unknown.

- Regarding freshwater resources there are several rivers and estuaries in PSEPA inland, but no data on annual flows were obtained. Regarding the island regions, there are no freshwater courses, however there are considerable underground aquifers, some of them with concerning concentration of sulphates.

- Information on mangrove forest of PSEPA is scarce. However two recent studies allowed characterizing it in terms of species composition (7 species were recorded). In Angoche and Moma districts most of the plant were adults (55% and 65%, respectively) followed by young plants (27%, and 19%) and a smaller proportion were cut (18% and 16%). Despite that, it was not possible to classify mangrove health or calculate any trend in PSEPA. Mangroves are depleted due to unsustainable harvesting of trees, particularly around the main cities, where mangrove trees are harvested for fuel wood and timber for constructions.

- Using the Global Forest Change webtool it was possible to identify that deforestation occurs all over the Park, focusing mostly along the main roads, especially between Pebane and Moma. Forest cover is considerably lower, and also occurs between Pebane and Moma, which may be compensating part of the recorded reforestation.

- There are no time-series data that would allow status trends of High-profile species to be drawn, and the current state of conservation of these species is largely unknown.

- Accordingly with PSEPA Management Plan, the districts where PSEPA is included (Angoche, Moma, Pebane and Larde) registered a growing pattern from 1997 to 2014, but it is also mentioned that the estimates are likely to have some degree of error. There are no projections available for the next year.

- According to the Agriculture Census done in 2007, less than 5% of the people interviewed Nampula and Zambezia Province have stated that they have experienced conflicts regarding land use. These conflicts are associated with zoning of the land and land being sold to different people.

- In general, in all districts, the existent infrastructure is in bad condition and need maintenance, namely the roads and bridges network (some are impassable, especially in rainy season) as well as the water pumps network. Concerning recent or future investments, in the last decade, DPCA from Zambezia has issued at least 11 licenses for Pebane district: 2 concerning tourist activities, 2 fish processing factories, 1 aquaculture, 1 fuel station and 3 mining projects. No further information was obtained for Moma and Angoche districts.

- The data for regions within the PSEPA shows that 93.8% of households in PSEPA use firewood as a cooking fuel and a small percentage uses charcoal, coal mineral and kerosene.

- Presently there is no oil & gas concession for research or exploration in the study area. However, the National Petroleum Institute launched recently a new contest, including two offshore blocks in Angoche (A5-A and A5-B), one of which partially overlaps PSEPA. Considering the cumulative effect of the impacts of the oil & gas industry and whole associated infrastructure, it is expected that the pressure on local ecosystems will increase significantly as well as the risk of hazards.

- There are currently 59 areas associated with mining activities, including seven mining concessions, i.e., that had already been approved before PSEPA declaration. Kenmare Resources holds the two biggest mining exploration in PSEPA, exploring heavy sands in Moma, Nampula Province. It is expected that the impacts will focus mainly inland, namely water and air pollution, terrestrial forest loss and habitat fragmentation, which will have consequences on several fauna species.

- The number of overnight stays has increased over the last years in Nampula province, rising from 14.000 in 2000 to 113.000 in 2014. Although dominated by national tourists, foreign tourists are increasing in recent years, with the number of nights by foreigners in 2014 quite similar to those by nationals. As a result of this increase, since 2002, every year were approved new touristic projects, especially between 2008 and 2011.

The most relevant information about the trends and projections in climate and related physical environment parameters is:

- Considering a time series from 1993 to 2013 for Angoche meteorological station there was an increase on the average temperature for the hot and the cold seasons of approximately 0.13 and 0.16 ˚C per year for December-January-February (DJF) and June-July-August (JJA), respectively. INGC study also indicates that annual averages maximum temperatures from 1960 to 2005 for the North region of Mozambique shows an increase of approximately 1.1 ˚C for the Mars-April-May (MAM) and September-October-November (SON). The average maximum annual temperature was usually bellow 30° C before 1990 but afterwards, higher temperatures became common, as a result of longer period of extreme hot days. No data is available on the impacts of extreme high temperature on agriculture, livestock, human health or wildlife in Mozambique, or the PSEPA, however there are several examples.

- The average annual precipitation in Angoche from 1991 to 2013 (excluding years with gaps) doesn't show a clear pattern. Although INCG reported a reduction of precipitation in December and an increase to a peak in February/March (rain may exceed 6 mm/day), showing a delay of the wet season and an increase of total number of dry days and extension of the dry season from September to November. Almost all the model projections for 2050-2200 indicate that November will become drier in northern Mozambique. From January to March, most of the models give indications of an increase in average monthly precipitation. Coral reefs and seagrass beds are able to cope with increased rainfall to a certain extent, as heavy floods usually result in massive amounts of nutrients, reduced salinity, light penetration and sedimentation leading to physiological stress, bleaching and ultimately coral death. Increased floods or drought would also have deleterious effects on mangroves due to their counter-effects over salinity.

- North of Mozambique is the region in the country with less tropical cyclones events. From 2008 to 2014, two tropical cyclones events were reported in Nampula, against eight that occurred from 1956 to 2007. However in recent years, reports of flood events have increased and were associated with tropical cyclones. No specific data on rainfall was obtained for Zambezia, nor about historic river flow for both provinces. Cyclones and flooding in PSEPA are known to occur in February and March when farmers are carrying out their second harvest. The resilience of local communities to these events is low, however some strategies are currently being employed by community members to deal with hazards. In northern Mozambique was also found that artisanal annual catch is significantly correlated with coastal rainfall emphasising the role of freshwater in the productivity of coastal waters and in the survival and growth rate of the fish population.

- Data on Sea Surface Temperature (SST) for the northern Mozambique registered a rise of ca. 0.010° C/year over 50 years (1957-2007). Recent models predicted that globally averaged SSTs will increase by 0.3°C–0.6°C. An increase in SST is expected to have deleterious effects on both fish and invertebrate fisheries both directly and indirectly. With the predicted increase in SST, it is expected that coral reefs will suffer, further degradation, shift in distribution and composition, loss of biodiversity, productivity and ecological function.

- Recent estimates show that, globally mean seal level has risen at an average rate of between 1.4 to 2.0 mm/year over the 20th Century and between 2.7 and 3.7 mm/year since 1993. Looking at data from the tidal station network of Mozambique, including Angoche, Moma and Pebane, a 2002 study concluded that "No clear evidence has been found with regard to the variation of the mean sea levels particularly as an impact of global climate changes". Several impacts on mangroves are expected from sea level rise: decline of species diversity, change in species composition and distribution. This will result on loss of biodiversity, productivity, as well as coastal protection. INGC (2009a) suggests that the region of the PSEPA (especially the islands) is susceptible to sea level rise. The great majority coastal communities would be left without potable water due to the increases salinity of ground water. Sea level rise will certainly have deleterious effects on tourism infrastructures as well as other coastal settlements, which are located very close to the shoreline.

- Long-term wind data was not readily available for the area. Although the PSEPA is not prone to high cyclone and storm activity, the prevailing winds blow from the south and southeast, with an annual mean of 5 knots. It is expected that changes in the wind patterns (direction and strength) will strongly affect the local fishing communities. It will also have serious effects on the socio-economy of the region in general as trade and long distance travelling along the coast relies heavily on the large dhows. An increase in storm frequency and intensity will certainly have deleterious effects on tourism infrastructures as well as other coastal settlements, which are located very close to the shoreline. Increased winds and surge can potentially cause erosion and risk turtle nesting sites.

- Globally coral reefs are undergoing increasing physiological stress from ocean warming and acidification, both of which are gradually reducing their habitat. Negative direct impacts on small-scale fisheries and mollusc mariculture can be anticipated based on scenarios of decreasing pH by 0.5. The ecological and socio-economic consequences for the PSEPA would thus be devastating, giving the dependency of the local communities as well as the tourism industry on marine resources such as intertidal invertebrates and coral reefs.

- Dramatic impacts on fish production due to climate changes are expected, which can affect the protein supply and fish oils derived for local people. Several of the global climate-related changes and impacts are already being experienced or are expected to occur in the PSEPA region.

- Regarding high profile species, the loss of nesting habitat as well as productive feeding areas can potentially be conduct marine turtles towards local extinction if current anthropogenic stressors are not dealt with.

- In a public health perspective the frequency and intensity of extreme weather events, flooding or drought may also play an important role on population health. This impact will be determined by the future health status of the population (including the prevalence of cardiovascular diseases, HIV and TB, malnutrition or stunting especially in young children) and the capacity of communities to adapt to health threats as well as to cope with climate events and public health governance measures.

Several gaps in the current knowledge have been identified and they are summarized in this review.

LIST OF ACRONYMS AND UNITS

AQUA – Agência para o Controlo da Qualidade Ambiental

ARA – Administração Regional de Águas

CARE – Cooperative for Assistance and Relief Everywhere

CVCA – Climate Vulnerability and Capacity Analysis

DAS – Departamento de Águas e Saneamento

DNAIA – Direcção Nacional de Avaliação de Impacto Ambiental

DPOPH – Direcção Provincial de Obras Públicas e Habitação

DPCA – Direcção Provincial para Coordenação da Acção Ambiental

DPP – Direcção Provincial das Pescas

DPREME – Direcção Provincial dos Recursos Minerais e Energia

DPS – Direcção Provincial de Saúde

DPTUR – Direcção Provincial do Turismo

ha - hectare

IDPPE – Instituto Nacional de Desenvolvimento de Pesca de Pequena Escala

INAM – Instituto Nacional de Meteorologia

INGC – Instituto Nacional de Gestão de Calamidades

IIP – Instituto Nacional de Investigação Pesqueira

IPCC – Intergovernmental Panel on Climate Change

km - kilometer

MICOA – Ministério para a Coordenação da Acção Ambiental

MITUR - Ministério do Turismo

MSc – Master of Science

PhD – Doctor of Philosophy

PSEPA – Primeiras and Segundas Environmental Protection Area

PSEPA – Quirimbas National Park

t – metric tonne

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1. Background

Climate change is defined as "any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC, 2007), and is increasingly recognized as a serious, ongoing threat to human development (IPCC, 2001 and 2007) and ecosystems conservation (Parmesan & Yohe, 2003). It represents a classic multi-scale global problem characterized by diverse actors, numerous causes and multiple time scales (Adger, 2006), that must be addressed to achieve equitable and sustainable development. The impacts of climate change manifest in floods, droughts, unseasonal rains and extreme events. Those events create additional challenges for developing countries and the poorest communities that are more vulnerable due to their limited economic, technological and human capacities and their dependence on climate sensitive economic sectors (IPCC, 2001).

- Vulnerability to climate change is one of the crucial components of the problem, and is defined as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (Dazé et al., 2009; IPCC, 2001). Other relevant key concepts are:
- Adaptive Capacity is the "ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC, 2001);
- Resilience is "the ability of a community to resist, absorb, and recover from the effects of hazards in a timely and efficient manner, preserving or restoring its essential basic structures, functions and identity (UNISDR, 2009);
- Hazard is "a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage" (UNISDR, 2009);
- Adaptation to Climate Change is the "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities".

It should be noted that hazard does not translate directly into risk but it is qualified by the degree of vulnerability of the individual or system in question to a specific hazard and the factors causing vulnerability are what determines the risk. Poverty is often considered one of the main risk drivers but there are other causes like geographical location, gender, age, access to resources and wealth, etc. (Bohle et al., 1994; Adger, 1996; Cannon, 2000).

Sub-Saharan Africa is regarded as the region where there are most people vulnerable to climate change impacts. The continent is already prone to erratic rainfall, droughts, floods and cyclones and climate change is exacerbating these continuing challenges. At the same time, Africa fights poverty, environmental degradation, heavy dependence on natural resources for subsistence and occurrence of epidemic diseases (HIV-AIDS, malaria, etc). These factors increase vulnerably and limit the ability of people and institutions to adapt to climate change (CARE, 2010).

Regionally, Mozambique is recognized as one of the most vulnerable countries in Africa to climate change impacts due to its geographic location (INGC, 2009a). Mozambique has a coastline of about 2470 km (CIA, 2013) with more than 60% of the population (approximately 20.5 million) living in coastal areas. Survival and daily living in these areas depend largely on local resources, such as rain-fed agriculture and fishing, while the infrastructure is weak or non-existent (INGC, 2009a). Additionally, the Mozambican coastline consists of recent geological formations with great natural variability and has in general physically unconsolidated ecosystems, namely sandy beaches, estuaries and mangroves (Maueua et al., 2007). These fragility features coupled with the increasing resource consumption and the predicted impacts of climate changes result in a high vulnerability of both people and landscape to drastic events such tropical cyclones and sea level rise. Moreover, it is expected that exposure of Mozambique to the risk of natural disasters will increase significantly over the next 20 years and beyond, as a result of climate change (INGC, 2009a,b).

Worst-case scenarios in existing climate models point out different levels risks in different areas of the coast. The northern coast of Mozambique is susceptible to seawater rise and a marked reduction in water availability on the mainland, as well as a substantial reduction of available agricultural land and the increase of forest fires risk. Climate change is also a major threat to conservation areas and although very few evidence has been produced on conservation impacts, the likelihood of species extinctions is been increasingly accepted (Parmesan & Yohe, 2003). Therefore coastline Conservation Areas, like Primeiras e Segundas Environmental Protected Area (PSEPA), the Africa's largest coastal marine Reserve, is prone to be affected by climate change negative impacts

The PSEPA was created in 2012 (DL nº 42/2012, 12 December 2012) and is the largest marine protected in Africa, extending over 200 km of coastline, with more than 1.040.926ha. It comprises the Primeiras and Segundas Archipelago and the adjacent coastline to this island chain (about 30km inland) (Figure 1.1). Primeiras and Segundas Archipelago is a total of 10 islands running parallel to the Coast of Mozambique, facing the districts of Pebane (Zambezia) and Moma, Larde and Angoche (Nampula), namely: Ilha de Moma, Ilha de Caldeira, Ilha Nejovo, Ilha Puga-Puga e Ilha Mafamede). It should be noted that the 2012 Law Decree makes no reference to Larde District since it was created under the new administrative division in the region (MITUR, 2014a).

The Primeiras and Segundas Archipelago is a unique and beautiful area with considerable biological richness. It is the meeting point of the coral coast, which extends northwards through Nampula and Cabo Delgado Provinces and the swamp coast of Zambezia Province and the Banco de Sofala, which extend to the south. On the offshore among the islands, whales, dolphins, and sea turtles abound, with the archipelago being considered one of the most important areas for sea turtle reproduction in the eastern Indian Ocean. Coelacanths have also been captured in this area, and a variety of sea birds, including the endemic sooty tern (*Sterna fuscata*) also use the islands for nesting (MITUR, 2014a).

The importance of PSEPA in the national economy is recognized for several years, particularly with regard to the fishing and shrimp industries but also to the cashew and coconut culture, especially in Angoche, where cashew processing aims domestic market and also for export. The recent discovery of commercially viable heavy sands in Moma and Muebase areas as well as the growth of the human population in coastal areas and consequent deforestation, the collapse of the cashew industry, coconut, cassava due to illness, the over-fishing effort and the decreased of shrimp capture, among other problems led to the declaration of this Conservation Area. So the declaration of PSEPA aimed not only to guarantee the biodiversity conservation, but also the promotion of a sustainable use of natural resources through community involvement wherein the climate vulnerability is also a quite relevant subject (MITUR, 2014a).

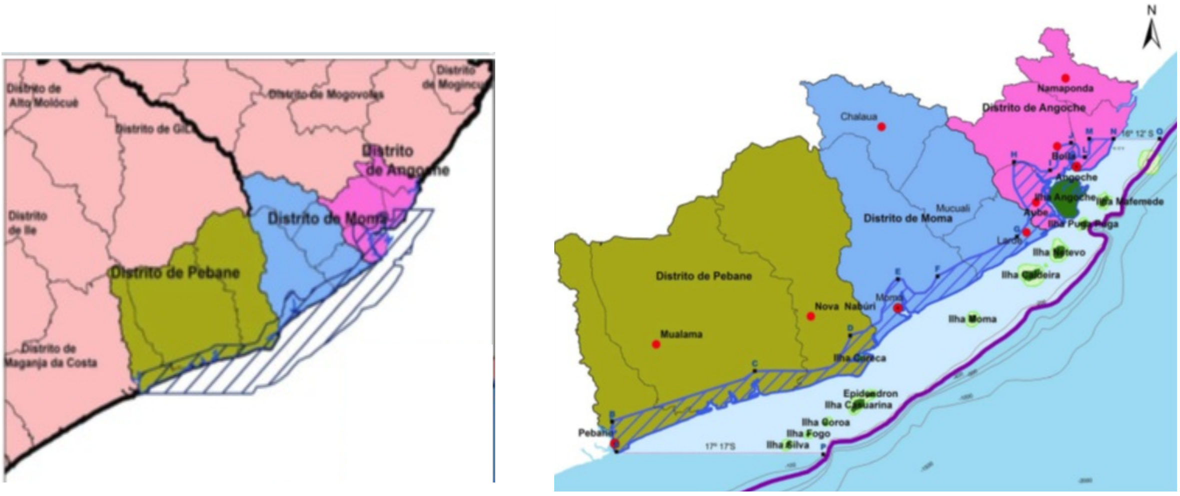


Figure 1.1– Primeiras e Segundas Environmental Protected Area (adapted from MITUR, 2014a)

Therefore, the objective of this assignment is to prepare a review, summarizing relevant available information and references to assess climate vulnerability in the PSEPA. This initiative is included in the WWF CEAGI Climate change adaptation programme. This programme was initiated in early 2011 and aims to ensure that WWF's conservation programme in coastal Eastern Africa recognizes and addresses the impacts of global climate change on priority ecosystems and on communities that depend on them. The PSEPA is one of the five priority landscapes selected by the programme to undertake climate change vulnerability assessments and to develop and implement climate change adaptation strategies, to ensure that climate adaptation is incorporated into natural resources management strategies. This review addressed the Step I of the Vulnerability Assessment process supported by WWF, covering the following main topics:

- Trends in status of key ecosystems, natural resources and natural resource-based livelihoods;
- Major development trends and pressures affecting the above;
- Trends and projection in climate and related physical environment parameters;
- Vulnerability and resilience of ecosystems, species, livelihoods and infrastructures to climate variability and change;
- Relevant management policies and strategies that address climate change.

2. Approach

This assessment is a literature review on climate vulnerability in the PSEPA that aims to summarize available information and identify the main knowledge gaps. For this purpose, the project team searched available data, both in electronic and print formats and grey and scientific literature, namely: national and regional official reports, development strategy plans, the PSEPA management plan, MSc and PhD thesis, peer reviewed papers, technical reports, among other documents. From all the available references for this review, 120 were considered relevant and analysed.

Additionally, to address the identified knowledge gaps (mostly data on trends in the PSEPA), relevant stakeholders (regional and national governmental institutions) were contacted. All requests were made officially. Provincial Directorates and Delegations of the relevant stakeholders were contacted (via phone and / or email) as many times as needed to gather the information. A few national level institutions were also visited. The work timeline is presented in Figure 2.1.

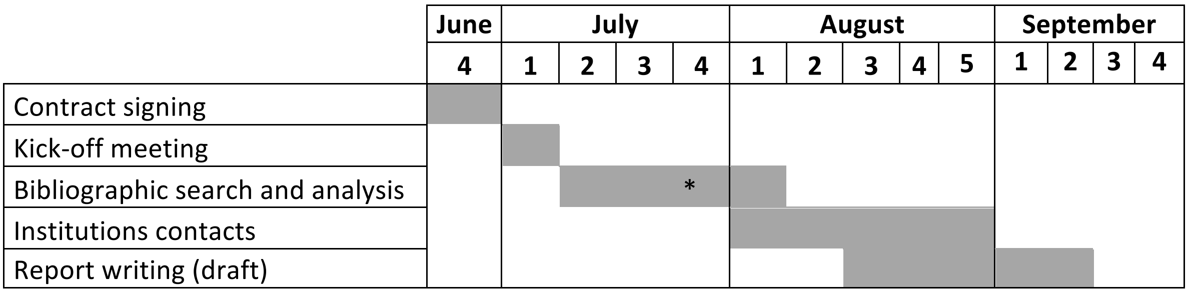


Figure 2.1 – Work timeline (* week when WWF's bibliography was received)

Table 2.1 summarizes the Governmental institutions contacted and the requested versus the obtained information. Information obtained was provided to the District or Provincial level. It was assumed that this information is representative of the PSEPA situation.

Table 2.1 – Governmental institutions contacted, requested and obtained information

Institution	Requested Information	Obtained Information
INAM (Central)	Annual average, in the last 30 years, of the following parameters: 1. rainfall; 2. temperatures; seawater temperature, wind patterns, mean sea level.	Rainfall (total) and average temperatures (from 1985 till present)
ARA Centro-Norte	For the last 30 years: surface and underground water resources (rivers, tributaries, estuaries, permanent and temporary freshwater lakes) and their average flows. Number and type of water supplies to the populations (boreholes, wells, etc.)	No information was provided till the moment this report was prepared
Water and sanitation Department (DPS) of the	Unfortunately it was not possible to establish direct contacts with people from these institutions.	---

Institution	Requested Information	Obtained Information
DPOPH of Nampula and Zambézia		
DPTUR from Nampula and Zambézia	Number of touristic projects submitted and approved; guest occupancy numbers (National and abroad) for the last 10 years. Unfortunately it was not possible to establish direct contacts with Zambézia department.	All requested information for Nampula only.
INGC provincial Delegation of Nampula	Disaster events (including cyclones, floods and others) for the past 30 years.	INGC indicated a website where the information was available for the last 30 years: http://www.desinventar.net/DesInventar/profiletab.jsp
DPP of Nampula and Zambézia	Unfortunately it was not possible to establish direct contacts with people from these institutions.	---
IDPPE provincial delegation	Artisanal fishing reports	2012 Artisanal fishing reports
IIP	Annual report of artisanal fisheries	Annual reports from 2001 till 2013 (except 2007)
DPCA of Nampula and Zambézia	Project category type A, B and C that have had environmental permit, for the last 10 years	Type B and C approved projects and some A type projects for Zambézia. No information was provided to Nampula till the moment this report was prepared.
DPRMEM	DPRMEM was not contacted since information was available on the website Mozambique Mining Cadastre Portal.	Available information in http://portals.flexicadastre.com/mozambique/en/
DPS	Data on diseases prevalence and human well-being over the last 10 years.	Data from 2010 till 2015;
AQUA	Project category type A that have had environmental permit, for the last 10 years	No information was provided till the moment this report was prepared

3. Trends in Status of key ecosystems, natural resources and natural resource-based livelihoods

3.1. Fisheries and aquaculture

The data to assess artisanal and semi-industrial fisheries was obtained from several references, especially IIP's annual reports (from 2001 to 2013), IDPPE's 2007 and 2012 artisanal fisheries census. The data presented in the IDDPE's report (2012) is provided at provincial level. This is something that should be improved in the next census. Therefore, it was not possible to compare the trends relatively to 2007 per district but only for the whole province.

