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Climate Vulnerability Assessment and Adaptation Priorities for the Quirimbas National Park (QNP)

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).

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). The northern coast of the country, like all coastal areas, is susceptible to sea-level rise and also to a marked reduction in freshwater availability on the mainland. In addition, a substantial reduction of available agricultural land and an increase of forest fires risk are expected. Climate change is also a major threat to conservation areas. Consequently, Quirimbas National Park (QNP), in Cabo Delgado Province, is prone to be affected by climate change negative impacts.

QNP is a global priority conservation area with 11 southern islands of the vast Quirimbas Archipelago. This area is a globally outstanding biodiversity hotspot, with magnificent marine and miombo ecosystems, but also has 166,000 people living permanently within the park boundaries. Both the Quirimbas archipelago and the Selous-Niassa miombo ecosystem (which includes the QNP terrestrial system) are recognized as priority areas under WWF's *Coastal East Africa Global Initiative (CEAGI)*, which has climate change vulnerability assessment and adaptation as one of its priority areas of work. 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, between 2012-2015, climate vulnerability assessments and adaptation planning were supported in five WWF priority areas in coastal East Africa. One of the five areas is the Mtwara-Quirimbas marine and coastal complex, focusing on the QNP. Accordingly, a climate change vulnerability assessment was conducted for QNP between November 2014 and December 2015, led by WWF in close collaboration with QNP and provincial, district, NGO and community partners. Three ecosystem-specific climate studies were supported by the Government of France (FFEM) through QNP/WWF. The final outcome of the vulnerability assessment, captured in this report, consists of a set of adaptation options that are expected to be adopted by QNP as it develops a strategy and projects to address climate adaptation, as per the QNP Management Plan of 2011-21.

The objectives of the QNP 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 QNP; (ii) to identify priority areas of environmental and social vulnerability to climate stresses and (iii) to identify priority adaptation options that address critical climate vulnerabilities within the landscape and which are aligned with QNP management approaches. 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 QNP.

The QNP vulnerability assessment followed the '*Flowing Forward'* 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) 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 eight analysis units (listed below) were identified for the QNP. These were further divided into sub-units:

- Forest (miombo & coastal);
- Mangrove forest & dunes;
- Coral reefs and seagrass;
- Species of high conservation value;
- Agricultural and livestock systems;
- Freshwater;
- Fisheries and aquaculture;
- Human settlements.

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 for the area of QNP, WWF-MCO undertook a community vulnerability & capacity assessment (CVCA) and FFEM supported 3 studies on miombo woodland, mangroves and coral reefs.

Findings from the UCT climate analysis indicated the climate is getting warmer in QNP 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 in 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, QNP 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 QNP 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, financing and know how, in a context of lack of access to basic health care and potable water supply.

The miombo woodland study found that there were changes in the miombo woodland, during the period 1991-2013 with substantial transitions from open miombo woodland to dense miombo woodland. It is expected that fire regime may change in the next 40 years given the expected

increase in temperature and precipitation for the region. The study also found that the biomass production in the last 60 years has decreased. For the next 40 years it is expected a 15% increase in precipitation and 3°C increase in temperature, which will cause a slight increase in biomass production. These may modify ecosystem diversity and structure and thus habitat for wildlife and availability of forest resources to local communities.

Findings from the mangrove study showed an increase of mangrove forest cover between 1991 and 2013. However, the mangrove forest structure reflected a high disturbance related to human induced actions and climate change. The findings also indicate that there was a clear evidence of healthy regeneration in this forest; nonetheless the regeneration was not uniform.

Findings from the coral reefs underscored their importance in the Western Indian Ocean (WIO), in terms of coral cover and coral diversity, since hard coral cover and coral diversity ranged between 30% and 59% higher than the average of the WIO. In terms of finfish and fishable biomass, the study showed that more than two thirds of the reefs are being exploited at a level showing loss of species, especially the large bodied fish ones.

During a 3-day stakeholder workshop in Pemba in November 2015, specialist working groups analysed the vulnerability of the eight resource units to development and climate stresses, using the *Flowing Forward*s analysis framework. Key results from this analysis were:

1) Terrestrial forest (miombo & coastal)

The three most vulnerable sub-units were:

i) Coastal forest areas of multiple use within QNP
ii) Use and Community development zones of QNP
iii) Forest around villages outside QNP

The three highest rated climate impacts were:

- The occurrence of the dry season and high temperature events will affect agriculture production and increase the local communities' dependence on forest resources, in the forest around villages outside the park;
- The occurrence of the dry season and high temperature events will affect agriculture production and increase the local communities' dependence on forest resources, in the use and community development zones within QNP;
- The increase of dry days will anticipate and extend the burning's season, affecting the forest's regeneration ability resources, in the use and community development zones within QNP.

2) Mangrove forest and dunes

The three most vulnerable sub-units were:

i) Low islands mangrove
ii) Estuarine mangrove
iii) Coastal mangrove

The three highest rated climate impacts were:

- Storm and strong wave events causing deposition of sediments and/or erosion of mangrove areas, on low island mangrove;
- Storm and strong wave events causing deposition of sediments and/or erosion of mangrove areas, on coastal mangrove;

- The markets' demand and the lack of subsistence options increases the demand for mangrove's timber products (coal, firewood, wood for construction) – on coastal mangroves.

3) Coral reefs and seagrass

The three most vulnerable sub-units were:

i) Sheltered coral reefs with fishing pressure
ii) Exposed reefs under fishing pressure
iii) Sheltered reefs without fishing pressure

The three highest rated climate impacts were:

- Sea water high temperature events, on sheltered coral reefs with fishing pressure;
- Tourism activities in the coral, on sheltered reefs without fishing pressure in Ibo, Matemo, Quilalea and Goludo;
- Heavy rains, on sheltered coral reefs with fishing pressure.

4) Species of high conservation value

The three most vulnerable sub-units were:

i) Sea turtles
ii) African wild dog
iii) Crocodiles/ Hippopotamus

The three highest rated climate impacts were:

- Human settlements and agricultural activities causing habitat fragmentation and disturbance to African wild dog;
- Rain affecting and destroying sensible areas for reproduction, causing habitat degradation by erosion and death of animals. This affects particularly the African wild dog;
- The drought, affecting specially Crocodiles/ Hippopotamus.

5) Agriculture and Livestock Systems

The three most vulnerable sub-units were:

i) Maize
iv) Livestock breeding (small ruminants)
v) Cassava

The three highest rated climate impacts were:

- The mine concessions to limestone extraction, of rock for construction or precious stones will affect the access to agriculture land (Maize) by the communities;
- The mine concessions to limestone extraction, of rock for construction or precious stones will affect the access to agriculture land (Cassava) by the communities;
- The transformation of potential agriculture and livestock areas into residential ones, with potential for aggravation of the already existing hunger spots, with special concerns on maize crops.

6) Freshwater

The three most vulnerable sub-units were:

ii) Wells (inland)
iii) Wells (coastal)
vi) Coastal basin

The three highest rated climate impacts were:

- Extended droughts causing coastal wells to go dry;
- Water contamination of coastal wells;
- Extended droughts causing inland wells to go dry.

7) Fisheries and aquaculture

The three most vulnerable sub-units were:

iv) Freshwater fish

v) Reef fish

vii) Shrimp

The three highest rated climate impacts were:

- Extended droughts causing fragmentation and decrease of river flows, on freshwater fish;
- The human population growth and the accessibility to collect marine invertebrates
- Sea high temperature events creates bleaching and death of coral, which, consequently, lead to reef fish's habitat, making them more vulnerable.

8) Human settlements

The three most vulnerable sub-units were:

vi) Sanitation

vii) Human settlements prone to cyclones

viii) Human settlements prone to flood

The three highest rated climate impacts were:

- Tropical cyclones causing the destruction of houses and food gardens, and also the death of people and animals;
- Heavy rains cause floods in residential areas that originate the destruction of houses and food gardens, and the loss of property;
- Sea level rise events causes abandonment of populations, destruction of houses and also stops economic activities from happen or develop.

Based on the above vulnerability results, each of the specialist working groups identified and elaborated two adaptation interventions considered important and/or likely to be effective in reducing the vulnerability of vulnerable sub-units. This resulted in 16 provisional adaptation intervention ideas.

In follow up, an adaptation planning meeting was held on Ibo Island, the marine headquarters of QNP. The aim was for the QNP management and local authorities to screen the proposed adaptation interventions, filtering those that are best aligned to QNP priorities and ongoing initiatives. A cross-cutting approach, namely the creation of sustainable "Model Villages" for integrated, sustainable development and adaptation and a total of 6 adaptation projects were selected as being the most appropriate given the QNP reality:

1. Implement climate resilient forest & agriculture management: improved forest fire management and sustainable agriculture practices in target or model communities within the inland areas of the QNP;
2. Reduce wildlife vulnerability: enhanced management of total protection blocks, including removal of human settlements from connectivity areas;
3. Promote resilient marine fisheries 1: create sanctuaries & co-management areas, which would enhance the productive of fish stocks and also raise community

awareness about the conservation of habitats and recovery of stocks. As such, communities will benefit through enhanced food security and contribution to livelihoods;

4. Promote resilient marine fisheries 2: develop and support sustainable small-scale aquaculture and mariculture projects to make it easier for fishing communities to abide by fisheries management measures;
5. Adaptive mangrove management: implement strategies such as restoration of vulnerable and critical areas, establish mangrove protected areas, rotation systems the mangrove logging and development of feasible local livelihood alternatives;
6. Implement adaptive management both in marine and inland areas by training the QNP management team on this subject and providing them the adequate means for promoting law enforcement.

The above areas are considered to be the climate adaptation interventions to which funding should be directed. Preferably the interventions should be applied in an integrated way at model or pilot communities, as appropriate, rather than being implemented alone.

Based on the above systematic approach undertaken to assess climate vulnerability and the potential adaptation strategies for the QNP, the agreed next steps were for QNP management to take immediate action to formulate a project around the above proposals and to secure funding for implementation.

LIST OF ACRONYMS AND UNITS

ADF – French Development Agency

ANE – Administration of Mozambique Roads

CARE – Cooperative for Assistance and Relief Everywhere

CBO – Community Based Organization

CCP – Community Fishing Councils

CEAGI - Coastal East Africa Global Initiative

CO_2 – Carbon dioxide

CVCA – Climate Vulnerability and Capacity Analysis

DBH – Diameter at Breast Height

DPA – Provincial Directorate for Agriculture

DPOPH – Provincial Directorate for Public Works and Housing

DPCA – Provincial Directorate for Coordination of Environmental Affairs

DPEC – Provincial Directorate for Education and Culture

DPMAS – Provincial Dorectorate for Women and Social Action

DPOPH – Provincial Directorate for Public Works and Housing

DPS – Provincial Directorate for Health

DPTADER – Directorate for Land, Environment and Rural Development

DUAT – Direito de Uso e Aproveitamento da Terra (Special licence for Land Use)

FFEM – French Fund for World Environment

FUNAB – National Environmental Fund

GAI - Global Accuracy Index

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

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

NAPA – National Strategy on Climate Change

NGO – Non Governmental Organization

NSCC – National Strategy for Climate Change

OSC – Civil Society Organization

PARP III – Action Plan for Poverty Reduction

PEDSA – Strategic Plan for the Agricultural Sector Development

QNP – Quirimbas National Park

SD – Standard Deviation

SDPI – District Services for Planning and Infrastructure

SDAE – District Services for Economic Activities

SST – Sea Surface Temperature

TB – Tuberculosis

UMC – Unit Climate Measurements

UCT CSAG – University of Cape Town - Climate Systems Analysis Group

USAID – United States Agency for International Development

WCS – Wildlife Conservation Society

WIO – Eastern Indian Ocean

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).

Southern Africa is widely recognized as one of the most vulnerable regions to climate change because of its low levels of adaptive capacity, combined with a high dependence on rain-fed agriculture (IPCC, 2007). This part of the globe is already prone to erratic rainfall, droughts, floods or 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's coastline has almost 2700 km and approximately 20,5 million people, more than 60% of the 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) because of its vast low-lying coastal plains with deltas and soft, erodible sections, its high population concentrations in close proximity to the sea, its poverty, its low capacity to defend infrastructure, its inadequate and ageing coastal defenses and its susceptibility to cyclone activity. It is expected that the increase in disaster risk along the coastline will occur progressively. The consequences of the impacts are, however, expected to increase exponentially (INGS, 2012). 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).

Cabo Delgado province in northern Mozambique is experiencing a marked reduction in freshwater availability, as well as a substantial reduction of available agricultural land and the increase of forest fires risk. The Cabo Delgado coastline, in common with coastlines elsewhere in the region and globally, is believed to be vulnerable to sea-level rise (MICOA, 2012) although tide-gauge data is not available for the province. 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 Quirimbas National Park (QNP) in Cabo Delgado Province, which includes the 11 southern islands of the vast Quirimbas Archipelago (a chain of 28 islands stretching over almost 400 km).

The QNP was gazetted as a national park by the Government of Mozambique on 6 June 2002 (Decree 14/2002). From 2005 to 2015, the park's development has been supported financially by the Government of France (ADF & FFEM) and WWF, and the park is recognized by WWF as a regionally important conservation area. As such, the park 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. Office Priority areas of work under the CEAGI from 2010 to 2016 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 Mtwara-Quirimbas marine complex, focusing on the Quirimbas National Park. The other four priority areas are the Lamu-Tana River Seascape in Kenya; the Rufiji-Mafia-Kilwa Seascape in Tanzania; the Ruvuma Landscape, a Tanzania-Mozambique transboundary area; and the Primeiras & Segundas marine protected area in Nampula Province, Mozambique. As such, supporting a better understanding how climate events biodiversity, ecosystems and related livelihoods, and identifying appropriate adaptation options, is part of the CEAGI approach to help QNP better achieve its overall management and conservation objectives.

The QNP 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 below. Alongside the WWF-supported vulnerability assessment, between 2014-15, FFEM also funded three ecosystem-specific climate studies on coral reefs, mangroves and miombo woodland through QNP/WWF. The results of these three studies contributed to the vulnerability results presented herein. 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 contains in the QNP Management Plan of 2011 to 2021.

2. OBJECTIVES

The objectives of this Quirimbas National Park climate vulnerability assessment are:

i) to better understand the nature of climate change-related resilience, impacts and vulnerabilities of selected ecosystems, species and livelihood resources within the QNP;

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

iii) to identify priority adaptation options that address critical climate vulnerabilities within the landscape and which are aligned with QNP management approaches

The objective of this report is:

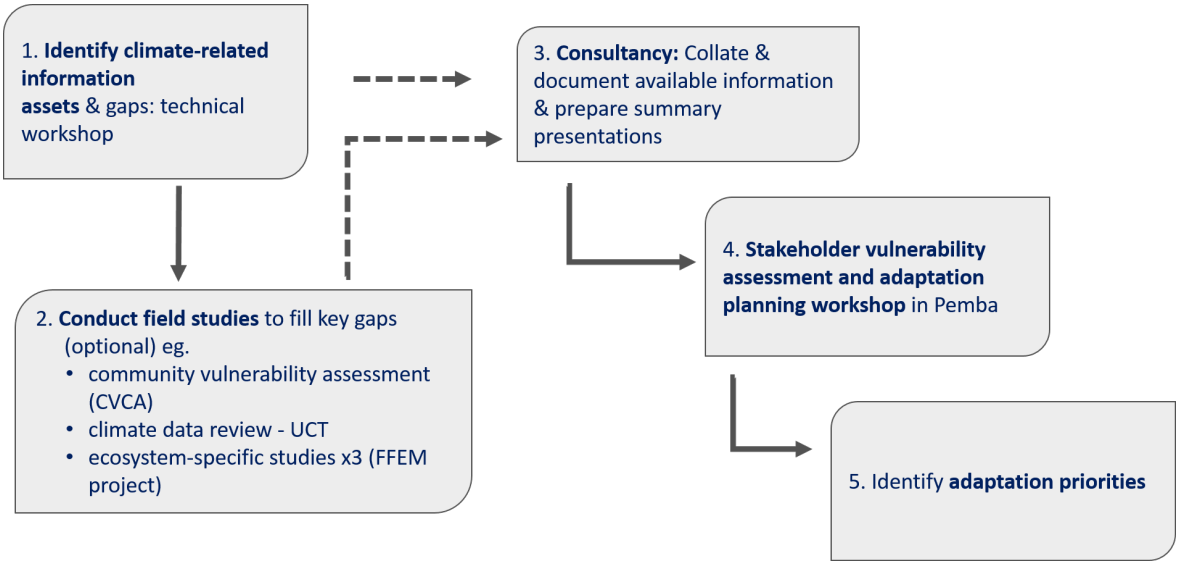
- Systematically to organize the information, results and adaptation interventions generated during the implementation of this assessment to provide QNP management and partners the information needed to develop future projects on climate change adaptation in the QNP.

3. METHODS

The QNP vulnerability assessment adopted a process comprised of several steps. It followed the '*Flowing Forward*' 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;
4. Conduct a stakeholder's planning workshop during which priority areas of vulnerability are systematically reviewed by specialist working groups;
5. Use the workshop results to identify adaptation options.

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 Quirimbas Archipelago, with emphasis on the issues regarding QNP and the climate changes. This meeting had as main objectives:

1. To identify, analyze and register the information needs for assessing the vulnerability to climate change in the QNP, considering the development scenarios and climate resilience, related to various prioritized analysis units;
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 17th and 18th November 2014 in Pemba, was selected a set of 8 analysis units, which was used as a reference for the next steps:

i. Forest (miombo & coastal);
ii. Mangrove forest & dunes;
iii. Coral reefs and seagrass;
iv. Species of high conservation value;
v. Agricultural and livestock systems;
vi. Freshwater;
vii. Fisheries and aquaculture;
viii. Human settlements.

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 II.

3.2. STEP 2 – FIELD & TECHNICAL STUDIES

Within step 2, a total of 5 specific studies were conducted to complement the available knowledge about QNP and climate change. During 2014-2015, three studies were supported by FFEM on climate change impacts on critical ecosystems, namely:

- Miombo woodland (Ribeiro *et al*., 2015),
- Mangroves (Nicolau, 2015)
- Coral reefs (MacClanahan & Muthiga, 2016).

During the same period, WWF funded two additional studies:

- Climate Vulnerability and Capacity Assessment (Ridell & Rosendo, 2015)
- Climate trends and projections for the QNP (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 provide 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 the Stakeholder Adaptation Planning Workshop, which was divided in two stages:

(i) A Pre-Workshop Meeting held immediately before the stakeholder workshop (between the 26th - 28th November 2015 in Pemba), which involved the WWF *Flowing Forward* facilitation team, eight group facilitators (one per each of the analysis units defined in step 1) and two consultants who would develop the current document. This had as goals: i) to prepare the facilitators for the workshop by training them on the *Flowing Forward* Process, namely on the excel based tool; ii) to provide them with enough information to facilitate a breakout group in the stakeholder workshop; iii) to work with them to develop the necessary presentations; and iv) to adjust the agenda to the final participants and to the outcomes of this preparation meeting. The report of this meeting is attached in Annex III.

(ii) The main Stakeholder Vulnerability Assessment & Adaptation Planning Workshop held over 4 days in Pemba (between 30th November and 3rd December 2015). It was attended by a broad range of institutions which can be seen in the report of the workshop (Annex III). The objectives of this workshop were to: i) identify and rate the vulnerabilities of species, ecosystems and livelihoods in the QNP to a range of development and climate pressures; ii) Identify and prioritize adaptation options that would reduce QNP's vulnerability to climate stresses in particular.

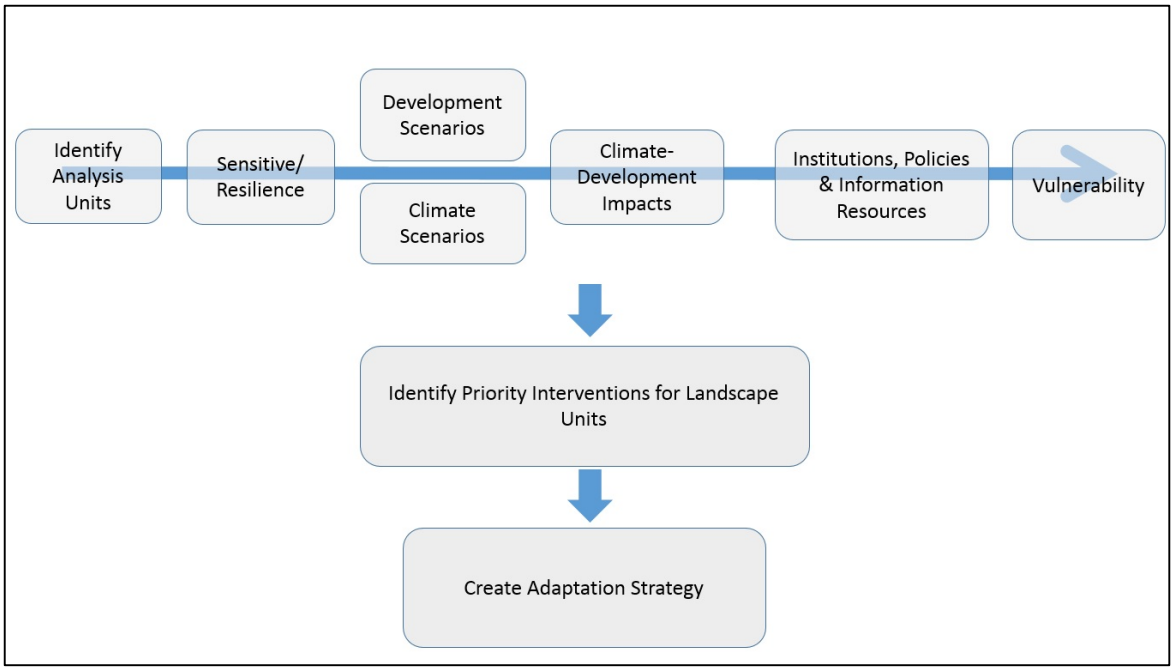
To meet these objectives, a group of individuals (i.e. decision makers, scientists, academics, NGO and local community representatives) was identified, and structured according to the eight thematic working groups, such that each group contained a mix of technical expertise, local governance officials and NGO and community representation. A total of number of 53 individuals attended the workshop. 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 QNP.

Figure 3-2 – Participants of the stakeholders adaptation planning workshop

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

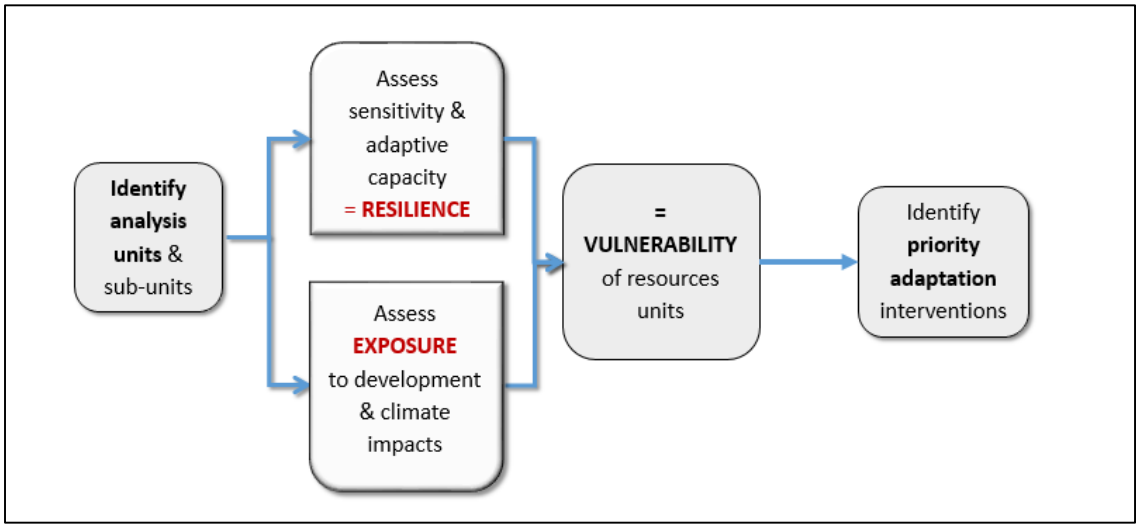
The *Flowing Forward* is a process, the broad outline of which is outlined in Figure 3-1 above. Nevertheless, the core of it is the final stakeholder workshop (3.4[ii] above) and the filling of an Excel based tool that facilitates analysis of the resilience and vulnerability of resource units and identification of priority adaptation interventions. A basic schematic of the *Flowing Forward* Excel-based tool is found below in Figure 3-3 and a simplified version in Figure 3-4.

Figure 3-3 – Schematic of the *Flowing Forward* analysis process



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 3-4 below).

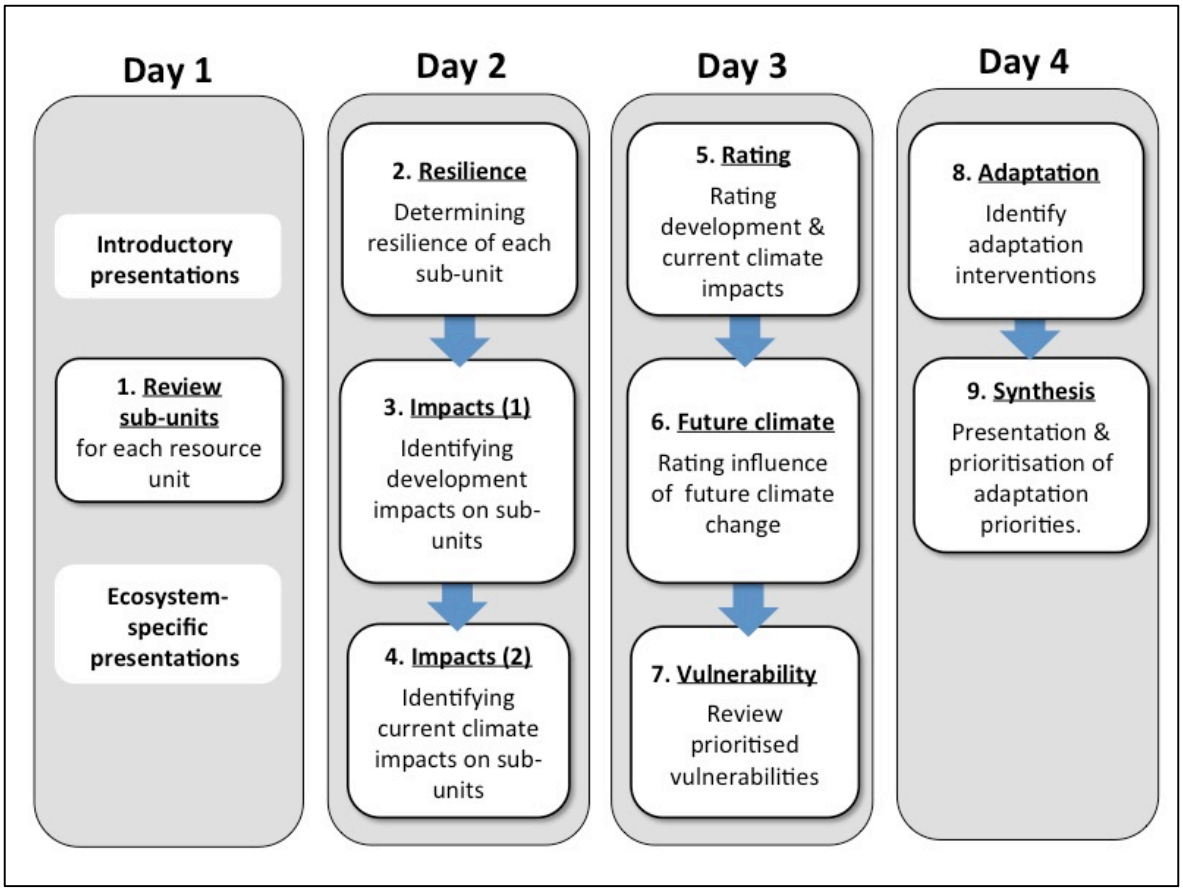
Figure 3-4 – Simplified schematic of the *Flowing Forward* analysis process



This 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 3-5. This figure also show how the stages were distributed by the workshop days.

Figure 3-5 – 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/behavioral/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* (i.e. with other populations, habitats, larval or seed inputs etc.)
  (ii) *natural variability* (i.e. degree of acclimatization to variable climate extremes)
  (iii) *refugia* (i.e. areas within a sub-unit that are naturally less exposed to hazards)
  (iv) *functional redundancy* (i.e. degree of dependence on other species, inputs etc.)
  (v) *natural productivity* (i.e. 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.

- **Steps 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-units; 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:
    - Intensity: represents the degree of disturbance as a result of an impact.
    - Extension: this represents the proportion of the sub-unit that is impacted by a given development or climate hazard
    - Manifestation: assesses how long the effects (as captured in intensity and extension above) will take to manifest. It can be immediate 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 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 3-6 below:

Figure 3-6 – Formula for calculating current vulnerability

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

I=Intensity; E=Extension; M=Manifestation; R=Resilience

Projected vulnerability was calculated by applying to current vulnerability the influence of future climate factor as shown in Figure 3-7 below

Figure 3-7 – Formula for calculating projected vulnerability

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

I=Intensity; E=Extension; M=Manifestation; R=Resilience

With these results in hand, working groups reviewed the results to consider whether there were any scores that needed to be revised. This was done by going back in the process and change resilience or exposure/impact scores so that each group felt confident with the results.

- **Step 8: Identifying adaptation options:** This step involved identification of adaptation interventions, aimed at reducing the vulnerability of vulnerable subunits. 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 subunit. 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.

3.5. STEP 5 – REVIEW OF ADAPTATION OPTIONS AND PLANNING WAY FORWARD

The objective of the QNP vulnerability assessment was to develop practical adaptation interventions that could be integrated into the QNP programme of work as part of the implementation of the QNP Management Plan, 2011-2012. Accordingly a further meeting was held on Ibo Island (marine HQ of the QNP) between 11-13th February 2016. The objectives were to review the adaptation options proposed and prioritized during the stakeholder workshop; revise and improve them; consider how they could be incorporated into QNP's programme development; and agree on next steps. Participants included the WWF facilitation team, the QNP

management, local authorities (Province and District), and NGO representatives working with QNP.

4. DESCRIPTION OF QUIRIMBAS NATIONAL PARK (QNP) & RESULTS OF VULNERABILITY STUDIES

4.1. OVERVIEW OF THE QNP

The QNP was gazetted on 6 June 2002 (Decree 14/2002). It is recognised by WWF as a conservation area of global significance, in part on account of its unusual combination of terrestrial and marine biodiversity in close proximity.

QNP is located in Cabo Delgado Province, and includes the 11 southern islands of the vast Quirimbas Archipelago (a chain of 28 islands stretching over almost 400 km). QNP partially covers 4 districts (Meluco, Pemba-Metuge, Ancuabe and Macomia) and includes the whole districts of Ibo and Quissanga. With a total area of 9 130 km², it includes both terrestrial (7 945 km²) and marine habitats (1 885 Km²). QNP is a globally outstanding biodiversity area, with its magnificent inland ecosystems (miombo, coastal forests, granite inselbergs holding many endemic plants, among others), and also sensitive marine ecosystems, namely mangroves, seagrass beds and some of the best kept coral reefs in the southern African region, as well as endangered marine species (e.g. five species of marine turtles, whales and dolphins). With about 154 villages and 166 000 people living permanently within the park boundaries and buffer zone, the population is mainly concentrated along the coast (20% of the QNP's population) and the main roads that cross the park (MITUR, 2011). As elsewhere in the province, the education level is low (illiteracy rates average 83%) and 95% of the economically-active population works in small-scale agriculture on family-run farms, and in fisheries (MITUR, 2011; Riddell & Rosendo, 2015). Food insecurity levels within QNP and Cabo Delgado are the highest in Mozambique (Riddell & Rosendo, 2015).

