Coastal Resilience to Climate Change (CRCC) Programme Baseline;

Coastal and Marine Ecosystems Restoration Assessment

March 2019
Acknowledgment

This assessment was conducted through collective contributions that involved the political, institutional and technical support from the Ministry of Sea, Inland Waters and Fisheries, Rare and the representatives and officials from the Inhamane, Sofala and Nampula provinces and 3 pilot districts of Inhassoro, Dondo and Memba. The technical inputs and analysis were provided by P. Bagesund, S. Bila, E. Cavoto, E. Imanirareba, E. Lehmann, F. Oloo, N. Raghunathan, V. Ruiz, A. Ndoli, J. Njue, C. Karangwa, M. Matidiane, J. Wakhayanga and R. Wild. Stakeholders, partners and other institutions from provinces that are too many to name here have been instrumental in developing this baseline.
Acronyms

ASCA  Accumulating Savings and Credit Association
CCP  Community Fishing Council (Conselho Comunidade das Pescas)
CRCC  Coastal Resilience to Climate Change
ETM  Enhanced Thematic Mapper
FAO  Food and Agricultural Organization
FFP  Fisheries Development Fund (Fundo de Fomento Pesqueiro)
GIS  Geographic Information Systems
GPS  Global Position Systems
IDPPE  Institute for Development of Small-Scale Fisheries (Instituto de Desenvolvimento da Pesca de Pequena Escala)
IUCN  International Union for Conservation of Nature
LULC  Land use/ Land cover
M&E  Monitoring and Evaluation
MIMAIP  Ministry for Sea, Inland Waters and Fisheries
OLI  Operational Land Imager
PCR  Rotating savings and credit groups (Poupança e Crédito Rotativo)
PESPA  Strategic Plan for the Artisanal Fisheries Sub-Sector
RCMRD  Regional Center for Mapping of Resources for Development
RLE  Red List of Ecosystems
ROAM  Restoration Opportunities Assessment Methodology
SBAFP  Sofala Bank Artisanal Fisheries Project
SLR  Sea Level Rise
VSLA  Village Savings and Loans Associations
WCMC  World Conservation Monitoring Center
WWF  Worldwide Fund for Nature
Coastal Resilience to Climate Change Baseline; Coastal and Marine Ecosystems Restoration Assessment

Table of contents
Acknowledgment ........................................................................................................................................................................... ii
Acronyms .................................................................................................................................................................................. iii
Table of contents ......................................................................................................................................................................... iv
Table of figures ............................................................................................................................................................................. vi
Table of tables ............................................................................................................................................................................ ix
Table of boxes ............................................................................................................................................................................... ix
Executive summary ....................................................................................................................................................................... 1
Microfinance ............................................................................................................................................................................... 2
1. Introduction ........................................................................................................................................................................... 4
1.1. Coastal and marine ecosystems in Mozambique ............................................................................................................... 4
1.2. Purpose and scope of the coastal and marine ecosystems restoration assessment ................................................................. 8
2. Methodology ....................................................................................................................................................................... 9
2.1. Inventory and assessment of biophysical and ecological conditions of coastal and marine ecosystems (RLE) ............. 9
2.2. Coastal land cover/land use change analysis ..................................................................................................................... 9
2.2.1 Satellite image analysis ..................................................................................................................................................... 9
2.2.2 Comparison of the mapping methods .......................................................................................................................... 12
2.2.3 Classification of seagrass and coral reef .......................................................................................................................... 13
2.2.4 Change detection and analysis ........................................................................................................................................ 13
2.3. Socio-ecological – socio-economic situation analysis .................................................................................................. 14
2.3.1. Nested conceptual framework of restorative development ......................................................................................... 14
2.3.2. Restoration diagnostic of successes and barriers ............................................................................................................. 14
2.3.3. Environmental economics ............................................................................................................................................ 15
3. Baseline profiles of the coastal and marine ecosystems .................................................................................................... 16
3.1. Red List of Ecosystems assessment .................................................................................................................................. 16
3.1.1. Coastal forest vegetation ............................................................................................................................................... 16
3.1.2. Mangrove ................................................................................................................................................................. 34
3.1.3. Coral reef .................................................................................................................................................................. 44
3.1.4. Seagrass beds .............................................................................................................................................................. 51
3.2. Mapping trends of coastal and marine ecosystem ............................................................................................................ 59
3.2.1. Baseline profile of Memba district in Nampula Province ................................................................................................. 62
3.2.2. Baseline profile of Dondo district in Sofala Province ................................................................................................. 68
3.2.3. Baseline profile of Inhassoro district in Inhambane Province .................................................................................... 71
3.3. Socio-economic results and interpretations ....................................................................................................................... 88
3.3.1. Review of previous projects and studies ....................................................................................................................... 88
3.3.2. Success factor analysis ................................................................................................................................................... 92
3.3.3. Institutions and culture ................................................................................................................................................. 94
3.3.4. Environmental economics and cost-benefit analysis ................................................................................................. 101
3.3.5. Socio-economic dimensions of coral reefs ................................................................................................................ 105
3.3.6. Socio-economic dimensions of seagrass beds ........................................................................................................... 105
3.3.7. Socio-economic dimensions of mangrove forests ................................................................................................... 105
3.3.8. Socio-economic dimensions of coastal forests ....................................................................................................... 109
3.3.9. Socio-economic dimensions of sand dunes .............................................................................................................. 112
Table of figures

