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Climate Vulnerability Assessment for the Primeiras and Segundas Environmental Protection Area (PSEPA)

Final Report

Prepared for:

WWF- MOZAMBIQUE COUNTRY OFFICE (MCO)

WWF for a living planet®

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EXECUTIVE SUMMARY

Southern Africa is recognized as one of the most vulnerable regions to climate change (IPCC, 2007). Coastal areas are especially vulnerable to climate changes, relatively speaking, on account of being exposed to a greater number of climate hazards, such as general marine environmental degradation, ocean acidification, flooding, accelerated erosion, seawater intrusion (Abuodha & Woodroffe, 2006; Blažauskas & Suzdalev, 2011), droughts (Blažauskas & Suzdalev, 2011), sea level rise, and sea temperature rise. Mozambique's coastline has almost 2700 km and more than 60% of its total population live there. It's recognized as one of the most vulnerable countries in Africa to climate change expected impacts along its coast (INGC, 2009a).

Mozambique is the fourth most vulnerable country in the world to climate change impacts and is expected that its exposure to the risk of natural disasters will increase significantly over the next 20 years and beyond (INGC, 2009 a,b). The northern coast of the country 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 are expected. Climate change is also a major threat to conservation areas. Consequently, marine and coastal conservation areas, like the Primeiras and Segundas archipelago, which extends through Nampula, and Zambezia Provinces, is prone to be affected by climate change impacts, namely extreme events like floods and sea level rise.

The Primeiras and Segundas Environmental Protection Area (PSEPA), with over 1 040 926ha, was created in 2012 (Decree 14/2012), being the largest Marine Protected Area in Africa, which is represented by 200 km of coastline. The population is approximately 628 765 people within the protection area. This protected archipelago is a unique and beautiful area with considerable biological richness and it covers estuarine areas, mangrove areas, intertidal areas and rivers that are exposed to tides. It is also included in the Coastal East Africa Global Initiative (CEAGI), which has Climate change resilience and adaptation as one of its priority working areas. The CEAGI climate change adaptation programme aims to ensure that WWF's conservation programs in coastal Eastern Africa recognize, and where possible address, the impacts of global climate change on priority ecosystems, and on communities that depend on the services and resources they provide. To this end, climate vulnerability assessments and adaptation planning have been initiated in five WWF priority areas in coastal East Africa, including in the PSEPA. Therefore, understanding the main processes and functions of the various components and the drivers of changes is part of the CEAGI approach to help PSEPA dealing with climate change. The final outcome of this report consists of a set of adaptation options that are expected to be adopted by PSEPA as per in the PSEPA Management Plan of 2014-2019.

The objectives of the PSEPA climate vulnerability assessment were: i) to better understand the nature of climate change related resilience, impacts and vulnerabilities of selected ecosystems, species and livelihood resources within the PSEPA; ii) To identify priority areas of environmental and social vulnerability to climate stresses and iii) identify preliminary adaption options that address critical climate vulnerabilities within the target area. This report's specific goal is to systematically organize the information gathered during the implementation of this assessment and the possible adaptation interventions to provide to potential donors the information they need to fund future projects on climate change adaptation in the PSEPA.

The PSEPA vulnerability assessment followed the '*Flowing Forward*' (FF) methodology, which is a framework originally developed by WWF US and the World Bank in 2010 for assessing climate vulnerability and developing adaptation interventions. Flowing Forward has five major steps:

1) Review existing information assets and gaps on climate vulnerability;

2) Fill any information gaps that can be addressed within a reasonable timeframe and within available resources;

3) Collate available reference material and prepare a summary document of what is currently known about both human and environmental climate vulnerability in the area;

4) Conduct a stakeholder's planning workshop during which priority areas of vulnerability are systematically reviewed by specialist working groups, based on the information gathered in steps 1-3 above;

(5) Use the workshop results to identify adaptation options.

The *Flowing Forward* framework has an accompanying Excel-spreadsheet based analysis tool with the following simplified steps:

i) Identify analysis units and sub-units; ii)

ii) Identify and rate the *resilience* characteristics of each sub-unit;

iii) Identify and rate development and climate impacts on each sub-unit;

iv) Calculate an overall *vulnerability* rating for each sub-unit;

v) Identify priority adaptation interventions to address the highest rated impacts.

For the purpose of the *Flowing Forward* assessment, a total of seven analysis units (listed below) were identified for the PSEPA:

i) Coral Reefs;

ii) Forest and Mangrove;

iii) Human Settlements;

iv) High-profile species;

v) Freshwater;

vi) Agriculture and Livestock systems;

vii) Fisheries and Aquaculture.

These units were then divided into sub-units.

As part of the above step (2) of the vulnerability assessment, the University of Cape Town (UCT) was contracted to undertake an analysis of climate trends and projections of the area of PSEPA, and CARE-WWF Alliance undertook three community vulnerability & capacity assessment (CVCA) on PSEPA.

In terms of climate trends and projections from the UCT climate analysis, there are some concerns, the climate is getting warmer in line with regional and global trends. A slight increase in the duration of dry spells is expected, which may imply a slight shortening of the rainy season. On the other hand, an increase in total rainfall as well as an increase in several parameters related to rainfall intensity and extreme events is also expected, implying that the amount and intensity of rain will increase when raining events occur. The findings also indicate a delay in the timing of onset of the wet season. The projections are thus suggesting that, in the future, PSEPA may experience an increase in overall rainfall and in the frequency and intensity heavy rainfall events, but with longer periods of dry spell in between, meaning that the extreme events will be more frequent. Extreme heat events are also likely to be hotter. This may play an important role on population health and also on biodiversity conservation.

Findings from the CVCA study showed that community members in PSEPA area have developed a number of strategies for short-term *coping* with the effects of climate stresses on livelihood resources. However, their capacity to *adapt* sustainable in the longer term is limited by the lack of alternative sources of livelihood and financing, in a context of lack of access to basic health care and potable water supply.

During a 3-day stakeholder workshop in Nampula in February 2016, specialist working groups analysed the vulnerability of the seven resource units to development and climate stresses, using the *Flowing Forward*s analysis framework. Key results from this analysis were:

1) Coral Reefs

The three most vulnerable sub-units were:

i) Exposed inter-tidal seagrass

ii) Non-protected & non-exposed coral reefs

iii) Protected & non-exposed coral reefs

The three highest rated climate impacts were:

- Cyclone events cause massive destruction of coral reefs in the PSEPA archipelago due to the high hydrodynamic tensions associated with cyclonic winds;
- Extreme temperature events of sea water can cause bleaching of coral reefs and mortality (zooxanthellae expulsion), linked to the loss of the physical structure and biodiversity of coral reef and biomass of other invertebrates, and loss of fish that depend on the sheltered coral structures of such reefs;
- Extreme temperature events cause changes in spatial distribution and in sexual reproduction patterns of seagrass, as well as changes in their growing rates, metabolism and in their carbon balance.

2) Forest & Mangrove

The three most vulnerable sub-units were:

i) Coastal forest of Tapuito

ii) Seaward fringing Mangroves

iii) Protected coastal forest of Potone

The three highest rated climate impacts were:

- Prolonged droughts associated with extreme atmospheric temperature events will contribute to the occurrence of fires and habitat loss in Potone forest;
- Strong wave events combined to storms in Angoche, Moma, Larde and Pebane lead to deposition of sediments in coastal area causing the burying of mangrove areas and compromising the potential for natural regeneration;
- Prolonged droughts associated with high temperature events reduce discharges of rivers, increases evaporation and salinity of the soil, thus causing changes in the structure of mangrove forests in estuaries of Angoche, Moma, Larde and Ligonha.

3) **Human settlements**

The three most vulnerable sub-units were:

i) Precarious constructions

ii) Infrastructures for public services

iii) Settlements and infrastructures in riparian and floodable zones

The three highest rated climate impacts were:

- The occurrence of cyclones, through strong winds and high waves, leads to destruction of houses and loss of mangrove forests that give protection to settlements in Coty Islands;
- The occurrence of cyclones, storms and high winds leads to destruction of precarious house construction;
- The occurrence of heavy rains can contaminate water sources that are used in communities.

4) High-profile species

The three most vulnerable sub-units were:

i) Icuria dunensis

ii) Marine turtles

iii) Sooty tern (*Onychoprion fuscatus*) & Greater Crested Tern (*Thalasseus bergii enigma*)

The three highest rated climate impacts were:

- Due to the characteristics of its habitat (dunes and sandy areas), Icuria dunensis is particularly exposed to cyclone events, storms, strong winds (south of Potone and Moebase forests);
- Cyclone events, storms, strong winds and high tides are eroding and flooding the nesting area of leatherback turtle mainly on the islands of Puga Puga, Coroa, Baixa Miguel and Baixa Sto. Antonio with less vegetation cover, which causes the loss of habitat conditions for nesting, compromising the reproduction of the local marine turtle population;
- Cyclone events, storms, strong winds and high tides are eroding and flooding the nesting area of terns on the islands of Puga Puga, reducing the available area for laying eggs, compromising the reproduction of the local species population.

5) Freshwater

The three most vulnerable sub-units were:

i) Lagoons

ii) Gutter pipes & water tanks

iii) Lakes

The three highest rated climate impacts were:

- Heavy rains lead to floods that cause contamination of drinking water sources in low areas along the coast and destruction of wells
- Periods of high air temperatures (max and min) cause the increase of evaporation in lakes, ponds, wells and boreholes, which decreases the availability of freshwater
- Long period rains cause floods and leads to contamination of drinking water source

6) Agriculture & Livestock

The three most vulnerable sub-units were:

i) Cereals

ii) 2.Leguminous

iii) 3.Roots & tubers

The three highest rated climate impacts were:

- Heavy rainfall events that cause floods and erosion of the area that is intended to agriculture production, causing loss of crops in the districts of Angoche, Larde, Moma and Pebane;
- The occurrence of cyclones followed by strong winds cause the loss of cultures or the layering in the coastal region of Angoche district;
- Unpredictable rainfall events (late onset of the rains) associated with high temperatures cause the outbreak of pests and diseases that cause loss of crops in the districts of Angoche, Moma, Larde and Pebane;

7) Fisheries & Aquaculture

The three most vulnerable sub-units were:

i) Shrimp

ii) MozambiqueTilapia

iii) Reef & rocky bottom fish

The three highest rated climate impacts were:

- Prolonged droughts cause the drought of Maganha lake, reducing the population of Tilapia;
- The occurrence of cyclones has caused the destruction / collapse of aquaculture tanks built near or in the mangrove areas in the districts of Angoche, Moma and Pebane with consequent escape from fish farms and loss of stock;
- Low rainfall during wet season suppresses dispersal of juvenile prawns into deeper water leading to lower catches.

Based on the above vulnerability results, each of the specialist working groups identified and elaborated two adaptation interventions considered important and/or more effective in reducing the vulnerability of vulnerable sub-units. The three highest voted interventions were applied to High profile species, followed by Fisheries & Aquaculture and finally Human settlements and Agriculture & Livestock systems (both with the same number of votes).

It is relevant that a meeting is held between the PSEPA manager and the WWF team in order to select the priority interventions. A systematic approach has been undertaken to assess the climate vulnerability for the PSEPA. Therefore, before entering the next stage, which should be writing an application to get funding from donors to implement adaptation interventions, the priority adaptation interventions should be clearly defined and selected.

LIST OF ACRONYMS AND UNITS

ALP – Adaptive Learning Programme

AMA – Environmental NGO

ANAC - National Agency for the Management of Protected Areas

APAIPS – Management Plan for Conservation area in Nampula and Zambezia Archipelago in Mozambique

CARE – Cooperative for Assistance and Relief Everywhere

CBO – Community Based Organization

CCP – Community Fishing Councils (CFC)

CEAGI - Coastal East Africa Global Initiative

CVCA – Climate Vulnerability and Capacity Analysis

DPTUR - Provincial Directorate of Tourism

DPASA - Provincial Directorate of Agriculture and Food Security

DPCA – Provincial Directorate for Coordination of Environmental Affairs

DPEC – Provincial Directorate for Education and Culture

DPMAP – Provincial Directorate of the Sea, Inland Waters and Fisheries

DPMAS – Provincial Directorate for Women and Social Action

DPOPHRH – Provincial Directorate for Public Works, Housing and Water resources

DPS – Provincial Directorate for Health

DPTADER – Directorate for Land, Environment and Rural Development

FF - Flowing Forward methodology

FUNAB – National Environmental Fund

GPS – Global Positioning System

ha – hectare

HIV - Human Immunodeficiency Virus

IDPPE – National Institute of Small Fisheries Development

INAM – National Meteorology Institute

INGC – National Institute of Disaster Management

IIAM - Institute of Agricultural Research of Mozambique

IIP – National Fisheries Research Institute

IPCC – Intergovernmental Panel on Climate Change

ITCZ - Inter-tropical Convergence Zone

km – quilometre

km^2 – square quilometre

kg – kilogram

MICOA – Ministry for Coordination of Environmental Action

MITADER – Ministry of Land, Environment and Rural Development

MITUR - Ministry of Tourism

MOMS - A participative methodology tracking of Fauna

NAPA – National Strategy on Climate Change

NGO – Non Governmental Organization

NSCC – National Strategy for Climate Change

PEDSA – Strategic Plan for the Agricultural Sector Development

PSEPA - Primeiras and Segundas Environmental Protection Area

SD – Standard Deviation

SDAE – District Services for Economic Activities

SDPI – District Services for Planning and Infrastructure

SST – Sea Surface Temperature

TB – Tuberculosis

UCT CSAG – University of Cape Town (Climate Systems Analysis Group)

UMC – Unit Climate Measurements

WS – Workshop

WWF – World Wide Fund for Nature

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1. RATIONALE FOR CONDUCTING A CLIMATE VULNERABILITY ASSESSMENT

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).

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).

Coastal areas are especially vulnerable to climate changes, relatively speaking, on account of being exposed to a greater number of climate hazards, *i.e.*: general marine environmental degradation, ocean acidification (due to the increased CO_2 concentrations), flooding, accelerated erosion, seawater intrusion (Abuodha & Woodroffe, 2006; Blažauskas & Suzdalev, 2011), droughts (Blažauskas & Suzdalev, 2011), sea level rise, sea temperature rise, being downstream of changing rainfall patterns in river basins.

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. It is recognized as the fourth most vulnerable country in the globe to climate change impacts due to its geographic location (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).

Zambezia and Nampula provinces, in northern Mozambique, are experiencing a marked reduction in freshwater availability, as well as a substantial reduction of available agricultural land and the increase of forest fires risk. Nampula and Zambezia coastlines, in common with coastlines elsewhere in the region and globally, are believed to be vulnerable to sea-level rise (MICOA, 2012) although tide-gauge data is not available for the area. Climate change is also potentially a major threat to conservation areas and biodiversity and although very little evidence has been produced on conservation impacts in Mozambique, the likelihood of species extinctions is been increasingly accepted in a global context (Parmesan & Yohe, 2003). Consequently, there is a need at the very least to investigate likely climate change impacts on marine and coastal conservation areas, like the Primeiras and Segundas archipelago, which extends through Nampula, and Zambezia Provinces, and are prone to affect by extreme events like floods and sea level raise. Due to its biological richness, the government of Mozambique formally designated, in 2012, Primeiras and Segundas, as an Environmental Protection Area covering an area of 1,040,926 ha, the largest marine protected area in the western Indian Ocean.

This area is recognized by WWF as a regionally important conservation area. As such, is included as one of nine priority areas under WWF's Coastal East Africa Global Initiative (CEAGI). The CEAGI is an umbrella WWF programme that aims to add regional strategic focus to WWF's work in Kenya, Tanzania and Mozambique. Priority areas of work include: natural resources governance in nine

priority landscapes & seascapes; governance of western Indian Ocean tuna fisheries; fisheries certification, esp. shrimp fisheries in Mozambique; Africa-China natural resources trade, especially timber; and **Climate change resilience and adaptation.**

The CEAGI climate change adaptation programme was initiated early in 2011 and aims to ensure that WWF's conservation programs in coastal Eastern Africa investigate, identify, and where possible address, the impacts of global climate change on priority ecosystems, and on communities that depend on the services and resources they provide. To this end, climate vulnerability assessments and adaptation planning have been conducted in five WWF priority areas in coastal East Africa, including the Primeiras and Segundas Environmental Protection Area (PSEPA). The other four priority areas are the Lamu-Tana River Seascape in Kenya; the Rufiji-Mafia-Kilwa Seascape in Tanzania; the Ruvuma Landscape, the Tanzania-Mozambique transboundary area; and the Mtwara-Quirimbas marine complex, focusing on the Quirimbas National Park, Cabo Delgado province, Mozambique. As such, supporting a better understanding how climate events affects biodiversity, ecosystems and related livelihoods, and identifying appropriate adaptation options, is part of the CEAGI approach to help PSEPA dealing with climate change.

The PSEPA vulnerability assessment process supported by WWF from 2014-2015, and implemented in conjunction with Governmental, non- Governmental and community partners, follows a methodological approach, called 'Flowing Forward', which is explained in the Methods section 2.6 below. The final outcome of the process, as contained in this report, consists of set of priority adaptation options that, if adopted and elaborated in a climate adaptation project, would contribute to effective implementation of the conservation strategies that are expected to be integrated in the PSEPA Management Plan.

2. OBJECTIVES

The objectives of the Primeiras and Segundas Environmental Protection Area climate vulnerability assessment are:

i. To better understand the climate change related resilience, impacts and vulnerabilities of selected ecosystems, species and livelihoods within the PSEPA

ii. To identify priority areas of environmental and social vulnerability to climate stresses

iii. To identify priority adaption options that address critical climate vulnerabilities within the landscape and which are aligned with PSEPA Management Plan.

The objective of this report is:

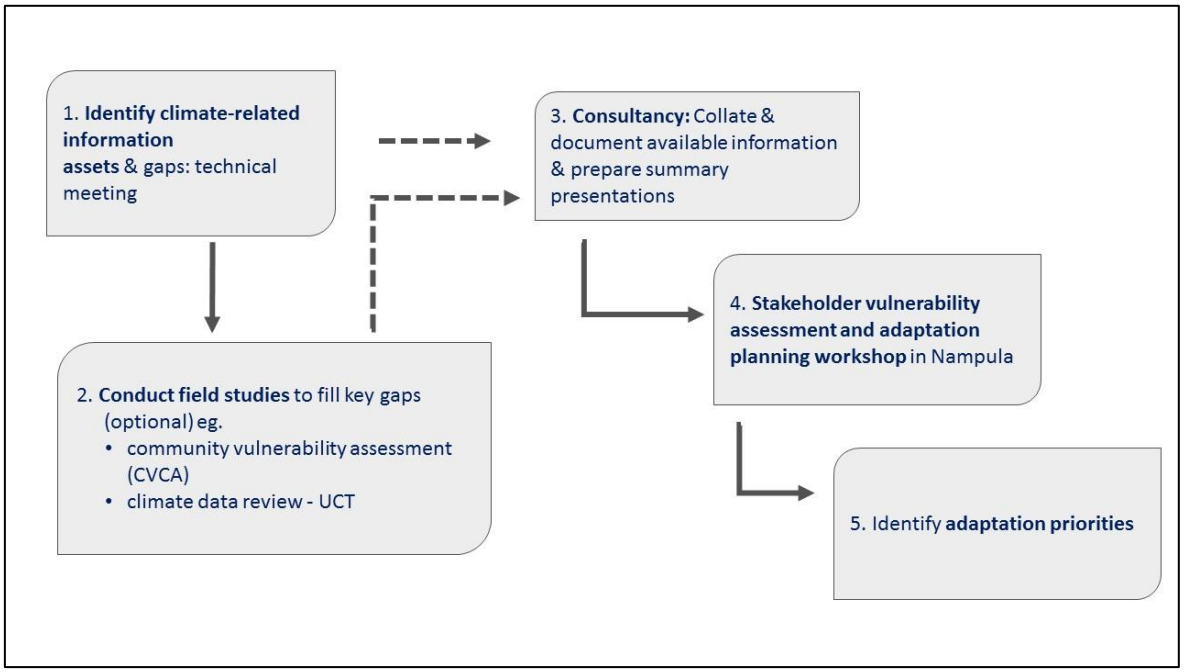
- Systematically to organize the information, results and adaptation interventions generated during the implementation of this assessment to provide PSEPA management and partners the information needed to develop future projects on climate change adaptation in the PSEPA.

3. METHODS

The PSEPA vulnerability assessment adopted a process comprised of several steps. It followed the 'Flowing Forward' (FF) methodology, originally developed by WWF and the World Bank in 2010 and subsequently elaborated (Le Quesne *et al.*, 2010). Initially developed for freshwater ecosystems, *Flowing Forward* is a framework for assessing climate vulnerability and developing adaptation interventions. It has been adapted over time for a broader range of applications, and the methodology that was used in the current approach includes the following major steps (Figure 3.1):

1. Review existing information assets and gaps on climate vulnerability;
2. Fill any gaps that can be addressed within a reasonable timeframe and within available resources (typically includes conducting a community vulnerability assessment, might also include other field studies or downscaled modelling of climate scenarios if not available);
3. Collate available reference material and prepare a summary document of what is currently known about both human and environmental climate vulnerability in the area in question;
4. Conduct a stakeholder's planning workshop;
5. Use the workshop results as a reference point and systematically review priority areas of vulnerability and adaptation options, using Flowing Forward assessment framework.

Figure 3.1 - Vulnerability assessment process (Flowing Forward)



The following chapters detail each of the steps mentioned above.

3.1. STEP 1 – VULNERABILITY ASSESSMENT TECHNICAL MEETING

The first action was to prepare and hold a technical meeting to assess the vulnerability of the ecosystems in the PSEPA and the climate changes. This meeting had as main objectives:

1. To identify the information needs for assessing the vulnerability to climate change in the PSEPA;

2. Provide the technical team, with the knowledge and understanding of the methodology "Flowing Forward" related to the evaluation process of vulnerability to climate change.

In this meeting, held between the 20th and 21st November 2014 in Angoche, was selected a set of 7 analysis units, which were used as a reference for the next steps:

i. Coral Reefs
ii. Forest and Mangrove
iii. Human Settlements
iv. High-profile species
v. Freshwater
vi. Agriculture and Livestock systems
vii. Fisheries and Aquaculture

For each of this units, a set of sub-units were then chosen. The definition and importance of each can be found in Annex I. The report of this meeting is also attached in Annex VI.

3.2. STEP 2 – FIELD & TECHNICAL STUDIES

Within step 2, a total of 4 specific studies were conducted to complement the available knowledge about PSEPA and climate change, namely:

i. Three studies on community Climate Vulnerability and Capacity Assessment (CVCA) (Cosijn, 2011, Skinner *et al*. 2014, Artur *et al*. 2015)
ii. Climate trends and projections for the PSEPA (Pinto *et al*., 2016).

3.3. STEP 3 – CLIMATE VULNERABILITY BACKGROUND REVIEW

A climate vulnerability background desk-review was also done in 2015 (Paula *et al*., 2015), and had as specific objectives:

i. Identify trends in status of key ecosystems, natural resources and natural resource-based livelihoods;
ii. Identify the major development trends and pressures affecting the above;
iii. Identify trends and projection in climate and related physical environment parameters;
iv. Identify the vulnerability and resilience of ecosystems, species, livelihoods and infrastructures to climate variability and change;
v. Identify relevant management policies and strategies that address climate change.

3.4. STEP 4 – STAKEHOLDER ADAPTATION PLANNING WORKSHOP

The analysis units defined in Step 1 and to which Steps 2 and 3 contributed with valuable additional information, provided the structure for the organization of Step 4, which is the core of the process. Hence, once all the necessary information was gathered together, the technical team organized a Stakeholder Adaptation Planning Workshop, which was divided in two stages:

i. a Pre-Workshop Meeting held immediately before the stakeholder workshop (between the 4th and the 6th February 2016 in Nampula), which involved the WWF *Flowing Forward* facilitation team (one group facilitator per each of the analysis units defined in step 1) and

a group of specialists who together, estimated the resilience of each subunit. The report of this meeting is attached in Annex VII.

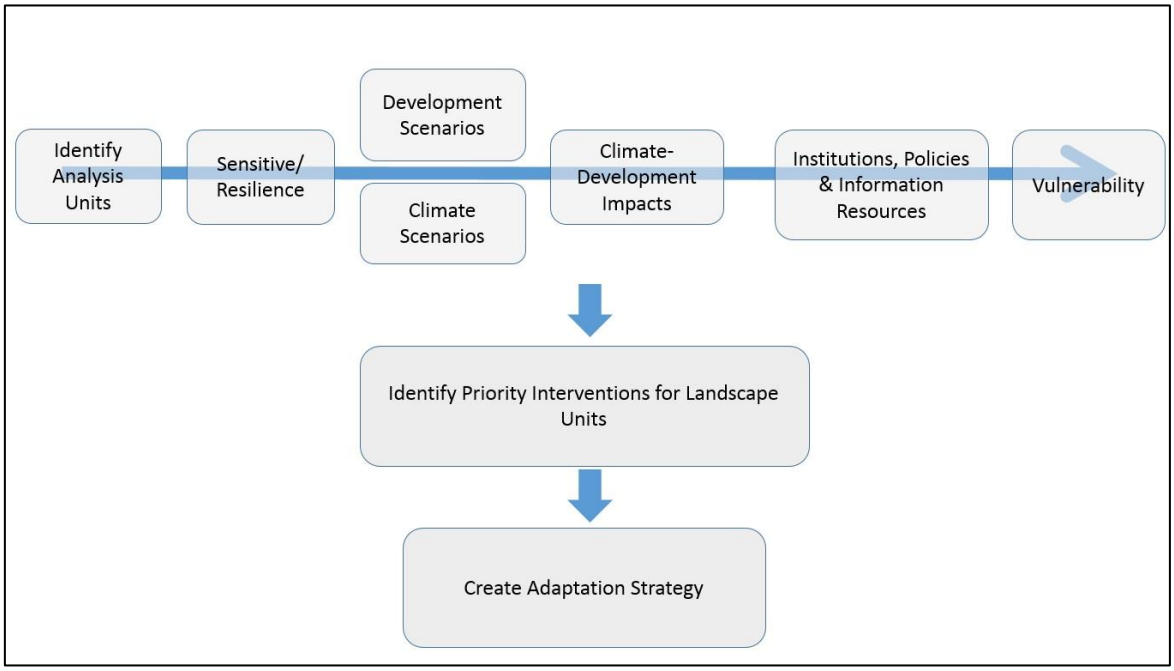
ii. The main Stakeholder Vulnerability Assessment & Adaptation Planning Workshop held over 3 days in Nampula (between the 8th and 10th February 2016). It was attended by a broad range of institutions wchi can be seen in the report of the workshop (Annex VII). The objectives of this workshop were to: i) identify and rate the vulnerabilities of species, ecosystems and livelihoods in the PSEPA to a range of development and climate pressures; ii) Identify and prioritize adaption options that would reduce PSEPA's vulnerability to climate stresses in particular; iii) to ensure that the two priority CCA strategies are of consensus from the local people and have been agreed with key people in each thematic area.

   To meet these objectives, a group of 30 individuals (i.e. Provincial and district representatives, scientists, academics, NGO and local community representatives) was identified, structured according to seven thematic working groups, such that each group contained a mix of technical expertise, local governance officials and NGO, and community representation. With overall guidance from the WWF facilitation team on the Flowing Forward Process, each group facilitator then guided group members to work on and fill the Flowing Forward excel based tool, using information gathered in the background studies and their own experience in the topic. The information and rankings generated from this process were then used to develop and rank adaptation interventions, which could serve as an initial step in developing an adaptation strategy for PSEPA.

