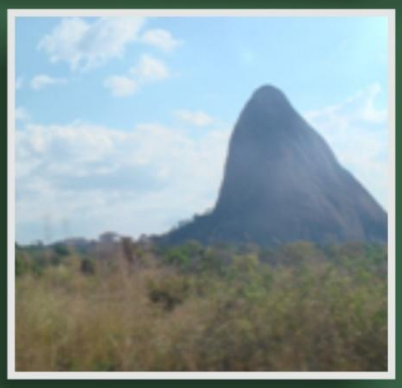
RESPONDING TO CLIMATE CHANGE IN MOZAMBIQUE

REPUBLIC OF MOZAMBIQUE
MINISTRY OF STATE ADMINISTRATION
NATIONAL INSTITUTE OF DISASTER MANAGEMENT

Instituto Nacional de
Gestão de Calamidades



THEME 4A

National Institute for Disaster Management (INGC)
PHASE II

THEME 4A
Building Resilience with the Private Sector

October 2012

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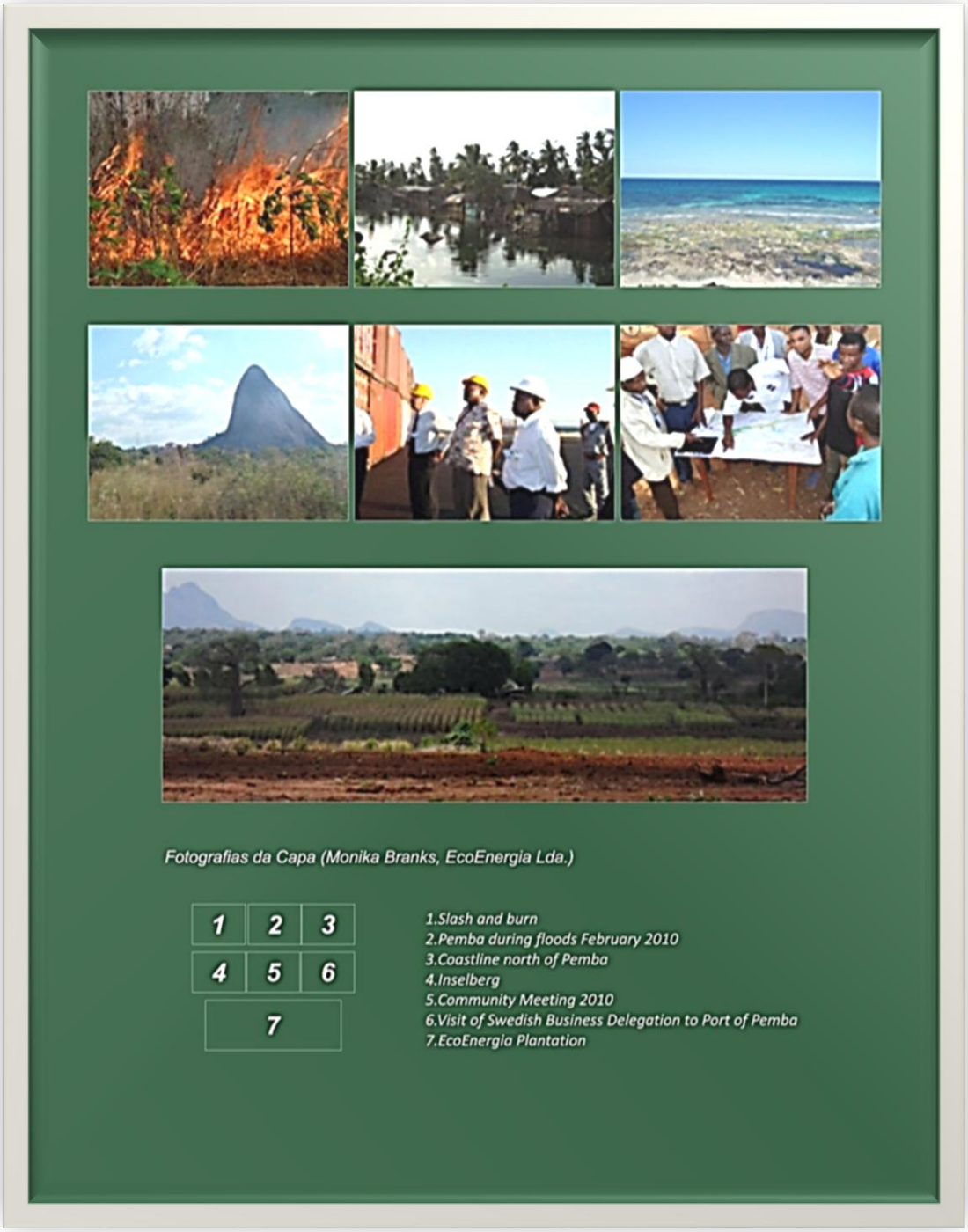

Fotografias da Capa (Monika Branks, EcoEnergia Lda.)

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1.Slash and burn
2.Pemba during floods February 2010
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BACKGROUND

The Mozambican National Institute for Disaster Management (INGC) concluded in June 2009 Phase I of a study on the macro impacts of climate change by year 2030 and year 2060 in Mozambique[1]. The study confirms that Mozambique with its long coast line, self-subsistence economy and weak infrastructure is one of the countries in Africa most vulnerable to extreme weather patterns. The study presents various scenarios which indicate sea level rise, more intense cyclones, land right conflicts due to permanent inundation, water shortages, degrading land due to salt water intrusion, escalating food shortages, more epidemics and an exponential increase in wildfire spread and damage. It also states that Mozambique holds adaptive capacity with substantial well kept natural resources and that the extent to which this vulnerability will increase depends on the decision makers. The study asserts that the key issue is one of timing and that the implications for no action are severe. One of the conclusions is that Mozambique will require a significant acceleration of economic growth in order to sustainably deal with climate change. The private sector is the major source for this growth and their decisions on *how* to implement investment will either optimize the benefits of ecosystems or contribute to their degradation.

INGC started in October 2009 phase II of this project 'Responding to Climate Change in Mozambique'[2], focusing on the identification and implementation of adaptation measures and on the strengthening of national capacity to deal with climate change. One of the objectives is to ensure the start of implementation of adaptation and resilience building (with emphasis on disaster risk reduction), by engaging the private sector in a structured and effective manner.

[1] Study on the Impact of Climate Change on disaster risk in Mozambique, National Institute for Disaster Management (INGC), May 2009

[2] Responding to Climate Change – Project Proposal INGC phase II – June 2009

INTRODUCTION

The National Institute for Disaster Management (INGC) Phase II which commenced in October 2009 focuses on adaptation around eight priority themes. VerdeAzul Consult Lda, a Mozambican consultancy company with commitment and capacity for sustainable private sector development, was contracted by INGC to implement a pilot project for Theme 4: 'Resilience Building through the Engagement of the Private Sector'.

The key questions to be answered through this project are:

- Given the current state of knowledge about the key drivers and impacts of climate change in Mozambique, what is the impact and its significance in a pilot geographical area of interest by a private investor?
- What would be the most effective 'portfolio' of adaptation measures for building resilience in the pilot geographical area?
- What could the role of the private sector be in climate change adaptation in the pilot geographical area?

The pilot project has two components through which answers to the above questions are sought:

- Component I, which studies a pilot geographical area culminating into recommendations for an adaptation and investment plan.
- Component II, which is a pragmatic learning-by doing implementation of an adaptation project.

Component I has been implemented by VerdeAzul Lda, and component II by a private sector investor, EcoEnergia de Mozambique Lda. in collaboration with VerdeAzul Lda. Both components are cost shared (overall 60% private, 40% public funding) and this public/private cost sharing initiative and other sharing mechanisms will also be evaluated at the end of the project time period.

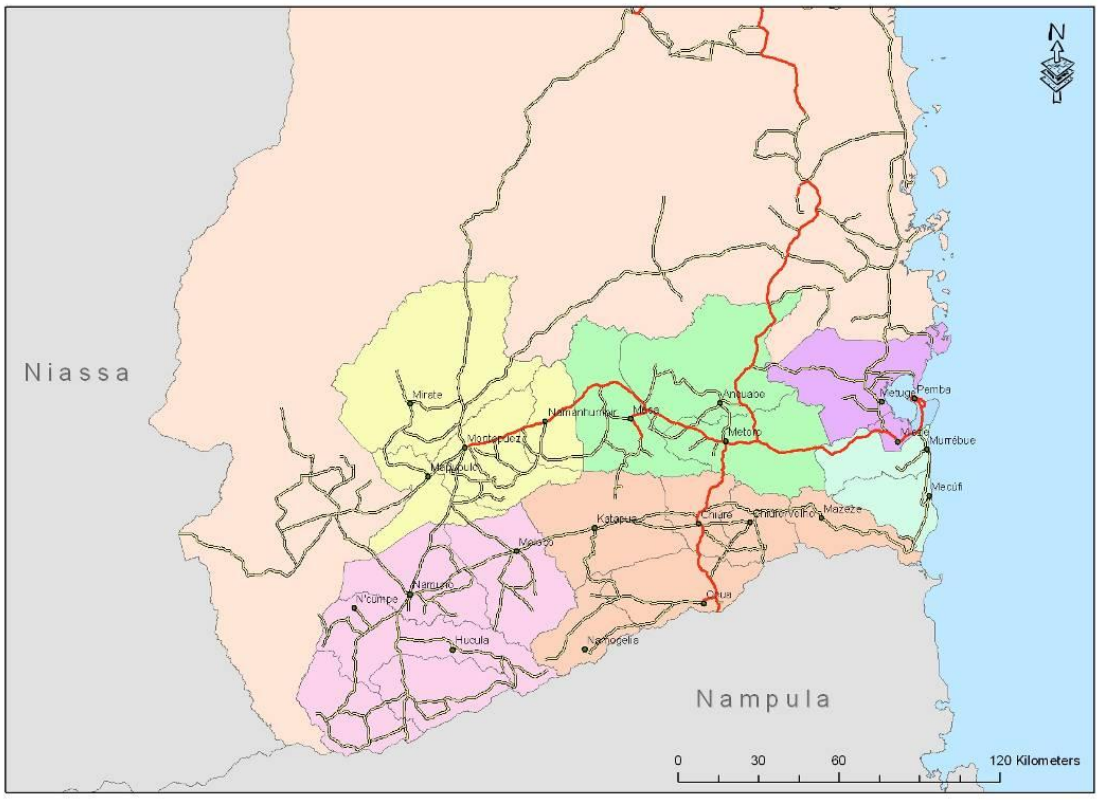
A pilot area was chosen attractive to private investors to work out a methodology for replication in other areas. This pilot area is also where EcoEnergia is implementing an adaptation project.