Figure 1: Map of the study area, covering the three districts of Dondo in Sofala province, Inhassaro in Inhambane province and Mema in Nampula province ................................................................. 5
Figure 2: Map of Mema district depicting the 4 administrative posts and the neighbouring districts ...................... 6
Figure 3: Map of Dondo districts depicting the 2 administrative posts and the neighbouring districts .................... 7
Figure 4: Map of Inhassaro district depicting Inhassaro mainland and Bazaruto Island ........................................ 7
Figure 5: Structure of IUCN Red List of Ecosystems categories ........................................................................... 9
Figure 6: Map of the Landsat tiles showing the respective image scenes for each of the case study districts ............ 10
Figure 7: An image grab of a mosaic of false color composite of landsat tiles covering the three districts in the study area. The mosaic was created from the images captured in 2017 ........................................................................................................ 10
Figure 8: Summarized workflow of the main steps of image analysis for mangrove and coastal forest mapping ...... 12
Figure 9: A graphical representation of the change detection process ................................................................. 13
Figure 10: Restorative development (Wild, 2015) ..................................................................................................... 14
Figure 11: Extent of the major upland areas in eastern and south-eastern Africa, the Zanzibar-Inhambane regional mosaic and the Coastal Forest belt (source: Burguess and Clarke (2000)) ............................................................. 17
Figure 12: Area of endemism ............................................................................................................................... 21
Figure 13: Distribution of forest vegetation in studied area ..................................................................................... 23
Figure 14: Dynamics of land-use and forest-cover changes (adapted from: (A. Sitoe, Salomão, and Wertz-Kanounikoff 2012)) .......................................................................................................................... 25
Figure 15: Simplified cause-and-effect conceptual model of the ecological processes most relevant to the Mozambican’s forest ecosystem risk assessment .......................................................... 26
Figure 16: Change analysis of forest cover in studied district over the 1996-2017 period ........................................ 28
Figure 17: Forest cover change analysis in studied districts ...................................................................................... 29
Figure 18: Distribution of coastal forest in 2017, minimum convex polygon around the ecosystem (EOO) .......... 31
Figure 19: Location of forest concession in Mozambique ........................................................................................ 33
Figure 20: Distribution of mangrove forests in Mema district in 2017 (WWF Deutschland 2018b) ......................... 36
Figure 21: Distribution of mangrove forests in Dondo district in 2017 (WWF Deutschland 2018b) ....................... 37
Figure 22: Distribution of mangrove forests in Inhassaro & Bazaruto in 2017 (WWF Deutschland 2018b) .......... 37
Figure 23: Simplified cause-and-effect conceptual model of the ecological processes most relevant to the Mozambican’s mangrove ecosystem risk assessment ................................................................. 39
Figure 24: Evolution of surface area (Ha) covered by mangroves between 1995 and 2015 in Mema and Dondo (A) and in Inhassaro and Bazaruto (B) ............................................................................................ 41
Figure 25: Distribution of mangrove forests in 2018 (WWF Deutschland 2018a), minimum convex hull around the ecosystem, and area of occupancy determined by determining the number of 10 x 10 km grid cells that contain more than 1 ha of the ecosystem. .................................................................................. 43
Figure 26: Distribution of corals and seagrasses in Mozambican coast. Data generated from Landsat-8 OLI sensor data between 2013 and 2015. Source RCMRD, open source data. Permission to publish without prior consent .... 46
Figure 27: Distributions of corals in two districts in Mozambique. Data generated from Landsat, 30 m resolution ... 47
Figure 28: Simplified cause-and-effect conceptual model of the ecological processes most relevant to the Mozambican’s coral ecosystem risk assessment ................................................................. 48
Figure 29: Contrasting extents of occurrence of coral reefs between Inhassaro & Bazaruto, and Mema districts. Polygon with hatched lines shows EOO .......................................................................................... 49
Figure 30: Seagrass distribution along the coast of a) Mema (a), and b) Inhassaro and Bazaruto ......................... 54
Figure 31: Conceptual model of the seagrass of Mema, Inhassaro and Bazaruto. 1 dredging, port construction, alteration water, mining, gas/oil extraction, tourism, plastic marine pollution .................................................... 55
Figure 32: Representation of the EOO and AOO for the seagrass of Mema, Inhassaro and Bazaruto ................. 57
Figure 64: Summary diagram of ecological services and sensitivities in Inhassoro District. (from EOH, 2015) ...........112
Figure 65: Fishing Centers in the District of Memba (Source: Impacto, 2012, in IUCN 2017) ...........................................114
Figure 66: High priority conservation landscapes in the coastal forests of Mozambique (including Dondo) ........116
Figure 67: CCP in Inhassoro district visited during the project scoping mission in 2017................................................120
Figure 68: Map of CCP areas from Inhassoro from community CRCC consultation meetings 2017 .........................121
Table of tables

Table 1 Comparison of major differences between forest and woodland where both main vegetation formation types have continuous stands of large (10 m) trees. (source: Burgess and Clarke (2000)) ................................................................. 17
Table 2 Forest vegetation classes obtained from remote-sensing analysis ........................................................................................................... 18
Table 3 Extent of occurrence (EOO) and area of occupancy of the Coastal Forest distribution ................................................................. 30
Table 4 RLE assessment summary for Coastal Forest ecosystem (with criteria presenting the highest risk category in brackets) ................................................................. 34
Table 5 Extent of occurrence (EOO) and area of occupancy of the 2018 mangrove distribution ................................................................. 42
Table 6 RLE assessment summary for mangrove ecosystem (criteria with the highest risk category in brackets) ................................................................. 44
Table 7 Extent of occurrence (EOO) and area of occupancy of the coral distribution ............................................................................................. 50
Table 8 RLE assessment summary for coral ecosystem (criteria with the highest risk category in brackets) ................................................................. 51
Table 9 - Seagrass species along the coast of Membas, Inhassoro and Bazaruto .............................................................................................. 52
Table 10 Extent of occurrence (EOO) and area of occupancy (AOO) of the seagrass beds in Membas, Inhassoro and Bazaruto .............................................................................................. 57
Table 11 RLE assessment summary for seagrass beds ecosystem (criteria with highest risk category in brackets) ................................................................. 58
Table 12 Variation in selected land cover classes in Inhassoro district between 1996 to 2017 .................................................................................. 64
Table 13 Variation in area of coverage of land cover classes in Dondo district in Mozambique from 1996 to 2017 ................................................................. 70
Table 14 Variation in the area of select land cover classes in Inhassoro district in Mozambique between 1996 and 2017 ................................................................. 73
Table 15: Land cover change (in hectares) in Membas district between 1996-2017 .................................................................................. 80
Table 16: Land cover change (in hectares) in Dondo district from 1996-2017 .................................................................................. 83
Table 17 Land cover change (in hectares) in Inhassoro district from 1996-2017 .................................................................................. 87
Table 18 Links between socio economic behaviours and ecosystems .............................................................................................. 88
Table 19: Preliminary restoration success factor analysis .............................................................................................................................. 93
Table 20: Regulo in the project area ................................................................................................................................................... 95
Table 21 List of 11 sacred natural sites in the project area and detail .......................................................................................................................... 96
Table 22 Total number of fishers ................................................................................................................................................... 98
Table 23 PCR groups in the project districts ................................................................................................................................................... 101
Table 24 Total estimated annual economic losses from selected ecosystems in the CRCC project area ................................................................. 101
Table 25 Loss from degradation of Mangrove forests, seagrass and Coral reefs in Membas District ................................................................. 102
Table 26 Loss from degradation of Mangrove forests, seagrass and Coral reefs in Dondo District ................................................................. 102
Table 27 Loss from degradation of mangrove forests, seagrass and coral reefs in Inhassoro District ................................................................. 103
Table 28 Summary of mangrove forest cover trends ................................................................................................................................................... 106
Table 29 Provisional mangrove restoration costs per hectare ................................................................................................................................................... 108
Table 30 Example details of main fisheries from Sirissa CCP ................................................................................................................................................... 113
Table 31 Source timber for boat construction in Membas ................................................................................................................................................... 114
Table 32 High priority conservation landscapes in the coastal forests of Mozambique (including Dondo) ................................................................. 117
Table 33 RLE assessment summary for coastal ecosystems in study areas .............................................................................................. 126

Table of boxes

Box 1 Sofala Bank Artisanal Fishing Project microfinance results .............................................................................................................................. 89
Box 2 MKUBA model ................................................................................................................................................................. 100
Box 3 Sketch-map of loss of seagrass from Fequete and Petane CCP’s Inhassoro District .............................................................................................. 118
The Coastal Resilience to Climate Change initiative (CRCC) is a response of the Government of Mozambique to the increasing challenges coastal communities face as a result of climate change. With support and cooperation of the Swedish Government, the Government of Mozambique, through its Ministry for Sea, Inland Waters and Fisheries (MIMAIP) and in partnership with IUCN and Rare, is seeking to increase the resilience of men and women in coastal communities through rights and ecosystem based approaches. IUCN’s Regional Forest Landscape Restoration Hub have teamed up with IUCN’s Ecosystem Management Programme to generate baseline data and maps of the status and projected trends of these ecosystems along with socio-economic context information in three pilot districts of Mozambique namely; Inhassoro (in Inhambane province), Dondo (in Sofala province), and Mamba (in Nampula province). The purpose of this information is to guide the design of interventions necessary for the management and restoration of the four main ecosystems Coastal Forest, Mangroves, Seagrass and Coral reefs through an adaptive management strategy and responses to threats. This data also provides supporting information to enable the detailed design, monitoring and evaluation of the identified ecosystems.