Considering these characteristics, both people and QPN 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 Quirimbas National Park 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 & 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 QNP resources systems given below is formulated as per the final analysis units and sub-units identified for the purpose of this vulnerability assessment. There are 8 analysis units and 54 sub-units in total. 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. Forest (Miombo & Coastal)

The Forest includes five sub-units:

i. Coastal forest areas of multiple use;
ii. Use and community development zones;

iii. Forest around villages outside the park;
iv. Buffer Zone;
v. Total protection zones.

Overall, this unit has great value for biodiversity conservation in QNP, because these ecosystems present great diversity of endemic and poorly studied flora and fauna species. The ecosystems are important for the local communities as they allow the sustainable use of resources for traditional purposes.

2. Mangrove Forest & Dunes

This unit includes four sub-units:

i. Low islands mangrove;
ii. Estuarine mangrove;
iii. Coastal mangrove;
iv. Coastal dunes with invasive trees and autochthonous flora

Mangrove forests are an extremely important ecosystem, acting as nursery for several marine species, providing food for local communities and wild species, coastal protection, water purification, among other services. The dunes in the QNP are very important as a physical barrier, controlling coastal erosion.

3. Coral reefs and seagrass

This unit has six sub-units:

i. Sheltered coral reefs with fishing pressure;
ii. Exposed reefs under fishing pressure;
iii. Sheltered reefs without fishing pressure;
iv. Exposed coral reefs without fishing pressure;
v. Seagrass of the shallow waters;
vi. Seagrass of the deep waters.

Both coral reefs and seagrass 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.

4. Species of high conservation value

This unit is divided into ten sub-units:

i. Sea turtles;
ii. African wild dog;
iii. Crocodiles/ hippopotamus;
iv. Elephant;
v. Kudu;
vi. Lion/ Leopard;
vii. Shark;
viii. Dolphin;
ix. Whales;
x. Southern ground hornbill.

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

5. Agricultural and Livestock Systems

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

i. Maize;
ii. Livestock breeding (small ruminants);
iii. Cassava;
iv. Vegetables;
v. Fruit (mango, cashew, coconut, maçanica).

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.

6. Freshwater

Freshwater unit has eight sub-units:

i. Wells (inland);
ii. Wells (coastal);
iii. Coastal basin;
iv. Lagoons (Bilibiza);
v. Montepuez;
vi. Swamps (Kagavero);
vii. Goundwater;
viii. Seasonal rivers (Messalo, Muaguide, Muagamula).

The QNP is crossed by a number of periodic rivers and tributaries watercourses. The main rivers in the park include Montepuez (the most important river in the Park), Muagamula, Muaguide, Mivoroto, Mezingue, Sivuca. Another charismatic hydrological resource is Lake Bilibiza located in the Quissanga district. There is also a smaller lagoon, Kagavero, where the water diminishes dramatically during the dry season, yet it has never dried up entirely. These are extremely important, as water is a basic and fundamental resource. Moreover communities usually cultivate the second season near water bodies. Signals of negative climate effect events such as storms, cyclones, floods and disasters are visible in this area.

7. Fisheries and Aquaculture

This unit has eight sub-units:

i. Pelagic fish;
ii. Reef fish;
iii. Freshwater Fish (Tilapia, cat-fish);
iv. Lobster;
v. Marine invertebrates (Oysters and “Pinas”);
vi. Cephalopods (octopus and squid);
vii. Crab;
viii. Shrimp.

These 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.

8. Human settlements

The human settlements unit has eight sub-units:

i. Sanitation;
ii. Tourism;

iii. Human settlements prone to flood;
iv. Human Settlements prone to sea level rise;
v. Human Settlements prone to cyclones;
vi. Human Settlements prone to droughts;
vii. Key-social infrastructures (schools and health centers);
viii. Economic infrastructures (roads and bridges).

Forest degradation, deforestation of large areas, the vulnerability of islands and areas under 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.

4.3. DEVELOPMENT TRENDS

A Climate Vulnerability Background Review for Quirimbas National Park was prepared by Paula *et al*. (2015) from Biodinâmica, S.A. which summarizes relevant available information and references to assess climate vulnerability in the QNP. 143 documents were identified and 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 the last decade the Provincial Directorate for the Coordination of Environmental Affairs (DPCA), currently Directorate for Land, Environment and Rural Development (DPTADER), has issued at least 30 licenses for the following infrastructures in the main districts that are included in the QNP:

- **14** concerning tourist accommodations;
- **7** seven electrification projects;
- **4** fuel stations;
- **1** one water bottling project;
- **3** three mining projects and;
- **1** oil & gas project.

The local development trends are therefore associated with existing/planned tourism, oil & gas and mining developments. As a consequence, it is expected that other related projects like roads and social infrastructures will be developed in the future.

4.3.2. DEMOGRAPHICS

There is no consistent data for the calculation of growth rate regarding the QNP population. However, according to the latest Quirimbas Management Plan (2011-2021), there are currently 166000 people, with approximately 95000 people (57%) within the park limits and 71000 (43%) in the buffer zone. Assuming that the QNP population will grow in conformity with the growth rate of the Cabo Delgado Province (approximately 2% a year), it is expected that this growth may be associated with the existing/planned developments. These are likely to alter migration patterns, particularly in terms of the influx of people after the establishment of the new mega projects and associated value chains. It is important to note that most of the developments in the Cabo Delgado Province and around QNP are along the coast, where the highest concentrations of local communities are located.

4.3.3. ENERGY

The entire offshore area of Cabo Delgado (Rovuma basin) is devoted to gas exploration (currently exploration and future exploitation). The Rovuma basin covers approximately 64000 km2 and is formed by six offshore blocks. The current potential will increase in future from ongoing exploration in blocks and 3 and 6 (Petronas) and in blocks 2 and 5 (Statoil). Statoil blocks are located offshore the QNP area. However, until now, no commercially viable wells have been reported and apparently those blocks were relinquished (Berry, 2015). The QNP buffer zone also includes a small part of the Anadarko Onshore Area 1. It is expected that the number of oil & gas projects will increase in the future. Current power supply to the QNP is scarce and there are plans to improve the powerline infrastructure. Considering the cumulative effect of the impacts of the oil & gas industry and whole associated infrastructures, it is expected that the pressure on local ecosystems, namely seagrass, coral reefs and/or mangrove, will increase significantly as well as the risk of hazards.

4.3.4. MINING

According to the data provided by Provincial Directorate for Mining Resources and Energy from Cabo Delgado and the information available on the Mozambique Mining Cadastre Portal in the QNP and surroundings there are currently 20 areas associated with mining activities, of which: nine are in operation, seven correspond to requests for exploration, one still needs to collect the mining certificate, one is awaiting approval, other has its mining certificate expired and the last one has the extension request pendant. Minerals like graphite, vanadium and ruby have been found in Cabo Delgado, near the QNP, and the first mines are now starting to operate. It is possible that mining projects will happen in the region in the next years. So it is expected that the impacts will focus inland with terrestrial forest loss and habitat fragmentation and in pristine marine environments, as chemicals are emptied or washed into waterways leading to the sea.

4.3.5. TOURISM

Tourism is one of the greatest economic resources in the QNP that is actually seen as a new ecotourism destination, remote and not deteriorated. The number of hotel units has increased over the last decade, rising from 32 in 2004 to 127 in 2014 (a four-fold increase), as well as the number of beds that rose from 800 to almost 2500 (a three-fold growth). 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.

The strategy proposed for the QNP aims at sustainable tourism that should maintain the characteristics of an exclusive destination by developing medium/high quality tourism with low volume/density that must be consistent with the QNP conservation objectives (Paula *et al*. 2015). As a consequence it is expected that the number of hotel units as well the number of beds and tourists continue to increase in QNP.

4.3.6. LAND & RESOURCE USE

According to the Agriculture Census 2009-2010, the Cabo Delgado Province has 491 151 ha of cultivated land (8,72% of the total Mozambique cultivated land). Although no official numbers about agriculture are available for the QNP, farming and fishing are the predominant activities among households and the main sources of income. Agriculture prevails mostly in the interior of the park and fishing in the coast (MITUR, 2011).

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

No trends were possible to analyse relative to agricultural land, crops & livestock. Land cover of Miombo woodlands has reduced over the years in QNP (Ribeiro *et al*, 2015). According to Ribeiro *et al.* (2015) southern Block A, located in the Meluco and Ancuabe districts, shows a major spot of woodlands loss in recent years. Conversion to agriculture, fire, logging among other activities that implicate deforestation are the main causes for this reduction. Deforestation occurs all over the Park, focusing mostly along the main roads. Slash and burn of Miombo woodland seem to have been increasing in the QNP, which normally is associated with agricultural land, crops & livestock. Charcoal and firewood obtained from Miombo woodlands are commonly used by households as cooking fuel within QNP.

Using the Global Forest Change web tool it was possible to identify that deforestation occurs all over the Park, focusing mostly along the main roads, especially in the northern section (Tanguia Region). It also seems to have a higher concentration in the eastern zone. Forest cover gain also occurs in Tanguia region and QNP east area, which may be compensating part of the recorded deforestation.

The data for regions within the QNP area shows that 70% of households in Ancuabe use charcoal as a cooking fuel and 35% use firewood; the data for Metuge shows that 63% of households use charcoal as a cooking fuel and 47% use firewood; while in Bilibiza and Mahate 35% of households use charcoal as a cooking fuel and as much as 71% use charcoal.

Given all this it is expected that loss of Miombo woodland will continue and may increase due to: a) the expected population growth and human related activities (e.g. mining); b) the predicted increase in rainfall that will increase the production of grass biomass which combined with the predicted increase in temperature, may result in high fuel loads and in an increase in the frequency, intensity and extent of fires.

The population living within the QNP exploits mangroves for various purposes including fuel, wood (including illegal timber trade) and construction materials, fencing and boat repairing. According to Nicolau (2015) mangrove forests of QNP suffer low decrease in recent years, despite healthy regeneration, reflecting a high disturbance related to human induced actions and climate change factors. So it is expected that in the next years Mangrove forests cover will continue to decrease as a consequence of population growth and climatic changes.

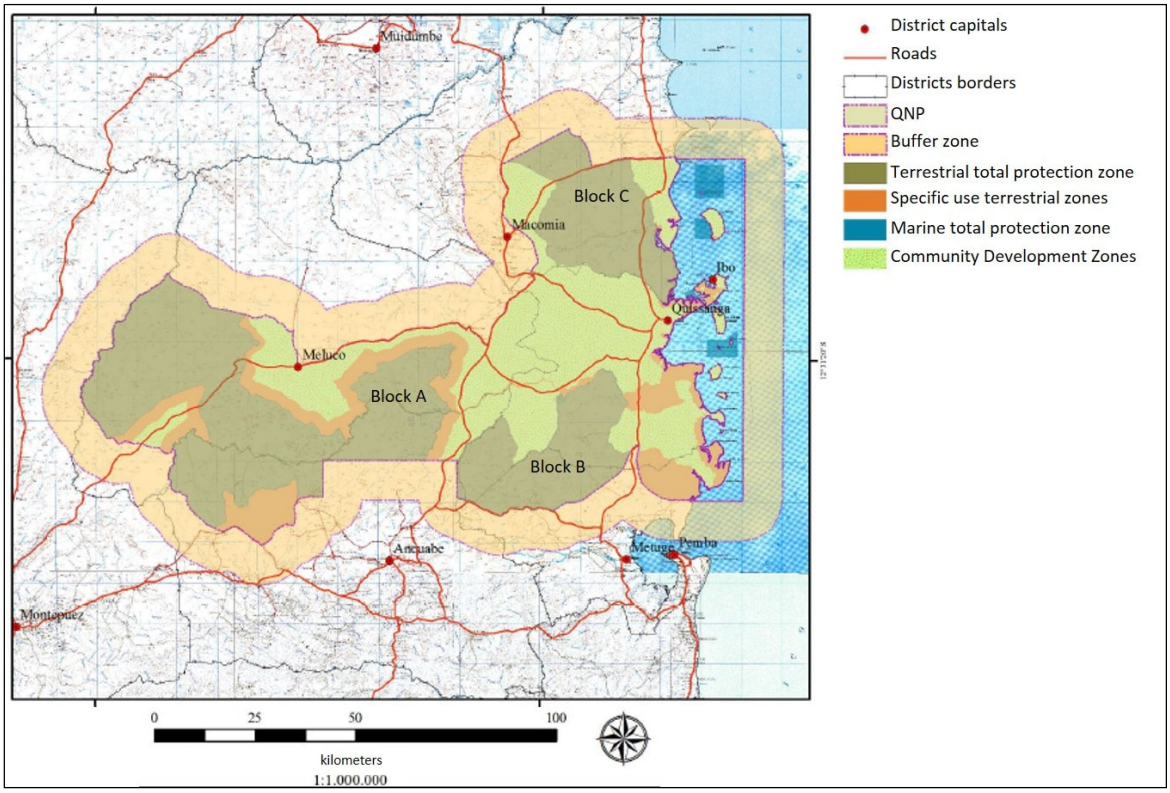
There are no evidences of anthropogenic influence on Coral cover in the reefs of QNP (McClanahan and Muthiga, 2015). However, like previously said, the expected increase of oil & gas projects could lead to an increase of pressure in this ecosystem that could influence coral cover.

It should be noted that the QNP management plan has developed a land use zoning with the categories described below. Should the management plan be properly applied, it is expected that the land use trends previously described change gradually fitting this zoning plan. The QNP zoning includes (Figure 4-1):

- **Total protection zone** (46% of QNP's total area) – this zone is the core of QNP, where patrolling and biodiversity conservation activities are primarily focused. Its terrestrial section is composed by Blocks A, B and C;
- **Specific use terrestrial zones** (13% of QNP) – in this zones the main concern is to keep ecological conditions, preventing illegal activities and human invasion;
- **Community development zones** (41% of QNP) – in this zones the goal is to reconcile the human development with the sustainable use of resources, in an harmonious way;

- **Buffer zone** – this zone has an extension of 10 km around the QNP border and its objective is to mitigate the possible negative impacts of surrounding human activities on the park.

Figure 4-1 – QNP zoning.



Source: adapted from MITUR, 2011.

4.3.7. FISHERIES AND AQUACULTURE

The numbers of fishermen, fishing gear, fishing vessels and fishing centres have been increasing in recent years, as it can be observed in the table below (Table 4-1).

Table 4-1 – Evolution of the fisheries items through the survey years.

Items/Year	1995	2002		2007		2012	
No. of fishermen	4469	15875	255,2%	14261	-10,2%	19097	33,9%
No. of fishing gears	475	4359	817,7%	4764	9,3%	6417	34,7%
No. of fishing vessels	1885	4124	118,8%	4439	7,6%	5615	26,5%
No. of fishing centres	114	141	23,7%	197	39,7%	225	14,2%

Source: Sitoe *et al.* , 2010 *in* Paula *et al.*, 2015; Ministério das Pescas / IDPPE,2013 *in* Paula *et al.*, 2015

Overall there is a positive trend in terms of total catches with the four most representative fishing gears (beach seine, handline, surface gillnet and bottom gillnet) and beach seine is the fishing gear with the higher catches in the four main fishing districts of QNP (Meluco, Macomia, Quissanga and Ibo). Most of the fish families that were caught by the four fishing gears mentioned above are declining in terms of percentage of occurrence (Paula *et al.* 2015). Studies revealed that fishable biomass in more than two thirds of the reefs in QNP are being exploited at a level showing loss of species especially of the large bodied fish species (McClanahan and Muthiga,

2015). Currently there are no active processing units in the districts overlapped by the QNP (Metuge, Meluco, Macomia, Quissanga, Ibo and Ancuabe), nor under a licensing process. Regarding aquaculture and mariculture, although some studies have been made in the past, currently, Cabo Delgado's Provincial Directorate for Fisheries does not have any projects in operation or at the licensing stage. So with population growth and the lack of investment in aquaculture/mariculture and fish processing centres it is expected that the number of fisherman increase and consequently the exploitation of the fishable biomass.

4.3.8. FRESHWATER

The annual water flow of some rivers outside the QNP (e.g. Massalo river) has suffered a reduction in recent years (from 1997 to 2013). It is expected that this could be the trend in the rivers and water bodies present in QNP due to the climatic changes and the population growth expected for this protected area.

There is no indication of a potential dam construction inside the QNP. Several rivers have been identified in this study and the only Dam, which is known to be under assessment, is the Megaruma River Dam, south of Pemba, significantly far from the QNP and out of the catchment of any of those rivers. This will be used both for irrigation and water supply to Pemba. The adverse environmental and socioeconomic impacts of the construction of dams are widely known and therefore the development of a dam inside QNP could ultimately be detrimental to either the environment or the surrounding population.

4.3.9. HABITATS AND HIGH-PROFILE SPECIES

Pre-existing information, together with new data collected under ecosystem-specific studies funded by FFEM, for coral reefs, mangroves and miombo woodland habitats, is summarised below in Section 4.4.

High-profile species present in the QNP include marine turtles, marine mammals (dolphins and whales), whale shark and the elephant. Although widely recognized for their conservation value as well as for their tourism potential, the knowledge of their status in the QNP is very poor. Studies have been conducted mainly as part of Environmental Impact Assessments, and mostly provide little more than general descriptions and species occurrence. Unfortunately there are no time-series data that would allow status trends to be drawn, and the current state of conservation of these species is largely unknown. Regarding the specific case of the elephant, the available information, dated from 2010 and 2011, is that the QNP population is around 1000 individuals (DNAC, 2010; MITUR, 2011).

4.4. SUMMARY OF SPECIFIC STUDIES UNDERTAKEN FOR THE QNP

As referred in Section 3, six climate-related studies were undertaken under the umbrella of the climate vulnerability assessment for QNP. They were:

i) Coral reefs and climate change (MacClanahan & Muthiga, 2015);
ii) Mangroves and climate change (Nicolau, 2015);
iii) Miombo woodland and climate change (Ribeiro *et al.,* 2015)
iv) Community vulnerability & capacity assessment (CVCA) (Riddell & Rosendo, 2015);
v) Climate Vulnerability Background Review (Paula *et al.*, 2015);
vi) Analysis of observed climate trends and downscaled projections (Pinto *et al.,* 2016).

Results of (i) to (iv) above are summarized in this section 4.4. Results of (v) and (vi) above are summarized in Section 5 below. Detailed information about each of the themes, can be found in the original documents, mentioned above.

4.4.1. CORAL REEFS AND CLIMATE CHANGE

The assessment of the impact of climate change and adaptation options for the coral reefs of Quirimbas National Park was undertaken by MacClanahan & Muthiga (2015), from the Wildlife Conservation Society, Mombasa, Kenya. Its objective was to evaluate the ecological status of the QNP's reefs, anthropogenic and climate impacts and make recommendations for management.

The status of the QNP coral reef habitats was evaluated from the 27th June to 7th July 2015 based on field assessments of benthic substrate, coral community assemblage, finfish and sea urchin community and environmental characteristics of the reefs. Sites were sampled according to management categories that included two basic gear use restrictions, none and some gear restrictions, and two levels of closure compliance, low and high. The results were compared with data from previous surveys that were carried out from Nacala south to Pemba north from 2008 to 2014 in order to get a more comprehensive understanding of the climate impacts and human pressures of the larger Quirimbas area.

Summary of key findings

Coral cover and diversity: The reefs within the QNP had hard coral cover and coral diversity that ranged between 30% and 59% generally higher on average than the Western Indian Ocean (WIO) regional averages for these metrics, underscoring the importance of these reefs for the WIO. Hard coral cover was particularly high in the Lighthouse, Bunting and Quilelea reefs (59%, 52%, 49% respectively) and lowest at Rolas East, Pachamba and Coliseum (30%, 36% and 37% respectively). In general coral taxa diversity were relatively similar across all sites and was highest at Lighthouse (36 genera) and lowest at Rolas west. Comparison with previously sampled sites within the broader Quirimbas archipelago and urban areas showed no significant differences in coral cover but the coral community bleaching susceptibility was highest in the non-QNP sites and lower but insignificant differences were found between the QNP and urban sites. When comparing sites by management category, coral site susceptibility was highest and coral diversity lowest in the high compliance closures.

Finfish and fishable biomass: The average biomass of reef fish in the QNP was ~ 700 kg/ha (range 260 kg/ha to 1490 kg/ha). The biomass was highest at Matemo, Dogtooth and Lighthouse (1488 kg/ha, 1011 kg/ha, 968 kg/ha respectively). The fishable biomass averaged 633 kg/ha (range 270 kg/ha – 1420kg/ha) the same sites also had the highest fishable biomass of reef fish (1420 kg/ha, 958 kg/ha, 920 kg/ha respectively). Studies in the WIO have shown that fishable biomass of reef fish below 300kg/ha show rapid changes leading to phase shifts to highly degraded states, between 300 – 600kg/ha confer some resilience and reduce the chances of deleterious phase shifts while fishable biomass above 600kg/ha maintain ecological integrity and potential resilience

to climate change. Reefs at Rolas E, Luju and Pachamba had fishable biomass below 300kg/ha; sites at Buntings and Coliseum had ~400 – 500 kg/ha while Rolas W, Quilelea, Lighthouse (1 and 2), Dogtooth and Matemo had fishable biomass of 600 – 1400kg/ha. The Matemo site had fishable biomass that was above 1200kg/ha the pristine biomass level for the WIO. More than two thirds of the reefs are being exploited at a level showing loss of species especially of the large bodied fish species.

Comparison between QNP, non-QNP and urban reefs showed no significant differences between the QNP and non-QNP reefs but total and fishable biomass were significantly higher on the Qurimbas reefs (30%) than on urban reefs. Fish diversity was also higher in these sites than urban reefs. In addition, fish in the urban reefs differed from the QNP and non-QNP reefs in their life histories with urban reefs having smaller fish, smaller lengths at sexual maturity and higher mortality than the Quirimbas reefs. There was not only no significant differences in fish biomass and fishable biomass between the QNP and non-QNP reefs, but life histories of fish also did not differ. Of the non-QNP sites, the Vamizi closure had the highest total fish biomass and fishable biomass ~1500kg/ha.

Sea urchin biomass: The biomass of sea urchins in the QNP averaged 150kg/ha and ranged from < 10 to ~730 kg/ha with most sites below the problem level threshold for urchin biomass. When sites within the larger Quirimbas archipelago were compared, the sea urchin biomass showed high variability and a general but statistically insignificant increase from QNP to non-QNP to urban reefs and low values in the low to high compliance closures and high values in the reefs were no gears were restricted.

Environmental gradient and bleaching susceptibility: There was no significant difference between the sites within the QNP and reefs in the Quirimbas archipelago and the urban areas.

4.4.2. MANGROVES AND CLIMATE CHANGE

A study titled *Climate Change Impact on Mangrove Ecosystem and Development of an Adaptation Strategy For Quirimbas National Park* (Nicolau, 2015) was undertaken by WWF, funded by FFEM through QNP. This study had as general objective to perform a mangrove ecosystem assessment for Quirimbas National Park (QNP) in order to understand mangrove forest biophysical and anthropogenic dynamics in the context of climate change, and to guide the park administration and local communities on development of an adaptation strategy for climate change for QNP. The specific objectives were:

a. Conduct a mangrove change-detection analysis of relevant satellite imagery to assess changes on mangrove cover within QNP and its buffer zone over a 20 year timeframe up to the present;

b. Describe the mangrove forest structure status and assess to the current level of cutting and regeneration status of mangrove forests on QNP;

c. Develop climate change scenarios for biophysical impact assessment of climate change on mangrove ecosystem;

d. Identify the main gaps in the present state of climate change knowledge in relation to the current and possibly future management objectives of the QNP;

e. Develop an adaptive resource management strategy that involves local community to improve the resistance and resilience of the mangrove ecosystem of Quirimbas National Park to climate change.

A (a) Mangrove Cover Change Detection, a (b) Mangrove Structure and Regeneration Status, a (c) Conservation Status assessment of the mangrove and a (d) Regeneration Classes set were made:

a. The mangrove cover change-detection was based on analysis of relevant acquired satellite imageries supported by groundtruthing. It included:
   - Image acquisition and processing;
   - Mangrove mapping and land change analysis;
   - Assessment of mangrove deforestation status and future modeling.

b. Regarding the Mangrove Structure and Regeneration Status the sampling design used to assess the mangrove structure of QNP was based on a combination of the protocol developed by Kauffman and Donato (2012) and the applied methodology to assess mangroves forest structure (Kairo *et al.*, 2002 and Bandeira *et al.*, 2009 *in* Nicolau, 2015).

c. The conservation status was assessed by the level of cut according to the methodology described by Cintron and Schaeffer-Novelli (1984), FAO (1994); Kairo et al. (2002) and Kauffman and Donato (2012) (Nicolau, 2015).

d. Regarding the regeneration classes, within the sample sub-plots 5 x 5 meters subplots (quadrat) were set and all trees with a diameter at breast height (DBH) ≤ 2.5 cm were identified and counted (Kairo *et al.*, 2002, Kairo *et al.*, 2008 and Bandeira *et al.*, 2009 *in* Nicolau, 2015).

Summary of key findings

Mangrove forests of QNP are not pristine. This assessment revealed an increase of mangrove forest cover between 1991 and 2002, followed by a decrease between 1991 and 2013 (Table 4-2).

Table 4-2 - Mangrove change area between 1991 and 2013 in the QNP.

	Timeline		
Variables	**1991**	**2002**	**2013**
Area extent (ha^{-1})	11244	12812	12348
Cover variation (gain and loss) (ha^{-1})	-	+1568	-464
Annual loss percentage (%)	-	+1,27	-0,33

Source: Nicolau, 2015

Analyses of mangrove forest structure reflected a high disturbance related to human induced actions and climate change factors. Despite that, there was a clear evidence of healthy regeneration in this forest considering the high densities of juveniles; nonetheless the distribution of regeneration classes was not uniform suggesting a relation to the forest cover or harvesting areas.

Detailed results on the mangrove assessment, namely the composition and conservation status of the sites surveyed, can be found in the original report (Nicolau, 2015).

4.4.3. MIOMBO FOREST AND CLIMATE CHANGE

The assessment of climate change impact and adaptation options for QNP's Miombo forest was undertaken by Ribeiro *et al.* (2015), from WWF, with support of FFEM. This study was conducted with the aim of understanding the effects of climate change on miombo woodlands and thus, to contribute to QNP's new management plan. The specific objectives were:

a. Mapping and assess recent (22-year) trends in the extent of miombo cover;

b. Describing the status of miombo forests with respect to human disturbance;

c. Describing the status of wildlife resources in miombo forests with respect to human disturbance;

d. Identifying, analysing and evaluating observed changes in miombo forests and the ecosystem services they provide, and the possible or probable links to climate change trends and/or extreme events;

e. Identifying the main gaps in the state of knowledge of the impacts of climate change on miombo ecosystems; and

f. Identifying priority adaptation recommendations that would enhance resilience to climate change of miombo forests and related resources and livelihoods.

The selected methodology had five main steps (Ribeiro *et al.,* 2015):

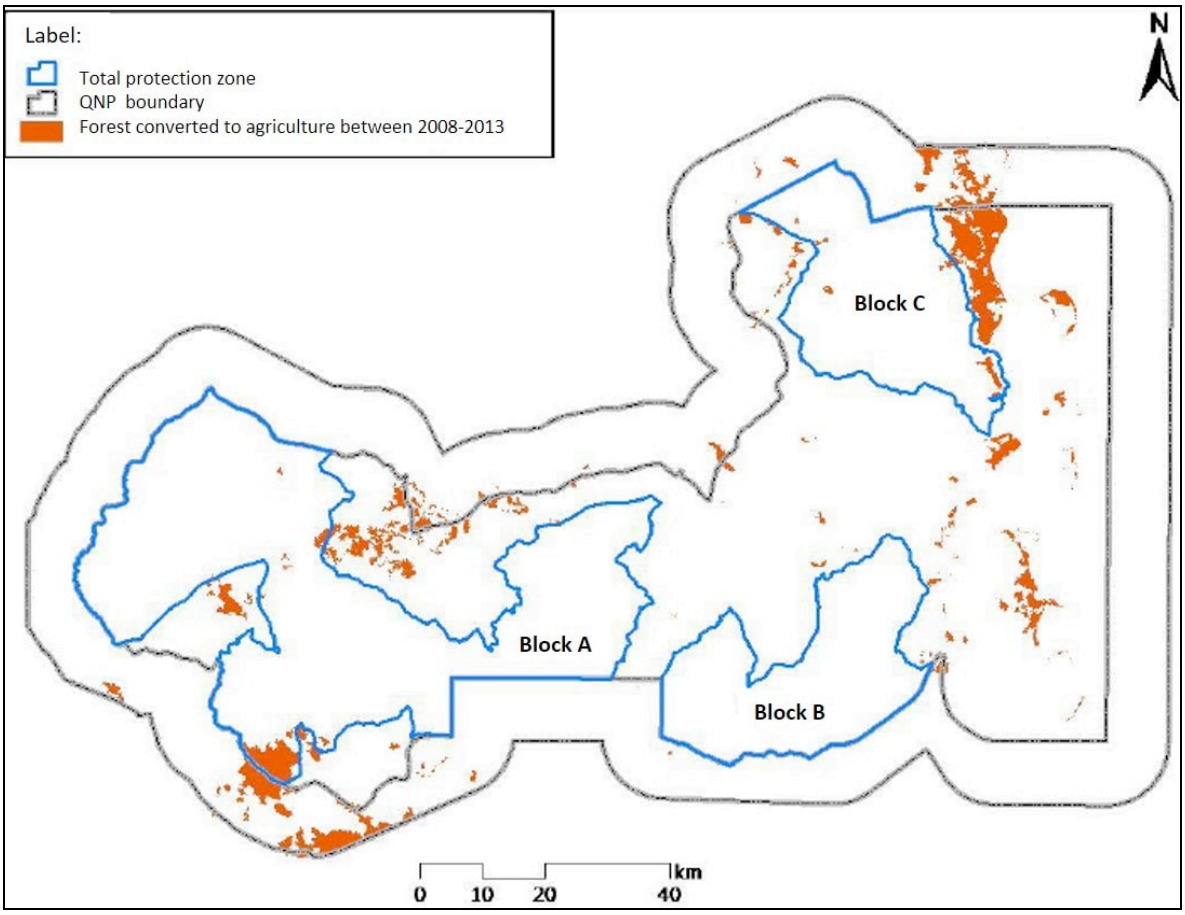
1. Five villages (Namitil, Nanduli, Nguia, Napala and Miegane) were chosen. Around each one were established transects and plots for biodiversity assessment;
2. Landsat images for the years 1991, 1998, 2003, 2008 and 2013 were classified using a supervised classification in ERDAS 2014, to separate different land cover classes;
3. Freely available MODIS data (MOD14A1 and MCD45A1A) was used to characterize the fire regime;
4. The socio economic approach to the communities was simplified from the CVCA. 9 discussion groups and 49 semi-structured interviews were conducted in the selected villages;
5. To address the impact of climate changes on the ecosystem, Biome-BGC Version 4.10 was selected, using climate prediction from the INGC for northern Mozambique. Global atmospheric carbon was also input in the model to predict changes in ecosystem's net primary production.