This document contains the executive summary and key messages based on the following technical reports, which can be consulted for more details:

(i) Baseline & Trends – Description of Pilot Geographical Area & Climate Scenario's
(ii) Private Sector Investment for Climate Resilience Building
(iii) Vulnerability and Impact Assessment using a Strategic Environmental Assessment Approach
(iv) Implementation of Adaptation Project

STUDY AREA

The study area is located in Cabo Delgado Province, covers 6 districts over an area of 2.4 million ha and includes coastal areas, agricultural and forestry land and conservation areas. This area was chosen from the perspective of private sector involvement in a number of key sectors (Agriculture, Forestry, Tourism) as well as from the perspective of incorporating the priority themes resulting from the INGC Phase I study. Another reason for choosing this area is practical: as much as possible, use has to be made of existing information and studies and EcoEnergia was able to make available recent information of use for this project and has located its adaptation project in this area. Thirdly, as the aim is to multiply the process to other areas with higher climate change risk zones, it is more the approach to be developed and tested which is the main focus of study.



Map of the 2.4 million ha pilot area which cover the districts of Chiure, Namuno, Ancuabe, Pemba-Metuge, Mecufi and part of Montepuez (south of Messalo river only).

COMPONENT I

ENGAGEMENT WITH THE PRIVATE SECTOR

COMPONENT I – ENGAGEMENT WITH THE PRIVATE SECTOR

ANALYTICAL FRAMEWORK

The objective of the first component is to (i) determine adaptation options for the pilot geographical area in the face of climate change and (ii) develop a process for the formulation of an adaptation and investment plan for the pilot area as a model for replication in other areas.

The framework that was developed for analysis under this component is presented in the diagram below, and represents the process followed, analysis conducted and methodologies used.

PROCESS	DATA ANALYSIS	METHODOLOGY
BASELINE & TRENDS	• Description of pilot geographical area • High Conservation Value • Climate Change Scenarios • Investment Climate	• Consultations • Geographic information Systems (GIS) • High Conservation Value (HCV) analysis
VULNERABILITIES & IMPACTS	• Vulnerability to climate change (exposure, underlying vulnerability and adaptive capacity) • Climate change impact	• Consultations • Strategic Environmental Assessment (SEA) • Ecosystem Supply and Demand Analysis
RISKS, OPPORTUNITIES & ADAPTATION OPTIONS	• Business risks and opportunities • Adaptation options for and with private sector	• WSCSB model for adaptation with private sector
ADAPTATION AND INVESTMENT PLANNING	• Win-win options • Adaptation investments	• Climate Proofing of investment plans

BASELINE AND TRENDS

The baseline information and trends focus on the issues that are relevant for this study and ensure a focus on climate change and private sector. Hence it was decided to collect information on:

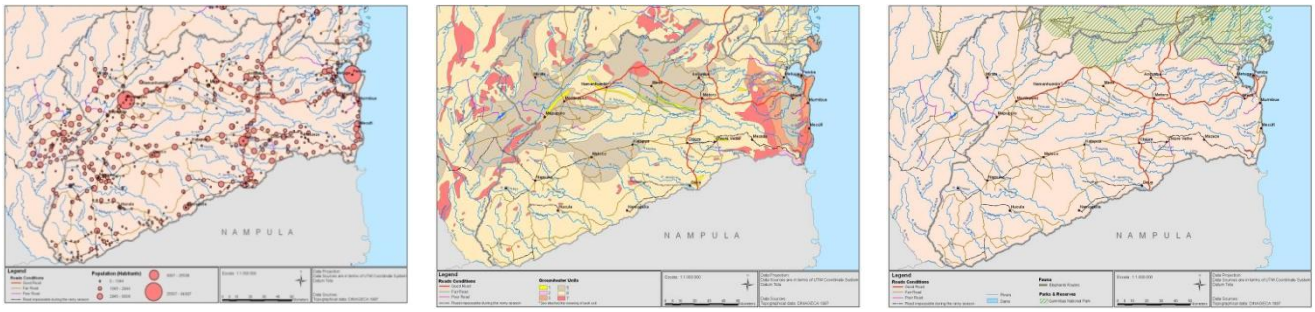
(i) The study area itself with focus on those issues that are vulnerable to climate change and have a strategic value for a number of investment options (natural resources, infrastructure, population, conservation areas, ..)
(ii) Current climate and predictions for the future
(iii) High Conservation Value which provides a tool for land use decision making and opportunities for corporate social responsibility and carbon off-setting
(iv) Investment climate to assess opportunities for attracting new investors

DESCRIPTION OF THE PILOT GEOGRAPHICAL AREA

The description of the pilot geographical area was based on existing reports, plans and studies of the area, obtained initially during a two week data collection campaign and complemented with information from stakeholder consultations both in Maputo and Pemba. The project also benefitted from the detailed studies that were conducted by EcoEnergia and were made available for consultation. The description covers the ecosystems, water resources, fauna, demography, infrastructure, economic activities. The ecosystems have been covered in more detail as they provide the basis for livelihood security and land use and would later be the main subject of the vulnerability assessment.

The GIS team of VerdeAzul gathered spatial data and prepared a series of maps, which include:

- Hydrology (groundwater units, rivers and dams)
- Geomorphology (topography, soils)
- Vegetation cover
- Climate (temperature, rainfall)
- Conservation (fauna, QNP and elephant routes)
- Current land use, Land Use Titles and Concessions
- Infrastructure & Road conditions
- Demography (population centers, schools)



Maps of population, water resources and elephant routes in the pilot geographical area

CLIMATE

The vulnerability assessment was made for the following three climate scenarios:

1. Current climate - (based on current data of the pilot area)
2. Climate change - likely scenario for 2030 (based on results of INGC Phase I)
3. Climate change – worst case scenario / tipping points (extracted from INGC Phase I results)

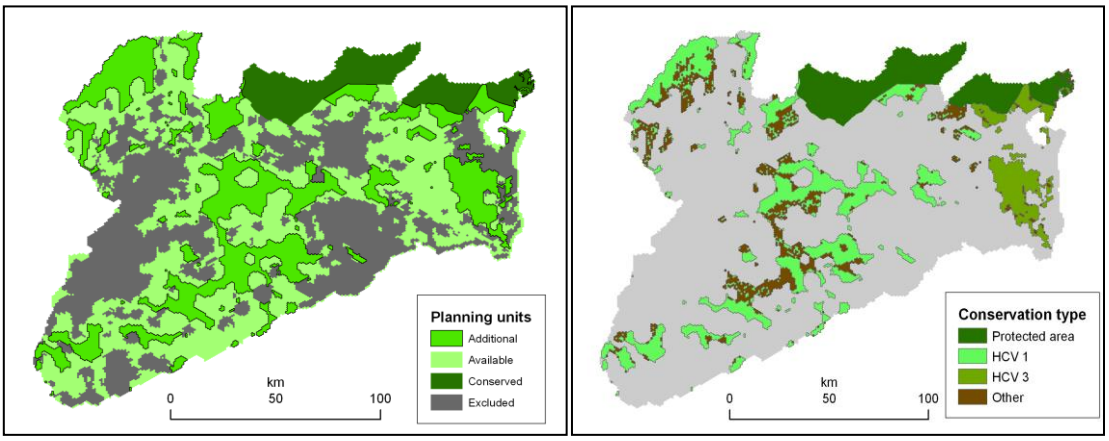
The temperature in the study ranges between 25-27 ^{o}C in the hot/wet season and 22-25 ^{o}C in the cold/dry season, but may see a slight increase of 2-3 ^{o}C with a 2 -25% increased probability of daily high critical temperature levels (above 35^{o}C) in the likely and worst case scenario respectively. Rainfall which ranges currently between 200 and 800 mm per annum, is expected to increase by 10-20%. The likely climate scenario predicted that rains will start later and will be more intense, and this has already been observed by the local communities, hence it looks like the predicted likely climate change scenario for 2030 has already started!

Sea level is predicted to rise with 10 cm in next 20 years, with potential 100 to 500 m in far future and worst case scenario. The area should have no increased risk in drought or other extreme events, such as floods and cyclones but the intensity when they occur might increase.

HIGH CONSERVATION VALUE

As part of the description, a High Conservation Value Assessment of the pilot area was completed by an independent consultant. In this study, the consultant used a systematic conservation planning approach, together with criteria developed through the High Conservation Value certification scheme, to identify important habitat patches that are needed to maintain the conservation value of the study area. The key to this approach was the identification of the six High Conservation Values (HCVs), which cover the range of conservation priorities shared by a wide range of stakeholder groups, and include social values as well as ecological values. A HCV area then is simply the area (e.g. a forest, a grassland, a watershed, or a landscape-level ecosystem) where these values are found, or, more precisely, the area that needs to be appropriately managed in order to maintain or enhance the identified values. Three of the land cover types in the analysis were given HCV 1 status, ten were given HCV 3 status and nine were not given a specific HCV status (Figure 2). HCV1 refers to areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, endangered species, refuge areas) and HCV 3 refers to areas that are in or contain rare, threatened or endangered ecosystems. HCV 2 areas refer to large landscape areas, which are not relevant for the pilot geographical area, while HCV5 and HCV6 relate to livelihoods and cultural

aspects of biodiversity, ecosystems and/or ecological processes. It has been and can be assumed that HCV5 and HCV6 are found in all areas of natural vegetation within and surrounding human habitation.



Best portfolio identified. Conserving the Additional areas (shown in bright green in left map) is an efficient approach for meeting the targets. The map on the right shows the current conservation status of the "additional" planning units in the best portfolio.

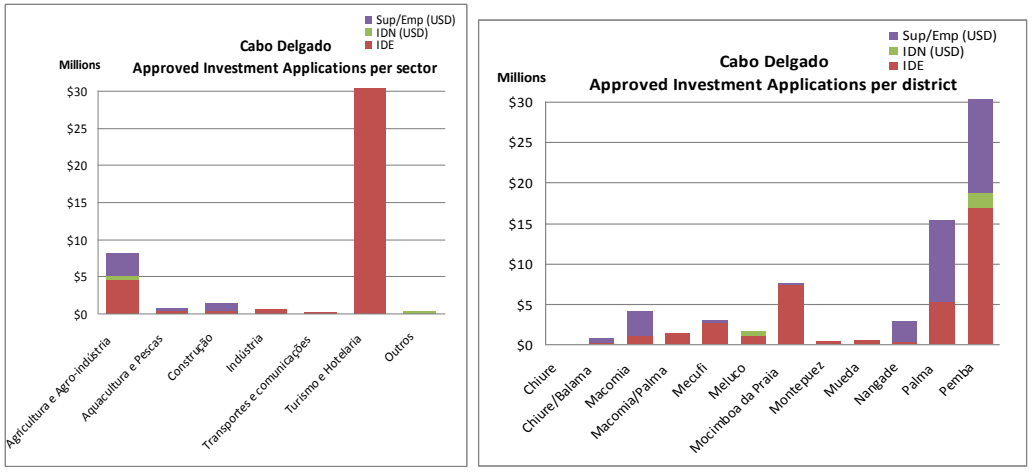
Best portfolio details	Area (km^2)
Additional (needed to meet targets in combination with already existing protected areas)	5469.8
Available (natural vegetation not selected)	9447.8
Conserved (existing protected areas)	1961.6
Excluded (agricultural or urban land)	8572.8

The analysis of the area identified 200 different portfolios as part of the simulation process and the best of these identified important patches of land throughout the planning region. The best portfolio added 5470km^2 (21.5%) to be protected in addition to the 1961km^2 (7.7%) already existing protected areas, totalling the total area to be conserved to 29.20 % . The study also revealed that there is space for land investments of approximately 9500 km^2 (37%), under the condition that these maintain HCV areas and co-finance conservation areas.