The Coastal Forests of the studied districts are overall Critically Endangered (CR) according to spatial and functional symptoms. Assessment of the spatial distribution of the Coastal Forests in Mamba, Dondo and Inhassoro & Bazaruto classified all of them within the highest threaten categories of risk, as Vulnerable (VU), Endangered (EN) and Critically Endangered (EN) respectively. The assessment of Coastal Forests led also to similar conclusions in the three studied districts due to unsustainable use of forest resources, standing stocks of first-class and precious species. This degradation of species characteristic of the native biota assigned the Coastal Forests to the Critically Endangered (CR).

Restricted geographic distribution and the proximity of expanding agricultural, urban and touristic areas constitute a direct threat to these mangrove ecosystems in the three districts which are mainly distributed in patches. The mangrove forests of the studied districts are therefore Critically Endangered (CR). Seagrass beds and Coral are not present in Dondo district. Nevertheless, the situation in the other two studied districts is critical due to their restricted geographical distribution and inferred threatening processes such as continuous decline in their cover and continuous disruption of biotic interactions. Influencing processes that drive seagrass distribution, categorized seagrass beds as Critically Endangered (CR). The overall risk status of the ecosystem is assigned as the highest category of risk obtained through any criterion. Both ecosystems in the studied districts are therefore Critically Endangered (CR).

Summary of geospatial mapping outputs

i. **Coral reefs**

Of the three districts of Mamba, Dondo and Inhassoro, coral reefs were only detected and observed in Mamba and Inhassoro districts, and not Dondo. From the results of image analysis, the coverage of corals has remained stable, averaging 10,000 hectares in Mamba between 2006 and 2017, while remaining around 17,000 hectares in Inhassoro as at 2017 - around the same figure it was a decade earlier in 2007. The figures for 1996 and 2010 appeared distorted due to poor image quality during those years and therefore were not considered in observing this trend. The increase in acreage of corals may be an evidence of bleaching, since whitened coral reefs are more easily detected by remote sensing energy. Yamano and Tamura (2004), observed that bleaching in coral reefs results in increased reflectance and the bleached areas would become easier to be captured by remote sensing energy. Field validation visits to sampled locations confirmed that the locations of these corals are true as per the mapping results. The mapping of coral reefs in this study provides a basis for validating and updating other global and regional coral reef data that seem to miss or at times exaggerate the coverage of corals along the coastline of Mozambique.

ii. **Seagrass beds**

The results from mapping showed the presence of seagrass in Mamba and Inhassoro districts, but not in Dondo district. In Mamba district, a comparison made between the years 2007 and 2017 showed that seagrass reduced from 18,200 to 17,600 hectares. This represents a very marginal loss of about 3% over ten years or 0.3% per annum. In Inhassoro district, a similar comparison made between the years 2006 and 2017 showed that seagrass reduced from about 8,900 hectares to about 8,200 hectares. This also represents a very marginal loss of about 6% over ten years or 0.6% per annum. Field validation around the island of Santa Carolina showed that the area is rich in segmented seagrass beds. These are represented in this study, but there are neither coral reefs nor seagrass beds in this area according to other studies done in past around the coastline. It is therefore likely that global and regional datasets are too generalized for smaller scale studies, as they may only map the larger seagrass beds with little verification data or clear procedure. An extensive mapping of seagrass beds requires a combination of high resolution satellite imagery and elaborate field work. In addition, change detection of seagrass from remote sensing may be hindered by a combination of cloud cover and variability of ocean characteristics during the different epochs of analysis.
Communities selecting a limited number of the 32 success factors to be part of their action learning groups. An important overall recommendation is that it is important not allow in-tact areas to slide into degradation while attempting to restore others. Restoration is more expensive than socially sound protection and sustainable use. There is no point and it is very costly to restore in one place and let another area to degrade only to be restored later. This recommendation is underscored by the joint RLE and ROAM approach where the RLE identifies the risks to ecosystems and ecosystem services while ROAM addresses opportunities for restoration.

A total of 25 detail recommendations were made in the socio-economic section. The most important 13 of these recommendations are summarised here.

### Institutional support and coordination

1. Recommendation: CRCC project support the enhanced coordination and cooperation between the key coastal zone management institutions including government agencies, the Regulo, CCP and the Natural Resource Management committees.

2. Recommendation: The project works proactively with the Regulos of the project area and supporting them to become champions for ecological restoration. This effort should start first with their own sacred natural sites under their custodianship several of which have become degraded.

3. Recommendation: Mangrove management is used as a testing ground for integrated institutional coordination where the CCP, Natural Resource Management Committees, Regulos and government support institution’s work in concert

### Microfinance

4. Recommendation: Implement the IUCN MaliVerde (Mkuba) solidarity evolution of the PCR – in the project area. This model has been specially designed to incentivise the development and implementation of community resource management plans such as the CRuRAPs.

5. Recommendation: CRCC to consider strengthening the conducive policies towards linking microfinance institutions with ecosystem management

### Public awareness

6. Recommendation: Establish radio programmes for public awareness of restoration in the project areas.

### Gender

7. Recommendation: The project pays greater attention to female foot fishers in areas of coral reefs and associated sand and mud flats
Community reserves in coral reef areas

8. **Recommendation:** Expand the successful community reserve in the Membba district to other areas within the district and other CRCC sites.

9. **Recommendation:** Carry out an in-depth joint scientific and participatory study involving local stakeholders (fishers and diver operators) into the reported widespread loss of seagrass beds in Inhassoro district.

Mangrove re-establishment

**Recommendation:** Provide improved information on the current best practices in mangrove re-establishment. This may require the establishment of Fire management in coastal forests and dunes.

10. **Recommendation:** The project should assist the identification and sustainable management of high conservation value forests where fire is not normally a feature – through a stakeholder engagement process.

11. **Recommendation:** The ecological dimension of fire in the project terrestrial ecosystems and vegetation types needs to be properly assessed and a nuanced fire policy, tailored to each vegetation type should be produced and promoted.

12. **Recommendation:** Develop policies and land-use plans that maintain effective vegetation cover on sand dunes such that their stability is not compromised. Ensure planning departments do not allow the development of unplanned settlement where they damage sand dunes, and prevent local damage through the use of appropriate infrastructure.
1.1. Study background

The Coastal Resilience to Climate Change initiative (CRCC) is a response of the Government of Mozambique to the increasing challenges coastal communities face as a result of climate change. With support and cooperation by the Swedish Government, the Government of Mozambique, through its Ministry for Sea, Inland Waters and Fisheries (MIMAIP) and in partnership with IUCN and Rare, is seeking to increase the resilience of men and women in coastal communities through rights and ecosystem based approaches. Over the course of four years, CRCC will work with coastal communities in three districts of three provinces: Inhassoro District (Inhambane Province); Memba District (Nampula Province) and Dondo District (Sofala Province).