Summary of key findings

The results indicate that the miombo woodlands occupy a total area of 3 551.57 km^2, which represents 44,7% of QNP's total terrestrial area (The total terrestrial area of the QNP is 7943,1 km^2). Agriculture/settlement areas cover 419.98 km^2, which represent 5,3% of the terrestrial area of the park. Block A presented the biggest area of miombo woodlands with about 59,15 % of the block's total area. Block C had the lowest coverage of miombo with only 6,67 % of its area.

Land cover changes for the period 1991-2013 revealed changes in miombo woodland. There were substantial transitions from open miombo woodland to dense miombo woodland (3101 ha) and some loss of miombo to agriculture was observed (Figure 4-2).

Figure 4-2 – Miombo areas lost to agriculture between 2008-2013.



Source: Ribeiro *et al.* (2015)

The pattern of forest fires between 2000 and 2014 showed an inter-annual cycle, an intra-annual variation associated with the rainfall distribution and an average frequency of 2-3 years. However, at particular places (in the north and west) annual fires were observed, which may impose changes in the woodland. Fire regime may change in the next 40 years given the expected increase in temperature and precipitation for the region.

The biomass production in the last 60 years has decreased as a result of changes in precipitation, temperature and CO_2. For the next 40 years it is expected that a 15% increase in precipitation and 3ºC increase in temperature will cause a slight increase in biomass production. These may modify ecosystem diversity and structure and thus habitat for wildlife and availability of forest resources to local communities.

Climate changes have been felt in the last 20 years in the park and it was related to modifications in precipitation frequency and intensity. Napala community indicated drought problems, while all other communities suggested infrequent but very abundant rain. Excessive rains were associated with soil erosion and excessive accumulation of water in the crops, causing the roots to rot. Lack of rain was also mentioned as causing soil erosion, particularly associated to the effect of uncontrolled burning. People perceived that climate influences the seasonal availability of most forest products, although just a few trends through time have been noticed. Overexploitation of forest resources was referred as the main cause of ecosystem change and resources depletion. Napala presented the highest evidence of human pressure. In Miegane, conflicts with elephants were appointed as the cause for reduced availability of five different resources: bamboo (for construction), two fruits, one bean and one tuber (for food). Namitil indicated that forests are currently “further away” from the village than it was 10 years ago, the main reason being

agriculture expansion. Napala community referred that uncontrolled burning and deforestation are causes of the reduction in thatching grass. Both gender in the family share the responsibility of agricultural activities and the collection of forest resources. The two groups have a common perception about the availability of resources. Women are also generally aware of conservation agriculture techniques. Most villages have diversified their activities and include commercialization in their livelihoods in the last 10 years. In Miegane a potential conflict with the Taratibo conservation area was identified. People state that it is an obstacle to livelihoods improvement since the local inhabitants are not involved in forest resources management.

All communities sampled have benefited from economic and social development projects (Aga Khan, Helvetas and Kulima) such as agriculture and market access and they have some capacity to implement those activities. Vulnerability analysis revealed that the 5 communities are in general highly exposed to droughts, floods and storms, but Napala, Miegane and Nguia have the highest vulnerability given their respective location.

The main conclusions of the study are:

- Miombo woodlands occupy 44,7% of the QNP terrestrial area and its coverage has been relatively well maintained over the years.
- The woodland has considerable level of biodiversity and forest stocks (volume and biomass), but Blocks A and B are better stocked. These have potential for engaging in REDD+ projects.
- Local people rely deeply on the woodlands all year round, but especially during the dry season. The main woodland resources are: mushroom, wild fruits, honey and construction materials including thatch grass. Resources are mainly used for subsistence, but commercialization has become important in villages with better accessibility to roads and markets (Nguia and Napala).
- Fire frequency and intensity in the area are not particularly high in the park and thus it might not be one of the major drivers of forest degradation in the area. However, areas of greater concern in regard to fire are the western and northern regions of the park.
- Changes in fire regime related to climate changes are expected and already observed in some portions of the park (Napala).
- Ecosystem primary production is expected to have a slight increase with changes in precipitation and temperature in the next 30-40 years. This trend must be carefully monitored over time since the predictions present some level of inaccuracy.
- Changes in primary production may change availability of forest resources to local people but also of habitat for wildlife, but this is also a matter of further follow up.
- Local communities have some level of organization and capacity to adapt to climate change. Conservation agriculture techniques are well spread, livelihood diversification was observed in Napala and Nguia, but it is related to better accessibility to roads and markets. There is, however, a need to capacitate communities in forest management practices and engage them in tourism related activities.

4.4.4. CLIMATE VULNERABILITY AND CAPACITY ASSESSMENT (CVCA)

The community Climate Vulnerability and Capacity Assessment (CVCA) was conducted by Riddell & Rosendo (2015) in six communities within the QNP between February and March 2015. The study was undertaken as part of this broader WWF-supported climate vulnerability assessment process within the park that aims to identify adaptation priorities to be incorporated into the implementation strategy and management plan of QNP.

The methodology applied for this study was based on the Climate Vulnerability and Capacity Assessment (CVCA) method developed by CARE International (CARE, 2009). CVCA studies are intended to support identification of adaptation measures through a wider participatory process involving a range of stakehodlers. The approach is not specific to particular livelihoods or resources, but is designed to highlight the key issues that require further attention across the broad range of livelihood activities and strategies in these communities. The CVCA was planned and completed in six coastal villages, including two inland mainland sites (Mahate, Namirumo), two mainland coastal sites (Darumba, Mussemoco) and two island sites (Quirambo, Rituto) in the Districts of Quissanga, Macomia and Ibo. Seven different Participatory Rural Appraisal (PRA) methods were employed, including participatory hazard mapping, seasonal calendars, vulnerability matrix, Venn diagramming, historical timeline, key informant interviews, and village transect walks.

Summary of key findings

The study found there is a high dependence on subsistence agriculture and fishing in all of the six sites. Variation in the land availability, topography and ecosystems adjacent to villages influences the types of agriculture and the fishing techniques and gears employed. Livelihood activities are highly seasonal and affected in particular by rainfall patterns and winds. Communities reported pronounced seasonal hunger during January and February. Low and highly variable agricultural productivity, increasing levels of damage due to crop raiding by wildlife, a lack of storage facilities for harvest, and reductions in fishing catches all contribute to food insecurity.

Of the three critical conservation habitats considered in the study, mangroves have the highest socioeconomic importance and appear to be under the most anthropogenic pressure. Although communities depend mostly on natural resources, social resources such as mutual support, family and local institutions are also essential. Physical infrastructure and public services are extremely limited in the coastal zone of QNP.

Coastal communities refer that the storms have affected coral reefs and seagrass, not only through direct destructive impact, but also through sedimentation (areas of coral reefs and seagrass covered by sand). The extreme effects of the climate change also cause variation in physical parameters such as temperature and salinity of the oceans and estuaries, sea level rise causing coastal erosion. Increased coastal erosion has been reported in many areas of the QNP, although it was clear that this fact is being caused by rising sea levels, effects of strong winds and more frequent storms and cyclones. Some local communities have reported episodes of high mortality of fish and algae. This phenomenon can potentially be associated with the highest temperatures of the sea water.

Communities perceive a later start in the rainy season, heavier rainfall and a drier and longer dry period. This perceptions are supported by INGC data (2009). Changes in the rains and winds that relate to the observed scientific data, and also perceive changes in critical ecosystems due to changes in resource exploitation and population, growing markets, use of destructive fishing gears, a lack of capacity to enforce fishing legislation, and climate-related drivers of change in marine and coastal habitats.

The local communities recognized that the weather events such as cyclones, floods, droughts, coastal erosion, heavy rain, strong winds and changes in wind season have been more frequent in the QNP region. Most prominent risks and stresses are self-explanatory to communities, but droughts cause some consternation, and sometimes confusion, due to the complex nature of the change in standards and annual variations in precipitation. The communities said cyclones usually occurred every 5 years, and currently they occur almost every year. The general consensus among the communities is that the winds grew stronger and less predictable, changing frequently the direction and appearing outer their normal periods, but the flooding is one of the main hazards in QNP.

The most frequently mentioned hazards and stresses were floods, droughts and strong and variable winds. Floods impact on agriculture, houses, buildings, and roads, while droughts impact on agricultural productivity and water sources. Winds impact infrastructure, particularly housing, and fishing. The recent floods of 2014 (February-March 2014), and long dry spells of (2012 and 2013) were key points of reference for communities.

Climate-related hazards and stresses included diarrhoea, malaria, and wildlife conflict. Each village had different level of exposure to climate-related hazards, depending on quite specific biophysical and livelihood characteristics of the site. Making generalizations about the impacts of climate hazards and stresses within the broader area of QNP and the Quirimbas Archipelago is therefore challenging. Seemingly small context-specific factors play a key role in how different people are exposed or sensitive to climate-related hazards and stresses.

Household roles and access to different livelihood activities is structured largely by gender in coastal communities. As a result men and women experience climate hazards and stresses very differently. Although a number of impacts affect the whole community, women are affected most by droughts impacting agriculture and water sources, and children are most susceptible to climate-related disease.

Communities have developed a range of responses to climate-related hazards and stresses, but their ability to adapt is constrained by a lack of alternative sources of subsistence, finances, and capacity to adapt, in a context lacking in basic health care and water supply. In particular, a lack of resistant building techniques and materials and a lack of maintenance of basic services, particularly roads, act as barriers to adaptation. Low and variable agricultural production due to increasing wildlife conflict and crop failure due to floods and droughts adds an additional burden to rural households' livelihoods. Fishing councils lack the means or capacity to prevent increasing levels of natural resource extraction.

Some community responses can lead to further pressure on critical habitats as people increase the frequency and type of resource use, and more people engage in resource extraction. This means that conservation regulations within the QNP should take into consideration that resource extraction can be (but is not always) a climate-adaptation strategy. Therefore conservation policy and regulations could also include ways to maintain and even increase the productive capacity of these marine and coastal resources, as a complementary strand to the current conservation focus on strict protection zones (sanctuaries).

Unfortunately, in many cases where institutions external to the communities have provided development support, such as borehole or latrine construction, these activities were not climate resilient and some investments appear to have been futile. Another complaint by the communities is the timing and quality of road repairs. These included delays in the repairs, which often are still being carried out during the rainy season, the quality of the selected materials and the low quality standards. They also complained that the work of the private contractors, hired by the National Administration of Mozambique Roads (ANE), was not monitored and that there was no communication between community leaders and contractors. This led, in a particular case, to the extraction of sand from a place below the local cemetery, causing its erosion.

5. OBSERVED CLIMATE TRENDS AND DOWNSCALED PROJECTIONS

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

- *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 Quirimbas National Park, 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 CLIMATIC ENVIRONMENT

The majority of the Mozambican territory is situated in the intertropical zone. As a result, it's 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. The coastal strip of QNP receives about 800 to 1000 mm of rainfall per year, with 1000 to 1200 in the central parts of QNP (Pinto *et al.,* 2016).

According to Pinto *et al.* (2016), on the coast the temperature is generally higher, with an annual mean of 24-27 °C in QNP. There is a very clear annual variation in the amount of rainfall, with a rainy and hot season, lasting from November to April, and a dry and cooler season, from May to September.

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.

According to INGC (2009) and Tadross *et al.* (2009) *in* Paula *et al*. (2015), Mozambique country-wide data 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. Almost all the model projections for 2050-2200 indicate that November will become drier in northern Mozambique. From January to March, most of the models give indications of an increase in average monthly precipitation. 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). In the QNP there are evidences on changes on temperature and rainfall (Pinto *et al*., 2016).

5.2. AIR TEMPERATURE

Trends

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.

Pinto *et al.* (2016) found that all locations in northern Mozambique were warmer, on average, in the 2000s than in the 1970s. Maximum and (minimum) temperatures in QNP have increased by 0.2-0.3 °C and (0.3-0.4°C) in the 2000s respectively. Similarly, records of atmospheric temperatures from 1985 to 2013 observed at the Pemba meteorological station show an increase of average temperature for the hot and the cold seasons, of 0.03 and 0.04 ˚C per year for December-January-February (DJF) and June-July-August (JJA), respectively (INGC, 2009 *in* Paula *et al.,* 2015). A reduction of the number of cold nights and increase of warmer days has also been registered.

According to INGC (2009) *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. INGC study 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

Trends

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

i. reduction of the rainfall on the coast and increase onshore, in the first decade of the 2000s;
ii. increase, by up to 100 mm, of interior rainfall, in the first decade of the 2000s (in the previous decade there was a reduction);
iii. decrease of 60-80 mm in coast rainfall, of the first decade of the 2000s (in the previous decade there was an increase);
iv. an increase of the consecutive dry days of about 0-10 days per decade;
v. an increase of the total annual rainfall and very wet days in the interior, and a decreasing trend along the coast;
vi. an increase of the number of days with rainfall above 20mm/day of about 0-10 days per decade;
vii. total annual rainfall and very wet days increase, in the interior, and decrease, along the coast;
viii. the reduction of the maximum rainfall in five consecutive days;
ix. an increase of the rainfall intensity;
x. the rainfall season is becoming shorter.

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. More detailed information can be found in the original study (Pinto *et al*. 2016).

Projections

Pinto *et al*. (2016) has concluded that the following trends are projected to occur in Cabo Delgado: 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 the QNP in 10% in the coast and 20% onshore (over 20mm); iv) a 20% increase of the total rainfall in the days when it rains a lot in many areas of the QNP; v) a 10% increase of the maximum rainfall in five consecutive days in most of the QNP; vi) a 10% increase of the rainfall intensity in most of the QNP.

The projections are thus suggesting that in the future QNP 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).

Pinto *et al*. (2016) also refers that the projections suggest that the extreme events continue to be more frequent. The increase of the dry days is also expected, which may cause the reduction of the raining periods. On the other hand an increase of the total rainfall together with extreme events is expected, meaning that the amount and intensity of rain will increase when raining events occur.

According to KNMI (2007) in Paula et al. (2015), data suggest 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. Almost all the model projections for 2050-2200 indicate that November will become drier in northern Mozambique (zone 13) while for December there are fewer consensuses. From January to March, most of the models give indications of an increase in average monthly precipitation.

5.4. CYCLONES

Trends

According to Guha-Sapir *et al.* (2015) *in* Paula *et al*. (2015), in recent years, from 2008 to 2014, four tropical cyclones were reported in Cabo Delgado, against five that occurred from 1956 to 2007. These events became more frequent, leading to devastating flood events (Tadross & Johnston, 2012*,* Hellmuth *et al.*, 2007 *in* Paula *et al*., 2015). An increase in storm frequency and intensity will certainly have deleterious effects on island and coastal settlements, which are located very close to the shoreline as well as tourism and other coastal infrastructures.

Projections

It is expected that changes in the wind patterns (direction and strength) will strongly affect the local fishing communities. It will also have serious effects on the socio-economy of the region in general as trade and long distance travelling along the coast relies heavily on the large dhows. Increased winds and surge can potentially cause erosion and risk turtle nesting sites (Paula *et al*., 2015).

5.5. 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. In QNP, SST showed a high variability year to

year but, in general, there was a positive trend of 0.21 to 0.33 °C, over the period 1982 to 2014. SST fluctuations and changes around north Mozambique plays a role in marine ecosystem, weather and climate of the coastal area and possibly further inland as well.

McClanahan *et al*. (2007), reported for "northern Mozambique", a SST rise of ca. 0.010° C/year over 50 years (1957-2007). This contrasts with the global average, which as increased by 0.5°C since 1961 (IPCC, 2007). According to the IPCC (2007), tropical oceans are projected to experience the greatest increases. Recent models predicted that globally, 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.

According to IPCC (2013) *in* Paula *et al*. (2015) recent estimates show that, global 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. Looking at data from the tidal station network of Mozambique, including Pemba and Mocímboa da Praia, a 2002 study (Sete *et al.*, 2002 *in* Paula *ei 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". However, it was acknowledged that long time series of mean sea levels have been lacking and a permanent sea level monitoring is required. On the other hand, Cazanave & Remy (2011) studies based on satellite altimetry data show long-term increase in sea level over the Mozambique Channel. This increases vary from 0 to 4 mm per year, depending on location.

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

INGC (2009) suggests that the coastline of the QNP (especially the islands) is susceptible to sea level rise. According to the High Sea Level Rise Scenario – "worst case" it is estimated that the coastline may recess as far as 500 m, due to a sea level rise of 30cm until 2030, 100 cm until 2060 and 500 cm until 2100. The great majority coastal communities would be left without potable water due to the increases salinity of ground water. Sea level rise will potentially have negative effects on tourism infrastructures and settlements in the coast and islands.

5.6. POTENTIAL CLIMATE TRENDS EFFECTS ON BIODIVERSITY, ECOSYSTEMS AND LOCAL COMMUNITIES

In some the specific studies undertaken for QNP (Paula *et al.*, 2015; Ridell & Rosendo, 2015 and Ribeiro *et al*. (2015)), the following potential effects on biodiversity, ecosystems and local communities were identified:

Biodiversity and ecosystems

- **Loss of nesting habitat and productive feeding areas for sea turtles** – this can potentially be conducting marine turtles towards local extinction if current anthropogenic stressors are not dealt with (Paula *et al*. 2015);
- **Physiological stress on coral reefs** – this is due to ocean warming and acidification, both of which are gradually reducing the habitat availability (Veron, 2011 *in* Paula *et al*. 2015);
- **Habitat loss for corals and seagrass –** coastal communities of the QNP refer that the storms have affected coral reefs and seagrass, not only through direct destructive impact, but also through sedimentation (areas of coral reefs and seagrass covered by sand) (Ridell & Rosendo, 2015);

- **Fish and algae mortality episodes** – some local communities have reported episodes of high mortality of fish and algae. This phenomenon can potentially be associated with the highest temperatures of the sea water (Ridell & Rosendo, 2015);
- **Reduction of fish reproductive performance –** increases of sea surface temperature within shallow coastal environments up to 2.5–3°C by 2100 are expected to have limited direct effects on survival of adults for most fisheries species, but may still interfere with reproduction, recruitment and juvenile growth. Even temperature increases of 1–2°C can affect the reproductive performance of some reef fish and are likely to lead to shifts in the timing of spawning, and possibly falling egg production, in some populations (Maueua, 2007, Bell *et al.* 2011 *in* Paula *et al*., 2015);
- **Coral bleaching** – high temperatures in the past caused coral bleaching in the region (Ridell & Rosendo, 2015);

Local communities

- **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 the QNP 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);
- **Reduction of fish production** – this can be expected, primarily due to sea temperature rise, and 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 (Maurea, 2007 *in* 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 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);
- **Reduction of agriculture production** – according the local communities, currently the highest temperatures during the rainy season have caused thermal stresses and stunted growth in agricultural crops and hence reduction in crops, which is also causing negative impact to the fisheries (Ridell & Rosendo 2015).
- **Floods** – Paula *et al.* (2015) refer that flooding is one of the main hazards in QNP and is known to occur along the banks of the Montepuez and Messalo rivers. Flooding affects the two main sectors that provide cash income for local communities, namely: fishing and agriculture. According to Hoegh-Guldberg (1999) *in* Paula *et al.* (2015) total artisanal annual catch seems to be significantly correlated to the coastal rainfall lagged two years. Coral reefs and seagrass beds are able to cope with increased rainfall to a certain extent. Heavy floods usually result in massive amounts of nutrients, reduced salinity, light penetration and sedimentation;
- **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 will result in significant destruction of infrastructure. Additionally, the rising of sea level is expected to cause negative effects on the walls of aquaculture tanks (Ridell & Rosendo, 2015).

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

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) has 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. 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 (former MICOA) 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 the provincial level, the following actions related to climate change are planned:

- Increase the water storage capacity
- Reduction of water losses

- Encourage reducing water use by new tariff policies
- Creation of protection capacity against floods
- Improve the pre-warning system
- Plantation of mangrove in the Quirimba island

At the QNP level, the current Management Plan considers the following milestones that include activities directly related to deal with climate change:

- Know, document and protect the species and threatened habitats and/or in critical condition;
- Promote livelihood and income basis to the local population;
- Draft, approve and adopt the internal PNQ Regulation
- Establish and implement a monitoring and evaluation system
- Reinvest the funds deriving from transactions of carbon credits in PNQ

The implementation and management of the QNP Zoning system is essential in terms of climate change adaptation. It includes Total Protection Areas, Specific Use Areas (terrestrial), Community Development Areas (terrestrial and marine) and Buffer Areas.

6.2. COPING AND ADAPTATION STRATEGIES

The literature makes an important distinction between coping and adaptation strategies. Coping strategies refer to immediate and usually short-term ways of responding to an experienced climate hazard. They are generally motivated by a crisis and reactive, and often degrade the resource base. Adaptation strategies are more proactive and involve planning. They are oriented towards longer-term livelihood security and, importantly, they use resources sustainably (Ridell & Rosendo, 2015).

In order to analyse the coping and adaptation strategies that are or have been implemented/developed for the QNP, several bibliographic references and other sources were consulted:

- Ridell & Rosendo, 2015;
- Paula *et al.,* 2015;
- MCAA, 2005;
- MICOA, 2012;
- Pemba City Council.

According to Ridell & Rosendo (2015), community members in QNP 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 the increasing conflict with wildlife and crop losses due to floods and droughts represent an additional pressure to the livelihoods of rural households. Additionally, some community councils have lack of resources and / or capacity to avoid increasing levels of extraction of natural resources. So in this context some of the strategies have the potential to be

adaptive measures, others are short-term answers to manage crises (coping), and may potentially have negative impacts on ecosystems and resources on which they depend.

Table 6-1 below summarises coping and adaptation responses to climate risks and stresses adopted by communities living in QNP (adapted from Ridell & Rosendo, 2015).

Table 6-1 – Distinction between coping and adaptation responses in different domains

Domain	Risks and stresses	Measures	Coping / adaptation
Agriculture	Heavy rains & floods	Change the fields to a new area	Adaptation
		Establish rice nurseries in a safe area and transplant the seedlings to rice fields as soon as possible	Adaptation
		Fill bounds with vegetable matter	Adaptation
	Drought	Practice activities that generate income to buy food, including the collection and sale of grass, straw and wood, manufacture and sale of charcoal, cutting and sale of mangrove stakes, fishing	Depending of the activity but in majority are Coping
		Collect and eat wild foods	Coping
		Seek employment in salt pans	Adaptation
		Planting drought tolerant crops	Adaptation
		Changing farmland to areas where the soil better retains humidity	Adaptation
	Changes in rainfall	Adjust planting time	Adaptation
		Planting varieties of short cycle crops	Adaptation
		Planting varieties of crops with different growth periods	Adaptation
	Extreme high temperatures	Practice activities that generate income to buy food	Depending of the activity but in majority are Coping
Fishery	Strong winds and storms	Cut and sell mangrove stakes	Coping
		Fishing in more sheltered fishing sites	Adaptation
Aquatic resources	Drought	Travel long distances to find water	Coping
Infrastructures	Floods	Use sandbags to protect homes	Coping
		Rebuild homes in the same places	Coping
		Build with more resistant materials	Adaptation
		Change houses away from the areas most prone to flooding	Adaptation
		Repair of roads	Coping
	Strong winds	Repair of houses	Coping

At an Institutional level, FFEM has financed a project titled: *Adaptation to Climate Change in the Quirimbas National Park*. This project, which includes the funding of three of the specific studies already mentioned in section 3.2, specifically aims to strengthen the resistance of the QNP's ecosystems to cope with climate change. It comprises four components: 1) study the impact of climate change on critical ecosystems and develop an adaptation strategy; 2) promote better management in order to strengthen marine ecosystems to cope with climate change; 3) Promote better connection in order to strengthen terrestrial ecosystems to cope with climate change; 4) Obtain revenue generated by conservation: payments by systemic eco services, including REDD +.

In 2005 (MCAA, 2005) national authorities defined broad strategies to adapt to climate change, which were later reflected in the National Climate Change Strategy (MICOA, 2012). Table 6-2 below summarises proposed measures outlined at national level for different sectors.

Table 6-2 – Adaptation measures to cope climate change defined by national authorities (2005)

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
	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

Considering the regional level, although outside the QNP, the Pemba Municipality is developing, since late 2013, a Municipal Adaptation Plan to Climate Change that is being financed by USAID. The plan is supposed to be finished in 2018. Should this plan be successful implemented it might be a reference for future adaptation projects in the region, including the QNP and its buffer zone.

7. RESULTS OF THE VULNERABILITY ASSESSMENT

As outlined in Section 2 of this report, a stakeholder vulnerability assessment workshop was held in December 2015 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 QNP 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 IV, V and VI.

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. GENERAL OVERVIEW OF VULNERABILITY RESULTS

As explained in Section 4.2, above, 8 resource or analysis units were identified and assessed:

i. Forest (Miombo & Coastal);
ii. Mangrove Forest & Dunes;
iii. Coral reefs and seagrass;
iv. Species of high conservation value;
v. Agricultural and Livestock Systems;
vi. Freshwater;
vii. Fisheries and Aquaculture and;
viii. Human settlements.

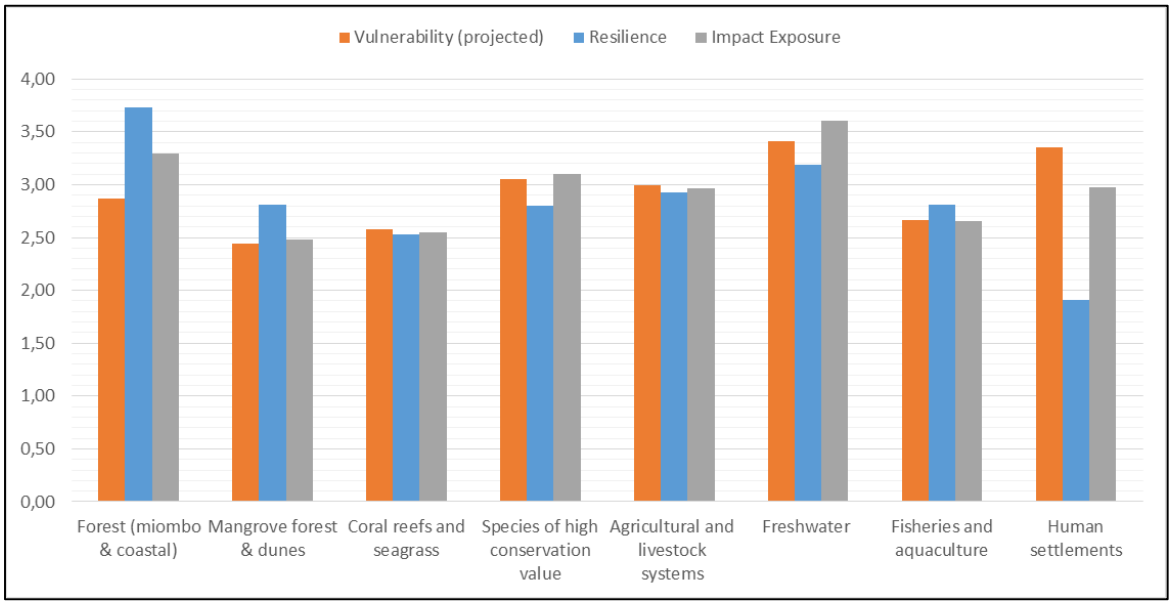
Table 7-1 shows the top 3 scoring analysis units for each analysed parameter.

Table 7-1 – Rankings of the 3 highest scoring units (resilience, exposure and vulnerability).

	Resilience	Exposure	Vulnerability
Highest scoring analysis units	1. Coastal Forest & Miombo woodland 2. Freshwater 3. Agricultural Livestock System	1. Freshwater 2. Coastal Forest & Miombo woodland 3. Species of high conservation value	1. Freshwater, 2. Human settlements 3. Species of high conservation value

Figure 7-1 below shows a comparison of the grand totals of each unit, for projected vulnerability, resilience and exposure.

Figure 7-1 – Grand totals of projected vulnerability, resilience and impact exposure of each unit.



7.2. GENERAL OVERVIEW BY ANALYSIS UNIT

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

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

i. Forest (miombo & coastal)

Table 7-2 shows the top 3 scoring analysis sub-units of forest (miombo & coastal) unit, for each analysed parameter.

Table 7-2 –Rankings of the 3 highest scoring sub-units of forest (miombo & coastal) unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Total protection zones in QNP 2. Buffer zone in QNP 2. Use and community development zones in QNP	1. Use and community development zones in QNP 1. Forest around villages outside the Park 2. Coastal forest areas of multiple use	1. Coastal forest areas of multiple use 2. Use and Community development zones of QNP 3. Forest around villages outside the Park

Coastal forest areas of multiple use had the highest vulnerability score, with relatively high exposure rates, especially due to the projected increase of dry days and high temperatures, which will anticipate and extend the burning's season, affecting forest's regeneration and agriculture production – which will increase the pressure and the levels of forest resources exploitation. This sub-unit also has relatively low resilience. On the other hand, total protection zones had the lowest vulnerability score. The identified projected impacts on this sub-unit are not expected to be exacerbated by climate changes because they are all related to development impacts.

The low scores obtained for the Buffer Zone of QNP, in particular vulnerability and impact exposure are quite odd. In fact, after these results were processed, the forest working group facilitator mentioned that the QNP buffer zone should actually have had a much higher score for these two parameters. Hence, this has probably resulted from an overview by the group during

the main workshop. As explained further ahead in this report, the Flowing Forward methodology is dependant on each group ability to analyse all sub-units in detail and equivalently so overviewing any sub-unit can result in similar situations.

The figure below (Figure 7-2) shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7-2 – Averages for each sub-unit of forest (miombo & coastal) analysis unit.

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

Table 7-3 below **Erro! A origem da referência não foi encontrada.Erro! A origem da referência não foi encontrada.Erro! A origem da referência não foi encontrada.Erro! A origem da referência não foi encontrada.Erro! A origem da referência não foi encontrada.**shows that the hazard responsible for the highest two vulnerability ratings is a climate hazard, namely: *The occurrence of the dry season and high temperature events* which affects agriculture production and increase the local communities' dependence on forest resources. This will increase the pressure and the levels of forest resources exploitation. This impact is predicted in particular to affect two sub-units: Forests around villages outside the Park and forests in use and community development zones of QNP.

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

Table 7-3 – Top 10 scoring impacts (Projected vulnerability) on forest (miombo & coastal) sub-units.