INVESTORS AND INVESTMENT CLIMATE

Based on consultations with stakeholders and literature review of the most recent documents on the investment climate and Doing Business in Mozambique, a list of barriers to investment and doing business in Mozambique and in Cabo Delgado in particular compiled and discussed. The study found that while the investment climate and doing business in Mozambique is perceived to be improving, Mozambique is still lagging behind its neighbouring countries.

Data from the Centro de Promoção dos Investimentos (CPI) reveals an approval of investment proposals for Cabo Delgado for a total of US$ 68 million over the period 2005-2009 with more than 50% of these with foreign funding. Largest investment proposals came from the Tourism and Hotel business, which also explains that Pemba district and the more vulnerable coastal zone received most applications during that period.



Approved investment applications per sector and per district for the period 2005-2009

The main barriers to investment in Mozambique are governance, crime, access to finance, tax and infrastructure. For already established businesses, informality and labour issues join this list. A closer look into the country reveals differences across the provinces, with investors ranking Cabo Delgado only 8th with regards to confidence to invest, with Nampula and Inhambane Provinces earning the highest confidence. They find that investing in Cabo Delgado is characterised by a very high operational cost, mainly due to the poor infrastructure (especially roads), slow and non transparent regulations, inexperienced civil servants that delay approval and registration processes, high tax rates, crime and corruption and high cost for skilled labour.

It clear from recent studies and stakeholder interviews, that unless there is a massive improvement and investment, especially in infrastructure, Cabo Delgado will continue to have difficulties attracting the right type of investors (corporate responsible investors) and compete with other provinces and other African countries, especially as a tourist destination.

From the experience of EcoEnergia, we could also learn that the delays that coincide with overcoming barriers, do not only frustrate the private investor, who may lose interest and decide to invest elsewhere, but also affects the local authorities and communities, who see this as broken promises and who lose confidence in the investor.

It is therefore important to attract investors and facilitate investments from responsible companies that show “sustainable behaviour” and can lift some of the frustrations and barriers mentioned by Government and local communities. These companies see the benefit to having a social, environmental and financial sound investment and would be willing to invest in mitigation and adaptation. There are a number of climate funds available to assist companies with climate related business risks.

The anchor investments envisaged for the pilot area focus on investments by such responsible companies with “real” investments that have started or are likely to be implemented over the next five years and that due to their scale of operation and the resources provided from the owners can afford to pay for adaptation. For the pilot geographical area, these potentially include:

- EcoEnergia Lda. For agro-energy production (+1000 ha starting with 100,000 ha planned over 20 years)
- Banana production for export in a consortia with an international off-take agreement (+- 3000 ha)
- A large scale plantation by an internationally recognized forestry operator (+ 100 000 ha)
- A consortia of international and national investors for a tourism complex near Pemba city (+-500 ha)

CLIMATE CHANGE VULNERABILTY ASSESSMENT

In order to study the impacts of climate change in the study area, it was decided to use a Strategic Environmental Assessment (SEA) approach. With the assistance of Dr. Maria do Rosário Partidário, Professor and researcher at the Technical University of Lisbon, and expert in Strategic Environmental Assessment and with guidance from the advisory note "SEA and Adaptation to Climate Change", which was produced by ENVIRONET, the DAC network on Environment and Development Co-operation, a specific analytical framework was developed ensuring a climate change and private sector focus.

ANALYTICAL FRAMEWORK

The **objective** of the SEA was "to assess private investment options for the pilot geographical area under various climate change scenario's and develop a framework for strategic assessment of private investment options following a pathway that will increase resilience to climate change". And the **objects of assessment** for this study are the land use and private sector investment options for the pilot geographical area under various climate change scenario's.

The **Critical Factors for Decision-Making** (CFD) provide an overall structure or framework of the SEA and represent the key, critical uncertainties that matter and that require the inclusion of views and engagement of parties involved. The factors listed below are the four critical factors for decision-making (CFD) that were chosen as they may determine the success, or the risks, of the proposed investment options.

CFD1 - Ecosystem Services

Ecosystem services are the outputs of nature that generate quality of life or well being for people. Climate has a profound impact on the condition and functionality of the various ecosystems and hence on the services it provides. Ecosystems can exist without human interference, but not the other way around. Decline of quantity and quality of ecosystem services therefore is seen as generating costs for society and the supply of high value services is becoming a major economic and social focus. A focus on ecosystem services can make it clear just what services change under the predicted climate change, and whose wellbeing will change, which is the focus of the next three critical factors of decision making.

CFD2 - Local Community Livelihoods

The livelihood of local communities in the study area is largely based on natural resource use and extraction, with a very high dependence on agriculture. It makes them very vulnerable to climate change as their livelihood any of these become scarce or degraded, the use of the resources local communities depend on by the private sector will have to be considered and studied in more detail.

CFD3 - High Conservation Value Areas

High Conservation Values cover a wide range of conservation priorities that are shared by a wide range of stakeholder groups, and includes social values as well as ecological values. A HCV framework is usually used to ensure that land developments do not damage critical areas which are important for environmental and/or social values, and because HCV areas are spatially explicit, it is important to know how these may shift spatially under the various climate change scenarios.

CFD4 - Private Sector Investment Attraction

Some of the strategic issues identified for various investment options in the pilot area are vulnerable to climate change and influences the decision by the private sector to (further) invest in a particular area.

The **assessment criteria** used to allow for 'climate proofing' of the various investment options are:

- ***Exposure*** to climate-related hazards (droughts, storms, floods, cyclones)
- ***Underlying vulnerability*** driven by socio-economic, environmental and other factors
- ***Adaptive Capacity*** to resist, absorb, cope and respond to climate change impacts

CFD1 - ECOSYSTEM SERVICES

The vulnerability of the ecosystems to climate change has been described in detail for the three climate scenario's. Below is a summary of the main issues.

SUMMARY OF VULNERABILITY ASSESSMENT OF ECOSYSTEMS IN THE PILOT GEOGRAPHICAL AREA

- Higher temperatures and precipitation may cause higher erosion of the granite rock in I***nselberghs*** contributing to a progression of vegetation in the eroded areas.
- Expected changes in rainfall, especially the shift in the onset of the rainy season may affect vegetation growth of the ***miombo woodlands***, on fire regime and intensity (due to higher level of grass biomass), the consequences of which are likely to change composition of woodlands with fire resistant species taking over the typical species. It will also affect the dynamics with some drying up and others flooded, depending on their location.
- Sea level rise will impact on the ***coastal and dune vegetation***, which is likely to reduce and even disappear in certain areas. Due to its protection role, it is important that this vegetation is kept and rehabilitated to fact the effects of climate change and be able to adapt.
- Temperature and rainfall pattern may induce a change in pattern and stock of fish in ***mangroves***, but due to its location, they will be most impacted by sea level rise.
- The level of precipitation is likely to cause a shift in season and affect the timing and level of flooding of the ***riparian areas.*** The consequences are a likely change to the ecosystem's composition and the dynamics of these areas (some may dry up, while other may be flooded).
- The changes in rainfall pattern will impact on the ***ground water supply and river flow***, which are currently very peaky with water rising rapidly during the rainy season. The quick run-off and little recharge to the groundwater will contribute to the low base flow during the dry season, and this may complicate localisation of appropriate areas for opening new water points. However all rivers in the study area are internally draining and the region offers the best opportunities with predictions that with current per capita use rates, all rivers will have enough water to meet demands till 2050. However with an increasing population, 60% of rivers could become water scarce by 2050 compared to 25% in 2000. [3]
- Changes in temperature and rainfall pattern are likely to impact on crop yields and agricultural productivity and hence the crop suitability of the ***agro-ecologies***. It is expected that the area is to experience the largest gain in suitable areas for cultivation of most crops which are adapted to wetter conditions, although that crops like sorghum and soybean may show some limitations. Crops such as cassava, maize and groundnut represent a great opportunity to realise high potential through the introduction of suitable high yielding varieties.

[3] This data refers to the results from the NGC phase I study and were later confirmed in the Ecosystem Services Demand and Supply Analysis, which predicted that access to water will be severely limited in some areas.

The vulnerability to climate change of the various ecosystems depends in the first place on its conservation status and/or its management to maintain this status. Ecosystems have the inherent ability to adapt to changing conditions, of which gradual climate change is one, but this ability and its capacity to deliver services to a wide range of stakeholders can be distorted by other natural drivers, such as extreme climatic events, but more so by anthropogenic drivers, such as overexploitation and uncontrolled fires.

The functionality and ability of an ecosystem to provide services are therefore very much function of the initial condition of the ecosystem. In a separate exercise, a more detailed analysis was made what services the various ecosystems are able to deliver in pristine conditions and how – in what magnitude - these change under the three climate scenarios.

CFD2 - LOCAL COMMUNITY LIVELIHOODS

The vulnerability assessment of the local community livelihoods in the pilot geographical area is based on a number of base-line studies that were undertaken in the pilot area. Two of the studies, conducted by the NGO's HELVETAS and CARE were specifically oriented to assessing climate change vulnerability and adaptability, using methodologies and tools specifically designed for such discussions with the communities. These include the 'Community Risk Screening Tool and Adaptation & Livelihoods (CRISTAL)' methodology developed by IISD, IUCN and the Stockholm Environment Institute (SEI), and the 'Climate Vulnerability and Capacity Analysis (CVCA)', which was developed by CARE as a framework for dialogue around hazards associated with climate change, existing adaptive mechanisms and potential new strategies.

In the context of this study and the pilot area, the vulnerability assessment consists of a discussion of:

- **Exposure** of the communities to climate change, based on the discussions and meetings held by EcoEnergia, and the studies of HELVETAS and CARE on how climate change has been perceived by the local communities.
- Sensitivity or **underlying vulnerability** is based on the impact of climate change on the 5 livelihood capital categories: social, human, financial, natural, physical and human capital.
- **Adaptive capacity** that is not to be confused with how communities "cope".