Table 3.1 – Number of fishermen, fishing gears, fishing vessels and fishing centres registered in 2002, 2007 and 2012 and trends in % between the survey years in Nampula province and Zambezia province. (Sources: Santos, 2007; IDPPE, 2007 and 2012).

	Items/Year	2002		2007		2012	
		Number	Trend	Number	Trend	Number	Trend
Nampula	Nr of fishermen	38373	*	37185	↓ -3,1	48715	↑ 31,0
Nampula	Nr of fishing gears	*	*	8648	*	10966	↑ 26,8
Nampula	Nr of fishing vessels	*	*	7880	*	9003	↑ 14,3
Nampula	Nr of fishing centres	158	*	212	↑ 34,2	195	↓ -8,0
Zambézia	Nr of fishermen	13787	*	21611	↑ 56,7	32368	↑ 49,8
Zambézia	Nr of fishing gears	*	*	5880	*	9603	↑ 63,3
Zambézia	Nr of fishing vessels	*	*	5510	*	7817	↑ 41,9
Zambézia	Nr of fishing centres	114	*	162	↑ 42,1	214	↑ 32,1

Overall, in Nampula the number of fishing centres has increased from 2002 to 2007 but it has slightly decreased from 2007 to 2012 whereas in Zambezia the number of fishing centres has been increasing from 2002 to 2012 as it can be seen in Table 3.1. In general, in Nampula the number of fishermen has slightly decreased from 2002 to 2007 (about 3%) and from 2007 to 2012 it increased about 31%, while in Zambezia the number of fishermen has been increasing: about 56.7% from 2002 to 2007 and 49.8% from 2007 to 2012 (Table 3.1). We highlight that there are differences on how the information is presented in the reports along the years which makes the direct comparison between data not possible.

Analysing the information in Nampula at the District level in 2007 (IDPPE, 2007), there were 48 fishing centres in Angoche and also 48 in Moma, making a total of 96 artisanal fishing centres, which represented 45.3% of all fishing centres in the province. Whereas in 2002 (Santos, 2007), Angoche registered 40 fishing centres and Moma 35, totalizing 73 artisanal fishing centres, representing 46.2% of the whole province. Regarding Zambezia, in 2007 (IDPPE, 2007), the District of Pebane had 66 artisanal fishing centres, which represented 40.7% of all fishing centres in the province. While in 2002 (Santos, 2007), Pebane registered 50 fishing centres, representing 43.8% of the whole province. Also in 2007 the number of fishermen in the districts of Angoche and Moma was 19827, which corresponded to about 53.3% of the fishermen recorded in the province. Whereas in 2002 there was a total of 16671 fishermen in the districts of Angoche and Moma, which corresponded to about 43.3 % of the fishermen recorded in the province of Nampula. On the other hand, in 2007 Pebane had a total of 10 521 fishermen, which corresponded to about 48.7% of all the fishermen recorded in the province. Whereas in 2002 there was a total of 5978 fishermen in Pebane corresponding to about 43.4% of fishermen recorded in the province.

Because the 2012 census does not present information per district it is not possible to compare the trends of the fishing centres and fishermen in 2012 with 2002 and 2007.

In 2012 Nampula had a total of 9 003 fishing vessels and 10 966 fishing gears. The trend is therefore positive: increase of 14.3% in fishing vessels, and 26.8% in fishing gears, when compared to 2007. In 2012 Zambezia had a total of 7817 fishing vessels and 9603 fishing gears. The trend is therefore positive with an increase of 41.9% in fishing vessels, and 63.3% in fishing gears, when compared to 2007. These parameters could not be compared to earlier years due to the lack of information (data) presented on the reports (Table 3.1).

Regarding the types of vessels, in 2012 Nampula had 40.8% of dugout canoes, 52.6% of "Moma" type canoes, 0.1% of skiboats, 3.4% of dhows, 3.0% of flat tenders, and 0.1% others. Whereas in 2012 Zambezia had 70.9% of dugout canoes, 28.3% "Moma" type canoes, 0.4% of dhows, and 0.1% others. The following table shows the trends (in %) per comparable types of vessels (Table 3.2). No data from previous years was obtained about the type of vessels for both provinces. Between 2007 and 2012 the previous tables show significant increases in the use of "Moma" type canoes, and flat tenders and a significant reduction in the use of dugout canoes, skiboats, rafts, dhows and other types in the province of Nampula. For Zambezia, we can see an increase in the use of "Moma" type canoes, dugout canoes, and dhows and "others" from 2002 to 2012 and a decrease in the use of the flat tenders, ski boats and rafts.

Table 3.2 Numbers of each type of vessels in 2007 and 2012 and trend in % for Nampula and Zambezia.

	Year	"Moma" type canoes	Dugout canoes	Flat tenders	Skiboat	Raft	Dhows	Others	Total
Nampula	2007	2118	4851	14	8	33	847	9	7880
	2012	4735	3677	271	5	4	305	6	9003
	Trend	↑ 123,6	↓ -24,2	↑ 1835,7	↓ -37,5	↓ -87,9	↓ -64,0	↓ -33,3	↑ 14,3
Zambézia	2007	1237	4207	29	7	17	5	8	5510
	2012	2212	5543	1	2	0	32	27	7817
	Trend	↑ 78,8	↑ 31,8	↓ -96,6	↓ -71,4	↓ -100,0	↑ 540,0	↑ 237,5	↑ 41,9

Also regarding the types of vessels, data was found for the districts of Angoche, Moma and Pebane for the years 2002 and 2007. The following table shows the trends (in %) per comparable types of vessels (Annex 1a). No data from other years was obtained for comparison between the districts. Between 2002 and 2007 there were significant increases in the use of "Moma" type canoes (9.5%), dugout canoes (303.4%) and flat tenders (50.0%) in the district of Angoche. Moma had a reduction in the use of skiboats, but there was increase on the use of "Moma" type canoes (12.6%), dugout canoes (1216.7%), flat tenders (200.0%) and dhows (400.0%). For Pebane, there was an increase in the use of "Moma" type canoes (190.9%) and dugout canoes (42.6%), but a decrease of dhows (98.9%).

Regarding the types of fishing gears, in 2012, there were 38.8% hand line, 33.7% beach seine, 19.3% gillnet, 4.5% spear, 1.9% traps, and 1.7% others. The following table shows the trends (in %) per comparable types for Nampula and Zambezia (Table 3.3). No data from previous years was obtained about the types of fishing gears for the whole province. As it can be seen in Nampula there was significant increase on the use of beach seine, gillnet and hand line (beach seine had the highest increase – 108.3%) with a decrease on the use of the rest of the gears. On the other hand, Zambezia showed an increase on all the fishing gears presented except for the "others" category. The use of traps had the highest increase with 578.6%.

Table 3.3 – Number of each type of fishing gears in 2007 and 2012 and trend in % for Nampula and Zambezia

	Year	Beach seine	Gillnet	Trap	Hand Line	Longline	Purse seine	Others	Total
Nampula	2007	1776	1457	264	3404	232	261	1254	8648
	2012	3699	2115	208	4259	21	139	525	10966
	Trend	↑ 108,3	↑ 45,2	↓ -21,2	↑ 25,1	↓ -90,9	↓ -46,7	↓ -58,1	↑ 26,8
Zambézia	2007	1570	1623	112	1030	263	31	1251	5880
	2012	2372	3268	760	2033	496	56	618	9603
	Trend	↑ 51,1	↑ 101,4	↑ 578,6	↑ 97,4	↑ 88,6	↑ 80,6	↓ -50,6	↑ 63,3

The following table (Annex1b) shows the trends for Angoche, Moma and Pebane (in %) per comparable types of vessels. No data from other years was obtained for comparison between the districts. In Angoche there was significant increase on the use of beach seine, gillnet, hand line and purse seine, including “others” category (increasing over 1600%) having the use of longline maintained stable between the years. Moma also showed increase on the use of beach seine, gillnet, hand line (with the highest increase – 641.6%) and “others” category, but showing decreases on traps and longline. Pebane showed reduction on the use of traps and hand line but had significant increase on all the other fishing gears. Purse seine had the highest increase with 2900%.

Although lacking information from several years, relevant information about this topic was found in IIP's Annual Reports, allowing the analysis of data between 2000 and 2013 (the most recent available report). Because the types of fishing gears registered were variable among years, we've decided to compare trends among years using the 4 types that were more frequently registered during this 14-year period (beach seine, hand line, surface gillnet and bottom gillnet). The other types of fishing gears were discarded due to the lack of data in most of the studied years.

Annex 1c show the yearly trends for the 14-year period to the whole Nampula and Zambézia province, both for Total Catches (TC) and for Catch Per Unit Effort (CPUE). As it can be seen, globally the trend has been variable, increasing or decreasing between years in both provinces. It should also be highlighted that in Nampula it was only possible to analyse continuous data from 2008 till 2013. For these two provinces there is an issue on how the data is presented in most of IIP’s reports. Instead of tables with the values, the reports show the data only using graphs, which does not allow registering the exact number that was calculated both for TC and CPUE. In these cases we had do to an approximate estimate.

Table 3.4 and Annex 1d show the trends for the 3 districts overlapped by the Primeiras and Segundas Islands from 2000 to 2013: Angoche and Moma (Nampula) and Pebane (Zambézia). As it can be seen it is not possible to compare the Districts between them, because the available data varies significantly within each District. Information regarding several fishing gears is missing in many years and the data available in some years create doubts. Of the four fishing gears analysed, beach seine is the one with more catches in the three Districts (Table 3.4), ranging from 62.8% of the total aatches in Angoche to 87.8% in Moma. Surface gillnet is the second most representative (values ranging between 8.0% and 20.7% within the three Districts) followed by hand line (values from 3.6% to 16.4%) and bottom gillnet being the less representative with values ranging from 0% to 2.4%.

Table 3.4 – Percentage of each of the four analysed fishing gears in terms of total catches per each of the three districts under study (Angoche, Moma and Pebane).

Fishing gear	Nampula - Angoche	Nampula - Moma	Zambézia - Pebane
Beach seine	62.8	87.8	83.8
Hand line	16.4	3.6	5.9
Surface gillnet	20.7	8.6	8.0
Bottom gillnet	0.1	0.0	2.4
Total	100.0	100.0	100.0

Within Angoche and Moma Districts, the data is so few that it is not possible to determine a trend. For Pebane, more data was available for comparison except from 2006 to 2009. The general trend shows decreases in both Total Catches and CPUE on the first few years (2000-2003) in all the fishing gears analysed and started to show more increases and variations from 2003-2013. Beach seine has shown decline in both total captures and CPUE from 2000 to 2005 having increased significantly form 2005-2006 and going back down in TC from 2009-2012, increasing again (about 190.5%) in 2012-2013 (Annex 1d).

IIP's annual reports also present information about the fish species caught by each fishing gear (but not for the total) within the Nampula and Zambézia Provinces (no data at district level was obtained). Therefore, in order to determine any trends between years, several types of analysis were conducted. Because the information presented in the annual IIP's reports is: i) at family level; ii) the type of analysis is different from year to year; and iii) the methodology used in each year is not explained in detail, the analysis herein presented should be interpreted cautiously.

Fish families caught by each fishing gear

To analyse the trends of the families caught by each fishing gear the following analysis were conducted:

- The top five fish families caught by each type of fishing gear in each year were chosen and their % of occurrence relatively to the total catch (data obtained from IIP's annual reports). This was done for each province covered by the Primeiras and Segundas Islands (Nampula and Zambézia);
- Each time a new fish family was recorded, its percentage in the previous years was recorded (in the cases were the species of the family had been caught);
- The trend in % of occurrence between each two consecutive years was calculated;
- In the following step, a trend analysis was performed:
  - The number of times that a fish family showed an increase, decrease or stayed stable, per type of fishing gear during the analysed period with data for Nampula (from 2001 to 2008) and Zambézia (from 2001 to 2010) was counted;
  - The trend of each family in the last year with available data was recorded (2008 or 2006 for Nampula and 2010 for Zambézia);
  - Combining the previous data it was determined, on a semi-quantitative basis, a possible trend for each family according to each fishing gear type, using 4 categories: Decreasing; Stable-Decreasing; Stable and Increasing;
  - Using the trend obtained in the previous step, it was determined, on a semi-quantitative basis, a possible trend for the most representative families among the analysed fishing gear types;

- Also using the same information, it was determined, on a quantitative basis (average of the number of times each trend category was accounted for), the average percentage for each trend category per fishing gear type.

Annex 2 and 3 show the results of the global trend analysis for Nampula and Zambézia, respectively. As it can be seen, data from some years was not available due to the way it was presented in the reports which made it impossible for comparison (the 2007 report was not available for this study). For Nampula (Annex 2), the last comparable year is 2008 for all the fishing gear types except Bottom gillnet (last year considered was 2006 due to the lack of data). On the other hand, for Zambezia (Annex 3) the data from all fishing gear types from 2004 were compared to 2003 except for Hand line which had to be compared to 2001 due to lack of data in 2003. The same thing happened in 2008 where bottom gillnet had to be compared relatively to 2005 instead of 2006. As it can be seen on a global view the data presented in both Annex 1 and 2 is not very informative and there is not a pattern per species and/or per fishing gear. However, analysing each row independently, it was possible to estimate a global trend per family per fishing gear and the variability of the trend between years.

Table 3.5, shows the percentage of families for each trend category per fishing gear, and the average percentage of families for each trend category considering all fishing gears for the provinces of Nampula and Zambezia.

Table 3.5 – Percentage of fish Families for each trend category per fishing gear, and average percentage of Families for each trend category considering all fishing gears in Nampula (2001-2008) and Zambezia (2001-2010).

	Fishing gear	Decreasing	Stable-Decreasing	Stable	Increasing	Total number of most frequent Families
Nampula	**Beach seine**	27,3	27,3	0,0	45,5	11
	Hand line	28,6	28,6	14,3	28,6	7
	Surface gillnet	16,7	25,0	33,3	25,0	12
	Bottom gillnet	23,1	30,8	7,7	38,5	13
	Average %	23,9	27,9	13,8	34,4	-
Zambézia	**Beach seine**	12,5	25,0	25,0	37,5	8
	Hand line	22,2	11,1	11,1	55,6	9
	Surface gillnet	9,1	9,1	27,3	54,5	11
	Bottom gillnet	8,3	25,0	50,0	16,7	12
	Average %	13,0	17,6	28,3	41,1	-

In Nampula, the fishing gear with more fish Families in the "Decreasing" Category seems to be the Hand line (28.6%) followed closely by Beach seine (27.3%). Zambézia, seems to follow the same trend with Hand line (22.2%) being the fishing gear with more fish Families within the "Decreasing" category, followed by Beach seine (12.5%). Surface gillnet (33.3%) is the fishing gear with more families within the "Stable" category in Nampula and Beach seine (45.5%) the one with more families within the "Increasing" category. While in Zambezia Bottom gillnet (50.0%) was the fishing gear with more families in the "Stable" category and Hand line (55.6%) the one with more families within the "Increasing" category (Table 3.5).

For Nampula, considering the two negative trends together ("Decreasing" and "Stable-Decreasing"), Hand line is the fishing gear with the highest percentage (57.2%), followed by Beach seine (54.6%). On the other hand, considering the two negative trends together for Zambezia (Table 3.5), Beach seine had the highest percentage (37.5%) followed by both Hand line and Bottom gillnet (33.3% each) (Table 3.5).

Considering the positive categories "Stable" and "Increasing" together, Surface gillnet accounts for 58.3% of fish Families followed by bottom gillnet with 46.2% in Nampula (Table 3.5,), while the same categories in Zambezia show 81.8% of fish Families for Surface gillnet and 66.7% (each) for both Hand line and Bottom gillnet (Table 3.5).

The category "Increasing" is the one with the highest percentage of occurrence in both provinces (with 34.4% of fish Families in Nampula and 41.1% in Zambezia). In Nampula, the second highest percentage of fish Families belongs to the "Stable-Decreasing" category (with 27.9%) followed by "Decreasing" (23.9%) and "Stable" (13.8%), as seen in Table 3.5. Whereas in Zambezia, the second highest was the "Stable" category (with 28.3% of fish Families) followed by "Stable-Decreasing" (17,6%) and "Decreasing" (13.0%) as seen in Table 3.5.

In Nampula (Table 3.5,), the two negative trends together ("Decreasing and Stable-Decreasing"), account for a total of 51.8% of the fish Families (which is higher than the positive trends). While in Zambezia (Table 3.5), the two positive trends ("Stable" and "Increasing") account for a total of 69.4% of the fish Families (higher than the negative trends).

Finally, the overall analysis per fish family in each province (Table 3.6) shows that: In Nampula, from the 10 most representative Families caught by the four analysed fishing gears between 2001 and 2008, four (40%) seem to be "Decreasing", three (30%) are "Increasing", one (10%) is "Stable-Decreasing", and two (20%) are "Stable". While in Zambezia, from the 13 most representative Families caught from 2001 to 2010, six (46.1%) are "Increasing", four (30.8%) are "Stable" and three (23.1%) are "Stable-Decreasing".

Table 3.6 – Trends of the most representative Families caught by Hand line, Surface gillnet, Bottom gillnet and Beach seine, in Nampula (2001-2008) and Zambezia (2001-2010).

	Family	Trend	Relevant notes
Nampula	Carangidae	Increasing	Stable-Decreasing in Beach seine and decreasing in Bottom gillnet
	Scombridae	Decreasing	Increasing in Surface gillnet
	Clupeidae	Stable-Decreasing	
	Leiognatidae	Decreasing	Stable-Decreasing in Surface gillnet
	Acanthuridae	Increasing	
	Haemulidae	Decreasing	Decreasing in Bottom gillnet and Stable-Decreasing in Hand line
	Lutjanidae	Stable	Stable in Hand line and Stable-Decreasing in Bottom gillnet
	Serranidae	Stable	Stable in Bottom gillnet and Stable-Decreasing in Hand line
	Mugilidae	Decreasing	Stable-Decreasing in Bottom gillnet and Decreasing in Surface gillnet
	Mobulidae	Increasing	Stable on Surface gillnet and increasing on Bottom gillnet
Zambezia	Clupeidae	Stable	Decreasing in Surface gillnet
	Sciaenidae	Increasing	Stable in Surface gillnet
	Ariidae	Stable-Decreasing	Increasing in Surface gillnet and Decreasing in Bottom gillnet
	Haemulidae	Stable	Stable-Decreasing in Bottom gillnet and increasing in Hand line
	Carangidae	Increasing	Stable-Decreasing in Bottom gillnet
	Carcharhinidae	Stable-Decreasing	Decreasing in Hand line
	Engraulidae	Increasing	
	Trichiuridae	Stable	Decreasing in Beach seine and Increasing in Surface gillnet
	Serranidae	Stable-Decreasing	Stable in Beach seine and Decreasing in Hand line
	Lobotidae	Increasing	Stable in Hand line and Increasing in Bottom gillnet
	Chirocentridae	Increasing	Stable in Bottom gillnet and Increasing in Surface gillnet
	Scombridae	Stable	
	Muranesocidae	Increasing	Stable in Bottom gillnet and Increasing in Hand line

3.2. Aquaculture

There is no information available in IIP reports regarding aquaculture in Angoche, Moma and Pebane Districts. In 2011 and 2012 an assessment was done in the centre and north of Mozambique to determine which native species had potential for aquaculture development (IIP, 2011, 2012). According to the data presented in these IIP reports, Lagoa Manganha has *Oreochromis mossambicus* specimens large enough to be able to be used as a source of fingerlings. In the same year, a study about the environmental impacts caused by aquaculture showed that the project analysed could have auto-pollution problems, and therefore, further studies were required.

Accordingly with the data provided by the Zambézia Provincial Delegation for Environmental Affairs (DPCA), in the last decade, only one licence was issued for aquaculture. However, by the time this report was prepared it was not possible to establish contacts with the Provincial Directorates for Fisheries of Zambézia and Nampula for updated information. Therefore it is assumed that information on this issue is lacking for the three districts covered.

3.3. Agricultural land, crops & livestock

The population in the area of the PSEPA makes it's living almost entirely from fishing and agriculture. Reports on the relative importance of these two activities vary, with different studies citing fishing as contributing from 30 to 60 % of family income (WWF brief, 2012).

During the colonial times, farmers in the region were engaged in commercial agriculture – working with cashew, copra, sisal, cassava and rice plantations. Today, it is subsistence agriculture which dominates the regions of the PSEPA (Nhancale & Mbeve, 2008).

Principal food crops produced are: rice, sorghum and millet, cassava, groundnuts, cashew, grain legumes, sesame, maize and sweet potatoes.

According to a participatory rural diagnostic carried out by WWF-CARE in the villages of Namagula, Saua Saua and Mucuvula; the three most practised subsistence crops (in order) are: cassava, groundnuts and rice. The three most produced cash crops are cashews, sesame and peanuts (WWF-CARE, 2012).

Trees cultivated include cashew, papaya, banana, custard apple (ata), mango, and coconut. Coconut is cultivated for sale particularly in the Angoche and Pebane areas (WWF brief, 2012). According to a socio-economic survey carried out in 2007, the average ownership of trees in the region was 54% for cashew trees and 60% for coconut trees (Nhancale & Mbeve, 2008).

Animal husbandry also contributes to livelihoods, with small stock such as chickens, goats, pigs, and ducks being common. Cattle raising is generally an activity beyond the reach of the rural farmer. Animal husbandry is a highly desirable activity, with families owning goats being considered wealthy in the community context. According to a socio economic study carried out in 2007; an average of 6.2% of households have ownership of cows; 20.9% have goats; and 39% have chickens and/or ducks (Nhancale & Mbeve, 2008). Another study shows that Livestock ownership in the PSEPA region was considerably low: less than ¼ of households owned at least 5 chickens; Less than 15% of households owned two goats or 5 ducks. Although the coastline area showed slightly higher levels in comparison with other areas, the rates were still low (co-Arq, 2008).