The programme will support the provincial and district governments as well as traditional and community leaders to work with coastal communities to restore critical terrestrial landscapes (including mangroves, sand dunes and coastal forests) and seascapes (including coral reefs and seagrass). It will identify and introduce nature based enterprises, geared towards providing coastal communities, particularly women, with supplementary livelihoods to reduce unsustainable pressures on the natural resource base and increase local level resilience.

Mozambique has one of the longest coastlines in Africa, estimated to be 2,700 km long. In fact, seven of its eleven provinces and six of its top ten towns and cities are coastal. At least 80% of jobs nationwide are dependent upon natural resources, most of which are coastal. There is therefore growing pressure on coastal resources to meet high demand for food, fuelwood, construction materials, agricultural expansion and settlement.

Mangrove ecosystem is considered among the key habitats that support marine life and coastal livelihoods, yet highly vulnerable to the projected impacts of climate change, particularly sea-level rise (SLR). In Mozambique, mangroves have been lost due to a combination of both, climate related risks and non-climate related anthropogenic impacts. Examples of climate related risks include sea level rise and increased storm events while anthropogenic include degradation resulting from human activities including demand for fuel wood, building materials, salt production, urbanization, rice production, and uncontrolled grazing. Coastal forests are an important source of ecosystem services and yet are under grave threat particularly to create room for human subsistence and development.

In order to effectively restore and manage the mangrove and coastal forests, it is important to undertake comprehensive assessments, to capture accurate data about the status of these ecosystems. The empirical evidence can then be used to improve conservation and promote sustainable use, and management through implementation of community-based landscape/seascape approaches. The data that is collected and generated during ecosystem assessment can also guide the design of interventions that are necessary for the restoration of these ecosystems through an adaptive management strategy and responses to threats.

In this work, the main ecosystems that will be analyzed, mapped and assessed will include mangroves, coastal forests, coral reefs and seagrass beds in the target areas of the project. This will underpin the establishment of the change detection M&E (sub-result 4.6.3 of CRCC) for land and sea habitats and will support the long-term follow up and progress of restoration activities.

The project is working in three pilot districts of Mozambique namely; Mamba in Nampula province, Dondo in Sofala province and Inhassoro in Inhambane province. Specifically, the assessment focused on the coastal strip of the three districts. Initially the coastal strip was considered to be the seascape which is the region of about 5-6km radius of the shoreline and 100m offshore from the highest water mark. However, it was decided to broaden the analysis to the total area of the project districts and to 50kms off shore. For the analysis to capture interlinked social–economic and biophysical conditions, additional data was collected at the district level, in some cases covering some neighboring districts. For example, the historical trends of land use surrounding the coastal strip was considered an important indicator of the drivers of change in the coastal areas. Figure 1 shows a map of Mozambique highlighting the location of the three case study districts of Dondo, Inhassoro and Mamba.
1.2 District Level Situation Analysis

Memba District:

Memba district is located in the north-eastern part of Nampula province of Mozambique. The district is approximately 4,622 km² in size. It is bordered in North by Chiure District, in South by Nacala-Velha District, in West by Erati and Nacaroa Districts and in East by Indian Ocean (MAE, 2012).

The district is divided by four (4) administrative posts: Lurio, Mazua, Chipene and Memba-Village. The Lurio administrative post possesses one (1) locality (Lurio-Village); Mazua possesses three (3) localities (Mazua-Village, Simuco and Cava); Chipene administrative post possesses one (1) locality (Chipene Village) and Memba administrative post is comprised by four (4) localities (Memba-Village, Miaja, Niaca, Tropene) (GDM, 2015).

The total population in the district is approximately 268,600 inhabitants, which corresponds to about 4.5% of the total population of the coastal zone of Mozambique. The population density is approximately 58.1 inhabitants/km². This density is above the average population density of the coastal districts of Mozambique which is estimate at 46.4 inhabitants/km² and the national population density which is approximately 25.3 inhabitants/km². The population is unevenly distributed in the district with approximately 47.8% of the population concentrated in the district headquarters of Memba Sede.
Membæ district has coastal strip which is characterized by dry sub-humid climate. The average annual precipitation in the district varies between 800 and 1000 mm (Mossuril) while the potential evapotranspiration varies from 1400 to 1600 mm. In the northern part of the district, the average annual rainfall varies between 600 and 800 mm. The relatively lower rainfall amounts and the elevated temperatures in the north result in critical water deficiency for agricultural production.

Agriculture is the dominant activity in almost all households with a total of 92.4% of inhabitants engaged in primary crop farming, forestry and fishery. In general, agriculture is practiced through small scale farming and through the propagation of local varieties of crops. The dominant crops which are propagated in the area include cassava and grain legumes (beans and peanuts). In the alluvial and estuarine plains, rainfed rice is the main farming practice. Noteworthy also is the significant contribution of coconut trees in boosting food security and revenues for rural farmers in the coastal areas. Fishing is the second largest activity in the district after agriculture. In addition to sea fishing, it is also practiced in the various rivers across the district.

Membæ district is one of the districts with a vast forested area in the Province of Nampula. The forest host high economic value trees such as Ironwood, Blackwood, Umbila, Jambir and, Methyl, Moco and several others. The wood from the forests is mainly in construction also as the main source of energy for cooking. The dependence on the forest for timber and for fuel wood contributes to the deforestation of the forests in the district.

**Dondo District:**

Dondo is one of the 7 coastal districts of Sofala province. The district is located in the centre of the province. The neighbouring districts include Muanza District in the north, the city of Beira and Buzi District in the south, and Nhamatanda district in the west. In the east part the district neighbors the Indian Ocean. The area of the district is approximately 2,308 km² comprising of two administrative posts, Dondo Sede (with two localities: Dondo-sede and Chinamacondo) and Mafambisse (with two localities: Mafambisse-Sede and Mutua). Dondo Sede administrative posts is coastal. The total population in the district is approximately 141,000 inhabitants, which corresponds to about 8.6% of the total population of the province.

The population density in the district is approximately 61.08 inhabitants/km². This density is above the average population density of coastal districts of Mozambique which is approximated as 46.4 inhabitants per square kilometer. Similarly, the population density is relatively higher than that of Sofala Province which stands at approximately 24.3 inhabitants/km² and the national population density which is estimated at approximately 25.3 inhabitants/km². Dondo is the second coastal district in the province with the largest number of inhabitants after Buzi district. Buzi district accounts for 2.7% of the total coastal population of Mozambique. Within Dondo district, the population is unevenly distributed throughout the district, with 50.2% of the population concentrated in the district headquarter (Dondo Sede). The 2007 Census indicated that 50.2% of the population of the district resides in the urban areas, contrary to the current scenario where the majority of the population in coastal areas of Sofala province resides in rural areas. The age structure of the district reflects an economic dependency ratio of 1:1.2, implying that for every 10 children or elderly people, there are 12 people of working age.
About 74.1% of the district area is occupied by different types of natural habitats including forests, wetlands and mangrove and the remaining is occupied by settlements (13.5%) and cultivated areas of (12.4%). According to 2007 census, 58.1% of the working population of Dondo were engaged in primary sectors of the economy such as agriculture, forestry and fishing. About 15% of the working population in the district were employed in the industrial sectors including in Mozambique Sugar Cane Company, cement factory, Lusalite and concrete sleepers. The trade sector absorbs 13% of the workers, mostly related to the informal commerce including commercialization of fish and other products. Livestock stock keeping, forestry and farming are the main economic activities of families.