Exposure

Local communities reported having been affected by climate change especially by changing temperature and rainfall patterns. Rainfall pattern has become more erratic with a shorter and later rainfall period and with substantial gaps, of up to 6-8 weeks. Communities also reported more intense rains, causing seeds to be washed away, erosion and local flooding. In terms of temperature, there has been a shift in hot and cold season, with the hot season starting earlier and lasting longer. Salt water intrusion is affecting communities in the coastal areas affecting drinking water and agricultural productivity. The exposure of communities to extreme events, such as droughts, storms and cyclones are more localized.

Underlying vulnerability

Human capital - The time and effort for collecting water, fuel wood and for producing food is likely to increase with migration of people into the resource-full areas and emigration of community members in search of food for work likely to increase. Climate change, especially the heavy rains is

also likely to increase the frequency of epidemic diseases. Reproduction from malaria transmitting insects' is enhanced by increasing temperatures and insufficient hygiene due to water scarcity and/or standing water bodies during floods can provoke cholera outbreaks.

Financial capital - Economic activities and cash income is almost entirely based on natural resource use and extraction and seasonal work, and hence income is very vulnerable to climate change, especially as there are not many alternatives available within the area. Since the current erratic rainfall pattern and shortage of water is already limiting cash income, there is not much scope for improvement, unless salaried employment or production and market for climate resilient products develop.

Natural capital - Climate change will further impact on the productivity of **land** and force communities to look for new and/or additional farming plots. This problem will be compounded by the influx of people from other areas looking for land and access to water. Uncontrolled burning of new land areas will become more severe due to the hotter day time temperatures and shorter rainfall periods.

Communities are facing seasonal **water** shortage with a major impact on health and hygiene due to rationing. The impact on female labour during the dry season when rivers are not flowing or shallow wells have dried up is severe as they have to walk up to 5 km to neighbouring lakes and boreholes to obtain water. The Inselbergs are important sources of water but they can be are over 10 km away. Some communities consider migrating to areas where surface waters flow all year.

Deforestation is likely to increase due to the opening up of new land for agriculture and due to the increase in wild fires, thereby making the collection of **wood** more difficult and time consuming. Unless deforestation is being replaced through the replanting of deforested areas, local communities, women and children in particular have to walk even longer distances to collect the amount of wood they need.

In some areas **wildlife** is the only source of protein for the local communities and wild fruits and crops assist local communities in nutrition and medical needs. Uncontrolled fires are likely to increase, impacting the access to wildlife, wild fruits and tubers, which are also a critical source of food during hunger months, but are likely to become scarcer due to increased extraction during periods of food shortages. Communities located close to conserved areas are facing increased human-wildlife with elephants, rats, bushpigs, monkeys and baboons damaging assets and crops in the fields.

Physical capital - Communities are likely to face more damage to infrastructure (houses and roads) by heavy rain and uncontrolled fires, and may face more frequent or longer periods of isolation during certain periods of the year, due to the inaccessibility of the roads. Communities will rely during these periods completely on their own food supplies and internal network for assistance in social services (health and education). Houses in rural areas and in part of urban areas are made from clay and thatch, and although they are highly vulnerable to climate and other hazards, they can also more easily be repaired.

Adaptive Capacity

Adaptive capacity is the ability of a system to adapt to changes by changing its properties and behaviour in a way that it enables it to resist, absorb, cope and respond to impacts associated with

new or evolving hazards. Adaptation is quite complex and involves a process rather than a single action or application of a specific measure. Studies from the area have found that local communities have a number of coping strategies to deal with changing conditions, which include moving their production zone and planting alternative crops. However, some of these strategies are not sustainable and hence will not contribute to long term adaptation or resilience building. Government, NGO's and the private sector can play a role in enhancing the adaptive capacity of the local communities by for example (i) creating new sources of income, (ii) by modifying current coping strategies so that they become sustainable, (iii) by removing barriers and creating more favourable conditions for an improved livelihood, and/or (iv) introducing more sustainable adaptation measures or technologies.

CFD3 - HIGH CONSERVATION VALUE AREAS

A vulnerability assessment of the HCV's identified by the vulnerability to climate change of the identified HCV areas and because they are spatially explicit, it describes how these may shift spatially under the various climate change scenarios.

Under the current climate and as a result of human impact, HCV areas are already impacted by a decline in the number of species, by erosion of the coastal forest (which is the primary constituent of HCV3) and fragmentation of the landscape thereby reducing effective population sizes and patch sizes. The resulting fragmentation of the landscape reduces the ability of species to move across the landscape and respond to changes in environmental conditions, hence increase their vulnerability. Species with longer development time or limited ability to move are especially vulnerable.

Climate change will have most impact on fresh water and aquatic systems, and on forests (including riverine/riparian, coastal, mangrove, sand/dune). HCV areas, already fragmented, will further be impacted by human populations resulting in the accelerating of the decline of species. The increased use of riverine forests will significantly impact on their inherent biodiversity, but also as their value as corridors that facilitate migration of species. Increased number and intensity of fires will reduce forest cover and remove those species that are less adapted to fire. Expected changes in marine environment, such as increase in sea-level, increased water temperature, shifting currents will have significant impacts on the inter-tidal, sub-littoral and continental shelf zones. Reef biodiversity will be impacted and fish abundance will drop. Changes will be pronounced in the mangrove and coastal forests as the microclimate that allows them to flourish changes. Species will be lost from the smaller fragments and connectivity between fragments will be very important as is the maintenance of north-south connectivity.

In general however, changes will be slow and tourism should remain comparatively unaffected. As the effects of climate change are global, northern Mozambique however may retain whatever relative comparative advantage it has over its competitors, if these HCV resources are managed properly.

Of critical importance for adaptation to changing environments due to climate change will be the following:

1. Maintenance of corridors that will allow species to migrate as conditions change. The following areas will be of particular importance:
    a. Riverine or riparian woodland and forests
    b. Natural vegetation on steep slopes

   c. Corridors maintained between patches
2. Maintaining the continuity of the East African Coastal Forests (HCV3). These forests run along the East African Coast from Somalia to Xai-Xai in Mozambique. Given that Cabo Delgado forms an important link in the continuity of these coastal forests and that their continuity is a key aspect of their resilience to climate change, every effort should be made to ensure the integrity of these forests.
3. Conserving sufficiently large patch sizes that can sustain species and ecological processes
4. Conserving a representative diversity of habitats

Incorporating the assumption that the Quirimbas National Park would be adequately and effectively protected, the HCV areas that resulted from modeling are under-estimates of the areas needed to conserve the biodiversity, ecosystems and ecological processes in the pilot area because they assume climate stability. The HCV study suggested an area of 5470km^2 to be protected in addition to the 1961km^2 identified as already existing protected areas. By effectively conserving these additional areas HCV1 and HCV3 will be conserved. However, since this model did not incorporate climate change and is based on the current climate, incorporating the effects of climate change would increase the 'additional' area by at least 25%. These areas would largely be ensuring the integrity of links and corridors among the HCV areas that are sufficiently intact and large enough to allow migration of species.

It is also suggested that expansion of agriculture and industry remains within the 'excluded' areas and that development within the 'Available' areas should proceed only cautiously following analyses that ensure that any developments do not threaten the integrity of corridors. No development should occur in the 'additional' areas.

The private sector can play a significant role in reducing the impact of climate change related threats, which include:

- Offset of their spatial and carbon footprint through setting aside areas and resources (human and financial) for conservation (and in the pilot area, these would include HCV1 and HCV3 areas as well as corridors among the areas) as well as actively restoring habitats. Restoring habitats includes not only restoring natural vegetation but also removing alien, invasive and weed species.
- Assist with building capacity and making plans regarding adaptation and investment in response to climate change. This comes with the responsibility to act responsibly not only in their investment plans but also to build the capacity of the public sector and of civil society.
- Contributing to and partnering with civil society organizations that are directed to climate change mitigation or adaptation programs.

CFD4 - PRIVATE SECTOR INVESTMENT ATTRACTION

The attraction of the pilot area for the private sector, depends on a number of strategic issues, some of which are vulnerable to climate change. A number of strategic issues that investors are likely to consider when deciding to invest into this particular area were assessed in terms of their vulnerability to climate change.

Vulnerability of Strategic Issues for Investment

Location. Cabo Delgado is strategically located to fast growing markets such as Asia and Middle East and becoming a preferred place in Mozambique for investment in agriculture and forestry. Although the strategic position of Cabo Delgado and Mozambique for investment is strong, its attraction is mainly based on the presence of its natural resources, and hence makes it position vulnerable to climate change if not properly managed (see discussion of CDF1 and CDF3).

Water resources. One of the main assets and comparative advantages of Cabo Delgado is that the rivers are contained in Mozambique and therefore not susceptible to cross-border water agreements and conditions (shortage, excess water release, …). The amount currently available is enough for more than 200,000 ha additional areas of cultivation/plantation. There is no commercial usage of the water of the rivers as yet, but would be available for use in support of agricultural and industrial development. At current per capita usage rates, all river reaches have adequate water to meet demands until 2050. However, with an increasing population, about 60% of river reaches could become water scarce by 2050 compared to 25% in 2000. With new investments especially in the agricultural sector this may however be earlier. The water quality (in terms of salinity) will not be affected, compared to other river delta's in north and mostly south of pilot area, because of the nature of delta's of Lurio and Montepuez rivers being less prone to salt water intrusion. Increased rainfall will result in outflows rather than inflows.

Availability of arable land. According to HCV there is approximately 950,000 ha of land available for use, and most of this land has agricultural and forestry potential with good quality soils and suitable topography (reasonably flat land). Under current climate the availability of arable land is an asset for the pilot area and an attraction point for investors. However, land that is currently considered to be of acceptable quality may become marginal with increased frequency and intensity of droughts, or as a result of high intensity rains and floods. The change in seasonal rainfall patterns will increase the risk of dry land agriculture by making it more difficult to accurately predict the starting and ending time of the wet and dry seasons. Investment and insurance cost becomes higher.

Limited social and environmental constraints. There are large open areas with very low human population density and limited ecological conservation value due to the degradation of the natural environment that has taken place in the past. These sparsely populated areas with limited environmental value however are suitable and of interest to the investor for the establishment of large-scale modern agricultural and forestry development. Climate change likely to have a major impact on land as migration and re-settlement of population in search of better livelihoods is likely to increase to rural or urban areas of low risk (e.g. population movement from high climate risk Central Mozambique to low climate risk Northern Mozambique). This migration will increase pressure on natural resource base and may have an indirect impact on nearby or downstream located investments that are likely to experience a reduced supply of natural resources, especially water.

Infrastructure. Infrastructure is one of the weak points for Cabo Delgado and makes transport and communication also highly vulnerable to climate change. Many important arterial roads are unpaved and are impassable under high rainfall conditions. The reduced access during the rainy season increases transport costs and the general cost of developing and maintaining rural enterprises such as agricultural and forestry projects. The only resources assets in terms of private sector investment which are also less vulnerability to climate change are the ports Pemba and Nacala. They are wind and wave sheltered and they have excellent maneuverability within the basins. They are less

vulnerable to cyclones and storms compared to other ports along the Mozambican coastline. If no improvements and investments are made in the public infrastructure, its vulnerability is likely to increase due to the predicted increased frequency of heavy rains, storms and cyclones, especially along the coast. The cost of constructing and maintaining infrastructure such as roads and drains is likely to increase and hence the transport and other transaction costs.