3.4.1. THE FLOWING FORWARD ANALYSIS PROCESS AND EXCEL-BASED TOOL

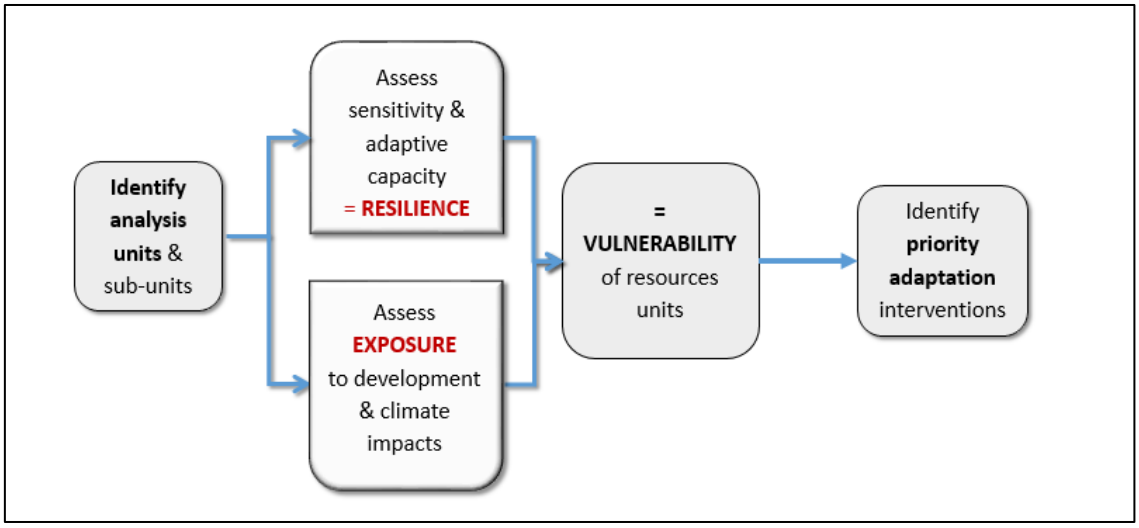
The *Flowing Forward* is a process, the broad outline of which is outlined Figure 3.1 above. Nevertheless, the core of it is the final stakeholder workshop and the filling of an excel-based tool that facilitates analysis of the resilience and vulnerability of resource units and identification of priority adaptation interventions. A basic schematic of the Flowing Forward Excel-based Tool is found below in **Erro! Fonte de referência não encontrada.**. and a simplified version in Figure 3.3.

Figure 3.2 - Schematic of the Flowing Forward



Flowing Forward conceptualizes vulnerability in accordance with the IPCC definition of vulnerability whereby vulnerability is a function of *exposure*, *sensitivity,* and *adaptive capacity.* However in the Flowing Forward formulation, sensitivity and adaptive capacity are combined together and assessed as *resilience* (see Figure 3.3 below).

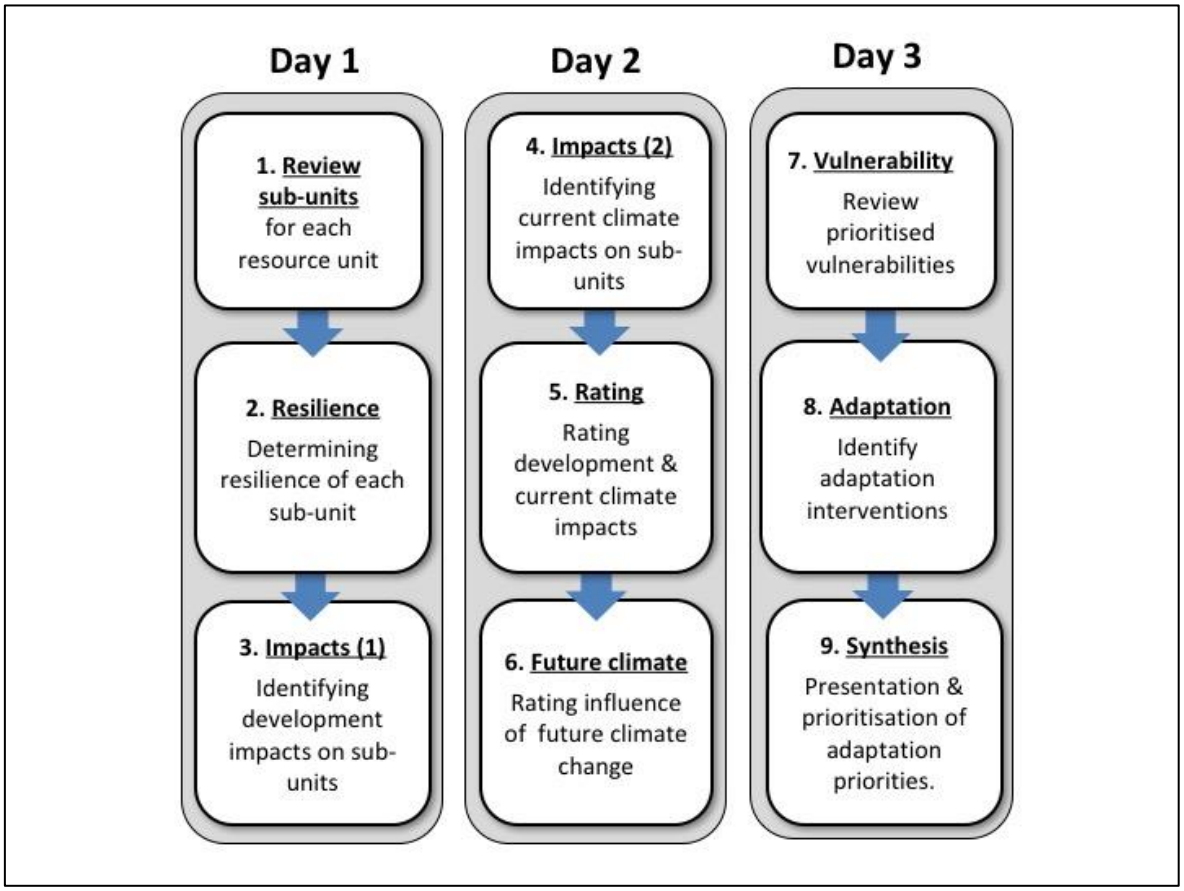
Figure 3.3 - Simplified schematic of the Flowing Forward analysis process



These schematic figures above represent the basic steps taken during the stakeholder workshops to guide participants through the process of understanding vulnerability and coming up with adaptation strategies to address these vulnerabilities.

The following paragraphs summarize each of the stages of the assessment, which are graphically represented in Figure 3.4. This figure also shows how the stages were distributed by the workshop days.

Figure 3.4 - Schematic representation of the assessment stages during stakeholder workshop



- **Step 1: Review Units and Sub-Units**: As explained before, the analysis units and sub-units had been provisionally identified during the Technical Meeting (Step 1 of the process) held in Nov 2014. During the main stakeholder workshop, the groups were given the opportunity to review the sub-units, grouping them, excluding some or adding others according to their initial analysis and to the information that they've perceived from the ecosystem-specific presentations.
- **Step 2: Determining Resilience**: Resilience is understood in this context to be an individual or system's ability to withstand impacts and/or recover. Greater resilience equates to less vulnerability. There are two components to resilience: i) Inherent resilience–namely the inherent characteristics or conditions of an individual or system (physiological/behavioural/social/ecological etc.) that determine how sensitive an individual or system will be a given hazard in terms of being able to maintain functionality and well-being ; (2) Social Adaptive Capacity: namely the ability of people to manage (or intervene in) natural or other resource systems through institutional actions, policies, and natural resource management practices. The Flowing Forward methodology identifies the following properties of a species, ecosystem or livelihood resource sub-unit that combine to define its resilience:

  (i) *connectivity* (ie. with other populations, habitats, larval or seed inputs etc.)

  (ii) natural variability (ie. degree of acclimatization to variable climate extremes)

  (iii) refugia (ie. areas within a sub-unit that are naturally less exposed to hazards)

  (iv) functional redundancy (ie. degree of dependence on other species, inputs etc.)

  (v) natural productivity (ie. growth rates, fecundity etc.)

(vi) *genetic diversity / biodiversity*

During the stakeholder workshop the above parameters were evaluated by each working group, for each sub-unit, ranking them on a semi-quantitative scale from 1 to 5, where 5 was the most resilient. A final resilience score for each sub-unit was obtained as the average of the scores for each parameter.

- **Step 3 & 4: Identifying development and climate Impacts**: this stage of the analysis consists of assessing the exposure of each sub-unit to development and climate impacts. First, based on an expert presentation on development trends, the groups identified development pressures affecting their respective sub-unit; second, based on expert presentations on observed climate trends (by UCT) and community vulnerability studies (CVCA), the groups identified specific impacts of climate hazards on their sub-units.
- **Step 5: Rating**: During this step, each development and climate impact identified for each sub-unit was ranked from 1 to 5 according to three factors:
    i) Intensity: represents the degree of disturbance as a result of an impact, where 5 represents the highest disturbance.
    ii) Extension: this represents the proportion of the sub-unit that is impacted by a given development or climate hazard, where 5 means greater extension.
    iii) Manifestation: assesses how long the effects (as captured in intensity and extension above) will take to manifest. It can be immediate (scored as 5) or it can occur shortly after the action that generates the impact, a few years after it or several years after it.

  The final score for each impact is an average of the above three parameters.
- **Step 6**: **Influence of Future Climate:** This exercise determines how future climate change will influence current development & climate impacts in QNP. Guided by the UCT expert presentation on **future climate projections**, each working group rated the additional effect, if any, of climate change on the current impacts on each sub-unit identified under steps 3 & 4 above. A qualitative scale with options: greatly decreases; slightly decreases; no change; slightly increases; greatly increases was used.
- **Step 7: Determining the vulnerability results:** The results of the analysis contained in steps 2 to 6 above were entered into the *Flowing Forward* Excel tool by working groups at each step. The Flowing Forward tool automatically calculates integrated vulnerability ratings for each sub-unit and generates tabulated results that highlight:
    i) the most significant impacts on particular sub-units and
    ii) the most vulnerable sub-units overall

Vulnerability is calculated as a function of:

current vulnerability * coefficient for future climate impact = *projected vulnerability*

Current vulnerability was calculated applying the formula in Figure 3.5 below:

Figure 3.5 - Formula for calculating Current vulnerability.
I – Intensity; E – Extension; M – Manifestation; R – Resilience

$$\frac{I + 0{,}5 \times ((E + M) + 2 \times (5 - R))}{3}$$

Projected vulnerability was calculated by applying to current vulnerability the influence of future climate factor as shown in below:

Figure 3.6 - Figure 3.6 - Formula for calculating Projected vulnerability.
I – Intensity; E – Extension; M – Manifestation; R – Resilience.

$$\left[\frac{I + 0{,}5 \times ((E + M) + 2 \times (5 - R))}{3}\right] \times \begin{cases} 1{,}2 & \text{if Much worse} \\ 1{,}1 & \text{if Worse} \\ 1 & \text{if The same} \\ 0{,}9 & \text{if Better} \\ 0{,}8 & \text{if Much better} \end{cases}$$

- **Step 8: Identifying adaptation options:** This step involved identification of adaptation interventions, aimed reducing the vulnerability of vulnerable sub-units.. The first step was to focus the attention on sub-units and specific impacts that scored highly on vulnerability ratings. To ease the analysis the impacts were ranked and the top 10 were selected. Then, as a second step, working groups were guided to consider if there was an intervention that would either (i) reduce exposure of the sub-unit to the impact in question or (ii) increase resilience of the sub-unit . Based on such an approach, the working groups each identified two potential interventions and outlined the following information for each:
    i) What sub-unit(s) and vulnerabilities does the intervention address?
    ii) Describe the intervention
    iii) How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?
    iv) Where should the intervention be implemented?
    v) Who should implement the intervention?
    vi) Are there negative consequences to the intervention?
    vii) What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)
    viii) Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?
    ix) Is there a supportive policy environment?
    x) Are there any specific research or data needs to ensure success?
- **Step 9: Synthesis & priorities:** Each working group presented their two proposed adaptation interventions in a plenary session. Participants then voted on their preferred interventions and the interventions were ranked accordingly.

4. DESCRIPTION OF THE PRIMEIRAS AND SEGUNDAS ENVIRONMENTAL PROTECTION AREA & RESULTS OF VULNERABILITY STUDIES

4.1. OVERVIEW OF THE PSEPA

The Archipelago of PSEPA is formed by two groups of islands, with 5 islands each, extending over the coastline of Mozambique. The southern group (Primeiras islands) is located in Zambezia province, and it is composed by the islands of Silva, Fogo, Coroa, Casuarina and Epidendron. The northern group (Segundas islands) is in Nampula province and it includes the islands of Moma, Caldeira, Nejovo, Puga-Puga and Mafamede.

The Primeiras and Segundas Environmental Protection Area (PSEPA), of more than 1.040.926ha, was created in 2012 (Decree 14/2012), being the largest marine protected area in Africa, which is represented by 200 km of coastline. This protected archipelago is a unique and beautiful area with considerable biological richness and it covers estuarine areas, mangrove areas, intertidal areas and rivers that are exposed to tides. Its importance in the national economy is recognized, particularly with regard to the fishing and shrimp industries, but also to the cashew and coconut production, especially in Angoche, where cashew processing aims domestic market and also exportation. So the declaration of this conservation area 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, 2014).

Considering these characteristics, both people and PSEPA's ecosystems and species, are vulnerable to climate change impacts, namely extreme events like floods and sea level raise.

The current assessment concentrates on systems within the PSEPA that are critical to people and ecosystems with an emphasis on those which are believed to be more sensitive to climate.

4.2. DESCRIPTION OF CRITICAL RESOURCE SYSTEMS: ANALYSIS UNITS AND SUBUNITS

The Flowing Forward is a dynamic framework and the initial units and sub-units identified in the technical meeting were revised, achieving a final list that was the baseline for the process, which is presented in this topic.

The description of PSEPA resources systems given below is formulated as per the final analysis units and sub-units identified for the purpose of this vulnerability assessment. A total of 11 analysis units were identified for the PSEPA, and each one was divided into sub-units (48 in total). However, during the pre-workshop meeting, a rearrangement was made in order to reduce it for the following 7 units, where each one was divided into sub-units (40 in total) as described below. The main criterion for differentiating different sub-units was that they are likely to be differently impacted by development or climate stresses on account of having different exposure characteristics and/or different resilience properties. Below one can find the list of sub-units for each unit.

1. Coral reefs

The unit of coral reefs also includes seagrass, having a total of six sub-units:

i. Protected & Non-Exposed Coral Reefs;

ii. Non-Protected & Non-Exposed Coral Reefs;

iii. Protected & Exposed Coral Reefs;

iv. Non-Protected & Exposed Coral Reefs;

v. Exposed Inter-tidal Seagrass;

vi. Non-Exposed Seagrass in deep lagoons.

Both ecosystems are highly productive and provide shelter, feeding and breeding ground for many unique species. They are both located in areas exposed to human actions and climatic events.

2. Forest & Mangrove

The mangrove forest unit also includes coastal forest and is divided in six sub-units:

i. Landward Estuarine Mangroves (River-dominated);

ii. Seaward Fringing Mangroves (wave dominated);

iii. Seaward Estuarine Mangroves (tidal dominated);

iv. Coastal Forest of Muebase;

v. Coastal Forest of Tapuito (partially protected);

vi. Protected coastal forest of Potone.

Forests and Mangroves are extremely important ecosystems, acting as nursery for several species, providing food and goods for local communities and wild species, coastal protection, the sustainable use of resources for medical and traditional purposes, water purification, among other services.

3. Human settlements

The human settlements unit includes six sub-units:

i. Precarious constructions;

ii. Infrastructures for public services;

iii. Settlements and infrastructures in estuarine and coastal zones;

iv. Settlements and infrastructures in riparian and floodable zones;

v. Settlements and infrastructures in islands;

vi. Settlements and infrastructures in inland regions.

Forest degradation, deforestation of large areas, the vulnerability of the islands to the risk of sea level rising, the great irregularity of rainfall, heavy rains, lack of sanitation, cultural habits are some of the problems that this unit faces and all the surrounding ecosystems.

4. High-profile Species

This unit includes seven sub-units:

i. Marine turtles;

ii. Whales;

iii. Sharks;

iv. Sooty tern (*Onychoprion fuscatus)* and Greater Crested Tern (*Thalasseus bergii enigma*);

v. *Icuria dunensis;*

vi. Hippopotamus;

vii. Dolphins.

Besides its uniqueness, several of these species of high conservation value have important roles in the local ecosystems, and the reduction of its populations and local extinction may compromise those ecosystems and even cause ecological / environmental disasters.

5. Freshwater

Fresh water unit has seven sub-units:

i. Permanent Rivers;

ii. Seasonal Rivers;

iii. Lagoons;

iv. Lakes;

v. Gutter pipes & water tanks;

vi. Wells;

vii. Water holes.

These are extremely important, as water is a basic and fundamental resource for communities. Signals of negative climate effect events such as storms, cyclones, floods and disasters are visible in this area.

6. Agricultural & Livestock Systems

The agricultural and livestock systems unit has five sub-units:

i. Fruit trees;

ii. Leguminous plants;

iii. Cereals;

iv. Roots and tubers;

v. Livestock;

These units have great importance both for subsistence and economically. These are extremely exposed to climate hazards and potential climate change, therefore they are an important analysis unit.

7. Fisheries & Aquaculture

This unit includes four sub-units:

i. Shrimp;

ii. Reef and rocky bottom fish;

iii. Mozambique Tilapia;

iv. Small Pelagic Fish.

These are important resources for local communities and are considered organisms of great economic value that can be negatively influenced by effects of climate such as the reduction of salinity levels, the sedimentation caused by rain and the rise of sea temperature.

4.3. DEVELOPMENT TRENDS

A Climate Vulnerability Background Review for Primeiras and Segundas was prepared by Paula *et al*. (2015) from Biodinâmica, S.A. which summarizes relevant available information and references to assess climate vulnerability in the PSEPA. 120 documents were analysed, in addition relevant stakeholders, including Provincial Directorates and Delegations were contacted for complementary information and clarification. What follows is a brief overview of the information in Paula et al. (2015).

4.3.1. GENERAL

In all districts, the existent infrastructure are 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, the Provincial Directorate for Land, Environment and Rural Development (DPTADER, former DPCA) from Zambezia, has issued at least 11 licenses for the following infrastructures in Pebane district:

i. 2 concerning tourist activities;
ii. 2 fish processing factories;
iii. 1 aquaculture;
iv. 1 fuel station;
v. 3 mining projects.

No further information was obtained for Moma and Angoche districts.

4.3.2. DEMOGRAPHICS

According to the 2007 Census mentioned on the PSEPA Management Plan (MITUR, 2014a), the Primeiras and Segundas Archipelago has an approximate population of 772 494 people. Regarding the districts where PSEPA is included (Angoche, Moma, Pebane and Larde) the population is approximately 628 765 people (for the same year).

From 1997 to 2014, and accordingly with that Management Plan, those same districts registered a growing pattern between those years, 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 (Paula *et al*. 2015).

4.3.3. ENERGY

Currently there is no oil & gas concession for research or exploration in the study area. However, the National Petroleum Institute launched recently a new bidding process, including two offshore blocks in Angoche, one of which partially overlaps PSEPA. One was awarded to ENI and the other to EXXON MOBIL. Current power supply to the regions within PSEPA is scarce. It is expected that oil & gas exploration projects will increase in the future, and 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, namely seagrass, coral reefs and/or mangrove, will increase significantly as well as impacts on marine wildlife, water quality and the risk of hazards.

4.3.4. MINING

According with the PSEPA Management Plan in the protected area and surroundings, 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.

According with International Finance Corporation (IFC) principles, the PSEPA Management Plan (draft version) defined that 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 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).

It is expected that the impacts will focus mainly inland, namely water and air pollution, soil productivity, terrestrial forest loss and habitat fragmentation, which will have consequences on several fauna species

4.3.5. TOURISM

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 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. No touristic information was obtained for the Zambezia province.

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), water supply, energy, the lack of attractions for the non-specialist tourist, etc. Therefore tourism in this area is mainly related with adventure, fishing sport, whale watching, bird-watching, diving and snorkelling.

Currently, tourist development may pose some threats to the integrity of natural areas, as it cannot happen without bringing changes to the natural environment. Still, revenues from tourism activities are minimal and are likely to remain so for the next decade (MITUR 2014a).

However, 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).

4.3.6. LAND & RESOURCE USE

According to the Agriculture Census of 2009-2010, in Nampula and Zambezia provinces are respectively, 1.037.748 ha and 1.071.170 ha of cultivated land (18,42% and 19,01% of the total Mozambique cultivated land). PSEPA population lives almost exclusively from fishing and farming, being these activities the main source of income. Different studies on the importance of these activities for households have different results, with fishing representing 30 to 60% of families' income (ANAC, 2015).

Less than 5% of the people interviewed in Nampula and Zambezia Province have stated that they have experienced conflicts regarding land use. According to the 2007 agriculture inquiry, these conflicts are associated with zoning of the land and land being sold to different people.

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 (by order of importance) 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 the PSEPA.

Using the Global Forest Change webtool it was possible to identify that deforestation occurs all over the area, 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.

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.

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.

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.

It should be noted that the PSEPA management plan has developed a land use zoning with the categories described below. It aims to reduce the potential conflicts over the use of resources through physical separation of conflicting uses, and to open space for each type of major activity. The PSEPA zoning includes:

- **Integral Natural Reserves** (land reserves and marine reserves) – total conservation zones where no extractive activity of resources are allowed. Communities can contribute for the conservation of these areas.
- **Sanctuari**es – The aim of these areas is the conservation of a species or a set of important species for biological and ecological balance of the region. Two Sanctuaries for marine wildlife migration and reproduction were defined, based on the connectivity between the mangroves on the mainland and the coral reefs.
- **Community conservation areas –** this includes mangroves and estuaries and it should be managed by communities, who have already created two sectors to be included in this area: the fisheries sector and the donor community. These zones aimed the reproduction of marine species, therefore any extractive activity of resources is allowed.
- **Multiple use zones** – Land areas for the sustainable use of resources by local populations and other actors properly licensed by the government of Mozambique. These areas are intended for a sustainable, economic and social development, environmental protection,

habitats and ecosystem processes protection and for other activities that could maintain the ecological and environmental integrity of the area.

- **Touristic investment zones –** areas that are available for implementation of projects and touristic buildings. It is required to obey with the touristic guidelines.
- **Vacation housing zones -** individuals will be allowed to establish holiday houses, with the permission of the APAIPS Administration, and payment of an annual rate of biodiversity maintenance to be established by MITADER and ANAC.

4.3.7. FISHERIES AND AQUACULTURE

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%), as it can be observed in the table below.

Table 4.1 - Evolution of the fisheries items and its trends between the survey years (*no data available).

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

Sources: Santos, 2007 *in* Paula *et al.*, 2015; IDPPE, 2007 and 2012 *in* Paula *et al.*, 2015

Overall 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. Regarding aquaculture, currently there are at least two approved processing units and one fish farm in Pebane district, according with data provided by the DPTADER of Zambezia. However, there may be more, since it was not received data from the DPTADER of Nampula nor from Zambezia and Nampulas's Provincial Directorate for Fisheries (Paula *et al.* 2015). So, with the poor investment in aquaculture and with the increase of fishermen numbers, it is expected that the exploitation of the fishable biomass also increases.

4.3.8. FRESHWATER

The Islands 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. These waters generally have high temperatures and low salinity, when compared to seawater and are rich in nutrients, which influences the distribution of fauna and flora in the region (MITUR, 2014a). Regarding the islands regions, there are considerable underground aquifers, for instance, the water retention rate in the coastal of Moma district is around 294mm per year. Some of them, like Muebase underground, the water has a concerning concentration of sulphates, which may affect many forms of life (MIITUR, 2014a). There is no indication of a potential dam construction inside the PSEPA Archipelago (AquaGlobal, 2014).

4.3.9. MOST RELEVANT HABITATS AND HIGH-PROFILE SPECIES

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.

The area 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. According to PSEPA Management Plan, on this area could also exist the most important distribution area for Coelacanth (*Latimeria chalumnae)*. 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).

Onshore there are: at least 32 amphibian species, including an endemic toad - Lindler's dwarf toad (*Bufo linderi*); at least 60 reptile species, with the occurrence of two endemic species: the snake (*Dromophis* sp.) and the diurnal gecko (*Lygodactylus* sp.); around 230 bird species with important nesting places for sooty terns (*Sterna fuscata*) and for swift terns seagulls *(Thalasseus bergi)*. For mammals, at least 19 are included in the IUCN Red List and there is occurrence of lions, hippopotamus, elephants, African wild dogs, etc.

Regarding Flora species, 21 deserve special attention as threatened species, and there is also an important endemic tree - *Icuria dunensis* – as well as the occurrence of eight mangrove important species.

4.4. SUMMARY OF THE CLIMATE VULNERABILITY AND CAPACITY ASSESSMENT (CVCA) UNDERTAKEN FOR PSEPA

A total of three assessments were undertaken for the PSEPA area between 2011 and 2015, in order to evaluate the adaptive capacities of the communities to the implications of climate changes on their lives.

The methodology applied for these studies was based on the Climate Vulnerability and Capacity Assessment (CVCA) method developed by CARE International (CARE, 2009) and WWF Alliance for the Adaptive Learning Programme (ALP).

The main purposes of CVCA process is to analyze livelihoods of vulnerable communities and the climate-related challenges they face, help communities to understand climate risks and identify the resources available to them to adapt and gather information to design adaptation strategies.

All assessments identified communities highly vulnerable to climatic changes, and that depend on the resources from fisheries and agriculture sectors, essentially. Therefore, the main required

strategies to enhance communities capacity lies on resources management improvement, including fisheries and agriculture, as well as the importance of gender and power dynamics in determining strategies, in more knowledge and education for communities, and in access to more diversified livelihood sources.

These three assessments took place in different communities of Nampula Province, as it has the typical characteristics of coastal areas in Mozambique and the east coast of Africa in general.

4.4.1. SUMMARY OF THE CVCA UNDERTAKEN IN 2011

The first assessment (Cosijn, 2011) was undertaken in nine communities of Angoche district, Nampula province: Inland communities of Sinhanhe, Geba and Namupa, the coastal communities of Fungo, Thopa, Lipuene and Gelo-Sede and the island communities of Quelelene of Metubane.

All nine communities are exceptionally vulnerable to climate change and its impacts due to their high reliance of natural resources and lack of livelihoods capital are: i) declining access to potable water sources; ii) declining agricultural production due to erratic rainfall and crops diseases; iii) increasing food insecurity and hunger; iv) declining / collapse of fisheries resources in coastal and inland areas; v) increasing uncontrolled fires, causing crop and infrastructure damage, and vi) lack of alternative income sources, resulting in a high dependency on natural resource use, causing depletion and increased vulnerability.

There is potential to trial more resilient livelihoods, increase capacity, reduce risks to disasters and examine mechanisms to address the underlying causes of vulnerability. There is a need to engage with as many other stakeholders and institutions to create solid partnerships and mechanisms of working in order for successes to be achieved. Key focuses should be on strategies to strengthen the capacity of women and young people, who will bare the burden of the climate impacts, as access to water becomes scarcer, agricultural production declines and access to resources becomes more conflictual. The project should focus on lessons learnt from other organizations, quick wins which can be built on, and rolled out; and then expanded in order to harness the successes.

The proposed strategies to increase resilience are focused on:

- Fisheries and agriculture management;
- Rain water storage facilities;
- Diversification of crops and fruits for commercialization;
- Post harvest storage;
- Animal husbandry;
- Fish preservation;
- Mangrove replanting and dune planting;
- Disaster risk management plans and early warning systems;
- Training on technical and commercialization skills;
- Formulation of alternative incomes for communities;
- Community funds allocation;
- Strengthen the capacity of women and young people, who will take the burden of the in access to water and agricultural production, and;
- Develop skills in the community groups to conflict resolution.

4.4.2. SUMMARY OF THE CVCA UNDERTAKEN IN 2014

The second CVCA (Skinner et *al*., 2014*)* was only focused on coastal communities, which greatly depend on fishing resources. This assessment was carried out in two communities Mucuvula and Thapua, in Angoche and Moma Districts, and researchers worked with sex-disaggregated focus groups. The research answers the question, how do exposures, sensitivities and adaptive capacities mediate shocks to affect well-being and resilience over time?