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	The occurrence of the dry season and high temperature events will affect agriculture production and increase the local communities' dependence on forest resources. This will increase the pressure and the levels of forest resources exploitation- QNP villages	3,80	Forest around villages outside the Park
2	The occurrence of the dry season and high temperature events will affect agriculture production and increase the local communities' dependence on forest resources. This will increase the pressure and the levels of forest resources exploitation- Community	3,73	Use and Community development zones - QNP

Rank #	Impact	Vulnerability (projected)	Sub-unit
3	The increase of dry days will anticipate and extend the burning's season, affecting the forest's regeneration ability- Community	3,73	Use and Community development zones - QNP
4	The occurrence of high temperature average events (maximum and minimum) will lead to a faster dry of the grass, creating conditions for strong fires, which will have consequences in regeneration- Coastal multiple use	3,64	Coastal forest areas of multiple use
5	The occurrence of the dry season and high temperature events will affect agriculture production and increase the local communities' dependence on forest resources. This will increase the pressure and the levels of forest resources exploitation- Coastal multiple use	3,64	Coastal forest areas of multiple use
6	The increase of dry days will anticipate and extend the burning's season, affecting the forest's regeneration ability- Coastal multiple use	3,34	Coastal forest areas of multiple use
7	The increasing number of people inside the park and in its surroundings will lead to an expansion of agriculture and housing areas, which will means more deforestation and fragmentation of habitats- Community	3,33	Use and Community development zones - QNP
8	The growth of farming areas will lead to deforestation and degradation of forest, which will increase the shortage of goods and services for local communities- QNP villages	3,30	Forest around villages outside the Park
9	The growth of farming areas will lead to deforestation and degradation of forest, which will increase the shortage of goods and services for local communities- Community	3,24	Use and Community development zones - QNP
10	The increase of wood fuel's demand will lead to more degradation, deforestation and, consequently, habitat fragmentation- QNP villages	3,00	Forest around villages outside the Park

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

ii. Mangrove forest & dunes

Table 7-4 shows the top 3 scoring analysis sub-units of Mangrove Forest & Dunes unit, for each analysed parameter.

Table 7-4 – Rankings of the 3 highest scoring sub-units of mangrove forest & dunes unit.

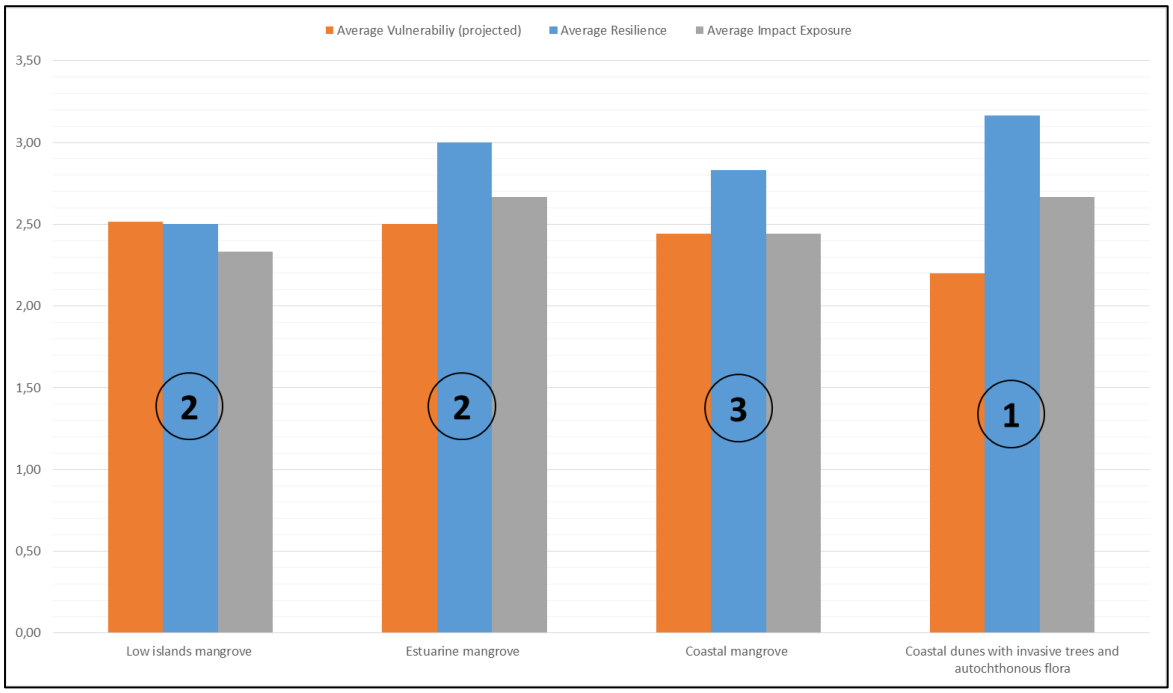
	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Coastal dunes with invasive trees and autochthonous flora 2. Estuarine mangrove 3. Coastal mangrove	1. Estuarine mangrove 1. Coastal dunes with invasive trees and autochthonous flora 2. Coastal mangrove	1. Low islands mangrove 2. Estuarine mangrove 3. Coastal mangrove

The three mangrove sub-units had roughly equally high vulnerability ratings, their different resilience and exposure ratings generally balancing to the same level of vulnerability. The estuarine mangrove sub-unit, for example, has a higher level of exposure on account of human pressures and vulnerability to extremes of salinity (during drought and heavy rains) but also higher resilience values on account of high growth and regeneration rates and relatively higher

species diversity. Coastal dunes with invasive trees was rated as less vulnerable, based on moderately high resilience ratings across all resilience properties.

The figure below (Figure 7-3) shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7-3 – Averages for each sub-unit of mangrove forest & dunes.



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

The hazard responsible for the highest rated vulnerability is climatic: *Storm and strong wave events,* which leads to deposition of sediments in, and/or erosion of mangrove areas causing tree mortality and compromising the potential for natural regeneration. This impact is predicted particularly to affect mangroves around low-lying islands and coastal mangroves.

Two of the top identified impacts are climatic, while five are caused by development pressures (**Erro! Autorreferência de marcador inválida.**). This unit was the only one where the working group didn't identify 10 impacts.

Table 7-5 – Top scoring impacts (Projected vulnerability) on mangrove forest & dunes.

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	Storm and strong wave events causing deposition of sediments and/or erosion of mangrove areas, which leads to tree mortality, compromising the potential for natural regeneration.	2,93	Low island mangrove
2	Storm and strong wave events causing deposition of sediments and/or erosion of mangrove areas, which leads to tree mortality, compromising the potential for natural regeneration.	2,63	Coastal mangrove
3	The markets' demand and the lack of subsistence options increases the demand for mangrove's timber products (coal, firewood, wood for construction) leading to a mangrove's area reduction	2,56	Coastal mangrove
4	Mining concessions for construction's stone extraction in the buffer area of the Park contribute to rivers silting,	2,50	Estuarine mangrove

Rank #	Impact	Vulnerability (projected)	Sub-unit
	changing the flow and quality of water and nutrients.		
5	Population increase and the opening of new agriculture areas on the coastal dunes destruct the coastal geomorphology	2,20	Coastal dunes with invasive trees and autochthonous flora
6	Construction and seasonal fishing centres (migratory fishermen) increase the pressure on the mangrove to collect stakes for houses and fishing gears' construction, reducing the coastal mangrove area	2,15	Coastal mangrove
7	Tourism development, along with the construction of tourist infrastructures using local materials (mangrove stakes) increases pressure on the mangroves and leads to a structure modification and to cover reduction of the forest	2,10	Low islands mangrove

Note: Impacts shaded in yellow are climatic whereas the grey are development impacts

iii. Coral reefs and seagrass

Table 7-6 shows the top 3 scoring analysis sub-units of Coral reefs and seagrass unit, for each analysed parameter.

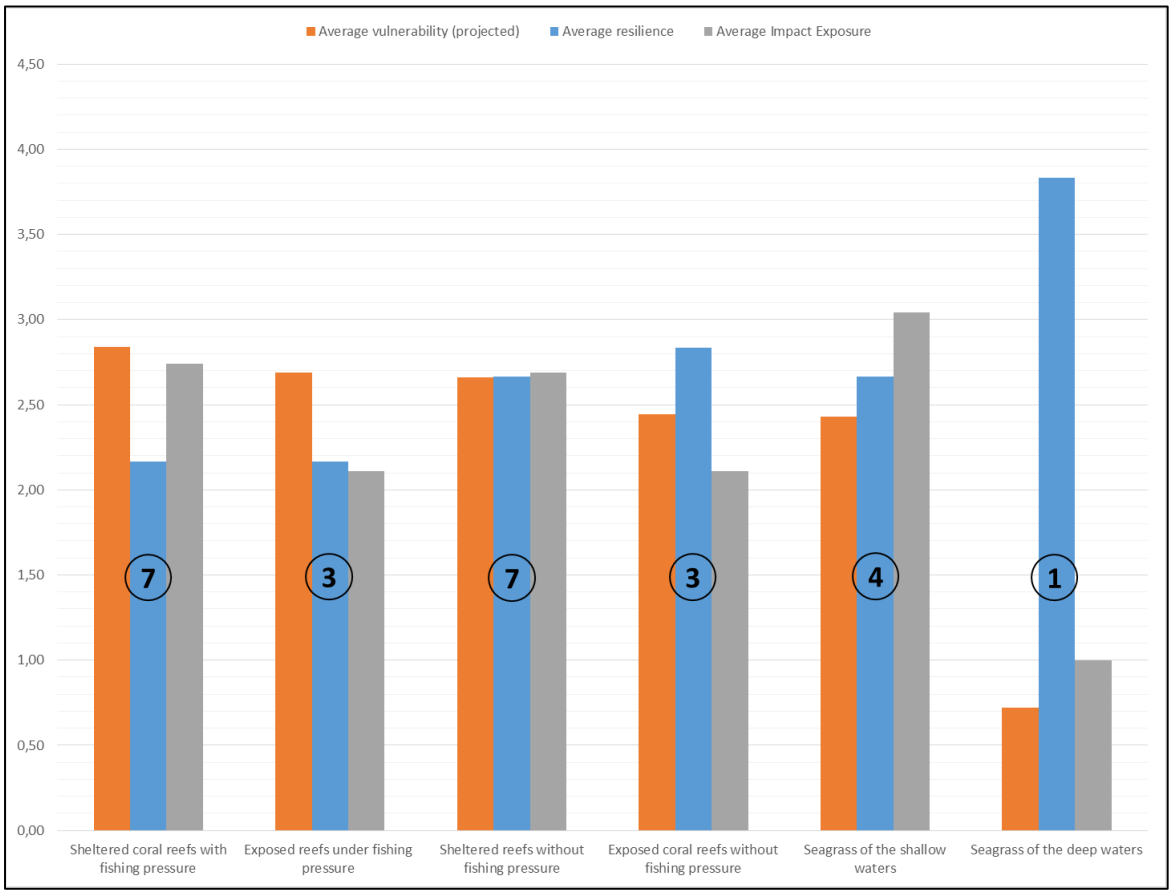
Table 7-6 – Rankings of the 3 highest scoring sub-units of coral reefs and seagrass unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Seagrass of the deep waters 2. Exposed coral reefs without fishing pressure 3. Sheltered reefs without fishing pressure / Seagrass of the shallow waters	1. Seagrass of the shallow waters 2. Sheltered coral reefs with fishing pressure 3. Sheltered reefs without fishing pressure	1. Sheltered coral reefs with fishing pressure 2. Exposed reefs under fishing pressure 3. Sheltered reefs without fishing pressure

Overall the sub-unit with the highest vulnerability was sheltered coral reefs with fishing pressure. These reefs are exposed to a higher number of both development and climate impacts and have relatively low resilience on account of having relatively lower connectivity, high interspecific dependence (i.e. low functional redundancy), limited refugia areas and slow regeneration.

The figure below (Figure 7-4) shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7-4 – Averages for each sub-unit of coral reefs and seagrass unit.



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

The hazard responsible for the highest rated impact was: *high seawater temperature events* which cause bleaching and mortality of corals. This in particular affects sheltered coral reefs with fishing pressure, which is the subunit with higher vulnerability.

90% of the 10 highest scoring impacts are climatic (Table 7-7).

Table 7-7 – Top 10 scoring impacts (Projected vulnerability) on coral reefs and seagrass unit.

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	Sea water high temperature events will cause bleaching and death of coral reefs- Sheltered coral reefs with fishing pressure	3,61	Sheltered coral reefs with fishing pressure
2	Tourism activities in the coral areas (dive, anchorage, motorized) will degrade marine habitats- Sheltered reefs without fishing pressure in Ibo, Matemo, Quilalea and Goludo	3,44	Sheltered coral reefs with fishing pressure
3	Heavy rains will cause sedimentation of seagrass carpets and corals- Sheltered coral reefs with fishing pressure	3,42	Sheltered coral reefs with fishing pressure
4	Sea water high temperature events will cause bleaching and death of coral reefs- Sheltered reefs without fishing pressure	3,42	Sheltered reefs without fishing pressure
5	Heavy rains will cause sedimentation of seagrass carpets and corals- Seagrass of the shallow waters	3,42	Seagrass of the shallow waters

Rank #	Impact	Vulnerability (projected)	Sub-unit
6	Heavy rains will cause sedimentation of seagrass carpets and corals- Sheltered reefs without fishing pressure	3,24	Sheltered reefs without fishing pressure
7	Acidification will reduce genetic biodiversity until the risk of extinction of the species- Exposed reefs under fishing pressure	3,24	Exposed reefs under fishing pressure
8	Acidification will reduce genetic biodiversity until the risk of extinction of the species- Sheltered reefs without fishing pressure	3,06	Sheltered reefs without fishing pressure
9	Acidification will reduce genetic biodiversity until the risk of extinction of the species- Sheltered reefs without fishing pressure	3,06	Sheltered reefs without fishing pressure
10	Acidification will reduce genetic biodiversity until the risk of extinction of the species- Exposed coral reefs without fishing pressure	2,99	Exposed coral reefs without fishing pressure

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

iv. Species of high conservation value

Table 7-8 shows the top 3 scoring analysis sub-units of Species of high conservation value unit, for each analysed parameter.

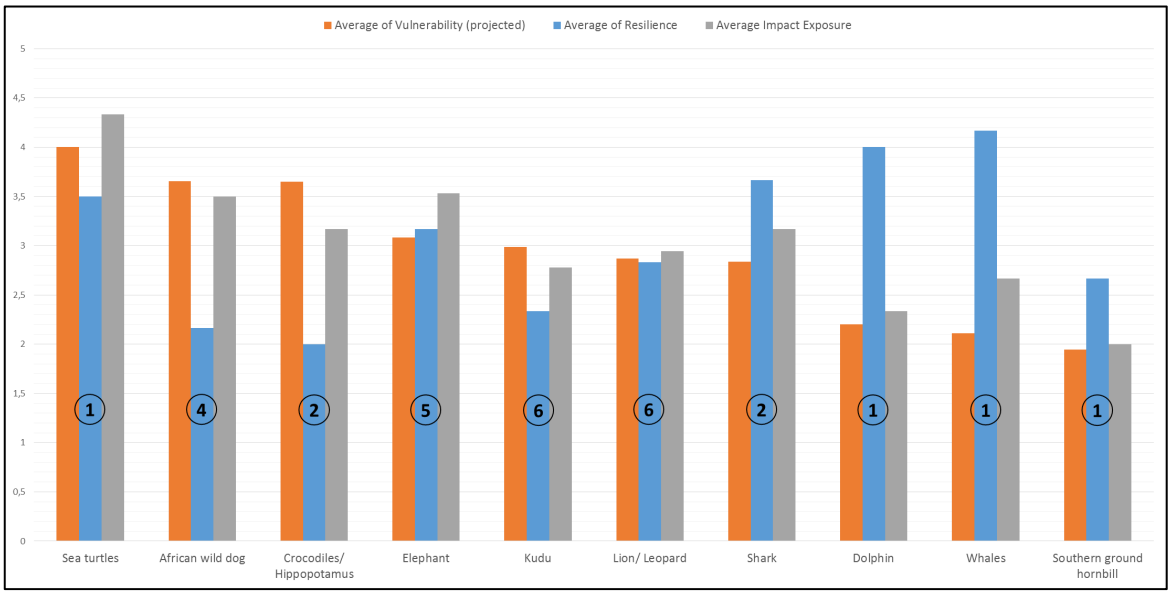
Table 7-8 – Rankings of the 3 highest scoring sub-units of coral reefs and seagrass unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Whales 2. Dolphins 3. Sharks	1. Sea turtles 2. Elephants 3. African wild dog	1. Sea turtles 2. African wild dog 2. Crocodiles/ Hippopotamus

Sea turtles was the sub-unit with the highest vulnerability. These species are very sensitive in terms of nesting sites and the exposure to sea level rise can destroy their available nesting areas I the QNP. The southern ground hornbill, on the other hand, is the sub-unit with lower score for vulnerability. This is mainly due to the fact that the impact predicted on this sub-unit is development related and are not expected to be exacerbated by climate changes.

Figure 7-5 below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7-5 – Averages for each sub-unit of species of high conservation value.



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

Table 7-9 below shows that the hazard responsible for the highest vulnerability impact is *human settlement and agricultural activities* which cause habitat fragmentation and disturbance. This affects wild dogs in particular, a species that is highly mobile and ranges over a large territory for hunting, not coping with major disturbance.

40% of the top 10 identified impacts are climatic, while 60% are due to development.

Table 7-9 – Top 10 scoring impacts (Projected vulnerability) on species of high conservation value.

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	Human settlements and agricultural activities causing habitat fragmentation and disturbance	4,34	African wild dog
2	The rain can affect and destroy sensible areas for reproduction and cause habitat degradation by erosion. It can also cause death of animals- African wild dog	4,13	African wild dog
3	The drought will contribute to habitat degradation of rivers, swamps and water sources. It will also lead to the death of animals- Crocodiles/Hippopotamus	4,00	Crocodiles/ Hippopotamus
4	Cyclones increase the sea level rising, causing destruction of turtle's nesting areas	4,00	Sea turtles
5	Poaching- Elephant	3,94	Elephant
6	Human settlements and agricultural activities- Lion/ Leopard	3,73	Lion/ Leopard
7	Poaching- Kudu	3,67	Kudu
8	The construction of the road Muepane/Mocimba through Mucojo will disturb the animal's habitat, causing stress and the occurrence of settlements inside the park- African wild dog	3,61	African wild dog
9	Human settlements and agricultural activities- Elephant	3,61	Elephant
10	The drought will contribute to reduce the grazing and	3,54	Kudu

Rank #	Impact	Vulnerability (projected)	Sub-unit
	watering areas and to increase the death of animals- Kudu		

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

v. Agricultural and livestock systems

Table 7-10 shows the top 3 scoring analysis sub-units of Agricultural and Livestock Systems unit, for each analysed parameter.

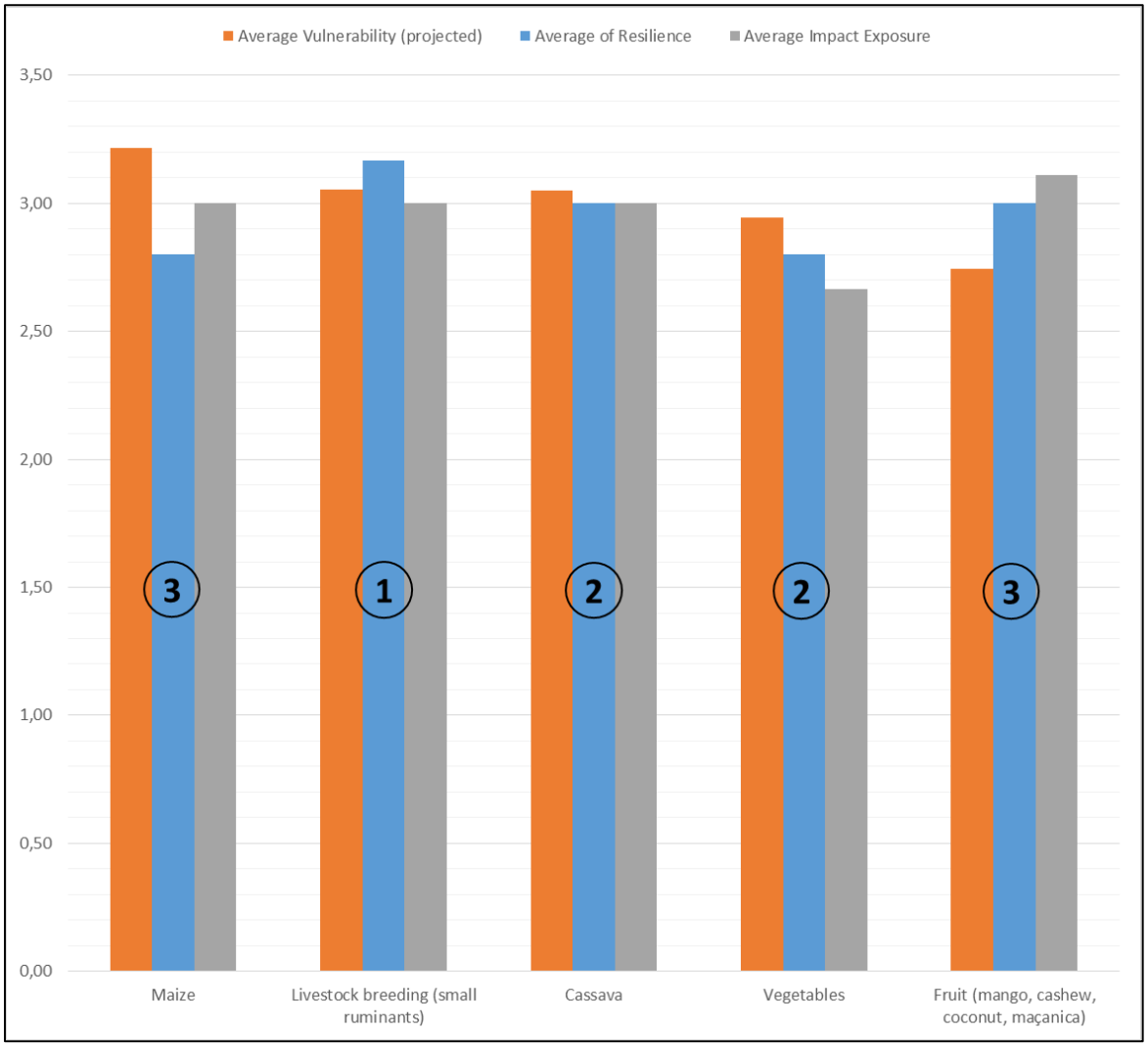
Table 7-10 – Rankings of the 3 highest scoring sub-units of agricultural and livestock systems unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Livestock breeding (small ruminants) 2. Cassava 2. Fruit (mango, cashew, coconut, "maçanica")	1. Maize 1. Livestock breeding (small ruminants) 1. Cassava	1. Maize 2. Livestock breeding (small ruminants) 3. Cassava

Overall the sub-unit with the highest vulnerability was Maize. This can be explained by its great exposure to the mine concessions of limestone extraction that will affect the access to agriculture land by the communities. Fruit was the sub-unit with lowest vulnerability. All of the identified impacts for this sub-unit were scored with relatively low exposition rates because local farmers have adapted their cultures to the local conditions.

Figure 7-6 below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7-6 – Averages for each sub-unit of Agricultural and livestock systems analysis unit.



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

The hazard responsible for the highest scoring impact is *concessions for extraction of limestone, rock for construction or precious stones* which affects access to agricultural land by the communities. This in particular affects maize and cassava sub-units.

40% of the 10 highest scoring impacts are climatic, whereas 60% are related to development (Table 7-11).

Table 7-11 – Top 10 scoring impacts (Projected vulnerability) on agricultural and livestock systems.

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	The mine concessions to limestone extraction, of rock for construction or precious stones, will affect the access to agriculture land by the communities. Maize	3,37	Maize
2	The mine concessions to limestone extraction, of rock	3,30	Cassava

Rank #	Impact	Vulnerability (projected)	Sub-unit
	for construction or precious stones, will affect the access to agriculture land by the communities. Cassava		
3	The transformation of potential agriculture and livestock areas into residential ones, due to increased internal and external migration will affect the production levels of food crops, with potential for aggravation of the already existing hunger spots. Maize	3,19	Maize
4	The Fruit's productivity will decrease because a great number of trees will be cut, over the coastal road route Muepane-Palma and the future pipeline North/South	3,17	Fruit (mango, cashew, coconut, "maçanica")
5	The great dry periods cause problems to water supply for domestic animals, and also for the food crops, decreasing the production levels and the incomes. On the other hand, it increases the conflicts with wildlife due to foraging in the food gardens.	3,08	Maize
6	The transformation of potential agriculture and livestock areas into residential ones, due to increased internal and external migration will affect the production levels of food crops, with potential for aggravation of the already existing hunger spots. Livestock breeding	3,06	Livestock breeding (small ruminants)
7	The pressure over irrigated agriculture lands, and not only, will increase substantially due to the possibility of new tourism resorts and the demand for specific products.	3,01	Vegetables
8	Periods with heat waves, either in the rain or in the dry season, burn the food crops, especially in the beginning of its grow season. This makes it necessary to resowing and/or replant. It also decreases rivers caudal as well as the water quality of lagoons, fountains, wells, etc., usually used for irrigation.	2,88	Vegetables
9	The rain excess in a short period of time causes floods in susceptible areas and cause the rot of plants and tubers (Cassava, sweet potato, etc.)	2,80	Cassava
10	Strong winds with torrential rain cause erosion, drag seeds, plants and rip out some trees.	2,57	Fruit (mango, cashew, coconut, "maçanica")

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

vi. Freshwater

Table 7-12 shows the top 3 scoring analysis sub-units of Freshwater unit, for each analysed parameter.

Table 7-12 – Rankings of the 3 highest scoring sub-units of freshwater unit.

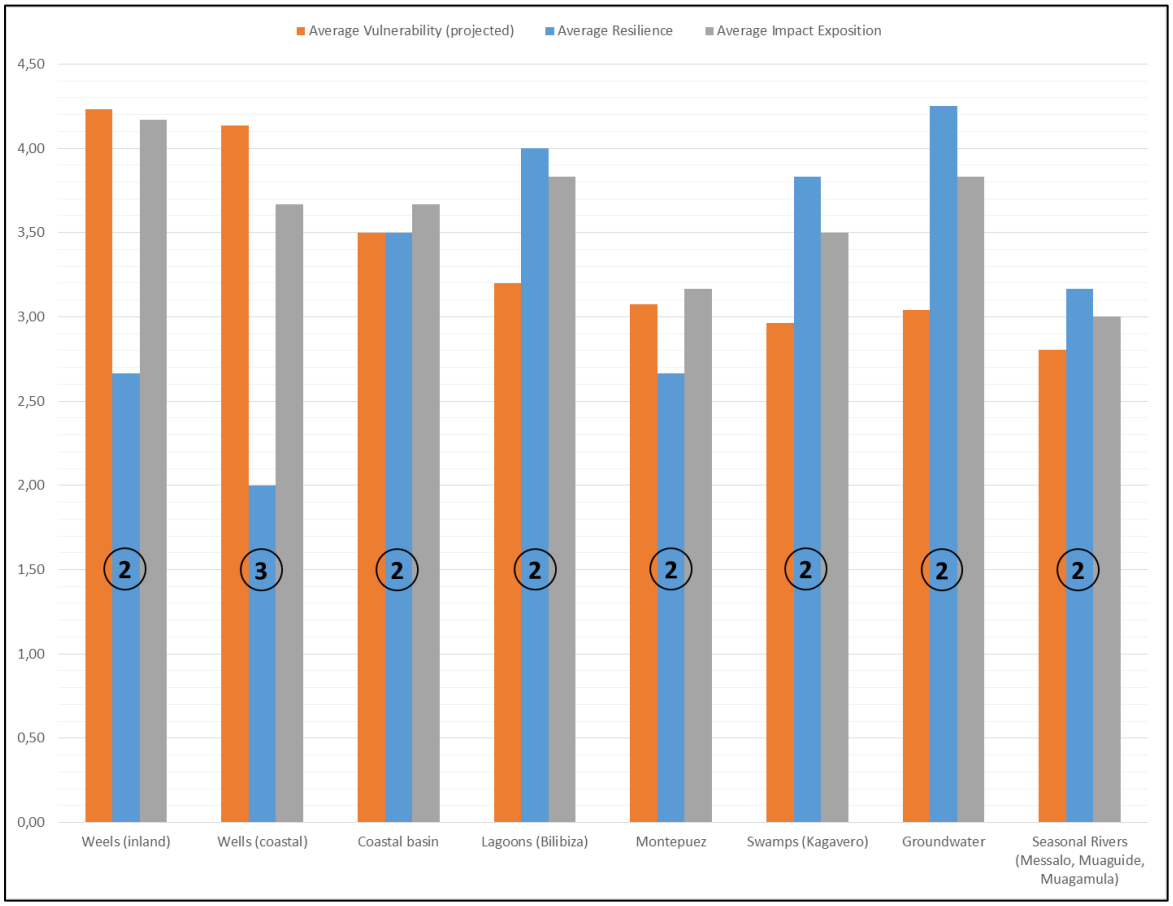
	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Groundwater 2. Lagoons (Bilibiza) 3. Swamps	1. Wells (inland) 2. Lagoons (Bilibiza) 2. Groundwater	1. Wells (inland) 2. Wells (coastal) 3. Coastal basin

(Kagavero)

The sub-unit with the highest vulnerability was inland Wells. These wells are very exposed to development and climate impacts such as water contamination due to inadequate sanitation systems, or widespread droughts. Seasonal rivers was the sub-unit with lowest vulnerability, mainly because the identified impacts have less intensity and extension compared to the other sub-units. This is probably because it was considered that this type of rivers is already adapted to continuous changes in the landscape.

Figure 7-7 below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7-7 – Averages for each sub-unit of freshwater analysis unit.



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

Table 7-13 shows that the hazard that is responsible for the highest rated impact is: *droughts which causes drying of wells and water shortage amongst communities.* This hazard is climatic and particularly affects coastal and inland wells.

70% of the 10 highest scoring impacts are climatic, whereas 30% are related to development.

Table 7-13 – Top 10 scoring impacts (Projected vulnerability) on freshwater.

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	Extended droughts causing wells to go dry, causing water shortage amongst communities	4,40	Wells (coastal)
2	Water contamination of wells due to	4,40	Wells (coastal)

Rank #	Impact	Vulnerability (projected)	Sub-unit
	inadequate sanitation systems - Wells (coastal)		
3	Extended droughts causing wells to go dry, causing water shortage amongst communities	4,33	Wells (inland)
4	Water contamination of wells due to inadequate sanitation systems - Wells (inland)	4,13	Wells (inland)
5	The extended droughts currently induce coastal basin's drought, causing crop's wither - Coastal basin	4,00	Coastal basin
6	Well's water contamination by sea water, due to the sea level rise.	3,60	Wells (coastal)
7	Extreme events (droughts and floods) and the disorganized land use cause erosion and inability for water storage by the rivers - Montepuez	3,53	Montepuez
8	Extended droughts induce low recharge ability in aquiferous.	3,50	Groundwater
9	Extended droughts cause a decrease in water availability, making communities to open traditional wells in the lagoon's banks.	3,40	Lagoons (Bilibiza)
10	Extreme events (droughts and floods) and the disorganized land use cause erosion and inability for water storage by the rivers - Seasonal Rivers	3,33	Seasonal Rivers (Messalo, Muaguide, Muagamula)

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

vii. Fisheries and aquaculture

Table 7-14 shows the top 3 scoring analysis sub-units of fisheries and aquaculture unit, for each analysed parameter.