Vulnerability of Investment Options

Tourism. The pilot area has a high potential for tourism, which include areas of interest such as the coastal and marine area's (part of the Quirimbas National Park). There is also considerable potential for ecotourism related to game viewing and hunting. Conservation of these areas is important and as discussed in previous sections (CDF1 and CDF2) the ecosystems that provide the tourism services are highly vulnerable to degradation and fragmentation caused by anthropogenic drivers rather than natural drivers, including climate change. The predicted changes in climate will have limited direct impact on the areas of interest for tourists under the condition that they are well protected and preserved. As discussed under CDF2, more prolonged dry spells and/or shortage of water however, will influence the migration of wildlife in search of water and food, and hence increase incidents of human-wildlife conflict. Numbers of elephants and other wildlife is likely to decline. Increased rainfall could increase the risk of malaria, which may influence tourism flow during the rainy season.

Agriculture. Large areas are suitable for large scale agricultural and forestry development such as food and biofuel crops and plantation forests. As the pilot area is already experiencing more heavy rainfall and prolonged dry spells during the growing season, investments in commercial farming with crops and varieties that are less sensitive to climate change are most likely to do better. Water storage and irrigation will likely become necessary.

Forestry. Forestry is less vulnerable to climate change, however, changes in temperature, precipitation and increased atmospheric CO_2 concentration has an impact on productivity. Forests are however very vulnerable to the increased incidence of forest fires, and increased pressure from local communities in search of wood and wild foods.

CLIMATE CHANGE IMPACT ON THE STUDY AREA

The more general nature and broad statements on climate change vulnerability of the various critical factors of decision making discussed in the previous sections, are valuable for general awareness and strategic planning, but for more targeted decision making, decision makers would like to know to what degree changes will occur and/or what these changes mean in terms of supply and demand, especially in terms of ecosystem services which are the basis of livelihood securities, investment opportunities, etc. The SEA team was invited to a workshop where they able to apply their expertise and the assessment made in previous section into an analytical model that:

- identified in detail the type of services supplied and the relative supply levels
- Identified the demand and/or role of those services for users at various levels (local, downstream, provincial, national and international level) and the dependence on those services
- Identified the relative changes in service supply level under the three climate scenario's

It has to be noted and stressed that the estimates of supply values and demand numbers serve to provide **orders-of-magnitude indicators**. These values are therefore only indicators useful for

comparisons between different services, users, land units and future scenarios. Their relative values are important and not their absolute values, and should therefore be used as such. The Box below shows the change in the supply of the various ecosystem services that can be expected as a result of climate change for the Maguide River Basin.

Ecological Services *Listed in descending order of supply magnitude (highest supply on top, lowest supply at bottom of list)*	**Total supply score**	**Fraction remaining under Scenario 1**	**Fraction remaining under Scenario 2**
Natural heritage	2253898	0.81	0.38
Food - plants, fish, bushmeat	2153262	0.78	0.50
Flood attenuation	2091005	0.78	0.41
Sense of place	2058387	0.78	0.46
Land based recreation	2012736	0.84	0.44
Micro climate management	1958845	0.78	0.37
Marketing icons	1919232	0.77	0.36
Refuge or nursery for wild plants and animals	1829975	0.83	0.39
Water quality management	1787761	0.75	0.35
Disease control	1786932	0.77	0.37
Medicinals	1646168	0.79	0.42
Fibre for construction	1492120	0.95	0.50
Fire damage control	1448563	0.74	0.42
Fodder	1282043	0.93	0.57
Energy –wood	1246119	0.94	0.50
Cultural heritage	1228677	0.85	0.63
Carbon sequestration	1223445	0.94	0.43
Soil stability	1190233	0.93	0.50
Water based recreation	1102965	0.65	0.32
Ground water recharge	1103116	0.92	0.50
Soil formation and fertility	1029604	0.96	0.44
Water supply regulation	1030828	0.94	0.52
Wind damage control	908506	0.95	0.54
Pest control	753982	0.81	0.39
Coastal storm damage control	484479	0.97	0.66
Water supply	194736	0.94	0.46
Salinity control	86398	0.99	0.49

The following observations are notable for the status quo:

- The area has high capability of supplying natural heritage, recreation, sense of place, and marketing icon services – which are all suited to conservation and tourism land uses.
- The area has a high capability to supply food security services – both cultivated and wild harvested (marine, freshwater and terrestrial), indicating high potential for sustaining rural livelihoods.
- The area has a variable capability to supply water security services, with water supply being the second lowest.
- The highest supply score is 26 times greater than the lowest score.

The following observations are notable for the future scenarios:

- The services with the greatest supply (the top half of the list) change the most, with many of the services declining some 20% in future 1 (moderate climate change predictions), and between 50% to 60% in scenario 2 (worst case scenario).
- The lowest scoring services change the least in future 1, with a 5% to 10% decline in services levels likely. However, these services reduce significantly in the worst case scenario – with a 45% to 55% reduction in services.
- The lowest scoring services are at least risk in Future 1 scenario, while the highest scores are at greatest risk in Future 1.

By combining a number of services into clusters, it was possible to formulate more specific risk and opportunity statements for livelihood securities and, highlighting key strategic issues for development in general and a number of investment options in the pilot area in particular. The results are summarized below.

IMPACT OF CLIMATE CHANGE ON ECOSYSTEM SUPPLY LEVELS – RISK & OPPORTUNITY STATEMENTS

LIVELIHOOD SECURITY

Food security

The area has inherently high capacity to support food security, with marine, estuary and terrestrial assets, but with probable high loss due to limited pest control. Overall the supply level becomes moderated by pests.

There are a wide range of services supporting food security, by a wide range of habitats – generating an inherently broad base for food supply. However, with climate change there could be a 13% decline across the services. With the worst case scenario there could be a 54% decline in food security.

The area has a moderate potential in the soil formation and fertility service, offering good soils and heat units for production. Soil fertility is linked to the woodlands, and dependent on the current system of fallows. However, water is limiting.

Water Security

Access to water will severely limit development in this area. Access to surface water is vulnerable, with water supply one of the lowest scoring services. However, there is only a 5% reduction in supply expected under scenario 1, but in the worst case scenario, water security could be reduced by 51%. There is unlikely to be sufficient water for large scale users such as irrigation and timber.

Energy Security.

The area has a good capacity to supply wood energy, but is moderated by the slow regeneration of miombo. The wood energy supply is vulnerable due slow regeneration and due to a narrow range of services - only wood supplies energy

Health Security.

The area has a high capacity for health security given the relatively high food score above, and the good water quality accessible. Access to medicinals helps elevate security.

Whilst supply is currently good, this service is vulnerable, with a possible 23% reduction in scenario 1. Healthy security services are likely to change by the greatest degree when compared to all other services. The worst case scenario shows a 62% possible reduction.

Disaster Management.

The supply of disaster management services shows that marine linked services are low, whist land based

services supply are moderate (fire management) to high (flooding management).
However, the land based services are vulnerable to climate change, with a 22 to 26% reduction possible. The marine based services are less vulnerable, with only a 3 to 5% possible reduction.

Wood and Fibre Security.
There is a moderate potential to supply wood fuel energy from current stocks. Production is limited by dry season temperatures and water stress - hence the deciduous nature of miombo. Fibre for household construction is moderate to high, being limited also due to slow regeneration of miombo. The supply of wood and fibre is vulnerable to climate change due to the slow regeneration and narrow range of services available.

DEVELOPMENT OPPORTUNITIES AND CONSTRAINTS

Natural Heritage.
The top scoring service - with the highest national demand. Potential for growing the national conservation estate is high, especially with links to Quirimbas. However, conservation as a land use is vulnerable to climate change

Land Based Recreation. High potential to supply tourism services, with large international demand for wilderness and combined coastal experiences. Low current demand, with a moderate vulnerability to climate change.

Sense of Place & Marketing Icons. The sense of place and marketing icon services of this region are high. The outstanding marine assets represent a global opportunity for tourism. Climate change has the potential to seriously impact on quality of coral reefs, with implications for this region in terms of its international competitiveness or comparative global advantage.

Cultural Heritage. The social and cultural traditions linked to the areas with natural assets are an important national asset, with potential for tourism. These services are moderately vulnerable to climate change. However, cultural values are seldom transformed into significant economic opportunities in Africa.

Water Based Recreation. The marine and estuary assets offer significant tourism opportunities, especially at a regional and global scale. The local market for recreation is small. However, climate change has a potentially high impact on coastal tourism, and consequently any venture will need to diversify its focus to ensure sustainability. A 35% reduction is possible with climate change

Carbon Sequestration. This has moderate potential for the area. However, it offers a significant opportunity for low income households to engage in a growing global market. There is a moderate potential to supply wood fuel energy from current stocks. Production is limited by dry season temperatures and water stress.

From the above analysis it can be concluded that the area has a clear opportunity for natural areas management, for biodiversity conservation, carbon sequestration and tourism. Good management in this area would also promote water security for the areas livelihoods.