In general, agriculture is practiced manually in small holdings by family members. In moderately well-drained soils the main crops are maize, sorghum, Nhembali and Boere beans. Cotton and sugarcane are main cash crop produced under a monoculture regime. Agricultural production is predominantly under rainfed conditions, heightening the risk of crop failure. Cashew, mango, and the papaya are the main fruit trees which also source of income to farmers but have production limitations due lack of seeds and drought.

According to the Koppen climate classification, the climate of Dondo is transition from rainy tropical to dry season in winter. The average air temperature is about 27 °C, with an average amplitude of 7°C. Relative humidity in the district is between 75-76% with small variation over of the year. The mean annual precipitation varies from 1,000mm to 1,459mm and the annual average potential evapotranspiration is approximately 1,496mm.

### Inhassoro District:

The Inhassoro district is situated in the northern part of Inhambane province in Mozambique. Its neighbours are Govuro district to the north, the Indian Ocean to the east, Vilanculos, Massinga and Funhalouro districts to the south and Mabote district to the west. Inhassoro district covers an area of approximately 4,746 km² and hosts a population of approximately 48,537 people according to the preliminary results of the 2007 population census. The population density of the district is approximately 10.2 inhabitants / km² with approximately 76.6% of the inhabitants residing in the rural areas. The population density around the district headquarters which is approximately at 15.1 inhabitants/km2 is relatively higher when compared to other rural locations in the district. The population is young with most individuals falling within the age bracket of 10 to 14 years. In 2007, the life expectancy of the district was estimated at 48.7 years for men and 54.9 years for women. The relatively lower life expectancy may be an indicator of high levels of vulnerability exemplified by poor accessibility to quality health care and nutrition.

The age structure of the district reflects an economic dependency ratio of 1: 1.1, implying that for every 10 children or elderly persons there are 11 people of working age. With a young population (44%), under 15 years old, it has a masculinity index of 85% (for every 100 female people there are 85 male) and an urbanization rate of 23%, concentrated in Inhassoro Village and peripheral areas of semi-urban matrix.
The latitudinal extent of Inhassoro district and its contrasting relief have resulted in diverse climatic conditions in different parts of the district. Climatic diversity is reflected in regional variations in temperature, amount of rainfall, soils, vegetation, agro-ecological conditions and the timing and duration of seasons. The climate of Inhassoro is tropical humid in the coastal strip and dry tropical in the interior, being characterized by two seasons (dry and rainy). The hot and rainy season runs from August to February, dry and cool from February to July. In the hot and rainy season average temperatures range from 28 to 30 °C, with an average annual rainfall of 865 mm, with a lower incidence in the interior, while in the dry and cool season temperatures vary between 18 to 27 °C, with a higher incidence on the coast. Consequently, the way in which the population uses the land differs significantly from the coastal area to the interior.

It is in the Inhassoro district that the natural gas extraction and processing facilities of Temane are located. The island of Bazaruto (the largest island of the Bazaruto Archipelago) which is part of the district is a major tourist attraction. Govuro river traverses through the district, because of the geomorphology of the river, the river banks are not conducive for agricultural activities particularly due to the large amounts of limestone in the banks.

The relief consists of altitudinal range of about 239 meters. In terms of soils, the district is characterized by sandy soils in dune phase, hydromorphic sandy soils and clayey alluvial soils and the predominant vegetation is the open forest of miombo and mangal. In the mainland, sandy soils predominate in the coastal zone, French-sandy and loamy-clayey within the district, with sediments that occupy extensive areas, dunes on the island of Bazaruto and limestone rocks on the island of Santa Carolina. The sandy soils along the coastal area are characterized by low water and nutrient retention capacity, low fertility, limiting agricultural activity. However, in the inland parts of the district, soils are fertile, providing a suitable land for the development of agriculture and pasture.

1.2. Purpose and scope of the coastal and marine ecosystems restoration assessment

The assessment was carried in three main components namely:

a. Inventory and assessment of biophysical and ecological conditions of the existing coastal and marine ecosystems (RLE);

b. Coastal land cover/land use change analysis, ecosystem mapping, and restoration opportunities assessment;

c. Social-ecological and socio-economic situation analysis, and inputs for community based restoration plans.

The three are intertwined in the sense that the inventory and assessment, social situation analysis, and the coastal land cover/land use change analysis have provided data necessary for ecosystem mapping while the inferences gauged in the mapping was used to enrich the inventory and social situation analysis. The loop of the above components has then provided the basis for the inputs to community based restoration plans and marine ecosystems.
2. Methodology

2.1. Inventory and assessment of biophysical and ecological conditions of coastal and marine ecosystems (RLE)

Three districts were selected as pilot sites for assessment of the ecological conditions through the Red List of Ecosystem (RLE) assessment method. It was assumed that the case study sites, which are located along the coast were representative of other areas of the Mozambican coastline. The case study sites were selected to represent the three main regions of the Mozambican coastline which include, the coralline with coral limestone in the north, estuarine coastlines in the central region, and the sandy coastline in the southern region of the country (Spalding, Blasco, and Field 1997). Consequently, the three representative districts from north to south included Mamba, Dondo and Inhassoro.

The IUCN Red list of Ecosystems (RLE) is a set of categories and criteria for assessing the risks to ecosystems and to focus attention on where ecosystems are threatened. It is part of a growing toolbox for analysing risk to biodiversity at all scales and it aims at supporting conservation, resource management and decision making by identifying ecosystems most at risk (IUCN 2016).

Detailed description of the RLE assessment process is provided in the IUCN guidelines for application documentation and training material (IUCN 2015; Murray et al. 2016). A practical guide was also issued in 2015, it is specially addressed to practitioners who want to implement this protocol (Rodriguez et al. 2015). In short, the RLE approach comprises a five rule-based criteria (A-E, Annex 1) for assigning ecosystems to a risk category. Each of the five RLE criteria addresses different groups of symptoms and identifies the corresponding means that link the symptoms to the risk that an ecosystem will collapse (i.e. lose its defining features). Symptoms may be measured by one or more, generic or specific, proxy variables. Once suitable variables to assess distributional and functional symptoms are identified, ecosystem collapse thresholds are defined to assign each ecosystem type to one of the categories of risk (Keith et al. 2013). Two of the five criteria are based on spatial symptoms of ecosystem collapse: the rates of decline in distribution (A), and the degree to which the distribution is restricted (B). Two criteria are based on functional symptoms of ecosystem collapse: the rate and extent of environmental degradation (C), and the rate and extent of disruption of biotic processes and interactions (D). The fifth criterion facilitates the integration of multiple threats and symptoms into a model to produce quantitative estimates of the risk of collapse (E) (IUCN 2016). It is noteworthy that criterion E was out of the study-scope and therefore was not evaluated (NE).

2.2. Coastal land cover/land use change analysis

To facilitate the assessment of the status of the coastal ecosystem, the understanding of the historical trends in different ecosystem, including mangroves, coastal forests, seagrass and coral was considered to be essential to the entire assessment process. The identification of biodiversity hotspots and degraded areas can not only inform the process of identifying restoration opportunities and priority areas but also provide an entry point into developing restoration intervention and community plans.