During the study, local communities have reported more regular cyclones with stronger winds, increasingly variable rainfall and higher temperatures. Overfished stocks, depleted soils and food insecurity in coastal communities appear to suggest distinct, technical interventions. Ecological shocks are indeed, the key threat to livelihoods in Nampula Province. But the importance of holistic gender and power analysis for designing programs to help marginalized community members stay out of poverty cannot be overstated. Authors reported the importance in remind that ecological shocks are not isolated from economic, social and political stressors. Rather, they occur simultaneously or successively, with cumulative impacts. Only by understanding the cumulative impacts of idiosyncratic and covariate shocks and stressors on poor fishermen, women and children can ecologically, socially and economically-savvy investments be made.

Summary findings on this assessment indicate:

- In order to increase the adaptive capacities of communities dependent on small-scale fisheries, additional investments or coordination are required to ensure access to a suite of financial and social services and safety nets;
- The importance of gender and power dynamics in determining the strategies that people access to manage risks, stressors and shocks, once they mediate it by gender and power dynamics. For instance, before wet season, women reinforce houses with mud and leaves, while men are in charge of using grass and sticks for the same purpose;
- Interventions should promote the access of small-scale fishermen, poor women and girls to strategies for adapting to idiosyncratic shocks, economic risks and climate change impacts;
- Improvement of fisheries governance by expanding the meaningful participation of male and female marine resource users in fisheries co-management as well as the enforcement capacity of the Ministry of Fisheries;
- Requirements to empowering communities with knowledge of their rights increasing their power to negotiate with companies for more equitable benefit-sharing from exploitation of the natural resources upon which their livelihoods depend, and;
- The importance in access to price information, weather alerts, climate projections, education and training can improve assessment and management of diverse risks.

4.4.3. SUMMARY OF THE CVCA UNDERTAKEN IN 2015

The third assessment (Artur *et al*. 2015) was undertaken in a total of 9 communities, 7 in Agoche (Quiloua, Catamoio, Manziwane, Mauanamogore, Boila-Velha, Namiepe and Namaule) and 2 in Moma district (Coropa and Mavule).

The assessment used four main tools for CVCA, namely (i) resource & hazard mapping (ii) seasonal calendars (iii) historical timelines and (iv) vulnerability matrix with three different social groups (men, women and youth). These tools were used to map (i) communities' relationship with different natural resources used; (ii) community perceptions of climatic and environmental change; (iii)

community climate vulnerability; (iv) community capacity and priorities and (v) community adaptation priorities.

The local communities have recognized a shift of the rainy season with stronger, increasingly variable and more intense rainfall, and that clime is much warmer now than it used to be before. The author reported the occurrence of 5 cyclones between 1984 and 1997, and 11 cyclones between 2000 and 2012 in Mozambique. Besides, according to local leaders of Quiloua (Angoche district), cyclones are notable by the level of destruction and damage they cause, even causing the loss of human lives.

Findings also reveal that these communities depend on natural resources for making a living. Their livelihoods are heavily based on fishing, forest products and agriculture. Fishing is mainly a male domain while agriculture is mainly a female domain and forest products are explored by both genders.

There was a consensus that (natural) resources – they depend on for making a living – are decreasing while climate risks are on the rise. And besides climate risks, local livelihoods are being jeopardized by increased bush fires, deforestation and erosion. Over the past years fish catches have been decreasing (in quantity and quality); forest (including mangroves) is decreasing as well as the fauna and flora that depend on the forest. Agriculture outputs are decreasing either because of unpredictable rainfall, reduction in fertile soils or due to increased pests and diseases.

The findings also show that their vulnerability to climate changes is related to higher exposure due to geographical location (close to the sea or deltas), higher susceptibility due to widespread poverty and limited adaptive capacity related mainly to poverty and weak social organization. Responses to climate risks are very limited. Generally people do what they have learnt from their ancestors and keep on digging the same practices again and again; innovation has been limited and this is leading to maladaptation, which is related to over fishing and over deforestation. In some communities, government and partners have made interventions to increase local organization and discipline the use of natural resources though local Natural Resource Management Committees (CGRN) or Community Fishery Councils (CCP), but the overall perception is that these have limited impact as people hardly obey them. In order to increase resilience there is a bold need for better natural resource management. This includes:

- Reducing pressure on fishing and forest exploitation by strengthening local institutions and by increasing monitoring and sanctions;
- Provide fishing boat licensing and control;
- Diversification of livelihood sources;
- Introduction/expansion of technical assistance (extension worker) for the livestock sector;
- Creation or reinforcing of CGRN and CCP in communities;
- Creation of community-run marine reserves where conditions allow it;
- Construction of community shelters especially for islands where possible and needed (especially on densely populated islands);
- Provide technical knowledge of erosion and forestry management mechanisms (especially of mangroves) and if possible intervention in areas that have been critically affected by erosion;
- Creating job or self-employment opportunities away from natural resource dependence and;
- Improving access roads to ensure better trading.

5. OBSERVED CLIMATE TRENDS AND DOWNSCALE PROJECTIONS

To access this particular subject, two main sources were used:

- *Analysis of observed trends and projections for selected climate parameters in Quirimbas National Park and Primeiras & Segundas* (Pinto *et al.,* 2016) – a Climate Systems Advisory Group (CSAG) of University of Cape Town (UCT) report, commissioned by WWF Mozambique, to provide a trend analysis of historical climate data and downscaled rainfall projections for QNP. The historical trend analysis looks at the period 1981-2014, while projections focus on the 2036-2065 period under a high-level emission scenario (RCP8.5). The historical trend analysis used satellite data from two gridded products, CRU TS (monthly temperature statistics) and CHIRPS (daily rainfall);
- *Climate Vulnerability Background Review for The Primeiras and Segundas Marine Reserve, Mozambique* (Paula *et al.*, 2015) – a review of trends and projections in climate and related physical and environmental parameters from other available literature.

5.1. OVERVIEW OF MOZAMBIQUE CLIMATE ENVIRONMENT

The majority of the Mozambican territory is situated in the intertropical zone. As a result, it is subject to four main factors of atmospheric circulation (Tyson and Preston-White, 2000 *in* Pinto *et al.,* 2016): (1) the Inter-tropical Convergence Zone (ITCZ); (2) the semi-permanent South Indian Anticyclone and South Atlantic Anticyclone; (3) thermal lows along the coast, as result of the deepening of semi-permanent trough over Mozambique Channel during summer; and (4) tropical storms and cyclones over the Mozambique Chanel. Rainfall events in north of Mozambique occur due to convective events linked to the migration of the ITCZ about the equator, leading to just one precipitation season over the region (Mutai and Ward 2000 *in* Pinto *et al.,* 2016). Heavy rainfall events are however associated with the passage of tropical cyclones in summer months which emanate from the tropical Indian Ocean and pass along the Mozambique Channel, usually from north to south. The rainfall has moderate spatial variability over the region. Northern Mozambique has two seasons, the rainy and hot season, lasting from November to April, and a dry and cooler season, from May to September (Pinto *et. al*, 2016).

According to INGC (2009) and Tadross *et al.* (2009) *in* Paula *et al*. (2015), Mozambique country-wide model projections for 2050-2200 indicate that November will become drier in the north region. Data also suggests a reduction of precipitation in December and an increase to a peak in 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. Yet, in Pinto *et al*. (2016), analysis of extreme climate indices suggest that rainfall in PSEPA area is becoming more intense, with longer dry spell durations in between, reflecting indeed, an overall shortening of the rainfall season.

Pinto *et al*. (2016) reports that globally the climate is unequivocally getting warmer. Since 1850 that each of the 3 last decades has been warmer than the previous ones. During the last 30 years, the influence of Man on climate has had visible effects on physical and biological systems.

The same study also shows for PSEPA, that temperature was between 0.2 and 0.4 °C higher in the first decade of the 2000s, when compared to average temperature for the period 1963 to 2012. Cyclones seem to have become more frequent, leading to devastating flood events. Sea level rise and storms will certainly have deleterious effects on tourism infrastructures as well as other coastal settlements, which are located very close to the shoreline (INGC, 2009 *in* Paula *et al*. 2015).

5.2. AIR TEMPERATURE

Trends

According to INGC study (2009), the average temperature of Angoche district is 25˚C, with temperatures in the main growing season on average exceeding 30.4˚C and average minimum of 20.8˚C.

The analysis by Pinto *et al.* (2016) clearly detects a warming signal, as all locations in northern Mozambique were warmer, on average, in the 2000s than in the 1970s. Over PSEPA maximum (minimum) temperature has increased by 0.3-0.4°C (0.2-0.3 °C) in the 2000s. Similarly, records of atmospheric temperatures from 1993 to 2013 observed at Angoche meteorological station show an increase of the average temperature for the hot and the cold seasons, of 0.13 and 0.16 ˚C per year for December-January-February (DJF) and June-July-August (JJA), respectively (INGC, 2009b *in* Paula *et al.,* 2015).

According to INGC, 2009b *in* Paula *et al*. (2015), considering a time series from 1960 to 2005 for the northern region of Mozambique, there is an increase of approximately 1.1˚ C for the months March-April-May (MAM) and September-October-November (SON) for the average maximum annual temperature. The INGC report also indicates that the average maximum annual temperature was usually bellow 30° C before 1990 but afterwards, higher temperatures became common. The increase in average maximum annual 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 in the northern region of Mozambique.

5.3. RAINFALL

In PSEPA, average rainfall ranges from 800 to 1200 mm a year (Pinto *et. al*, 2016).

Trends

Pinto *et al*. (2016) found the following observed trends for PSEPA, over the 1981 to 2014 period:

i. Decrease of the rainfall since the 1990s
ii. Rainfall reductions of more than 80 mm in the first decade of the 2000s.
iii. An increase in the number of consecutive dry days of about 0-40 days per decade.
iv. Decrease of the total annual rainfall.
v. More dry days ans less overall rainfall
vi. Decrease of the number of rain days with precipitation above 20mm and of very wet days.
vii. Increase of the five day rainfall and rainfall intensity.
viii. Rainfall season is becoming shorter but more intense, and a shift in the rainy season into later dates in November have been registered.

This shows that while there are indications of changes to the way it rains in QNP, there are also indications of changes to when it rains through a shortening of the rainfall season.

Projections

Pinto *et al*. (2016) has concluded that the following trends are projected to occur in PSEPA: i) an increase of the dry days in about 10%; ii) increase of the annual rainfall in 10%; iii) a 10% increase of the average annual rainfall in P&S; iv) a 20% increase of the total rainfall in the days when it rains

a lot in many areas of the P&S; v) a 10% increase of the maximum rainfall in five consecutive days in most of the P&S; vi) a 10% increase of the rainfall intensity in most of the P&S islands.

The projections are thus suggesting that in the future, PSEPA may experience an increase in overall rainfall and in the frequency and intensity of heavy rainfall events, but with longer periods of dry spell in between. Pinto *et al*. (2016) also refers that the extreme events will continue to be more frequent.

According to KNMI (2007) in Paula et al. (2015), data suggest 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 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 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 in Paula et al., 2015).Cyclones

Trends

According to Paula *et al*. (2015), the 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. Nevertheless in recent years, reports of flood events have increased and heavy rainfall events are indeed associated with the passage of tropical cyclones in summer months which emanate from the tropical Indian Ocean and pass along the Mozambique channel usually from north to south (Pinto *et. al*, 2016).

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.

According to Østergaard (2008) in Paula *et al*., 2015, the PSEPA area is most affected by cyclones and flooding. Logchem et *al*. in Paula *et al*., 2015, further attribute the frequency of these events to climate change. This region is considered a high-risk zone for such climate shocks.

Projections

Cyclones, heavy rains and floods, sea level rise, saltwater intrusion, coral reef discoloration, will have adverse impacts on socio-economic life and in local ecosystems. It is expected that changes in the wind patterns (direction and strength) will strongly affect the local fishing communities. Increased winds and surge can potentially cause erosion and risk turtle nesting sites at low lying islands such as Mafamede and Puga-Puga (Paula *et al*., 2015)

Although the PSEPA is not prone to high cyclone and storm activity (INAM, 2009 *in* Paula et *al.,* 2015), 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).

5.4. PHYSICAL OCEANOGRAPHY

Trends

Pinto *et al.* (2016) reports that the sea surface temperature (SST) on the Mozambican coast were warmer, on average, in the 2000s than in the 1980s.

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).

In Pinto *et al*. (2016), for PSEPA, data on SST shows a high variability year to year, presenting a general positive trend of 0.22 to 0.31°C over the period 1982 to 2014.

According to the IPCC (2007), tropical oceans are projected to experience the greatest increases. Recent models predicted that globally, average sea surface temperatures will increase by 0.3°C–0.6°C, and ocean acidification is expected to compound the negative effects of this phenomena. With the predicted increase in sea surface temperature, 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 sea 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 (Paula *et al*. 2015)

Projections

Looking at data from the tidal station network of Mozambique, including Angoche, Moma and Pebane, a 2002 study (Sete *et al.*, 2002 *in* Paula *et al.*, 2015) 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.

The INGC report (2009), suggests 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 are lacking. Additionally, INGC 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 of coastal communities would be left without potable water due to the increases salinity of ground water.

Sea level rise will also 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, 2009). Turtle nesting sites (mainly on selected islands such as Puga-Puga and Mafamede) are also at risk.

The extreme effects of climate change also cause variation in physical parameters such as temperature and salinity of the oceans and estuaries, causing coastal erosion.

5.5. POTENTIAL CLIMATE TRENDS EFFECTS ON BIODIVERSITY, ECOSYSTEMS, PHYSICAL OCEANOGRAPHY, LOCAL COMMUNITIES, RAINFALL AND EXTREME EVENTS

Biodiversity and Ecosystems

- **Loss of nesting habitats as well as productive feeding areas for sea turtles** – this can potentially conduct marine turtles towards local extinction if current anthropogenic stressors are not dealt with.
- **The change in daily patterns of other high profile species** - species such marine mammals and whale sharks may need to seek for refugee and to find other foraging grounds being

relatively resilient to climate change at local level, given their ability to migrate long distances (Paula *et al*. 2015).

- **Negative effects for fish and invertebrates** - 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.
- **Physiological stress on coral reefs** – this is due to ocean warming and acidification, both of which are gradually reducing their habitat (Veron, 2011 *in in* Paula *et al*. 2015).
- **Habitat loss for coral reefs and seagrass** - Heavy floods usually result in massive amounts of nutrients, reduced salinity, light penetration and sedimentation (areas of coral reefs and seagrass covered by sand) (Paula *et al*. 2015).
- **Coral reefs degradation** - 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 (Paula et *al.,* 2015)
- **Several impacts on mangroves –** it is expected from sea level rise the 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 in Paula et *al*., 2015).

Local communities

- **Dramatic impacts on fish production** - this 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 North of Mozambique (Mauea, 2007 *in* Paula *et al*. 2015);
- **Reduction of small-scale fisheries and mollusc mariculture** - this can be anticipated based on scenarios of decreasing pH by 0.5 (Sumaila *et al*., 2015 *in* Paula *et al*. 2015). The ecological and socio-economic consequences for 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 (Paula *et al*. 2015);
- **Increase of the prevalence of diseases** - from 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 (Nicholls *et al.* (2007) *in* Paula *et al*., 2015).
- **Decrease of fish catches** - PSEPA communities have the perception of the climatic change and people refer that fish catches and forest (including mangroves) are decreasing as well as the fauna and flora that depend on the forest (Artur *et al*. 2015).
- **Reduction of aquaculture production -** 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 (Maueua, 2007 in Paula *et al.,* 2015).
- **Deleterious effects on fish and invertebrate fisheries** - 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 in Paula et *al*., 2015)

- **Reduction of agriculture production** - The inherently low fertility of the sandy soils found in the coastal areas, high temperatures, and erratic rainfall all make it difficult for farmers to produce certain crops which are rainfall variability sensitive (such as maize) (Co-Arq, 2008 in Paula et *al.,* 2015)

6. SUMMARY OF EXISTING CURRENT CLIMATE COPING AND ADAPTATION MEASURES IN PSEPA

6.1. SUMMARY OF KEY GOVERNANCE INSTITUTIONS, SYSTEMS AND POLICIES

Paula *et al.* (2015) assessed the Mozambican relevant policies & strategies on Climate Change.

In 2005, MICOA (current MITADER) published a first national approach to this subject called Assessment of the Vulnerability to Climate Change. In 2007 the same institution published the National Adaptation Programme of Action (NAPA). This document included the summary of four initiatives, for various economic and social development sectors, with special emphasis on the prevention of natural disasters and Alert and Early Warning Systems; the agricultural, fisheries, energy, environmental and water sectors; coastal zones; and erosion control. Finally, in 2012, this institution published the National Strategy on Climate Change (2013-2025), which intended to establish action guidelines 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 giving priority to local resilience, combating poverty and identifying opportunities (Paula *et al*. 2015). The following activities should be included and implemented in district, provincial and national planning:

- 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;
- Crop diversification and introduction of crops more resistant to variations in climate parameters and improve the agricultural productivity with appropriate technology and inputs adapted to climate change;
- Regenerate mangroves and implement protective measures on seaweed, seagrass, coral reefs and other critical ecosystems. Increase adaptive capacity of vulnerable people by applying innovative approaches to community-based adaptation, and improving the effectiveness of programs on social protection and 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; and
- Promote best practice amongst operators and tourists, through public-private partnerships aimed at the resilience of the sector and the conservation of ecosystems.

In terms of governance, MITADER is the institution that coordinates the activities related to climate change, FUNAB coordinates financing issues and UMC undertakes monitoring and evaluation. Several stakeholders like the private and public sectors, civil society, community organizations, cooperation partners, among others, will implement the NSCC.

Provincial governments and Municipalities are supposed to integrate this issue in their policies and plans.

Two other institutions are also relevant regarding climate change: i) INAM – does the surveillance and monitoring of the weather; and ii) INGC – manages day-to-day matters related to disasters.

At PSEPA, the current Management Plan doesn't include activities and measures to deal directly to climatic changes. However, according to Artur *et al*. (2015) the governments of the districts of Angoche and Moma developed, in 2014, their district level adaptation plans, which seek to provide

the major intervention lines for climate adaptation. The Angoche climate adaptation plan focuses on increasing agriculture and livestock resilience, increasing the resilience of fisheries and promoting sustainable trade and resilient infrastructure; while the Moma plan focuses on increasing agriculture and fisheries resilience, improve water and flora/fauna management and improving institutional capacity- building.

6.2. COPING AND ADAPTION STRATEGIES

The literature makes an important distinction between coping and adaptation strategies. Coping strategies refer to reactive and short-term initiatives that help individuals and households get by in the face of a particular shock, whereas adaptation strategies refers to the practices and ability of individuals or communities to adjust to shocks that anticipate a challenge, facilitating longer-term growth through change (Skinner *et al.* 2014).

According to Skinner *et al.* (2014) and Cosijn (2011), community members in PSEPA have developed a number of strategies to cope with the effects of climate risks and stresses on livelihood resources. However, their capacity to adapt is limited by the lack of alternative sources of livelihood and finance, in a context of lack of access to basic health care and potable water supply. In particular, the lack of construction techniques and materials resistant to weathering and lack of maintenance of basic infrastructure, particularly roads, constitute barriers to adaptation. Low and variable agricultural production due to crop losses due to floods and droughts represent an additional pressure on the livelihoods of rural households. Additionally, some communities have lack of resources and / or capacity to avoid increasing levels of extraction of natural resources. Therefore, in this context some of the strategies have the potential to be adaptive measures, which are practices that anticipate a challenge and promote longer-term resilience. Others are short-term answers to manage crises (coping), and may potentially have negative impacts on ecosystems and resources on which they depend on.

Table 6.1 below summarises adaptation and coping responses to climate risks and stresses adopted by communities living in PSEPA (adapted from Cosijn, 2011 and Skinner *et al*. 2014).

Table 6.1 – Distinction between coping and adaptation responses to different risks and stresses

Risks and stresses	Measures	Unsustainable coping / adaptation
Heavy rains & floods	Rebuild homes in the same places	Coping
	Changing farmland to higher fields	Adaptation
	Gather food and water to survive bad weather	Coping
Drought	Travel long distances to find water	Coping
	Ration water for drinking and cooking	Coping
	Use of river water	Coping
	Changing farmland to areas where the soil better retains humidity	Adaptation
Declining Fisheries productivity	Use mosquito nets to capture smaller fish	Coping
	Hand collection of marine products for nutrition & income	Coping
	Fall back in agriculture for nutrition & income	Coping
	Report industrial infractions to the Ministry of Fisheries	Coping
	Migrate seasonally for improved fish captures & income generation	Adaption
Lower Agriculture Productivity	Fall back on fishing or hand collection of marine products	Coping

Risks and stresses	Measures	Unsustainable coping / adaptation
	Purchase agriculture products outside of communities	Coping
	Pull crops early to avoid brown streak	Coping
	Migration of young men to obtain incomes	Coping
	Use of Pesticides	Coping
Hunger & malnutrition	Reduction in meal number &/or size	Coping
	Hand collection of marine products & wild fruits	Coping
	Exchange crops or fish products for food	Coping
	Change of eating habits – eat leaves of cassava	Coping
	Sell household goods to buy food	Coping
	Plant fruit trees for communal use	Adaption
Illness, old age & death	Treatment by traditional plants/medicine	Coping
	Travel to hospital in Angoche	Coping
	Sell household goods to pay for medical treatment	Adaptation

In 2012 (ENAMMC, 2012) national authorities have already defined strategies to adapt to climate change, which have then been reflected in the National Strategy mentioned before. In Table 6.2 the proposed measures defined for each strategy are presented.

Table 6.2 – National adaptation measures to cope climate change defined to 2013-2025, by national authorities

Strategies	Domain	Adaptation measures
Institutional		Reinforce the previous warning system
		Reinforce preparation and actions capacities
		Adjustment of legislation
		Adjustment of institutional framework
		Reinforce research institutions
		Capacitation through technology and financial resources
Sectorial	Hydrological resources	Improvement of water management resources
		Build infrastructure for increased access, catchment capacity, storage, treatment and distribution of water
	Agriculture, Fishery, food Security and nutrition	Increase of agriculture and livestock resilience
		Increase of fishery resilience
		Ensure suitable levels of food security and nutrition
	Biodiversity	Ensure biodiversity protection
		Plan and manage biodiversity and coastal ecosystems

Strategies	Domain	Adaptation measures
	Forests	Develop programs that promote plantation of trees with multiple use and economic value
		Explore agro-sylvan-pastoral systems
		Encourage the participation of communities in the management of forest resources
		Encourage the participation of communities and other forest users to prevent and combat deforestation and uncontrolled fires.
	Carbon emissions	Mitigation and development of low carbon
		Promote low carbon urbanization
		Develop agricultural practices of low carbon
	Industrial processes	Emission control of the industrial processes including wastes and associated effluents
	Wastes	Manage and promote reduction, reutilization and recycling

7. RESULTS OF THE VULNERABILITY ASSESSMENT WORKSHOP

As described in section 3.4 a Pre-Workshop Meeting was held, immediately before the stakeholder workshop, between the 4th and the 6th February 2016 in Nampula. It was directed to the organizing team, group facilitators, one specialist per group (each group represented a unit) as well as to the consultants who would develop the current document.

As outlined in Section 2 of this report, a stakeholder vulnerability assessment workshop was held in February of 2016 with the aim of reviewing and synthesizing information from the vulnerability studies outlined in section 4 and 5 above, together with the experience and expertise of workshop participants, using the *Flowing Forward* assessment framework and Excel tool. The aim of the workshop was: (1) to identify and rate the vulnerability of PSEPA resources units and sub-units and; (2) identify and prioritize possible climate adaptation measures. Summarized results are presented below in this Section 7 and more detailed results are attached in Annexes II, III and IV.

Figure 7.1 - The Stakeholder Adaptation Planning Workshop held in Nampula, between 8th and 10th of February, 2016

7.1. VULNERABILITY

Projected vulnerability was assessed for each sub-unit according to the methodology explained in Section 2 above, where vulnerability is calculated as a function of (i) resilience; (ii) exposure to impacts and (iii) the additional influence of projected future climate change. It should be noted that

the 'scores' reported in this section are relative, semi-quantitative ratings assigned by expert working groups. As such scores are not comparable between different analysis units (i.e. different working groups).

7.1.1. General Overview of vulnerability results

As explained in section 4.2 above, 7 resource or analysis units were identified and assessed:

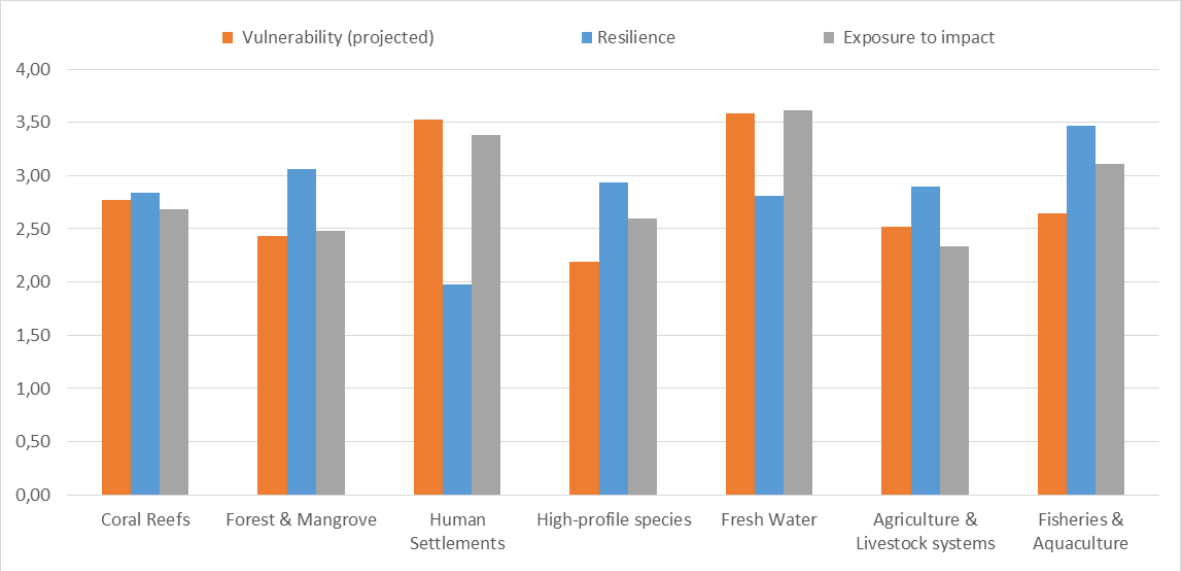
i. Coral Reefs;
ii. Forest & Mangrove;
iii. Human Settlements;
iv. High-profile species;
v. Fresh Water;
vi. Agriculture & Livestock systems and;
vii. Fisheries & Aquaculture.

Table 7.1 - Rankings of the 3 highest scoring units in terms of resilience, exposure and vulnerability.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Fisheries & Aquaculture 2. Forest & Mangrove 3. High-profile species	1. Freshwater 2. Human settlements 3. Fisheries & Aquaculture	1. Freshwater, 2. Human settlements 3. Coral Reefs

The figure below shows a comparison of the grand totals of each unit, for projected vulnerability, resilience and exposure.

Figure 7.2 - Grand Totals for projected vulnerability, resilience and impact exposure of each unit.



7.1.2. General overview by analysis unit

This section summarizes results for the different sub-units of each analysis unit. Detailed scores for impacts for the different sub-units can be seen in Annexes II to IV.

Detailed results for current vulnerability scores are available in Annex III.

7.1.2.1. Coral Reefs

Table 6.1Table 7.2 shows the top 3 scoring analysis sub-units of Coral Reefs unit, for each analyzed parameter.