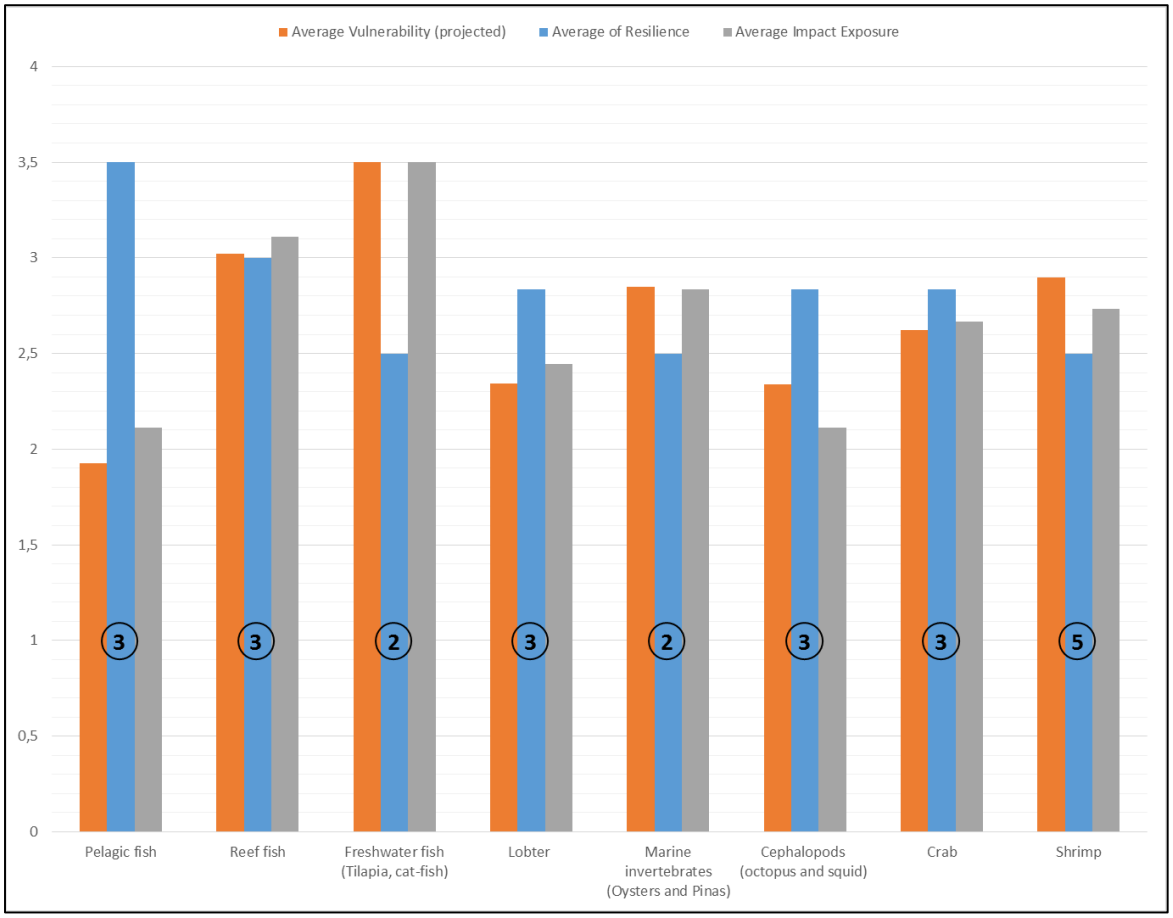
Table 7-14 – Rankings of the 3 highest scoring sub-units of fisheries and aquaculture unit.

	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Pelagic fish 2. Reef fish 3. Lobster/ cephalopods (octopus and squid) / Crab	1. Freshwater fish (Tilapia, cat-fish) 2. Reef fish 3. Marine invertebrates (Oysters and "Pinas")	1. Freshwater fish (Tilapia, cat-fish) 2. Reef fish 3. Shrimp

Freshwater fish was the sub-unit with highest vulnerability. This sub-unit is exposed to impacts such as extended droughts, which cause fragmentation and decrease of its populations and the loss of some species. Indirectly, extended droughts may also lead local communities to intensify freshwater fishing, by lacking of further resources. Pelagic fish, on the other hand, was rated as less vulnerable and the impacts on this sub-unit are not expected to be exacerbated by climate changes.

Figure 7-8 below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7-8 – Averages for each sub-unit of fisheries and aquaculture analysis unit.



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

Table 7-15 below shows that the hazard responsible for the highest rated impact is *extended droughts* which cause fragmentation and decrease of river flows, drying out of associated lakes and small lagoons and a decrease in associated freshwater fish abundance and, potentially the loss of some species. This hazard in particular affects the freshwater fish (tilapia and catfish) sub-unit and is climate related.

Overall 50% of the 10 highest scoring impacts are climatic.

Table 7-15 – Top 10 scoring impacts (Projected vulnerability) on fisheries and aquaculture.

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	Extended droughts causing fragmentation and decrease of river flows, drying out of associated lakes and ponds and loss of associated fish abundance and, potentially, diversity Indirectly, extended droughts may also drive populations to intensify freshwater fishing, by lack of other resources.	4,00	Freshwater fish (Tilapia, cat-fish)
2	The human population growth and the accessibility to collect this invertebrates, increases the pressure on this resources,	3,50	Marine invertebrates

Rank #	Impact	Vulnerability (projected)	Sub-unit
	which, in turn, leads to a marine invertebrates' population decrease.		(Oysters and "Pinas")
3	Sea high temperature events creates bleaching and death of coral, which, consequently, lead to reef fish's habitat, making them more vulnerable.	3,40	Reef fish
4	Because of the development of the QNP coastal area, mainly due to the expansion of Cabo Delgado's hotel industry and the increasing demand for fish, the pressure on the fishing will increase, causing a diminution in the shrimp population.	3,33	Shrimp
5	The increasing number of fishermen leads to an increasing commercial and subsistence fishing pressure which, in turn, leads to a change of the reef ecosystem and to the reduction of reef fish populations.	3,17	Reef fish
6	The demand for this resource by foreigners and tourism resorts, increases the fishing pressure, which may cause decline of this population.	3,06	Crab
7	The increasing number of fishermen leads to an increasing subsistence river's fishing pressure which, in turn, leads to a reduction of freshwater fish's populations.	3,00	Freshwater fish (Tilapia, cat-fish)
8	Changes in precipitation patterns may affect shrimp's spawning, because its spawning behaviour depends on the freshwater that flows to the estuary areas	2,93	Shrimp
9	Sea high temperature events can affect the recruitment rate of shrimp and the number of diseases, which may lead to the population's decline.	2,80	Shrimp
10	The sea acidification events can hamper the shrimp's carapace formation and affect its reproduction and growth.	2,75	Shrimp

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

viii. Human settlements

Table 7-16 shows the top 3 scoring analysis sub-units of human settlements unit, for each analysed parameter.

Table 7-16 – Rankings of the 3 highest scoring sub-units of human settlements unit.

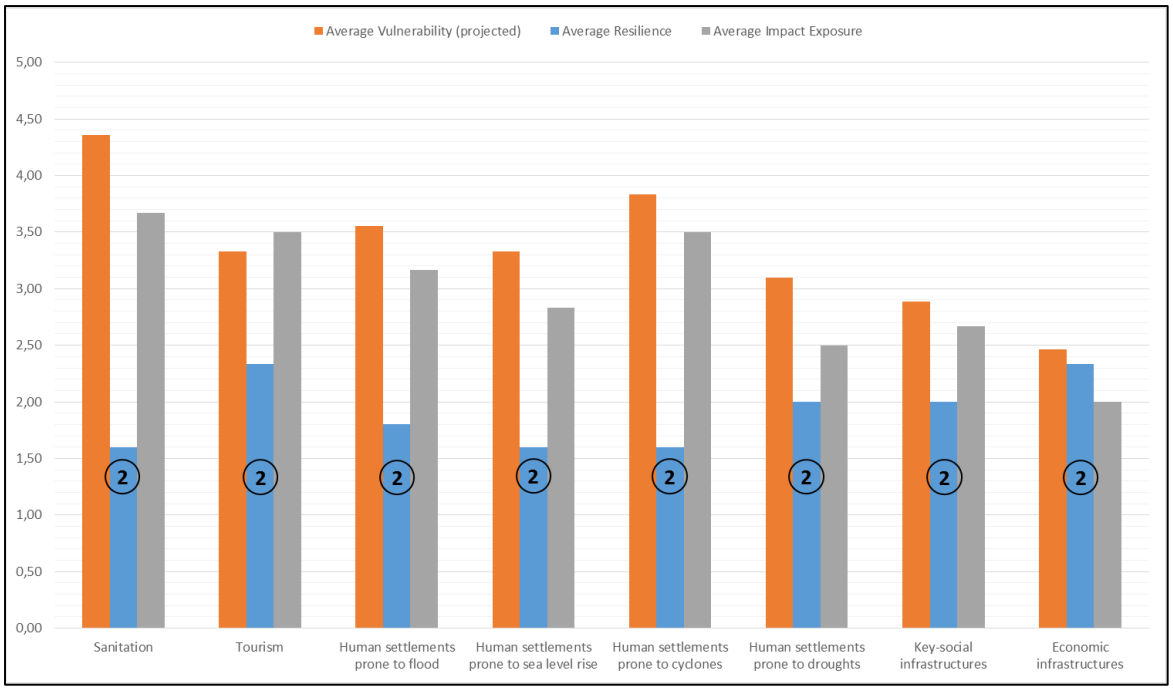
	Resilience	Exposure	Vulnerability
Highest scoring analysis sub-units	1. Tourism/ Economic infrastructures (roads and bridges) 2. Human settlements prone to droughts/ Key-social infrastructures (schools and health centres) 3. Human settlements prone to flood	1. Sanitation 2. Tourism/ Human settlements prone to ciclones 3. Human settlements prone to flood	1. Sanitation 2. Human settlements prone to ciclones 3. Human settlements prone to flood

Overall the sub-unit with the highest vulnerability was sanitation. This sub-unit is exposed to a greater emergence of diseases such as HIV/AIDS, cholera, malaria and diarrhoea. Economic infrastructures is the sub-unit with the lowest score for vulnerability, on account of its relatively low scores for intensity, extension and manifestation, across all its identified impacts.

For this specific unit it is worthwhile mentioning that there was a problem with the naming of the sub-units, which was only detected after the final workshop was held. It is very problematic to define the sub-units in terms of vulnerability to particular hazards as it is circular because that way the vulnerability is being pre-defined. What should be defined is what is a household subject to flood and where is it located. Moreover the sub-units defined in that way are not mutually exclusive, which is one of the first rules of defining sub-units. The same households, for example, might be subject to drought, flooding and sea level rise. The sub-units should have been identified by spatial categories such as island communities or coastal communities or low-lying communities or any other that was appropriate.

Figure 7-9 below shows a comparison of projected vulnerability, resilience and impact exposure, between sub-units.

Figure 7-9 – Averages for each sub-unit of human settlements unit.



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

Table 7-17 below shows that the hazard responsible for the highest rated impact is *tropical cyclones* which can cause physical damage to houses and food gardens, and also the death of people and animals. This climatic impact is also predicted to affect the human settlements prone to cyclones.

80% of the top 10 identified impacts are climatic.

Table 7-17 – Top 10 scoring impacts (Projected vulnerability) on human settlements

Rank #	Impact	Vulnerability (projected)	Sub-unit
1	Tropical cyclones cause the destruction of houses and food gardens, and also the death of people and animals.	5,36	Human settlements prone to cyclones
2	Heavy rains cause floods in residential areas that originate the destruction of houses and food gardens, and the loss of property.	4,88	Human settlements prone to flood
3	Sea level rise events causes abandonment of populations, destruction of houses and also stops	4,36	Human settlements prone to sea level

Rank #	Impact	Vulnerability (projected)	Sub-unit
	economic activities from happen or develop		rise
4	The more people get together in the same space, the greater is the emergence of diseases such as HIV/AIDS, cholera, malaria and diarrhea.	4,36	Sanitation
5	Floods cause the destruction of latrines, wells and water supply systems that, in turn, contribute to the emergence of diseases such as cholera, diarrhea and malaria. The temperature rise creates a propitious environment for the reproduction of the malaria caused mosquito.	4,36	Sanitation
6	Frequent cyclones cause destruction in Tourism infrastructures.	4,27	Tourism
7	High temperatures cause extended droughts.	3,60	Human settlements prone to droughts
8	Tropical cyclones cause the destruction of schools, hospitals and health centres.	3,60	Key-social infrastructures (schools and health centres)
9	Heavy rains destroy roads and bridges, compromising circulation of people and goods.	2,87	Economic infrastructures (roads and bridges)
10	Water, latrines and sewers shortage due to an undersized infrastructure for the amount of existing people	2,60	Human settlements prone to droughts

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

8. ADAPTATION INTERVENTIONS

8.1. POTENTIAL ADAPTATION INTERVENTIONS

Four of the specific studies undertaken for QNP (MacClanahan & Muthiga, 2015; Nicolau, 2015; Ribeiro *et al.,* 2015; and Riddell & Rosendo, 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 QNP.

Coral reefs and climate change (MacClanahan & Muthiga, 2015)	*Mangroves and climate change (Nicolau, 2015)*	*Miombo woodland and climate change (Ribeiro et al., 2015)*	*Community vulnerability & capacity assessment (CVCA) (Riddell & Rosendo, 2015)*
(A) Adaptive management – build capacity for adaptive management of QNP throught training in monitoring and enforcement.	**(H) Sustainable use of mangroves –** raise awareness of mangrove importance, ecosystem services assessment, protection of vulnerable areas, harvesting control, policy enforcement and promotion of restoration programme.	**(N) Consider Blocks A and B as pilot areas for REDD+ projects –** in developing REDD+ the identified knowledge gaps and research questions must be taken into consideration. Also, a detailed carbon inventory must be carried out beforehand.	**(U) Infrastructure development should take into account the impacts of climate-related hazards and stresses –** i.e., latrines and boreholes need to be designed in a manner that prevents collapse.
(B) Improved regulation of fishing – restriction of highly destructive gears, enforcement of fishing activities to ensure only licensed fishers are allowed and set management targets based on a fishable biomass above 500kg/ha.	**(I) Policy improvement – c**onsider appropriate policies for mangroves and inclusion in initiatives to generate local incentives.	**(O) Support sustainable livelihoods in the protection zones, buffer zone and in the corridor –** this will help maintain habitat suitability in wildlife dispersal areas, which will be increasingly important to sustain wildlife populations under climate change.	**(V) Housing quality and type improve – s**upporting households to access robust construction materials and techniques that are flood resistant.
(C) Zoning – additional closures sites can be selected based either in their high site susceptibility and high fishable biomass.	**(J) Inclusion of mangrove carbon assessment for the QNP –** this ecosystem has good prospect in storage carbon which is an ecological service contributing for climate change mitigation.	**(P) Monitor changes in the distribution of density of large mammals in relation to natural and anthropogenic factors –** as a basis for identifying priorities areas of the park for the allocation of management resources.	**(W) Introduce certified timber sources in or round Cabo Delgado –** its lack constrains the sourcing of alternative sustainable timber for housing.
(D) Community closures – consider the establishment of community-managed closures.	**(K) Assessment of hydrology dynamics and sedimentation in QNP –**to understand the dynamic and	**(Q) Define a global strategy for the QNP and resident communities to minimize the impact of climate phenomena and reinforce the local**	**(X) Improved monitoring of road contractors.**

Coral reefs and climate change (MacClanahan & Muthiga, 2015)	*Mangroves and climate change (Nicolau, 2015)*	*Miombo woodland and climate change (Ribeiro et al., 2015)*	*Community vulnerability & capacity assessment (CVCA) (Riddell & Rosendo, 2015)*
	adaptation ability of this important ecosystem;	**capacities to adapt to potential changes –** this must engage local institutions. Further training in climate-resilient agricultural practices and support for income diversification is needed.	
(E) Learning forum – create a learning and exchange network for local communities similar to the Annual Fishers Forum in Kenya.	**(L) Establish Permanent Monitoring Plots –** it would be possible to assess the change in forest composition and structure over time.	**(R) Donation of improved seeds –** particularly of second-season and green vegetables, to ensure diet requirements in lean periods caused by floods or droughts.	**(Y) Implement plans and resources for the maintenance of new infrastructures in villages.**
(F) Livelihood diversification – crease livelihood options to reduce nearshore fishing effort and pressure.	**(M) Restoration Programme for QNP.**	**(S) Infrastructures maintenance –** regular road maintenance and construction or rehabilitation of communal infrastructures.	**(Z) Investigate options for management of existing traditional water sources and conservation techniques.**
(G) Research - understand the local context to inform and strengthen community management most effectively.		**(T) Building knowledge and skills on adaptation strategies with women –** this will increase individual capacity for adaptation, especially amongst most vulnerable groups in society.	**(AA) Improve access to weather and climate information –** information on weather and weather events needs to be more accessible, particularly to farmers.
			(AB) Involve more the local institutions in planning of infrastructure developments, to prevent conflicts – i.e. villages could feed into construction plans to prevent construction in areas of floodwater run-off.
			(AC) Create new local committees – i.e. disaster risk committees (GRC) or natural resource management committees should not be done at the expense of building the capacity and legitimacy of existing local institutions.

Coral reefs and climate change (MacClanahan & Muthiga, 2015)	*Mangroves and climate change (Nicolau, 2015)*	*Miombo woodland and climate change (Ribeiro et al., 2015)*	*Community vulnerability & capacity assessment (CVCA) (Riddell & Rosendo, 2015)*
			(AD) Improve agriculture practives to increasing crop yields and resilience – this could include improved seed varieties, improved agricultural techniques or introduction of drought or flood resistant crops.
			(AE) Reduce wildlife conflicts – this is not only important for peoples' food and physical security, but could reduce fishing pressure and resource extraction rates.
			(AF) Research possibilities for reducing farmer risk – it would be interesting for QNP to learn about innovative crop insurance schemes such as those being initiated in Kenya.
			(AG) Improve Participatory Land Use Planning – this would help farmers plan field extension and nurseries that takes into account climate hazards and stresses.
			(AH) Consider the potential of the provision of distant water sources for wildlife – to prevent attraction to the village in the dry season.
			(AI) Improved facilities for food storage.
			(AJ) Increase the capacity of fishing councils (CCPs) and resource management committees.
			(AK) Promote diversification on

Coral reefs and climate change (MacClanahan & Muthiga, 2015)	*Mangroves and climate change (Nicolau, 2015)*	*Miombo woodland and climate change (Ribeiro et al., 2015)*	*Community vulnerability & capacity assessment (CVCA) (Riddell & Rosendo, 2015)*
			fishing gears and activities – support fishers for gear types that spread effort beyond solely the near-shore estuarine and coral reefs, and promotion of income diversifying activities that are not reliant on natural resources.
			(AL) Recognize the importance of natural source in all management regulations and legislation – as both a safety net in times of need, as a response strategy to climate hazards and risks, and as an essential food and income.
			(AM) Reduce the focus on the strict protection zones (sanctuaries) as the principal conservation tool – invest in the introduction forms of marine and coastal resource management that aim to sustain and even increase production of marine resources.

During the stakeholder vulnerability assessment workshop in Pemba in November 2015, the working groups identified two adaptation interventions for each of the eight analysis units, 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. **Erro! A origem da referência não foi encontrada.** shows the most voted interventions.

Table 8-2 – List of the highest ranked interventions and its respective analysis unit.

Proposed adaptation intervention	Relevant analysis unit
1. Conduct ongoing awareness and training campaigns on fire management at communities, schools and religious institutions	Forest (Miombo & Coastal)
2. Improved planning & regulation of agricultural land-use	Agricultural and Livestock Systems
2. Promote freshwater aquaculture to reduce pressure on the natural fishing resources	Fisheries & aquaculture
2. Enhance sustainability of shellfish production	Fisheries & aquaculture
2. Effective co-management of marine fisheries resources within QNP, addressing tourism and fishing pressure, illegal fishing and destructive gears use in particular	Coral reefs and seagrass
3. Develop, through a participatory/ community approach, a mangrove management and zoning plan with no-take/ restoration zones, rotary cutting areas, protection belts, mangrove buffers and critical areas for restoration	Mangrove Forest & Dunes

Annex 3 provides a full profile of information for the 16 adaptation interventions that were identified for each resource unit, as per the format outlined in the methods section 2, while Table 8-3 presents its summary.

It is worth noting that two adaptation interventions were independently identified by two different working groups. Promoting conservation agriculture and provision of improved crops seeds was identified by both the agriculture and livestock systems working groups and the forest working group. Improving community latrines and sanitation was identified by both the freshwater and the human settlements working groups (Table 8-3).

Table 8-3 – Summary of the selected adaptation interventions identified for each analysis unit and their ranking

Unit	Strategic adaptation interventions	Sub-units & impacts addressed	Ranking	Number of votes	Reference of the QNP specific study where it has been mentioned
Agricultural and Livestock Systems	**1. Improved planning & regulation of agricultural land-use** ▪ Introduce micro-zonation in the *Use & Community Development Zones* of QNP; ▪ Bound and ensure DUAT (special licenses) of every village areas; ▪ Strengthen the CBO capacity and support its legalization; ▪ Demarcate and deliver DUAT (special licenses) to operational CBO.	Maize, cassava, fruits, vegetables and livestock (small ruminants). Development impacts but increased by climate. The pressure on land as a consequence of population increase and migration; new road construction, mining concessions and tourism development. The pressure on land is also exacerbated by great dry periods, increase of heat waves, floods and strong winds.	2	18	Ribeiro *et al.*, 2015 – **(R)** Riddell & Rosendo, 2015 – **(AG)**
	2. Conservation agriculture (inc.improved seed varieties) ▪ Introduce and adopt short-cycle and more tolerant improved seeds; ▪ Introduce and adopt water conservation and soil fertility techniques (sustainable and conservation agriculture); ▪ Construction of dikes that allow water retention for crop irrigation.	Maize and cassava. Climatic impact, namely the extended dry periods cause vulnerability to some staple food crops	9	4	Riddell & Rosendo, 2015 – **(AD)**
Species of high conservation value	**3. Strengthen protection of wildlife resources in QNP** through: ▪ Resize protection blocks ▪ Attract animals to stay within total protection blocks by creating water-holes	Elephant, African wild dog, Kudu, Crocodiles and Hippopotamus, Lion and Leopard Mostly development impacts, such as poaching or disturbance and habitat fragmentation caused by human activities or settlements (agriculture, roads, etc.). The	4	13	Ribeiro *et al.*, 2015 – **(P)** Riddell &Rosendo, 2015 – **(AH), (AM)**

Unit	Strategic adaptation interventions	Sub-units & impacts addressed	Ranking	Number of votes	Reference of the QNP specific study where it has been mentioned
	▪ Reinforce controls against poaching ▪ Remove human settlements from the corridors between the total protection blocks.	interventions will contribute to increase species' resilience.			
	4. Improve protection of sea turtles and sharks in QNP through: ▪ Better control of immigrant fishermen ▪ Reinforce surveillance through community inspectors, providing them with proper means and equipment ▪ Control human settlements and touristic resorts in turtles' nesting sites.	Sea turtles, Sharks Mostly development impacts, such as illegal fishing or disturbance and habitat loss caused by human activities or settlements (tourism and settlements in turtles' nesting sites). The intervention will contribute to increase species' resilience and to reduce exposure	5	12	
Forest (Miombo & Coastal)	**5. Conduct ongoing awareness and training campaigns on fire management at communities, schools and religious institutions**, including on: ▪ Fire management (use of fire in adequate periods to eliminate the biomass fuel); ▪ Warning systems on the danger level in communities through different colour flags; ▪ regular collection of dry combustible material that can be used for different purposes	Use & Community Development Zones – QNP Multiple-use coastal forest areas Combination of climate and development impacts. The risk of fire is exacerbated by prolonged dry spells which are getting longer as a result of climate change	1	19	
	6. Improve sustainable agriculture	Use & Community Development Zones, QNP	7	9	Ribeiro *et al.*,

Unit	Strategic adaptation interventions	Sub-units & impacts addressed	Ranking	Number of votes	Reference of the QNP specific study where it has been mentioned
	technics and diversify other income activities ▪ Promote improved agriculture production techniques, which enhance productivity, including: - Conservation agriculture; - Improved seeds; ▪ Promote added value agricultural products to increase income ▪ Sustainable exploitation of non-timber forest products (i.e. honey, mushrooms)	Combination of climate and development impacts. The occurrence of the dry season and high temperature events will affect agriculture production and increase the local communities' dependence on forest resources. This will increase the pressure and the levels of forest resources exploitation. The intervention intends to reduce the forests' exposure to deforestation and fragmentation in result of agricultural areas' growth.			2015 – **(O)**
Human settlements	**7. Developing and implementing a climate resilient settlement policy for communities within QNP. Promote construction materials and techniques that are more resilient to storms and high winds**	Human settlements prone to flood in exposed low-lying, coastal shorelines Climate related impact, namely cyclones and storms coupled with high tide events, exacerbated in the longer term by sea level rise	6	11	Riddell & Rosendo, 2015) – **(U), (V), (Y)**
	8. Improve sanitation through construction of improved latrines and cistern tanks for water catchment and treatment.	Sanitation Climate related impacts. Floods, causing the destruction of latrines, wells and water supply systems that, in turn, contribute to the emergence of diseases such as cholera, diarrhoea and malaria. In addition, the temperature rise creates a propitious environment for the reproduction of the malaria caused mosquito. This intervention intends to reduce the exposure of communities to diseases and also to increase its resilience.	9	4	
Fisheries and Aquaculture	**9. Promote freshwater aquaculture to reduce pressure on the natural**	Freshwater fish (tilapia, cat-fish)	2	18	

Unit	Strategic adaptation interventions	Sub-units & impacts addressed	Ranking	Number of votes	Reference of the QNP specific study where it has been mentioned
	fishing resources	Combination of development and climate related impacts. The increasing number of fishermen leads to an increasing subsistence river's fishing pressure which, in turn, leads to a reduction of freshwater fish's populations. In addition, extended droughts may drive populations to intensify freshwater fishing, by lack of other resources. With pisciculture, communities get less dependent on rivers and reduce their fishing effort. This will allow to increase fish's resilience in the rivers; Pisciculture fish will be less exposed to climate change effects, such as droughts.			
	10. Enhance sustainability of shellfish production ▪ Create rotary community reserves that allow the establishment of temporary closed areas for replenishment of marine invertebrates. ▪ Promote oyster mariculture	Marine invertebrates (Oysters and "Pinas") Development related impacts. The human population growth and the accessibility to collect this invertebrates, increases the pressure on this resources, which, in turn, leads to a marine invertebrates' population decrease. With this intervention, the marine invertebrate communities will have more proliferation capacity, increasing their populations.			MacClanahan & Muthiga, 2015 – **(C)**
Coral reefs and seagrass	**11. Effective co-management of marine fisheries resources within QNP, addressing tourism and fishing pressure, illegal fishing and destructive gears use in particular always following an integrated approach that involves communities, QNP management and district authorities**	Seagrass (shallow waters); Sheltered coral reefs with fishing pressure; Sheltered reefs without fishing pressure Combination of development and climate related impacts. Illegal fishing and tourism activities in the coral areas (dive, anchorage, motorized) that degrade marine habitats and. This degradation exacerbated by sea water high temperature events (that cause bleaching and death of coral reefs), heavy rains (causing sedimentation of seagrass carpets and corals) and acidification (that reduces genetic	2	18	MacClanahan & Muthiga, 2015 – **(D)**

Unit	Strategic adaptation interventions	Sub-units & impacts addressed	Ranking	Number of votes	Reference of the QNP specific study where it has been mentioned
		biodiversity until the risk of extinction of the species). This intervention intends to increase resilience and decrease exposure of the addressed sub-units.			
	12. Resilience and adaptive management of coral reefs and Law enforcement ▪ Provide training in monitoring and enforcement ▪ Set management targets based on fishable biomass ▪ Improve fishing regulation ▪ Create new high compliance closure sites and consider a community-management approach	Exposed reefs under fishing pressure, Exposed coral reefs without fishing pressure, Sheltered coral reefs with fishing pressure, Sheltered reefs without fishing pressure Combination of development and climate related impacts. Illegal fishing and tourism activities in the coral areas (dive, anchorage, motorized) that degrade marine habitats and. This degradation exacerbated by sea water high temperature events (that cause bleaching and death of coral reefs), heavy rains (causing sedimentation of seagrass carpets and corals) and acidification (that reduces genetic biodiversity until the risk of extinction of the species). This intervention intends to increase resilience and decrease exposure of the addressed sub-units.	6	11	MacClanahan & Muthiga, 2015 – **(B)**
Freshwater	**13. Creation of hydrographic sub-basin's management committees;** Provide training to the basin's committee members.	Seasonal Rivers (Messalo, Muaguide, Muagamula) Combination of climate and development related impacts. Extreme events (droughts and floods) and the disorganized land use cause erosion and inability for water storage by the rivers. This intervention will encourage the integrated management of water resources.	10	0	Riddell & Rosendo, 2015 – **(AC)**
	14. Improve the sanitation system, through the construction of improved latrines and public toilets.	Wells (Coastal); Wells (inland) Combination of development and climate related impacts. Water contamination of wells due to inadequate sanitation systems, exacerbated by extreme events (droughts and floods) and the disorganized land use that can be the cause	4	13	

Unit	Strategic adaptation interventions	Sub-units & impacts addressed	Ranking	Number of votes	Reference of the QNP specific study where it has been mentioned
		water storage capacity decrease.			
Mangrove Forest & Dunes	**15. Support implementation of a mangrove management and zoning plan through surveillance, re-planting activities and promotion of mangrove-related livelihood activities (apiarist co-op, medicines and ecotourism)**	Low islands mangrove (Quirimba, Ibo, Quirambo, Situ) Coastal mangrove (Quissanga, Mussemuco, Arimba) Combination of development and climate related impacts. The markets' demand and the lack of subsistence options increase the demand for mangrove's timber products, leading to a mangrove's area reduction. Construction and seasonal fishing centres (migratory fishermen) increase the pressure on the mangrove to collect stakes for houses and fishing gears' construction, also reducing the coastal mangrove area. Tourism development, along with the construction of tourist infrastructures using local materials increases pressure on the mangroves as well and leads to a structure modification and to cover reduction of the forest. This impacts can be exacerbated by the frequency's increase of extreme events.	8	6	MacClanahan & Muthiga, 2015 – **(F)** Nicolau, 2015 – **(H), (I), (M)**
	16. Develop, through a participatory/ community approach, a mangrove management and zoning plan with no-take/ restoration zones, rotary cutting areas, protection belts, mangrove buffers and critical areas for restoration	Low islands mangrove (Quirimba, Ibo, Quirambo, Situ) Coastal mangrove (Quissanga, Mussemuco, Arimba) Combination of development and climate related impacts. The markets' demand and the lack of subsistence options increase the demand for mangrove's timber products, leading to a mangrove's area reduction. Construction and seasonal fishing centres (migratory fishermen) increase the pressure on the mangrove to collect stakes for houses and fishing gears' construction, also reducing the coastal mangrove area. Tourism development, along with the construction of tourist infrastructures using local materials increases pressure on the mangroves as well and leads to a	3	14	Nicolau, 2015 – **(I), (M)**

Unit	Strategic adaptation interventions	Sub-units & impacts addressed	Ranking	Number of votes	Reference of the QNP specific study where it has been mentioned
		structure modification and to cover reduction of the forest. This impacts can be exacerbated by the frequency's increase of extreme events.			