2.2.1. Satellite Image analysis

To understand the evolution of ecosystem and environmental changes in the study area, systematic analysis of satellite imagery was adopted. Specifically, an analysis of Landsat 5 and Landsat 8 images for the study areas was carried out to reveal the changes in the main land cover classes in the coastal ecosystem. The aim of the image analysis is to reveal potential drivers of ecosystem degradation and to highlight hotspots that can be targeted for interventions and restoration. Landsat satellite images capture the surface characteristics at 30m resolution and have a revisit.
A schedule of 16 days. Dondo district falls within two Landsat tiles of 167/73 and 167/74, Inhassoro district falls within titles 167/75 and 166/75 while Memba district is within tiles 164/69 and 164/70 as indicated in Figure 6.

Figure 6: Map of the Landsat tiles showing the respective image scenes for each of the case study districts.

Figure 7: An image grab of a mosaic of false color composite of landsat tiles covering the three districts in the study area. The mosaic was created from the images captured in 2017.
Ancillary datasets including high resolution images from Google Earth and data on mangrove from other regional projects including RCMRD and WWF were studied and used in the preparation of training sample for the mangrove classification. In addition, other ancillary data including existing land cover maps and GPS data from the field were used to improve the output from satellite image analysis with sensitive land cover types in the coastal and marine ecosystems such as coastal forest, mangrove forest, seagrass and settlements among other clusters.

The study period for the image analysis ranged from 1996 to 2017 with four epochs in 1996, 2003, 2010 and 2017. The time space between each epoch is seven (7) years. Freely available satellite data, including Landsat 5 and 8 were used as the main datasets. High resolution images from Google Earth platform were also used, particularly for validation and detailed analysis within the hotspots of degradation. Due to the substantial challenge of cloud cover within the tropics, in some instances cloud free images were not available for the epochal years. In such instance, images from the neighboring years were mosaicked and used to provide representative land cover characteristics for the epochal years.

Apart from satellite data, standard GIS files including vector and raster data were used. Accurate data on boundaries, infrastructure, population, elevation, water bodies and other auxiliary data were incorporated in the spatial analysis workflow. GPS points were also collected within the districts and incorporated into the study. This was particularly the case for the seagrass and coral classes that were improved by incorporating GPS locations and stakeholder input during the validation workshop.

**Image Interpretation**

There are a number of remote sensing methods that can be applied to interpret satellite datasets into land cover maps. The mapping of coastal areas presents a unique landscape mosaic and careful selection of mapping algorithm is important in order to achieve highly accurate results. In order to have this comparison and chose the best algorithm, this study used a combination of two methods in the analysis of satellite datasets. Standard image supervised classification using Random Forest script in open source software R, was used as the steps summarized in Figure 8. In addition, a new set of results was obtained by automating the processes of image retrieval and analysis in Google Earth Engine, which proved to be both efficient and resulting in improved accuracies. The final image analysis process was therefore implemented in Google Earth Engine, with the initial results from desktop-based analysis informing classification in Google Earth Engine.

Random forest classification, is a semi-automated approach with the ability to collect training samples for every available class and guide software algorithm. The training samples were gathered from the time stamped images within Google Earth API and in ArcGIS software. The R scripts then had commands to specify the specific folders with the image to be classified and the corresponding training data, as well as the output folder. Further, the color codes and desired output format were also specified within the scripts. As a starting point, standard software image analysis software, ERDAS and ENVI were used to perform the image pre-processing and classification. Rapid results were then ably achieved and analyzed to give a comparative analysis with available dataset. Then robust training sites were generated based on the these initial results and the images, to form the basis for classification in R software. In areas of low clarity of features and also in high priority areas, high resolution images (including Google earth) were used to confirm the land cover characteristics and associated changes.

Ancillary data, which included field data and land cover data from Africover datasets were used to aid mapping and ensure probable characteristics of land cover are mapped in their appropriate places. In the second set of results, similar training samples were collected and applied within the Google Earth Engine on selected satellite images.
2.2.2. Comparison of the mapping methods

This project produced the final version of maps using Google Earth Engine platform, with inputs from initial results obtained from random forest classification method. This was to use open source software R and apply the random forest script. The results were compared in terms of consistency and replicability.

It was found that random forest classification is very sensitive to changes in training samples and gives variant results if the same ground knowledge and familiarity is applied to collect training samples by varying the time or person analysing. In fact, the same person would get different results if they pick a new sample of training data without referring to the previous version. Google Earth Engine on the other hand was found to be robust and able to replicate results with different persons of the same familiarity or the same person at different times.

One limitation with Google Earth Engine was that it applies the script and training data on selected images within the platform, which are therefore on the cloud. This makes it impossible to apply image corrections for cloud cover and gap strips that are inevitable in coastal areas.

The first batch of results from random forest was therefore less accurate and yet better image quality was available due to pre-processing techniques, than the second batch of results from Google Earth Engine which were higher quality even though cloud cover and gap strips limited the images available for selection.
2.2.3. Classification of seagrass and coral reefs

Sensitive habitats like seagrasses and coral reefs typically appear below the sea surface, making them particularly challenging to discriminate from conventional classification schemes (Ferreira et al, 2012). A separate classification scheme was adopted. Specifically, when using Landsat imagery, bands blue and band green have been used to eliminate the influence of water depth on seabed reflectance (Purnawan et al, 2016, Hashim et al, 2014). Here, the same bands were considered by first performing radiometric and geometric correction of the images to produce bands with calibrated spectral reflectance and to reduce the effect of sunlight. Thereafter, band rationing of green and blue bands was carried out. With the resulting image, ISOCLUST classification was performed initially at 20 classes which were iteratively reduced to 10. Consequently, it was possible to discriminate the seagrass and coral classes based on the historical locations of these classes for auxiliary data from RCMRD and WCMC.

2.2.4. Change Detection and Analysis

Change Detection Analysis encompasses a broad range of methods used to identify, describe, and quantify differences between images of the same scene at different times or under different conditions. A change detection module offers an approach to measuring changes between a pair of images that represent an initial state and final state. For mangrove and coastal forest mapping, we used the change detection statistics tool in ENVI to carry out post classification change comparisons (Vemu, S & Udaya B, P. 2010).

This procedure used change detection difference map module to produce a classification image characterizing the differences between any pair of initial state and final state images. The input images were classified maps of different dates. The difference was computed by subtracting the initial state image from the final state image (that is, final - initial), and the classes were defined by change thresholds.

Figure 9: A graphical representation of the change detection process
2.3. Socio-ecological – socio-economic situation analysis

The overall methodology for the both the land cover analysis and the socio-economic elements is the IUCN and WRI developed Restoration Opportunities Assessment Methodology (IUCN and WRI 2014a). This has embedded within in the Success Factor Analysis (WRI, 2015) and other methodologies that cover culture. The tools used for the social, economic and cultural assessment were literature review, key informant interviews, focus group discussion and group discussions at stakeholder workshops. The baseline context was additionally informed by the work carried out in 2017 in 10 districts of Nampula and Zambezia Provinces during 2017 (IUCN 2018).

The overall methodology was to understand the social (including, cultural socio-ecological, and the socio-economic) context through a) a systems-based conceptual a nested conceptual framework, b) the application of the analysis of success factors and barriers and c) by the application of environmental economics methodologies. Gender issues are being addressed by a separate process and did not form a focus of this work. Relevant gender issues observed have be commented on as an input into the separate gender analysis.