Table 7.2 - Rankings of the 3 highest scoring sub-units of Coral reefs unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Non-protected & exposed coral reefs / Protected & exposed coral reefs 2. Non-exposed seagrass in deep lagoons 3. Protected & non-exposed coral reefs	1. Exposed inter-tidal seagrass 2. Non-protected & exposed coral reefs 3. Protected & non-exposed coral reefs	1. Exposed inter-tidal seagrass 2. Non-protected & non-exposed coral reefs 3. Protected & non-exposed coral reefs

Exposed inter-tidal seagrass had the highest vulnerability and exposure scores, especially because it is exposed to a high number of both development and climate impacts (which will increase the degradation of benthic habitats), and due to its low resilience score. On the other hand, protected & exposed coral reefs had the lowest vulnerability score, due to its higher resilience on account of its favorable conditions for refuge. Non-protected & exposed coral reefs had the same resilience score, but these reefs are no sheltered, being more exposed to impacts.

The figure bellow shows a comparison of projected vulnerability, resilience and impact exposure between sub-units.

Figure 7.3 - Averages for each sub-unit of the Coral Reefs Unit.

Note: Numbers inside the circles represent the number of impacts for each sub-unit.

Table 7.3 below shows that the hazard responsible for the highest vulnerability rating was a development hazard, namely: *Increase of fishing effort,* which will increase the degradation of benthic habitats. This impact is predicted to increase vulnerability in four sub-units: Protected & non-exposed coral reefs, protected & exposed coral reefs, exposed inter-tidal seagrass and non-exposed seagrass in deep lagoons.

It should be noted that 60% of the top 10 identified impacts are climate related.

Table 7.3 - List of the10 highest scoring impacts in terms of Projected Vulnerability in Coral Reefs sub-units

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	Degradation of benthic habitats (seagrass) by fishing effort increase	6,36	Exposed Inter-tidal Seagrass
2	Cyclone events cause massive destruction of coral reefs in the PSEPA archipelago due to the high hydrodynamic tensions associated with cyclonic winds	3,83	Exposed Inter-tidal Seagrass
3	Extreme temperature events of sea water can cause bleaching of coral reefs and mortality (zooxanthellae expulsion), linked to the loss of the physical structure and biodiversity of coral reef and biomass of other invertebrates, and loss of fish that depend on the sheltered coral structures of such reefs	3,67	Non-protected & non-exposed coral reefs (Inner reef)

Rank #	Impact	Vulnerability (projected)	Sub-unit
4	Degradation of benthic habitats (coral reefs) by fishing effort increase	3,48	Protected & non-exposed coral reefs (Inner Reef)
5	Extreme temperature events cause changes in spatial distribution and in sexual reproduction patterns of seagrass, as well as changes in their growing rates, metabolism and in their carbon balance	3,48	Exposed inter-tidal seagrass
6	Cyclone events cause massive destruction of coral reefs in the PSEPA archipelago due to the high hydrodynamic tensions associated with cyclonic winds	3,33	Protected & Non-Exposed Coral Reefs (Inner Reef)
7	Cyclone events cause massive destruction of coral reefs in the PSEPA archipelago due to the high hydrodynamic tensions associated with cyclonic winds	3,06	Non-Protected &Exposed Coral Reefs
8	Silting of the seagrass of the Casuarina and Epidendrum islands due to inadequate techniques of agriculture in the coastal area and to the absence of mangrove (Estuary of the river Ligonha, Mulela)	2,75	Exposed Inter-tidal Seagrass
9	Risk of marine pollution by spill of vessels' oils that support mineral resources operations	2,63	Non-Protected & Non-Exposed Coral Reefs (Inner Reef)
10	Risk of Coral reefs mortality by marine pollution by spill of vessels' oils that support mineral resources and oil operations in Segundas islands archipelago	2,57	Protected & Non-Exposed Coral Reefs (Inner Reef)

Note: Impacts represented in yellow are the climatic ones whereas the grey are the development impacts.

7.1.2.2. Forest & Mangrove

Table 7.4 shows the top 3 scoring analysis sub-units of Forest & Mangrove unit, for each analysed parameter.

Table 7.4 - Rankings of the 3 highest scoring sub-units of Forest & Mangrove analysis unit

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Protected coastal forest of Potone 2. Coastal Forest of Muebase	1. Coastal forest of Tapuito 2. Protected coastal forest of Potone	1. Coastal forest of Tapuito 2. Seaward fringing Mangroves

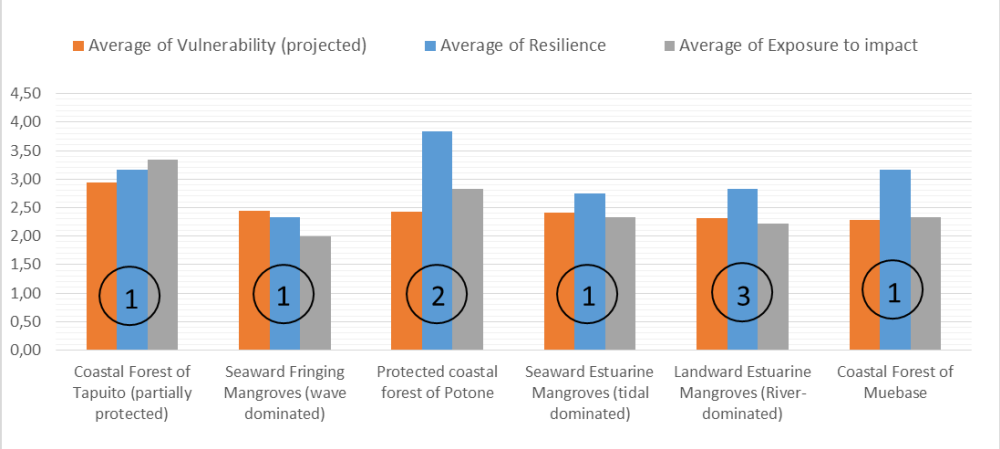
	Resilience	Exposure	Vulnerability
	3. Coastal forest of Tapuito	3. Seaward estuarine mangroves / Coastal forest of Muebase	3. Protected coastal forest of Potone

Coastal forest of Tapuito sub-unit presented the highest score for vulnerability, and the remaining sub-units presented similar scores for the same parameter. The same sub-unit had also the highest level of exposure, on account of human pressures which turn it more vulnerable to rivers siltation and loss of habitats.

The three coastal forest sub-units had high resilience ratings on account of higher species diversity and high dispersal rates. Costal forest of Potone for being protected, allows system to recover after extreme events, presenting the highest resilience score.

The figure below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7.3 – Averages for each sub-unit of the Forest & Mangrove analysis unit.



Note: Numbers inside the circles represent the number of impacts for each sub-unit.

For this unit, only 9 impacts were identified, as shown in Table 7.5.

The hazard responsible for the highest rated vulnerability was development type: *Logging and mining,* which leads to siltation of rivers and loss of habitats in the estuary of the Larde river. This impact is predicted to affect coastal forest of Tapuito (which is partially protected).

Analysing these top impacts on Forest and Mangrove, only 33,3% of are Climatic**.**

Table 7.5 - List of the top scoring impacts in terms of Projected Vulnerability for Forest and Mangrove sub-units.

Rank #	Impact	Vulnerability (projected)	Subunit
1	Logging and mining will lead to siltation of rivers and loss of habitats in the estuary of the Larde river	2,94	Coastal forest of Tapuito (partially protected)
2	The development of the mining industry (extraction of heavy sands) in the coastal zone of PSEPA islands (estuary of Larde and	2,89	Landward Estuarine Mangroves (River-dominated)

Rank #	Impact	Vulnerability (projected)	Subunit
	Sangage) removes the vegetation cover of mangrove forests creating habitat fragmentation		
3	Prolonged droughts associated with extreme atmospheric temperature events will contribute to the occurrence of fires and habitat loss in Potone forest	2,63	Coastal Forest of Potone
4	Strong wave events combined to storms in Angoche, Moma, Larde and Pebane lead to deposition of sediments in coastal area causing the burying of mangrove areas and compromising the potential for natural regeneration	2,44	Seaward Fringing Mangroves (wave dominated)
5	The disordered cut of mangrove for firewood and charcoal in the main channels of estuaries of Angoche, Moma, Larde and Pebane, greatly contributes for the increase of erosion	2,42	Seaward Estuarine Mangroves (tidal dominated)
6	The disordered exploitation of wood and mineral resources can contribute to reduction of coastal forest cover leading to loss of habitat	2,28	Coastal Forest of Muebase
7	The wood exploitation associated with the opening of new agricultural areas will lead to siltation of rivers and loss of habitats in the estuary of Angoche	2,22	Protected coastal forest of Potone
8	The increase in human settlements associated with the development of the extractive industry and tourism, can reduce the area of coastal mangrove in Moma and Sangage	2,15	Landward Estuarine Mangroves (River-dominated)
9	Prolonged droughts associated with high temperature events reduce discharges of rivers, increases evaporation and salinity of the soil, thus causing changes in the structure of mangrove forests in estuaries of Angoche, Moma, Larde and Ligonha	1,89	Landward Estuarine Mangroves (River-dominated)

Note: Impacts represented in yellow are the climatic ones whereas the grey are the development impacts.

7.1.2.3. Human settlements

Table 7.6 shows the top 3 scoring analysis sub-units of Human settlements unit, for each analysed parameter.

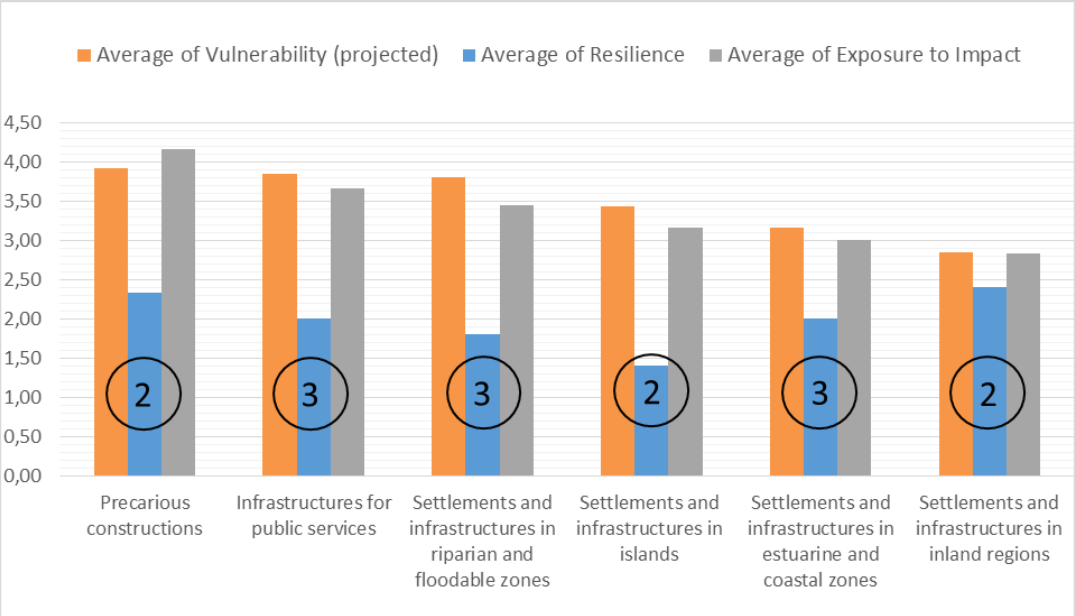
Table 7.6 - Rankings of the 3 highest scoring sub-units of Human settlements analysis unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Settlements and infrastructures in inland regions 2. Precarious constructions 3. Settlements & infrastructures in estuarine and coastal zones / Infrastructures for public services	1. Precarious constructions 2. Infrastructures for public services 3. Settlements and infrastructures in riparian and floodable zones	1. Precarious constructions 2. Infrastructures for public services 3. Settlements and infrastructures in riparian and floodable zones

The sub-units with the highest vulnerability rankings were precarious constructions and infrastructures for public services mainly due to high exposure rates to the projected occurrence of cyclones, storms and strong winds, which leads to destruction of houses and in case of infrastructures for public services it also may lead to power and access roads cuts. On the other hand, settlements and infrastructures in inland regions had the lowest vulnerability scores, due to its localization in areas with more miombo forests and reserves, allowing a greater protection to high winds and rains, and because these constructions are considered more robust.

The figure below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7.4 - Averages for each sub-unit of the Human Settlements analysis unit.



Note: Numbers inside the circles represent the number of impacts for each sub-unit.

The hazard responsible for the highest rated impact is the occurrence of cyclones, through strong winds and high waves, which may lead to destruction of houses and loss of mangrove forests that five protection to settlements in the islands.

This climate impact is expected to affect Settlements and infrastructures in the islands.

For this unit, all the top 10 impacts are climate type.

Table 7.7 – Top 10 scoring impacts (Projected Vulnerability) on Human settlements sub-units.

Rank #	Impact	Vulnerability (projected)	Subunit
1	The occurrence of cyclones, through strong winds and high waves, leads to destruction of houses and loss of mangrove forests that give protection to settlements in Coty Islands	4,44	Settlements and infrastructures in islands
2	The occurrence of cyclones, storms and high winds leads to destruction of precarious house construction	4,28	Precarious constructions
3	The occurrence of heavy rains can contaminate water sources that are used in communities	4,22	Infrastructures for public services
4	Heavy rains cause flooding in coastal areas of Larde contributing to flood and destruction of settlements and infrastructures, such as wells, houses and farms in the riverside areas of Larde and Meluli rivers	3,92	Settlements and infrastructures in riparian and floodable zones
5	The occurrence of cyclones, through strong winds followed by heavy rains, leads to flood and destruction of houses, farms and infrastructure in settlements of coastal and floodable areas	3,92	Settlements and infrastructures in riparian and floodable zones
6	The occurrence of heavy rains causes floods in the districts of Angoche, Moma and Larde, which contributes to cutting access roads to the Angoche district and regular power cuts in the city of Angoche	3,67	Infrastructures for public services
7	Occurrence of heavy rainfall that creates stagnant water ponds that increases waterborne diseases (e.g. cholera, diarrhea, dysentery through water contamination) and which are sites of Mosquitoes reproduction - Malaria vector) in the low areas of settlements and in estuarine and coastal areas infrastructures	3,67	Settlements and infrastructures in estuarine and coastal zones

Rank #	Impact	Vulnerability (projected)	Subunit
8	The occurrence of prolonged droughts will cause a shortage of water in wells and water sources used by communities, which will put pressure on the existing infrastructures (fountains) and will create disputes for lakes and ponds with other living beings	3,67	Infrastructures for public services
9	Occurrence of heavy rainfall that creates floods leading to stagnant water puddles that increases waterborne diseases (e.g. cholera, diarrhea, dysentery through water contamination) and which are sites of Mosquitoes reproduction - Malaria vector) in the coastal and floodable areas	3,56	Settlements and infrastructures in riparian and floodable zones
10	The occurrence of heavy rains which leads to floods that cause total or partial destruction of precarious house constructions	3,54	Precarious constructions

***Note:** Impacts represented in yellow are the climatic ones.

7.1.2.4. High-profile species

Table 7.8 shows the top 3 scoring analysis sub-units of High-profile species, for each analysed parameter.

Table 7.8 - Rankings of the 3 highest scoring sub-units of High-profile species analysis unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Whales 2. Dolphins 3. Sharks / Sooty tern (*Onychoprion fuscatus*) & Greater Crested Tern (*Thalasseus bergii enigma*)	*1.Icuria dunensis* 2.Hippopotamus 3.Marine turtles	*1. Icuria dunensis* 2. Marine turtles 3. Sooty tern (*Onychoprion fuscatus*) & Greater Crested Tern (*Thalasseus bergii enigma*)

Icuria dunensis was the sub-unit with the highest vulnerability. This is an endemic species of the PSEPA, threatened by anthropogenic activities. It is also the sub-unit with higher levels of exposure mainly due to the characteristics of its habitat, which make it particularly exposed to cyclone and storm events. Whales, on the other hand, was the sub-unit with lower score for vulnerability. This is mainly due to the fact that this was the sub-unit with the highest resilience and the impacts predicted on it are not expected to be exacerbated by climate changes.

The figure below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7.5 - Averages for each sub-unit of High-profile species

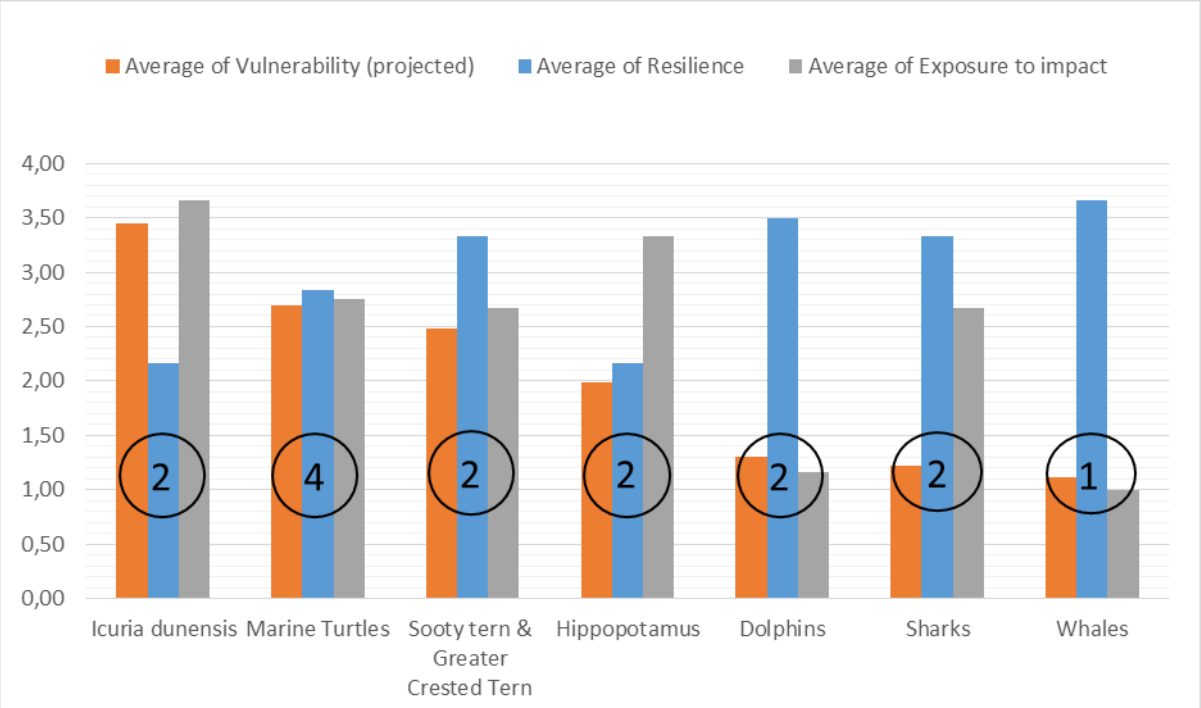


Table 7.9 shows that the hazard responsible for the highest vulnerability impact was *expansion of farm areas mainly along the Munir rivers, Mulela, Molocué, Ligonha*, which is projected to cause conflicts and competition for space with large Fauna, to compromise the local population of hippopotamus and to cause disrupts in the functioning of ecosystems. This development impact is predicted to affect hippopotamus, especially during the dry season. At this time of the year the water resources are scarce and both humans and hippos use the same areas. This also happens close to the coastal area. Hippos play an important role in the ecosystem, mainly in the cleaning and sediment retention of rivers.

Regarding the type of impact for this unit, only 30% of the top 10 are Climatic.

Table 7.9 – Top 10 scoring impacts (in terms of Projected Vulnerability) in High-profile species sub-units.

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	Expansion of farm areas mainly along the Munir rivers, Mulela, Molocué, Ligonha, causing conflicts and competition for space with large fauna and involving hunting, whether legal or illegal, which compromises the local population of hippo and disrupts the functioning of the local ecosystems	3,97	Hippopotamus
2	Due to the characteristics of its habitat (dunes and sandy areas), *Icuria dunensis* is particularly exposed to cyclone events, storms, strong winds (south of Potone and Moebase forests)	3,79	*Icuria dunensis*

Rank #	Impact	Vulnerability (projected)	Sub-unit
3	Associated operations to the extractive industry are approaching the places where *Icuria dunensis* occurs, which may directly affect the species aggregates - heavy areas in Moebase, Sangage and Larde - oil and gas prospection	3,11	*Icuria dunensis*
4	The increasing number of fishermen is forcing them to go to the PSEPA islands, collecting turtle eggs	3,06	Marine Turtles
5	Illegal and accidental hunting of turtles is affecting the local population in every PSEPA islands	3,06	Marine Turtles
6	The increasing number of fishermen is forcing them to go to the Puga Puga area, collecting the tern eggs causing decline in adult populations	2,89	Sooty tern (*Onychoprion fuscatus*) & Greater Crested Tern (*Thalasseus bergii enigma*)
7	Cyclone events, storms, strong winds and high tides are eroding and flooding the nesting area of leatherback turtle mainly on the islands of Puga Puga, Coroa, Baixa Miguel and Baixa Sto. Antonio with less vegetation cover, which causes the loss of habitat conditions for nesting, compromising the reproduction of the local marine turtle population	2,63	Marine Turtles
8	Illegal and accidental hunting of sharks is affecting the local population in every islands of PSEPA, mainly: Njovo and Ponta caldeira, in Larde district. They mainly operate with bottom gillnets	2,44	Sharks
9	Cyclone events, storms, strong winds and high tides are eroding and flooding the nesting area of terns on the islands of Puga Puga, reducing the available area for laying eggs, compromising the reproduction of the local species population	2,08	Sooty tern (*Onychoprion fuscatus)* &Greater Crested Tern (*Thalasseus bergii enigma*)
10	Increase of water pollution, that may affect feeding areas: the corals around the Second islands or the islands themselves, nesting sites.	2,06	Marine Turtles

Note: Impacts represented in yellow are the climatic ones whereas the grey are the development impacts.

7.1.2.5. Freshwater

Table 7.10 shows the top 3 scoring analysis sub-units of Freshwater unit, for each analysed parameter.

Table 7.10 - Rankings of the 3 highest scoring sub-units of Freshwater analysis unit.

	Resilience	Exposure	Vulnerability

Highest scoring analysis sub-units	1. Permanent rivers 2. Water holes 3. Lakes	1. Lakes / Lagoons 2. Gutter pipes & water tanks 3. Wells / Permanent rivers	1. Lagoons 2. Gutter pipes & water tanks 3. Lakes

The sub-unit with highest vulnerability was lagoons, which for being water bodies with small extension are very exposed to water contamination. This is mainly due to floods and to the decrease of freshwater availability when evaporation increases during high temperatures periods. Water holes was the sub-unit less vulnerable, mainly because the availability of freshwater on it, not always is affected by climate events and because of its great connectivity to water table.

The figure below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7.6 – Averages for each sub-unit of the Freshwater analysis unit.

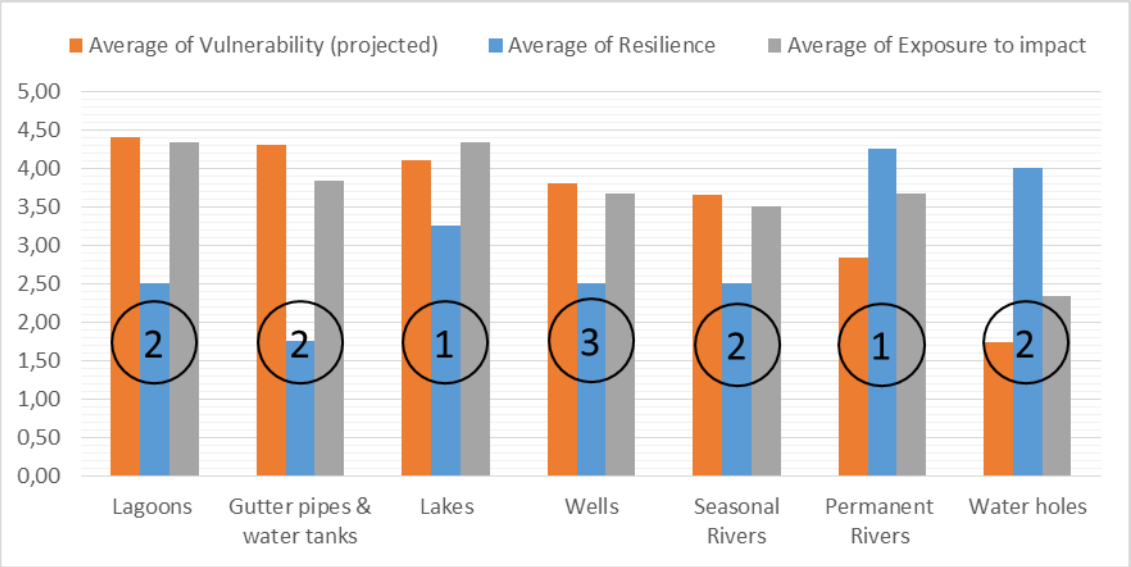


Table 7.11 shows that the hazard that was responsible for the highest rated impact is *heavy rains* which leads to floods that cause contamination of drinking water sources in low areas along the coast and destruction of wells. This is a climatic impact and is predicted to affect wells.

For this top 10 impacts, 80% are Climate type.

Table 7.11 – Top 10 scoring impacts (Projected Vulnerability) on Freshwater sub-units.

Rank #	Impact	Vulnerability (projected)	Subunit
1	Heavy rains lead to floods that cause contamination of drinking water sources in low areas along the coast and destruction of wells	5,00	Wells

Rank #	Impact	Vulnerability (projected)	Subunit
2	Periods of high air temperatures (max and min) cause the increase of evaporation in lakes, ponds, wells and boreholes, which decreases the availability of freshwater	4,40	Lagoons (E.g. Larde: Maganha, Cerema, Ninte, Carroa, Incurro, Iriata e Mpaia; in Angoche: Sangage)
3	Long period rains cause floods and leads to contamination of drinking water source	4,40	Lagoons (E.g. Larde: Maganha, Cerema, Ninte, Carroa, Incurro, Iriata e Mpaia; in Angoche: Sangage)
4	High tide events cause saline intrusion in Moma Island, where the underground water, the main source of fresh water for consumption, becomes brackish (salinization of drinking water)	4,40	Wells
5	Long periods without rain causes a decrease in freshwater availability	4,20	Seasonal Rivers (E.g. Larde River)
6	Periods of high air temperatures (max and min) cause the increase of evaporation in lakes, ponds, wells and boreholes, which decreases the availability of freshwater	4,10	Lakes
7	The increase in social infrastructures (e.g. schools) is followed by an increase in water retention systems which causes the increase of freshwater availability	3,90	Gutter pipes & water tanks
8	Drought periods caused by lack of precipitation in local rivers basins, lead to lack of water in the seasonal rivers and its lakes, affecting agriculture, human consumption and wildlife	3,12	Seasonal Rivers (E.g. Larde River)
9	The periods of drought are associated to the reduction in the river flow and lead to the increase of saline intrusion which makes the water unsuitable for use in agriculture	2,84	Permanent Rivers (E.g. Ligonha River, Meluli River)
10	The population increase in the insular area increases the pressure on water resources and reduces the availability of water in aquifers of the Islands	2,00	Wells

Note: Impacts represented in yellow are the climatic ones whereas the grey are the development impacts.

7.1.2.6. Agriculture & Livestock systems

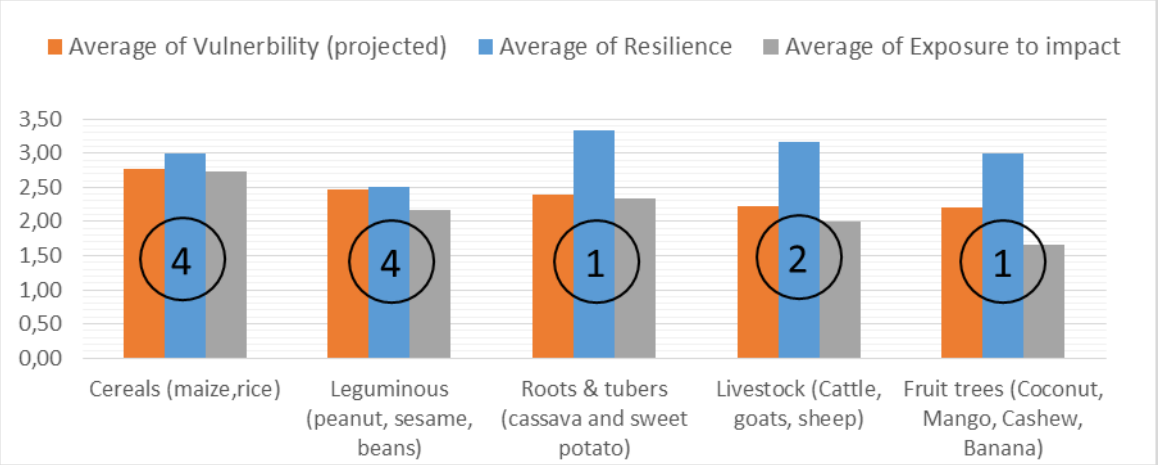
Table 7.12 shows the top e scoring analysis sub-units of Agricultural & Livestock Systems unit, for each analysed parameter.