8.2. SYNTHESIS OF ADAPTATION INTERVENTIONS BY QNP MANAGEMENT

As outlined in the methods section 2 above, the final consultation step of the vulnerability assessment process was a meeting held on Ibo Island that gathered WWF team, the consultancy team who is preparing this report, the QNP warden and the local authorities, with the objective of reviewing the selected adaptation interventions and adjusting them to the reality of the QNP management priorities and capabilities. The adaptation interventions below resulted from that meeting, - preferably to be implemented as an integrated package in pilot or model areas, as per the cross-cutting point A below. The adaptation intervention options are not in any order of priority.

A. Model villages for integrated, sustainable development and adaptation (cross-cutting approach)

Currently, QNP faces a major, over-arching management challenge of regulating the community presence within the boundaries of the park. This was inherited at the time of the park's gazettment in 2002 at which time tens of thousands of people were already living within the area proposed for gazettement. To this day, the precise number is not known or monitored but it is estimated in over 166 000 people. Implementing climate adaptation interventions potentially presents an opportunity to take a strategic, long-term approach to this challenge by using adaptation interventions to incentivise communities to settle in less vulnerable buffer zones, where their livelihood activities will be more sustainable and have less impact on the park's wildlife and core habitats.

The main workshop working groups proposed the adaptation interventions n. 3 and 7 that intend to address this problem (Table 8-3). Such an approach would initially require baseline studies to map and quantify existing settlements and agricultural activity. It would then involve, through extensive community consultation, selecting suitable locations in the buffer zone of the QNP or (less desirably) in the use and community development zones, wherein to focus investment in basic social infrastructure and services such as schools, health centres, freshwater boreholes and other social infrastructures. The latter might include water capture and retention systems and improved sanitation, something considered extremely important, as climate change effects are expected to increase the prevalence of some water borne diseases amongst others. Both coastal and inland location would be identified (i.e. adaptation intervention 7 focuses on human settlements prone to seal level rise). These model communities could then become centres around which community livelihood and resource use could be better managed through micro-zonation of agricultural areas, creation of community forests, aquaculture trials and so on.

1. Climate resilient forest & agriculture management (Adaptation project 1)

This would involve improved forest fire management and sustainable agriculture practices in target or model communities within the inland areas of the QNP, especially targeting the vulnerable *use & community development* and *multiple-use coastal forest zones* of QNP. In relation to the forest, the project would implement actions (Table 8-3) to reduce the exposure to fires that might become out of control. In what concerns agriculture, the proposed management actions intend to reduce the forests' exposure to deforestation and fragmentation in result of the increasing of agricultural areas. The microzoning of the areas of community development and multiple use and issuing of DUATs for the villages areas and its surrounding would be a complementary action. In both cases these should be implemented by local communities through their leaders (traditional, religious and

management committees) and by focal points, selected from the communities and duly trained. The strengthening of the existing CBO capacity and the to support its legalization would be necessary actions to implement.

This project integrates the adaptation interventions n. 1, 2, 5 and 6 proposed by the working groups (Table 8-3), that explain each of the potential activities in more detail.

2. Reducing wildlife vulnerability: enhanced management of total protection blocks (Adaptation project 2)

One of the main problems in inland areas within QNP is the expansion and shifting of human settlements. This is fragmenting important corridors and disturbing core areas for fauna, increasing the vulnerability of high-profile wildlife species. This adaptation intervention has the objective of removing human settlements from corridors between the total protection blocks and creating more favourable, climate resilient conditions for fauna inside the blocks and less exposure, by creating watering-holes and improving food resources through vegetation management. Total protection blocks A, B e C located in the districts of Macomia, Quissanga, Meluco and Ancuabe would be the areas where this project should be implemented.

This project can be combined with Adaptation project 1 and includes the adaptation interventions n. 3 and 7 described in Table 8-3.

3. Resilient marine fisheries 1: creating sanctuaries & co-management areas (Adaptation project 3)

Fishing sanctuaries have proven to be a somewhat effective strategy in some communities within Quirimbas National Park. The FFEM-funded coral reef resilience study (Mclanahan & Muthinga, 2015) also suggests the same. The establishment of community-managed closures has the potential to enhance the productive of fish stocks and also raise community awareness about the conservation of habitats and recovery of stocks. As such, communities will benefit through enhanced food security and contribution to livelihoods. The concept of managing fishing effort within defined zones can then be expanded to a broader fisheries co-management initiative whereby all marine areas of QNP are zoned, and fishing effort regulated, through a participatory, community-led approach. This intervention, which was identified by one of the working groups (adaptation intervention n. 11 in Table 8-3) would in particular target shallow marine habitats identified as vulnerable, namely: shallow water seagrass; and sheltered coral reefs under fishing pressure. This intervention could be combined with Adaptation projects 4 and 5 described below..

4. Resilient marine fisheries 2: sustainable mariculture and aquaculture (Adaptation project 4)

Mariculture and aquaculture projects to be implemented with the communities of the islands and coastal communities, where oyster fisheries and freshwater tilapia and catfish are important, can have a significant positive impact on the reduction of effort on local resources. This is expected to have a positive effect both in the local ecosystems and communities. Quissanga and the Quirimba island are two potential areas of implementation, as well as certain areas to be identified in the interior of QNP. The implementation of this type of projects must however consider that the production techniques must be simple so that the local communities can learn it and implement it effectively.

Regarding aquaculture it is expected that by implementing it, the inland communities become less dependent on river and lake fisheries, putting less effort on freshwater fish. Additionally, it is expected that aquaculture tanks are less exposed to the effects of climate change.

The mariculture would have similar effects and could be very relevant for the most vulnerable coastal and island communities that would have more food resources and a potential increase of its income by selling the products to the tourism sector.

Rotational community reserves for harvesting marine invertebrates can also be a complementary option, which would include the establishment of closed areas for the reproduction of the different species. This would allow the increasing of the invertebrate populations and that these would only be harvested only when reaching the ideal size.

Overall, it is expected that this intervention would create capacity on local communities for producing their own food and establishing an alternative source of income on a sustainable manner. The production of oyster and fish would diversify the livelihoods and potentially reduce the fishing pressure on the primary sources used by local communities, either fish or invertebrates. This would also allow to diversity their diet, contributing to the improvement of the local living conditions, especially women and children who are the most vulnerable.

This project includes the adaptation intervention n. 9 and 10 described in Table 8-3 and can be combined with the adaptation projects 3 and 6.

5. Adaptive mangrove management (Adaptation project 5)

Mangrove management strategies such as restoration of vulnerable and critical areas, establishing mangrove protected areas, rotation systems for the cutting of the mangrove, protection belts and the development of feasible local livelihood alternatives (i.e. apiculture and ecotourism) should be implemented with target or model communities, especially in the vulnerable low-lying islands (Quirimba, Ibo, Quirambo, Situ) and coastal mangrove areas (Quissanga, Mussemuco, Arimba).

Pilot projects can be implemented in Quissanga and Mussemuco. NGO and local authorities' involvement would be necessary to train the local communities in these types of natural resources management.

This project includes the adaptation interventions n. 15 and 16 (Table 8-3).

6. Building capacity to QNP management staff for implementing adaptive management for coral reefs and marine species (Adaptation project 6)

Considering both the recommendations of the coral reef assessment and the implementation of the *Flowing Forward* methodology, corals, marine species and habitats in general are suffering an enormous pressure due to human development. This means a very relevant added stress factor besides climate change. Therefore, building the capacity of the QNP management staff for implementing adaptive management in the protected area, including the related training in monitoring and law application enforcement would be a very efficient adaptation intervention.

For example, according to the coral specific study setting management targets based on a fishable biomass above 500kg/ha would ensure that the habitat and species are protected while sustaining fisheries. The same can be done for other habitats and species. Groups of key species such as turtles and sharks are suffering significant pressure due to human development. The reinforcement and training of the inspection staff, either from the QNP

and from the local communities, and providing them with the adequate equipment would be an effective intervention, considering the current lack of means. The range of inspection activities should cover illegal fishing activities and land occupancy. The latter can play a relevant role considering that the effects of climate change will potentially reduce the availability of areas that can be relevant for turtle nesting, touristic activities or the establishment of human settlements.

Turtle nesting site areas and coral reefs of the marine protected area of QNP should be the focus of this project, which includes the adaptation interventions n. 4, 11 and 12 (Table 8-3).

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. INTEGRATED ADAPTATION

The adaptation interventions shown in **Erro! A origem da referência não foi encontrada.**section 8.2 above are all potentially feasible, including the five most voted by the workshop participants (see Table 8-2). However, some of them might be difficult to implement and others might be ineffective if implemented in isolation. On the other hand, their potential to be effective depends upon their integration into the overall QNP Management Plan, 2011-2021 and its programme of implementation.

The cross-cutting proposal to develop model villages for integrated, sustainable development and adaptation within QNP is a very ambitious concept. However it can potentially provide a framework to resolve most of the problems QNP is confronted with, both related to climate change and development. At the heart of that is the fact QNP has inherited a situation whereby tens of thousands of people are residing within the park area, something that is at odds with national legislation, and those people are currently dependent on agricultural and fisheries resources within the park for their livelihoods. This situation greatly exacerbates the natural vulnerability to climate stresses of QNP's ecosystems and species. By the same token, the vulnerability of human settlements and agricultural activity within QNP is exacerbated through being unplanned. Better management and regulation of that is therefore the key to reducing climate vulnerability of the whole QNP system.

Depending on whether the selected suitable locations for new model settlements are along the coast or inland, this cross-cutting approach can provide a foundation for implementation of all six adaptation projects proposed above. Projects 4, 5 and 6 can be implemented alone or combined in communities already established in the islands and/or along the coast in areas where the current settlements are considered suitable. The same can happen for Project 1 in areas that are considered suitable for human settlements, but in this case it would be more effective if implemented together with Project 2, which is focused on removing human settlements from the corridors between the total protection blocks, creating favourable conditions for the fauna inside the blocks and to create a flow between them. Project 6 is more generic but extremely important as building the capacity for implementing a real adaptive management in QNP by the park authorities. The related training in monitoring and law application enforcement would be a very efficient adaptation intervention. Figure 9-1 below provides a graphic overview of this potential relations.

Figure 9-1 – Relation between interventions and potential combination to get top efficiency

(A – Cross-cutting point A; AP – Adaptation projects)

9.3. WAY FORWARD

Considering that a systematic approach was undertaken to assess climate vulnerability and potential adaptation interventions for the QNP, and that urgent action is needed, the next steps should focus on formulating the proposed adaption projects into proposals to secure necessary funding.

It was noted that at least one major donor with a history of supporting QNP has an interest in continuing to support climate adaption in QNP and that this presents an important opportunity.

9.4. GAPS AND LESSONS LEARNED

The approach that was used for assessing in detail the climate vulnerability of the QNP provided detailed results and allowed the definition of realistic adaptation interventions tailored to the current reality of QNP. 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.

Two examples of this issue has been described in section 7. The first one was related to the overview of one particular sub-unit (Buffer Zone of the QNP) during the main workshop. In this case the working group focused its attention on other sub-units and dedicated less effort to identifying impacts for the buffer zone. That has resulted in low scores for vulnerability and impact exposure, something that is very odd because the QNP buffer zone is under a very strong human pressure. The second example is related to the naming of the sub-units that belong to the forest unit. The sub-units were defined in terms of vulnerability to particular hazards, instead of defining its structural characteristics and/or location. The sub-units should have been identified by spatial categories such as island communities or coastal communities or low-lying communities or any other that was appropriate.

Considering what has been explained 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. Providing more technical capacity to each group will allow overcoming the issues that have been identified in the former paragraphs.

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11. ANNEXES

11.1. ANNEX I: DEFINITION AND IMPORTANCE OF EACH SUBUNIT

11.1.1. FOREST (MIOMBO & COASTAL)

Subunit	Definition	Importance
Forest around villages outside the Park	Villages located on the periphery or within the miombo forest, but outside of the QNP	They're important when its location is close to urban centres, due to the demand and purchase of wood and coal.
Total protection zones - QNP	The total protection zones are part of the QNP macrozoning. These areas aim to protect and conserve biodiversity, and should be used only for research. They have no human influence and there are no settlements inside. They are often prone to illegal actions of hunting and logging.	There are three total protection zones in QNP identified as blocks A, B and C. All of them have miombo ecosystems. Block C also has coastal forest. Its importance is high for the QNP.
Miombo sacred forests	These areas are protected and do not have settlements. Some community actions and activities are allowed, such as traditional ceremonies, collecting plants and roots for traditional medicine, berry picking, etc., but always bearing in mind the conservation of biodiversity and the protection of habitats. It is intended that the management of these areas is made in a participatory and engaging way (with QNP communities).	These areas have great importance for the QNP because are focused on conservation and biodiversity protection activities, and also have a very strong traditional value, as they are used for traditional ceremonies and for the collecting of plants and roots for medicinal purposes.
Use and community development zones - QNP	The use and community development zones are areas where human presence is evident. These zones geographical definition will be subjected to a more detailed zoning with the intention of mapping every village. This area comprises all existing settlements in the QNP and its areas of production and expansion. In this zones activities like intensive livestock farming and intensive production of income crops such as cotton, tobacco, etc., are not allowed. It is also not allowed logging neither to perform any income activities that threats ecosystems or their habitats.	The earnings that communities can have with the park's existence are the main reason for its importance. The use and community development zones are also important because of the perspective of integrate communities in the management and sustainable use of natural resources.
Buffer zone - QNP	The buffer zone is a defined area of 10 km around the park boundaries.	This zone is the first filter to ensure the conservation of QNP biodiversity.
Coastal forest areas of multiple use	Coastal forests due to their characteristics are used for several purposes, of which we highlight the traditional ceremonies, the collecting of plants and roots for medicinal purposes and also the collecting of berries.	The areas of multiple use in coastal forests are important because of its traditional use and also because of its relation to culture and African roots.
Coastal and Miombo forest for multiple use outside QNP	These areas are mostly used for hunting concessions, which are not allowed within the QNP, but they exist in some areas further north in Palma district and in Mocimboa da Praia. Hunting concessions are exploited for touristic purposes	These are important areas for a climate change analysis due to the possibility to measure and monitor all the fauna and flora in the area. The area is subjected to great control of

Subunit	Definition	Importance
	which main activity is a sustainable and balanced hunting.	park rangers.

11.1.2. MANGROVE FOREST & DUNES

Subunit	Definition	Importance
Estuarine mangrove (fresh water dependent)	Mangrove located along the river course with high influence of freshwater. Connects areas between the river and the sea. In the dry season have more salty water and in the rainy season have more fresh water.	Reproduction of marine species; bio filtration; carbon capture
Coastal mangrove (salty water and tidal movements dependent)	Mangrove located on the coastal fringe with high influence of tidal cycle, currents, waves and sedimentation	Coastal protection against winds and strong waves
Low islands mangrove (salty water and tidal movements dependent)	Mangrove exposed to the sea; High influence of currents, waves and sedimentation, located on islands or rocky areas	Protection of the geomorphological structure of the island, coastal barrier, protection against erosion.
Coastal dunes with invasive trees and autochthonous flora	Areas of dunes with trees for erosion control (pines, casuarina, etc.) and usually with no local flora. *Europstum*, *Pemphis acidula* and *H. acidula*. It can also be dune areas with great vegetation ground cover. With native vegetation.	Are important, even though this vegetation acidifies the soil, when its leaves fall – it's a mechanism to prevent the development of other plants.

11.1.3. CORAL REEFS AND SEAGRASS

Subunit	Definition	Importance
Exposed reefs under fishing pressure	Reef areas that are exposed to climatic events such as storms and cyclones because they are facing the open sea and are within parks and/or reserves. These coral reefs can be inside or outside the area of protection and are prone to great fishing pressure (e.g.: Ibo, Quirimbas, Matemo)	Climatically speaking, this areas are important because they located in conservation areas (parks and reserves), but exposed to climatic events of the open sea. Control and monitoring is constant and systematic in this areas.
Sheltered reefs without fishing pressure	Sheltered reef areas between islands and mainland and that are less exposed to climatic events. They are outside the parks and/or reserves. The coral reefs can be within or outside the protected area and don't have fishing pressure (e.g.: sanctuary areas, away from fishing centres).	Its importance is great because they allow us to assess the impact of human and climate actions.

Subunit	Definition	Importance
Exposed coral reefs without fishing pressure	Reef areas that are exposed to climatic events such as storms and cyclones because they are facing the open sea and are within parks and/ or reserves. This areas are not prone to fishing pressure.	Climatically speaking this reefs are important because are located in areas subjected to human and climatic actions.
Sheltered coral reefs with fishing pressure	Sheltered reef areas between islands and mainland and that are less exposed to climatic events. These areas are located within the parks and/or reserves and are prone to fishing pressure..	Climatically , these are important areas, because are located in conservation sites (parks and reserves). Control and monitoring is constant and systematic.
Seagrass of the deep waters	Seagrass areas that at low tide are exposed and without water to coverage. Seagrass is defined as the base of the food chain in the ecosystems.	The importance of these areas, besides acting as shelter to some marine life, is that they are also more accessible to man and prone to climatic events.
Seagrass of the shallow waters	Rocky areas where seagrass grows.	These areas have great importance as they offer excellent conditions for species' breeding. They are under the influence of human activities, such as calcareous rock collecting for construction and "cal" production

11.1.4. SPECIES OF HIGH CONSERVATION VALUE

Subunit	Definition	Importance
Elephant	Protected terrestrial mammals in serious risk of extinction	Important because the extinction or population's decrease of any of these species may cause serious ecological and environmental disasters.
Lion/ leopard	Protected terrestrial mammals in serious risk of extinction	Important because the extinction or population's decrease of any of these species may cause serious ecological and environmental disasters.
African wild dog	Protected terrestrial mammals in serious risk of extinction	Important because the extinction or population's decrease of any of these species may cause serious ecological and environmental disasters.
Crocodiles/ hippopotamus	Large size wildlife whose main habitat are rivers and lakes	Important because the extinction or population's decrease of any of these species may cause serious ecological and environmental disasters.
Dolphin	Protected marine species (cetaceans) of high importance that are endangered	Important because its extinction may affect marine ecology, as dolphins control large shoals of fish.
Sea turtle	Protected marine species of high importance, that are endangered and no longer exist in some areas	Important because the extinction or population's decrease of any of these species may cause serious ecological and environmental disasters.
Dugong	Protected marine species and of high importance, that are endangered and no longer exist in some areas	Important because the extinction or population's decrease of any of these species may cause serious ecological and environmental disasters.
Whales	Protected marine species of high importance, that are endangered and no longer exist in some areas	Important because the extinction or population's decrease of any of these species may cause serious ecological and environmental disasters.

Subunit	Definition	Importance
Shark	Protected marine species of high importance, that are endangered and no longer exist in some areas	Important because the extinction or population's decrease of any of these species may cause serious ecological and environmental disasters.
Southern ground hornbill	Bird species of high ecological value within the park	Important because it acts as a great controller of reptiles, frogs, snails, insects and small mammals populations.
Kudu	Mammal species that is the symbol of the park and is endangered	It has an ecological importance because it feeds on some plant species harmful to the park

11.1.5. AGRICULTURAL AND LIVESTOCK SYSTEMS

Subunit	Definition	Importance
Livestock breeding (cattle)	Livestock breeding of cattle. In rural areas these animals have natural feeding resources (grass, grass' seeds, etc.).	The importance of livestock breeding can be negative or positive. The intensive creation of cattle may endanger the balance of ecosystems.
Livestock breeding (small ruminants)	Livestock breeding of small ruminants. In rural areas these animals have natural feeding resources (grass, grass' seeds, etc.).	The importance of livestock breeding can be negative or positive. The intensive creation of small ruminants may endanger the balance of ecosystems.
Livestock breeding (poultry)	Livestock breeding of small birds. In rural areas these animals have natural feeding resource (grass, insects, grasses seeds, etc.).	The importance of livestock breeding can be negative or positive. The intensive creation of poultry may endanger the balance of ecosystems.
Fruit (mango, cashew, coconut, "maçanica")	Fruit plants described here are the most important species, economically speaking, to rural populations. The fruit trees are usually planted next to residential areas and are used as a sign of land ownership.	Its importance is more in terms of economic value for communities, not so much in terms of climate, because the exploitation is familiar and not intensive. "Maçanica" is very tolerant to large dry periods. It is widely consumed by communities, fresh, dried and processed (as a drink or a candy). It also provides some income to rural families. Its leaves and branches are used for cattle feed.
Maize	Rainfed food crops (1st season); Rainfed food crops are the main livelihoods of rural people in Mozambique (+/- 80%). The sowing follows the rainfall cycle.	The importance of rainfed food crops is great because in addition of depending on rainfall, they deplete soils very quickly, forcing rural families to open new areas of production which means destroying forests.
Cassava	Rainfed food crops (1st season); Rainfed food crops are the main livelihoods of rural people in Mozambique (+/- 80%). The sowing follows the rainfall cycle.	The importance of rainfed food crops is great because in addition of depending on rainfall, they deplete soils very quickly, forcing rural families to open new areas of production which means destroying forests.
Mapira*	Rainfed food crops (1st season); Rainfed food crops are the main livelihoods of rural people in Mozambique (+/- 80%). The sowing follows the rainfall cycle.	The importance of rainfed food crops is great because in addition of depending on rainfall, they deplete soils very quickly, forcing rural families to open new areas of production which means destroying forests.

Subunit	Definition	Importance
Vegetables	Irrigated food crops (1st and 2nd season); Usually these crops are in specific areas with possibility of irrigation. They are placed in low areas and near water sources (rivers, lakes, ponds, etc.)	Its importance is relative. Can be greater when its practice affects normal riverbeds and also when increases man-wildlife conflicts.
Rice	Irrigated food crops (1st and 2nd season); Usually these crops are in specific areas and with possibility of irrigation. They are placed in low areas and near water sources (rivers, lakes, ponds, etc.)	Its importance is relative. Can be greater when its practice affects normal riverbeds and also when increases man-wildlife conflicts.
Sesame	Income rainfed crops (1st season); The situation of these cultures is identical to "rainfed food crops". We can also include here the cotton, tobacco and “jatropha”, but those are forbidden within the QNP.	Same mentioned for rainfed food crops
Beans	Same mentioned for other rainfed food crops (maize, cassava and sorghum). Note: the word beans is widespread and includes some wild species such as the "mucuna", "monkey bean", etc..	Being a leguminous, helps improving soil fertility through nitrogen fixation.

* No impacts have been identified for this sub-unit.

11.1.6. FRESHWATER

Subunit	Definition	Importance
Coastal basin	No definition given by the group	Signs of negative effects of climatic events, such as storms and cyclones are quite visible in some areas of rivers’ influence, causing floods, disasters, etc.. It has great importance.
Seasonal Rivers (Messalo, Muaguide, Muagamula)	No definition given by the group	Signs of negative effects of climatic events, such as storms and cyclones are quite visible in some areas of rivers’ influence, causing floods, disasters, etc.. It has great importance.
Montepuez	No definition given by the group	No importance defined by the group
Lagoons (Bilibiza)	Areas with available freshwater all year and with a huge richness of fauna and flora (e.g. Bilibiza lagoons, Kagavero, Nguri, Nangade, Chai)	Its importance is relative and mainly felt in years when the dry season is longer and the rainy season is very short, but with great intensity of rains.
Wells (coastal)	Water supply sources created by man and sometimes protected and equipped with manual, mechanical or electrical pumping systems.	The wells are the first obvious vulnerability factor, because of its importance to communities. The negative effects are noted in the dry season by salinization in the coastal zone (saltwater intrusion) and by absence of water. In the rainy season the silting is also a constant evidence.
Wells (inland)	Water supply sources created by man and sometimes protected and equipped with	The wells are the first most obvious vulnerability factor, because of its importance to communities. The negative effects are noted in the dry season by salinization in the

Subunit	Definition	Importance
	manual, mechanical or electrical pumping systems.	coastal zone (saltwater intrusion) and by absence of water. In the rainy season the silting is also a constant evidence.
Swamps (Kagavero)	Areas with water availability in seasonal periods, where the groundwater is very superficial during dry weather.	They have a median importance, and mostly for man, as an economic factor. Exist in areas of second season crops, as well as in rice fields.
Groundwater	No definition given by the group	No importance defined by the group

11.1.7. FISHERIES AND AQUACULTURE

Subunit	Definition	Importance
Shrimp	Marine species that mostly reproduces in the estuaries of rivers	The decline in salinity levels and sedimentation brought by the rains, decreases shrimp breeding levels, and is the reason of its importance.
Lobster	Marine species that inhabits rocky and coral areas	High temperatures cause habitat loss and consequently the reduction of this species.
Reef fish	Fish species that reproduce and grow on coral reefs. As adults, some of these species come out from reef areas and migrate to other areas.	Some changes in the temperature of sea water causes the death of microalgae and live coral and also coral bleaching. Fish living in these ecosystems are the first to suffer from this situation.
Freshwater fish (Tilapia, cat-fish)	These species live in freshwater ponds, exposed to water level changes according to the season (dry or wet). Species to highlight: tilapia and cat-fish	Its exposure to irregular rainfall, and to climatic events (storms, cyclones, erosion, etc.) gives it a great importance in economic and vulnerability assessment terms.
Marine invertebrates (Oysters and "Pinas")	Benthic species that inhabit the intertidal area in seagrass zones	Because these resources are close to the coast and prone to silting it´s important to assess the vulnerability of this sub-unit.
Cephalopods (octopus and squid)	Octopuses and squids are marine mollusc species of the class of cephalopods. They live in shallow waters with emphasis on coral reefs and rocky areas.	Because these animals live in shallow waters, the increase of seawater temperature affects its replication and growth. Their vulnerability is important to consider.
Crab	Marine species that inhabit in mangrove areas	The lowering salinity levels, siltation and mangrove log may affect their reproduction and growth. Their vulnerability is important and should be considered.
Pelagic fish	Pelagic fish (sardines, mackerel, tuna, etc.) are surface migrant species that feed primarily on phytoplankton and zooplankton, being a central part of the food chain.	Because these are an important component of the food chain and its habitat is located in shallow waters, they are prone to suffer from sea rising temperatures and climatic events (hurricanes, storms, etc.) that destroy the fields of zooplankton and phytoplankton.

Subunit	Definition	Importance
Sea cucumbers	Group of invertebrates that occur in the mainland and island coastal zones.	This is the most important group for local population revenues

11.1.8. HUMAN SETTLEMENTS

Subunit	Definition	Importance
Economic infrastructures (roads and bridges)	These are infrastructures that allow the movement of people and goods ensuring mobility throughout the QNP.	The vulnerability of these infrastructures is of great importance especially in the years of great irregularity of rainfall and heavy rains, because the damage is visible and economically relevant.
Tourism	With a great economic projection in the coastal zone, these are areas along the beach, which are under conservation rules when located within the QNP. It is one of the main factors of development of coastal populations.	The proximity of this settlements to the coast turns these settlements more vulnerable to climatic events, both in the rainy season and in the dry season, and is the main reason of its importance.
Forest and fauna resources exploitation	The exploitation of forest and wildlife resources, consists on the production and sale of coal, on the firewood cutting, on selling for construction materials, and on the hunting and sale of meat. In QNP these activities are illegal.	Forest degradation and deforestation of large areas are the main vulnerability factors, leading to situations of great impoverishment of soils, erosion, etc., which should be assessed.
Key-social infrastructures (schools and health centres)	These infrastructures allow the function of health and education services.	No importance defined by the group
Human settlements prone to droughts	Settlements (villages or agglomerations), mainly located in coastal areas, prone to the effect of the lack of rain	No importance defined by the group
Human settlements prone to flood	Settlements (villages or agglomerations), mainly located in coastal areas prone to the effect of large erosions and without any natural or artificial protection.	The effect on local economies and the safety of populations is important and justifies to assess the vulnerability to floods.
Human settlements prone to sea level rise	Settlements (villages or agglomerations), mainly located in coastal areas prone to the effect of large erosions and without any natural or artificial protection	The effect on local economies and the safety of populations is important and justifies to assess the vulnerability to sea level rise.
Human settlements prone to cyclones	Settlements (villages or agglomerations), located in low areas, without sanitation, along rivers and prone to flooding in the rainy season and when there are heavy rains.	The effect on local economies and the safety of populations is important and justifies to assess the vulnerability to cyclones.

Subunit	Definition	Importance
Sanitation	Sanitation in the coastal area and in the islands is almost non-existent if we consider the rules of hygiene and environmental protection. Its definition is due to the existence of latrines and to the access to fresh water.	The sanitation in the coastal area doesn't obey to the basic principles of health, hygiene and environment. Cultural habits lead people to use the beaches as toilets, which threats the environment and coastal ecosystems. Its vulnerability should take this principles into consideration.