2.3.1. Nested conceptual framework of restorative development

This assessment has taken a nested systems framework for the major component of the landscape. This approach is and expression of restorative development. Over the past decade, restorative development has become the fastest-growing economic sector, currently accounting for almost $2 trillion annually. Source: (Cunningham, 2003). Restorative Development: The New Growth Strategy for Communities of All Sizes).

2.3.2. Restoration diagnostic of successes and barriers

The Success Factor Analysis (SFA) is a methodology that analyses key success factors that have been demonstrated to promote restoration as well as the barriers. It is also termed the ‘restoration diagnostic’ and the details of the methodology are contained within a manual titled ‘The Restoration Diagnostic. A Method for Developing Forest Landscape Restoration Strategies by Rapidly Assessing the Status of Key Success Factors’. (WRI, 2015).

![Figure 10: Restorative development (Wild, 2015)](image)
2.3.3. Environmental economics

The literature desk review was useful in gathering secondary data to be used economic analysis. This was conducted to get an overview of mangrove forest restoration and in assessing the economic value of coastal ecosystem services through benefit transfer method.

The benefit transfer method was used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context. And this refers to the process of applying valuation results, functions, data or models derived in one location or context (study site) to estimate monetary values of ecosystem services in an alternative context or location.

Benefit transfer has been described as the “application of values and other information from a ‘study’ site where data are collected to a ‘policy’ site with little or no data” or the “practice of adapting value estimates from past research to assess the value of a similar, but separate, change in a different resource” (Johnston, R. J et al., 2010).

Benefit transfers are most often used when data availability, funding, time other constraints do not allow original research, so that pre-existing estimates must be used instead. The use of high-quality primary research to estimate values is often preferred. However, the realities of the policy process, particularly time and budget constraints, often prescribe that benefit transfer is the only feasible option. Therefore, benefit transfer has become a central component of virtually all large-scale benefit-cost analyses (Johnston, R. J et al., 2010).
3. Baseline profiles of the coastal and marine ecosystems

3.1. Red List of Ecosystems assessment (Results and interpretations)

3.1.1. Coastal forest vegetation

3.1.1.1. Classification

IUCN Habitats Classification Scheme (Version 3.1) is a global typology of habitat types. This classification is used here to provide a harmonized classification of the ecosystems, comparable at the global level. The IUCN Habitats Classification Scheme is composed three hierarchic levels describing 18 habitats. The following habitats were identified in the studied districts: Subtropical/Tropical Dry Forest (level 1.5), Subtropical/ Tropical Moist Lowland Forest (level 1.6) and Dry Savanna (ex: miombo / Brachystegia woodlands) (level 2.1).

3.1.1.2. Ecosystem description

3.1.1.2.1. Characteristic native biota

Forests cover 40% of Mozambican territory, representing up to 32 million hectares of natural forests, of which 27 million hectares are categorized as productive forests. Miombo woodlands are the most extensive forest ecosystem, covering approximatively two-thirds of the country’s forest land (World Bank 2018). Miombo are composed mainly of deciduous woody vegetation that dominate the area (WWF 2018). The Miombo physiognomy is characterised by a dense vegetation cover, with deciduous and semi-deciduous trees, with heights reaching between 10 and 20 metres when mature and non-degraded. It is estimated that there are approximately 334 tree species in the Mozambican Miombo forests (Ribeiro and Ribeiro 2008). Miombo are composed mainly of deciduous woody vegetation where Brachystegia spp. and Strychnos spinosa are often the dominant species. They can appear in pure stand but most likely in association with other species. Brachystegia spp. is commonly associated with Julbernadia globiflora, Pterocarpus angolensis (Umbila), Burkea africana, Bridelia micrantha, Cynometra sp., Dalbergia melanoxylon, Swartzia madagascariensis, Millettia stuhlmannii (Panga-Panga), etc. Strychnos spinosa is usually found in association with Combretum spp, Terminalia spp, Pteleopsis myrtilifolia, etc. These formations occur more in the northern provinces, including Napula and Mamba district. In the centre of the country and Southern Provinces, Trichilia emetica and Sclerocarya birrea becomes sometimes dominant (Soto 2007). Other forest ecosystem types include the Coastal Forests in the south and afro-montane forests in central Mozambique (e.g. outside the study area).

Coastal Forests are considered by Conservation International to be a global biodiversity hotspot and an area of high diversity and endemism (Timberlake et al. 2011). The terminology “Coastal Forest” has been used widely in the past decades but there has been inconsistency in the definition. As described by Timberlake et al. (2011), it designated in some cases, most of the dense vegetation formations found in the coastal area (e.g. within 100-150 km of the coast or White’s (1983) Zanzibar-Inhambane phytochorion, whilst others (e.g. WWF-EARPO 2006) have included various forest or woodland formations (except mangroves) up to 300 km inland. Even though some vegetation classifications identify a clear difference between forest and woodland the application of recognized standard vegetation confirms the existence of forest sensu stricto in this area. Descriptive vegetation classifications such as by White (1983) for the whole Africa, and by Greenway (1973) both recognize the existence of a number of smalls areas of dense closed canopy tree stands in coastal lowlands of eastern Africa which fit their forest classifications. The “Coastal Forests” encompass all such forests, excluding the halophytic mangrove forests (Burgess and Clarke 2000). Mangrove forests are assessed separately in the following section (3.2).

As aforementioned, in the eastern African context, there is a clear difference between woodland and forest. Coastal Forest and woodland can be differentiated both on physiognomic differences and on ecological basis. Physiognomic differences are presented in Forest and woodland require different ecological conditions for species recruitment and the attainment of their climax communities. Fire plays a pivotal role in the dynamics of establishment of forest, woodland and grassland vegetation. Highly seasonal precipitation (varying between 650 and 1’400 mm per year) leave the vegetation dry for several months. Under this dry climate, fire frequency but also time of occurrence will considerably influence establishment of woody vegetation. Under annual burning, regardless of the intensity, woodland and forest are converted to grassland. Wetter biomass and more benign fire weather, have shown that early-season burning allows woody biomass to develop further compared to late-season burning. In general, regular fire burning will favour the more open woodland formation. The grass layer tends to densify with increased light levels reaching the ground in open woodland formations and renders the habitat more susceptible to fire, thereby potentially perpetuating the woodland state. On the contrary, in the absence of fire, miombo starts to form closed-canopy forest. Greater
shading reduces the development of a grass layer, thus making the vegetation less prone to fire burning, thereby perpetuating the existence of the forest state. Miombo woodland is therefore fire derived, while forest depends on the absence of fire to perpetuate itself (Burgess and Clarke 2000; Ryan and Williams 2011).

The three studied districts are located in the phytogeographical region originally defined by White (1983) as: The Zanzibar-Inhambane regional mosaic extending from the mouth of the Limpopo River (latitude 25°S) to the Rovuma River (and northward). This phytochorion comprised a complex matrix of forests: Sand Forests, Miombo woodlands, Undifferentiated forests, Evergreen forests, Riverine forests, Dune forests, Wooded grassland, Secondary grassland, seasonally flooded Edaphic grasslands, and Mangroves communities (Soto 2007). The delineation of this phytochorion was based on a high level of floristic endemism that was found to exist to about 200-300 km inland of the Indian Ocean where approximatively 35% of the larger woody plants were found to be endemic to that part of the Indian Ocean coastal belt (Burgess and Clarke 2000). More recently, on the basis of species richness, Clarke (1998) split White’s Zanzibar-Inhambane regional mosaic into two separate phytochoria – the Swahilian regional centre of endemism in the north and the Swahilian/Maputaland regional transition zone in the south. This definition aimed at reflecting the difference in endemic plant species present in the north compared to the low number of endemic species recorded from Inhambane Province in the south (Burgess and Clarke 2000). Mombwa district is part of the Swahilian regional centre of endemism.