Table 7.12 - Rankings of the 3 highest scoring sub-units of Agricultural & Livestock Systems unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Roots & tubers	1.Cereals	1.Cereals
	2. Livestock	2.Roots & tubers	2.Leguminous
	3. Fruit trees / cereals	3.Leguminous	3.Roots & tubers

Overall the sub-unit with the highest vulnerability was Cereals. This can be explained by its high number of impacts associated and to its exposure to cyclones, storms and heavy rain events, which may lead to the loss of crops or to the decrease of production. Roots & tubers were the most resilient sub-unit due to its tolerance to heavy rain events and to its great capacity of regeneration.

Figure 7.7 - Averages for each sub-unit of the Agriculture & Livestock systems.



The impact with the highest associated Vulnerability was: *Heavy rainfall events* that cause floods and erosion of the area that is intended to agriculture production, causing loss of crops in the districts of Angoche, Larde, Moma and Pebane,. This is a Climatic impact and is predicted to affect mainly leguminous and also cereals.

From the top 10 impacts of this unit, 90% are Climate type.

Table 7.13 - Top 10 scoring impacts (Projected Vulnerability) in Agriculture & Livestock systems sub-units

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	Heavy rainfall events that cause floods and erosion of the area that is intended to agriculture production, causing loss of crops in the districts of Angoche, Larde, Moma and Pebane (Leguminous)	3,85	Leguminous (peanut, sesame, beans)
2	The occurrence of cyclones followed by strong winds cause the loss of cultures or the layering in the coastal region of Angoche district (cereals)	3,80	Cereals (maize,rice)

Rank #	Impact	Vulnerability (projected)	Sub-unit
3	Heavy rainfall events that cause floods and erosion of the area that is intended to agriculture production, causing loss of crops in the districts of Angoche, Larde, Moma and Pebane (cereals)	2,93	Cereals (maize,rice)
4	Unpredictable rainfall events (late onset of the rains) associated with high temperatures cause the outbreak of pests and diseases that cause loss of crops in the districts of Angoche, Moma, Larde and Pebane	2,57	Cereals (maize,rice)
5	Reduction of the area for agricultural production in the communities of Nathire and Kanhawa due to the presence of industry production and sisal processing (roots)	2,39	Roots and tubers (cassava and sweet potato)
6	Unpredictable rain events (late onset of rains) which lead crops to not reach their productive potential, causing the reduction of production (cereals)	2,38	Cereals (maize,rice)
7	Unpredictable rainfall events associated with high temperatures cause the outbreak of pests that cause animal diseases in the districts of Angoche, Moma, Larde and Pebane	2,33	Livestock (Cattle, goats, sheep)
8	Unpredictable rain events (late onset of rains) which lead crops to not reach their productive potential, causing the reduction of production	2,20	Leguminous (peanut, sesame, beans)
9	The occurrence of cyclones followed by strong winds cause the removal of the fertile layer of soil for agriculture (erosion) providing the impoverishment of the soil and consequently reduction of production	2,20	Cereals (maize,rice)
10	The occurrence of cyclones followed by strong winds cause the loss of crops in the coastal region of the Angoche district	2,20	Fruit trees (Coconut, Mango, Cashew, Banana)

Note: Impacts represented in yellow are the climatic ones whereas the grey are the development impacts.

7.1.2.7. Fisheries & Aquaculture

Table 7.14 shows the top 3 scoring analysis sub-units of Fisheries & Aquaculture unit, for each analysed parameter.

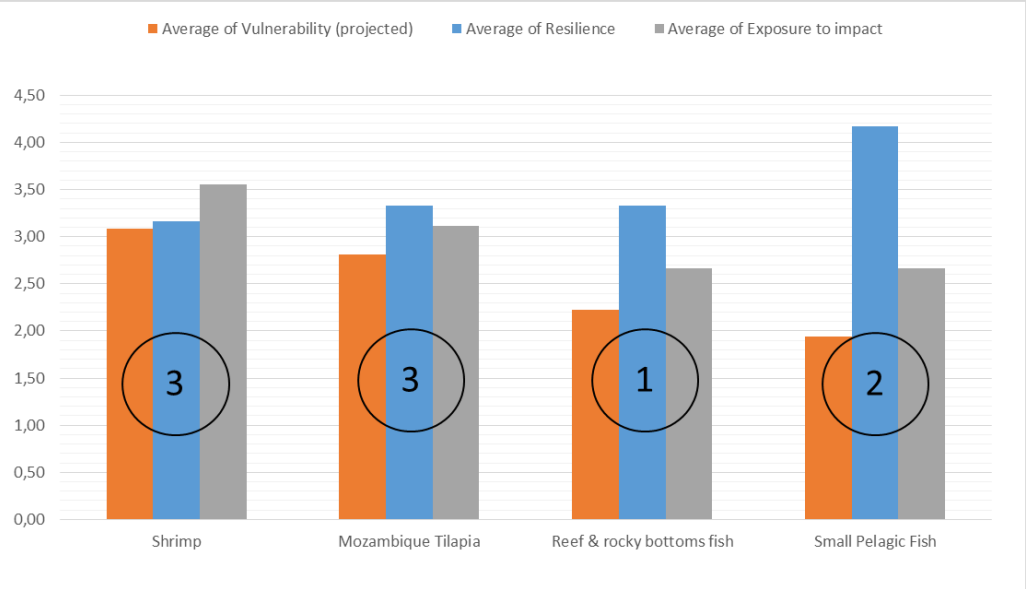
Table 7.14 - Rankings of the 3 highest scoring sub-units of Fisheries & Aquaculture unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Small pelagic fish 2. Mozambique Tilapia / Reef & Rocky bottom fish 3. Shrimp	1. Shrimp 2. Mozambique Tilapia 3. Small pelagic / reef & rocky bottom fish	1. Shrimp 2. MozambiqueTilapia 3. Reef & rocky bottom fish

For this unit the most vulnerable and exposed sub-unit was Shrimp, mainly due to fishing pressure which reduces populations. Low rainfall during wet season also affects shrimp behaviour leading to less cacthes. Small pelagic fish, on the other hand, was rated as less vulnerable. The impacts on this sub-unit are not expected to be exacerbated by climate changes.

The figure below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7.8 – Averages for each sub-unit of the Fisheries & Aquaculture unit.



As well as for the Forest and Mangrove unit, for Fisheries & Aquaculture, only 9 impacts were identified.

Table 7.15 shows that the hazard that was related to the highest Vulnerability is *Prolonged droughts* which cause the drought of Maganha lake, reducing the population of Mozambique Tilapia.

For this unit, 44,4% of the impacts are climate type.

Table 7.15 – 9 scoring impacts (Projected Vulnerability) in Fisheries & aquaculture sub-units.

Rank #	Impact	Vulnerabily (projected)	Subunit
1	Prolonged droughts cause the drought of Maganha lake, reducing the population of Tilapia.	3,54	Mozambican Tilapia

Rank #	Impact	Vulnerabily (projected)	Subunit
2	The free access to artisanal fishing together with the increasing in fishermen number (local and migratory) in the coastal area of Angoche, Moma, Larde and Pebane districts, has increased shrimp fishing pressure and caused the reduction in stock resource.	3,28	Shrimp
3	The intensive use of nonselective harmful fishing gear (trawl nets and mosquito nets) in fishing shrimp in the coastal area of Angoche district, leads to indiscriminate catch of juvenile fish, causing a negative impact on the recruitment of shrimp species, with reduction of the population and size of individuals	3,11	Shrimp
4	The occurrence of cyclones has caused the destruction / collapse of aquaculture tanks built near or in the mangrove areas in the districts of Angoche, Moma and Pebane with consequent escape from fish farms and loss of stock	2,99	Mozambcan Tilapia
5	Low rainfall during wet season suppresses dispersal of juvenile prawns into deeper water leading to lower catches	2,87	Shrimp
6	Extreme sea temperature events can lead to bleaching and mortality of corals, gradual degradation of physical structure of the reef, and eventually reduction in population size and mortality of reef fish	2,22	Reef and rocky bottom fish
7	The intensive use of nonselective harmful fishing gear (trawl nets and mosquito nets) in fishing for demersal fish in the coastal area of Angoche district, leads to indiscriminate catch of juvenile fish, causing a negative impact on the recruitment of demersal fish, with the reduction of the population and size of individuals.	1,94	Small Pelagic Fish

Rank #	Impact	Vulnerabily (projected)	Subunit
8	The free access to artisanal fishing together with the increasing in fishermen number (local and migratory) in the coastal area of Angoche, Moma, Larde and Pebane districts, has increased fishing pressure of small pelagic and caused the reduction in stock resource.	1,94	Small Pelagic Fish
9	With the population increase in the coastal zone and open defecation in the areas of mangroves and estuaries, increases the risk of spread of animal diseases in surrounding areas of the mangroves.	1,89	Mozambican Tilapia

Note: Impacts represented in yellow are the climatic ones whereas the grey are the development impacts.

8. ADAPTION INTERVENTIONS

8.1. ADAPTION INTERVENTIONS IDENTIFIED BY WORKING GROUPS

Three CVCA's undertaken in PSEPA (Cosijn, 2011; Skinner *et al*. 2014; Artur *et al*. 2015) propose a set of recommendations as possible climate change adaptations. The summary is presented below (Table 8.1).

Table 8.1 – Climate change adaptations recommended by the specific studies undertaken for the PSEPA.

CVCA, 2011 (Cosijn, 2011)	*CVCA, 2014 (Skinner et al., 2014)*	*CVCA, 2015 (Artur et al. 2015)*
(1) Rain water storage facilities: Investigate options for installing small rain water storage facilities and liaise with government to prioritise communities where the ALP works to obtain boreholes.	**(17) Empowering communities with knowledge of their rights**: increase their power to negotiate with companies for more equitable benefit-sharing from exploitation of the natural resources.	**(19) Interventions on fishing**: introduction of new fishing technologies (including fishing gears); fish processing and marketing.
(2) Conservation agriculture– Introduce a programme of conservation agriculture to improve crops yields, diversify crops, reduce soil erosion and declines in fertility, improve water management and decrease labour demands.	**(18) Improvement of communities knowledge:** Access to price information, weather alerts, training (such as animal husbandry, fish processing and conservation, conservation agriculture etc)and education. This can improve assessment and management of diverse risks.	**(20) Forest management:** develop and implement rules and technical knowledge for forest management (especially of mangroves) and reforestation programmes using local seedlings.
(3) Diversification of crops and fruits for commercialisation: alternative crops and/or increasing yields should be introduced to provide alternative and diversified income source for these communities.		**(21) Improvement of agriculture and livestock:** expand extension services including the introduction of new technologies, especially around coconut and cassava.
(4) Post harvest storage: introduce post harvest storage facilities.		**(22) Creation of community-run marine reserves:** where conditions allow it.
(5) Animal husbandry: : Investigate the introduction of alternative animal protein sources, such as goats, cane rats and ducks, especially in communities which are reliant on fish as their primary meat source.		**(23) Donation of improved seeds –** particularly of second-season and green vegetables, to ensure diet requirements in lean periods caused by floods or droughts.
(6) Fish preservation: All the coastal and island communities does not have electricity and therefore a lot of the marine products which are caught cannot be conserved in fridges or freezes. Smoking and salting of these products are simple means of preservation which can be undertaken in the communities.		**(24) Infrastructures maintenance –** regular road maintenance and construction or rehabilitation of communal infrastructures.

CVCA, 2011 (Cosijn, 2011)	*CVCA, 2014 (Skinner et al., 2014)*	*CVCA, 2015 (Artur et al. 2015)*
(7) Fisheries management: Work with PSEPA in the coastal and island community waters to support fisheries management techniques, including community fisheries sanctuaries, community fisheries councils, and mangrove replanting, as a means of encouraging fisheries populations to recover.		**(25) Building knowledge and skills on adaptation strategies with women –** this will increase individual capacity for adaptation, especially amongst most vulnerable groups in society.
(8) Training of Government Extensions: Include Government extension workers in future training on the identification of barriers to increasing adaptation capacity and in the implementation process.		**(26) Fishing boat licencing and control;**
(9) Wildfire control: Introduce an education programme on the disadvantages of burning and uncontrolled fires, as well as techniques to reduce the incidence of wildfires, such as cold burning and fire breaks.		**(27) Creation of effective early warning systems for climatic events**: the government should help to sustain the community radios, which are vital in informing communities a range of critical issues including warning on upcoming climate risks.
(10) Human-wildlife control: Introduce pilot projects on the control of animals, like planting crops in blocks so that it is easier to control wild animals		**(28) Creation of new opportunities**: job or self-employment opportunities away from natural resource dependence
(11) Community funds allocation: investigate mechanisms to influence the decision-making of the CDL (Committee of Local Development) to ensure that 7 million (LOL) are allocated to projects which increase climate resilience and do not increase vulnerability.		**(29) Revitalize the existing local committees:** create or reinforce of CGRN and CCP in communities**.** Important for disaster management and provide knowledge to communities on how to best respond to climate risks.
(12) Savings and loans: Investigate the formation or strengthening of "Savings and Loans Groups" in the communities as a buffer in times of stress or crisis.		**(30) Construction of community shelters:** especially for islands where possible and needed (especially on densely populated islands).
(13) Land-use Zoning: Based on the hazard mapping already undertaken, with the community undertake a land-use zoning process to reduce vulnerability to hazards and reduce human-animal conflict.		
(14) Erosion control: Mangrove replanting and dune planting: CARE		

CVCA, 2011 (Cosijn, 2011)	*CVCA, 2014 (Skinner et al., 2014)*	*CVCA, 2015 (Artur et al. 2015)*
and WWF in the PSEPA programme is already piloting mangrove planting and investigating dune planting to reduce coastal erosion. Discussions should be held with the project to ascertain what the possible synergies are.		
(15) Group strengthening: for poor households it is important that they are able to work collective to resolve issues relating to climate change, as well as to engage collectively in generating incomes, so that products are aggregated and markets can be reached.		
(16) Commercialisation Training: if generating alternative incomes is a key strategy then households need to receive training on how the market works and how they can engage in the market.		

During the stakeholder vulnerability assessment workshop in Nampula in February 2016, the working groups for each of the seven analysis units, identified two adaptation interventions, based on the vulnerability results outlined in Section 7 above. These interventions were identified as strategic options that, in the group's judgment, would be more important and/or more effective in reducing the vulnerabilities of sub-units and/or in mitigating the specific impacts that scored highly on the vulnerability ratings. The working groups were guided to consider interventions that would either i) reduce sub-units' exposure to relevant climate hazards or ii) increase the resilience score of the sub-units in question.

Figure 8.1 – Examples of the two adaption interventions for each unit that each group developed at the end of the workshop.

Table 8.3 below summarizes the adaptation interventions for each unit and the respective ranking that was given by all participants of the workshop based on a voting system. The last column of this table specifies if each adaptation intervention had been already proposed in any of the four specific studies undertaken (CVCA's).

The four highest ranked interventions were:

Table 8.2 – List of the three highest ranked interventions and its respective analysis unit.

Proposed adaptation intervention	Relevant analysis unit
1. Implement surveillance and inspection activities	High-profile Species
2. Creation of Marine Sanctuaries	Fisheries & Aquaculture
3. Provide tanks for collecting water. Develop a campaign to eliminate ponds that enable mosquitoes' proliferation trough capacitation and regular actions of cleaning and maintenance of house covers. Build improved buildings to use as shelter to face extreme events, as well as for social purposes (Schools, health centres…).	Human Settlements
3. Create a genetic improvement program in order to create new varieties capable of adaptation to drought and flood events or to high temperatures. Use of sustainable agriculture practices (mulching, intercropping, minimum tillage, cultivation in contour lines). Improving the provision of accessible inputs to farmers	Agriculture & Livestock

In Annex V all the strategic options chosen for each resource unit are described in detail.

Table 8.3 – Resume of the selected adaptation interventions for each unit and their ranking

Unit	Strategic options	Sub-units and impacts addressed	Number of votes	Ranking	Reference of the CVCA where it has been mentioned
Coral reefs	**Work with local communities** • Identify protected zones of seagrass carpets (based on Ecosystem marine resources approach)	Exposed Inter-tidal Seagrass Climate and development impacts such as degradation of benthic habitats (seagrass) by fishing effort increase	11	4	Artur *et al.* 2015 – **(19)** Skinner *et al.*, 2014 – **(18)**
	Creation of protected marine zones • Marine sanctuaries or zones of fish replenishment to coral protection and other fragile ecosystems	Non-protected & non-exposed coral reefs (Inner Reef) Development and climatic impacts such as risk of marine pollution by spill of vessels' oils	9	5	Artur *et al.* 2015 – **(22)** Cosijn, 2011 – **(7)**

Unit	Strategic options	Sub-units and impacts addressed	Number of votes	Ranking	Reference of the CVCA where it has been mentioned
		that support mineral resources operations			
Forest & Mangrove	**Improve Institutional coordination capacity** • Addressed to the different actors involved in the management and use of coastal forest of PSEPA islands	Coastal Forest of Tapuito Development impact. Logging and mining will lead to siltation of rivers and loss of habitats in the estuary of the Larde river.	9	5	Cosijn, 2011 – **(8;11)** Artur *et al.* 2015 – **(29)**
	Implementation of Sustainable Management Measures of Coastal Mangrove	Seaward Estuarine Mangroves; Seaward Fringing Mangroves Mostly development impacts such as the disordered cut of mangrove for firewood and charcoal in the main channels of estuaries of Angoche, Moma, Larde and Pebane, greatly contributes for the increase of erosion.	11	4	Cosijn, 2011 – **(7;14)** Artur *et al.* 2015 – **(20)**
Agriculture & Livestock	**Creation of an improved program** • Create a genetic program in order to create new varieties capable of adaptation to drought and flood events or to high temperatures. • Use of sustainable agriculture practices (mulching, intercropping, minimum tillage, cultivation in contour lines). • Improving the provision of accessible inputs to farmers	Cereals; Leguminous Climate impacts such as unpredictable rain events (late onset of rains) which lead crops to not reach their productive potential, causing the reduction of productions.	12	3	Cosijn, 2011 – **(2)** Artur *et al.* 2015 – **(21;23)** Skinner et al., 2014 **– (18)**

Unit	Strategic options	Sub-units and impacts addressed	Number of votes	Ranking	Reference of the CVCA where it has been mentioned
Human Settlements	**Provide water storage and improved buildings** • Provide water tanks for collecting water. • Develop a campaign to eliminate ponds that enable mosquitoes' proliferation trough capacitation and regular actions of cleaning and maintenance of house covers. • Build improved buildings to use as shelter to face extreme events, as well as for social purposes (Schools, health centres…).	Precarious Constructions; Settlements and infrastructures in riparian and floodable zones; Settlements and infrastructures in islands Only climate impacts such as the occurrence of heavy rains can contaminate water sources that are used in communities	12	3	Cosijn, 2011 – **(1)** Artur *et al.* 2015 – **(24; 30)**
High-profile Species	**Mitigation of Man-Hippo conflicts** Define a participatory strategy to these conflicts including the key actors of the estuary (peasants, fishermen and populations of hippos)	Hippopotamus Development impact namely expansion of farm areas causing conflicts and competition for space with large fauna and involving hunting, whether legal or illegal, which compromises the local population of hippo and disrupts the functioning of the local ecosystems.	8	6	Cosijn, 2011 – **(10; 13)**
	Implement surveillance and inspection activities	Marine Turtles; Terns; Sharks; Dolphins and Whales Mainly development impacts such as illegal and accidental hunting of turtles is affecting the local population in every PSEPA islands.	17	1	Artur *et al.* 2015 – **(26)** Cosijn, 2011 – **(8)**
Freshwater	**Opening of more water holes for each community**	Water holes; Lagoons; Lakes; Seasonal Rivers and Permanent Rivers Mainly climate impacts as heavy rains that lead to floods that cause contamination of	6	7	

Unit	Strategic options	Sub-units and impacts addressed	Number of votes	Ranking	Reference of the CVCA where it has been mentioned
		drinking water sources in low areas along the coast and destruction of wells.			
	Construction of stronger guttering and increase of volumetric capacity of water tanks	Gutter pipes and water tanks Development impact, namely: the increase in social infrastructures (e.g. schools) is followed by an increase in water retention systems which causes the increase of freshwater availability	9	5	Cosijn, 2011 – **(1)** Artur *et al.* 2015 – **(24)**
Fisheries & Aquaculture	**Establishment of Marine Sanctuaries**	Shrimp; Small pelagic fish Mainly development impact such as the intensive use of nonselective harmful fishing gear (trawl nets and mosquito nets) in fishing for demersal fish in the coastal area of Angoche district, leads to indiscriminate catch of juvenile fish, causing a negative impact on the recruitment of demersal fish, with the reduction of the population and size of individuals.	13	2	Cosijn, 2011 – **(7)** Artur *et al.* 2015 – **(22)**
	Development of integration systems for a responsible and Sustainable aquaculture	Mozambican Tilapia Climate impacts such as the occurrence of cyclones has caused the destruction / collapse of aquaculture tanks built near or in the mangrove areas in the districts of Angoche, Moma and Pebane with consequent escape from fish farms and loss of stock	9	5	

9. DISCUSSION AND WAY FORWARD

9.1. METHODOLOGICAL APPROACH

The *Flowing Forward* framework, while relying on input of scientific and other documented sources of information, is a stakeholder based process. As such, the quality of the information provided in this report is in large part dependent upon the workshop participants' knowledge and expertise on the discussed topics.

It is also worth while referring that the nature of *Flowing Forward* is such that one can not directly compare the results across different units as the scoring is done by different working groups that apply it in a relative, discretionary way. One can only compare sub-units within each resource unit, meaning that it is not valid to compare results between the working groups, only within each group.

9.2. SUB-UNIT ANALYSIS

Considering each of the analysis Units, 60% of the top 10 impacts identified for the Coral reefs sub-unit are climatic. Exposed inter-tidal seagrass, followed by Non-protected & non-exposed coral reefs, and Protected & non-exposed coral reefs are the sub-units where the impacts have the highest projected vulnerability scores. These are all considerable exposed to climate events and man-made actions. Exposed inter-tidal seagrass is actually considered extremely exposed to impacts compared to the other sub-units. Some of the most relevant climatic impacts are: i) *Cyclone events cause massive destruction of coral reefs in the PSEPA archipelago due to the high hydrodynamic tensions associated with cyclonic winds*; ii) *Extreme temperature events of sea water can cause bleaching of coral reefs and mortality (zooxanthellae expulsion), linked to the loss of the physical structure and biodiversity of coral reef and biomass of other invertebrates, and loss of fish that depend on the sheltered coral structures of such reefs*; and iii) *Extreme temperature events cause changes in spatial distribution and in sexual reproduction patterns of seagrass, as well as changes in their growing rates, metabolism and in their carbon balance*. Nevertheless, the top score was given to a development impact, *Degradation of benthic habitats (seagrass) by fishing effort increase*, which shows the man-made stress that this sub-unit is exposed to. Considering the relevance of this unit and analysed sub-units efforts should be put on adaptation strategies directed to climate change.

In the case of Forest & Mangrove climatic impacts represent only 33,3% of the top 10 identified. Development impacts associated to mining, firewood and charcoal production, and also opening of areas for agricultural purposes seem to have a strong effect on sub-units such as the Coastal Forest of Tapuito (partially protected), Landward Estuarine Mangroves (River-dominated), Seaward Estuarine Mangroves (tidal dominated), Coastal Forest of Muebase, Protected coastal forest of Potone and Landward Estuarine Mangroves (River-dominated). The most relevant climatic impacts were i) the *Prolonged droughts associated with extreme atmospheric temperature events will contribute to the occurrence of fires and habitat loss in* Potone forest, and ii) the *Strong wave events combined to storms in Angoche, Moma, Larde and Pebane lead to deposition of sediments in coastal areas causing the burying of mangrove areas and compromising the potential for natural regeneration*; in this case the sub-unit is Seaward Fringing Mangroves (wave dominated). The potential increase of droughts and of strong waves combined to storms seem to be the most relevant climate impacts for the analysed sub-units.

The top 10 identified impacts for the sub-units of Human settlements are all climatic. Precarious Constructions, Infrastructures for public service and Settlements and infrastructures in riparian and floodable zones are the sub-units where the impacts have the highest projected vulnerability scores. All sub-units have Resilience scores lower than Vulnerability and Exposure to impacts, which

shows how these are weakly adapted to the variability in the environment. It's the case of Settlements and infrastructures in islands, Precarious constructions, Infrastructures for public services, Settlements and infrastructures in riparian and floodable zones and Settlements and infrastructures in estuarine and coastal zones. Some significant impacts on these sub-units are i) *The occurrence of cyclones, through the strong winds and high waves, leads to destruction of houses and loss of mangrove forests that give protection to settlements in Coty Islands*; ii) *The occurrence of cyclones, storms and high winds leads to destruction of precarious house construction*; iii) *The occurrence of heavy rains can contaminate water sources that are used in communities*; iv) *Heavy rains cause flooding in coastal areas of Larde contributing to flood and destruction of settlements and infrastructures, such as wells, houses and farms in the riverside areas of Larde and Meluli rivers*; v) *The occurrence of cyclones, through strong winds followed by heavy rains, leads to flood and destruction of houses, farms and infrastructure in settlements of coastal and floodable areas*; vi) *The occurrence of heavy rains causes floods in the districts of Angoche, Moma and Larde, which contributes to cutting access roads to the Angoche district and regular power cuts in the city of Angoche*. This clearly shows that urgent intervention is needed in the sub-units considered for this Unit.

In the case of the High-profile species, only 30% of the top 10 impacts are related to climate. *Icuria dunensis* is the sub-unit with impacts with the highest projected vulnerability scores. This species is endemic from this region and confined to a very restricted area, therefore being the most exposed sub-unit to impacts. Due to the characteristics of its habitat (dunes and sandy areas), *Icuria dunensis* is particularly exposed to cyclone events, storms, strong winds (South of Potone and Moebase forests). Additionally, in terms of human development, the associated operations to the extractive industry are approaching the places where *Icuria dunensis* occurs, which may directly affect the species aggregates - heavy areas in Moebase, Sangage and Larde - oil and gas prospection. Two other climate type impacts are the cyclone events, storms, strong winds and high tides are eroding and flooding i) the nesting area of leatherback turtle mainly on the islands of Puga Puga, Coroa, Baixa Miguel and Baixa Sto. António with less vegetation cover, which causes the loss of habitat conditions for nesting, compromising the reproduction of the local marine turtle population; and ii) the nesting area of terns on the islands of Puga Puga, reducing the available area for laying eggs, compromising the reproduction of the local species population. Still for the high-profile species it is worth mentioning the case of the marine turtles and the hippopotamus, both considerable affected by the development impacts. On the first case the i) increasing number of fishermen is forcing them to go to the PSEPA islands, collecting turtle eggs and the ii) illegal and accidental hunting of turtles is affecting the local population in every PSEPA islands. This impact is also affecting the terns' eggs causing a decline of the local population. In the case of the hippo, the expansion of farm areas mainly along the Munir rivers, Mulela, Molocué, Ligonha is causing conflicts and competition for space with large Fauna and involving hunting, whether legal or illegal, which compromises the local population of the species and disrupts the functioning of the local ecosystems.