11.2. ANNEX II – REPORT OF TECHNICAL MEETING "AVALIAÇÃO DA VULNERABILIDADE (VA) NAS QUIRIMBAS"

11.3. ANNEX III – REPORT OF WORKSHOP MEETING "SEMINÁRIO DE AVALIAÇÃO DA VULNERABILIDADE CLIMÁTICA"

11.4. ANNEX IV – DETAILED RESILIENCE SCORES FOR ALL THE INITIAL SUB-UNITS

NA – Not applicable/ Not available

11.4.1. COASTAL FOREST AND MIOMBO WOODLAND

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity (vegetation & recharge)	Genetic diversity/ biodiversity	Average
Forest around villages outside the Park	2	4	2	4	5	4	3,5
Total protection zones - QNP	4	5	3	5	5	5	4,5
Miombo sacred forests	3	5	3	5	5	5	4,3
Use and Community development zones - QNP	3	4	2	4	5	4	3,7
Buffer zone - QNP	3	4	2	4	5	4	3,7
Coastal forest areas of multiple use	2	4	NA	3	3	5	3,4
Coastal and Miombo forest for multiple use outside QNP	3	4	NA	NA	3	4	3,5

11.4.2. MANGROVE FOREST & DUNES

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity	Genetic diversity/ biodiversity	Average
Estuarine mangrove	3	3	3	2	4	3	3,0
Coastal mangrove	3	2	4	3	3	2	2,8
Low islands mangrove	3	3	3	1	3	2	2,5
Coastal dunes with invasive trees and autochthonous flora	4	3	3	3	3	3	3,2

11.4.3. CORAL REEFS AND SEAGRASS

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity (vegetation & recharge)	Genetic diversity/ biodiversity	Average
Exposed reefs under fishing pressure	2	2	3	1	2	3	2,2
Sheltered reefs without fishing pressure	3	3	2	1	3	4	2,7
Exposed coral reefs without fishing pressure	4	2	3	1	3	4	2,8
Sheltered coral reefs with fishing pressure	2	3	2	1	2	3	2,2
Seagrass of the deep waters	4	4	5	2	4	4	3,8
Seagrass of the shallow waters	2	3	2	2	4	3	2,7

11.4.4. SPECIES OF HIGH CONSERVATION VALUE

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity	Genetic diversity/ biodiversity	Average
Elephant	2	5	4	4	2	2	3,2
Lion, Leopard	2	2	3	2	4	4	2,8
African wild dog	1	1	2	1	4	4	2,2
Crocodiles/ Hippopotamus	1	1	1	3	3	3	2,0
Dolphin	5	5	5	3	2	4	4,0
Sea turtle	3	4	3	3	4	4	3,5
Dugong	1	4	3	3	2	3	2,7
Whales	5	5	5	4	2	4	4,2
Shark	3	5	4	4	2	4	3,7
Southern ground hornbill	3	1	4	3	2	3	2,7
Kudu	2	2	3	3	2	2	2,3

11.4.5. AGRICULTURAL AND LIVESTOCK SYSTEMS

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity	Genetic diversity/ biodiversity	Average
Livestock breeding (cattle)	4	2	4	4	4	1	3,2
Livestock breeding (small ruminants)	4	2	4	4	4	1	3,2
Livestock breeding (Poultry)	5	4	5	5	5	1	4,2
Fruit (mango, cashew, coconut, maçanica)	4	3	NA	1	3	4	3,0
Maize	4	1	NA	4	1	4	2,8
Cassava	4	3	NA	4	1	3	3,0
Mapira	4	3	NA	4	1	4	3,2
Vegetables	3	2	NA	2	2	5	2,8
Rice	4	2	NA	4	1	4	3,0
Sesame	4	1	NA	1	1	4	2,2
Beans	4	2	NA	4	1	4	3,0

11.4.6. FRESHWATER

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity (vegetation & recharge)	Genetic diversity/ biodiversity	Average
Coastal basin	5	5	NA	2	2	NA	3,5
Seasonal Rivers (Messalo, Muaguide, Muagamula)	5	5	3	2	3	1	3,2
Montepuez	2	5	3	2	3	1	2,7
Lagoons (Bilibiza)	2	5	3	5	5	4	4,0
Wells (coastal)	1	2	NA	NA	3	NA	2,0
Wells (inland)	1	2	NA	NA	5	NA	2,7
Swamps (Kagavero)	5	4	4	3	3	4	3,8
Groundwater	5	3	NA	5	4	NA	4,3

11.4.7. FISHERIES

Sub-unit	Connectivity	Natural variability	Refugia	Functional redundancy	Natural Productivity (vegetation & recharge)	Genetic diversity/ biodiversity	Average
Shrimp	3	2	3	2	3	2	2,5
Lobster	3	2	3	3	4	2	2,8
Reef fish	3	2	3	3	3	4	3,0
Freshwater fish (Tilapia, cat-fish)	2	2	2	3	3	3	2,5
Marine invertebrates (Oysters and "Pinas")	3	3	3	2	2	2	2,5
Cephalopods (octopus and squid)	3	3	3	3	3	2	2,8
Crab	4	3	3	2	3	2	2,8
Pelagic fish	3	3	4	4	3	4	3,5

11.4.8. HUMAN SETTLEMENTS

Sub-unit	Accessibility	Natural variability (idea and construction)	Natural variability (operation and maintenance)	Functional redundancy	Refugia	Average
Economic infrastructures (roads and bridges)	3	2	2	NA	NA	2,3
Tourism	3	2	2	NA	NA	2,3
Key-social infrastructures (schools and health centres)	2	2	2	NA	NA	2,0
Human settlements prone to droughts	5	1	1	1	2	2,0
Human settlements prone to flood	3	1	2	1	2	1,8
Human settlements prone to sea level rise	2	1	2	1	2	1,6
Human settlements prone to cyclones	2	1	2	1	2	1,6
Sanitation	2	1	3	1	1	1,6

11.5. ANNEX V: DETAILED SCORES BY UNIT AND SUB-UNIT.

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

11.5.1. COASTAL FOREST AND MIOMBO WOODLAND

Subunit	Resilience (R)	Sensitivity (5-R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg.		
Buffer zone - QNP	3,67	**1,33**	The increasing number of people inside the park and in its surroundings will lead to an expansion of agriculture and housing areas, which will means more deforestation and fragmentation of habitats	3	2	2	***4***	**2,33**	***2,11***	***2,32***
Use and Community development zones - QNP	3,67	**1,33**	The increasing number of people inside the park and in its surroundings will lead to an expansion of agriculture and housing areas, which will means more deforestation and fragmentation of habitats	4	3	3	***6***	**3,33**	***2,78***	***3,33***
Buffer zone - QNP	3,67	**1,33**	The agriculture mechanization trend, due to the creation of the Agriculture Mechanization Centres in the Park districts, will lead to destruction of the miombo root system, affecting negatively its regeneration ability	2	2	2	***4***	**2,00**	***1,78***	***1,78***
Use and Community development zones - QNP	3,67	**1,33**	The agriculture mechanization trend, due to the creation of the Agriculture Mechanization Centres in the Park districts, will lead to destruction of the miombo root system, affecting negatively its regeneration ability	3	3	3	***6***	**3,00**	***2,44***	***2,44***
Forest around villages outside the Park	3,50	**1,50**	The increase of wood fuel's demand will lead to more degradation, deforestation and, consequently, habitat fragmentation	5	3	4	***7***	**4,00**	***3,33***	***3,00***
Use and Community development zones - QNP	3,67	**1,33**	The increase of wood fuel's demand will lead to more degradation, deforestation and, consequently, habitat fragmentations	5	3	4	***7***	**4,00**	***3,28***	***2,95***
Buffer zone - QNP	3,67	**1,33**	The increase of wood fuel's demand will lead to more degradation, deforestation and, consequently, habitat	3	2	3	***5***	**2,67**	***2,28***	***2,05***

Subunit	Resilience (R)	Sensitivity (5-R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg.		
			fragmentation							
Total protection zones - QNP	4,50	**0,50**	Increase of illegal logging inside the Park, leading to more degradation and deforestation	4	4	4	***8***	**4,00**	***2,83***	***2,83***
Coastal forest areas of multiple use	3,40	**1,60**	Increase of illegal logging inside the Park, leading to more degradation and deforestation- Coastal multiple use.	3	3	3	***6***	**3,00**	***2,53***	***2,53***
Forest around villages outside the Park	3,50	**1,50**	The increase of illegal artisanal mining inside the Park will contribute to more deforestation and degradation of miombo forest- QNP villages.	4	2	3	***5***	**3,00**	***2,67***	***2,67***
Total protection zones - QNP	4,50	**0,50**	The increase of illegal artisanal mining inside the Park will contribute to more deforestation and degradation of miombo forest- QNP.	3	2	2	***4***	**2,33**	***1,83***	***1,83***
Total protection zones - QNP	4,50	**0,50**	Infrastructure construction (roads, bridges, pipelines) implicates deforestation, which will contribute to habitat fragmentation	5	3	3	***6***	**3,67**	***2,83***	***2,83***
Total protection zones - QNP	4,50	**0,50**	The increase of human settlements, due to the infrastructuring (roads and bridges) will increase deforestation and, consequently, habitat fragmentation	2	2	3	***5***	**2,33**	***1,67***	***1,67***
Forest around villages outside the Park	3,50	**1,50**	The growth of farming areas will lead to deforestation and degradation of forest, which will increase the shortage of goods and services for local communities	4	4	3	***7***	**3,67**	***3,00***	***3,30***
Use and Community development zones - QNP	3,67	**1,33**	The growth of farming areas will lead to deforestation and degradation of forest, which will increase the shortage of goods and services for local communities	4	4	3	***7***	**3,67**	***2,94***	***3,24***
Buffer zone - QNP	3,67	**1,33**	The increase of dry days will anticipate and extend the burning's season, affecting the forest's regeneration ability	3	3	4	***7***	**3,33**	***2,61***	***2,87***
Use and Community development zones - QNP	3,67	**1,33**	The increase of dry days will anticipate and extend the burning's season, affecting the forest's regeneration ability	4	4	4	***8***	**4,00**	***3,11***	***3,73***
Coastal forest areas of multiple use	3,40	**1,60**	The increase of dry days will anticipate and extend the burning's season, affecting the forest's regeneration ability	4	3	4	***7***	**3,67**	***3,03***	***3,34***
Buffer zone - QNP	3,67	**1,33**	The occurrence of high temperature average events (maximum and minimum) will lead to a faster dry of the grass, creating conditions for strong fires, which will have consequences in	3	3	3	***6***	**3,00**	***2,44***	***2,69***

Subunit	Resilience (R)	Sensitivity (5-R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg.		
			regeneration							
Coastal forest areas of multiple use	3,40	**1,60**	The occurrence of high temperature average events (maximum and minimum) will lead to a faster dry of the grass, creating conditions for strong fires, which will have consequences in regeneration	4	4	3	***7***	**3,67**	***3,03***	***3,64***
Forest around villages outside the Park	3,50	**1,50**	The occurrence of the dry season and high temperature events will affect agriculture production and increase the local community's dependence on forest resources. This will increase the pressure and the levels of forest resources exploitation	4	3	5	***8***	**4,00**	***3,17***	***3,80***
Use and Community development zones - QNP	3,67	**1,33**	The occurrence of the dry season and high temperature events will affect agriculture production and increase the local communities' dependence on forest resources. This will increase the pressure and the levels of forest resources exploitation	4	3	5	***8***	**4,00**	***3,11***	***3,73***
Buffer zone - QNP	3,67	**1,33**	The occurrence of the dry season and high temperature events will affect agriculture production and increase the local communities' dependence on forest resources. This will increase the pressure and the levels of forest resources exploitation	3	2	3	***5***	**2,67**	***2,28***	***2,73***
Coastal forest areas of multiple use	3,40	**1,60**	The occurrence of the dry season and high temperature events will affect agriculture production and increase the local communities' dependence on forest resources. This will increase the pressure and the levels of forest resources exploitation	4	3	4	***7***	**3,67**	***3,03***	***3,64***

11.5.2. MANGROVE FOREST & DUNES

Sub-unit	Resilience (R)	Sensitivity (5- R)	Impact/Exposition							Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg			
Low islands mangrove (salty water and tidal movements dependent)	2,50	**2,50**	Tourism development, along with the construction of tourist infrastructures using local materials (mangrove stakes) increases pressure on the mangroves and leads to a structure modification and to cover reduction of the forest	3	1	2	***3***	**2,00**		***2,33***	***2,10***
Coastal mangrove (salty water and tidal movements dependent)	2,83	**2,17**	The markets' demand and the lack of subsistence options increases the demand for mangrove's timber products (coal, firewood, wood for construction) leading to a mangrove's area reduction	3	1	4	***5***	**2,67**		***2,56***	***2,56***
Coastal mangrove (salty water and tidal movements dependent)	2,83	**2,17**	Construction and seasonal fishing centres (migratory fishermen) increase the pressure on the mangrove to collect stakes for houses and fishing gears' construction, reducing the coastal mangrove area	3	2	2	***4***	**2,33**		***2,39***	***2,15***
Coastal dunes with invasive trees and autochthonous flora	3,17	**1,83**	Population increase and the opening of new agriculture areas on the coastal dunes destruct the coastal geomorphology	3	3	2	***5***	**2,67**		***2,44***	***2,20***
Estuarine mangrove (fresh water dependent)	3,00	**2,00**	Mining concessions for construction's stone extraction in the buffer area of the Park contribute to river's silting, changing the flow and quality of water and nutrients.	3	3	2	***5***	**2,67**		***2,50***	***2,50***
Coastal mangrove (salty water and tidal movements dependent)	2,83	**2,17**	Frequency increase of strong winds and waves, leads to transport of sediments, causing erosion on the coastal areas and changing the structure of the mangrove forest, reducing the cover area	3	1	3	***4***	**2,33**		***2,39***	***2,63***
Low islands mangrove (salty water and tidal movements dependent)	2,50	**2,50**	Events of strong waves combined with storms lead to deposition of sediments in the coastal zone, causing overwhelm of mangrove areas and compromising the potential for natural regeneration.	3	2	3	***5***	**2,67**		***2,67***	***2,93***

11.5.3. CORAL REEFS AND SEAGRASS

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposition: Impact	I	E	M	E+M	Avg	Vulnerability (current)	Vulnerability (projected)
Seagrass of the shallow waters	2,67	**2,33**	The increase of artisanal trawling will degrade marine habitats- Seagrass of the shallow waters	4	4	5	0	4,33	***2,11***	***2,53***
Sheltered coral reefs with fishing pressure	2,17	**2,83**	The increase of artisanal trawling will degrade marine habitats- Sheltered coral reefs with fishing pressure	2	2	5	***7***	3,00	***2,78***	***3,33***
Sheltered reefs without fishing pressure	2,67	**2,33**	Tourism activities in the coral areas (dive, anchorage, motorized) will degrade marine habitats- Sheltered reefs without fishing pressure in Ibo, Matemo, Quilalea and Goludo	2	3	2	***5***	2,33	***2,28***	***2,28***
Sheltered coral reefs with fishing pressure	2,17	**2,83**	Tourism activities in the coral areas (dive, anchorage, motorized) will degrade marine habitats- Sheltered coral reefs with fishing pressure in Ibo, Matemo, Quilalea and Goludo	4	3	4	***7***	3,67	***3,44***	***3,44***
Sheltered coral reefs with fishing pressure	2,17	**2,83**	Coral exploitation for handicraft reduces coral reef coverage- Sheltered coral reefs with fishing pressure	2	1	1	***2***	1,33	***1,94***	***2,14***
Sheltered coral reefs with fishing pressure	2,17	**2,83**	Marine pollution caused by human development puts at risk the species' survival- Sheltered coral reefs with fishing pressure	2	0	0	***0***	2,00	***1,61***	***1,61***
Sheltered reefs without fishing pressure	2,67	**2,33**	Marine pollution caused by human development puts at risk the species' survival- Sheltered reefs without fishing pressure	2	0	0	***0***	2,00	***1,44***	***1,44***
Seagrass of the shallow waters	2,67	**2,33**	Coastal habitat modification creates erosion that will affect seagrass and coral reefs- Seagrass of the shallow waters, due to Ibo infrastructures construction	3	2	0	***2***	2,50	***2,11***	***2,32***
Sheltered coral reefs with fishing pressure	2,17	**2,83**	Coastal habitat modification creates erosion that will affect seagrass and coral reefs- Sheltered coral reefs with fishing pressure, due to Ibo infrastructures construction	2	3	0	***3***	2,50	***2,11***	***2,32***
Sheltered reefs without fishing pressure	2,67	**2,33**	Coastal habitat modification creates erosion that will affect seagrass and coral reefs- Sheltered reefs without fishing pressure, due to Ibo infrastructures construction	2	3	0	***3***	2,50	***1,94***	***2,14***
Seagrass of the deep waters	3,83	**1,17**	Marine pollution caused by human development puts at risk the species' survival- Seagrass of the deep waters	1	0	0	***0***	1,00	***0,72***	***0,72***
Seagrass of the shallow waters	2,67	**2,33**	Marine pollution caused by human development puts at risk the species' survival- Seagrass of the shallow waters	2	0	0	***0***	2,00	***1,44***	***1,44***

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposition: Impact	I	E	M	E+M	Avg	Vulnerability (current)	Vulnerability (projected)
Exposed reefs under fishing pressure	2,17	**2,83**	Sea water high temperature events will cause bleaching and death of coral reefs- Exposed reefs under fishing pressure	3	2	2	***4***	2,33	***2,61***	***2,87***
Exposed coral reefs without fishing pressure	2,83	**2,17**	Sea water high temperature events will cause bleaching and death of coral reefs- Exposed coral reefs without fishing pressure	3	2	2	***4***	2,33	***2,39***	***2,63***
Sheltered reefs without fishing pressure	2,67	**2,33**	Sea water high temperature events will cause bleaching and death of coral reefs- Sheltered reefs without fishing pressure	4	3	3	***6***	3,33	***3,11***	***3,42***
Sheltered coral reefs with fishing pressure	2,17	**2,83**	Sea water high temperature events will cause bleaching and death of coral reefs- Sheltered coral reefs with fishing pressure	4	3	3	***6***	3,33	***3,28***	***3,61***
Seagrass of the shallow waters	2,67	**2,33**	Heavy rains will cause sedimentation of seagrass carpets and corals- Seagrass of the shallow waters	4	3	3	***6***	3,33	***3,11***	***3,42***
Sheltered reefs without fishing pressure	2,67	**2,33**	Heavy rains will cause sedimentation of seagrass carpets and corals- Sheltered reefs without fishing pressure	3	3	4	***7***	3,33	***2,94***	***3,24***
Sheltered coral reefs with fishing pressure	2,17	**2,83**	Heavy rains will cause sedimentation of seagrass carpets and corals- Sheltered coral reefs with fishing pressure	3	3	4	***7***	3,33	***3,11***	***3,42***
Exposed reefs under fishing pressure	2,17	**2,83**	Acidification will reduce genetic biodiversity until the risk of extinction of the species- Exposed reefs under fishing pressure	1	5	5	***10***	2,67	***2,94***	***3,24***
Exposed coral reefs without fishing pressure	2,83	**2,17**	Acidification will reduce genetic biodiversity until the risk of extinction of the species- Exposed coral reefs without fishing pressure	1	5	5	***10***	2,67	***2,72***	***2,99***
Sheltered reefs without fishing pressure	2,67	**2,33**	Acidification will reduce genetic biodiversity until the risk of extinction of the species- Sheltered reefs without fishing pressure	1	5	5	***10***	2,67	***2,78***	***3,06***
Sheltered reefs without fishing pressure	2,67	**2,33**	Acidification will reduce genetic biodiversity until the risk of extinction of the species- Sheltered reefs without fishing pressure	1	5	5	***10***	2,67	***2,78***	***3,06***
Exposed reefs under fishing pressure	2,17	**2,83**	Strong winds and cyclones will cause damage into the hard and soft coral- Exposed reefs under fishing pressure	1	2	1	***3***	1,33	***1,78***	***1,96***
Exposed coral reefs without fishing	2,83	**2,17**	Strong winds and cyclones will cause damage into the hard and soft corals- Exposed coral reefs without fishing pressure	1	2	1	***3***	1,33	***1,56***	***1,71***

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposition						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
pressure										

11.5.4. SPECIES OF HIGH CONSERVATION VALUE

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Elephant	3,17	**1,83**	The construction of the road Muepane/Mocimba through Mucojo will disturb the animal's habitat, causing stress and the occurrence of settlements inside the park- Elephant	4	3	3	***6***	**3,33**	***2,94***	***2,94***
Lion/ Leopard	2,83	**2,17**	The construction of the road Muepane/Mocimba through Mucojo will disturb the animal's habitat, causing stress and the occurrence of settlements inside the park- Lion/ Leopard	2	3	3	***6***	**2,67**	***2,39***	***2,39***
African wild dog	2,17	**2,83**	The construction of the road Muepane/Mocimba through Mucojo will disturb the animal's habitat, causing stress and the occurrence of settlements inside the park- African wild dog	4	4	4	***8***	**4,00**	***3,61***	***3,61***
Kudu	2,33	**2,67**	The construction of the road Muepane/Mocimba through Mucojo will disturb the animal's habitat, causing stress and the occurrence of settlements inside the park- Kudu	2	1	3	***4***	**2,00**	***2,22***	***2,22***
Southern ground hornbill	2,67	**2,33**	The construction of the road Muepane/Mocimba through Mucojo will disturb the animal's habitat, causing stress and the occurrence of settlements inside the park- Southern ground hornbill	1	2	3	***5***	**2,00**	***1,94***	***1,94***
Elephant	3,17	**1,83**	Limestone extraction inside the park (3 areas in Macomia Buffer zone) will disturb the normal course of species, due to habitat destruction and obstruction of the elephant corridor in the two protection blocs. The noise of the machines will cause stress to the animal	3	2	4	***6***	**3,00**	***2,61***	***2,61***
Lion/ Leopard	2,83	**2,17**	Limestone extraction inside the park will disturb the normal course of species- Lion/ Leopard	2	2	3	***5***	**2,33**	***2,22***	***2,22***
Kudu	2,33	**2,67**	Limestone extraction inside the park will disturb the normal course of species- Kudu	1	2	3	***5***	**2,00**	***2,06***	***2,06***
Whales	4,17	**0,83**	The big number of tourist resorts will contribute to an increase of motor vehicles, which could contribute to the marine species' stress	3	2	3	***5***	**2,67**	***2,11***	***2,11***
Elephant	3,17	**1,83**	The drought will contribute to reduce the grazing and watering areas and to increase the death of animals- Elephant	2	2	3	***5***	**2,33**	***2,11***	***2,32***
Lion/ Leopard	2,83	**2,17**	The drought will contribute to reduce the grazing and watering areas and to increase the death of animals- Lion/ Leopard	2	2	3	***5***	**2,33**	***2,22***	***2,44***
African wild dog	2,17	**2,83**	The drought will contribute to reduce the grazing and watering areas and	1	2	3	***5***	**2,00**	***2,11***	***2,53***

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
			to increase the death of animals- African wild dog							
Kudu	2,33	**2,67**	The drought will contribute to reduce the grazing and watering areas and to increase the death of animals- Kudu	4	3	3	***6***	**3,33**	***3,22***	***3,54***
Crocodiles/ Hippopotamus	2,00	**3,00**	The drought will contribute to habitat degradation of rivers, swamps and water sources. It will also lead to the death of animals- Crocodiles/Hippopotamus	4	3	3	***6***	**3,33**	***4,00***	***4,80***
Lion/ Leopard	2,83	**2,17**	The rain can affect and destroy sensible areas for reproduction and cause habitat degradation by erosion. It can also cause death of animals- Lion/ Leopard	3	3	3	***6***	**3,00**	***2,72***	***3,27***
African wild dog	2,17	**2,83**	The rain can affect and destroy sensible areas for reproduction and cause habitat degradation by erosion. It can also cause death of animals- African wild dog	4	4	3	***7***	**3,67**	***3,44***	***4,13***
Kudu	2,33	**2,67**	The rain can affect and destroy sensible areas for reproduction and cause habitat degradation by erosion. It can also cause death of animals- Kudu	2	3	3	***6***	**2,67**	***2,56***	***3,07***
Dolphin	4,00	**1,00**	High sea temperatures will cause death of corals, affecting marine ecology (feeding)- Dolphin	2	3	2	***5***	**2,33**	***1,83***	***2,20***
Shark	3,67	**1,33**	High sea temperatures will cause death of corals, affecting marine ecology (feeding)- Shark	3	3	2	***5***	**2,67**	***2,28***	***2,73***
Sea turtle	3,50	**1,50**	Cyclones increase the sea level rising, causing destruction of turtle's nesting areas	4	4	5	***9***	**4,33**	***3,33***	***4,00***
Elephant	3,17	**1,83**	Human settlements and agricultural activities- Elephant	4	4	4	***8***	**4,00**	***3,28***	***3,61***
Lion/ Leopard	2,83	**2,17**	Human settlements and agricultural activities- Lion/ Leopard	4	4	4	***8***	**4,00**	***3,39***	***3,73***
African wild dog	2,17	**2,83**	Human settlements and agricultural activities- African wild dog	5	4	4	***8***	**4,33**	***3,94***	***4,34***
Crocodiles/ Hippopotamus	2,00	**3,00**	Human settlements and agricultural activities- Crocodiles/Hippopotamus	3	2	4	***6***	**3,00**	***3,67***	***4,03***
Kudu	2,33	**2,67**	Human settlements and agricultural activities- Kudu	3	3	4	***7***	**3,33**	***3,06***	***3,36***
Elephant	3,17	**1,83**	Poaching- Elephant	5	5	5	***10***	**5,00**	***3,94***	***3,94***
Lion/ Leopard	2,83	**2,17**	Poaching- Lion/ Leopard	3	2	5	***7***	**3,33**	***2,89***	***3,18***
Kudu	2,33	**2,67**	Poaching- Kudu	3	2	5	***7***	**3,33**	***3,06***	***3,67***
Shark	3,67	**1,33**	Shark illegal fishing, to collect fins, causes decline of population	4	3	4	***7***	**3,67**	***2,94***	***2,94***

11.5.5. AGRICULTURAL AND LIVESTOCK SYSTEMS

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposition						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Fruit (mango, cashew, coconut, "maçanica")	3,00	**2,00**	The Fruit's productivity will decrease because a great number of trees will be cut, over the coastal road route Muepane-Palma and the future pipeline North/South	4	2	5	**7**	**3,67**	***3,17***	***3,17***
Maize	2,80	**2,20**	The mine concessions to limestone extraction, of rock for construction or precious stones, will affect the access to agriculture land by the communities. Maize	4	3	3	**6**	**3,33**	***3,07***	***3,37***
Cassava	3,00	**2,00**	The mine concessions to limestone extraction, of rock for construction or precious stones, will affect the access to agriculture land by the communities. Cassava	4	3	3	**6**	**3,33**	***3,00***	***3,30***
Vegetables	2,80	**2,20**	The pressure over irrigated agriculture lands, and not only, will increase substantially due to the possibility of new tourism resorts and the demand for specific products.	4	2	2	**4**	**2,67**	***2,73***	***3,01***
Livestock breeding (small ruminants)	3,17	**1,83**	The transformation of potential agriculture and livestock areas into residential ones, due to increased internal and external migration will affect the production levels of food crops, with potential for aggravation of the already existing hunger spots. Livestock breeding	4	3	2	**5**	**3,00**	***2,78***	***3,06***
Maize	2,80	**2,20**	The transformation of potential agriculture and livestock areas into residential ones, due to increased internal and external migration will affect the production levels of food crops, with potential for aggravation of the already existing hunger spots. Maize	4	3	2	**5**	**3,00**	***2,90***	***3,19***
Maize	2,80	**2,20**	The great dry periods cause problems to water supply for domestic animals, and also for the food crops, decreasing the production levels and the incomes. On the other hand, it increases the conflicts with wildlife due to foraging in the food gardens.	3	3	2	**5**	**2,67**	***2,57***	***3,08***
Vegetables	2,80	**2,20**	Periods with heat waves, either in the rain or in the dry season, burn the food crops, especially in the beginning of its grow season. This makes it necessary to resowing and/or replant. It also decreases river's caudal as well as the water quality of lagoons, fountains, wells, etc., usually used for irrigation.	2	2	4	**6**	**2,67**	***2,40***	***2,88***

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposition						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Cassava	3,00	**2,00**	The rain excess in a short period of time causes floods in susceptible areas and cause the rot of plants and tubers (Cassava, sweet potato, etc.)	2	2	4	**6**	**2,67**	***2,33***	***2,80***
Fruit (mango, cashew, coconut, "maçanica")	3,00	**2,00**	Strong winds with torrential rain cause erosion, drag seeds, plants and rip out some trees.	2	2	4	**6**	**2,67**	***2,33***	***2,57***
Fruit (mango, cashew, coconut, "maçanica")	3,00	**2,00**	Heavy thunderstorms in the wet season have been very dangerous, because besides burning large trees, they also burn houses and sometimes people die.	2	3	4	**7**	**3,00**	***2,50***	***2,50***

11.5.6. FRESHWATER

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Coastal basin	3,50	**1,50**	Basin's water contamination by faeces in the open and inadequate sanitation systems.	3	2	4	**6**	**3,00**	***2,50***	***3,00***
Seasonal Rivers (Messalo, Muaguide, Muagamula)	3,17	**1,83**	Water pollution due to mining activities, especially the out of control ones in Meluco (Muaguide river) and Nairoto (Messalo river).	2	1	5	**6**	**2,67**	***2,28***	***2,28***
Montepuez	2,67	**2,33**	Water pollution due to mining activities, especially the out of control ones in Meluco and Sitate village (Montepuez river).	2	2	5	**7**	**3,00**	***2,61***	***2,61***
Lagoons (Bilibiza)	4,00	**1,00**	Water pollution through the use of harmful fishing gears (mosquito nets and chemical products) - Lagoons	4	5	3	**8**	**4,00**	***3,00***	***3,00***
Wells (coastal)	2,00	**3,00**	Water contamination of wells due to inadequate sanitation systems - Wells (coastal)	4	5	3	**8**	**4,00**	***3,67***	***4,40***
Wells (inland)	2,67	**2,33**	Water contamination of wells due to inadequate sanitation systems - Wells (inland)	4	5	3	**8**	**4,00**	***3,44***	***4,13***
Swamps (Kagavero)	3,83	**1,17**	Water pollution through the use of harmful fishing gears (mosquito nets and chemical products) - Swamps	4	5	3	**8**	**4,00**	***3,06***	***3,06***
Groundwater	4,25	**0,75**	Contamination due to inadequate sanitation systems - Groundwater	3	5	3	**8**	**3,67**	***2,58***	***2,58***
Coastal basin	3,50	**1,50**	The extended droughts currently induce coastal basin's drought, causing crop's wither - Coastal basin	4	5	4	**9**	**4,33**	***3,33***	***4,00***
Seasonal Rivers (Messalo, Muaguide, Muagamula)	3,17	**1,83**	Extreme events (droughts and floods) and the disorganized land use cause erosion and inability for water storage by the rivers - Seasonal Rivers	3	3	4	**7**	**3,33**	***2,78***	***3,33***
Montepuez	2,67	**2,33**	Extreme events (droughts and floods) and the disorganized land use cause erosion and inability for water storage by the rivers - Montepuez	3	3	4	**7**	**3,33**	***2,94***	***3,53***
Lagoons (Bilibiza)	4,00	**1,00**	Extended droughts cause a decrease in water availability, making communities to open traditional wells in the lagoon's banks.	4	3	4	**7**	**3,67**	***2,83***	***3,40***
Wells (coastal)	2,00	**3,00**	Due to the widespread droughts, the wells also go dry and	4	4	4	**8**	**4,00**	***3,67***	***4,40***

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
			there is water shortage - Wells (coastal)							
Wells (inland)	2,67	**2,33**	Due to the widespread droughts, the wells also go dry and there is water shortage - Wells (inland)	4	5	4	**9**	**4,33**	***3,61***	***4,33***
Swamps (Kagavero)	3,83	**1,17**	Extended droughts cause a decrease in water availability, making communities to open traditional wells in the rivers' beds and banks, which brings erosion and deforestation - Swamps.	3	2	4	**6**	**3,00**	***2,39***	***2,87***
Groundwater	4,25	**0,75**	Extended droughts induce low recharge ability in aquifers.	4	4	4	**8**	**4,00**	***2,92***	***3,50***
Wells (coastal)	2,00	**3,00**	Well's water contamination by sea water, due to the sea level rise.	3	2	4	**6**	**3,00**	***3,00***	***3,60***