According to the baseline carried out for the WWF-Care project in 2008: Medium to large-scale agriculturalists, or those who plant more than 1 hectare, constituted 30% of the population. Their presence was more often found in the coastal area, where 43% of the households planted more than 1 hectare. This group only constituted 13% of the urban areas. Subsistence agriculturalists and non-agriculturalists accounted for less than 15% of the population in the rural areas. On the other hand, they accounted for 65% of the population in the urban area (Co-Arq, 2008). Another socio economic study carried out by Nhancale & Mbeve (2008) shows that households have on average two fields (machambas) for cultivation. According to the national agricultural census (1999/2000), households in Nampula province have an average of 1ha of cultivated land while in

Zambezia it is 0.84 ha. No detailed information was available specifically for the PSEPA communities.

Farm sizes are limited by labour availability. Labour is needed for opening fields, planting, weeding, and harvesting, with opening fields and weeding needing the most labour. The majority of farmers practice slash and burn agricultural practices. This often leads to wild fires, poor soils, destruction of ecosystems and desertification (Nhancale & Mbeve, 2008). Fields will only be used for three or four years at most before fertility is exhausted. When this happens, fields are abandoned and new fields are opened.

Only 12% of families are able to provide enough food for themselves regularly, with 53% having problems sometimes and 35% of families having difficulties finding food right throughout the year (WWF brief, 2012). The inherently low fertility of the sandy soils found in the coastal areas, ambient high temperatures, and erratic rainfall all make it difficult for farmers to produce cereal crops. Cassava is therefore chosen as a key crop due to its ability to grow in less fertile regions. Another report however carried out for the WWF-CARE alliance project in 2008 indicates that the districts of Pebane and Moma produce enough cereals and tubers (cassava) for own consumption and surplus to export to markets such as Angoche and Nampula. Staple crop production in the district of Angoche was however recorded not to meet local needs. This is associated to the larger population of the region (Co-Arq, 2008).

The Alliance project executed by the WWF-CARE partnership in the PSEPA is working with 4000 community members to improve farming practices, access to markets and food security in the region. Although not explicitly mentioned in the project description, the activities also focus on the adaptation of farming practices to climate vulnerabilities (WWF-CARE 2012).

3.4. Shallow marine habitats

The coastline of northern Mozambique has been classified by Tinley (1971) as a coralline coast, typically characterized by an almost continuous fringe of coralline islands and reefs. Associated habitats include extensive seagrass beds and mangrove formations, not only along estuaries, but also bays and other protected sites. These productive ecosystems provide valuable natural resources that sustain the livelihoods of the local populations (Whittington & Heasman, 1997; Nhancale & Mbeve, 2008).

The Primeiras and Segundas islands are known for their high biodiversity and productivity and have captured the interest of marine researchers for a long time (e.g. Hughes, 1971; Hughes & Oxley-Oxland, 1971; Saldanha, 1973; Whittington & Heasman, 1997). However, logistical challenges have hindered research activities in the area and very few ecological studies have been published. Therefore, much information is still needed in order to provide a sound basis for management and conservation, especially in view of the recently proclaimed conservation areas.

Relevant shallow marine habitats of the P&S include coral reefs and seagrass beds, which are further discussed below.

Coral Reefs

Coral reefs are arguably the most studied ecosystem in the area. Studies have been especially under the EIA for the Kenmare heavy sands project (e.g. Schleyer, 1999; Schleyer & Celliers, 2000), but also as part of the WWF conservation project (e.g. Pereira & Videira, 2008; Teixeira et al., 2015).

The reefs occur mostly around the islands in an atoll formation (Pereira & Videira, 2008), in a similar pattern: a spurs and grooves zone in the South and East, with well-developed coral building up towards the reef crest. The spurs and grooves follow a South-Southeast direction due to the prevailing currents and wind. Progressing from the seaward side around the reef crest towards the landward side the coral becomes less developed and flatter, and the grooves become broader and filled with more sand (Schleyer, 1999; Teixeira et al., 2015). The lagoons (about 2 meters deep during high tide) are generally sandy rubble, made of weather-broken coral, seagrass and algae (Teixeira et al., 2015).

Within the PSEPA, coral reefs cover about 22 km^2 and despite the reported overall reduction of reef cover from 2006 to 2010 (60% to 40%), the overall condition in terms of the live coral cover seems to be unchanged (Teixeira et al., 2015). The area has been classified as some of the best-developed reefs in Mozambique (Schleyer, 1999; Schleyer & Celliers, 2000) and the reduction is likely the result of different locations being analysed. Table 3.7 shows the percentage cover of the main coralline benthic categories within the PSEPA. A very high coral cover was reported for Epidendron and Ndjovo islands.

Table 3.7 – Percentage cover (± SE) of the main benthic categories at selected location within the Primeiras and Segundas Environmental Protection Area (from Pereira & Videira, 2008).

Category	Fogo	Epidendron	Ndjovo	Puga Puga	Mafamede
Branching hard coral	17.5 ± 3.7	25.4 ± 5.6	12.2 ± 1.5	4.4 ± 0.7	7.7 ± 1.0
Encrusting hard coral	3.0 ± 0.7	6.3 ± 0.9	3.9 ± 0.8	1.6 ± 0.6	6.0 ± 1.2
Massive hard coral	4.8 ± 0.8	4.9 ± 0.0	7.6 ± 1.3	22.5 ± 1.5	9.8 ± 2.8
Submassive hard coral	0.3 ± 0.2	1.7 ± 0.6	2.8 ± 1.2	2.0 ± 0.4	23.5 ± 4.9
Tabular hard coral	2.6 ± 0.7	7.9 ± 2.0	1.3 ± 0.4	0.1 ± 0.1	1.7 ± 0.6
Total hard coral	*29.8 ± 4.4*	*48.0 ± 5.2*	*30.4 ± 1.9*	*32.2 ± 2.6*	*50.5 ± 5.7*
Soft coral	*22.5 ± 2.3*	*23.2 ± 3.0*	*35.8 ± 1.6*	*22.7 ± 3.7*	*12.0 ± 1.9*
Total live coral	*52.4 ± 5.3*	*71.2 ± 3.8*	*66.1 ± 2.6*	*54.9 ± 2.6*	*62.5 ± 4.2*
Dead coral and algae	2.3 ± 0.6	3.0 ± 1.0	1.0 ± 0.3	1.0 ± 0.3	2.6 ± 0.8
Rock and algae	28.3 ± 3.1	15.7 ± 4.2	19.7 ± 2.4	35.3 ± 1.9	25.0 ± 2.9

Benayahu et al. (2003) reported 46 species of soft corals from "northern Mozambique", which included collection stations in Caldeira island (Primeiras and Segundas) and a couple of stations further north (near Mozambique Island and at the QNP). It total, 58 genera of corals (hard - 43 and soft - 15) have been reported (Schleyer, 1999; Schleyer & Celliers, 2000; Pereira & Videira, 2008). Given the irregular sampling and no monitoring of the reef communities, it is difficult to establish a trend in terms of their condition both with regards to their diversity and abundance.

Seagrass Beds

Seagrass beds are very poorly studied in the PSEPA. Two species have been reported (*Zostera capensis* and *Thalassodendron ciliatum*), and occur close to estuaries and around coral reefs and lagoons in sheltered areas (CES, 2000). Although it was previously reported that the area has extensive seagrass beds that represent the most important foraging grounds for dugongs (Hughes, 1971; Hughes & Oxley-Oxland, 1971), there are no published data in terms of its area and distribution, as well as any trends.

3.5. Freshwater resources

The Islands region do not have freshwater courses, however the PSEPA coastline has several rivers and estuaries, namely the following main rivers: Sangage, Meluli, Larde, Moma, Ligonha, Naburi, Molócue, Muebase, Moniga, Molócue, Licungo and Laula. Those rivers drain huge volumes of freshwater during summer months every year. For example, the average annual flow of the Rio Licungo is about 6.600.000 m3. These waters generally have high temperatures and low salinity, when compared to seawater and are rich in nutrients. Obviously, this fact influences the distribution of fauna and flora in the region (MITUR, 2014a).

There are also several underground aquifers, including in the islands. For instance, the water retention rate in the coastal of Moma district is approximately 294 mm per year. Here, the groundwater has a pH around 5 whereas in Muebase underground the water has a high concentration of sulphates, in some cases up to a toxic level, which may affect many forms of life (MITUR, 2014a).

Hydrologic information of freshwater resources and trends has been requested to ARA Centro-Norte but, by the time this report was prepared, we have not received any information.

3.6. Mangroves

Information on mangroves of the Primeiras and Segundas Islands is scanty but it is estimated that about 400Km^2 of mangrove forests occur in Angoche and Moma districts (MITUR, 2014a). However, two recent works had gather some information on PSEPA mangroves, and there are seven species in the area: *Rhizophora mucronata, Ceriops tagal, Avicenia marina, Sonneratia alba, Bruguiera gymnorrhiza, Xilocarpos granatum, Lumnitzera racemose* (CREMASS, 2014; Abreu, 2007).

In a rapid assessment conducted by Abreu et al. (2007), in the Mombassa and Sanja Island, they classified the mangrove forests of this region as follows: *Sonneratia alba / Avicenia* marina: this is the most dominant mangrove community, which is usually close to water-line, at the forest's lower zone; *Rhizophora mucronata / Ceriops tagal / Avicennia marina*: this association is usually common in the intermediary zone; Avicennia marina- this community normally dominates the forest's upper zone adjacente to other terrestrial non-marine plants. In Mocoroje (Moma districts), mangroves form two associations: *Sonneratia alba*/*Avicennia marina* and *Rhizophora mucronata*/*Bruguira gymnorrhiza*/*Avicennia marina*. Islolated individuals of *Lumnitzera racemosa* and X*ylocarpus granatum* are also found in Sanja Islands (Abreu et al., 2007).

Latter, in 2014, a Mangrove status survey was also performed in PSEPA, revealing that Angoche mangroves has 55% adults plants, 27% were young plant and 18% were cut, while the mangrove in Moma district presents the following results: 65% of the plants were adults, 19% young and 16% had been cut. Although data from this study were not sufficient to classify mangrove forest health (did not covered the Biological and Environmental indicators to access mangrove forest) it gives the perception of the existence of a higher proportion of bigger trees within the visited areas (CREMASS, 2014). Despite those two works, there is no information about density, number of stems, or species cover percentage or any evaluation of mangroves trends for this region.

As suggested on the draft version of the Management Plant (MITUR, 2014a,) mangroves of the Primeiras and Segundas Islands are under particular threat from over-use, especially excessive cutting for domestic use and for sale. Other threats include changes in salinity and sedimentation due to increased agricultural activity. Mining activities in Moma and Zambezia are also a potential concern. However, some conservations actions can reduce the impacts on mangroves, and some had already been taken. Additionally, it is likely that the full impact of mining operations on mangroves in this area may be less than the situation without mining, once mining operators may resettle local communities, and otherwise these would continue to cut mangroves for domestic use and for sale. There are also reports of loss of invertebrates that are used for food, like the fishing of the mangrove crab *Scylla serrata*, both in Angoche and Moma.

A key activity of the conservation area will be the protection of mangroves, which consist on a combination of:

- a strong public awareness campaign at the local level, on the importance of mangroves to fisheries;
- support to local fishermen communities , both in shrimp capture techniques such as the imposition of legally established artisanal fishing zones to increase the "ownership" of the mangrove resource by the community ;
- creation of Total Protection Marine Zones covering about 30% of the total area of mangrove to allow the reproduction and restoration of mangrove resources (crab, mullet and others);
- research into the production of oysters (*Pinctada capensis*) within the mangrove channels to further enhance the economic value of mangroves to the domestic economy of local communities;
- development of conservation farming systems on the continent to reduce erosion and runoff, and increase food security at household level;
- development of local alternatives to the use of mangroves;
- Ban mangrove logging for sale;

3.7. Terrestrial Forests

Information about specific terrestrial forest trends or even current cover in the PSEPA was not obtained. Nevertheless, in order to analyse the general trend of the forests within the PSEPA, the Global Forest Change website was consulted (Hansen et al., 2013). Hansen and colleagues performed a globally time-series analysis of Landsat images characterizing forest extent and change. ‘Forest Cover Loss’ was defined as a stand-replacement disturbance, or a change from a forest to non-forest state, during the period 2000-2013. ‘Forest Cover Gain’ was defined as the inverse of loss, or a non-forest to forest change entirely within the period 2000-2012.

The following images from Hansen et al. (2013) show the forest cover loss in the PSEPA between 2000 and 2013 (Figure 3.1a) and the forest cover gain between 2000 and 2012 (blue area; Figure 3.1b). The deforestation is of great concern throughout PSEPA area, particularly along the main roads, especially between Pebane and Moma. It is also remarkable that the main exception in the region concerns Gilé Nacional Reserve, which confirms the importance of Conservation Areas. Forest cover gain is considerably lower, and also occurs between Pebane and Moma, wich may be compensating part of the recorded reforestation.

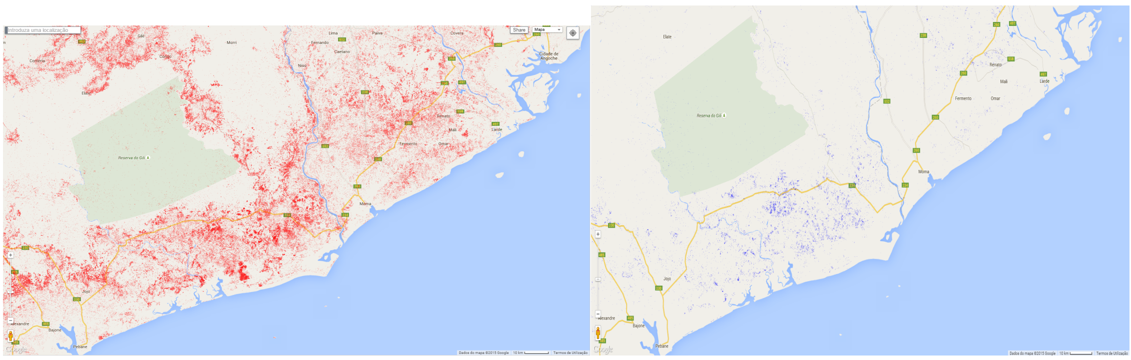


Figure 3.1 – Forest change in PSEPA, namely: a) Forest cover loss between 2000-2013 (red area) and b) Forest cover gain 2000-2012 (blue area) (from: Hansen et al., 2013 website http://earthenginepartners.appspot.com/science-2013-global-forest)

Coastal Forest

Isolated patches of very threatened coastal forest in East Africa occur in the Caldeira and Fogo Islands, near Farol da Ponta Caldeira and elsewhere immediately west of the dunes parallel to the coastline. The coastal forest occurs on sandy soils of marine origin. These are often the poorest in terms of soil fertility and water retention capacity; it is unclear whether this is due to ecological issues or due to human impacts in the most fertile areas of the region (e.g. agriculture). One type of perennial forest dominated by endemic tree *Icuria dunensis*, occurs only along this stretch of the coast, and it is assumed that it is adapted specifically to low regime soil fertility/high groundwater sulphate content of this area. The *Icuria dunensis* dominates the evergreen forest here (70% coverage), reaching heights of 40 meters and a diameter of 2 meters, and dominating a lower vegetation layer: Icuria immature and some other species, grasses, and herbs. Other types of coastal forest also occur on the continental side of the region. One is the miombo forest, which is generally found in higher areas of Dunal origin, with deeper soils and rich than other types of coastal forest. The most common species include those miombo characteristics, e.g. *Brachystegia spiciformis*, which often reaches about 40 meters and with good diversity of other species also. The vegetation of this miombo forest and savannas that will be mentioned below differs by the presence of the following species in the forest: *Diospyros natalensis*, *Allophyllus africanus*, *Transzambezica grewia* and *Abyssinica pavetta* (MITUR, 2014a).

In the previously mentioned Islands and immediately behind the front dunes, vegetation is more characteristic of the coastal forest, a subgroup of the coastal forest. The structure and composition are variable species, including woody shrubs such as *Strychnos spinosa*, *Strychnos myrtoides* and *Flaucortina indicus* as well as trees such as *Swartzia madagascarensis*. The shape community is a dense, impervious woody plants, shrubs and small trees up to 5 meters and a total coverage of plants of approximately 90%. There is little or no herbaceous layer.

Dune vegetation

The dune vegetation exists along the coast, and where wave action is more intense, replaced the mangrove as a first line of defence against the waves and the sea. The vegetation is established along the coast in parallel strips, depending on the salt content in the soil and the dune mobility. The first track only grows grasses and tree-creepers pioneers, including the *Ipomaea pescaprae* (Convolvulaceae), *Scaevola plumieri*, *Sarmentosa launea*, and *Cyperus crassipes*. The Cyperaceae represent herbaceous species and *Dactylotenium geminatum* grass. In some areas, the vegetation is dominated by pioneer grassy areas such as *Dactylotenium geminatum* and *Digitaria eriantha*, mixed with shrubs such as *Sulcata grewia*, *Petersiana Ancyclobotrys*, *Gercinia livingstonii* and *Hypenae coriacea*. This vegetation formation usually occurs to the inner zone mentioned before, herbaceous tree-creeper. Moving further inland, the prairie gives way to dune bushes increasingly dense, and finally to the coastal forest, as described above.

Wetlands vegetation

Wetlands with vegetation and marshes or seasonal wetlands occur in the lowlands between the crests of the dunes, parallel to the shoreline, according to the deposition of the original dunes. They occur near the coast, immediately behind the second row of dunes in many cases. Here the water is fresh, with salinity below 5% and a pH value neutral. Rushes and reeds (for example *Cyperus papyrus*, *Phragmites australis* and *Miscanthus capensis) and* permanent water lilies (*Nymphaea capensis* and *Nymphoides forbesiana)* dominates the water banks. In drier parts plants such as *Cyperius ciliaris*, *Eragrostis* spp and *Hyphaena coriacea* occur. There are also some areas of swamp forest, containing species such as *Ficus trichopoda*, *Phoenix reclinata*, *Syzigium* spp., *Psychotria* spp., *Gracillipes Uvaria* as well as a variety of herbaceous tree-creepers such as *Thelypteris dentata*, and *Panicum brevifolium*.

Savannah

The savannas of the Primeiras and Segundas Islands have very variable density, blending one end to the other with prairies and forests. They are also very diverse in terms of species, with the following dominating trees: *Brachystegia spiciformis*, *Croton gratissimus*, and *Strychnos myrtoides*. When dense, this Savannah is considered the forerunner of *Brachystegia* forest (miombo) cited above, so conservation efforts should result in the expansion of this valuable form of coastal forest (Coastal and Environmental Services, 1998a). There are also secondary savannahs that form where there has been recent disturbance caused by man, and can be identified by the presence of cashew trees and shrubs most characteristic of dune vegetation and coastal forest. The riverside of Savannah is characterized by the presence of alternating palm trees with bamboo, *Tamamrindus indicus*, *Barringonia racemes*, *Faidherbia albida* and *Ficus* spp.

The following table (Table 3.8) gives an idea about the main type of land use and vegetation types found within the terrestrial PSEPA. It stands out the representativeness of some types of vegetation (considering coverage), such as the mangrove forests that occurs approximately in 75.300 ha (27% of the area). About 15% of the area is covered by flood zones forming an ecosystem suitable for the refuge of many species. The open scrub is also a critical habitat where occur some protected species and currently occupies approximately 7% of the area.

Table 3.8 – Terrestrial land use and vegetation cover (ha and %) in the PSEPA (Adapted from: MITUR, 2014a).

Land use and vegetation type	**Area (ha)**	**%**
Residential Area (non-urban and urban-alike)	724	0,27
Agriculture (rainfed crop	86.916	31,5
Open Forest of low altitude	170	0,06
Herbaceous formation	37.121	13,45
Herbaceous formation with trees	3.363	1,22
Herbaceous formation (flooded or flooding)	40.466	14,67
Lakes, ponds	583	0,21
Mangroves (locally degraded)	75.336	27,30
Open scrub	18.561	6,73
Low bushes	5.786	2,1
Bare Soil	60885	2,5
Total Area	275.910	100%

3.8. High profile species

Apart from marine turtles, information on other high profile species as well as other marine megafauna is very poor. The areas was previously reported as one of the most important for dugongs in the Western Indian Ocean (Hughes & Oxley-Oxland, 1971), but it is believed that dugongs are now extinct, as no sightings have been reported (CES, 2000). The five species of marine turtles that occur in Mozambique, also occur in the area, with four (green, hawksbill, loggerhead) being common. Greens, olive Ridleys and hawksbills have been reported to nest in the area, although no regular monitoring have been conducted. A tagging program was implemented (118 turtles were tagged from 2005-2007), with the majority being green turtles

(101) and the remaining hawksbills (Costa & Sitoe, 2008). It is believed that the whale shark occurs offshore (Rowat, 2007; Rohner et al., 2013), as well as the bottle-nosed and the humpback dolphin (CES, 2000).

4. Development trends and pressures

4.1. Population growth

The PSEPA Management Plan (MITUR, 2014a) suggests that according to the 2007 Census, the Primeiras and Segundas Archipelago has an approximate population of 628 765 (Table 4.1).

Table 4.1. Population per district at the PSEPA.

District	Relevant for the Environmental Protection Area for the Archipelago of Primeiras e Segundas	
	Population	**Area (km^2)**
Angoche		
AP Angoche-Sede	89998	480
AP Aube	43765	558
AP Boila/Nametória	105586	1268
Moma		
AP Moma	164564	2535,4
Pebane		
AP Pebane	60711	1638
AP Mulela	65041	5171
AP Naburi	59581	3448
Larde	39519	743,4
TOTAL	**628765**	**15842,2**

The total population of the Districts of Angoche, Moma, Pebane and Larde is approximately 772 494 people, including those administrative posts for each District that are not part of PSEPA. According to Table 1, 628 795 out of 772 494 currently live within PSEPA and its buffer zone. The PSEPA Management Plan (2014) has provided a projection since 1997 to 2014 for the total population of the Districts mentioned above (Table 4.2).

Table 4.2. Projection for the population growth of the four districts within the PSEPA.