Freshwater is also a unit where the analysed sub-units are extremely vulnerable to climate type impacts (80% of the top 10). Lagoons, Gutter Pipes and Water Pipes and Lakes are the sub-units where the impacts have the highest projected vulnerability scores. Lagoons and lakes are actually considered the most exposed to impacts. Analysing the impacts individually, Wells are the sub-unit with two of the most scored climatic impacts: i) *Heavy rains lead to floods that cause contamination of drinking water sources in low areas along the coast and destruction of wells* and ii) *High tide events cause saline intrusion in Moma Island, where the underground water, the main source of fresh water for consumption, becomes brackish (salinization of drinking water)*. The Lagoons (e.g. Larde: Maganha, Cerema, Ninte, Carroa, Incurro, Iriata e Mpaia; in Angoche: Sangage) are also a sub-unit that is worth mentioning due to two hugh-scored climatic impacts: i) *Periods of high air temperatures (max and min) cause the increase of evaporation in lakes, ponds, wells and boreholes, which decreases the availability of freshwater*; ii) *Long rains cause floods and leads to*

contamination of drinking water source. Finally, it is also worth mentioning that the Seasonal Rivers (like the Larde River) are subject to long periods without rain, which causes a decrease in freshwater availability and that drought periods caused by lack of precipitation in local rivers basins, lead to lack of water in the seasonal rivers and its lakes, affecting agriculture, human consumption and wildlife. Considering the significance of this resource (freshwater) for human population, all associated activities and wildlife, the analysed sub-units deserve special attention when planning adaptation strategies related to climate change.

The agricultural and livestock systems include 90% of impacts related to development in the top 10 scored. Cereals is the sub-unit where the impacts have the highest projected vulnerability scores. All the other sub-units have similar scores. Actually of the top 5 climatic impacts, 4 of them are related to Cereals (Corn, Rice); namely: i) *The occurrence of cyclones followed by strong winds cause the loss of cultures or the layering in the coastal region of Angoche district (cereals)*; ii) *Unpredictable rainfall events (late onset of the rains) associated with high temperatures cause the outbreak of pests and diseases that cause loss of crops in the districts of Angoche, Moma, Larde and Pebane*; iii) *Unpredictable rain events (late onset of rains) which lead crops to not reach their productive potential, causing the reduction of cereal production*; and iv) *Heavy rainfall events that cause floods and erosion of the area that is intended to agriculture production, causing loss of crops in the districts of Angoche, Larde, Moma and Pebane*. This impact is also affecting the Leguminous (peanut, sesame, beans) sub-unit, and was actually the one that reached the highest score of the top 10. The only development impact was the *Reduction of the area for agricultural production in the communities of Nathire and Kanhawa due to the presence of industry production and sisal processing (roots)*, which seems to be affecting the sub-unit: Roots and tubers (cassava and sweet potato).

Regarding Fisheries and Aquaculture 44,4% of the top 10 impacts are climate related. Shrimp and Mozambican Tilapia are the sub-units where the impacts have the highest projected vulnerability scores and these are also the ones that are most exposed to impacts. The top scored impact (and also climate type) was the i) *Prolonged droughts cause the drought of Maganha lake, reducing the population of Tilapia*. Also noteworthy to refer one other climate type impact on the Mozambican Tilapia, namely: *The occurrence of cyclones has caused the destruction / collapse of aquaculture tanks built near or in the mangrove areas in the districts of Angoche, Moma and Pebane with consequent escape from fish farms and loss of stock*. Regarding shrimp, *Low rainfall during wet season suppresses dispersal of juvenile prawns into deeper water leading to lower catches* is the most scored climatic impact. The last climate type impact is the *Extreme sea temperature events can lead to bleaching and mortality of corals, gradual degradation of physical structure of the reef, and eventually reduction in population size and mortality of reef and rocky bottom fish*. Regarding the development impacts, which are the majority, it should be referred that i) *The free access to artisanal fishing together with the increasing in fishermen number (local and migratory) in the coastal area of Angoche, Moma, Larde and Pebane districts, has increased shrimp fishing pressure and caused the reduction in stock resource* and that the ii) *The intensive use of nonselective harmful fishing gear (trawl nets and mosquito nets)* is having impacts on a) *shrimp in the coastal area of Angoche district, leading to indiscriminate catch of juvenile fish, causing a negative impact on the recruitment of shrimp species, with reduction of the population and size of individuals*; and on b) *demersal fish in the coastal area of Angoche district, leading to indiscriminate catch of juvenile fish, causing a negative impact on the recruitment of demersal fish, with the reduction of the population and size of individuals*. As it can be seen some adaptation interventions related to climate change are needed at least for the Mozambican Tilapia and Shrimp sub-units.

9.3. ADAPTATION INTERVENTIONS

The adaptation interventions proposed by the groups are all related to the analysis made during the FF process and they generally seem to suit the identified needs of PSEPA. However, it is necessary to determine if the ranking that was given to the adaptation interventions by the workshop participants is aligned with the PSEPA management options. The current Management Plan does not include any specific management options for dealing with climate change so this analysis is extremely pertinent at the current stage.

Considering that Freshwater, Human settlements and Fisheries and Aquaculture seem to be the most vulnerable / exposed to impacts units, adaptation interventions should potentially focus on these. Regarding Freshwater, the i) *Construction of stronger guttering and increase of volumetric capacity of water tanks*; and the ii) *Opening of more water holes for each community* were the selected adaptation interventions and were only ranked 5th and 7th respectively.

The adaptation intervention for Human Settlements was ranked 3rd overall but it needs to be better detailed so that it can be effectively implemented. It is related with the improvement of resilient construction techniques, eliminating sources of mosquito proliferation and water contamination and with the regular maintenance of roads and bridges. The way the adaptation interventions were conceived it is too generic and actually quite confusing, so these need to be worked out in a specific session.

Regarding Fisheries and Aquaculture, two adaptation interventions have been proposed. One was ranked 2nd overall, i) the Establishment of Marine Sanctuaries, which is intended to the Shrimp and Small pelagic fish sub-units; and the other ii) Development of integration systems for a responsible and Sustainable aquaculture, directed to the Mozambican Tilapia, was ranked 5th overall.

It is also important to refer that the top scored adaptation intervention is related to adaptive management, namely the Implementation of surveillance and inspection activities in the PSEPA region.

9.4. WAY FORWARD

A systematic approach has been undertaken to assess the climate vulnerability for the PSEPA. Therefore, before entering the next stage, which should be writing an application to get funding from donors to implement priority adaptation interventions, these should be clearly defined and selected. it is therefore relevant that a meeting is held between the PSEPA managing team and the WWF team in order to undertake this process. The separate document resulting from that meeting should be then attached to the current vulnerability assessment so that the process in complete

9.5. GAPS AND LESSONS LEARNED

The approach that was used for assessing in detail the climate vulnerability of the PSEPA provided detailed results and allowed the definition of realistic potential adaptation interventions. Nevertheless, there are some aspects that could be improved, namely the outcomes of the final workshop. On future occasions it will be important that each working group is oriented to put more effort on revising the relevance of the initial set of sub-units and analysing in detail the resilience of each one. This will be determinant for conducting a more comprehensive analysis, without leaving any gaps in the process. This will also allow that the majority of the proposed adaptation interventions are related to climate and main vulnerabilities detected for the sub-units.

It is recommendable that in future applications of the Flowing Forward methodology, a considerable amount of effort is put in the working group members' selection process, so that these

are comprised of more than one specialist for the unit and with a reasonable knowledge of the study area. Providing more technical capacity and knowledge of the site to each group will allow developing customized adaptation priorities to the main vulnerabilities that have been assessed.

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11. ANNEXES

11.1. ANNEX I: DEFINITION AND IMPORTANCE OF EACH SUBUNIT

11.1.1. CORAL REEFS

Sub-Unit	Definition	Importance
Protected and Non-Exposed Coral Reefs* (Inner Reef).	Are benthic habitats of coral reefs located in the protected part (Management of Marine Conservation Areas Category (ACMs)) of the reef between the islands, calm waves.	Soft corals, more connected to other mangrove and seagrass ecosystems.
Non-Protected and Non-Exposed Coral Reefs* (Inner Reef).	These are benthic habitats of the reef top of the coral reef which are visible when the tide is low.	Dampens at a second level the wave energy, protect the islands against coastal erosion, etc.
Protected and Exposed Coral Reefs* (Outer Reef).	These are benthic habitats of coral reefs exposed to the ocean side, subjected to high hydrodynamic stress, strong currents and high turbulence where hard corals live and within the Management of Marine Conservation Areas Category (ACMs).	Dampens at a first level the wave energy, protect the islands against coastal erosion, etc.
Non-Protected and Exposed Coral Reefs* (Outer Reef).	These are benthic habitats of coral reefs exposed to the ocean side, subjected to high hydrodynamic stress, strong currents and high turbulence where hard corals live.	Dampens at a first level the wave energy, protect the islands against coastal erosion, etc.
Exposed Inter-tidal Seagrass	São habitats bentónicos de ervas marinhas que encontram-se localizadas entre marés e sofrem variações diárias de marés.	These are collector areas of sediment, which comes from the continent.
Non-Exposed Seagrass in deep lagoons	These are benthic habitats of seagrass that are in deep lagoons and do not suffer tidal variations (S. António and S. Miguel).	These are collector areas of sediment, which comes from the continent.

* **Protected =** Management category of Marine Conservation Areas (MCA's)

* **Non protected =** Management category of Marine Conservation Areas (MCA's)

11.1.2. FOREST & MANGROVE

Sub-unit	Definition	Importance
Landward Estuarine Mangroves (River-dominated)	Mangrove located in estuaries, under low influence of seas. Influence of freshwater discharges, nutrients and sediments from rivers (Angoche, Moma, Larde and Pebane).	Goods: wood products (timber and fuelwood), non-wood products (honey production, medicine and natural dyes) Services: nursery for marine species; circulation of nutrients, physical barrier against extreme events, crustaceans and fish fishing; carbon sequestration.
Seaward Fringing Mangroves (wave dominated)	Mangrove located in the coastal area exposed to the action of waves, strong winds and sediments.	Coastal protection against winds and erosion; soil fixing.
Coastal Forest of Muebase	Coastal forest in the conservation area of the P & S islands, suffering logging and mining.	Occurrence zone of *Icuria dunensis* (endemic species of high conservation value for the region of P & S islands); protects the river that feeds the estuary of Ligonha.
Floresta costeira de Topuito (parcialmente protegida)	Coastal forest located in Rio Larde partially located in the conservation area of P & S Islands .	Goods: wood products (wood for construction and fuel woody, wood of commercial value), non-timber products (honey production, medicines, ropes for construction, grazing areas, grasses for home coverage, wild fruits) Fauna: small and large size. Services: carbon sequestration; reducing erosion of the river; mangrove protection against deposition of sediments.
Floresta costeira protegida de Potone	Sacred coastal forest partially located in the area of conservation of P & S Islands.	Place for conducting worship the ancestors; tourist area; protects the river that feeds the estuary of Angoge.
Seaward Estuarine Mangroves (tidal dominated)	Mangrove forest located in the estuaries channels, with influences of tides and changing sediments (Angoche, Moma, Larde and Pebane Estuaries).	Goods: wood products (wood for construction and fuel woody, wood of commercial value), non-timber products (honey production, medicines and natural dyes) Services: nursery for marine species; circulation of nutrients, physical barrier against extreme events, crustaceans and fish fishing; carbon sequestration.

11.1.3. HUMAN SETTLEMENTS

Sub-unit	Definition	Importance
Precarious constructions	Constructions and Infrastructures basically made of local material used for habitation, social acividades and open areas where there is a flow of people (eg markets; public squares; football fields; houses of the communities of Angoche, Moma, Larde and Pebane; people without conditions, for example the elderly, disabled, women heads of family, pregnant women and orphans and vulnerable children; Mosques; churches and schools in rural communities)	Used for habitation and worship for local communities.
Improved constructions and productive infrastrustures	Constructions and Infrastructures basically made of conventional material used to provide public services to the community (eg schools, hospitals, governmental buildings, churches and mosques, houses of people with good conditions, particularly in cities and headquarters towns of the districts of Angoche, Moma, Larde and Pebane).	Used for shelter by local communities, providing public services and local development.
Infrastructure for public service	Physical elements that enable communication / link between different communities and provision of public services. Eg roads, bridges, power lines and water pipes.	Used for flow of products, communication and service provision.
Settlements and infrastructures in estuarine and coastal zones	Protected areas with natural mangrove and furthest from the open sea that are particularly less exposed to extreme climatic events. Ex: City of Angoche, Mpivi beach and Mingolene in Moma.	Areas of crustaceans reproduction that are important for fishing and where women make catches; are also used for human habitation.
Settlements and infrastructures in riparian and floodable zones	Areas where people live and of infrastructure (eg small-scale irrigation systems) that are located along the rivers in a low area (eg Nathere in Larde, Boila and Nacala-Luazi in Angoche).	Used by communities as fertile areas for agricultural production and fisheries (case of low and riverine areas) and for communities houses.
Settlements and infrastructures in islands	Areas that have some natural cover of mangroves and others are repopulated by the community but are exposed to extreme climatic events. Eg: Quelelene Islands, Mitepene, Metubane and Pulizika, Larde and Topuito.	Islands and coastal areas not protected by mangroves wherelocal communities live and practice activities, especially fishing.

Sub-unit	Definition	Importance
Settlements and infrastructures in inland regions	More areas of forests and reserves, mostly miombo that have a greater protection of trees to high winds and rains. Eg Mucuvula, Namizope, Natire, Namagula.	Residential areas and which are used for hunting, cutting trees for construction and power plant, to practice agriculture and for ecosystems conservation.

11.1.4. HIGH-PROFILE SPECIES

Sub-unit	Definition	Importance
Marine Turtles	It includes the 5 species of turtles in Primeiras and Segundas	Three of these species are vulnerable, one is threatened and another is critically endangered. These are threatened species by fishing activities and hunting.
Whales	There are 4 whale species, none of them is threatened in Primeiras and Segundas	They are iconic species and of great importance to the functioning of marine ecosystems. It is not known yet if the P & S are indeed important for whales.
Sharks	It includes all shark species highlighting the saw shark (*Pilotrema warreni*)	They are very important to the ecosystem, as top predators. They are very threatened by fishing. The shark saw is "almost threatened" by the IUCN. Its distribution area is very localized and P & S are isolated from other known distribution sites.
Sooty tern (Onychoprion fuscatus) and Greater Crested Tern (Thalasseus bergii enigma)	Species that in the region, occur only on an island	Although not endangered species, it is confined to the island of Puga Puga, which is undergoing a lot of pressure
Icuria dunensis	Endemic species of tree of the P & S, whose distribution is unknown elsewhere in the world	It is still not classified in the IUCN Red List and is threatened by mining, logging and fires.
Hippopotamus	Occur in Ligonha rivers (Tomei), Molocué (Naburi) Mulela (Moebase) and Munir (Pebane)	Hippopotamus is one of the first species to suffer from climate change, because during dry season it occurs very close to the coastal areas and plays an important role in the ecosystem, mainly in the cleaning and sediment retention of rivers.
Dolphins	There are three species of dolphins in Primeiras and Segundas, one of them near threatened (NT)	They are iconic species and of great importance to the functioning of marine ecosystems. Although two of the species are not yet endangered, one is near threatened, and all suffer from bycatch.

11.1.5. FRESHWATER

Sub-Unit	Definition	Importance
Water holes	Greater depth and smaller diameter.	Domestic use and irrigation. Mining
Wells	Shallower and larger diameter.	Domestic use.
Permanent Rivers (E.g. Ligonha River, Meluli river)	Surface runoff that starts upstream and with water over the year.	Domestic use, livestock watering, irrigation and mining, navigation, fishing.
Seasonal Rivers (E.g. Larde river)	Surface runoff that starts upstream during the rainy season and ends at the beginning of the dry season	Domestic use, livestock watering, irrigation and mining, navigation, fishing.
Lagoons (E.g. in LARDE: Maganha, Cerema, Ninte, Carroa, Incurro, Iriata and Mpaia; in ANGOCHE: Sangage)	Small extension bodies of water with low flow, but no standing water; It can be natural or artificial.	Domestic use, livestock watering, irrigation and mining, navigation, fishing.
Lakes	Natural depression with greater extension than lagoons; with equally low flow, and flow from rain, local fountains, or water courses (e.g.: rivers).	Domestic use, livestock watering, irrigation and mining, navigation, fishing.
Gutter pipes and water tanks	Artificial deposit of rainy waters	Domestic use

Rain is not a subunit despite of being a fresh water resource, but is also a climatic factor; Desalination never happens naturally.

11.1.6. AGRICULTURE & LIVESTOCK

Sub-Unit	Definition	Importance
Fruit trees (Coconut, Mango, Cashew, Banana)	Annual or perennial crops that have fleshy fruits often sweetened, usually consumed in nature	Used in agro-industry for the production of juices and also as windbreaks, production of coal and for construction of boats and houses. The almonds are a source of vitamins and minerals and are used for the production of vegetable oil, as well as an exporting product for the generation of income and are used for food subsistence
Leguminous (peanut, sesame, beans)	Short cycle cultures (3 to 4 months) in which the fruits are within pods, may be consumed raw or cooked, or eaten as salads,	Are used as a protein source in the diet, and have been used for the production of vegetable oils and income generation. Cultures are considered atmospheric nitrogen fixers for improving soil fertility and structure.
Cereals (Corn,Rice)	Annual or semi-annual crops, grown for its fruit, usually edible in grains. Grasses are part of this group	Rich source of carbohydrates and some minerals, used as the main food of the families living in rural areas, source of income generation due to its high commercial value, ensures food security.
Roots and tubers (cassava and sweet potato)	Cultures with its fruit under the ground that is, with fleshy roots and consumed raw or prepared with other food	Source of carbohydrates and protein when leaves are consumed; family income source and main food for families living in rural areas
Vegetables	Short cycle cultures; preferably produced in irrigated systems; used in meals as side dishes; preferably used as salads	Products used as a source of vitamins in families; source of family income
Livestock (Cattle, goats, sheep)	Big size animals, which feed preferably of herbs or leaves of some forest species.	Source of family income, used in farming as animal traction, as well as means of transport of goods; animal protein source.
Poultry (chickens, ducks)	Small size animals, with the ability to fly; they feed mainly of grains and insects.	Source of family income and diet, animal protein, meat and eggs source.

11.1.7. FISHING & AQUACULTURE

Sub-Unit	Definition	Importance
Shrimp	Surface shrimp fishing (beach trawl) and depth (bottom trawl), in estuarine and coastal areas; and as main target species have: *Penaeus indicus, Metapenaeus monocerus. P. monodon, P. japonicus, P. latisulcatus and Acetes erythraeus.*	High-value species; Economic benefits, subsistence and income source for communities.
Crab mangrove	Activity characterized by manual collection crab (*Scylla serrata*) in intertidal areas during low tide. Found in large quantities in sandy substrates, mangroves and estuaries in the coastal zone of the region of PS islands.	It is a resource of economic importance and source of subsistence of the people of the region. Activities of crab fattening have been developed in Angoche.
Small Pelagic Fish	Fishing of coastal pelagic fish of the sardine, anchovy, horse mackerel and mackerel Families, but the dominant small pelagic in PS are sardines (Clupeidae and Engraulididae Families). The main gear is the surface drag.	It is one of the main sources. Economic benefits, subsistence source of populations and communities income. Important for the commercial sector - exportation.
Big pelagic Fish	Fishing of oceanic pelagic fish such as tuna (mainly yellowfin tuna, *Thunnus albacares*), saw (especially S*comberomorus commerson*) and also *marlin, barracuda and xareu*; Main fishing gear: fishing line and trawl.	Economic benefits, subsistence source of populations and communities income.
Demersal fish	Fishing unconsolidated bottom fish (with the line and trawl nets, soft bottoms; Main target species: corvina fish (Sciaenidae), catfish (Ariidae family) and fish-tape (Trichiuridae family).	Economic benefits, subsistence source of populations and communities income.
Reef and rocky bottoms fish	Fishing of demersal fish of consolidated ground (rocky), with the main target species: groupers (Serranidae), snappers (Lutjanidae) and emperors (Lethrinidae); line fishing gear.	High-value species; Economic benefits, subsistence and income source for communities.
Octopuses	Fishing octopuses in bedrock with harpoon use.	Economic benefits, subsistence source of populations and communities income.
Mozambique Tilapia	Aquaculture of Tilapia Mozambique (*Oreochromis mossambicus*) usually made in earthen ponds in the adjacent intertidal areas of the mangrove zones and of brackish waters.	Economic benefits, subsistence source of populations and communities income.

11.2. ANNEX II DETAILED RESILIENCE SCORES FOR ALL THE SUB-UNITS

NA – Not applicable / Not available

11.2.1. CORAL REEFS

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity (vegetation & recharge)	Genetic diversity/ biodiversity	Average
Protected & Non-Exposed Coral Reefs	4	3	2	1	4	4	3,0
Non-Protected & Non-Exposed Coral Reefs	3	4	3	1	3	3	2,8
Protected & Exposed Coral Reefs	4	3	4	1	4	4	3,3
Non-Protected & Exposed Coral Reefs	4	3	4	1	4	4	3,3
Exposed Inter-tidal Seagrass;	2	2	2	2	2	2	2
Non-Exposed Seagrass in deep lagoons	2	4	4	2	4	3	3,2

11.2.2. FOREST & MANGROVE

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity (vegetation & recharge)	Genetic diversity/ biodiversity	Average
Landward Estuarine Mangroves (River-dominated	3	3	4	1	4	3	2,8
Seaward Fringing Mangroves (wave dominated);	3	2	3	2	3	1	2,3
Seaward Estuarine Mangroves (tidal dominated);	3	3	3	NA	NA	2	2,8
Coastal Forest of Muebase	2	4	3	4	3	3	3,2
Coastal Forest of Tapuito (partially protected)	3	4	3	3	3	3	3,2

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity (vegetation & recharge)	Genetic diversity/ biodiversity	Average
Protected coastal forest of Potone	4	4	4	4	3	4	3,8

11.2.3. HUMAN SETTLEMENTS

Sub-unit	Accessibility	Natural variability (conception and construction)	Natural variability (operation and maintenance)	Functional redundancy	Refugia	Average
Precarious constructions	2	2	3	NA	NA	2,3
Improved constructions and productive infrastructures	4	4	2	NA	NA	3,3
Infrastructures for public services	2	2	2			2,0
Settlements and infrastructures in estuarine and coastal zones	2	2	2	1	3	2,0
Settlements and infrastructures in riparian and floodable zones	2	1	2	1	3	1,8
Settlements and infrastructures in islands	1	1	2	1	2	1,4
Settlements and infrastructures in inland regions.	3	3	2	1	3	2,4

11.2.4. HIGH-PROFILE SPECIES

Sub-unit		Connectivity	Natural variability	Refugia	Interactions between species	Natural Productivity	Genetic diversity/ biodiversity	Average
Whales	*Marine turtles*	3	4	2	3	2	3	2,8
		4	4	5	4	2	3	3,7
	Sharks	3	3	3	4	3	4	3,3

Sub-unit	Connectivity	Natural variability	Refugia	Interactions between species	Natural Productivity	Genetic diversity/ biodiversity	Average
*Sooty tern (*Onychoprion fuscatus) *and Greater Crested Tern (*Thalasseus bergii enigma*)*	5	5	1	3	2	4	3,3
Icuria dunensis	1	2	1	3	3	3	2,2
Hipppopotamus	1	2	1	5	2	2	2,2
Dolphins	4	4	4	4	2	3	3,5

11.2.5. FRESHWATER

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity (vegetation & recharge)	Genetic diversity/ biodiversity	Average
Permanent rivers	5	4	NA	4	4	NA	4,3
Seasonal rivers	3	3	NA	3	1	NA	2,5
Lagoons	2	2	NA	3	3	NA	2,5
Lakes	4	3	NA	3	3	NA	3,3
Gutter pipes & water tanks	1	1	NA	4	1	NA	1,8
Wells	2	1	NA	5	2	NA	2,5
Water holes	4	5	NA	3	4	NA	4

11.2.6. AGRICULTURE & LIVESTOCK SYSTEMS

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity	Genetic diversity/ biodiversity	Average
Fruit trees	4	4	NA	3	1	3	3,0
Leguminous plants	3	1	2	3	4	2	2,5
Cereals	3	3	2	4	3	3	3,0
Roots & tubers	4	4	3	3	4	2	3,3
Vegetables	1	1	2	1	2	2	1,5
Livestock	3	4	3	3	2	4	3,2
Poultry farming	3	3	4	2	3	3	3,0

11.2.7. FISHERIES & AQUACULTURE

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity	Genetic diversity/ biodiversity	Average
Shrimp	4	3	2	3	4	3	3,2
Reef and rocky bottom fish	5	3	3	2	3	4	3,3
Demersal fish	5	3	3	4	3	4	3,7
Mozambique Tilapia	1	5	3	4	5	2	3,3
Octopuses	5	2	2	2	3	3	2,8
Mangrove crab	4	3	3	4	5	2	3,5
Big pelagic fish	5	5	5	2	2	4	3,8
Small pelagic fish	5	4	4	4	4	4	4,2

11.3. ANNEX III – DETAILED SCORES BY UNIT AND SUB-UNIT.

I = Intensity; E – Extension; M – Manifestation; Avg – Average

11.3.1. CORAL REEFS

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Protected and Non-Exposed Coral Reefs (Inner Reef)	3,00	**2,00**	Degradation of benthic habitats (coral reefs)by fishering effort increase	4	3	4	***7***	**3,67**	***3,17***	***3,48***
Protected and Exposed Coral Reefs (Outer Reef)	3,33	**1,67**	Degradation of benthic habitats (coral reefs) by fishing effort increase	2	3	2	***5***	**2,33**	***2,06***	***2,26***
Exposed Inter-tidal Seagrass	2,00	**3,00**	Degradation of benthic habitats (seagrass) by fishering effort increase	5	3	2	***5***	**3,33**	***3,50***	***3,85***
Non-Exposed Seagrass in deep lagoons	3,17	**1,83**	Degradation of benthic habitats (seagrass) by fishing effort increase	3	2	2	***4***	**2,33**	***2,28***	***2,50***
Protected and Non-Exposed Coral Reefs (Inner Reef)	3,00	**2,00**	Risk of Coral reefs mortality by marine pollution by spill of vessels' oils that support mineral resources and oil operations in Segundas islands archipelago	4	1	1	***2***	**2,00**	***2,33***	***2,57***
Non-Protected and Non-Exposed Coral Reefs (Inner Reef)	2,83	**2,17**	Risk of marine pollution by spill of vessels' oils that support mineral resources operations	4	1	1	***2***	**2,00**	***2,39***	***2,63***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Exposed Inter-tidal Seagrass	2,00	**3,00**	Silting of the herbs of the Casuarina and Epidendrum islands due to inadequate techniques of agriculture in the coastal area and to the absence of mangrove (Estuary of the river Ligonha, Mulela)	2	2	3	***5***	**2,33**	***2,50***	***2,75***
Protected and Non-Exposed Coral Reefs (Inner Reef)	3,00	**2,00**	Silting of corals of the Casuarina and Epidendrum islands due to inadequate techniques of agriculture in the coastal area of the Estuary of the river Ligonha and Mulela	1	1	2	***3***	**1,33**	***1,50***	***1,65***
Non-Protected and Non-Exposed Coral Reefs (Inner Reef)	2,83	**2,17**	Coral reef destruction by anchored boats, combined to the increase of ships parking, motivated by oil fundings at PSEPA archipelago	1	2	3	***5***	**2,00**	***1,89***	***1,89***
Protected and Non-Exposed Coral Reefs (Inner Reef)	3,00	**2,00**	Coral reef destruction by anchored boats, combined to the increase of ships parking, motivated by oil fundings at PSEPA archipelago	3	2	2	***4***	**2,33**	***2,33***	***2,33***
Protected and Non-Exposed Coral Reefs (Inner Reef)	3,00	**2,00**	Cyclone events cause massive destruction of coral reefs in the PSEPA archipelago due to the high hydrodynamic tensions associated with cyclonic winds	4	4	4	***8***	**4,00**	***3,33***	***3,33***
Exposed Inter-tidal Seagrass	2,00	**3,00**	Cyclone events cause massive destruction of coral reefs in the PSEPA archipelago due to the high hydrodynamic tensions associated with cyclonic winds	4	4	5	***9***	**4,33**	***3,83***	***3,83***
Non-Protected and Exposed Coral Reefs (Outer Reef)	3,33	**1,67**	Cyclone events cause massive destruction of coral reefs in the PSEPA archipelago due to the high hydrodynamic tensions associated with cyclonic winds	4	4	3	***7***	**3,67**	***3,06***	***3,06***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Exposed Inter-tidal Seagrass	2,00	**3,00**	Extreme temperature events cause changes in spatial distribution and in sexual reproduction patterns of seagrass, as well as changes in their growing rates, metabolism and in their carbon balance	4	3	2	***5***	**3,00**	***3,17***	***3,48***
Non-Exposed Seagrass in deep lagoons	3,17	**1,83**	Extreme temperature events cause changes in spatial distribution and in sexual reproduction patterns of seagrass, as well as changes in their growing rates, metabolism and in their carbon balance	2	2	2	***4***	**2,00**	***1,94***	***2,14***
Protected and Exposed Coral Reefs (Outer Reef)	3,33	**1,67**	Ocean acidification risk may cause reduction of coral formations, reducing associated marine biodiversity	4	1	1	***2***	**2,00**	***2,22***	***2,22***
Non-Protected and Exposed Coral Reefs (Outer Reef)	3,33	**1,67**	Ocean acidification risk may cause reduction of coral formations, reducing associated marine biodiversity	4	1	1	***2***	**2,00**	***2,22***	***2,22***
Non-Protected and Non-Exposed Coral Reefs (Inner Reef)	2,83	**2,17**	Extreme temperature events of sea water can cause bleaching of coral reefs and mortality (zooxanthellae expulsion), linked to the loss of the physical structure and biodiversity of coral reef and biomass of other invertebrates, and loss of fish that depend on the sheltered coral structures of such reefs	3	4	4	***8***	**3,67**	***3,06***	***3,67***