11.5.7. FISHERIES

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Shrimp	2,50	**2,50**	Sea high temperature events can affect the recruitment rate of shrimp and the number of diseases, which may lead to the population's decline.	2	1	4	***5***	**2,33**	***2,33***	***2,80***
Shrimp	2,50	**2,50**	The sea acidification events can hamper the shrimp's carapace formation and affect its reproduction and growth.	3	1	3	***4***	**2,33**	***2,50***	***2,75***
Shrimp	2,50	**2,50**	Changes in precipitation patterns may affect shrimp's spawning, because its spawning behaviour depends on the freshwater that flows to the estuary areas.	3	1	4	***5***	**2,67**	***2,67***	***2,93***
Shrimp	2,50	**2,50**	Because of the development of the QNP coastal area, mainly due to the expansion of Cabo Delgado's hotel industry and the increasing demand for fish, the pressure on the fishing will increase, causing a diminution in the shrimp population.	4	3	4	***7***	**3,67**	***3,33***	***3,33***
Lobster	2,83	**2,17**	Sea high temperature events can affect the reproduction and habitat of the lobster, which may lead to the population's decline.	1	1	4	***5***	**2,00**	***1,89***	***2,08***
Lobster	2,83	**2,17**	The road, electricity and hotel networks increase, along with the high commercial value of lobster, enhances the fishing pressure, which may lead to this population's decline.	2	3	3	***6***	**2,67**	***2,39***	***2,39***
Reef fish	3,00	**2,00**	Sea high temperature events creates bleaching and death of coral, which, consequently, lead to reef fish's habitat, making them more vulnerable.	4	3	2	***5***	**3,00**	***2,83***	***3,40***
Reef fish	3,00	**2,00**	The increasing number of fishermen leads to an increasing commercial and subsistence fishing pressure which, in turn, leads to a change of the reef ecosystem and to the reduction of reef fish populations.	4	3	4	***7***	**3,67**	***3,17***	***3,17***
Freshwater fish (Tilapia, cat-fish)	2,50	**2,50**	Extended droughts cause fragmentation and decrease of river flows. Lakes and small lagoons can dry out, affecting fish habitat, which may cause a decrease in its populations and the loss of some species. Indirectly, extended droughts may take populations to intensify freshwater fishing, by lacking of further resources.	4	3	4	***7***	**3,67**	***3,33***	***4,00***
Freshwater fish	2,50	**2,50**	The increasing number of fishermen leads to an increasing	3	4	3	***7***	**3,33**	***3,00***	***3,00***

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
(Tilapia, cat-fish)			subsistence river's fishing pressure which, in turn, leads to a reduction of freshwater fish's populations.							
Marine invertebrates (Oysters and "Pinas")	2,50	**2,50**	The sea acidification events can hamper this animals shell's formation, making them more susceptible to predation, diseases or to die.	2	1	2	***3***	**1,67**	***2,00***	***2,20***
Marine invertebrates (Oysters and "Pinas")	2,50	**2,50**	The human population growth and the accessibility to collect this invertebrates, increases the pressure on this resources, which, in turn, leads to a marine invertebrates' population decrease.	4	4	4	***8***	**4,00**	***3,50***	***3,50***
Cephalopods (octopus and squid)	2,83	**2,17**	Sea high temperature events may lead to destruction of this specie's habitats (i.e. coral reefs) making them more vulnerable.	2	1	1	***2***	**1,33**	***1,72***	***2,07***
Cephalopods (octopus and squid)	2,83	**2,17**	The demand for this resource by national, international and tourism resorts market, increases the fishing pressure and may cause decline of this population.	3	1	3	***4***	**2,33**	***2,39***	***2,39***
Crab	2,83	**2,17**	Heavy rain events may cause sea salinity variation and, consequently, affect crab reproduction.	2	2	2	***4***	**2,00**	***2,06***	***2,26***
Crab	2,83	**2,17**	The demand for this resource by foreigners and tourism resorts, increases the fishing pressure, which may cause decline of this population.	4	3	3	***6***	**3,33**	***3,06***	***3,06***
Pelagic fish	3,50	**1,50**	Sea high temperature events can affect the development of fish larvae and, consequently, the survival of adults.	1	1	1	***2***	**1,00**	***1,17***	***1,28***
Pelagic fish	3,50	**1,50**	The artisanal and immigrant (from Tanzania and Nacal) fishermen increase, the motorizes gears and the use of harmful fishing gears (mosquito nets, "cocota", drags with very thin mesh size) causes pressure on that fishing resources, leading to its population decrease.	3	3	4	***7***	**3,33**	***2,67***	***2,67***
Shrimp	2,50	**2,50**	The increase and improvement of the road's network inside QNP and its surroundings will facilitate the flow of products to the markets and, potentially, increase the number o fishermen, with impact on the captures - Shrimp	3	2	3	***5***	**2,67**	***2,67***	***2,67***

Sub-unit	Resilience	Sensitivity (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Lobster	2,83	**2,17**	The increase and improvement of the road's network inside QNP and its surroundings will facilitate the flow of products to the markets and, potentially, increase the number o fishermen, with impact on the captures - Lobster	3	2	3	***5***	**2,67**	***2,56***	***2,56***
Pelagic fish	3,50	**1,50**	The increase and improvement of the road's network inside QNP and its surroundings will facilitate the flow of products to the markets and, potentially, increase the number o fishermen, with impact on the captures - Pelagic fish	2	1	3	***4***	**2,00**	***1,83***	***1,83***
Reef fish	3,00	**2,00**	The increase and improvement of the road's network inside QNP and its surroundings will facilitate the flow of products to the markets and, potentially, increase the number o fishermen, with impact on the captures - Reef fish	3	2	3	***5***	**2,67**	***2,50***	***2,50***
Crab	2,83	**2,17**	The increase and improvement of the road's network inside QNP and its surroundings will facilitate the flow of products to the markets and, potentially, increase the number o fishermen, with impact on the captures - Crab	3	2	3	***5***	**2,67**	***2,56***	***2,56***
Cephalopods (octopus and squid)	2,83	**2,17**	The increase and improvement of the road's network inside QNP and its surroundings will facilitate the flow of products to the markets and, potentially, increase the number of fishermen, with impact on the captures - Cephalopods	3	2	3	***5***	**2,67**	***2,56***	***2,56***

11.5.8. HUMAN SETTLEMENTS

Subunit	Resilience	Sensitivity (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Economic infrastructures (roads and bridges)	2,33	**2,67**	Automobile fleet's increase and the excess of load (in high tonnage trucks) contributes for road and bridges degradation.	1	3	2	***5***	**2,00**	***2,06***	***2,06***
Tourism	2,33	**2,67**	Transformation of tourism resorts in private cottages.	1	5	2	***7***	**2,67**	***2,39***	***2,39***
Key-social infrastructures (schools and health centres)	2,00	**3,00**	Overcrowd classrooms; Overcrowd Health centres; Decrease of teach and health care quality services.	1	3	2	***5***	**2,00**	***2,17***	***2,17***
Human settlements prone to droughts	2,00	**3,00**	Water, latrines and sewers shortage due to an undersized infrastructure for the amount of existing people	1	3	2	***5***	**2,00**	***2,17***	***2,60***
Human settlements prone to flood	1,80	**3,20**	Human resettlements due to the appearance of oil and gas projects (pipelines, roads and bridges) - Human settlements prone to flood	1	2	3	***5***	**2,00**	***2,23***	***2,23***
Human settlements prone to cyclones	1,60	**3,40**	Human resettlements due to the appearance of oil and gas projects (pipelines, roads and bridges) - Human settlements prone to cyclones	1	2	3	***5***	**2,00**	***2,30***	***2,30***
Human settlements prone to sea level rise	1,60	**3,40**	Human resettlements due to the appearance of oil and gas projects (pipelines, roads and bridges) - Human settlements prone to sea level rise	1	2	3	***5***	**2,00**	***2,30***	***2,30***
Sanitation	1,60	**3,40**	The more people get together in the same space, the greater is the emergence of diseases such as HIV/AIDS, cholera, malaria and diarrhea.	4	3	4	***7***	**3,67**	***3,63***	***4,36***
Economic infrastructures (roads and bridges)	2,33	**2,67**	Heavy rains destroy roads and bridges, compromising circulation of people and goods.	3	1	2	***3***	**2,00**	***2,39***	***2,87***
Tourism	2,33	**2,67**	Frequent cyclones cause destruction in Tourism infrastructures.	3	5	5	***10***	**4,33**	***3,56***	***4,27***
Key-social infrastructures (schools and health centres)	2,00	**3,00**	Tropical cyclones cause the destruction of schools, hospitals and health centres.	2	3	5	***8***	**3,33**	***3,00***	***3,60***

Subunit	Resilience	Sensitivity (5- R)	Impact/ Exposure						Vulnerability (current)	Vulnerability (projected)
			Impact	I	E	M	E+M	Avg		
Human settlements prone to droughts	2,00	**3,00**	High temperatures cause extended droughts.	3	3	3	***6***	**3,00**	***3,00***	***3,60***
Human settlements prone to flood	1,80	**3,20**	Heavy rains cause floods in residential areas that originate the destruction of houses and food gardens, and the loss of property.	5	3	5	***8***	**4,33**	***4,07***	***4,88***
Human settlements prone to sea level rise	1,60	**3,40**	Sea level rise events causes abandonment of populations, destruction of houses and also stops economic activities from happen or develop	4	5	2	***7***	**3,67**	***3,63***	***4,36***
Human settlements prone to cyclones	1,60	**3,40**	Tropical cyclones cause the destruction of houses and food gardens, and also the death of people and animals.	5	5	5	***10***	**5,00**	***4,47***	***5,36***
Sanitation	1,60	**3,40**	Floods cause the destruction of latrines, wells and water supply systems that, in turn, contribute to the emergence of diseases such as cholera, diarrhea and malaria. The temperature rise creates a propitious environment for the reproduction of the malaria caused mosquito.	4	3	4	***7***	**3,67**	***3,63***	***4,36***

11.6. ANNEX VI – SUMMARY OF AVERAGE CALCULATED VALUES PER SUB-UNIT

11.6.1. FOREST (MIOMBO & COASTAL)

Sub-unit	Average Vulnerability (projected)	Average Resilience	Average Impact Exposure
Coastal forest areas of multiple use	3,29	3,40	3,50
Use and Community development zones - QNP	3,24	3,67	3,67
Forest around villages outside the Park	3,19	3,50	3,67
Buffer zone - QNP	2,41	3,67	2,67
Total protection zones - QNP	2,29	4,50	3,08
Grand Total	**2,87**	**3,73**	**3,29**

11.6.2. MANGROVE FOREST & DUNES

Sub-unit	Average Vulnerabiliy (projected)	Average Resilience	Average Impact Exposure
Low islands mangrove (salty water and tidal movements dependent)	2,52	2,50	2,33
Estuarine mangrove (fresh water dependent)	2,50	3,00	2,67
Coastal mangrove (salty water and tidal movements dependent)	2,44	2,83	2,44
Coastal dunes with invasive trees and autochthonous flora	2,20	3,17	2,67
Grand Total	**2,44**	**2,81**	**2,48**

11.6.3. CORAL REEFS AND SEAGRASS

Sub-unit	Average vulnerability (projected)	Average resilience	Average Exposure to Impact
Sheltered coral reefs with fishing pressure	2,84	2,17	2,74
Exposed reefs under fishing pressure	2,69	2,17	2,11
Sheltered reefs without fishing pressure	2,66	2,67	2,69
Exposed coral reefs without fishing pressure	2,44	2,83	2,11
Seagrass of the shallow waters	2,43	2,67	3,04
Seagrass of the deep waters	0,72	3,83	1,00
Grand Total	**2,57**	**2,53**	**2,55**

11.6.4. SPECIES OF HIGH CONSERVATION VALUE

Sub-unit	Average of Vulnerability (projected)	Average of Resilience	Average Impact Exposure
Sea turtles	4,00	3,50	4,33
African wild dog	3,65	2,17	3,50
Crocodiles/ Hippopotamus	3,65	2,00	3,17
Elephant	3,09	3,17	3,53
Kudu	2,99	2,33	2,78
Lion/ Leopard	2,87	2,83	2,94
Shark	2,84	3,67	3,17
Dolphin	2,20	4,00	2,33
Whales	2,11	4,17	2,67
Southern ground hornbill	1,94	2,67	2,00
Grand Total	**3,05**	**2,80**	**3,10**

11.6.5. AGRICULTURAL AND LIVESTOCK SYSTEMS

Sub-unit	Average Vulnerability (projected)	Average Resilience	Average of Exposure to Impact
Maize	3,21	2,80	3,00
Livestock breeding (small ruminants)	3,06	3,17	3,00
Cassava	3,05	3,00	3,00
Vegetables	2,94	2,80	2,67
Fruit (mango, cashew, coconut, "maçanica")	2,74	3,00	3,11
Grand Total	**2,99**	**2,92**	**2,97**

11.6.6. FRESHWATER

Sub-unit	Average Vulnerability (projected)	Average Resilience	Average Impact Exposure
Weels (inland)	4,23	2,67	4,17
Wells (coastal)	4,13	2,00	3,67
Coastal basin	3,50	3,50	3,67
Lagoons (Bilibiza)	3,20	4,00	3,83
Montepuez	3,07	2,67	3,17
Swamps (Kagavero)	2,96	3,83	3,50
Groundwater	3,04	4,25	3,83
Seasonal Rivers (Messalo, Muaguide, Muagamula)	2,81	3,17	3,00
Grand Total	**3,41**	**3,19**	**3,61**

11.6.7. FISHERIES AND AQUACULTURE

Sub-unit	Average Vulnerability (projected)	Average of Resilience	Average Impact Exposure
Pelagic fish	1,93	3,50	2,11
Reef fish	3,02	3,00	3,11
Freshwater fish (Tilapia, cat-fish)	3,50	2,50	3,50

Lobter	2,34	2,83	2,44
Marine invertebrates (Oysters and "Pinas")	2,85	2,50	2,83
Cephalopods (octopus and squid)	2,34	2,83	2,11
Crab	2,62	2,83	2,67
Shrimp	2,90	2,50	2,73
Grand Total	**2,66**	**2,81**	**2,65**

11.6.8. HUMAN SETTLEMENTS

Sub-unity	Average Vulnerability (projected)	Average Resilience	Average Impact Exposure
Sanitation	4,36	1,60	3,67
Tourism	3,33	2,33	3,50
Human settlements prone to flood	3,56	1,80	3,17
Human settlements prone to sea level rise	3,33	1,60	2,83
Human settlements prone to cyclones	3,83	1,60	3,50
Human settlements prone to droughts	3,10	2,00	2,50
Key-social infrastructures	2,88	2,00	2,67
Economic infrastructures	2,46	2,33	2,00
Grand Total	**3,36**	**1,91**	**2,98**

11.7. ANNEX VII – ADAPTATION INTERVENTIONS CHOSEN FOR EACH RESOURCE UNIT

11.7.1. FOREST (MIOMBO & COASTAL)

	Option 1	Option 2
Title of intervention	**Introduce continuous awareness and training campaigns on fire management**	**Improve techniques for sustainable agriculture and diversify other income activities**
What sub-unit(s) and vulnerabilities does the intervention address?	*Use and community development zones - QNP and Coastal forest areas of multiple use*	*Use and community development zones*
Describe the intervention	*Initiate continuous awareness and training campaigns on fire management at communities, schools and religious institutions, including:* *a) Fire management (use of fire in adequate periods to eliminate the biomass fuel);* *b) Warning systems on the danger level in communities through different colour flags;* *c) Collection of combustible material (dry branches) that can be used to different purposes*	*a) Intensify disclosure of improved agriculture production technics, which allow to improve productivity, including:* *- Conservation agriculture;* *- Improved seeds;* *b) Promote chain values of the agricultural products that can contribute to the rent improvement;* *c) sustainable exploitation of non-timber forest products (i.e. honey, mushrooms)*
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	*The intervention intends to reduce the exposure to out of control forest fires in the areas mentioned above.*	*The intervention intends to reduce the forests' exposure to deforestation and fragmentation in result of agricultural areas' growth.*
Where should the	*This intervention will be implemented in the community development*	*This intervention will be implemented in the community use and*

	Option 1	Option 2
intervention be implemented?	*areas and in the coastal forest areas for multiple use*	*development areas*
Who should implement the intervention?	*This intervention should be implemented by local communities through their community leaders (traditional, religious and management committee)and by focal points, selected and trained in the communities*	*Communities/agricultural producers*
Are there negative consequences to the intervention?	*There are no consequences of this intervention's implementation*	*The use of some inputs may have negative consequences that should be warn.*
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	*The cultural and motivational habits of the focal points are the primary aspects that can compromise the implementation of this intervention*	*The consumption habits and the input's markets*
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	*In addition to the community leader, local governments (locality, administrative and district office) and partners (civil society organizations, donators and the academy) should also be involved*	*Agriculture sector (rural extension), NGO, academy, private sector*
Is there a supportive policy environment?	*Forestry and wildlife law, environmental law and conservation areas law*	*PEDSA, PARP III, Five-years government plan*
Are there any specific research	*Information on occurrence's distribution and behaviours of fires over the last few years*	*Soils' ability and selected varieties' adaptability*

	Option 1	Option 2
or data needs to ensure success?		

11.7.2. MANGROVE FOREST & DUNES

	Option 1	Option 2
Title of intervention	**Support the implementation of a management and zoning plan of the mangrove**	**Develop a management and zoning plan of the mangrove**
What sub-unit(s) and vulnerabilities does the intervention address?	***Low islands mangrove (Quirimba, Ibo, Quirambo, Situ), Coastal mangrove (Quissanga, Mussemuco, Arimba)***	***Low islands mangrove (Quirimba, Ibo, Quirambo, Situ), Coastal mangrove (Quissanga, Mussemuco, Arimba)***
Describe the intervention	*Support implementation of a mangrove management and zoning plan through surveillance, re-planting activities and promotion of mangrove-related livelihood activities (apiarist co-op, medicines and ecotourism)*	***Develop, through a participatory/ community approach, a mangrove management and zoning plan with no-take/ restoration zones, rotary cutting areas, protection belts, mangrove buffers and critical areas restoration***
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	*Through this initiative the mangrove is no longer the exploitation focus, and through the management activities we improve the structure of the forest, increasing the resilience (active re-planting, creation of nurseries, seedlings' sell)*	*Coastal mangrove protection, resilience increase, Mangrove cutting plan, exposure's reduction through the creation of alternative means of mangrove replanting*
Where should the intervention be implemented?	*The intervention should have 2 pilot locations. One in Quissanga area and another in Mussemuco*	*The intervention should have 2 pilot locations, one of them in Quissanga area, Quirimba*
Who should implement the intervention?	*Development of local communities' empowerment capacity on natural resources management to implement the goals of the management committee. NGO and local authorities should capacitate the local communities in management methods.*	*Development of local communities' empowerment capacity on natural resources management to implement the goals of the management committee. NGO and local authorities should capacitate the local communities in management methods.*
Are there negative consequences to the intervention?	*Non prioritization of this activity and switch of the cutting focus to inside/outside the Park*	*No*
What risks does the intervention entail? What	*Conflict of interests due to changing habits, Conflict between*	*Conflict of interests due to changing habits,*

	Option 1	Option 2
are the potential barriers to success (conflicts, political will, sustainability etc.)	*communities, empowerment of the initiative, leakage*	*Conflict between communities, empowerment of the initiative, leakage*
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 it is necessary to create a baseline of knowledge about sustainable mangrove management, basic ecology, seedlings for replanting, climate changes adaptation and community conflicts. It should be ensured that the local institutions, such as CBO, CCP, SDAE, SDPI, DPTADER or NGO, are involved.*	*In terms of expertise it is necessary to create a baseline of knowledge about sustainable mangrove management, basic ecology, seedlings for replanting, climate changes adaptation and community conflicts. It should be ensured that the local institutions, such as CBO, CCP, SDAE, SDPI, DPTADER or NGO, are involved.*
Is there a supportive policy environment?	*Yes, there are: Biodiversity law, Land and wildlife law and Conservation law*	*Yes, there are: Biodiversity law, Land and wildlife law and Conservation law*
Are there any specific research or data needs to ensure success?	*Yes, there are studies, field evidences and local knowledge about the area*	*Yes, there are studies, field evidences and local knowledge about the area*

11.7.3. CORAL REEFS AND SEAGRASS

	Option 1	Option 2
Title of intervention	**Implement marine resources co-management**	**Adaptive and resilience management of coral reefs and law enforcement**
What sub-unit(s) and vulnerabilities does the intervention address?	*Seagrass of the shallow waters, Seagrass of the deep waters, Sheltered coral reefs with fishing pressure, Sheltered reefs without fishing pressure*	*Exposed reefs under fishing pressure, Exposed coral reefs without fishing pressure, Sheltered coral reefs with fishing pressure, Sheltered reefs without fishing pressure*
Describe the intervention	*Implement the co-management of marine resources in an integrated approach (marine ecosystems - marine fauna - CBO - Government - OSC), addressing specifically tourism and fishing pressure, illegal fishing and destructive gears use*	*Resilience and adaptive management of coral reefs and Law enforcement, providing training in monitoring and enforcement for QNP staff, setting management targets based on fishable biomass, improving fishing regulation and creating new high compliance closure sites and consider a community-management*
How does the intervention specifically address climate change? Does the intervention address	*Increase resilience and decrease exposure*	*Increase resilience and decrease exposure*

	Option 1	Option 2
resilience, exposure, or both?		
Where should the intervention be implemented?	*In the entire QNP*	*QNP, Total protection areas*
Who should implement the intervention?	*CBO - Government (QNP) - OSC*	*QNP, district governments, local communities*
Are there negative consequences to the intervention?	*No*	*No*
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	*Resistance to change*	*Technical capacity, Lobby and advocacy capacity*
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	*Ministry of the Sea, Inland Waters and Fisheries, National administration of conservation areas, Province Direction of sea, inland waters and fisheries*	*Ministry of land, environment and rural development, Province direction of land, environment and rural development*
Is there a supportive policy environment?	*Yes, the new Fishing law - regulation and master plan of the fisheries sector both in progress*	*International protocols, law and environmental regulations*
Are there any specific research or data needs to ensure success?	*Yes*	*Yes*

11.7.4. SPECIES OF HIGH CONSERVATION VALUE

	Option 1	Option 2
Title of intervention	**Reinforce wildlife protection**	**Improve sea turtles' and shark's protection**
What sub-unit(s) and vulnerabilities does the intervention address?	*Elephant, African wild dog, Kudu, Crocodiles and hippopotamus, Lion and leopard*	*Sea turtles, Shark*
Describe the intervention	*Ensure the sustainable use of wildlife resources in QNP through resize protection blocks, confining the animals to total protection blocs. Create watering conditions around the blocks and reinforce control. Remove human settlements from the corridors between the total protection blocs.*	*Ensure the survival of Sea turtle and shark in QNP through a better control of immigrant fishermen. Encourage community inspectors and secure them with proper means and equipment. Reinforce surveillance. Control human settlements and tourist resorts in the turtles' nesting sites.*
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	*The intervention will contribute to species' resilience and to reduce exposure to drought*	*The intervention will contribute to species' resilience and to reduce exposure*
Where should the intervention be	*In A, B and C total protection blocs, located in the districts of*	*Along the coast, especially in the sea turtle's*

	Option 1	Option 2
implemented?	*Macomia, Quissanga, Meluco and Ancuabe*	*nesting beaches. In the Shark's case, all the marine area of the QNP*
Who should implement the intervention?	*QNP administration and partners*	*QNP, local Governments, partners and community*
Are there negative consequences to the intervention?	*The evacuation and resettlement of people will be expensive and affects economic and cultural aspects*	*Conflicts with resident fishermen in the nesting areas.*
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	*Conflicts and political will*	*Conflicts and political will*
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	*Government, partners and academic institutes*	*Government institutions, CCP, community supervisors and NGO.*
Is there a supportive policy environment?	*Yes, Environmental law and decree on resettlements.*	*Fishing law, Land law, QNP management plan, Environmental law, Conservation law*
Are there any specific research or data needs to ensure success?	*There are studies performed that support the intervention*	*There are data about the Sea turtle and its nesting areas. There are no profound studies*

11.7.5. AGRICULTURAL AND LIVESTOCK SYSTEMS

	Option 1	Option 2
Title of intervention	**Improve planning and regulation of agricultural land use**	**Conservation agriculture**
What sub-unit(s) and vulnerabilities does the intervention address?	*The pressure on land is a consequence of the impacts caused by the new road, the migration, the mine concessions and the tourist resorts, on the sub-units Maize, Cassava, fruits, vegetables and livestock breeding (small ruminants)*	*The extended dry periods cause great vulnerability to food crops, especially Maize and Cassava.*
Describe the intervention	*Microzone the use and community development areas;* *Bound and ensure DUAT (special licenses) of every village areas;* *Strenghten the CBO capacity and support its legalization;* *Demarcate and deliver DUAT (special licenses) to operational CBO*	*Introduce and adopt of small cycle and more tolerant improved seeds;* *Introduce and adopt water conservation and soil fertility technics (sustainable and conservation agriculture);* *Construction of dikes that allow water retention for crop irrigation.*
How does the intervention specifically address	*The intervention is directed to a development impact.*	*The extended dry periods are one of the*

	Option 1	Option 2
climate change? Does the intervention address resilience, exposure, or both?	*The proposed measures will bring a bigger resilience to the described units, because there will be sustainable alternatives (compensations) in case the proposed interventions are implemented. The production will keep in other areas, often in better conditions, depending on the negotiation.*	*consequences of climate changes.* *The exposure of food crops is big, because they are made during the wet season, which is pretty short (3-4 months)*
Where should the intervention be implemented?	*In the use and community development areas and in the QNP buffer area*	*In the use and community development areas and in the QNP buffer area*
Who should implement the intervention?	*QNP administration* *District governments* *Province Governments* *NGO (national and international)*	*QNP administration* *District governments* *Province Governments* *NGO (national and international)*
Are there negative consequences to the intervention?	*There are consequences in case of law breaking*	*There are no negative consequences*
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	*The main barriers can be the political will, the project sustainability from investment to disinvestment and the investor's interest.*	*The risks are connected with the disclosure (network and extension) and the adoption of the proper technics;* *The existence of enough improved seed is also a risk.*
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	*Local authorities;* *Geography and record;* *Legal and justice institutions.* *This institutions are present at the district level.*	*Associated agricultural producer to lead;* *Governmental and NGO extensions;* *Research and inquiry technical experts.*
Is there a supportive policy environment?	*The Land law and the environmental legislation gives cover to these interventions*	*Environmental legislation* *Agro-extension strategy* *Agro-sector strategy* *Rural development strategy*
Are there any specific research or data needs to ensure success?	*It would be great to be able to do some quick comparative evaluation, CVCA like*	*Quick participation diagnosis* *Baseline survey*

11.7.6. FRESHWATER

	Option 1	Option 2

	Option 1	Option 2
Title of intervention	**Creating sub-basin management committees**	**Construction of improved latrines and public toilets**
What sub-unit(s) and vulnerabilities does the intervention address?	*Seasonal Rivers (Messalo, Muaguide, Muagamula)*	*Wells (coastal), Wells (inland)*
Describe the intervention	*Ensure a better management and use of water by the creation of hydrographic basin's management committees; Provide training to the basin's committee members*	*Improve the sanitation system, through the construction of improved latrines and public toilets.*
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	Yes, because it will encourage the integrated management of water resources.	Does not address.
Where should the intervention be implemented?	In the rivers.	In the communities throughout the park
Who should implement the intervention?	Government and private sector, involving the QNP community	Government and private sector, involving the QNP community
Are there negative consequences to the intervention?	No	No
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	Conflicts between the community, the government (QNP) and the private sector.	Conflicts between the community, the government (QNP) and the private sector.
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	Academies (biologists, geographers, anthropologists, environmentalists)	Academies (biologists, geographers, anthropologists, environmentalists)
Is there a supportive policy environment?	Yes	Yes
Are there any specific research or data needs to ensure success?	Yes	Yes

11.7.7. FISHERIES AND AQUACULTURE

	Option 1	Option 2
Title of intervention	**Reduce the pressure on the fish resources of rivers and lakes**	**Improve the production of crustaceans sustainability**
What sub-unit(s) and vulnerabilities does the	*Freshwater fish (Tilapia, cat-fish)*	*Marine invertebrates (Oysters and "Pinas")*

	Option 1	Option 2
intervention address?		
Describe the intervention	*Reduce pressure on the fishing resources of river and lakes by practicing pisciculture;*	*Reduce the communities' oysters collecting effort, by investing in oyster mariculture and creating rotary community reserves - that allow the establishment of closed areas for species reproduction - to collect marine invertebrates, .*
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	*With pisciculture, communities get less dependent on rivers and reduce their fishing effort. This will allow to increase fish's resilience in the rivers; Pisciculture fish's will have less exposure to climate change effects, such as droughts*	*With mariculture practice and the creation of rotary community reserves, the marine invertebrate communities will have more proliferation capacity, increasing their populations.*
Where should the intervention be implemented?	*Bilibiza*	*Mariculture: Nanhoma, Arrimba* *Community reserves: Quirimbas, Mefunfo*
Who should implement the intervention?	*The local community (CCP) with support of the development institutions (INAQUA), research institutions (IIP, UniLúrio) and NGO.*	*The local community (CCP) with support of the development institutions (IDPPE), research institutions (IIP, UniLúrio) and NGO.*
Are there negative consequences to the intervention?	*No*	*No*
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	*Potential sites to practice pisciculture*	*The creation of associativism for the joint management of this resources.*
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	*Universities (UniLúrio), Research institutions (IIP) and NGO (WWF)*	*Universities (UniLúrio), Research institutions (IIP) and NGO (WWF)*
Is there a supportive policy environment?	*Yes. The environmental law.*	*Yes.*
Are there any specific research or data needs to ensure success?	*Yes. Research should focus on the ideal conditions for pisciculture practice and on methods for Tilapia and cat-fish farming.*	*Yes. Research should focus on methods for oysters farming.*

11.7.8. HUMAN SETTLEMENTS

	Option 1	Option 2
Title of intervention	**Develop and implement a climatic-resilient settlements policy to**	**Ensure sanitation**

	Option 1	Option 2
	communities	
What sub-unit(s) and vulnerabilities does the intervention address?	*Human settlements prone to sea level rise*	*Sanitation*
Describe the intervention	*Developing and implementing a climate resilient settlement policy for communities within QNP. Adopt a resilient to climate change house model.*	*Ensure the sanitation through the construction of improved latrines and cistern tanks for water catchment and its treatment.*
How does the intervention specifically address climate change? Does the intervention address resilience, exposure, or both?	*This intervention will decrease the exposure of people and will increase the resilience in the settling places.*	*This intervention will reduce the exposure of the communities to diseases such as malaria, cholera and acute diarrheas, and will increase resilience.*
Where should the intervention be implemented?	*The intervention should be implemented in the safe to climate impacts areas (away from the ocean areas - inland)*	*The intervention should be implemented in the new settlements*
Who should implement the intervention?	*INGC, DPTADER, Red cross, DPMAS, DPS, DPA, DPEC, QNP, WWF, District Government.*	*Government (DPTA,DPADER,INGC,DPMAS,DPS,DPEC, DPOPH, NGO,QNP)*
Are there negative consequences to the intervention?	*There are consequences. Populations subject to adapt to new ways of living that they are not used to.*	*Groundwater contamination*
What risks does the intervention entail? What are the potential barriers to success (conflicts, political will, sustainability etc.)	*Populations not happy with the new settlements. The main barriers are political will, when there are not created the conditions for water supply and sanitation; and the sustainability, when the existing lands are not suitable to the food crops that the population was used to.*	*Emergence of endemic diseases*
Which institutions or expertise needs to be engaged to ensure success? What opportunities are there to work with other specific initiatives?	*INGC,DPTA, Red cross, DPMAS, DPS, DPA, DPEC, QNP, WWF, district governments.* *Small scale economic activities practice.*	*Government (DPTA,DPA,INGC,DPMAS,DPS,DPEC, DPOPH, NGO, QNP)*
Is there a supportive policy environment?	*Yes*	*Yes*
Are there any specific research or data needs to ensure success?	*Yes, there is the need for investigation, to ensure success*	*Yes*