District	Population in 1997	Population in 2007	Projected Population for 2014
Angoche	228526	276471	328637
Moma	238655	271171	322337
Pebane	135275	182333	216737
Larde	(included in Moma)	39516	46976
Total	**602 456**	**772 494**	**914687**

There are no projections available for the PSEPA. Table 4.2 suggest a growing pattern for Angoche, Moma, Pebane and Larde from 1997 to 2014. The PSEPA Management Plan suggests however that these estimates are likely to have some degree of error for a number of reasons:

- The growth rate of the population for Angoche District is significantly lower than Moma and Pebane;
- A significant part of the Pebane District falls under the Gilé Reserve which is a protected area in which local communities are not allowed to live inside the park.
- The National Institute for Statistics (INE) provides information for provincial, district and administrative post layers and certain administrative posts are not part of the Archipelago therefore it is difficult to make estimates and projections.

4.2. Large scale irrigated agriculture

Detailed information could not be sourced for large-scale irrigated agriculture for the PSEPA. The sugar cane production industry is responsible for most irrigated land area in Mozambique. No sugar-cane projects have been identified in the region. A study done by FAO has identified all irrigation projects in the country, however none can be linked to the PSEPA (http://www.fao.org/nr/water/aquastat/countries_regions/Profile_segments/MOZ-IrrDr_eng.stm date accessed 12.08.2015)

4.3. Land-use conflict

The Primeiras e Segundas Archipelago became a protected area in 2012. Regarding the protected land, there is no information on this topic from the literature sourced. In terms of land use conflict for the Nampula and Zambezia Provinces, according to the Agriculture Census done in 2007, less than 5% of the people interviewed have stated that they have experienced conflicts particularly related to zoning of the land and land being sold to different people (MAG, 2007).

4.4. Major infrastructure development

The main information was obtained in the Environmental profile of Pebane, Angoche (both from 2005) and Moma (from 2013) districts. DPCA Provincial Delegation of Zambezia has also sent the environmental permits issued for the last 10 years to projects categorised as type A, B and C for the Pebane district. By the time this report was prepared, we did not receive any information for Angoche and Moma districts.

Moma's district

Accordingly with the Environmental Profile of Moma (MAE, 2013), the district has a road network of 597 km, of which only 387 km are passable. The District has 12 radio stations, which enable communication between the district headquarters and administrative posts, peripheral health facilities and other points of the province. The district is covered by three mobile networks and has also a fixed-line network of TDM at the headquarters of the district and Topuitho. Cahora Bassa Electricity supplies three administrative posts, namely Larde, Moma Headquarters and Chalaua. The district has 142 schools of which 98 primary school (level 1), 40 primary school (level 2), 3 Secondary education (level 1) and 1 secondary school (level 2). The district is served by 15 health facilities that enable a gradual access of the population to the National Health System services, though it is fairly insufficient.

Overall, the general condition and maintenance of the infrastructure is not enough, namely the network of water pumps that need maintenance, as well as the roads and bridges network, with some been impassable, especially in the rainy season. However, the Environmental Profile also refers the future implementation and/or maintenance of the following local infrastructures: construction of a residence type II in Pilivili Locality, Administrative Post of Macone, belonging to the Provincial Delegation of Fisheries of Nampula; construction of a Type II health center in Topuitho, Larde Administrative Post (Kenmare); construction of two aqueducts in Chalaua / Namiwi Road, on Nanvava and Sancusse rivers; road routine maintenance of the section Moma / Micane (20 km); Micane / Chalaua, (67 km); Cruz R324 / Ponta Caldeira (30 km); Chalaua / Muquiquisa (17 km); and Micane / Rio Miluli (MAE, 2013).

Angoche district

For Angoche it was not possible to obtain updated information, only the contained in Environmental Profile of 2005. At that time the district had 300 km of benefited road and some tertiary roads impassable due to the lack of rehabilitation namely: Namaponda / Muatua, Muatua

/ Carrane, Angoche / Sangage, Comba / Ice and Nameteira / Magira. The current conservation status of Angoche road network is unknown, but accordingly with recent news, apparently this problem remains and may affect the tourism development. The maritime commercial port operating in 2005 has several problems due to the silting of the channel and degradation of the pier. In 2005 there were plans to rehabilitate the port and drain the canal. However it seems that little has been done, since presently remains serious silting problems and lack of basic services (concerning infrastructures). Recently the Chinese company has expressed interest in modernizing the port of Angoche in order to use it to export the metals extracted from heavy sands deposits in Sangage.

The district also has an airfield, near Angoche town (7 km away), which in 2005 had 3 lanes with gravel pavement and the associated infrastructures in a reasonable state of repair. However, with the reopening of roads in 1992 (after the civil war) the frequency of air traffic reduced significantly, from an average of 70/80 aircraft/month to 1/5, and in 2003 any movement was recorded. It is unknown the current condition and use of this infrastructure.

In 2005, the district headquarters had a post office and small delegations in the administrative posts of Boila/Namitória, Namaponda and Mepapata. There was also a telecommunications network station. The town of Angoche and the Administrative Port of Boila / Nametória received energy of Cahora Bassa serving 2,500 consumers in 2005. At that time there were 82 schools (of which 74 primary school level 1) and 115 literacy centres. The district was served by 16 health units that were quite insufficient: 1 facility for every 19.000 people; 1 bed for every 1.800 inhabitants and one technician for every 1.500 residents. As in the previous cases, the current numbers are unknown.

Overall, in 2005 the general condition and maintenance of the infrastructure was not enough, namely the network of water pumps that needed maintenance, as well as the roads and bridges network, with some been impassable, especially in the rainy season.

Pebane district

According to the Environmental Profile of Pebane (2005), until that time none of the roads had benefited from rehabilitation works, just some maintenance work on tertiary roads linking to Maganja da Costa, via Mocubela and Mualama. There was also a maritime port in Pebane, which in 2005 was not operational, and 3 airfields (one of which inoperable). The energy in 2005 was completely supplied by a generator set 100kV. It is unknown the current state of conservation of these infrastructures. In 2005 there were 111 schools (105 of which the primary one school). The district was also served for 11 health facilities units, wich were quite insufficient: 1 health centre for every 17,000 people, one bed for every 2,500 inhabitants, one professional Technical 5700 for each resident.

As in the other districts the general condition and maintenance of the infrastructure was not enough, namely the network of water pumps that needed maintenance, as well as the roads and bridges network, with some been impassable, especially in the rainy season.

In the last decade the Zambezia Provincial Directorate for the Coordination of Environmental Affairs (DPCA) has issued at least 11 licenses for the following infrastructures in Pebane: 2 concerning tourist activities (1 for accommodation and 1 for fishing tourism), 2 fish processing factories, 1 aquaculture activity, 1 fuel station, three mining projects and two other project that was not possible to identify the core activity. From the 11 projects, 1 environmental license issued was Type A, 5 were type B and 5 Type C (Annex 4).

With regards to planned infrastructures for short/medium term, considering the eventual tourism development, the following investments may occur: road improvement and maintenance; traffic management plan; flood control through drainage; electricity improvement and expansion; improvement of waste disposal and Pemba airport upgrade (MITUR, 2014b). Since the discovery of large mineral reserves in PSEPA area as well as the new Oil&Gas research and exploitation block (5A) it is also expected the implementation of new supporting infrastructures, namely the Angoche maritime port. In summary, the potential future infrastructure concerns mainly tourism, oil & gas and mining activities. Impacts from oil & gas infrastructures, mining and tourism will be presented in Subchapters 4.7 and 4.8 and **Erro! A origem da referência não foi encontrada.**, respectively.

4.5. Dam construction

There is no indication of a potential dam construction inside the PSEPA Archipelago (AquaGlobal, 2014).

4.6. Charcoal & firewood use

According to a socio economic study carried out by Nhancale & Mbeve (2008), the majority of households (93.8%) in the PSEPA region use firewood as their main cooking energy source. Table 4.3 shows the remaining sources of cooking fuel.

Table 4.3. Cooking energy use by households at the PSEPA (adapted from AquaGlobal, 2014)

Cooking fuel source	Percentage of households
Firewood	93.8%
Charcoal	2.7%
Coal (mineral)	0.6%
Kerosene	0.6%

It is the female members of the households, which are primarily responsible for the collection of firewood from forest areas. In some households however it can be the children or men (Nhancale & Mbeve, 2008). Table 4.4 shows the time spent for the collection of firewood.

Table 4.4. Time spent for the collection of firewood at households within the PSEPA (adapted from AquaGlobal, 2014).

Time spent	Percentage of households
Less than ½ hour	27.9%
½ to 1 hour	26.2%
More than 1 hour	22.1%
More than 2 hours	23.5%

It is reported that the slash and burn shift agriculture patterns are leading to the clearance of forests in the region. This in turn reduces the source for firewood in the PSEPA. It has also been reported that deforestation forces households to rely on mangroves as a source of fuel-wood and building material. This may have a devastating effect on the marine environment, as mangroves are habitat to prawn populations and fish larva. A decline in Marine resources may increase the dependence on agriculture, which in turn might increase the pressures on forests and reduction of fuel wood sources (WWF brief, 2012).

4.7. Oil & gas extraction within PSEPA

Presently there is no oil & gas concession for research or exploration in the study area. However, the National Petroleum Institute launched in October 2014 the 5th international contest for 15 concessions areas for research and production of oil and gas, namely two offshore blocks in Angoche (A5-A and A5-B), one of which partially overlaps PSEPA. The contest was then postponed twice since that, and the bid submission deadline for Mozambique's fifth oil and gas licensing round was lately set to close on 30 July 2015. No further information is available at the moment, but it is expected that this activity will be an additional conservation challenge in PSEPA.

Oil & gas exploration projects are regulated by legislation (Decree 56/2010) and require environmental permits, since exploration methods can be invasive and damage sensitive ecosystems and threatened species. Considering oil & gas offshore projects the following major impacts may occur in PSEPA and/or its surroundings: the drilling of the offshore production wells may pose potential impacts to water quality and marine ecology. The deep-water reef structures and associated organisms may be at risk of enduring acute effects as the recovery of reef structures usually takes time due to the low growth rates of these organisms. Effects of vessel collisions or disturbance on whales may also be problematic due to their conservational importance. Changes in the character of the seabed are also likely to occur due to the addition of hard substrate (subsea infrastructure), which may result in changes to the benthic community structure (e.g. colonization by others organisms) (Abrahamson et al. 2013, EIA-Anadarko, 2014).

In the near-shore project area, where construction activities are focused, disruption of seagrass, coral reefs and/or mangrove are likely to occur. These features play critical roles in ecological interrelationships and directly and indirectly affect productivity and biodiversity due to the increased turbidity in the water column, the deposition of fine sediment on benthos and modifications on the seabed. The installation of near-shore infrastructure across the intertidal beaches and shallow subtidal zone will modify beach structure that may result in a loss of the productivity or allow the establishment of hard substrate communities. It may also facilitate colonisation by alien and potentially invasive species with potential negative effects on marine biodiversity. Impacts to fish, whales, dolphins and turtles from noise associated with pile driving may also occur, although the extent of the effects differs among groups. Discharged solid and liquid wastes from marine vessels during any phase of the project could also cause impacts related with the proliferation of litter and compromised water quality, harming marine organisms, seabirds and biodiversity in Palma Bay (Abrahamson et al. 2013, EIA-Anadarko, 2014).

It should be noted that the implementation of mitigation measures can help to reduce the significance of much of the identify impacts, and as such should be considered in all oil & gas projects, following the principles set out by IFC's Performance Standard 6 (IFC, 2012).

As stated before, a new bidding process for new oil & gas concessions is undergoing by the Mozambican Government so it is expected that the number of projects increase. Considering the cumulative effect of the impacts of the oil & gas industry and whole associated infrastructure, it is expected that the pressure on local ecosystems will increase significantly as well as the risk of hazards.

4.8. Mining

Mozambique has a large and diverse unexploited mineral resources potential, which has been manifested by a large number of exploration companies. Despite this, commercial mining has played a relatively minor role in the development of the country's economy. This situation is gradually changing mainly due to the production of aluminium and natural gas and development of world-class coal and heavy mineral sand deposits (Lehto & Goncalves, 2008; Callaghan et al., 2011).

Accordingly with the PSEPA Management Plan in the Primeiras e Segundas and surroundings there are currently about 59 actives or pending mining concessions. Most concessions are Licenses of Prospecting and Research, but the list includes seven mining concessions, i.e., that had already been approved before PSEPA declaration, particularly exploitation of heavy sands. The available information on the Mozambique Mining Cadastre Portal (http://portals.flexicadastre.com/mozambique/en/) may be less updated, as we identify only 38 mining activity (28 for research and exploration, 6 mining concession and 4 Mining certificate), with a total area of 410.299ha (317.446ha, 90.825ha and 1.535ha, respectively) (annex 5).

Kenmare Resources holds the two biggest mining explorations in PSEPA, exploring heavy sands in Moma, Nampula Province. Kenmare Mine contains reserves of heavy minerals including titanium minerals, ilmenite and rutile, used as feedstocks to produce titanium dioxide pigment, as well as the relatively high-value zirconium silicate mineral, zircon. Monazite, which is a phosphate mineral containing rare-earth elements (REEs) is also found at Kenmare's Moma mine. These reserves are estimated to be 869 meta-tons (Mt) at a grade of 0.021% Monazite. Most commonly, Monazite would be seen as a mineral, which may tend to cause environmental treats, however, it is a major ore of thorium, a rare earth element, which is certainly believed to be the major fuel source in the medium term. Thorium may replace uranium as a nuclear fuel and several countries including China and India are actively researching this technology. Despite this, the situation is not catastrophic at all as Kenmare Resources was engaged in a study on recovering monazite from mine tailings in 2011 (Costal & Environmental Service, 2000; CESML, 2012).

The specific risks of each project depend on mining technology and equipment used, type and quantity of minerals to be exploited, etc. The most obvious mining physical impacts are related with contamination. Air pollution from the mining industry is of increasing concern, producing pollutants such as dust, SO_2, lead, arsenic and other particles and gasses. When unregulated, such pollutants from upcoming large-scale mining projects could present respiratory risks to communities and decrease the tourism potential in certain parts of the country. Pollutants from industrial and artisanal mining can enter the waterways causing environmental damage to areas far from the mining sites and affect agricultural productivity. In addition, pollution from agriculture, industrial mining, and relatively unmonitored practices of artisanal mining, are sources of contamination to the country's pristine marine environments, as chemicals are emptied or washed into waterways leading to the sea. So, mining can affect air quality, water quality (surface water, underground water and rainwater) and, directly or indirectly, sensitive ecosystems and species. Deforestation is also a significant impact linked with mining activities that also cause interference with nature conservation, namely habitat fragmentation and fauna losses. There also impacts associated with soil productivity, noise, landscape quality, etc. (MITUR 2014a, Abrahamson et al., 2013; CESML, 2012).

The Conservation Law (no. 16/2014) Article no. 11.2 as well as international standards such as the International Finance Corporation (IFC) requires that within PSEPA all mining operations follow the principle of ´no net loss´ of biodiversity (IFC, 2012). Thus, mining companies should incorporate the cost of ecosystems rehabilitation and in cases where full rehabilitation is not possible, the company should offset the environmental damage (Abrahamson et al. 2013; IFC, 2012). Accordingly with IFC principles the PSEPA Management Plan (draft version) defined the general EIA guidelines for mining projects in the Reserve. Within the PSEPA, the Integral Natural Reserves defined are considered areas that cannot be disturbed. Mining or oil exploration in those areas are strictly prohibited, and can never be compensated or balanced. All concessions with Prospecting License and Research should act in accordance with the management plan for the issuance of concession or mining certificate. In those cases where the issue of mining concession is prior to PSEPA declaration, the activity could continue within legally stipulated limits in the environmental license, with the exception of the ones located in the proposed Integral Nature Reserve, where there cannot exist mining activities from the date of adoption of the proposed Management Plan (MITUR, 2014a).

4.9. Mangrove & non-mangrove timber logging

There is evidence of widespread illegal logging activities and timber exports. Deforestation is generally considered one of the key threats to marine ecosystems, particularly coral reefs through increased sedimentation. If logging in northern Mozambique remains uncontrolled, the impacts on marine ecosystems are likely to be significant (MITUR, 2014a).

Mangroves are depleted due to unsustainable harvesting of trees, particularly around the main cities, where mangrove trees are harvested for fuel wood, and for production of timber for building. Wood is the cheapest and most readily available source of energy, both for cooking and heating, for majority of people who cannot afford electricity. The second most important cause is the clearing of mangrove for the construction of saltpans, roads, urban and other developments (Cremass, 2014).

In a recent study, CREMASS (2014) observed signals of mangrove cutting in Angoche (18%) and Moma (16%) (with higher incidence for the Angoche district) where many communities living in the famous islands of Kotis without much construction to material alternative so as fuelwood rely on mangroves. Cutting signs observed in most cases in the two districts follow a certain profile: Communities living in the surrounding mangrove forests Zone surrounding communities, cut mangroves with no selective orientation due to increased pressure search of fuelwood and preferred stakes stakes for construction. On the other hand, it is possible to note the existence of huge shipyards mangrove stakes for sale, as well as firewood bundles already prepared for sale used as the main source of fuelwood communities.

However, it was not possible to have information of non-mangrove logging occurring in the Primeiras and Segundas Islands due to lack of data.

4.10. Increased investment in fisheries processing & landing sites

By the time this report was prepared it was not possible to establish contacts with the Provincial Directorates for Fisheries of Zambezia and Nampula. Therefore we assume that information on this issue is lacking for the three analysed Districts.

4.11. Aquaculture development

The situation is exactly the same as for the previous topic.

4.12. Coastal tourism

Mozambique is a very young and emerging touristic destination and is at the early stages of development (MITUR, 2014b). The PSEPA is located in two touristic regions, the North (the Nampula's districts of Moma and Angoche) and Centre (the Zambezia's district of Pebane). The Central region is characterized by limited accommodations with high prices and the North is seen as a relatively unspoilt "tourism jewl", with Nampula presenting a number of registered beds above the national average (MITUR, 2004). MITUR has launched various significant tourism investment programmes over the past eight years, mainly to unlock the ZITs. These include among others initiatives, the Project "Arco Norte" launched in January 2006, with technical assistance and funding from the United States Agency for International Development (USAID). This project is focused on natural resource conservation, historic preservation and attracting tourism-related investments into the northern provinces of Cabo Delgado, Nampula and Niassa – the Arco Norte (MITUR, 2014b).

The followings charts (Figure 4.1 and Figure 4.2) show the trends in tourism numbers in Nampula Province over the past 14 years (from 2000 till 2014), namely: the total overnight stays in each year and the number of approved touristic accommodations, respectively (data ceded by Provincial Delegation for the Tourism of Nampula - MITUR). To date, no touristic information was obtained for Zambezia province.

Figure 4.1 – Trends in the number of accommodation resorts and beds in the last 10 years, in Nampula Province

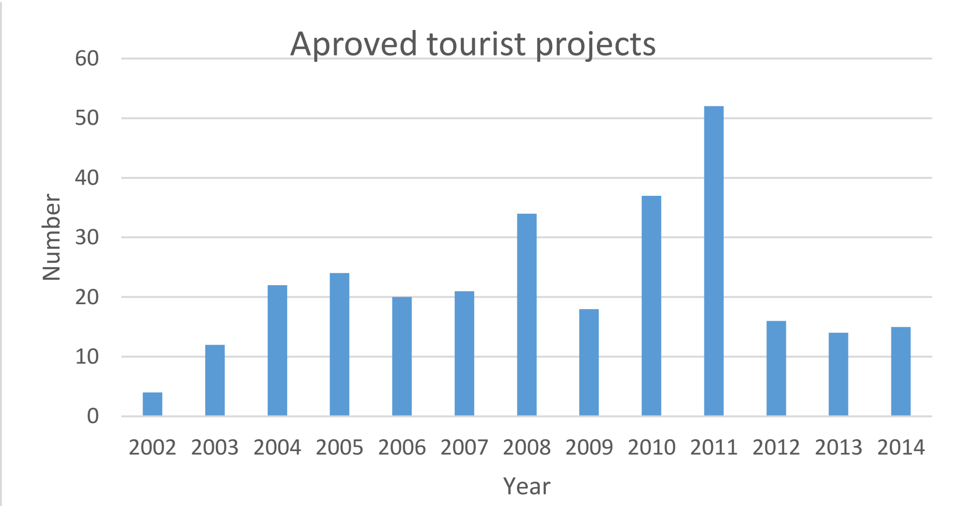


Figure 4.2 – Trends in the number of number of approved touristic accommodations in Nampula Province

Concerning overnight stays, Nampula province showed a slight increased from 2000 till 2004 (from about 14.000 overnight stays to 48.000), followed by a break in 2005 (with 21.000 overnight stays), which was followed by a steady increase. Initially very slight, and that started to become more evident between 2008 and 2012, peaking at around 160,000 in that year. The following two years presented a slight fall, remaining however above the 100,000 nights/year (148.500 and 113.000, in 2013 and 1014, respectively). In the last considered 3 years (between 2012 and 2014) it is also worth noting the increase of foreign stays that remain stable in that period. This tendency was also noted in Nampula airport, mainly related with business (mostly mining projects) (MITUR 2014b).

Regarding the approved touristic projects, since 2002 new projects were approved every year, with peak numbers in 2011 (52 projects), 2010 (37 projects) and 2008 (34 project). Between 2002 and 2014 were approved a total of 271 projects, however, we do not know if all were built.

The data provided by the Provincial Delegation for the Tourism of Nampula did not allowed to analyse touristic trends in PSEPA. However, accordingly with the Management Plan for the PSEPA, tourism is currently very underdeveloped, due to isolation of the area and its hard access, climate conditions (high winds) and the lack of attractions for the non-specialist tourist. Therefore touristic potential is mainly related with adventure, fishing sport, whale watching, bird-watching, diving and snorkeling. Some cultural and historical attractions also exist, namely at the Praia Nova area in Angoche, that has a number of houses that could be rehabilitated for tourism purposes. The reserve also has unused lighthouses (Sangage, Ponto Caldeira) in spectacular locations that can be rehabilitated for the same purpose. However, the islands present some difficulties in terms of distances, water supply, energy, etc. and together with the violence of the sea in the afternoons represents considerable impediment to tourism developments. Actually, revenues from tourism activities are minimal and are likely to remain so for the next decade (MITUR 2014a).