BUSINESS RISKS AND OPPORTUNITIES

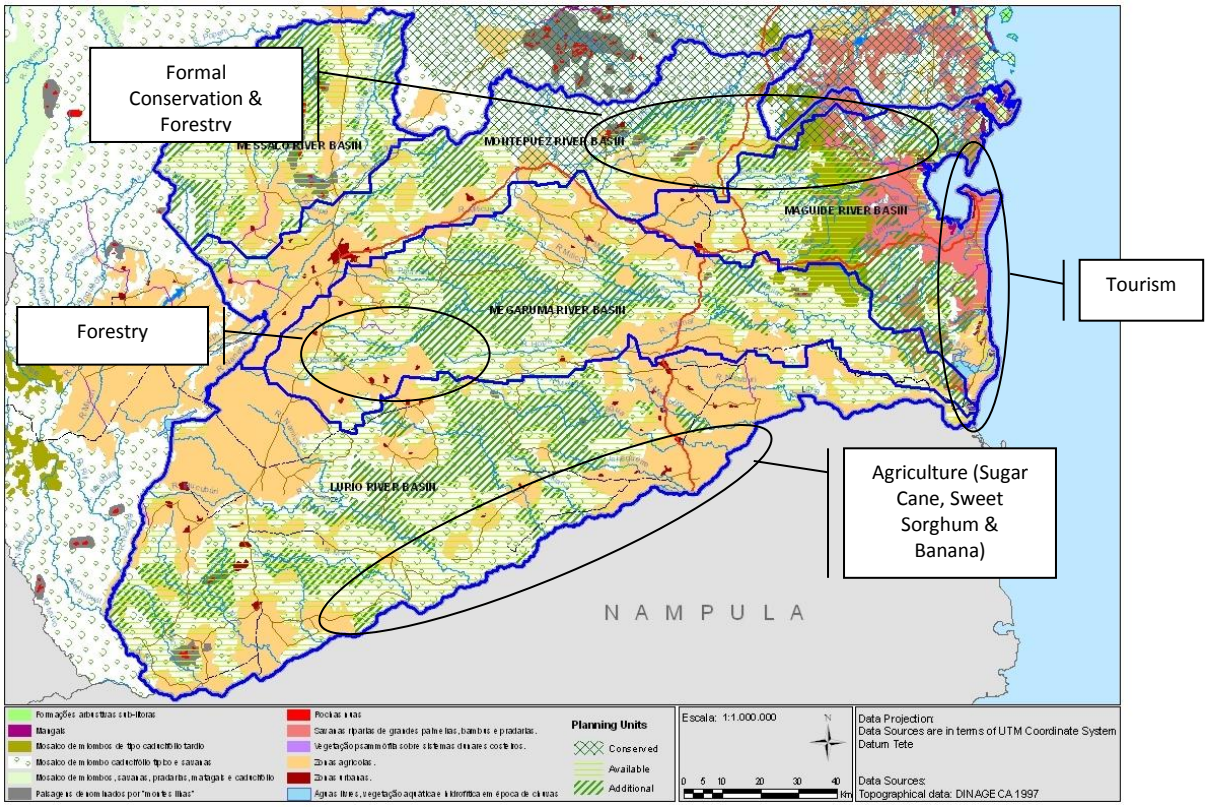
In its brief on Adaptation to Climate Change, the World Business Council for Sustainable Development (WBCSD) states since climate change is an inexact science and the impacts are still not fully understood. the effects of climate change are best evaluated on a sectoral and geographic basis.

The vulnerability assessment from this SEA and the tools used, such as the ecosystem supply and demand analysis are able to provide the basis for a geographical and sectoral analysis of the climate change impact, and the associated risks and opportunities for private sector and other stakeholders.

Geograpical Basis. Decision makers in Government and private investors will benefit from location-specific climate risk assessments. The ecosystem supply and demand analysis, which is based on geographical and population data, provides exactly this kind of information, indicating the areas of highest vulnerability to climate change or where the services they require for their business or investment is in sufficient supply and provide them with the required opportunities to develop their business. Using GIS tools area specific maps can be produced as a basis for decision making:

(i) **Location of investment** maps indicating the areas which are most suitable (or best to be avoided) for investment and which areas need to be conserved (see map below)

(ii) **Service supply vulnerability** map(s) for specific ecosystem supplies (e.g. water supply, water based recreation) underpinning livelihood securities and/or private sector investments.



Sectoral Basis. Business risks and opportunities resulting from climate change play a role in three spheres of activity and influence (WBCSD):

- within operations and supply chains ("within the fenceline")
- in partnership with surrounding communities ("beyond the fenceline")
- in collaboration with the wider community ("beyond the horizon")

This model was followed to summarise the information from the vulnerability and impact assessment for the three investment options to be considered most relevant to the study area: agriculture, forestry and tourism. Below is the example for tourism.

TOURISM	
Risks	**Opportunities**
Inside the Fence	
• Supply chain interruptions due to inaccessibility of roads during rainy season, especially in the start of especially in beginning of rainy season (NDJ), which is high tourist season in Southern Africa. • Increased cost of cooling during hot season. • Marketing icon affected due to degradation and loss of areas of interest to tourists, such as coastal erosion and loss due to sea level rise, encroachment of forest/wildlife areas by local population. • Wildlife tourism and hunting affected due to migration and loss of wildlife caused by increased human-wildlife conflict. • Increased risk for tourists and employees to catch malaria, cholera or other water borne diseases due to heavier rainfall and local flooding. • Inaccessibility during rainy season causing problems in arrival and departure, travel to places of interest and an increased risk of delays/cancellations. • Extreme weather events causing damage to tourist infrastructure.	• Marketing: the area is less vulnerable extreme events than other areas in Mozambique and than other popular tourist destinations in the world (e.g. Thailand, Brazil) • Later start of rains could benefit tourist season. • Beach resorts: the coastal area is still relatively scarcely populated (compared to e.g. Tanzania) and is endowed with pristine beaches and clean water for coastal recreation • Coastal/wildlife package: close to protected areas • Wildlife concentrations: concentration of wildlife around natural or manmade water-holes with increased dry spells • Eco-tourism with low-cost building/maintenance/repair but high cost service charge. • Social and cultural traditions linked to the area's natural assets are a national asset with potential for tourism.
Beyond the Fence	
• Workforce with increased risk of water borne and other climate related diseases. • Migration of skilled and educated labour to other areas. • Competition for water and fuel.	• Income generating activities for local communities • Expanded markets for products and services
Beyond the Horizon	
• Loss of link with regional and international landscape features and conservation areas	• Conservation of important HCV areas and other natural and cultural heritage sites of national and international importance. • Mozambique will benefit from increased revenue, and an expanded market for various products in other areas (markets in nearby towns, travelling through, stop-overs) • Positive marketing and experience will promote other tourist destinations in Mozambique. • Attraction due to relatively "safe" climate proof areas may increase.

ADAPTATION OPTIONS FOR AND WITH THE PRIVATE SECTOR

Based on the analysis of business risks and opportunities, and following the same model suggested by the WBCSD, the following are examples of adaptation options that could be considered by and with the private sector in the three areas of influence. The box below shows the resulting framework for adaptation options for private sector investments in the pilot geographical area.

WITHIN THE FENCELINE – Within operations and supply chains

Tourism

- Infrastructure adjustments to reduce risk of damage to the property and facilities (dune stabilization, cooling facilities, …)
- Investments to ensure/improve comfort of customers (malaria netting, cooling, spraying, water filtering, …)
- Invest in water and energy efficiency
- Emergency response plans
- Adapt activity programs to changing conditions

Agriculture

- Fire damage control
- Pest control
- Planting of suitable crops or varieties
- Water conservation and efficiency
- Investment in storage and transport facilities

Forestry

- Fire damage control
- Investment in transport facilities
- Replanting with species adapted and resilient to changing conditions

BEYOND THE FENCELINE – In cooperation with surrounding communities and organisations

Local Community Livelihoods

- Creating new sources of income (direct employment, market for their products,..)
- Investment in health and education facilities for a more healthy and skilled workforce
- Improve the livelihood resource situation, i.e. improve quality and quantity of existing resources or create (access to) new ones (provision of boreholes, planting of fruit trees, wood-lots, …)
- Assistance in creating fire-breaks and other fire damage control measures
- Provide technical assistance to reduce limitations and barriers of current coping strategies and develop measures for resilience and more sustainable 'adaptation' strategies (i.e. provision of improved and more resilient crop varieties, supporting the extension services promoting water and other conservation techniques and other agricultural, business or household ideas & techniques)
- Meeting with communities for information exchange and emergency planning

Conservation of High Conservation Value Areas

- Ensure that any developments (i) are not in areas earmarked for conservation, (ii) do not threaten the integrity of wildlife corridors and (iii) do not contribute to habitat fragmentation (e.g. location of new roads)
- Offset spatial and carbon footprint through setting aside areas and resources (human and financial) for conservation (and in the pilot area, these would include HCV1 and HCV3 areas as well as corridors among the areas) as well as actively restoring the habitats. Restoring habitats includes not only restoring natural vegetation but also removing alien, invasive and weed species.

BEYOND THE HORIZON – In collaboration with the wider community

- Avoiding a reputational risk as being seen as a contributor to climate change, by setting an example and promoting the use of technologies that are eco-friendly and build resilience to climate change.
- Producing products in an environmentally and socially responsible way can lead the way to certification and a brand name that differentiates itself from competitors in a crowded market.
- Contribute to conservation of natural heritage and maintenance of large landscapes, such as the East African Coastal Forests, that sustain species and ecological processes which provide resilience to climate change.

WIN-WIN OPTIONS FOR RESILIENCE BUILDING WITH THE PRIVATE SECTOR

The WBCSD states that " Business is positioned to be a very positive force in addressing the challenges of ecosystem changes (including climate change impacts) through the pursuit of new business opportunities and markets, reduction of operational footprints, development and deployment of new technology and establishment of effective partnerships. "

The following the models identifying risks and opportunities and for identifying adaptation options, illustrated and discussed in previous sections by the private sector. The government has however also an important role to play in making a difference between "business as usual" and "sustainable in the long term". This can be done in two ways:

(i) By promoting and supporting the adaptation by private sector companies already operating in the pilot area or investors with approved plans and/or allocated land in the area. Examples include supporting the introduction of green technologies by funding the difference in cost of the installation of standard technology and improved and energy efficient technology.

(ii) By identifying suitable and 'available' land for investment (using HCV, GIS & SEA) and pro-actively invite a selection of corporate responsible investors that can provide a role model to others in the sector.

While further investigation in this subject is beyond the scope of this project, one example has been worked out and illustrates how win-win options for resilience building with the private sector could work. Below is the "climate proofing" of EcoEnergia's planned BioEthanol & Sugar Investment with a list of adaptation options for suggested private and for public/private financing. A similar model could be followed for other planned investments in the area.

EcoEnergia BioEthanol & Sugar Investment "Climate Proofing"

Risks	Opportunities
Inside the Fence	
• Seeds washed away during heavy rainfall and replanting needed. • Increased risk of pests and disease, especially from birds (seeds of sweet sorghum), termites (eating the sugar cane), grasshoppers • Prolonged dry spells increasing the need and cost of irrigation. • Inaccessible roads during rainy season	• Opportunity for expansion with more 'degraded' but 'recoverable' land becoming available and water availability (Lurio River) ensured. • Opportunity to test new production techniques (e.g. combination of sugar cane and sweet sorghum for bio-ethanol production) • Testing of more suitable (drought & pest resistant) varieties • Increased supply of sweet sorghum through the development of out-grower systems
Adaptation Options – Private Financing	
• Selection of new varieties • Irrigation • Water harvesting and conservation techniques • Pest control • Development of out-grower systems for sweet sorghum	
Beyond the Fence	
Risks	**Opportunities**
• Shortage of water, firewood, energy • Health of local communities (including employees) • Roads inaccessible • Potential land conflicts with the expansion of crop area of local communities and the in-migration of people from Nacala that is more prone to cyclones. • Local communities further encroaching into riparian areas which will bring a higher risk of pests. • Competition for water from other large scale investments that will require lots of water. • Local communities not changing their farming practices (slash&burn, rotation) thereby taking more land from forests and wetlands where EcoEnergia also depend on.	• Small extra cost to install extra water storage facilities and boreholes for the local communities. This will also improve the good relationship with the communities. • Sweet sorghum produced in out-grower centers is also an opportunity crop for the local communities. • Diminished pressure on land and out of subsistence farming because a % of the population will turn into salaried employment. • Energy production supply to local market (BioEthanol and waste for briquette making) • Energy from solar/wind energy can contribute to the public energy grid, increasing the availability of energy for other potential investors. • Opportunity for conservation of protected areas • Rehabilitation/installation of water dams
Adaptation Options – Public/Private Financing	
• Promotion of improved agricultural techniques • Conservation of riparian areas and other protected areas • Installation of briquette making infrastructure to turn waste of factory into fuel • Installation of solar/wind energy • Installation of water storage and boreholes for local communities • Maintenance of access roads • Implementation of well designed Social & Environmental Management Plan	
Beyond the Horizon	
Risks	**Opportunities**
• Reputational risk for degradation of land associated with monoculture • Accusations of "Land Grab"	• Adaptation investments • Certification and premium price for products • "Designed-in" sustainability from outset • Risk mitigation tool