11.3.2. FOREST AND MANGROVE

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Landward Estuarine Mangroves (River-dominated)	2,83	**2,17**	The development of the mining industry (extraction of heavy sands) in the coastal zone of PSEPA islands (estuary of Larde and Sangage) removes the vegetation cover of mangrove forests creating habitat fragmentation	4	1	4	***5***	**3,00**	***2,89***	***2,89***
Landward Estuarine Mangroves (River-dominated)	2,83	**2,17**	The increase in human settlements associated with the development of the extractive industry and tourism, can reduce the area of coastal mangrove in Moma and Sangage	3	1	3	***4***	**2,33**	***2,39***	***2,15***
Coastal Forest of Muebase	3,17	**1,83**	The disordered exploitation of wood and mineral resources can contribute to reduction of coastal forest cover leading to loss of habitat	3	1	3	***4***	**2,33**	***2,28***	***2,28***
Protected coastal forest of Potone	3,83	**1,17**	The wood exploitation associated with the opening of new agricultural areas will lead to siltation of rivers and loss of habitats in the estuary of Angoche	3	2	3	***5***	**2,67**	***2,22***	***2,22***
Seaward Fringing Mangroves (wave dominated)	2,33	**2,67**	Strong wave events combined to storms in Angoche, Moma, Larde and Pebane lead to deposition of sediments in coastal area causing the burying of mangrove areas and compromising the potential for natural regeneration	2	1	3	***4***	**2,00**	***2,22***	***2,44***
Landward Estuarine Mangroves (River-dominated)	2,83	**2,17**	Prolonged droughts associated with high temperature events reduce discharges of rivers, increases evaporation and salinity of the soil, thus causing changes in the structure of mangrove forests in estuaries of Angoche, Moma, Larde and Ligonha	2	1	1	***2***	**1,33**	***1,72***	***1,89***
Protected coastal forest of Potone	3,83	**1,17**	Prolonged droughts associated with extreme atmospheric temperature events will contribute to the occurrence of fires and habitat loss in Potone forest	3	1	5	***6***	**3,00**	***2,39***	***2,63***
Coastal Forest of Tapuito (partially protected)	3,17	**1,83**	Logging and mining will lead to siltation of rivers and loss of habitats in the estuary of the Larde river	4	2	4	***6***	**3,33**	***2,94***	***2,94***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Seaward Estuarine Mangroves (tidal dominated)	2,75	**2,25**	The disordered cut of mangrove for firewood and charcoal in the main channels of estuaries of Angoche, Moma, Larde and Pebane, greatly contributes for the increase of erosion	3	1	3	***4***	**2,33**	***2,42***	***2,42***

11.3.3. HUMAN SETTLEMENTS

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Settlements and infrastructures in estuarine and coastal zones	2,00	**3,00**	The population increase will lead to pressure on the mangrove for construction of precarious houses and cutting for firewood, reducing the protection of settlements and infrastructure of estuarine and coastal areas.	3	3	3	***6***	**3,00**	***3,00***	***3,00***
Settlements and infrastructures in estuarine and coastal zones	2,00	**3,00**	The growth of the mining industry in the City of Angoche, Topuito and Sangage will lead to the cutting of mangroves to access the sea, by reducing settlements and infrastructures protection of estuarine and coastal areas.	3	2	3	***5***	**2,67**	***2,83***	***2,83***
Settlements and infrastructures in inland regions	2,40	**2,60**	Population growth will increase the pressure on the forests of the inland areas to cut firewood and charcoal as 93.8% of the population uses wood as energy source	2	3	2	***5***	**2,33**	***2,37***	***2,37***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Settlements and infrastructures in islands	1,40	**3,60**	The growth of tourism in the islands of Fogo, Ponta da Caldeira and Njovo, will bring more people to the islands and a need for new constructions, which will lead to the cutting of mangrove for construction of lodges, bars and houses that will increase pressure on mangrove leaving the settlements of the islands more exposed	3	1	2	***3***	**2,00**	***2,70***	***2,43***
Settlements and infrastructures in riparian and floodable zones	1,80	**3,20**	Heavy rains cause flooding in coastal areas of Larde contributing to flood and destruction of settlements and infrastructures, such as wells, houses and farms in the riverside areas of Larde and Meluli rivers	4	3	4	***7***	**3,67**	***3,57***	***3,92***
Settlements and infrastructures in islands	1,40	**3,60**	The occurrence of cyclones, through the strong winds and high waves, leads to destruction of houses and loss of mangrove forests that give protection to settlements in Coty Islands	4	4	5	***9***	**4,33**	***4,03***	***4,44***
Infrastructures for public services	2,00	**3,00**	The occurrence of prolonged droughts will cause a shortage of water in wells and water sources used by communities, which will pressure the existing infrastructures and will create disputes for lakes and ponds with other living beings	4	4	2	***6***	**3,33**	***3,33***	***3,67***
Infrastructures for public services	2,00	**3,00**	The occurrence of heavy rains can contaminate water sources that are used in communities	5	3	4	***7***	**4,00**	***3,83***	***4,22***
Settlements and infrastructures in riparian and floodable zones	1,80	**3,20**	The occurrence of cyclones, through strong winds followed by heavy rains, leads to flood and destruction of houses, farms and infrastructure in settlements of coastal and floodable areas	4	2	5	***7***	**3,67**	***3,57***	***3,92***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Precarious constructions	2,33	**2,67**	The occurrence of heavy rains which leads to floods that cause total or partial destruction of precarious house constructions	3	4	4	***8***	**3,67**	***3,22***	***3,55***
Infrastructures for public services	2,00	**3,00**	The occurrence of heavy rains causes floods in the districts of Angoche, Moma and Larde, which contributes to cutting access roads to the Angoche district and regular power cuts in the city of Angoche	3	4	4	***8***	**3,67**	***3,33***	***3,67***
Settlements and infrastructures in estuarine and coastal zones	2,00	**3,00**	Occurrence of heavy rainfall that creates stagnant water ponds that increases waterborne diseases (e.g. cholera, diarrhea, dysentery through water contamination) and which are sites of Mosquitoes reproduction - Malaria vector) in the low areas of settlements and in estuarine and coastal areas infrastructures	4	4	2	***6***	**3,33**	***3,33***	***3,67***
Precarious constructions	2,33	**2,67**	The occurrence of cyclones, storms and high winds leads to destruction of precarious house constructions	4	5	5	***10***	**4,67**	***3,89***	***4,28***
Settlements and infrastructures in inland regions	2,40	**2,60**	The occurrence of cyclones, through the strong winds leads to destruction of houses and loss of large forest trees that give protection to settlements and infrastructures in inland areas	3	2	5	***7***	**3,33**	***3,03***	***3,34***
Settlements and infrastructures in riparian and floodable zones	1,80	**3,20**	Occurrence of heavy rainfall that creates floods leading to stagnant water puddles that increases waterborne diseases (e.g. cholera, diarrhea, dysentery through water contamination) and which are sites of Mosquitoes reproduction - Malaria vector) in the coastal and floodable areas	4	3	2	***5***	**3,00**	***3,23***	***3,56***

11.3.4. HIGH-PROFILE SPECIES

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Icuria dunensis	2,17	**2,83**	Associated operations to the extractive industry are approaching the places of *Icuria dunensis* occurrence which may directly affect the species aggregations - heavy areas in Moebase, Sangage and Larde - oil and gas prospection	3	3	4	***7***	**3,33**	***3,11***	***3,11***
Marine turtles	2,83	**2,17**	Increase of water pollution, that may affect feeding areas: the corals around the Second islands or the islands themselves, nesting sites	2	2	2	***4***	**2,00**	***2,06***	***2,06***
Whales	3,67	**1,33**	Increase in maritime traffic, both the semi-industrial fishing and the boats associated with the extractive industry, in the region of the PSEPA Islands, produces increased sub-aquatic noise, possibility of collision, increased water pollution, affecting the areas of passage (PSEPA islands and offshore)	1	1	1	***2***	**1,00**	***1,11***	***1,11***
Marine turtles	2,83	**2,17**	Illegal and accidental hunting of turtles is affecting the local population in every PSEPA islands	4	3	3	***6***	**3,33**	***3,06***	***3,06***
Sooty tern (*Onychoprion fuscatus*) and Greater Crested Tern (*Thalasseus bergii enigma*)	3,33	**1,67**	The increasing number of fishermen is forcing them to go to the Puga Puga area, collecting the tern eggs causing decline in adult populations	4	4	2	***6***	**3,33**	***2,89***	***2,89***
Sooty tern (*Onychoprion fuscatus*) and Greater Crested Tern (*Thalasseus bergii enigma*)	3,33	**1,67**	Cyclone events, storms, strong winds and high tides are eroding and flooding the nesting area of tern on the islands of Puga Puga, reducing the available area for laying eggs, compromising the reproduction of the local species population	2	2	2	***4***	**2,00**	***1,89***	***2,08***
Marine turtles	2,83	**2,17**	Cyclone events, storms, strong winds and high tides are eroding and flooding the nesting area of leatherback turtle mainly on the islands of Puga Puga, Coroa, Baixa Miguel and Baixa Sto. Antonio with less vegetation cover that causes the loss of habitat conditions for nesting, compromising the reproduction of the local turtle population	3	2	2	***4***	**2,33**	***2,39***	***2,63***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Marine turtles	2,83	**2,17**	The increasing number of fishermen is forcing them to go to the PSEPA islands, collecting turtle eggs	4	3	3	***6***	**3,33**	***3,06***	***3,06***
Hippopotamus	2,17	**2,83**	Expansion of farm areas mainly along the Munir rivers, Mulela, Molocué, Ligonha, causing conflicts and competition for space with large Fauna and involving hunting, whether legal or illegal, which compromises the local population of hippo and disrupts the functioning of ecosystems	4	4	4	***8***	**4,00**	***3,61***	***3,97***
Dolphins	3,50	**1,50**	Increase in maritime traffic, both the artisanal and semi-industrial or boats associated with the extractive industry, in the region of PSEPA Islands leads to an increase of sub-aquatic noise, increase of water pollution, affecting coastal areas	1	2	1	***3***	**1,33**	***1,33***	***1,33***
Dolphins	3,50	**1,50**	The bycatch of dolphins is affecting the local population in all of the PSEPA Islands (caught in larger scale networks, and possibly in an opportunistic way by fishermen, with harpoon)	1	1	1	***2***	**1,00**	***1,17***	***1,28***
Sharks	3,33	**1,67**	Illegal and accidental hunting of sharks is affecting the local population in every islands of PSEPA, mainly: Njovo and Ponta Caldeira, in Larde district. They mainly operate with bottom gillnets	3	2	2	***4***	**2,33**	***2,22***	***2,45***
Icuria dunensis	2,17	**2,83**	Due to the characteristics of its habitat (dunes and sandy areas), *Icuria dunensis* is particularly exposed to cyclone events, storms, strong winds (South of Potone and Moebase forests)	3	4	5	***9***	**4,00**	***3,44***	***3,79***
Hippopotamus	2,17	**2,83**	Prolonged droughts periodically decrease the hippo refuge areas along the rivers; mainly Munir, Mulela, Molocué and Ligonha	2	4	2	***6***	**2,67**	***2,61***	***0,00***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Sharks	3,33	**1,67**	Extreme sea temperature events and possible eventual acidification may affect directly shark populations (olfactory system, among others) around the islands and coral reefs	3	5	1	***6***	**3,00**	***2,56***	***0,00***

11.3.5. FRESHWATER

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Water holes	4,00	**1,00**	Increase of mining (heavy sands) in Moma and Angoche represents an higher pressure on water from aquifers that feed the holes used for other purposes, and can lead to a decrease of water in aquifers	1	5	1	***6***	**2,33**	***1,67***	***1,83***
Wells	2,50	**2,50**	The population increase in the insular area increases the pressure on water resources and reduces the availability of water in aquifers Islands	2	1	2	***3***	**1,67**	***2,00***	***2,00***
Water holes	4,00	**1,00**	The population increase in the insular area increases the pressure on water resources and reduces the availability of water in Topuito communities (20km from Larde)	2	2	3	***5***	**2,33**	***1,83***	***1,65***
Wells	2,50	**2,50**	Heavy rains lead to floods that cause contamination of drinking water sources in low areas along the coast and destruction of wells	5	5	5	***10***	**5,00**	***4,17***	***5,00***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Lagoons (E.g. in LARDE: Maganha, Cerema, Ninte, Carroa, Incurro, Iriata and Mpaia; in ANGOCHE: Sangage)	2,50	**2,50**	Long rains cause floods and leads to contamination of drinking water source	4	5	4	***9***	**4,33**	***3,67***	***4,40***
Seasonal Rivers (E.g. Larde river)	2,50	**2,50**	Drought periods caused by lack of precipitation in local rivers basins, lead to lack of water in seasonal rivers and its lakes, affecting agriculture, human consumption and wildlife	3	3	3	***6***	**3,00**	***2,83***	***3,12***
Wells	2,50	**2,50**	High tide events cause saline intrusion in Moma Island, where the underground water, the main source of fresh water for consumption, becomes brackish (salinization of drinking water)	4	4	5	***9***	**4,33**	***3,67***	***4,40***
Permanent Rivers (E.g. Ligonha River, Meluli river)	4,25	**0,75**	The periods of drought are associated with reduction in the river flow and lead to the increase of saline intrusion which makes the water unsuitable for use in agriculture	3	4	4	***8***	**3,67**	***2,58***	***2,84***
Gutter pipes and water tanks	1,75	**3,25**	The increase in social infrastructures (e.g. schools) is followed by a increase in water retention systems which causes the increase of freshwater availability	3	3	4	***7***	**3,33**	***3,25***	***3,90***
Lagoons (E.g. in LARDE: Maganha, Cerema, Ninte, Carroa, Incurro, Iriata and Mpaia; in ANGOCHE: Sangage)	2,50	**2,50**	Periods of high air temperatures (max and min) cause the increase of evaporation in lakes, ponds, wells and boreholes, which decreases the availability of fresh water	4	5	4	***9***	**4,33**	***3,67***	***4,40***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Seasonal Rivers (E.g. Larde river)	2,50	**2,50**	Long periods without rain causes a decrease in freshwater availability	4	5	3	***8***	**4,00**	***3,50***	***4,20***
Lakes	3,25	**1,75**	Periods of high air temperatures (max and min) cause the increase of evaporation in lakes, ponds, wells and boreholes, which decreases the availability of fresh water	4	5	4	***9***	**4,33**	***3,42***	***4,10***
Gutter pipes and water tanks	1,75	**3,25**	Strong winds cause destruction of guttering	4	4	5	***9***	**4,33**	***3,92***	***4,70***

11.3.6. AGRICULTURE & LIVESTOCK SYSTEMS

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Livestock (Cattle, goats, sheep)	**3,17**	**1,83**	Reduced access to places for pasture and watering of animals due to the use of water resources (lakes) in the extraction process of heavy minerals in Murrua community in Sangage and Topuito	3	1	2	***3***	**2,00**	***2,11***	***2,11***
Roots and tubers (cassava and sweet potato)	3,33	**1,67**	Reduction of the area for agricultural production in the communities of Nathire and Kanhawa due to the presence of production industry and sisal processing (roots)	4	1	2	***3***	**2,33**	***2,39***	***2,39***
Leguminous (peanut, sesame, beans)	2,50	**2,50**	Reduction of the area for agricultural production in the communities of Nathire and Kanhawa due to the presence of production industry and sisal processing (leguminous)	3	1	1	***2***	**1,67**	***2,17***	***2,17***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Leguminous (peanut, sesame, beans)	2,50	**2,50**	Heavy rainfall events that cause floods and erosion of the area that is intended to agriculture production, causing loss of crops in the districts of Angoche, Larde, Moma and Pebane (Leguminous)	4	3	5	***8***	**4,00**	***3,50***	***3,85***
Cereals (Corn,Rice)	3,00	**2,00**	Heavy rainfall events that cause floods and erosion of the area that is intended to agriculture production, causing loss of crops in the districts of Angoche, Larde, Moma and Pebane (Cereals)	2	3	5	***8***	**3,33**	***2,67***	***2,93***
Livestock (Cattle, goats, sheep)	3,17	**1,83**	Rainfall events associated with high temperatures cause the outbreak of pests that cause animal diseases in the districts of Angoche, Moma, Larde and Pebane	2	1	3	***4***	**2,00**	***1,94***	***2,33***
Cereals (Corn,Rice)	3,00	**2,00**	Unpredictable rainfall events (late onset of the rains) associated with high temperatures cause the outbreak of pests and diseases that cause loss of crops in the districts of Angoche, Moma, Larde and Pebane	2	1	5	***6***	**2,67**	***2,33***	***2,57***
Cereals (Corn,Rice)	3,00	**2,00**	Unpredictable rain events (late onset of rains) which lead crops to not reach their productive potential, causing the reduction of production (cereals)	2	2	3	***5***	**2,33**	***2,17***	***2,38***
Leguminous (peanut, sesame, beans)	2,50	**2,50**	Unpredictable rain events (late onset of rains) which lead crops to not reach their productive potential, causing the reduction of production (Leguminous)	1	3	2	***5***	**2,00**	***2,00***	***2,20***
Fruit trees (Coconut, Mango, Cashew, Banana)	3,00	**2,00**	The occurrence of cyclones followed by strong winds cause the loss of crops in the coastal region of the Angoche district	2	1	2	***3***	**1,67**	***1,83***	***2,20***
Cereals (Corn,Rice)	3,00	**2,00**	The occurrence of cyclones followed by strong winds cause the loss of cultures or the layering in the coastal region of Angoche district (cereals)	4	3	4	***7***	**3,67**	***3,17***	***3,80***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Cereals (Corn,Rice)	3,00	**2,00**	The occurrence of cyclones followed by strong winds cause the removal of the fertile layer of soil for agriculture (erosion) providing the impoverishment of the soil and consequently reduction of production	2	1	2	***3***	**1,67**	***1,83***	***2,20***
Leguminous (peanut, sesame, beans)	2,50	**2,50**	Events of high tides combined with the saline intrusion causes the loss of area intended for the practice of agriculture in Angoche - headquarters and administrative office of Aube (Muzoa)	1	1	1	***2***	**1,00**	***1,50***	***1,65***

11.3.7. FISHERIES & AQUACULTURE

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Shrimp	3,17	**1,83**	The free access to artisanal fishing together with the increasing in fishermen number (local and migratory) in the coastal area of Angoche, Moma, Larde and Pebane districts, has increased shrimp fishing pressure and caused the reduction in stock resource	4	4	4	***8***	**4,00**	***3,28***	***3,28***
Small Pelagic Fish	4,17	**0,83**	The free access to artisanal fishing together with the increasing in fishermen number (local and migratory) in the coastal area of Angoche, Moma, Larde and Pebane districts, has increased fishing pressure of small pelagic and caused the reduction in stock resource.	2	4	2	***6***	**2,67**	***1,94***	***1,94***

Sub-unit	R	S (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Small Pelagic Fish	4,17	**0,83**	The intensive use of nonselective harmful fishing gear (trawl nets and mosquito nets) in fishing for demersal fish in the coastal area of Angoche district, leads to indiscriminate catch of juvenile fish, causing a negative impact on the recruitment of demersal fish, with the reduction of the population and size of individuals.	2	4	2	***6***	**2,67**	***1,94***	***1,94***
Shrimp	3,17	**1,83**	The intensive use of nonselective harmful fishing gear (trawl nets and mosquito nets) in fishing shrimp fish in the coastal area of Angoche district, leads to indiscriminate catch of juvenile fish, causing a negative impact on the recruitment of shrimp species, with reduction of the population and size of individuals	4	4	3	***7***	**3,67**	***3,11***	***3,11***
Mozambique Tilapia	3,33	**1,67**	With the population increase in the coastal zone and open defecation in the areas of mangroves and estuaries, increases the risk of spread of animal diseases in surrounding areas of the mangroves.	2	2	2	***4***	**2,00**	***1,89***	***1,89***
Shrimp	3,17	**1,83**	Low rainfall during wet season suppresses dispersal of juvenile prawns into deeper water leading to lower catches	3	3	3	***6***	**3,00**	***2,61***	***2,87***
Mozambique Tilapia	3,33	**1,67**	The occurrence of cyclones have caused the destruction / collapse of aquaculture tanks built near or in the mangrove areas in the districts of Angoche, Moma and Pebane with consequent escape of fish farming and loss of stock	3	3	4	***7***	**3,33**	***2,72***	***3,00***
Reef and rocky bottoms fish	3,33	**1,67**	Extreme sea temperature events can lead to bleaching and mortality of corals, gradual degradation of physical structure of the reef, and eventually reduction in population size and mortality of reef fish	2	3	3	***6***	**2,67**	***2,22***	***2,22***
Mozambique Tilapia	3,33	**1,67**	Prolonged droughts cause the drought of Maganha lake, reducing the population of Tilapia.	4	5	3	***8***	**4,00**	***3,22***	***3,55***

11.4. ANNEX IV – SUMMARY OF AVERAGE CALCULATED VALUES PER SUB-UNIT

11.4.1. CORAL REEF

Sub-unit	Average projected vulnerability (projected)	Average Resilience	Average Exposure to impact
Exposed Inter-tidal Seagrass	3,48	2,00	3,25
Non-Protected and Exposed Coral Reefs	2,64	3,33	2,83
Protected and Non-Exposed Coral Reefs	2,67	3,00	2,67
Non-Protected and Non-Exposed Coral Reefs	2,73	2,83	2,56
Protected and Exposed Coral Reefs	2,24	3,33	2,17
Non-Exposed Seagrass in deep lagoons	2,32	3,17	2,17

11.4.2. FOREST & MANGROVE

Sub-unit	Average of Vulnerability (projected)	Average of Resilience	Average of Exposure to impact
Coastal Forest of Tapuito (partially protected)	2,94	3,17	3,33
Seaward Fringing Mangroves (wave dominated)	2,44	2,33	2,00
Protected coastal forest of Potone	2,43	3,83	2,83
Seaward Estuarine Mangroves (tidal dominated)	2,42	2,75	2,33
Landward Estuarine Mangroves (River-dominated)	2,31	2,83	2,22
Coastal Forest of Muebase	2,28	3,17	2,33

11.4.3. HUMAN SETTLEMENTS

Sub-unit	Average of Vulnerability (projected)	Average of Resilience	Average of Exposure to Impact
Precarious constructions	3,91	2,33	4,17
Infrastructures for public services	3,85	2,00	3,67
Settlements and infrastructures in riparian and floodable zones	3,80	1,80	3,44
Settlements and infrastructures in islands	3,43	1,40	3,17
Settlements and infrastructures in estuarine and coastal zones	3,17	2,00	3,00
Settlements and infrastructures in inland regions	2,85	2,40	2,83

11.4.4. HIGH-PROFILE SPECIES

Sub-unit	Average of Vulnerability (projected)	Average of Resilience	Average of Exposure to impact
Icuria dunensis	3,45	2,17	3,67
Marine Turtles	2,70	2,83	2,75
Sooty tern (*Onychoprion fuscatus*) and Greater Crested Tern (*Thalasseus bergii enigma*)	2,48	3,33	2,67
Hippopotamus	1,99	2,17	3,33
Dolphins	1,31	3,50	1,17
Sharks	1,22	3,33	2,67
Whales	1,11	3,67	1,00

11.4.5. FRESHWATER

Sub-unit	Average of Vulnerability (projected)	Average of Resilience	Average of Exposure to impact
Lagoons	4,40	2,50	4,33
Gutter pipes and water tanks	4,30	1,75	3,83
Lakes	4,10	3,25	4,33
Wells	3,80	2,50	3,67
Seasonal Rivers	3,66	2,50	3,50
Permanent Rivers	2,84	4,25	3,67
Water holes	1,74	4,00	2,33

11.4.6. AGRICULTURE & LIVESTOCK

Sub-unit	Average of Vulnerability (projected)	Average of Resilience	Average of Exposure to impact
Cereals (Corn,Rice)	2,78	3,00	2,73
Leguminous (peanut, sesame, beans)	2,47	2,50	2,17
Roots and tubers (cassava and sweet potato)	2,39	3,33	2,33
Livestock (Cattle, goats, sheep)	2,22	3,17	2,00
Fruit trees (Coconut, Mango, Cashew, Banana)	2,20	3,00	1,67

11.4.7. FISHING & AQUACULTURE

Sub-unit	Average of Vulnerability (projected)	Average of Resilience	Average of Exposure to impact
Shrimp	3,09	3,17	3,56
Mozambique Tilapia	2,81	3,33	3,11
Reef and rocky bottoms fish	2,22	3,33	2,67
Small Pelagic Fish	1,94	4,17	2,67

11.5. ANNEX V – ADAPTION INTERVENTIONS CHOSEN FOR EACH RESOURCE UNIT

11.5.1. CORAL REEFS

	Option 1	**Option 2**
What sub-unit(s) and vulnerabilities does the intervention address?	Exposed Inter-tidal Seagrass	Non-Protected and Non-Exposed Coral Reefs (Inner Reef)
Describe the intervention	Work with local communities to identify protected zones of seagrass carpets (based on Ecosystem marine resources approach)	Establishment of protected marine zones (marine sanctuaries or zones of fish replenishment) to coral protection and other fragile ecosystems
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	Address Resilience	Increasing the resilience with refugee, connectivity, natural productivity, biodiversity.
Where the intervention should be implemented?	All PSEPA archipelago	All the non-protected and non-exposed reefs that are around in strategical places
Who should implement the intervention?	WWF, CSO, CBO, Local government	WWF, CSO, CBO, Local government
Are there negative consequences to the intervention?	If the approach isn´t well cared	If the approach isn´t well cared
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	Resistance to changes by the coastal communities	Resistance to changes by the coastal communities
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	APAIPS, ANAC, AMA, DPTUR, MITADER, IDPPE, DPMAP, IIP, etc.	APAIPS, ANAC, AMA, DPTUR, MITADER, IDPPE, DPMAP, IIP, etc.