It is also known that tourist development may pose some threats to the integrity of natural areas, as it cannot happen without bringing changes to the natural environment. It is of particular concern in the PSEPA as there are no sanitation infrastructure or solid/liquid waste management, and as it is a coastal zone groundwater is very close to the surface in most of the area, and can easily be contaminated by waste (MITUR 2014b). It can also support conservation, as tourist developments depend on natural and sensitive ecosystems (such as coral reefs, sandy beaches, mangroves) in order to offer a unique and pristine product. Therefore, eco-tourism may encourage investments and development of infrastructure that allow tourists to access to conservation areas, which may allow an economic revenue that should be used to manage tourism impacts and promote conservation measures (MITUR, 2004, 2014b).

5. Trends and projections in climate and related physical environment parameters

5.1. Surface air temperature (including extreme high temperature events)

30 year trends & 30 year projections for air temperature patterns

Nampula's climate is rainy and hot season from October/November to April/May and a dry from June to September.

Records of atmospheric temperatures from 1993 to 2013 observed at Angoche meteorological station show an average annual temperature of 25.3 ˚C (SD = 1.6 ˚C). There was an increase of the average temperature for the hot and the cold seasons, of 0.13 and 0.16 ˚C per year for DJF and JJA, respectively (Figure 5.1). The INGC (2009b) analysed annual averages maximum temperatures on a temporal series from 1960 to 2005 for the North region of Mozambique and detected an increase of approximately 1.1 ˚C for the MAM and SON months. INGC (2009a) also indicates that the annual average maximum temperature was frequently bellow 30°C before 1990 but afterwards, higher temperatures became common.

The seven General Circulation Models (GCM) projections for approximately 2046-2065 shows a decrease in seasonal variability of maximum temperatures during SON and an increase in seasonal variability of minimum temperatures during the MAM and JJA months (INGC, 2009a).

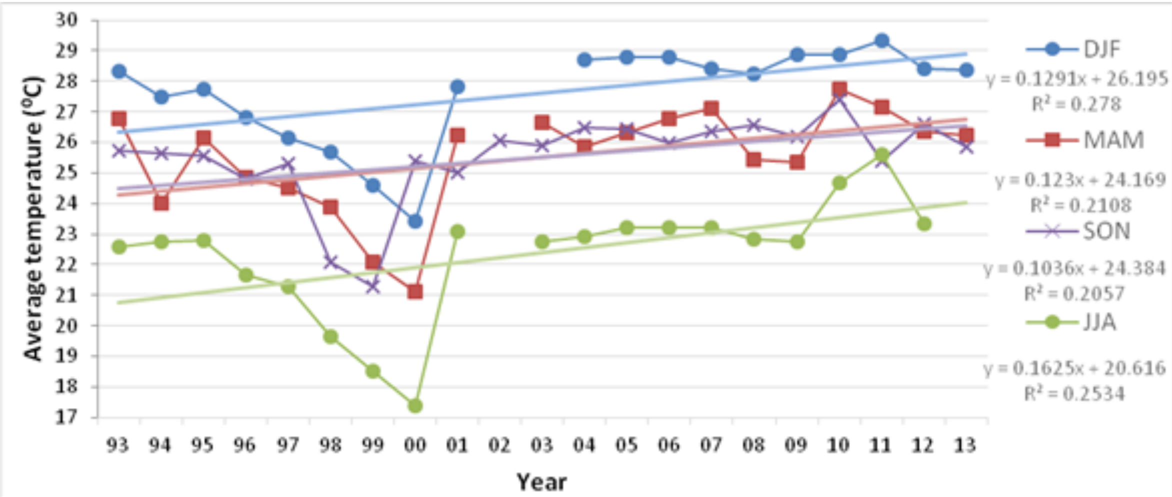


Figure 5.1 – Average daily temperatures for the hottest months – DJF (blue) and for coldest months – JJA (green), and intermediate months – MAM (red) and SON (purple), observed at the Meteorological Station of Angoche (16.23° S; 39.903° E and 61 meters above sea level and 0.1 km from sea.).

Frequency of extreme high temperature events

The increase in average annual maximum temperatures from 1960 to 2005 was also a result of longer period of extreme hot days, representing approximately an increase of 25% of the number of hot nights during the months DJF and 17% for SON on the North region of Mozambique (INGC, 2009a).

Existing research on impacts of extreme high temperature events on agriculture, livestock, human health, wildlife, turtle hatching

No data is readily available on the impacts of extreme high temperature on agriculture, livestock, human health or wildlife in Mozambique, or the PSEPA. Literature from abroad was consulted and relevant examples are presented here. As pointed out by Adams (1997), much of the literature on extreme heat impacts combines heat and drought into one climatological event and it is often unclear if the effects are from a short duration heat wave or a longer-term drought. In the area of health impacts, the focus has been on the temperature as a causal agent of health impacts. Several studies have reported that extreme high temperatures were associated with increased mortality (especially in large cities), after a short lag period, when temperatures exceeded obvious threshold levels (e.g. Adams, 1997; WHO, 2013; Gao et al., 2015). Those at greatest risk of death in heat waves are the urban-dwelling elderly without access to an air-conditioned environment for at least part of the day. Thus the issues of prevention and mitigation combine issues of the aging and of public health (Adams, 1997).

Extreme heat has severe impacts on agriculture and livestock, including rabbits, poultry, and cattle especially with regards to milk production and reproduction (Adams, 1997). Crops yields are also affected. This poses a high risk for food-security for the PSEPA communities.

Wildlife is also affected by heat waves and cases of widespread mortality have been reported for flying-foxes (a bat species) in Australia (Welbergen et al., 2008). Reproduction and fitness of marine animals such as marine turtles will certainly be affected as the viability and development of the embryos is very temperature sensitive (e.g. Godley et al., 2001; Wood et al., 2014).

5.2. Rainfall trends & variability (including drought and extreme high rainfall events)

30 year trends & 30 year projections for rainfall temperature patterns

The average annual precipitation in Angoche from 1991 to 2013 (excluding years with gaps) was 1110.9 mm (SD = 377.9 mm) with an average of 163.8 mm (SD = 49.5 mm) per month from December to April, to 24.1 mm (SD = 17.7 mm) per month from June to October. Precipitation variation doesn't show a clear pattern (Figure 5.2a), and the total precipitation differences between the years may be due to inter-annual variability. Figure 5.2b suggests a reduction of precipitation in December and an increase of the peak in February/March (amounts may exceed 6 mm/day; INGC, 2009a), showing a delay of the wet season. INGC (2009a) and Tadross et al. (2009) also report the delay of the wet season, as well as an increase of total number of dry days and extension of the dry season from September to November.

Almost all the 7 general circulation model (GCM) projections for approximately 2046-2065 indicate that November will become drier in the North of Mozambique, while for December there is fewer consensuses. From January to March, most of the models give indications for an increase in average monthly precipitation (KNMI, 2007), although there is no clear evidence for changes in wet extremes. This is probably because the models do not simulate the south-west Indian Ocean tropical cyclones, which are one of the major sources of torrential rainfall in southern Africa.

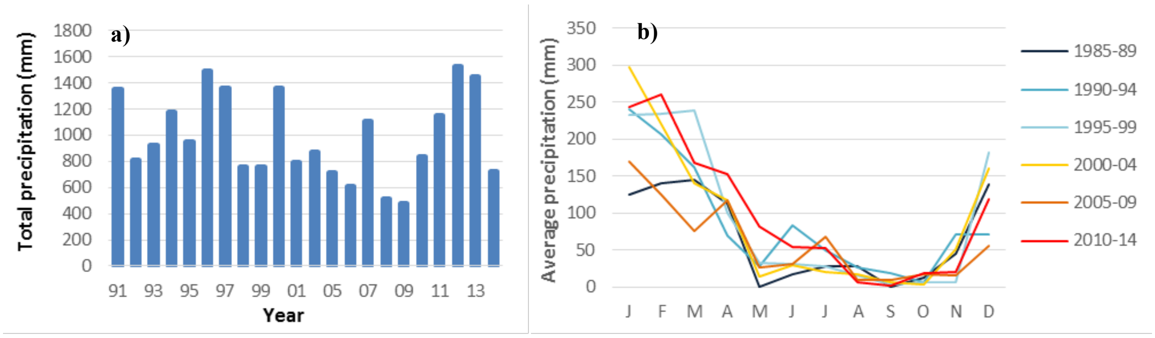


Figure 5.2 – a) Total rainfall observed at the Meteorological Station of Angoche from 1985 to 2014 Note that absent years were excluded due to data gaps. b) Intra-annual variation between annual series.

Frequency of drought and extreme high rainfall events

North of Mozambique is the region in the country with less tropical cyclones events (approximately 25%; INGC, 2009a). In recent years, from 2008 to 2014, two tropical cyclones events were reported in Nampula, against eight that occurred from 1956 to 2007 (See Figure 5.2.2.1). According to data shown in Figure 5.2.2.1 moderate droughts were common in Nampula costal districts, but the resident communities did not identified them as an extreme event (Østergaard, 2008). In recent years, reports of floods events have increased and were associated with tropical cyclones (Tadross & Johnston, 2012; Hellmuth et al., 2007). Floods in Nampula are also associated with cyclones that hit Zambezia province, as for example Fifteen/Guito and Chedza cyclones that occurred in 2014 and 2015, respectively (Figure 5.3).

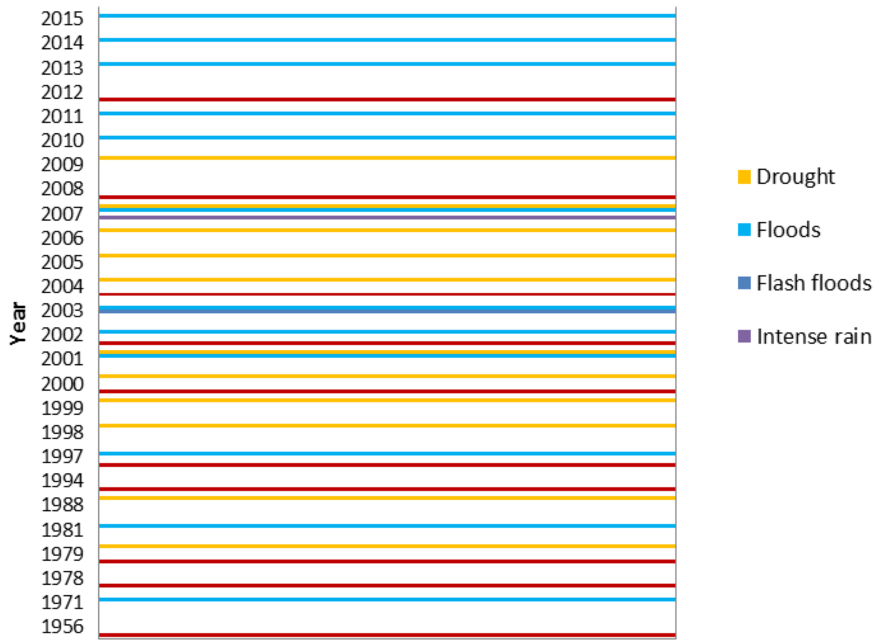


Figure 5.3 – Extreme events in Nampula from 1956 to early 2015 (Source Guha-Sapir et al., 2015 and; DesInventar, 2011).

Historic river flow data

Until the time this report was done, no data was obtained regarding this subject.

Information on coastal livelihood resilience and coping strategies in response to rainfall extremes (drought & flooding)

Cyclones and flooding in PSEPA are known to occur in February and March when farmers are carrying out their second harvest. This period has been entitled "the hungry period" in a study by Bossel in 2010. As stated before, the resilience of local communities to these events is low and although many acknowledge the risk, adapting to these events has been identified as difficult (Østergaard, 2008). The low resilience of these communities is often associated with high dependency in two main sectors for subsistence and income-generating activities (ibid):

- Coastal resources associated with declining fish populations and unsustainable fishing techniques such as the use of mosquito nets;
- Farming in areas characterized by low soil productivity, poor techniques and poor quality of seeds and low crop diversification. Cassava is one of the main crops utilized during flood and drought events; however it is affected by brown streak disease.

In the study climate vulnerability in Primeiras and Segundas, Østergaard (2008) has identified a number of coping strategies currently being employed by community members (both seafront and riverside) to deal with hazards:

- Collecting of shells and crabs mainly done by women and children;
- Cutting of mangroves and selling sand for reconstruction of houses post extreme events;
- Selling of handcrafts such as hats and mats from straw;
- Reduce food consumption to cassava and maize;
- Intensify agricultural production;
- Production and selling of charcoal and fuelwood;
- Selling of goods such as fuel, oil and sugar mainly done by wealthier community members.

Information on the effect of rainfall variability on nearshore fish and fisheries

Hoguane et al. (2012) analysed the effect of the freshwater input into the coastal zones through rainfall from 1995 to 2008 on the landing of artisanal catches 1998-2008 in northern Mozambique. The results showed that the total artisanal annual catch was significantly correlated to the coastal rainfall lagged two years. The two-year lag matched the longevity of three fish families (Engraulididae, Clupeidae and Leiognathidae), and the maturity age of Carangidea, the top four dominant fish families in the catches. The results emphasise the role of freshwater in the productivity of coastal waters and in the survival and growth rate of the fish population during the earlier stage of their life cycle.

Impacts of rainfall (run off) variabilities and coral reefs, sea grasses

Coral reefs and seagrass beds are able to cope with increased rainfall to a certain extent. Heavy floods usually result in massive amounts of nutrients, reduced salinity, light penetration and sedimentation. This results in physiological stress, bleaching and ultimately coral death (Hoegh-Guldberg, 1999). Although in the south of Mozambique, a study conducted at Xai-Xai after the 2000 floods, showed almost 60% mortality of corals due to the reduced salinity, light penetration and smothering of corals (Pereira & Gonçalves, 2004).

Impact of rainfall variability on patterns of sediment deposition and/or erosion, especially around river outlets

Coastal habitats and ecosystems in the PSEPA are heavily dependent on the input of nutrients and sediments. Estuaries, bays, mangroves and seagrass beds depend on these for their normal functioning. Rainfall variability will have consequences on sediment dynamics and probably exacerbate coastal erosion and the productivity of these ecosystems and habitats. According to the INGC (2009a) assessment, an increase of between 10-25% of precipitation is expected within the next 50 years with higher variability.

Impacts of increased incidence of flooding/drought on mangroves

Increased floods or drought would have deleterious effects on mangroves due to their counter-effects over salinity. The influx of fresh water from flooding would reduce salinity to very low levels and droughts would cause the contrary effect. This causes physiological stress, which impairs growth and reproduction and can ultimately cause a reduction of the mangrove area as reported for the Zambezi Delta (Davies et al., 2000), which is located within proximity of the PSEPA and most likely has had an impact on the mangroves of the area.

5.3. Sea temperature

20 year trends & 30 year projections for sea surface temperature patterns

Data on SST are not readily available in Mozambique. However, McClanahan et al. (2007), reported for "northern Mozambique", a SST rise of ca. 0.010° C/year over 50 years (1957-2007). This contrasts with the global average, which as increased by 0.5°C since 1961 (IPCC, 2007). According to the IPCC (2007), tropical oceans are projected to experience the greatest increases. Recent models predicted that globally averaged SSTs will increase by 0.3°C–0.6°C over the near term relative to 1986-2005 (IPCC 2013).

Effects of increasing SST on finfish, invertebrate fisheries and aquaculture

An increase in SST is expected to have deleterious effects on both fish and invertebrate fisheries both directly and indirectly. Indirectly it will have dramatic effects on the habitats of these species (see below). The sensitivity of fish stocks to these changes will determine the range of potential impacts to life cycles, species distributions, community structure, productivity, connectivity, organism performance, recruitment dynamics, prevalence of invasive species, and access to marine resources by fishers (Jonhson & Welch, 2009; Bell et al., 2011).

Effects of increasing SST on coral reef status

Sea surface temperature has dramatic effect on corals by causing physiologic stress, bleaching and ultimately death. This was demonstrated during the El Niño Southern Oscillation (ENSO) event of 1998, which caused 20% mortality in certain reefs in the PSEPA (Mafamede, Baixo Santo António; Schleyer et al., 1999). The ecological, social and economic consequences have been widely documented within the Western Indian Ocean region (e.g. Wilkinson et al., 1999; Westmacott et al., 2000; Obura, 2005; McClanahan et al., 2007; Ateweberhan & McClanahan, 2010). With the predicted increase in SST, it is expected that coral reefs will suffer, further degradation, shift in distribution and composition, loss of biodiversity, productivity and ecological function.

5.4. Sea level change

25 year trends & 30 year projections for sea levels

Global average sea level has risen since 1962 at an average rate of 1.8 mm/year and since 1993 at an average rate of 3.1 mm/year (IPCC, 2007). More recent estimates show that, globally mean seal level has risen at an average rate of between 1.4 to 2.0 mm/year over the 20th Century and between 2.7 and 3.7 mm/year since 1993 (IPCC, 2013).

A projected rise of 0.18 to 0.59 m above the 1980-1999 baseline by 2100, with a possible rise up to 1.4 m was reported by IPCC (2007). Under all model scenarios, the rate of sea level rise will very likely exceed that observed during the 191-2010 due to increased ocean warming and increased loss of mass from the glaciers and ice sheets. However, sea level rise will not be uniform.

Despite the global trend, a study by Sete et al. (2002) looking at data from the tidal station network of Mozambique, including Angoche, Moma and Pebane, concluded that “No clear evidence has been found with regard to the variation of the mean sea levels particularly as an impact of global climate changes”. A report by the INGC (2009b), suggested that only small areas in northern Mozambique are at risk, specifically the low-lying islands close to the border with Tanzania. However, it was acknowledged that long time series of mean sea levels have been lacking and a permanent sea level monitoring is required.

Impact of sea level rise on mangroves

Sea level rise is arguably the most important threat to mangrove ecosystems (Gillman et al., 2008; Ellison, 2015), mainly through sediment erosion, inundation stress and increased salinity at landward zones. These problems will be exacerbated for mangrove stands that are subjected to ‘coastal squeeze’, i.e. where landward migration is restricted by topography or human developments. The PSEPA area at risk with the growing human population adding pressure into the mangroves and its resources as well as the fact that large mangrove areas are located close to human settlements.

Several impacts on mangroves are expected from sea level rise: decline of species diversity, change in species composition and distribution. This will result on loss of biodiversity, productivity, as well as coastal protection (Ellison, 2015).

Impact of sea level on availability of ground water

The INGC (2009a) suggests that the northern region of the country (and coastal cities such as Angoche and Pebane with high density areas such as Ingúri) is susceptible to sea level rise. In the worst-case scenario of a high increase it is estimated that the coastline may recess as far as 500 m. This would be catastrophic and the great majority coastal communities would be left without potable water due to the increases salinity of ground water.

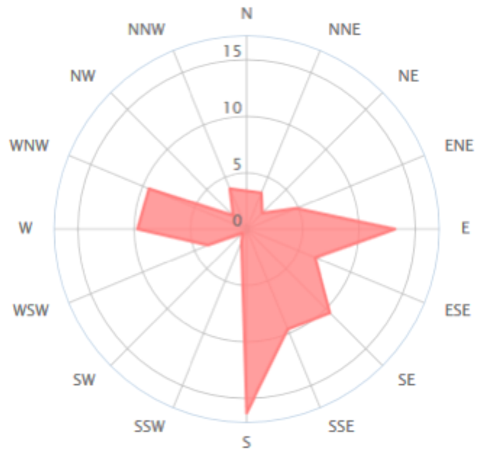
Impact of sea level rise on beach or coastline profiles (impacts on tourism, coastal settlements, turtle nesting sites)

Sea level rise will certainly have deleterious effects on tourism infrastructures as well as other coastal settlements, which are located very close to the shoreline. The low-lying islands and coastal zone are potentially at risk (INGC, 2009a). Turtle nesting sites (mainly on selected islands such as Puga-Puga and Mafamede) are at risk.

5.5. Changes in wind patterns & frequency of storm events (cyclones)

Trends in wind patterns over the past 25-30 years

Long term wind data was not readily available for the area. However, the prevailing winds blow from the south and southeast, with an annual mean of 5 knots (Figure 5.4).



	J	F	M	A	M	J	J	A	S	O	N	D	Annual mean
Wind probability >= 4 Beaufort (%)	0	1	2	3	1	1	0	9	9	9	3	1	3
Average Wind speed (kts)	4	5	5	5	5	5	5	6	6	7	6	6	5

Figure 5.4 – Wind patterns at the Primeiras and Segundas Environemtal Protection Area. Based on observations taken between 2010-2015 daily from 7am to 7pm local time (Source: windfinder.com).

Physical damage from increased storms frequency (tourism, coastal settlements, turtle nesting sites, aquaculture ponds)

Although the PSEPA is not prone to high cyclone and storm activity (INAM, 2009a), an increase in storm frequency and intensity will certainly have deleterious effects on tourism infrastructures as well as other coastal settlements, which are located very close to the shoreline (Angoche is particularly vulnerable). Increased winds and surge can potentially cause erosion and risk turtle nesting sites at low lying islands such as Mafamede and Puga-Puga.

Impact of changes in wind patterns on fishing activities

The great majority of artisanal fishers in Mozambique and within the PSEPA use non-motorized traditional vessels and rely on manpower or sailing to travel to and from the fishing grounds. These are consequently very dependent on wind and current patterns. Fishing and sailing has a long tradition in the area and the well-established weather patterns of the region are well known by the local communities. It is expected that changes in the wind patterns (direction and strength) will strongly affect the local fishing communities. It will also have serious effects on the socio-economy of the region in general as trade and long distance travelling along the coast relies heavily on large dhows.

Impact of storms on mangroves

Mangroves reduce coastal damage from storms by reducing wind, height and power of waves, and by reducing coastal flooding during tropical cyclones (McIvor et al., 2012a,b). However, the reverse is fewer documents and understanding, ie. the impact of storms on mangroves. Smith et al. (2009) reported damages via wind damage, storm surges and sediment deposition. Immediate effects included changes to stem size-frequency distributions and to species relative abundance and density. Despite the frequency and severity of tropical storms and cyclones, virtually no study has been published on the effects of these extreme events on mangroves.