MODEL FOR REPLICATION IN OTHER AREAS

Reference is made to the Analytical Framework on page 8 of this report. Following and tested this framework in terms of the information collected, studies consulted, approaches followed and tools used, resulted in a method to develop win-win options for resilience building with the private sector. The following are a few remarks that can be taken into account for replication in other areas:

Information requirements. The study area that was selected had a rich supply of information available. This may not be the case for other areas. However, both the SEA and Ecosystem Services Supply and Demand Analysis are tools that do not need a huge amount of scientific data. The advantage is that these are tools that work with and integrate local knowledge and expertise. Similarly, the tools developed and used for collecting information from and with local communities, such as CRISTAL and CVCA are based on discussions with the communities. If more quantitative data becomes available, this can be used and integrated in the process, thereby making the predictions of risks and opportunities for private sector and wider community more specific. However, in view of the 'pre-cautionary principle', there should be enough information in any study area to apply these tools and come to a set of adaptation options with the private sector that result in a higher resilience to climate change. There is no excuse to wait with action.

Geographical representation. Based on the approach and tools used, the geographical representation of the results suggested in this study would provide a strong and user-friendly tool for decision makers and potential investors. The HCV, and Ecosystem Services Supply and Demand analysis are based on the vegetation and land use maps of the area and allow for further analysis/overlays with GIS. Examples of other applied and/or thematic maps that can be generated include (i) areas depicting specific vulnerabilities, such as a shortage of water supply, or (ii) land management maps with proposed conservation areas and migration corridors, or (iii) maps showing areas with highest potential for specific land use or investment potential, etc..

Time & Cost. The analysis took longer than planned, as a number of approaches and methods were tested for the first time taking a climate focus and/or private sector approach. The consultants also needed more time to apply their expertise and knowledge to making predictions under three climate scenario's and using climate specific assessment criteria. For the consultant who facilitated the Ecosystem Services Supply and Demand workshop, it was also a new experience applying his model for climate change. Hence, replication in other areas would probably take less time, not only as there is now a model available, but also as most of the information generated in this study can be used in other areas (e.g. the vulnerability of the various ecosystems under the three climate scenario's) and would need only reviewing and/or complementing. Below is an estimate of how this process could be replicated in other areas. The total time required is estimated at 40 working days for the team leader or approximately 3 months for one study area. It has to be noted that replication of this exercise should include travel of the total team to the study area, which was not possible on this occasion due to shortage of funds. Similarly, the results of the study should be presented for review and comments at a meeting in the study area, where follow-up and an action plan can be agreed upon. The cost for replication can be worked out in detail.

Technical work	Activity	Human Resources	Days
Baseline & Trends	Literature review	Team Leader	5
	Local data collection	Team Leader	5
	Specific data collection	Team Leader	5
Climate Scenario Building	1 day meeting with Metereology & INGC	Team Leader	1
GIS	Data analysis and mapping	GIS specialist	4
High Conservation Value	Analysis by consultant	HCV Consultant	5
Strategic Environmental Assessment	• 2 day return travel Consultant (Durban-Maputo)	Team Leader	14
	• 2 day Preparation (team leader and consultant)	Consultant	16
	• 2 day Travel with Expert team	3 Experts	7
	• 5 day workshop with Experts and Local Stakeholders	6 Local Stakeholders	5
	• 5 day Report Writing (team leader and consultant)		
Report	Compilation of final report	Team Leader	10
Presentation of results and preparation action plan	Meeting in study area for (i) presentation of results, (ii) review and comments, (iii) formulation of action plan	Team Leader	4

COMPONENT II

IMPLEMENTATION OF ADAPTATION

COMPONENT II – ADAPTATION PROJECT

BACKGROUND

Component II of this project consist of a pragmatic learning-by doing implementation of an adaptation project. It has been implemented by a private sector investor, EcoEnergia de Mozambique Lda as part of their plans to develop a BioEthanol production cluster project of a net planted area of 125,000 ha.

EcoEnergia de Moçambique Lda is a Mozambican (98%) registered subsidiary of EcoDevelopment in Europe AB, and VerdeAzul Lda (2%) and has a mandate from its owners to identify and develop projects for investment and lead the development of an organisation that is aimed to produce AgroEnergy for the global market. EcoEnergia has selected Cabo Delgado for its investment in sugar cane and other energy crops.

EcoEnergia intends to develop a role-model cluster investment concept for the development of globally competitive, CO_2 optimal BioEthanol and BioElectricity production, guided by the principles of ecological, social and financial sustainability.

A cluster investment is a number of private investments concentrated in one geographical area that mutually support and strengthen each other, as well as reinforce parallel investments in public sector development in the surrounding communities. A Cluster forms a "critical mass" of production and know-how large enough to tap into the international market. Once in place it provides substantial spin-off effects for services and suppliers, opening up access to the international market for Mozambican enterprises and entrepreneurs.

EcoEnergia aspires to reach a number of key milestones which include:

- Activate the internal market for Biofuel with a view to reducing expensive import of fossil fuels;
- Put large areas of degraded land and land with low value vegetation into productive use (while taking water and crop change projections resulting from climate change in consideration);
- Create employment and business opportunities, lifting a significant part of the rural population out of poverty
- Investment in a dam for irrigation would provide water for agriculture and bring potable water to local communities - this is one of the highest priority issues presented by the population of Cabo Delgado as a development constraint. This provides a base for a win-win investment.

SELECTION OF CABO DELGADO FOR INVESTMENT

Cabo Delgado was finally selected for the following reasons: It has land available, good soil and water resources and the environmental and social/stakeholder limitations can be managed in such a way that a sustainable and successful project can benefit both the investor and the communities.

The provincial capital Pemba has a Port that is one of the three the most suitable port locations in the country. The port has potential for a large expansion and is the third largest natural deep sea bay in the world.

The National Power Grid that reaches Pemba and Montepuez and is now expanding further to the north almost up to the border with Tanzania. A tarred road of good quality called EN1 (National Highway #1) stretches from Nampula in the south to Pemba City/Port. A likewise good tarred road goes westwards from Pemba to Montepuez, and from there a continuation is being constructed to Lichinga, the capital of the neighbouring province Niassa to the west. From Pemba to the north there is another tarred road, but of less good quality, that goes up to the border with Tanzania.

The population density and therefore pressure of land in Cabo Delgado is low with an average of 10-12 persons per square km. Competition for land in Cabo Delgado is mainly for conservation and logging. There are substantial areas with low value vegetation cover and degraded land due to large scale cotton out grower production. Local farmers are organized and collaborating to undertake cash crop production. These farmers are interested and looking for alternative cash crops that can provide a secure income and higher value return.

OBJECTIVES OF THE ADAPATION PROJECT

EcoEnergia is committed to undertaking steps towards adaptation and climate resilience, by testing the combination of sugar cane with sweet sorghum – a climate resilient crop able to sustain changes in temperature, evaporation and longer dry spells. The intention of the adaptation project is to learn about the possibilities of substituting cane for sweet sorghum and combining the two crops to (i) produce food as an added product to ethanol, and (ii) maximise productivity, by guaranteeing the continued operation of a planned distillery under conditions less suitable for sugarcane and expanding the harvesting window to run the distillery for a longer than the region average distillery operation time. EcoEnergia has plans to install a "Natural Sugar"[4] factory by August 2011 and a laboratory size distillery by December of 2011.

The results from the adaptation project also expected to:

- Establish collaboration with local farmers to test and understand the potential of out-grower systems for sweet sorghum.
- Provide information and conclusions which feed into a feasibility study (social and environmental considerations) for scaling up to a commercial size investment.
- Create awareness on climate change and adaptation at the local community level.
- Provide lessons learnt for feedback to component I of the INGC Theme 4 project.

THE TEST SITES

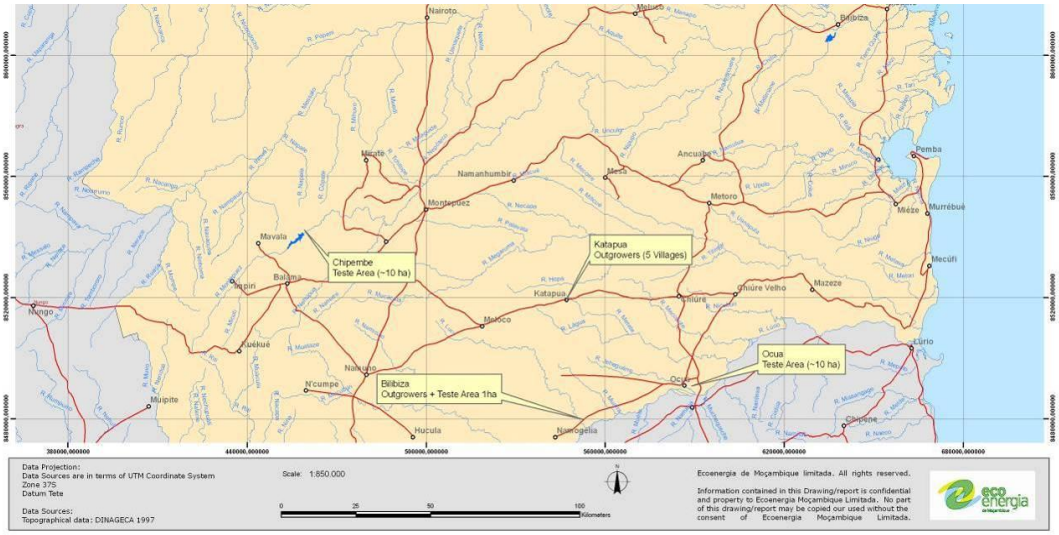
EcoEnergia has established the two test sites in close contact with the local villages. The test areas are situated on previously used farm land which has been degraded. The community has been part of taking the decisions on where the test sites would be located. The employees of each test site come from the area. The community expects that the investment will bring jobs and that the dams for irrigation of crop lands also will provide water to the villages. The community also expects improvement in the local social infrastructure such as schooling roads and health.

[4] "Natural Sugar" refers to organic, raw sugar.