	Option 1	**Option 2**
Is there a supportive policy environment?	Fishing law and Conservation law.	Fishing law and Conservation law.
Are there any specific research or data needs to ensure success?	Management Plan that will be the official document guide of APAIPS.	Management Plan that will be the official document guide of APAIPS.

11.5.2. FOREST & MANGROVE

	Option 1	**Option2**
What sub-unit(s) and vulnerabilities does the intervention address?	Coastal Forest of Tapuito	Coastal Mangrove
Describe the intervention	Improve Institutional Coordination capacity of the different actors involved in the management and use of coastal forest of PSEPA islands	Implementation of Sustainable Management Measures of Mangal Coastal
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	Reduction of the anthropogenic pressure on wood resources, ensure connectivity between habitats, refugee and improved regeneration potential	Protection of the coastal mangrove, implementation of a mangrove-cutting plan, creation of alternative means, replanting mangrove, awareness of communities
Where should the intervention be implemented?	The intervention should be implemented in Potone, Topuito and Moebase forests	The intervention should be implemented in the mangrove forests of the Angoche, Larde, Moma and Pebane estuaries
Who should implement the intervention?	Management Committees of Natural Resources, Private Sector, Government, CSOs and local leaders	Management Committees of Natural Resources, Private Sector, Government, CSOs and local leaders
Are there negative consequences to the intervention?	Lack of subsistence alternatives in short-term	Lack of subsistence alternatives in short-term; Extreme events as cyclones and extended rains/droughts

What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	Interest conflicts among stakeholders; demand for resources	Interest conflicts among stakeholders; demand for resources
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	In terms of expertise is necessary to create knowledge on sustainable management of mangroves, basic ecology and seedlings for replanting, climate change adaption, communitarian conflicts resolution and the involvement of local institutions as CBOs, CCPs, SDAE, SDPI, DPTADER and NGOs should be ensured	In terms of expertise is necessary to create knowledge on sustainable management of mangroves, basic ecology and seedlings for replanting, climate change adaption, communitarian conflicts resolution and the involvement of local institutions as CBOs, CCPs, SDAE, SDPI, DPTADER and NGOs should be ensured
Is there a supportive policy environment?	The Legal Framework for Conservation of Forests, Biodiversity Law, Lands and Wildlife Law, Conservation Law	Biodiversity Law, Lands and Wildlife Law, Conservation Law
Are there any specific research or data needs to ensure success?	CVCA Study, ongoing work activities with CGRN	CVCA Study, mangrove assessment, ongoing work activities with CGRN

11.5.3. HUMAN SETTLEMENTS

11.5.4. HIGH-PROFILE SPECIES

	Option 1	**Option 2**
What sub-unit(s) and vulnerabilities does the intervention address?	Hippopotamus	Marine Turtles; Terns; Sharks; Dolphins and Whales
Describe the intervention	Define a participatory strategy to mitigate the Men-Hippos conflicts including the key actors of the estuary (peasants, fishermen and populations of hippos)	Implement surveillance and inspection activities

	Option 1	**Option 2**
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	Both resilience - greater refugee areas, welfare and reproduction; and exposure - mutual acceptance and Hippo cohabitation with men	Both resilience - greater refugee areas, welfare and reproduction; and exposure -fight against fishing and poaching
Where should the intervention be implemented?	In the estuaries of Ligonha, Molocué, Mulela and Munir rivers	In the islands and reefs, especially on Segundas islands where human pressure is higher, mainly in Puga-Puga island
Who should implement the intervention?	The project should provide resources for setting a strategy with local people, ensure it implementation by local players and provide continuous monitoring. The strategy is being implemented by local actors.	In the current context, a conservation area has to have its monitoring program to ensure the protection of natural resources and the implementation of the approved management plan. The inspection has its costs; wage costs and operating costs. Initially, the project will financially support the Government to ensure the realization of this activity, which should be assumed by the state at a mid-term.
Are there negative consequences to the intervention?	There are no expected negative consequences for this option.	There are no expected negative consequences for this option.
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	The complexity of such an intervention is related to the work with local communities. In particular, this strategy may include spatial limitation measures of farming areas, acceptance of the animals presence in nearby communities, etc. requiring greater involvement of usual users of the distribution area of hippos.	This option corresponds to a position of repression, and should be ready to possible oppositions and conflicts with communities and resource users but also with other parties who are interested in same resources (tourism, various institutions)

	Option 1	**Option 2**
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	Gilé National Reserve, DPTADER (especially the Conservation and management department of wildlife), conservation NGOs and experts from Men-Animal Conflict (HWC)	ANAC, PRM/FPRNMA, Quirimbas National Park, DPMAIP, DPTADER, private sector
Is there a supportive policy environment?	Biodiversity conservation law and Forest and wildlife law (and also on the basis of the Management plan)	Biodiversity conservation law and Fishing law (and also on the basis of the Management plan)
Are there any specific research or data needs to ensure success?	A regular count of the animals is necessary over the above-mentioned rivers that could serve as a comparing over time to assess the initial situation and ensure the success of this action	Not really; but a participative methodology tracking of Fauna (MOMS) can be thought, to supplement this option

11.5.5. FRESHWATER

	Option 1	**Option 2**
What sub-unit(s) and vulnerabilities does the intervention address?	Water holes; reduction in water availability in Lagoons; Lakes and Rivers	Gutter pipes and water tanks, gutters' destruction during storms; reduced capacity of rain water retention (Volumetric)
Describe the intervention	Opening of more water holes for each community	Construction of stronger guttering and increase of the volumetric capacity of tanks
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	The intervention aims to reduce the dependence by the community of surface water in intermittent lakes and rivers, creating more alternative water sources; The intervention makes the system more resilient	The intervention aims to increase the resilience of tanks making them more able to withstand the strong winds and retain more water than the now

	Option 1	**Option 2**
Where should the intervention be implemented?	In every region, in particular in each population agglomeration	In residential centres, schools, hospitals, and improved residences (zinc coating, etc.)
Who should implement the intervention?	DPOPHRH (or local government) and drilling companies	Local government, NGO's, owners of improved houses
Are there negative consequences to the intervention?	Yes. The intervention can lead to overexploitation of aquifers by reducing them to the availability of fresh water	No
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	Because of the involved amounts, a political will to counter the intervention motivated by the prioritization of intervention, may happen	The resistance of the guttering is dependent on the wind/storm strength; Locally there can be no construction material for guttering to withstand extremely high winds
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	DPOPHRH (or local government) and drilling companies	Local government, NGO's, owners of improved houses
Is there a supportive policy environment?	There is no information	There is no information
Are there any specific research or data needs to ensure success?	The drilling should be preceded by topographical and hydrological studies	No

11.5.6. AGRICULTURE & LIVESTOCK SYSTEMS

	Option 1	**Option 2**
What sub-unit(s) and vulnerabilities does the intervention address?	Cereals (Corn, Rice)	Leguminous (Peanut, sesame, beans)
Describe the intervention	Create a genetic improvement program in order to create new varieties capable of adaptation to drought and flood events or to high temperatures. Use of sustainable agriculture practices (mulching, intercropping, minimum tillage, cultivation in contour lines). Improving the provision of accessible supplies to farmers	Create a genetic improvement program in order to create new varieties capable of adaptation to drought and flood events or to high temperatures. Use of sustainable agriculture practices (mulching, intercropping, minimum tillage, cultivation in contour lines). Improving the provision of accessible supplies to farmers
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	The creation of new varieties enhances the natural variability and genetic diversity. The use of techniques of sustainable agriculture will reduce exposure to erosion events, heavy rainfall and high temperatures. Use of inputs as pesticides and fertilizers to improve productivity	The creation of new varieties enhances the natural variability and genetic diversity. The use of techniques of sustainable agriculture will reduce exposure to erosion events, heavy rainfall and high temperatures. Use of inputs as pesticides and fertilizers to improve productivity
Where should the intervention be implemented?	All the PSEPA area for agriculture practice	All the PSEPA area for agriculture practice
Who should implement the intervention?	Farmers with the support of the government and NGO'S	Farmers with the support of the government and NGO'S
Are there negative consequences to the intervention?	At a long term, the resistance may be a problem for improved varieties or the absence of markets for supplies.	At a long term, the resistance may be a problem for improved varieties or the absence of markets for supplies.
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	Poor adoption of the measures by farmers	Poor adoption of the measures by farmers

	Option 1	**Option 2**
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	IIAM DPASA, universities, international research institutions, private sector, NGOs. The research institutions are constantly studying the possibilities of creating new varieties, the private sector may help in market creation, NGOs may facilitate the financing of development activities and search, the Government should facilitates the dissemination of techniques to other stakeholders. Moreover, there should exist openness to the level of Southern Africa for the exchange of improved varieties and availability in the markets	IIAM DPASA, universities, international research institutions, private sector, NGOs. The research institutions are constantly studying the possibilities of creating new varieties, the private sector may help in market creation, NGOs may facilitate the financing of development activities and search, the Government should facilitates the dissemination of techniques to other stakeholders. Moreover, there should exist openness to the level of Southern Africa for the exchange of improved varieties and availability in the markets
Is there a supportive policy environment?	Yes. Lands Law, Forest and Wildlife Law, The right to have access to information Law, legislation of genetic material exchange between institutions	Yes. Lands Law, Forest and Wildlife Law, The right to have access to information Law, legislation of genetic material exchange between institutions
Are there any specific research or data needs to ensure success?	Yes. Data on climatic conditions, existing local varieties, type of soils	Yes. Data on climatic conditions, existing local varieties, type of soils

11.5.7. FISHERIES & AQUACULTURE

	Option 1	**Option 2**
What sub-unit(s) and vulnerabilities does the intervention address?	Shrimp and small pelagic	Mozambique Tilapia
Describe the intervention	Establishment of Marine Sanctuaries	Development of integration systems for a responsible and Sustainable aquaculture
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	The intervention increases resilience, contributing to the protection of fish breeding areas and shrimp in estuaries. However, the intervention does not reduce the level of exposure to the stresses of climate change.	The intervention seeks the support of the private sector to facilitate access to inputs, management and marketing of tilapia produced in aquaculture. The introduction of responsible aquaculture practices, moving the small farms of risk areas for more protected areas and thus ensure the health of coastal ecosystems and reduce the exposure of aquaculture systems to extreme events.
Where should the intervention be implemented?	In Angoche, Mocoroge and Peban Estuaries	In Angoche e Moma, where the number of producers is greater
Who should implement the intervention?	The intervention would be implemented in the coastal community	The intervention would be implemented by aquaculture associations in partnership with the private sector
Are there negative consequences to the intervention?	Negative consequences were not identified	The poor implementation of the development plan can lead to bad adaptation situations
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	There are risks of conflicts in the implementation of surveillance activities with migratory and/or poachers fishermen.	There are logistic limitations for the establishment of the private sector in the area and lack of supplies in the national market.

	Option 1	**Option 2**
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	Governmental institutions (IDPPE, IIP), CCPs, Fishing associations, NGO's (Aliança CARE-WWF)	Governmental institutions (IDPPE, IIP), CCPs, Fishing associations, NGO's (Aliança CARE-WWF, private sector
Is there a supportive policy environment?	Yes	No, but the general regulation review of Aquaculture and the national development plan of Aquaculture are in the government schedule for this year
Are there any specific research or data needs to ensure success?	A basis study is needed (biological and social) for identification of areas for the sanctuaries establishment and success indicators	A genetic improvement study is needed for Tilapia and alternative and cheaper feed; as well as zoning of suitable areas for the development of aquaculture activities in the region

11.6. ANNEX VI – REPORT OF TECHNICAL MEETING "AVALIAÇÃO DA VULNERABILIDADE (VA) NAS ILHAS PRIMEIRAS E SEGUNDAS".

Helping People and the Planet Thrive

TECNICAL MEETING FOR THE VULNERABILITY ASSESSMENT OF THE ENVIRONMENTAL PROTECTION AREA OF PRIMEIRAS AND SEGUNDAS ISLANDS, MOZAMBIQUE, ANGOCHE

At November twenty-first days of two thousand and fourteen, at the meeting room of Primeiras and Segundas office, where the manager of the program welcomed the participants, having highlighted the importance of the meeting by the participation of several actors which have worked on these areas and which will facilitate the obtaining of a quality work. In this meeting representatives of several government sectors were present, such as INGC, Infra-structure, IIP, IDPPE, SDAE, MICOA, other partners (AENA) and Primeiras and Segundas program tecnichians. The meeting aims were the following:

1. Identify the information needed for climate change vulnerability assessment on PSEPA;
2. Familiarize the technical teem with the "Flowing Forward" methodology to the vulnerability assessment.

After the presentation of these goals, the meeting began with a brief background of participants and of the Environmental Protection Area of Primeiras and Segundas islands (PSEPA). It was highlighted the existing biodiversity reachness and the need of conservation of the area. Next, the facilitator talked abou the eastern coast of Africa priorities where Primeiras and Segundas also belongs to the 9 selected landscapes in this zone.

The facilitator presented the steps that have been taken in others conntries of the region as Tanzania and Kenia, regarding the elaboration of a climatic adaptation plan.

After, it was presented the Flowing Forward methodology which was the key of discussion during the 2 days.

At the end of the meeting all participants were already familiarized with the methodology, and the facilitator explained the following steps:

In mid-March or April the realization of a meeting with partners to present the information collected in these phase with several expersts linked to the climate changes, who were already identified during the exercise.

In the results are included:

- ✓ Units and sub-units
- ✓ Development impacts
- ✓ Climatic impacts
- ✓ Resilience

Attatched to this report are:

Annex a. Meeting agenda

Annex b. Participants list

Annexs a. Meeting agenda

Hours	**Activities**	**Responsibility**
08:00 – 08:30	Participants registration	Protocol
08:30 – 08:40	Welcome session, individual presentation and logistics	Cremildo
08:40 – 08:50	Opening	Henry
08:50 – 09:10	group leader and secretaries election (summary and notes)	Cremildo & Plenario
09:10 - 09:30	Brief background of P&S objectives	Simon
09:30 – 09:45	Approach for assessing vulnerability to climate change at WWF programs on the Easten Coast of Africa	J Rubens (JR)
09:45 - 10:00	Brief summary of vulnerability to climate changes in QNP Plenary discussion	Cremildo ?
10:00 – 10:20	**Coffee Break**	**ALL**
10:20 – 10:40	Introduction to the “Flowing Forward” – assessment structure of the vulnerability	JR
10:40 – 11:00	Discussion and questions	Plenary
11:00 – 11:40	Identification of analysis units (ecosystems and high-priority resources)	Groups
11:40 – 12:45	Identify the information needs for development scenarios	JR

12:45 – 14:00	**Lunch**	**ALL**
14:00 – 14:30	(cont.) Identify the information needs for development scenarios	Groups
14:30 – 16:00	Identify the information needs for climatic scenarios	Groups
16:50 – 17:00	Summary of the day	Secretary

Annex b. Participants List

Participants list			
Name	Distrit	Institution	Contact
Maria Isabel Cava	Nampula	INGC	826939370
Daniel Artur	Nampula	DPCA	828416170
Suale Salimo Alimo	Angoche	SDAE	845914647
Carlos Ibraimo B raimo	Angoche	IIP	829734436
Consolata Sacadura	Angoche	SDPI	845778600
Graça Hilario Raimundo	Moma	AENA	
José Luís Gigante	Angoche	IDPPE	847887872
Marcos Assane	Angoche	WWF-CARE	820722466
Jason Rubens	Tanzania	WWF CEA-NI	2,55754E+11
Dercio Dauto	Angoche	CARE	842007632
Simon Chitsenga	Angoche	WWF-CARE	822472560
Abu Junior	Angoche	AENA	847791365
Cremildo Armando	Angoche	WWF-CARE	842773966
Henry Khonyongwa	Angoche	WWF- CARE	823361232
Boaventura Macia	Angoche	CARE	840657447
Ruth Isabel	Angoche	CARE	844467954
Chande Vasconselos	Angoche	CARE	827402902
Fatima Agapito	Angoche	CARE	843566091

11.7. ANNEX VII – REPORT OF THE WORKSHOP MEETING "SEMINÁRIO DE AVALIAÇÃO DA VULNERABILIDADE CLIMÁTICA"

Cremildo Armando, February 24th of 2016

1. General Information of planned activities

Activity	Climatic vulnerability Assessment in the Ecosystems of Primeiras and Segundas islands, Nampula and Zambezia - Mozambique		
Realization place	Nampula City - Mozambique		
Dates	04th to 10th of February, 2016		
Activity Description	Workshop with Partners for climatic vulnerability assessment of Ecosystems of Primeiras and Segundas islands and prioritization of intervention measures		
Target group	Provincial and District Government Staff, Academic and research institutions, NGOs, WWF and communities representatives		
Objectives	1. Identify and prioritize the climate changes vulnerabilities of ecosystems and livelihoods in Primeiras and Segundas islands 2. Identify and prioritize the intervention measures for climate changes adaptation		
Facilitators	Institution	Name	Function
	WWF-TCO	Jason Rubens	Consultant
	WWF MCO	Denise Nicolau	Marine Officer
	WWF MCO	Alima Taju	Aquaculture Officer
	WWF P&S	Cremildo Armando	Marine Officer
	WWF P&S	Simon Chintsenga	Deputy Project Manager
	CARE WWF MCO	Jeremias Marques Antonio Serra	M&A Officer Rovuma Landscape Coordinator
	WWF MCO AENA	Joao Carlos Noimilto Mindo	Green Economy Project Manager Agriculture

2. Participants

Group	women	Men	Total	Duration (days)
Coral reefs and seagrass	0	4	4	3
Mangrove and Coastal forest	2	2	4	3
High-profile species	0	3	3	3
Fisheries and aquaculture	1	3	4	3
Human settlements	1	3	4	3
Freshwater	0	4	4	3
Agriculture and livestock	0	4	4	3
Total	**4**	**23**	**27**	

3. Results, Contributions and learned lessons

A – Results

Workshop preparation (04rh to 06th of February, 2016)

- Organization and preparation of materials, the presentations and spreadsheets to use in seminary during the group works;
- Facilitator groups with knowledge about the "flowing forward" methodology and who are able to lead the group works;
- Facilitators and experts prepared together the resilience exercise during the preparation phase.
- Workshop agenda reviewed and approved (Annex 2).

Workshop realization *(08th to 10th of February, 2016)*

The group facilitators and global facilitators, interacted and involved the participants, reaching the following results:

- Knowledge acquired, through several presentations done and by realization of several activities, as the process part "flowing forward";
- Familiarized participants with key ecosystems of Environmental Protection Area of Primeiras and Segundas island
- The participants with necessary extra information, which will facilitate the decision-making during the process. This extra information includes presentation about climate trends for the P&S, the results of CVCA, the results of bibliographic revision study of ecosystems Primeiras and Segundas islands.
- Identified the different sub-units vulnerabilities inside each work area;
- Classified the current threats and anticipated futures (Climatic and of development);
- Factors of resilience and future climatic scenarios, assessed and described;
- Based on vulnerabilities, identified, described and prioritized, based on votes, the adaptation's interventions

B – Contributions

The workshop of Climatic vulnerability assessment of Primeiras and Segundas islands with partners, is the third phase of the methodological process "flowing forward".

Till this phase, reviews and evaluations were done regarding climatic vulnerability of Primeiras and Segundas, that is:

- The CVCA assessment was performed – Climate Vulnerability and Analyses Capacity in Primeiras and Segundas
- Analyzed, collected, summarized information that allows as to know the trends of ecological, social and economical development of Primeiras and Segundas
- The future climate trends and projections of Primeiras and Segundas were presented;
- Having in count the participants knowledge, especially for community representatives, the vulnerability was assessed and adaption interventions associated were ranked;

The vulnerabilities and interventions measures of prioritized associated adaptation, will compiled and integrated in a document, that will be distributed to stakeholder for implementation

C – Lessons learned

Inclusion of experts in the groups allowed a good discussion dynamic and that the more complex exercise with resilience analysis, was completed during the preparation with the help of experts.

The three days work were not enough to well consolidate the group exercises, some groups did not have enough time for consolidate their results.

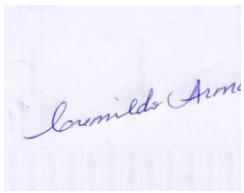
4. Report

A detailed report will be prepared by the consultant (Hugo Costa), supported by the workshop facilitation team.

The report of Vulnerability Assessment of Primeiras and Segundas islands should be presented until May 31st, 2016

5. Summary Report Responsible

Name: Cremildo Armando Activity area: VA P&S



ANNEX 1 OF THE WORKSHOP REPORT: Workshop program

Workshop for Adaptation Strategy to Climate Change Design of the Environmental Protection Area of Primeiras and Segundas Islands (PSEPA)

Dates: from 08th to 10th February, 2016

Local: Conference room of Copa Cabana, Nampula City

I. First day– Monday, 08th February

Period	Session/Topic	Responsible/Facilitator
08:00 - 08:30	Participants registration	Protocol
08:30 – 08:45	Welcome session	Henry Khonyongwa
08:45 – 09:10	Participants presentation	Armando Cremildo
09:10 – 09:20	Official opening of the Workshop	Henry Khonyongwa
09:20 – 09: 40	Workshop approach and Agenda Appreciation	Armando Cremildo
09:40 – 10:15	Presentation 1: Introduction about PSAPA (Environmental Protection Area of Primeiras e Segundas islands)	Simon Chitsenga
10:15 – 10: 45	Coffee break	
10:45 – 11:15	Presentation 2: Key concepts about climate change adaptation	João Carlos
11:15 -11:45	Presentation 7: Results about climate vulnerability in the communities (CVCA). P&S	Luis Artur
11:45 – 12:00	Presentation 3: "Flowing Forward" methodology	António Serra
12:00 – 12:10	Brief explanation about the facilitators work	João Carlos
12:10 -13:00	Presentation 4: Analysis of the 7 Identified Units in Primeiras and Segundas islands (P&S) Activity 1: Review of the sub-units in groups	Cremildo Armando António Serra
13:00 – 14:00	Lunch	
14:00- 14:20	Presentation 5: Bibliographic review and summary of information of available documents in P&S	Hugo Costa
14:20 – 15:05	Activity 2: Determination of resilience for each unit Organization of working groups (10 mins)	João Carlos/António serra
15:05- 15:35	Snack	
15:35 – 16: 45	Activity 3: Identification of development impacts in the Units Groups work (10 mins)	João Carlos/António Serra
16:45 – 17:00	End of the first day	João Carlos

I. Second day – Tuesday, February 09th

Period	Session/Topic	Responsible/Facilitator
8:30 – 08: 45	Review of the previous day	António Serra
8:45 – 09:25	Presentation 6: Climate trends in Nampula province + questions in plenary and discussion	Moises Dimande
09:25 – 10:15	Activity 4: Identification of climate impacts Groups work (10 mins)	João Carlos/ António Serra
10:15 – 10:35	Coffee Break	
10:35 – 12:45	Activity 5: Development & Climate impacts Groups work (10mins)	João Carlos/ António Serra
12:45 - 13:45	Lunch	
13:45 – 15:30	Activity 6: Future and Climate changes impacts	João Carlos
15:30 – 16:00	Presentation 8: Analysis of precipitation results + Presentation in plenary and questions	INAM
16:00 – 15:00	Snack	
16:15 – 16:45	Session end of the second day	Henry Chitsenga

II. Third day – Wednesday, February 10th

Period	Session/Topic	Responsible/Facilitator
08:30 – 08:45	Review of the previous day	João Carlos
08:45 – 10:25	Activity 7: Review and validation of vulnerability results	António Serra
10:25 -10:45	Coffee Break	
10:45 – 12:20	Activity 8: Formulation of interventions, adaptation mechanisms in P&S Working groups	João Carlos/António Serra
12:30 - 13:30	Lunch	
13:30 – 15:00	Presentation 9: Interventions summary, mechanisms of adaptation for each group (10 mins per group)	Group facilitators
15:00 – 16:30	Priority nterventions	João Carlos/António Serra
16:30 – 16:45	Summary, conclusions and Next steps	Jason Rubens
16:45 – 17:00	Final considerations and Workshop Closure Snack	Henry Chitsenga

ANNEX 2 of the workshop report: Participants list

Unit	Expertise/experience	Name	Affiliation	Contacts
Coral reef and Seagrass	Marine Biologist	Cremildo Armando	P&S	maria.rodrigues@wwf.org.mz
	Environmentalist	Rachide Momade	AMA	rachide1980@gmail.com
	Geographic Benthic mapping	Ivan Pelegrin	Maputo	ivandp72@gmail.com
	Fisher man	Bernardo Caximo	Community	847957682
Mangrove Forest and Coastal Forest	Mangrove specialist	Denise Nicolau	WWF MCO	dnicolau@wwf.org.mz
	Marine Science	Joana Jose	UEM	neljose2006@yahoo.com.br
	Forest Enginier	Antonio Serra	WWF Pemba	aserra@wwf.org.mz
	CBNRM Officer	Marcos Assane	WWF (CARE WWF Aliance)	acremildo@wwf.org.mz
High value spices	Agronomist	Simon Chintsenga	WWF (CARE WWF Aliance)	schitsenga@wwf.org.mz
	Wild life manager	Bernardo Mualeti	Provincial Departament of Turism Nampula	bermuaego@tdm.co.mz
	Wild life manager	Joao Baptista	Gile	jb.deffontaines@gmail.com
Fisheries & acquaculture	Social Developmemnt	Nuro Sele	IDPPE Nampula	isidrointave@yahoo.com.br
	Marine Science Especialist	Bonefacio Manuessa	UEM	bmanuessa@yahoo.com.br
	Biologist	**Alima Taju**	**WWF MCO**	ataju@wwf.org.mz
	Community	Sr Rogerio	Angoche	827066478
Human settlements	Agriculture Engenier	Jeremias Marques	CARE Angoche	jeremias@care.org.mz
	Eng civil	Abel Crisostomo	DPOPH Nampula	
	Architec	Antonio Amurrane	Nampula	tonydeamurane@gmail.com
	Project Manager	Antonio Victorino	Nampula	antoniovitorino27@gmail.com
	Reseacher	Luis Artur	Maputo	lartur@uem.mz
	M&E Specialist	Althea Skinner	Brasil	althea.skinner@wwfus.org
Fresh Water	INAM	Moises J. Dimande	Nampula	
	Water Technician	John Abudo	Provincial Department of Water Nampula	johnabudo@gmail.com
	Forest Engineer	Graciano Gereu	Nampula	gracianogereu@gmail.com
	UEM Teacher	Fialho Nehama	Quelimane	fialho.nehama@uem.mz
	Agriculture Engineer	Ali Omar	Nampula	isabel.cavo75@gmail.com
Agriculture and Livestock	Agriculture and livestock	Noimilto Mindo	CARE	noimilto@gmail.com
	Rural development specialist	Horacio Massique	SDAE Angoche	hmassique.horacio.massique@gmail.com
	Agriculture Engenier	Jose Abacar	NACC	zizibacar@gmail.com
	Agriculture Engenier	Henry Nkonyongwa	Angoche	hkhonyongwa@care-wwf-alliance.org

ANNEX 3 OF THE WORKSHOP REPORT: Adaption interventions and classification results

Interventions	Votes
1. Introduction of improved varieties in Agriculture	12
2. Promotion of Inputs sales markets	0
3. Use of Sustainable Agriculture	0
4. Implement marine protected areas for corals and seagrass	11
5. Implement the Communitarian Management of Mangrove Forest	9
6. Develop aquaculture systems integration	9
7. Establishment of marine sanctuaries	22
8. Surveillance of protected species	8
9. Mitigate the man – Hippo conflict	17
10. Increase water holes and reduce the pressure on rivers and lagoons	6
11. Catchment of water from rains	9
12. Promote resilient buildings to extreme events	12
13. Sanitation	0