5.6. Ocean acidification

Trends in ocean acidification

No research or monitoring on ocean acidification has been conducted in Mozambique. Globally, oceanic pH is estimated to have decreased 0.1 units since pre-industrial times (IPCC, 2013). There is very high confidence that oceanic uptake of anthropogenic CO_2 results in gradual acidification of seawater and decreasing pH in surface waters. The observed trends range between -0.0015 and 0.0024 units per year (IPCC, 2013). It was predicted that pH would fall 0.14 to 0.35 units by 2100 (IPCC, 2007).

Impact of acidification on coral reef communities

Corals are extremely sensitive to ocean acidification (Hoegh-Guldberg et al., 2007; Veron et al., 2009; Veron, 2011). The reduced pH lowers the solubility product of aragonite-calcium carbonate in sea water, which impairs reef-building by corals through inhibition of their skeletal deposition. As corals derive calcium directly from seawater, they are vulnerable to changes in the surrounding aquatic carbonate chemistry (Silvermann et al., 2007). Left unchecked, this process would ultimately dissolve existing coral reefs, by decreased growth rates and skeletal strength (Veron et al., 2009). Globally coral reefs are thus undergoing increasing physiological stress from ocean warming and acidification, both of which are gradually reducing their habitat. Veron (2011) concluded in his review that most impacts of ocean acidification on coral reefs will be synergistic and that the primary outcome will be a progressive reduction of species diversity correlated with habitat loss and widespread extinctions.

Impact of acidification on fish & calcareous invertebrates

Acidification has been shown to be deleterious to both fish and calcareous invertebrates throughout several phases of the life cycle with direct effect on the cellular physiology, which then affects the organisms' biology and ultimately population and ecosystem processes with socio-economic repercursions (Le Quesne & Pinnegar, 2012; Hilmi et al., 2015). It has been shown that acidification has negative impacts on fish egg and larvae survival and development (e.g. Kikkawa et al., 2004; Bignami, 2013), it decreases calcification of calcareous animals (e.g. Andersson et al., 2011; Riebesell & Tortell, 2011). This suggests that highly calcium-carbonate-dependent ecosystems, such as coral reefs and oyster and mussel beds - could be particularly vulnerable. Physiological effects on these calcified organisms can result in decreases in their abundance and shifts in the composition of communities and ecosystems (Hilmi et al., 2015).

The socioeconomic impacts of ocean acidification arise through direct effects on species, and through indirect effects on food or habitat resources, which in turn alter the availability or quality of species or natural resources of interest. Negative direct impacts on small-scale fisheries and mollusc mariculture can be anticipated based on scenarios of decreasing pH by 0.5 (Sumaila et al., 2015). The ecological and socio-economic consequences for the PSEPA would thus be devastating, giving the dependency of the local communities on marine resources such as intertidal invertebrates and coral reefs.

Studies (e.g. Lam et al., 2014), have shown that the impacts of ocean acidification on the different species taxa are likely to vary substantially so there is still much research to be done in this field.

Impact of pH on macro algae

Koch et al. (2013) review the impacts of climate change and ocean acidification (OA) on seagrasses and macroalgae. Examining more than 100 species, they showed that the majority (≥ 85%) of them have C3 photosynthesis and that photosynthetic and growth rates of marine macro-autotrophs are likely to increase under elevated CO_2 similarly to terrestrial C3 species.

Fundamental linkages between elevated CO_2 and temperature on photorespiration, enzyme systems, carbohydrate production, and calcification dictate the need to consider these two parameters simultaneously. Relevant to calcifiers, elevated CO_2 lowers net calcification and this effect is amplified by high temperature. Calcareous macroalgae are highly vulnerable to OA, and it is likely that fleshy macroalgae will dominate in a higher CO_2 ocean (Koch et al., 2013). However, recent work by Cornwall (2013), showed that OA could be ameliorated at slow flows for calcareous organisms that are capable of photosynthesizing, where the pH micro-environment is altered favouring higher calcification rates during the day. However, recent work by Cornwall (2013), showed that macroalgae are capable of acting as ecosystem engineers, altering both their chemical and physical environment. Also, their ability to alter their physical micro-environment has flow on effects for their chemical micro-environment. This alteration of their micro-environment has implications for both coralline macroalgae, and potentially other species that live within macroalgal beds.

6. Vulnerability and resilience of ecosystems, species, livelihoods and infrastructure to climate variability and change

6.1. Fisheries and aquaculture-based livelihoods

According to Wilkinson & Buddemeier (1994), Maueua (2007), Nicholls et al. (2007) and USAID (2013) several direct impacts on fisheries and aquaculture sectors in coastal zones are expected to happen due to the climate-related changes:

- Temperature sector rise (air and seawater)
- Changes in precipitation (reduce water flow to estuaries, increase salinity and runnof – sedimentation and pollution)
- Extreme events (storms, waves)
- Floods (sea level, runoff)
- Rising water tables (sea level)
- Erosion (sea level, storms, waves)
- Salt water intrusion (sea level, runoff)
- Biological effects (all climate drivers)

Dramatic impacts on fish production are expected, which can affect the protein supply and fish oils derived for local people (Mauea, 2007). The expected consequences of some of these impacts on fisheries are described below.

Temperature rise (Maueua, 2007; Bell et al. 2011):

Changes in water temperature have a major influence on most tropical marine and coastal fish and invertebrates, as they are sensitive to variations in SST because temperature regulates metabolism and development, and limits activity and distribution. As sea surface temperature (SST) increases due to global warming, significant consequences are expected on the distribution and abundance of key fish and invertebrate species, as well as productivity and composition of coastal fisheries. Projected increases in SST within shallow coastal environments of up to 2.5–3°C by 2100 are expected to have limited direct effects on survival of adults for most fisheries species, but may still interfere with reproduction, recruitment and juvenile growth. Even temperature increases of 1–2°C can affect the reproductive performance of some reef fish and are likely to lead to shifts in the timing of spawning, and possibly falling egg production, in some populations. Where reproductive development and spawning synchrony are cued to temperature, seasonal changes in SST may lead to alterations in the timing of breeding.

Increases in ambient temperature, and corresponding increases in food demands, are also expected to affect the survival of offspring, especially during pelagic dispersive phases.

Productivity of coastal fisheries is also likely to be reduced as a result of the effects of higher SST on metabolic rates. Overall fisheries production is expected to decline with increasing SST, except in locations of local nutrient enrichment.

Increased intensity of disease outbreaks frequencies and may result in frequent algae bloom in the coastal zone.

Ocean acidification (Bell et al., 2011):

Ocean acidification is expected to compound the negative effects of increasing SST for fish and invertebrates. Impaired larval behavior caused by elevated CO_2 could also affect the replenishment of populations, increasing the risks of decline in the stocks that support coastal fisheries.

Habitat degradation and loss (Bell et al., 2011):

Reef-associated fish and invertebrates are likely to become less abundant following extensive degradation and loss of the coastal habitats on which they depend, especially coral reefs. The demersal fish commonly associated with coral reefs that are expected to be affected include emperors, snappers, groupers, surgeonfish, parrotfish and rabbitfish. There may also be some replacement of specialist reef-associated species with more generalist species (e.g. Mugilidae).

Extreme weather events (Maueua, 2007):

Any increase in the intensity and frequency of extreme weather events such as cyclones, floods and droughts will bring negative impacts on aquaculture production and result in significant destruction of infrastructure. The rising sea level is expected to bring negative effects on the walls and aquaculture tanks.

Sea level rise (Davis, 2011):

Sea level rise may also affect coastal ecosystems, such as mangroves and coral reefs, with consequences for fisheries and tourism.

Several impacts are already being experienced by the local coastal fishing communities based in Angoche, Nampula (Østergaard, 2008). Table 6.1 shows the most relevant ones as well as projections estimated by local and international authorities, including predicted direct and indirect consequences on fisheries and local livelihoods.

Table 6.1 – Potentially climate-related effects that have been assessed to Angoche's coastal fishing communities (Nampula) and projections for climate changes (Østergaard, 2008).

Potential climate-related effects	Projections for climate changes	Predicted direct and indirect consequences of climate change on fisheries and local livelihoods
Soil erosion caused by the cutting of mangroves and other vegetation, natural change, torrential rains, cyclones and strong wind	---	- Coral bleaching and mortality - Seagrass/seaweed die off - Changes in fishing distribution and production - Higher ocean acidity and rising sea-surface temperatures - Increased human induced pressure on the natural resources - Increased coastal erosion due to higher sea-level rise and as both cause and effect of mangroves and palm trees disappearing (human cutting, cyclones and soil erosion) - Mangroves are reduced with sea-level rise - Sea level rise raises extreme water levels with possible increases in storm intensity - Food security is threatened when relying on marine resources as
A change in the wind patterns: wind is more frequent, stronger, lasts longer, unpredictable and changes direction more frequently than before, worsening fishing conditions	---	
Hotter temperatures, which were locally perceived as a cause for poor fishing conditions and as a factor increasing human illnesses, for example through exposure to mosquitoes during hot nights, where people sleep outside to avoid the heat indoors	Mean annual temperature is projected to increase by 1.0 to 2.8°C by the 2060s, and 1.4 to 4.6°C by the 2090s (more rapid in the interior)	
More unpredictable rainfall pattern	Tending towards decreases in dry season rainfall, offset	

Potential climate-related effects	Projections for climate changes	Predicted direct and indirect consequences of climate change on fisheries and local livelihoods
	partially by increases in wet season rainfall. Models consistently project increases in the proportion of rainfall that falls in heavy events, 1-day or 5-day ranges in the annual average under the higher emissions scenarios, of up to 15% by the 2090s	livelihood source; the result is malnutrition and micro-nutrient deficiencies.
Extreme events: Cyclones are predicted to become more frequent and intense	An increase in intensity and frequency in extreme events, such as cyclones, floods and earthquakes, although this is still very uncertain in the projections; Cyclones appear to be the most likely, due to the area's exposed character; Increases in the frequency and intensity of droughts	
Sea level rise: not perceived locally	Sea level projected to rise between .13m-0.56 m by 2090	

Analysing the previous information, it can be seen that several of the global climate-related changes and impacts are already being experienced or are expected to occur in the study area. As explained earlier in this document, data relatively to fisheries for Nampula and Zambezia has significant gaps between 2000 and 2013 and methodological issues might have biased the data analysed in the previous sections. Therefore the considerations we can do are limited by these facts. The only information that seems relevant is that the main families caught by the four analysed fishing gear types in Nampula seem to be stable in terms of frequency of occurrence, whereas in Zambezia seem to be increasing. One other fact is that Beach seine is the fishing gear type that accounts for more captures in the three districts of the study area (62.8% in Angoche, 87.8% in Moma and 83.8% in Pebane. This seems to be relevant as the sea level rise might compromise the use of this fishing gear.

Further data collection and analysis is needed to establish a relation between the information that has been collected over the years and the climate-related changes and impacts.

6.2. Agriculture and livestock-based livelihoods

The inherently low fertility of the sandy soils found in the coastal areas, ambient high temperatures, and erratic rainfall all make it difficult for farmers to produce certain crops which are rainfall variability sensitive (such as maize). According to Østergaard (2008), the PSEPA area is most affected by cyclones and flooding. Logchem et al further attribute the frequency of these events to climate change. This region is considered a high-risk zone for such climate shocks as per Figure 4.1.

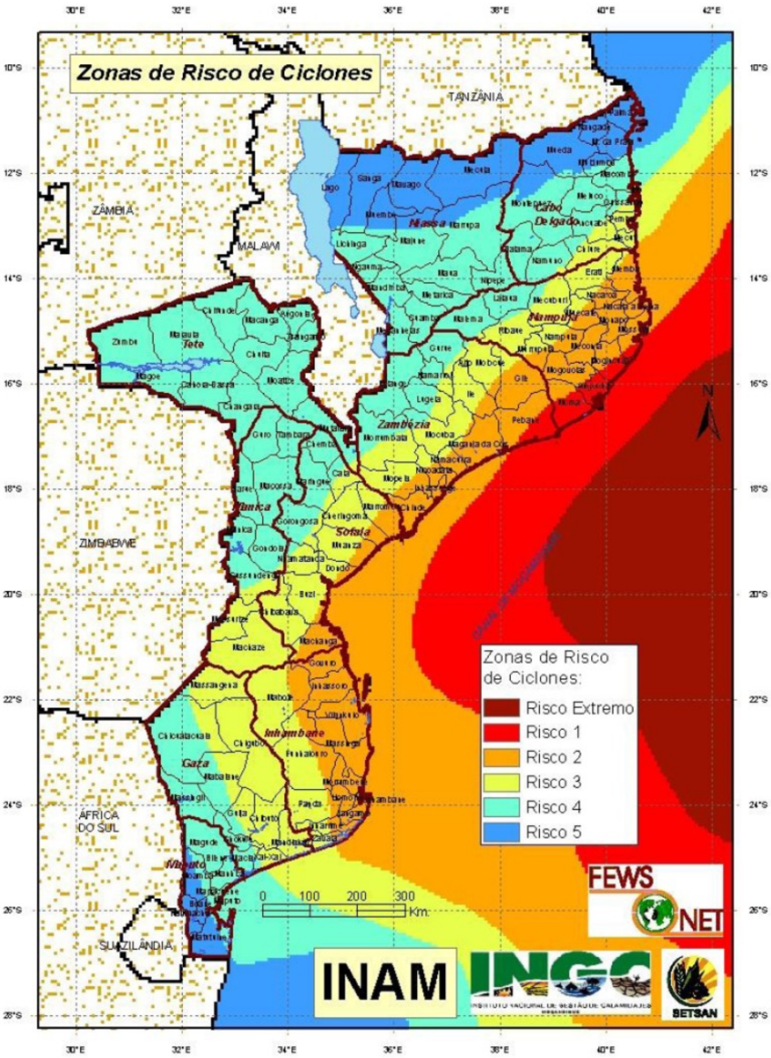


Figure 4.1. Cyclone risk areas in Mozambique.

According to the value chain assessment carried out by Bossel (2010), the cyclones and floods typically occurs at the end of what he calls "the hungry period" (months of February and March) when farmers are carrying out their second harvest. The resilience of the communities is low and the harvest is heavily impacted during times of heavy rain. Additional vulnerabilities include pests, plant disease and periods of drought.

A socio-economic survey carried out in 2008 shows that in total, 85% of households said that they suffered from an abnormal situation in the previous 6 months (Jan/Feb to Aug/08). The great majority of the households (70.4%) said that they suffered from the cyclone that occurred in February 2008. 12% of the households also said that they suffered from an increase in food prices.

Although few households identified agricultural pests as a shock, it is well known that the occurrence of pests in the coconuts, cashew-trees and cassava plants are constant in the areas. However, households may forget to identify these because of their cyclical and long-trend nature (co-Arq, 2008).

As a strategy to cope with climate variability, farmers have turned to the production of cassava as a source of food and income. Cassava is considerably resilient to rainfall variability and can be grown in poor soils. A threat to this crop is however the cassava brown streak virus. Surveys conducted in 2003 showed that the incidence of this disease has risen from zero in 2001 to 67% of plants examined in Angoche and 42% in Moma in 2003. This disease causes a dry rot of the tuber resulting greatly reduced tuber yield (WWF PSEPA brief, 2012; Co-Arq, 2008). Other diseases affecting agriculture include the lethal yellowing disease found in coconut trees and the *Oidio anacardii* fungus on cashew production. Data on the extent of the damaged caused by these could not be sourced. It is also not clear if climate change is responsible for occurrence of pests and diseases.

6.3. Shallow marine habitats (coral reefs and seagrasses)

Coral reefs within the PSEPA are usually located relatively far from the mainland (around the islands) and thus would be relative protected from flooding events. Seagrasses on the other hand are located much closer and would be potentially subjected to increased sedimentation and run off. Other important climate change stressors include SST rise as well as extreme events such as cyclones. In addition, both coral reefs and seagrass beds are under permanent anthropogenic stress, which is probably going to have deleterious effects on their natural recovery. Therefore there is a need to strengthen and consolidate the management and enforcement within the PSEPA in order to facilitate their natural recovery as it is highly unlikely in the near future, that active habitat restoration will be pursued by the park management due to the high costs involved.

6.4. Freshwater

The access to drinking water is a major challenge in the PSEPA, however so far no data was obtained from the ARA Centro/Norte. So the presented information was contained in the Environmental profile of Pebane, Angoche (both from 2015) and Moma (from 2013). Especially for the first two, the information may be quite out-dated.

In 2005, the Angoche District had 159 sources of water of which only 38 were operational. Most communities did not have access to an improved system of water supply. In some locations, populations walked about 5 kilometers distance until the source of the nearest water. At that time the Angoche district had a population density of 273.073 inhabitants and 11% had access to water in conventional houses and 10% in the suburbs (MAE, 2005a).

In the Pebane district, in 2005 the access to clean drinking water was not covered throughout the district and communities walked about 12 Km the nearest water supply source. The majority of the population was supplied by wells and water holes (86%) or relied directly on rivers and lakes (2%). The small fountains and water systems covered about 12% of housing in the district, most of which were located in the village (MAE, 2005b).

In 2013, in the Moma district, only 142,000 of the 329,000 inhabitants had access to drinking water. Of these, 33% had access to drinking water in conventional houses and 0.3% in basic traditional houses, and 6.7% of the inhabitants of conventional houses and 21.5% inhabitants of traditional houses got drinking water from fountains. In turn, only 3.2% of the populations who lived conventional homes and 4.8% inhabitants of basic house searched water in rivers, lakes and ponds. In general half of the population consumed inadequate water for human consumption. This situation also affected some public services. For example, due to lack of water in hospitals, particularly in maternity, people were forced to bring water to ensure personal hygiene of their relatives who were hospitalized (MAE, 2013)

No information was obtained regarding water quality.

6.5. Mangroves

Mangroves are sensitive to projected climate change. The primary impact likely to be rising sea level, affecting inundation period, productivity and sediment budgets to cause dieback from the seaward edge and migration landward, subject to topography, and human modifications. Climate warming is likely to have little negative impact, even increasing mangrove productivity and biodiversity at higher latitudes (McLeod & Salm, 2006)

Rainfall changes are of greater significance to mangroves, particularly reduced rainfall, with drier coastal areas showing lower tree stature and biodiversity relative to humid coastlines. Reduced rainfall may change sediment inputs and salinity to affect productivity. However, the effects of relative sea level rise are the primary climate change impact of concern, giving a range of severely detrimental effects on mangroves (Gilman et al., 2006).

Sedimentation in mangroves allows the mangrove substrate to keep-up with sea level rise, and so reduce impacts of increased inundation stress, as a natural adaptation process in mangrove systems. Different contributions to mangrove sediment accretion are organic detritus from the mangroves, mineral sediment from river discharge, and soil volume change/compaction (Alongi, 2008).

Mozambique is predicted to experience among the most direct consequences of global climate change, particularly low lying deltas in countries with low GDP limiting adaptive capacity. It is expected that many communities living around the Primeiras and Segundas Islands may experience floods every year due to sea level rise and Mozambique has been shown to have particular vulnerability to sea level rise (Østergaard, 2008; WWF, 2015). On these coastlines sedimentary sheltered areas are dominated by mangroves, which provide coastal accretion, stability and protection values, as well as a food resource for local communities. Direct human pressure has resulted in significant mangrove losses in the past few years, to which sea-level rise impacts will add further pressure (WWF, 2015; Bandeira et al., 2009).

The following measures to prevent mangrove forest of the Primeiras and Segundas Islands of climate changes should be noted:

- Identify adaptation measures to ensure that mangrove forests are not extinguished with sea level rising, extreme temperature, flooding and sedimentation;
- Establishment of sanctuaries to maintain the functions of mangroves and allow natural regeneration of forests
- Requalification and mapping of existing mangrove forests area on PSEPA, identifying areas of risk of forest loss.

6.6. High profile species

Within the PSEPA, apart from marine turtles, which are relatively resident to the feeding grounds, as well as very sensitive in terms of the nesting beaches and embryological development, the other high profile species (ie. marine mammals, whale shark) are relatively resilient to climate change at local level. Given their ability to migrate long distances and the fact that they spend their whole life cycle at sea, whales and dolphins as well as the whale shark can seek refuge and find other foraging grounds elsewhere in case of a major catastrophic event. The loss of nesting habitat as well as productive feeding areas can potentially be conduct marine turtles towards local extinction if current anthropogenic stressors are not dealt with.

This includes not only coastal and island development, the industrial and semi-industrial fishing industry, but also direct poaching of turtles as well as habitat degradation.

6.7. Infrastructure

There is no information found on literature sources regarding documented examples of infrastructure to climate change events in the PSEPA archipelago.

6.8. Human Health

As a result of climate changes several phenomena like the accelerating sea level and the increasing of flood peaks are expected in the north of Mozambique. The region will be more prone to severe cyclones placing several coastal areas and nearby islands at risk (INGC, 2009a).

In a public health perspective the frequency and intensity of extreme weather events, flooding or drought may also play an important role on population health (with population displacements outcome). Sea level rise is expected to exacerbate intrusion of saline water into the fresh groundwater aquifers in the coastal zone limiting the access to safe water (Matyas & Silva, unknown year).

Increasing temperature enhances soil evaporation, increasing soil salinization. This will cause the deterioration of crop quality and lower productivity with significant socioeconomic consequences and serious implications for food security (resulting in malnutrition and micro-nutrient deficiencies). Since in Mozambique communities coping strategies rely on women, inducing women over-burden is expected (Matyas & Silva, unknown year). Impairment of food quality with marine bacteria proliferation, shellfish poisoning and ciguatera will have particular impact on people living in coastal areas (Nicholls et al., 2007).

The scenario for the re-emerging and expanding of several diseases related with changing temperatures, rainfall patterns and environmental changes it is also cause of concern (Davis, 2011).

Warmer temperatures may prolong the seasonality and extend the range of transmission of vector-borne diseases such as malaria, dengue, chicungunya fever as well as favouring the expansion of the meningitis belt and the incidence of rodent borne diseases (Davis, 2011; INGC, 2009a,).

Water borne diseases such as diarrhoeal diseases (giardia, cholera), hepatitis, enteric fevers have its peaks following flooding and warm temperatures. Worth mention the cholera epidemics seen in Mozambique and Tanzania in 1998 during 1997/98 El Niño event (Nicholls et al., 2007; INGC, 2009a).