The adaptation project goes beyond the two test areas in that it involves collaboration with local farmers to test and understand the potential for out grower systems of sweet sorghum. Two villages, Katapua and Bilibiza have been selected and in each area EcoEnergia is working with around 56 farmers.

Current farm land practices by local communities demand large areas for each household and between 10 and 14 ha has been degraded by each family whilst the average plot size is around 1.3 hectare. The productivity on these plots is less than half of the productivity of similar land plots in the region. There is therefore potential to host a larger commercial crop land in the area *if* technologies are improved in the local communities.

The two test site locations and the two locations for collaboration with local farmers in Cabo Delgado which are being implemented are illustrated on the map below:



Ocua and Chipembe test site and test sites for plantations with local farmers in Cabo Delgado

ADAPTATION OF SUGAR CANE

In March of 2009, three varieties of water efficient sugar cane seedlings, that can grow under dry land conditions with supplementary irrigation were brought from the South Africa Sugar Cane Research Association (SASRI) and planted in EcoEnergia's test sites in Ocua and Chipembe. Trials were established to test and compare how more water efficient they are compared with other varieties. Water consumption of sugar cane is estimated at 10,000 mm/ha/year (= normal consumption) and testing of new varieties tries to bring this down to 50%.

First results indicated that performance of the varieties in Ocua was generally better than in Chipembe, which can be explained by the difference in rainfall pattern. In terms of varieties, it was noted that the N21 variety achieved best results with 60 tons/ha in Ocua and that the N31 variety performed poorest in both test sites (30-40 tons/ha). The two other varieties achieved a similar yield of 50 tons/ha in Ocua and 40 tons/ha in Chipembe. However, these results are not conclusive and further testing is needed, as (i) these are results from test sites and not commercial farms, and (ii) these dryland varieties received extra water via irrigation.

Although results are promising, there is at least one more season of testing in Ocua and Chipembes needed for the selection of at least two suitable varieties of sugar cane. These preliminary results indicate that it is possible to produce enough sugar cane seed to plant a total area of 120 ha and produce 1060 tons of sugar cane. This amount of sugar cane can be processed from May-June when sweet sorghum is not available. The combination between sweet sorghum and sugar cane will maximize the operation of the planned distillery and reduce the time of investments cost recovery.

TESTING OF SWEET SORGHUM AS ALTERNATIVE TO SUGAR CANE

has used for his/her household for generations and therefore know well. The advantage compared to sugar cane in general but also in terms of climate change is that:

- Sweet Sorghum grains can be kept for food, while the stem is used ethanol processing;
- Sweet Sorghum takes one third of the water and half of the fertilizer compared to Sugar Cane;
- It is more resilient to changes in climatic conditions;
- Sweet Sorghum is quicker in rotation. It gives a return to the farmer in four months;
- Ethanol can be used for stoves and diminish deforestation (often tropical high value timber).

Selection of suitable varieties

The sweet sorghum tests have been implemented in collaboration with the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and the Mozambique National Institute of Agriculture Research (IIAM). Prior to this project a total of 24 varieties of sweet sorghum were tested for both ethanol and grain production alongside with seven varieties from different sources in India, South Africa and Australia (December 2007 until June 2009). The parameters used are adaptation to the local conditions, biomass production, sugar content (brix), juice content and grain production.

From these the 5 best varieties were selected for further testing. The sweet sorghum that was planted however did not perform so well and although the sugar content was similar, they showed up to a 50% difference in yield of biomass. This difference could be due to the lower rainfall recorded during that period, but more likely due to the lower temperatures, as the crops benefitted from 395 mm of irrigation water.

The results however allowed to select the 2 best performing varieties from the 5 tested, but as the current harvesting results are not yet sufficient to come to definite conclusions, more research is needed into the less-sun sensitive hybrids. While they may have been performing well in India, (ICRISAT), they have as yet not shown the same results.

Sweet Sorghum production in the test site in Ocua, Cabo Delgado

Testing of out grower systems for sweet sorghum

The adaptation project goes beyond the two test areas in that it involves collaboration with local farmers to test and understand the potential for out grower systems of sweet sorghum. The project established adaptation tests of five pre-selected varieties in the two villages, Katapua and Bilibiza. In each of the two villages farmers were identified to participate in on-farm trials to analyse the performance of two varieties of sweet sorghum under traditional but improved technologies (plant spacing of 10 x50 cm and application of 50kg/ha NP fertilizer). The 25 farmers selected in each village received seeds and farming inputs such as fertilizer and herbicide, and planting was carried out in December 2009. The plots and plants were monitored in terms of biomass, sugar content, juice content and general performance of crops. The project also estimated the potential income of farmers compared to other cash crops and activities, and assessed the grains of sweet sorghum for use as food.

Harvest of the crops did not show significant results between the two technologies, and repetition of the trials in 2010 was needed. Results from 2010 harvest showed a significant improvement in Bilibiza with a 20% increase in yield under improved technologies. Katapua only recorded a 10% increase and this can be explained by the difference in soil quality. The soils in Katapua are shallow and the humid conditions created after heavy rainfalls are not ideal for sweet sorghum.

The best performing planting and harvesting windows for sweet sorghum found were December-February and March-April. If sweet-sorghum can be sown in March-April, this would be the best for out-growers, as it is during the “lean” season, or the low labour months and they could use and sell their produce in July, providing extra food and income during the winter months, when

opportunities for seasonal work are limited. But unfortunately, these are also the dryer months and it is probable that irrigation would be required.

Another potential constraint for out growers is that the harvest of sweet sorghum needs to be done when it is ready (12 hour window) and its processing has to be quick. There is however a possibility to turn the sweet sorghum into a syrup for sale later in the year. However, more research is needed and EcoEnergia in cooperation with a local NGO is planning to do more tests and have demonstrations for jaggery production, as this would really benefit farmers and alleviate poverty.

Testing sweet sorghum for food consumption provided the first feedback from the local communities, indicating a preference for the white varieties over the brown and red ones.

More research and tests are needed to improve sugar and biomass content. Further research is also needed to establish the right time for seed collection. If sweet sorghum is cut and harvested at the time ideal for ethanol (sugar content highest in stem), grain yield is only 2 ton/ha. However, if it is allowed to mature in the field grain yield will be 30% higher as sugar would have gone into the grain. Tests are now being conducted with fertilisers that could increase the sugar content.

MEETING WITH THE LOCAL COMMUNITIES

Every year, at their test site in Ocua, EcoEnergia organises a meeting with the local communities. While the main objective and topic of these meetings is to discuss progress on the EcoEnergia project, they offered at the same time an excellent opportunity to discuss other issues, such as climate change.

The advantage of this annual meeting, compared to organizing a separate meeting or survey on climate change, is the number and the variety of the audience gathered and hence the interaction and feedback that is obtained from the various levels of decision-making formally during the meeting, but also informally before and after the meeting through more in-depth discussions with a number of participants. The first meeting with local communities was held on 30 November 2009 and the second meeting on 15th December 2010. Participants included the the Permanent Secretary of Chiure, Chefes de posto, community leaders, representatives women and youth organizations, community council representatives, persons responsible for education and health and traditional leaders from the 35 villages in the district of Chiure - all involved in the EcoEnergia Project. The total number of participants amounted to 80 in 2009 and 97 in 2010. The discussions in both meetings were held in the local language Macua with translation to Portuguese.

Annual Meeting in November 2009

The ***objective of the 2009 meeting*** was to:

(i) identify the climate change challenges that the communities face in their daily lives and,
(ii) discuss how the communities cope with these challenges.

The ***objective of the 2010 meeting*** *was to*:

(i) review the discussion of last year on climate change impacts, and
(ii) discuss in more detail the main issues of concern which were mentioned at last year's session and the main issues that came out from the SEA analysis.

Annual Meeting inDecember 2010

The communities reported changes in rainfall and temperature with rain arriving too late and stopping too early, with heavy rains at the start of the rainy season and dry spells in mid-season. They have observed a shift of the hot season, which tends to start earlier and last longer, and with the cold season starting later and hence getting shorter. In the 2010 meeting the communities reported on a number of storms with wind and rain that caused significant damage to the villages hit. There were also reports on the increase of damage to crops by grasshoppers and termites as a result of the longer dry season and hot days "as there is nothing else for them to eat".

The changes in climate have had a number of impacts on their livelihoods. Production has not been as expected, which made farmers decide to farm extra land and expand from the average 1.3 to 2 ha. To minimise risk, they would open a plot in another location and with different characteristics (plot near a river vs. a plot in an upland area), they plant earlier to catch the first rains and plant different crops. Access to new land does not seem to be a problem in this area, but labour is. Since the biggest time consumer is fetching water and fuelwood, expansion of land has only been possible in those villages where there are boreholes. The other villages still experience shortage of water in the dry season (July to November), have to walk longer distances to collect water, and use less water during that period.

Due to the shifts in season, the time to rest ("tempo de descanso") between the two growing seasons has reduced from 3 months to 2 months.

The way farmers have started adapting to these changed climatic conditions include:

(i) cultivation of bigger areas to compensate for lower yields
(ii) formation of associations to manage the extra plots
(iii) sowing earlier to ensure to catch the first rains
(iv) growing of more second season crops (beans, cotton, sesame)
(v) making better use of, and/or increasing the cultivation in the low areas (basias) for fruit, sugar cane and vegetables
(vi) planting of more drought resistant crops such as banana, sweet potatoes and cassava

The participants are aware and agreed that there are other solutions, such as improved seeds, conservation farming as well as mechanization and irrigation, but would stressed that the improved access to clean water is their number one priority and concern.

CONCLUSION

KEY MESSAGES

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- Strategic Environmental Assessment approach proved to be a useful tool for (i) information integration (ii) climate vulnerability and impact assessment and (iii) awareness building tool for stakeholders at national/provincial/district level.

- Supply and Demand Analysis leading to formulation of specific "climate risk statements" for supply of ecosystem services that are underpinning livelihood securities, conservation values & investment options and the magnitude of change indicators are useful in estimating the social, environmental cost and cost of doing business in the pilot geographical area under climate change.

- The identification of Business Risks & Opportunities and suggestion of Adaptation Options for Private Sector need to be at the three spheres of activity (i) "within fenceline" (within operations and supply chains – options for private funding) (ii) "beyond the fenceline" (in partnership with surrounding communities – options for private/public funding) (iii) "beyond the horizon" (in collaboration with wider community – options for public/donor funding)

- Pilot adaptation project with EcoEnergia is an example and illustration of adaptation by and with Private Sector that benefits not only the company, but also the local communities. The benefit and incentive for the company is to have a brand name which will stand against competition and to obtain a premium price for its products on the market.

- Win-win options refer to making the difference between doing "business as usual" and "sustainable in the long term" and requires the promotion and facilitation of investments from "responsible" companies that are willing and able to pay for adaptation and for conservation to curb the depletion of natural resources due to human action and to climate change.