The official data supplied by DPS of Nampula (2015) only presents information from the year 2010 and beyond. In what regards the four major prevalent diseases and indicators of wellbeing in the last 5 years in Angoche and Moma, the DPS refers malaria, HIV, Tuberculosis and Lepra. Although some of the data could show that there is a trend to an increase (Annex 6a) there are no studies supporting this data relating it with climate change.

In what regards Pebane district, Annex 6b reveals an increase of measles, poliomyelitis, HIV and a stable increase of malaria. The number of cases of diarreha, dysentery and rabies seemed to have decreased in the past five years. However it is important to highlight that data from Pebane (Zambezia Province) provided by DPS Zambezia reports number of cases and not prevalences. Therefore conclusions about this data may incur in several errors.

The outlined above highlights the potential impacts of climate change on populations in coastal regions. This impact will be determined by the future health status of the population (including the prevalence of cardiovascular diseases, HIV and TB, malnutrition or stunting especially in young children) and the capacity of communities to adapt to health threats as well as to cope with climate events and public health governance measures (Nicholls et al., 2007).

7. Relevant policies & strategies

7.1. National Strategy on Climate Change

The National Strategy on Climate Change (2013-2025) of 2012, aims at establishing guidelines for action to build resilience, including the reduction of climate risks on communities and the national economy, and promote the development of low carbon and green economy by integration of these principles in the sectorial and local planning process. This is expected to be achieved by:

- Increasing resilience to climate change impacts, while minimizing risks to people and property, restoring and ensuring the rational use and protection of natural resources;
- Identifying and implementing opportunities to reduce greenhouse gases emissions that contribute to sustainable use of natural resources and low-carbon emission development;
- Creating institutional and human capacity, and explore opportunities for accessing technological and financial resources to implement the strategy.

Over the time scale of the Strategy, the priority will be to increase local resilience, combating poverty and identifying opportunities for adaptation and low carbon development at community level, to be included in district planning (2013-2015), provincial planning (2015-2019) and at national planning (2020-2025).

Areas of Intervention

Climate Risk

The aim is to strengthen the early warning system in order to protect people and assets from extreme events, such as floods, drought, and uncontrolled fires. The lack of an efficient national system is contributing to negative impacts often resulting in loss of lives. Here, the access to meteorological data is critically important, tailored to sector specific needs and with accurate forecast of extreme events.

Allied to this, the strengthening of preparedness and response to climate risks is of paramount importance to mitigate the impact of climate disasters. In this regard the strategy stresses the need to boost the coordination capacity of the INGC and that of the Multiple Use Resource Centres (CERUM) to assist the communities.

Water Resources

Water is becoming a major asset both in terms of human needs, storage for drought impact and in regards to flood management.

There is the need to manage shared river catchments and to boost dam discharge in order to limit flush flooding and water management to support agriculture and other human socio economic developments.

Agriculture, Fisheries, Food Security and Nutrition

The aim is to increase agriculture and livestock resilience by:

- Crop diversification and introduction of crops more resistant to variations in climate parameters;
- Improve agricultural productivity with appropriate technology and inputs adapted to climate change;
- Combat and control pests and diseases in crops;
- Strengthen the agro-ecological zoning and land use planning;

- Develop conservation programs and soil nutrition (conservation agriculture);
- Improve animal nutrition through pastures and forage production management techniques;
- Improve epidemiological surveillance and control of animal diseases;
- Improve and expand technical assistance to producers in terms of intervention quality.

On fisheries, emphasis is to increase resilience by:

- Aquaculture development as an alternative means to reduce fishing effort and sustain fish demand;
- Regenerate mangroves and implement protective measures on seaweed, seagrass, coral refs and other critical ecosystems;
- Improve small-scale fisheries;
- Reinforce fisheries management by applying clean fisheries technology to ensure the renewal and maintenance of stocks.

Adequate levels of food safety and nutrition are expected to be achieved by:

- Improved mechanisms for marketing of food products;
- Improve food stocks;
- Enhance nutrition by improving education and access to food;
- Develop community-based processing and value-adding;
- Promote agro-processing;
- Promote the use and value-adding of indigenous foods.

Social Protection

It is expected that climate change and extreme events have a more pronounced consequence on the most vulnerable groups, including women, children, elderly, disabled, displaced and climate chronically ill. These are expected to contribute to impoverishment and increased vulnerability of the population in general. The resilience can be increase by:

- Increase adaptive capacity of vulnerable people by applying innovative approaches to community-based adaptation, and improving the effectiveness of programs on social protection; and
- Strengthening the links between social protection systems and response to natural disasters systems, including coordination with early warning systems.

Health

Direct health risks are of physical safety and increased risk of disease spreading, particularly during extreme events:

- To increase resilience to transmission it is vital to strengthen the capacity to prevent and control the spread of vector-borne diseases;
- Expand and improve the operation of systems for collecting and treating solid waste and wastewater;
- Promoting and using clean technologies and create forest and recreation areas, and buffer zones in cities, including mangrove conservation in coastal areas.

Biodiversity

The overall objective of the country's Conservation Policy is "to develop and consolidate a national system of biological resources conservation and its aquatic and terrestrial biodiversity contributing to sustaining life, economic growth and poverty eradication". In turn, the policy and strategy on Forestry and Wildlife recognizes the social, ecological and economic measurements as the basis for a harmonious development of the sector.

In order to improve resilience on biodiversity conservation and protection the following actions are:

- Identify adaptation actions to ensure that wildlife does not go extinct;
- Establish transfrontier conservation areas to maintain ecosystem functions and allow migration of wildlife;
- Implement management practices that increase the adaptive capacity of ecosystems, maximizing the use of habitats and biodiversity conservation;
- Reclassify and resize conservation areas, identifying biodiversity loss risk areas.

Forests

The impact of climate change on forests are not well known, but direct effects of extreme events such as spread of fires in dry scenarios and temperature rise, leads to loss of biomass and possible endangered species.

The National Strategy of Forestry operationalize this vision aligning intervention measures that can either be used as mechanisms of adaptation as well as mitigation to climate change. However, deforestation and increased exposure of soil are highly adverse, affecting subsistence of rural communities. Thus, the strategic actions proposed include:

- Increasing the adaptive capacity of forests involves:
- Develop planting multi-purpose trees and economic value of programs to meet the needs of products to local communities, seeking to enhance local initiatives, combating deforestation and preventing fire and its spread;
- Explore agro-forestry-pastoral systems, allowing diversification of livelihoods and incomes.

Infrastructure

According to the Medium Term Expenditure Framework (2012-2014) (MTEF) most of the investments in Mozambique will be made in the construction or maintenance of infrastructure.

The integration of climate aspects in the urban planning process allows cities to develop their capacity to adapt effectively to current and future climate impacts, but also take the opportunity to develop, experiment and innovate in their urban planning policies.

Develop resilience mechanisms in urban areas and other settlements by:

- Draw up and update the planning tools and climatically robust territory planning and strengthen its implementation;
- Map the infrastructure vulnerable or at risk, depending on the type of weather phenomena (floods, cyclones, rising sea level);
- Revamp the building codes of transport infrastructure, telecommunications, power distribution, buildings, water infrastructure and wastewater treatment in order to make them resilient to climate;

- Ensure that investments, particularly public, in hazardous areas are climate-proof;
- Promote the design and implementation of potential insurance mechanisms against climate risks in built heritage.

Tourist and coastal infrastructure may be vulnerable. Therefore actions are needed to:

- Evaluate the main climate risks on the resources and tourist interest zones;
- Advise operators about the appropriate building codes;
- Promote best practice amongst operators and tourists, through public-private partnerships aimed at the resilience of the sector and the conservation of ecosystems;
- Develop conservation and coastal protection practices;
- Promote the adoption of climate insurance for activities and tourism infrastructure.

8. Conclusion and Recommendations

The fundamental starting point for the production of a climate vulnerability assessment is the acquisition of basic data on a number of important parameters that characterise the area. Relevant information relative to the PSEPA includes the following:

- Natural resources, ecosystems and biodiversity (condition, trends and threats);
- Socio-economic situation (human settlements and livelihoods, fisheries, agriculture, tourism, infra-structure and other coastal development)
- Climatic and weather parameters and trends (including climate stressors);
- Oceanography of the region;
- Hydrological/water resources
- Coastal geomorphology/topography (including erosion/accretion patterns);
- Legal and institutional framework

Based on the literature review several gaps in the current knowledge have been identified and are summarized below:

- Biodiversity assessments, monitoring programs and status assessments for high profile species and important ecosystems are urgently needed, not only to allow proper vulnerability assessments to be produced but also to support management and conservation (as a matter of priority the following ecosystems should be addressed: mangroves, coastal forests, coral reefs, seagrass beds and tidal flats, as well as marine megafauna ie. marine turtles, marine mammals and the whale shark and manta rays);
- Quantification of natural resource use is also a long felt need within the PSEPA, and should include both extractive and non-extractive uses (eg. fishing and invertebrates collection, charcoal and firewood, tourism);
- Monitoring of climate stressors within the PSEPA need to be implemented as a matter of priority as well as the acquisition of time-series data (such as satellite and modelling oceanographic and climate parameters);
- Additionally, an inventory of land use and crop regime at the PSEPA is needed, in order to foresee improved local based technologies to adapt to climate change.
- A comprehensive monitoring and evaluation framework to track major issues such as land use and agriculture vulnerability and resilience to climate change, and extent to which climate change adaptation is addressed in reducing climate change impacts and boosting sustainability, is required.

The National Strategy on Climate Change defines the actions to be taken to adapt and mitigate the impact of climate change and that of extreme events. These principles should be taken in light of climate vulnerability assessment and when reviewing priority areas of vulnerability and adaptation options to implement at the PSEPA.

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10. Annexes

10.1. Annex 1 – Fisheries data and trends in Angoche, Moma (in Nampula) and Pebane (in Zambezia)(* no data available for comparison).

a) Number of each type of vessels in 2002 and 2007 and trend in %

Districts	"Moma" type canoes			Dugout canoes			Flat tenders			Skiboat			Raft			Dhows			Others			Total		
	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend
Angoche	1012	1109	↑ 9.6	147	593	↑ 303.4	2	3	↑ 50.0	0	4	↑ 400.0	*	28	*	0	23	↑ 2300.0	0	4	↑ 400.0	1161	1764	↑ 51.9
Moma	783	882	↑ 12.6	30	395	↑ 1216.7	1	3	↑ 200.0	1	0	↓ -100.0	*	2	*	1	5	↑ 400.0	0	1	↑ 100.0	816	1288	↑ 57.8
Pebane	233	678	↑ 191.0	1007	1436	↑ 42.6	0	6	↑ 600.0	0	3	↑ 300.0	*	10	*	93	1	↓ -98.9	0	8	↑ 800.0	1333	2142	↑ 60.7

b) Number of each type of fishing gear in 2002 and 2007 and trend in %

Districts	Beach seine			Gillnet			Trap			Hand Line			Longline			Purse seine			Others			Total		
	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend	2002	2007	Trend
Angoche	473	685	↑ 44.8	438	502	↑ 14.6	0	15	↑ 1500.0	225	573	↑ 154.7	2	2	→ 0.0	1	4	↑ 300.0	22	376	↑ 1609.1	1161	2157	↑ 85.8
Moma	497	590	↑ 18.7	123	336	↑ 173.2	3	2	↓ -33.3	41	304	↑ 641.5	2	1	↓ -50.0	0	1	↑ 100.0	55	84	↑ 52.7	721	1318	↑ 82.8
Pebane	500	806	↑ 61.2	199	417	↑ 109.5	63	36	↓ -42.9	414	412	↓ -0.5	14	26	↑ 85.7	1	30	↑ 2900.0	165	437	↑ 164.8	1356	2164	↑ 59.6

c) Trends in Total Catches (TC) and Catches per Unit Effort (CPUE) for the whole Nampula Province and Zambezia Province between 2000 and 2013

	Fishing gear	2000-2001		2001-2002		2002-2003		2003-2004		2004-2005		2005-2006		2006-2007		2007-2008		2008-2009		2009-2010		2010-2011		2011-2012		2012-2013	
		TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE
Nampula	Beach seine	*	*	*	*	*	*	*	*	*	*	↓ -11,7	*	*	*	*	*	↑ 11,3	↑ 27,1	↑ 32,6	↑ 14,8	↑ 26,6	↓ -10,0	↓ -13,8	↑ 3,2	↓ -11,2	*
Nampula	Hand line	↑ 47,4	*	*	*	*	*	*	*	*	*	↓ -29,4	*	*	*	*	*	↑ 7,7	→ 0,0	↓ -23,5	↓ -10,0	↓ -22,2	→ 0,0	↑ 108,8	↑ 88,9	↓ -11,5	*
Nampula	Surface gillnet	↑ 20,9	*	*	*	*	*	*	*	*	*	↓ -7,6	*	*	*	*	*	↓ -24,5	↓ -16,0	↑ 34,3	↓ -23,8	↑ 30,3	↑ 81,3	↑ 3,4	→ 0,0	↓ -27,1	*
Nampula	Bottom gillnet	↑ 43,7	↓ -37,4	*	*	*	*	*	*	*	*	↑ 71,0	*	*	*	*	*	↓ -20,5	↑ 211,1	↑ 63,6	↑ 89,3	↑ 107,9	↓ -32,1	↓ -66,0	↑ 11,1	↑ 31,0	*
Nampula	Total	↑ 35,1		*		*		*		*		↓ -11,5		*		*		↑ 0,9		↑ 23,9		↑ 23,7		↓ -3,5		↓ -14,6	
Zambézia	Beach seine	↑ 3,7	*	↓ -18,3	*	↓ -12,9	*	↑ 6,2	↓ -50,9	↑ 0,9	↑ 0,5	↑ 54,5	↑ 75,4	↓ -25,7	↓ -42,2	↓ -7,8	↓ -28,3	↓ -22,4	↓ -63,4	↓ -25,6	↑ 80,9	↓ -35,4	↓ -29,7	↓ -18,2	↑ 2,2	↑ 62,3	↑ 5,8
Zambézia	Hand line	↓ -52,4	*	↑ 16,7	*	↓ -64,2	*	↑ 106,4	*	↑ 28,7	↑ 925,0	↓ -25,2	↓ -83,0	↑ 31,6	↑ 67,4	↑ 85,4	↑ 68,4	↑ 44,8	↓ -72,6	↓ -87,9	↓ -51,1	↑ 224,9	↑ 65,7	↓ -12,0	↑ 120,8	↓ -20,5	↓ -59,4
Zambézia	Surface gillnet	↑ 31,6	*	↑ 8,1	↑ 0,9	↓ -62,9	↓ -56,3	↑ 23,9	↓ -39,8	↑ 437,2	↓ -1,9	↓ -67,9	↓ -29,7	↓ -27,4	↑ 1102,3	↑ 222,5	↓ -73,5	↓ -60,2	↓ -65,7	↓ -14,7	↓ -27,5	↑ 142,8	↑ 35,5	↑ 72,3	↑ 170,4	↑ 42,2	↓ -47,3
Zambézia	Bottom gillnet	↓ -61,9	*	↑ 47,0	↓ -8,6	↑ 48,3	↑ -46,3	↓ -51,0	↓ -47,1	↑ 175,6	↓ -0,9	↑ 4,3	↑ 52,7	↑ 26,0	↑ 11,6	↑ 83,3	↑ 118,8	↓ -53,8	↓ -48,7	↓ -52,5	↓ -35,4	↑ 182,5	↓ -8,0	↓ -83,7	↓ -1,4	↑ 343,0	↓ -38,2
Zambézia	Total	↑ -4,3		↓ -14,1		↓ -18,9		↑ 8,2		↑ 19,7		↑ 29,0		↓ -21,6		↑ 11,4		↓ -20,4		↓ -40,3		↓ -3,0		↓ -9,5		↑ 49,4	

d) Trends in Total Catches (TC) and Catches per Unit Effort (CPUE) for the Angoche, Moma and Pebane District between 2000 and 2013

	Fishing gear	2000-2001		2001-2002		2002-2003		2003-2004		2004-2005		2005-2006		2006-2007		2007-2008		2008-2009		2009-2010		2010-2011		2011-2012		2012-2013	
		TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE	TC	CPUE
Nampula - Angoche	Beach seine	↓ -80,0	↓ -63,6	*	↑ 53,5	*	↑ 36,4	*	*	*	*	*	*	*	*	*	*	↓ -2,9	↑ 28,2	*	*	*	*	*	*	*	*
Nampula - Angoche	Hand line	↑ 480,9	↑ 187,9	*	*	*	*	*	*	*	*	↓ -45,3	*	*	*	*	*	↓ -29,4	↑ 12,5	*	*	*	*	*	*	*	*
Nampula - Angoche	Surface gillnet	↓ -12,4	↓ -16,4	*	*	*	*	*	*	*	*	*	*	*	*	*	*	↓ -36,2	↓ -9,5	*	*	*	*	*	*	*	*
Nampula - Angoche	Bottom gillnet	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Nampula - Angoche	Total	↓ -59,8		*		*		*		*		↓ -46,5		*		*		↑ -17,0		*		*		*		*	
Nampula - Moma	Beach seine	↓ -44,4	↓ -48,8	*	↑ 6,9	*	↑ 37,6	*	*	*	*	*	*	*	*	*	*	↑ 31,3	↑ 27,0	*	*	*	*	*	*	*	*
Nampula - Moma	Hand line	↑ 11,3	↓ -45,3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	↓ -75,8	↓ -54,8	*	*	*	*	*	*	*	*
Nampula - Moma	Surface gillnet	↓ -3,6	↓ -41,2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	↓ -63,9	↓ -86,5	*	*	*	*	*	*	*	*
Nampula - Moma	Bottom gillnet	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Nampula - Moma	Total	↓ -38,9		*		*		*		*		*		*		*		↓ 7,3		↑ 24,9		↑ 16,6		↑ 9,0		*	
Zambézia - Pebane	Beach seine	↓ -2,6	↓ -4,7	↓ -24,8	*	→ 0,0	*	↓ -13,4	*	↓ -9,9	↓ -24,7	↑ 111,2	↑ 198,0	*	*	*	*	*	*	↓ -32,1	*	↓ -52,2	*	↓ -28,5	*	↑ 190,5	*
Zambézia - Pebane	Hand line	↓ -29,2	↓ -54,5	↓ -100,0	*	*	*	↑ 80,0	*	↑ 147,1	↑ 220,0	↓ -35,7	↓ -21,6	*	*	*	*	*	*	↓ -82,3	*	↑ 179,9	*	↑ 35,8	*	↓ -55,2	*
Zambézia - Pebane	Surface gillnet	↓ -42,5	↓ -31,0	*	*	*	*	*	*	↑ 461,6	↑ 108,7	↓ -74,1	↓ -71,4	*	*	*	*	*	*	↓ -25,7	*	↑ 95,8	*	↑ 339,1	*	↑ 23,1	*
Zambézia - Pebane	Bottom gillnet	↓ -74,2	↓ -73,8	↑ 104,2	↓ -57,1	↓ -81,0	↓ -92,5	↑ 305,6	↑ 4122,2	↑ 97,8	↓ -18,4	↑ 11,1	↑ 40,5	*	*	*	*	*	*	↑ 88,5	*	↓ -21,7	*	↓ -100,0	*	*	*
Zambézia - Pebane	Total	↓ -7,3		↓ -26,2		↓ -0,9		↓ -6,1		↑ 17,4		↑ 60,3		*		*		*		↓ -41,2		↓ -31,4		↑ 35,7		↑ 64,5	

10.2. Annex 2– Trend analysis for the Fish Families that were caught by each type of fishing gear in Nampula Province between 2001 and 2008:

The comparison unit is the % of occurrence of the Family, per fishing gear per year. The colours represent the trend according to the classes identified in the column "Possible trend". Red arrows mean "Declining", Yellow arrows mean "Stable" and Green Arrows mean "Increasing".

Fishing gear	Family	2001		2004		2005		2006		2008		Trend analysis				
		%	Trend	%	Trend	%	Trend	%	Trend	%	Trend	Stable	Up	Down	Last year	Possible trend
Beach seine	Engraulidae	26	-	15	↓ -11	17.7	↑ 2.5	16.8	↓ -1	0	↓ -17	0	1	3	Decreased	Decreasing
	Carangidae	13	-	8	↓ -5	13.1	↑ 4.7	15.7	↑ 2.6	0	↓ -16	0	2	2	Decreased	Stable-Decreasing
	Scombridae	6	-	11	↑ 5.3	10.1	↓ -1	9.6	↓ -1	0	↓ -10	0	1	3	Decreased	Decreasing
	Trichiuridae	0	-	5	↑ 4.7	4	↓ -1	6	↑ 2	0	↓ -6	0	2	2	Decreased	Stable-Decreasing
	Clupeidae	8	-	13	↑ 4.9	10.2	↓ -3	12.9	↑ 2.7	0	↓ -13	0	2	2	Decreased	Stable-Decreasing
	Leiognatidae	6	-	8	↑ 2	8	→ 0	4.5	↓ -4	0	↓ -5	1	1	2	Decreased	Decreasing
	Acanthuridae	0	-	0	→ 0	0	→ 0	0	→ 0	45	↑ 45	3	1	0	Increased	Increasing
	Acropomatidae	0	-	0	→ 0	0	→ 0	0	→ 0	16	↑ 16	3	1	0	Increased	Increasing
	Albuidae	0	-	0	→ 0	0	→ 0	0	→ 0	6	↑ 6	3	1	0	Increased	Increasing
	Ariidae	0	-	0	→ 0	0	→ 0	0	→ 0	4	↑ 4	3	1	0	Increased	Increasing
	Aristeidae	0	-	0	→ 0	0	→ 0	0	→ 0	4	↑ 4	3	1	0	Increased	Increasing
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hand line	Haemulidae	34	-	7	↓ -27	12	↑ 5.2	23.5	↑ 12	10	↓ -14	0	2	2	Decreased	Stable-Decreasing
	Scombridae	19	-	10	↓ -9	8.9	↓ -1	12.5	↑ 3.6	5	↓ -8	0	1	3	Decreased	Decreasing
	Carangidae	8	-	10	↑ 2.2	19.3	↑ 9.1	12.3	↓ -7	18	↑ 5.7	0	3	1	Increased	Increasing
	Sillaginidae	6	-	0	↓ -6	0	→ 0	0	→ 0	0	→ 0	3	0	1	Stable	Decreasing
	Lutjanidae	6	-	27	↑ 21	10.8	↓ -16	3.1	↓ -8	5	↑ 1.9	0	2	2	Increased	Stable
	Lethrinidae	0	-	8	↑ 8.1	7	↓ -1	10.3	↑ 3.3	23	↑ 13	0	3	1	Increased	Increasing
	Serranidae	5	-	6	↑ 0.9	17.1	↑ 11	9.6	↓ -8	7	↓ -3	0	2	2	Decreased	Stable-Decreasing
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface gillnet	Chirocentridae	24	-	14	↓ -10	20	↑ 6	14	↓ -6	9	↓ -5	0	1	3	Decreased	Decreasing
	Mugilidae	15	-	4	↓ -11	0	↓ -4	6.3	↑ 6.3	5	↓ -1	0	1	3	Decreased	Decreasing
	Hemiramphidae	14	-	0	↓ -14	0	→ 0	0	→ 0	5	↑ 5	2	1	1	Increased	Increasing
	Carangidae	12	-	14	↑ 2.3	7	↓ -7	15.4	↑ 8.4	20	↑ 4.6	0	3	1	Increased	Increasing
	Clupeidae	9	-	22	↑ 13	0	↓ -22	25.5	↑ 26	21	↓ -5	0	2	2	Decreased	Stable-Decreasing
	Leiognatidae	0	-	9	↑ 8.7	0	↓ -9	5.4	↑ 5.4	0	↓ -5	0	2	2	Decreased	Stable-Decreasing
	Sphyraenidae	0	-	7	↑ 7.1	0	↓ -7	4.4	↑ 4.4	3	↓ -1	0	2	2	Decreased	Stable-Decreasing
	Scorpaenidae	0	-	0	→ 0	9	↑ 9	0	↓ -9	0	→ 0	2	1	1	Stable	Stable
	Chanidae	0	-	0	→ 0	7	↑ 7	0	↓ -7	0	→ 0	2	1	1	Stable	Stable
	Mobulidae	0	-	0	→ 0	7	↑ 7	0	↓ -7	0	→ 0	2	1	1	Stable	Stable
	Caesionidae	0	-	0	→ 0	7	↑ 7	0	↓ -7	0	→ 0	2	1	1	Stable	Stable
	Scombridae	7	-	6	↓ -1	0	↓ -6	6.8	↑ 6.8	7	↑ 0.2	0	2	2	Increased	Increasing
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottom gillnet	Haemulidae	18	-	0	↓ -18	5.9	↑ 5.9	0	↓ -6	-	-	0	1	2	Decreased	Decreasing
	Sphyrnidae	16	-	0	↓ -16	0	→ 0	0	→ 0	-	-	2	0	1	Stable	Stable-Decreasing
	Scombridae	12	-	8	↓ -4	0	↓ -8	0	→ 0	-	-	1	0	2	Stable	Stable-Decreasing
	Dasyatidae	11	-	0	↓ -11	3	↑ 3	5.2	↑ 2.2	-	-	0	2	1	Increased	Increasing
	Mugilidae	10	-	0	↓ -10	0	→ 0	0	→ 0	-	-	2	0	1	Stable	Stable-Decreasing
	Lutjanidae	0	-	27	↑ 27	0	↓ -27	0	→ 0	-	-	1	1	1	Stable	Stable-Decreasing
	Acanthuridae	0	-	10	↑ 10	0	↓ -10	4.4	↑ 4.4	-	-	0	2	1	Increased	Increasing
	Mobulidae	0	-	10	↑ 10	9	↓ -1	13.9	↑ 4.9	-	-	0	2	1	Increased	Increasing
	Scaridae	0	-	7	↑ 6.8	1.8	↓ -5	0	↓ -2	-	-	0	1	2	Decreased	Decreasing
	Carangidae	5	-	4	↓ -1	12.8	↑ 9.1	0	↓ -13	-	-	0	1	2	Decreased	Decreasing
	Serranidae	0	-	3	↑ 3	17.4	↑ 14	1.5	↓ -16	-	-	0	2	1	Decreased	Stable
	Carcharhinidae	9	-	3	↓ -6	15.5	↑ 12	57.6	↑ 42	-	-	0	2	1	Increased	Increasing
	Myliobatidae	0	-	0	→ 0	5.8	↑ 5.8	9.5	↑ 3.7	-	-	1	2	0	Increased	Increasing
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

10.3. Annex 3 – Trend analysis for the Fish Families that were caught by each type of fishing gear in Zambézia Province between 2001 and 2010:

The comparison unit is the % of occurrence of the Family, per fishing gear per year. Grey cells refer to the comparison between the closest year with available data (in cases where no data was available for the previous year). The remaining colours represent the trend according to the classes identified in the column "Possible trend". Red arrows mean "Declining", Yellow arrows mean "Stable" and Green Arrows mean "Increasing".

Fishing gear	Family	2001		2003		2004		2005		2006		2008		2009		2010		Trend analysis				
		%	Trend	%	Trend	%	Trend	%	Trend	%	Trend	%	Trend	%	Trend	%	Trend	Stable	Up	Down	Last year	Possible trend
Beach seine	Engraulidae	35	-	38	↑ 3	41	↑ 3	42	↑ 1	40	↓ -2	56	↑ 16	38	↓ -18	40	↑ 2	0	5	2	Increased	Increasing
	Trichiuridae	14	-	12	↓ -2	17	↑ 5	12	↓ -5	13	↑ 1	6	↓ -7	7	↑ 1	6	↓ -1	0	3	4	Decreased	Decreasing
	Clupeidae	10	-	9	↓ -1	7	↓ -2	6	↓ -1	24	↑ 18	12	↓ -12	15	↑ 3	15	→ 0	1	2	4	Stable	Stable
	Sciaenidae	8	-	12	↑ 4	10	↓ -2	11	↑ 1	7	↓ -4	9	↑ 2	10	↑ 1	16	↑ 6	0	5	2	Increased	Increasing
	Sergestidae	8	-	5	↓ -3	0	↓ -5	0	→ 0	0	→ 0	1	↑ 1	6	↑ 5	3	↓ -3	2	2	3	Decreased	Stable-Decreasing
	Serranidae	0	-	0	→ 0	0	→ 0	7	↑ 7	0	↓ -7	0	→ 0	0	→ 0	0	→ 0	5	1	1	Stable	Stable
	Caridae	0	-	0	→ 0	0	→ 0	7	↑ 7	4	↓ -3	2	↓ -2	5	↑ 3	6	↑ 1	2	3	2	Increased	Increasing
	Penaeidae	3	-	1	↓ -2	4	↑ 3	4	→ 0	1	↓ -3	8	↑ 7	9	↑ 1	1	↓ -8	1	3	3	Decreased	Stable-Decreasing
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hand line	Ariidae	46	-	-	-	25	↓ -21	34	↑ 9	23	↓ -11	40	↑ 17	52	↑ 12	23	↓ -29	0	3	3	Decreased	Stable-Decreasing
	Sciaenidae	18	-	-	-	11	↓ -7	8	↓ -3	7	↓ -1	24	↑ 17	16	↓ -8	31	↑ 15	0	2	4	Increased	Increasing
	Haemulidae	17	-	-	-	33	↑ 16	30	↓ -3	10	↓ -20	3	↓ -7	4	↑ 1	15	↑ 11	0	3	3	Increased	Increasing
	Muranesocidae	8	-	-	-	8	→ 0	8	→ 0	10	↑ 2	0	↓ -10	0	→ 0	3	↑ 3	3	2	1	Increased	Increasing
	Carangidae	4	-	-	-	7	↑ 3	3	↓ -4	24	↑ 21	6	↓ -18	10	↑ 4	12	↑ 2	0	4	2	Increased	Increasing
	Carcharhinidae	0	-	-	-	4	↑ 4	8	↑ 4	2	↓ -6	9	↑ 7	4	↓ -5	0	↓ -4	0	3	3	Decreased	Decreasing
	Serranidae	0	-	-	-	0	→ 0	0	→ 0	0	→ 0	7	↑ 7	3	↓ -4	0	↓ -3	3	1	2	Decreased	Decreasing
	Lobotidae	0	-	-	-	1	↑ 1	1	→ 0	5	↑ 4	1	↓ -4	7	↑ 6	0	↓ -7	1	3	2	Decreased	Stable
	Lethrinidae	0	-	-	-	0	→ 0	0	→ 0	0	→ 0	0	→ 0	0	→ 0	5	↑ 5	5	1	0	Increased	Increasing
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface gillnet	Clupeidae	39	-	20	↓ -19	51	↑ 31	59	↑ 8	47	↓ -12	52	↑ 5	50	↓ -2	25	↓ -25	0	3	4	Decreased	Decreasing
	Carangidae	29	-	15	↓ -14	5	↓ -10	6	↑ 1	23	↑ 17	3	↓ -20	3	→ 0	15	↑ 12	1	3	3	Increased	Increasing
	Chirocentridae	19	-	32	↑ 13	7	↓ -25	3	↓ -4	4	↑ 1	1	↓ -3	7	↑ 6	8	↑ 1	0	4	3	Increased	Increasing
	Sciaenidae	3	-	0	↓ -3	8	↑ 8	5	↓ -3	6	↑ 1	3	↓ -3	5	↑ 2	5	→ 0	1	3	3	Stable	Stable
	Haemulidae	0	-	18	↑ 18	0	↓ -18	0	→ 0	0	→ 0	0	→ 0	0	→ 0	0	→ 0	5	1	1	Stable	Stable
	Ariidae	0	-	7	↑ 7	8	↑ 1	1	↓ -7	0	↓ -1	4	↑ 4	5	↑ 1	6	↑ 1	0	5	2	Increased	Increasing
	Trichiuridae	0	-	0	→ 0	8	↑ 8	7	↓ -1	7	→ 0	18	↑ 11	9	↓ -9	11	↑ 2	2	3	2	Increased	Increasing
	Mugilidae	0	-	0	→ 0	0	→ 0	5	↑ 5	3	↓ -2	10	↑ 7	11	↑ 1	17	↑ 6	2	4	1	Increased	Increasing
	Scombridae	0	-	0	→ 0	0	→ 0	2	↑ 2	6	↑ 4	0	↓ -6	0	→ 0	0	→ 0	4	2	1	Stable	Stable
	Carcharhinidae	0	-	6	↑ 6	1	↓ -5	0	↓ -1	0	→ 0	2	↑ 2	5	↑ 3	0	↓ -5	1	3	3	Decreased	Stable-Decreasing
	Engraulidae	0	-	0	→ 0	1	↑ 1	2	↑ 1	0	↓ -2	2	↑ 2	3	↑ 1	9	↑ 6	1	5	1	Increased	Increasing
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottom gillnet	Haemulidae	22	-	29	↑ 7	11	↓ -18	10	↓ -1	-	-	10	→ 0	6	↓ -4	18	↑ 12	1	2	3	Increased	Stable-Decreasing
	Carcharhinidae	19	-	32	↑ 13	9	↓ -23	39	↑ 30	-	-	22	↓ -17	33	↑ 11	28	↓ -5	0	3	3	Decreased	Stable-Decreasing
	Ariidae	15	-	9	↓ -6	22	↑ 13	9	↓ -13	-	-	17	↑ 8	5	↓ -12	0	↓ -5	0	2	4	Decreased	Decreasing
	Carangidae	8	-	7	↓ -1	10	↑ 3	12	↑ 2	-	-	21	↑ 9	12	↓ -9	8	↓ -4	0	3	3	Decreased	Stable-Decreasing
	Sphyrnidae	7	-	0	↓ -7	6	↑ 6	3	↓ -3	-	-	3	→ 0	12	↑ 9	12	→ 0	2	2	2	Stable	Stable
	Clupeidae	3	-	6	↑ 3	0	↓ -6	0	→ 0	-	-	0	→ 0	0	→ 0	0	→ 0	4	1	1	Stable	Stable
	Scombridae	0	-	6	↑ 6	9	↑ 3	2	↓ -7	-	-	11	↑ 9	0	↓ -11	6	↑ 6	0	4	2	Increased	Stable
	Lutjanidae	0	-	0	→ 0	0	→ 0	6	↑ 6	-	-	0	↓ -6	5	↑ 5	0	↓ -5	2	2	2	Decreased	Stable
	Muraenesocidae	0	-	0	→ 0	0	→ 0	2	↑ 2	-	-	13	↑ 11	0	↓ -13	0	→ 0	3	2	1	Stable	Stable
	Lobotidae	0	-	5	↑ 5	8	↑ 3	5	↓ -3	-	-	2	↓ -3	9	↑ 7	12	↑ 3	0	4	2	Increased	Increasing
	Chirocentridae	0	-	0	→ 0	0	→ 0	0	→ 0	-	-	0	→ 0	9	↑ 9	0	↓ -9	4	1	1	Decreased	Stable
	Belonidae	0	-	0	→ 0	2	↑ 2	0	↓ -2	-	-	0	→ 0	0	→ 0	11	↑ 11	3	2	1	Increased	Increasing
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

10.4. Annex 4 – Licences issued by Zambezia Provincial Directorate for the Coordination of Environmental Affairs (DPCA) for Pabene district in the last 10 years

District	Project	Category	Type
Pebane	Komoz Fish Processing Factory	C	fishing industry
Pebane	Pebane Fishing Charts	A	Fishing tourism
Pebane	Pescadana	C	Fish processing factory
Pebane	Mil Roses Entreprises Lda.	B	?
Pebane	Sociedade Ilhas Primeiras e Investimentos	B	?
Pebane	Shuang Long. Lda.	B	Mining
Pebane	Pathfinder	B	Mining
Pebane	Room rental	C	Tourism
Pebane	Construction of a fuel pump station	C	Fuel pump station
Pebane	Activity to create aquatic species	C	Aquaculture
Pebane	Coastal prospection of Ilmenite and zircon	B	Mining

10.5. Annex 5 – Licenses Issued by Provincial Delegation of Mining resources and Energy from Cabo Delgado

District	Bidder	License type	License No.	Area (ha)	Covered minerals	Issuance date	Valid date	Current status
Pebane	Tazetta Resources, Lds	Research and Exploration	6181 L	18111,32	HSA, ILM, F	27-11-2013	27-11-2018	Active
Pebane	Tazetta Resources, Lds	Mining concession	7150 C	5230	HSA			Pending opposition
Pebane	Yolanda Pascoa Andrade Fernandes	Research and Exploration	5088 L	8520	REEA			Pending approval
Pebane	Patel Mining Activities	Research and Exploration	3918 L	3200	ILM, RUT; T	13-09-2010	23-08-2018	Pending approval
Pebane	Hong Ti Mineral, Lda.	Research and Exploration	4124 L	20440,00	ILM, RUT; T	16-05-2012	16-05-2012	Pending approval
Pebane	Shuang Long, Lda.	Research and Exploration	5310 L	9580,74	HSA, ILM, F	12-02-2013	12-02-2018	Active
Pebane	Mozambique International Mining Research and developmentes, S.A.	Research and Exploration	6887 L	17673,34	HSA			Pending approval
Pebane	ALMAZ - Companhia Moçambicana, Lda	Research and Exploration	4740 L	22760	HSA			Pending opposition
Pebane	Afrifocus Resources, Lda	Research and Exploration	2816 L	7700	MI, TI	31-08-2009	31-08-2017	Pending extension
Pebane	João Américo Mpfumo	Research and Exploration	5708 L	8400,73	HSA	27-12-2013	27-12-2018	Active
Pebane	Pathfinder Moçambique, S.A, Jacinto Soares Veloso	Mining concession	4623 C	32780	HSA	13-07-2011	13-07-2036	Active
Pebane	Shuang Long, Lda.	Research and Exploration	4462 L	7320	ILM, RUT, T	16-04-2012	16-04-2017	Pending approval
Pebane	Zamin Moçambique Mineração	Research and Exploration	4729 L	19635,07	ILM, RUT, Z	12-02-2013	23-05-2017	Active
Pebane	Clara Angelica Muchabje	Research and Exploration	6601 L	9733,73	HSA			Requested
Pebane	António Alfredo Muianga	Research and Exploration	6953 L	5909,56	HSA, MI			Pending approval
Pebane/Mo	Belmiro Destino Quive	Research and Exploration	4226 L	24540	HSA			Pending opposition
Pebane	AMBECO	Mining certificate	7372 CM	470,8	MI, TOU			Pending opposition
Pebane/Mo	Hong Ti Mineral, Lda.	Research and Exploration	4601 L	24420	ILM, TI, ZR	21-04-2014	21-04-2019	Active
Pebane	Érica Hudite Mata	Mining certificate	5816 CM	409,2	TAM			Pending approval
Pebane	Juwied, Lda	Mining certificate	6571 CM	245,57	STO			Requested
Moma	Afrifocus Resources, Lda	Research and Exploration	2829 L	2884,09	MI, TI	16-09-2008	16-09-2015	Active
Moma	Hong Ti Mineral, Lda.	Research and Exploration	4125 L	21380	ILM, RUT, T	30-01-2012	30-01-2017	Active
Moma	Di Yuan Mineral, Lda.	Research and Exploration	5858 L	11780	ILM, RUT, Z	17-07-2014	17-07-2019	Active
Moma	Kenmare Moma Mining	Research and Exploration	1462 L	3760	HSA	03-05-2007	03-05-2017	Active
Moma	Haiyu Mozambique Mining Co. Lda	Mining concession	7239 C	10175	HSA	15-06-2015	15-06-2040	Pending approval
Moma	Kenmare Moma Mining	Mining concession	735 C	34460	HSA	26-08-2004	26-08-2029	Active
Moma	Mineral resource Moçambique, Lda.	Research and Exploration	7026 L	2520	HSA	14-011-2014	14-11-2019	Active
Moma/Ang	Stélio Timótio Mavimbe	Research and Exploration	6762 L	8610	HSA, MI			Pending approval
Moma/Ang	Floriano Sozinho Muchabje	Research and Exploration	6609 L	16493	HSA, MI			Pending approval
Angoche	Afrifocus Resources, Lda	Research and Exploration	2813 L	13866	MI, TI	31-01-2008	31-10-2018	Active
Angoche	Antonio Alfredo Muianga	Research and Exploration	6948 L	3507	HSA, MI			Pending approval
Angoche	João Américo Mpfumo	Research and Exploration	5709 L	6650	Areias pesadas			Pending approval
Angoche	Chen Jun, Zociedade Unipessoal, Lda	Research and Exploration	4684 L	500	AU, QTZ, T	03-05-2012	03-05-2017	Active
Angoche	António Alfredo Muianga	Research and Exploration	6790 L	3881	HSA, Mi			Pending approval
Angoche	Concessão Mineira	Mining concession	4776 C	4920	Ilmenite, T	19-012-2011	19-12-2036	Active
Angoche	Kenmare Moma Mining	Mining concession	270 C	3260	HSA	28-02-2007	17-07-2029	Active
Angoche	Stélio Timótio Mavimbe	Research and Exploration	6777 L	13671	HSA			Pending approval
Angoche	Eusebio Coconote	Mining certificate	7800 CM	410	STO			Requested
Angoche	Pedro Francisco Pereira Junior		7166 CM	492	STO	23-02-2017	23-02-2017	Active

10.6. Annex 6a – Major prevalent diseases and indicators of wellbeing in the last 5 years in Angoche and Moma

Most prevalent diseases	2010		2011		2012		2013		2014		Trend analysis				
	Prev.	Trend	Prev.	Trend	Prev.	Trend	Prev.	Trend	Prev.	Trend	Stable	Up	Down	Last year	Possible trend
Malaria/1000 hab	200	-	110	↓ -90	86	↓ -24	103	↑ 17	237	↑ 134	0	2	2	Increasing	Stable-Increasing
HIV/AIDS/1000 hab	5	-	6	↑ 1	20	↑ 14	4	↓ -16	9	↑ 5	0	3	1	Increasing	Increasing
Lepra/100000 hab	3	-	4	↑ 1	4	→ 0	4	→ 0	7	↑ 3	2	2	0	Increasing	Increasing
Tuberculosis/100000 hab	74	-	5	↓ -69	85	↑ 80	22	↓ -63	129	↑ 107	0	2	2	Increasing	Stable-Increasing
Malaria/1000 hab	85	-	70	↓ -15	77	↑ 7	123	↑ 46	206	↑ 83	0	3	1	Increasing	Increasing
HIV/AIDS/1000 hab	5	-	6	↑ 1	20	↑ 14	4	↓ -16	9	↑ 5	0	3	1	Increasing	Declining
Lepra/100000 hab	8	-	8	→ 0	4	↓ -4	4	→ 0	4	→ 0	3	0	1	Stable	Stable-Declining
Tuberculosis/100000 hab	84	-	85	↑ 1	93	↑ 8	31	↓ -62	121	↑ 90	3	2	2	Increasing	Stable-Increasing

10.7. Annex 6b – Four major prevalent diseases and indicators of wellbeing in the last 5 years in Pebane

Most prevalent diseases	2010		2011		2012		2013		2014		Trend analysis				
	N. of cases	Trend	N. of cases	Trend	N. of cases	Trend	N. of cases	Trend	N. of cases	Trend	Stable	Up	Down	Last year	Possible trend
Malaria	18332	-	21166	↑ 2834	13324	↓ -7842	13324	→ 0	22430	↑ 9106	1	2	1	Increasing	Stable-Increasing
Diarrhea	5461		7276	↑ 1815	6002	↓ -1274	4954	↓ -1048	4052	↓ -902	0	1	3	Decreasing	Declining
HIV/AIDS*	3184	-	1097	↓ -2087	1274	↑ 177	3564	↑ 2290	4955	↑ 1391	0	3	1	Increasing	Increasing
Tuberculosis	148	-	145	↓ -3	162	↑ 17	182	↑ 20	353	↑ 171	0	3	1	Increasing	Stable-Increasing
Dysintery	1069	-	1071	↑ 2	970	↓ -101	931	↓ -39	692	↓ -239	0	1	3	Decreasing	Declining
Rabies	0	-	9	↑ 9	13	↑ 4	1	↓ -12	1	→ 0	1	2	1	Decreasing	Declining
Measles	0	-	12	↑ 12	4	↓ -8	7	↑ 3	28	↑ 21	0	3	1	Increasing	Increasing
Neo- Natal Tetanus	0	-	2	↑ 2	3	↑ 1	2	↓ -1	2	→ 0	1	2	1	Stable	Stable-Declining
Poliomielite	0	-	2	↑ 2	3	↑ 1	3	→ 0	8	↑ 5	1	3	0	Increasing	Increasing