---

Table 1 Comparison of major differences between forest and woodland where both main vegetation formation types have continuous stands of large (10 m) trees. (source: Burgess and Clarke (2000))

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Woodland</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treecrowns</td>
<td>Touch, but do not overlap</td>
<td>Overlap</td>
</tr>
<tr>
<td>Ground layer</td>
<td>Grasses well developed</td>
<td>Sparse or absent</td>
</tr>
</tbody>
</table>

---

2 i.e. neither Miombo nor Mopane Forests both other types occurring in Mozambique.
while the two other districts (Dondo and Inhassoro) are included in the Swahilian/Maputaland regional transition zone (Timberlake et al. 2011).

In the present assessment, definition of Coastal Forest proposed by Burgess and Clarke (2000) and acknowledged as the reference in this domain, was retained. The authors described the floristic composition as follows: Forest dominated (i.e. containing more than 50% of all individuals of trees with a diameter at breast height of 10 cm or more) by Swahili near endemic tree species, i.e. tree species whose global distribution is limited to the eastern African coastal area. Burgess and Clarke (2000) Coastal Forest classification identified 5 typical vegetation formation types. Except for the Eastern African Coastal/Afromontane transition forest, located at the base of the Eastern Arc and Chimanimani Mountains, and near the summit of the Shimba Hills, the following types can be found in at least one studied district.

**Eastern African Coastal Dry Forest (Typical Vegetation Formation Type)**

Semi-evergreen or evergreen undifferentiated dry forest sensu White (1983), with the amendments that

1. Eastern African Coastal Dry Forests can occur where atmospheric humidity is high throughout the dry season,
2. These eastern African Coastal Dry Forests may have a lower canopy (to 7 m) than the minimum limit of 10 m adopted in White (1983).

**Eastern African Coastal Scrub Forest (Variant Vegetation Formation Type)**

Scrub Forest sensu White (1983) which is intermediate in structure between forest (canopy height > 10 m) and bushland or thicket (canopy height < 10 m). In eastern Africa scrub forest may have a lower canopy (to 4 m) than the lower 7 m limit imposed by White (1983), but retains other forest features such as overlapping tree crowns, abundant lianes, a leaf-litter layer and emergent trees which often exceed 10 m in height. Herbs are scarce to absent.

**Eastern African Coastal Brachystegia Forest (Variant Vegetation Formation subtype)**

Transition Woodland sensu White (1983) dominated by either *Brachystegia speciformis* (Arabuko-Sokoke forest in Kenya, and forests in Mozambique) or *Brachystegia microphylla* (southern Tanzania). Occurs on degraded/poor soils. Canopy tree crowns rarely touch and do not interlock. Lianes are usually scarce. Grasses are scarce to absent. Fire does not normally penetrate this vegetation type.

**Eastern African Coastal Riverine/Groundwater/ Swamp Forest (Transition Vegetation Formation sub-type)**

Forest sensu White (1983) in areas where the water table is high or where drainage is poor. Dominant canopy trees are predominantly of species with wide tropical African distributions. Under storey trees and shrubs are dominated by species restricted to the Coastal Forest belt.

Although this classification stands as the reference for the definition of Coastal Forests, updated cartography of Coastal Forest vegetation types is lacking. The actual delineation of these vegetation types is rather vague on the local scale. Burgess and Clarke (2000) already outlined the difficulty to estimate cover change over the past 100 years, as prolonged civil war in the country has prevented access and assessment of many areas. In addition, without thorough ground-truthing and species inventory, remote-sensing analysis of coastal vegetation did not allow to accurately extract forest (sensu stricto) locations. The developed algorithm was ultimately able to categorised forest vegetation in only two classes: Open forest and Dense forest (Error! Reference source not found.).

Table 2 Forest vegetation classes obtained from remote-sensing analysis

<table>
<thead>
<tr>
<th>Forest vegetation classes</th>
<th>Dense forest</th>
<th>Open Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation type</td>
<td>Coastal Forests (sensus stricto)</td>
<td>Closed canopy woodlands</td>
</tr>
<tr>
<td>Parameters retained for remote-sensing analysis</td>
<td>&gt;50% forest coverage / pixel</td>
<td>&lt;30% forest coverage / pixel</td>
</tr>
</tbody>
</table>
In the absence of description of the extent of Coastal Forests in Mozambique, it was therefore not possible to conduct the assessment using the strict definition of this ecosystem. However, Membra, Dondo and Inhassoro are considered to be coastal districts. Rather than restricting the assessment to forests, it was decided to extend the assessment to the coastal forest vegetation mosaic presents in these districts and therefore included in the two aforementioned remote-sensed classes.

This coastal forest vegetation mosaic was described in the national inventory of forests conducted in 2007 by Antonio Marzoli and further used as reference for the national forest reporting (Marzoli 2007; Timana et al. 2014). This inventory indicated the presence of dense and open forests in Membra, shrub, open forests in flooded areas and open forests in Dondo and open forests and open forests with agriculture in Inhassoro. Marzoli (2007) provided also a reclassification of the 54 vegetation classes from the Flora Zambeziaca map in 9 ecological zones to describe the potential types of vegetation in Mozambique at a general level. The vegetation of the studied areas included 5 of these ecological classes. This classification indicated that miombo formations (Humid miombo and Deciduous miombo woodland drier type) generally dominate in Membra and Inhassoro districts while Dondo Coastal Forests are mainly composed of Sub-humid sub-Coastal Forest, Zambesian Woodland and Coastal vegetation mosaics. Based on this ecological zonation and in the absence of onsite inventory, the following description of the species composition of the coastal forest vegetation in the studied areas can be derived. This description is based on generic description of studies previously conducted at the national level and therefore present species and associations potentially present in the study areas. Field surveys are needed to provide a refined distribution of tree species within the studied districts.

The eastern African coastal strip north of the Zambezi River would be expected to support Tropical Dry Forest and Tropical Very Dry Forest as the vegetation climax, given its mean annual precipitation of between 510 and 2000 mm and a mean annual temperature exceeding 23°C (Burgess and Clarke 2000). Membra district is dominated by Miombo and dry deciduous forest vegetation. Dry Deciduous Miombo woodland, are semi-deciduous xerophilous forest that typically occupies areas of low altitude, with average annual rainfall between 600 and 800 mm. It occurs in several northern and central regions. It includes many sub-types and the heights of the trees are generally smaller (8-10 meters) than the previous type. The main species are generally: Brachystegia boehmii, Julbernardia globiflora, Burkea africana, Pseudolachnostylis maprouneifolia, Crossopterix febrifuga, Diplorhynchus condylocarpon, etc. Zambesian Woodland are also found in the north of the district. They are composed of tree or shrub formations characterized by a mixture of species and lack of predominance of floristic elements typical of the Mopane and Miombo forests. The woody species differ according to soil types and climatic conditions. Characteristic species are: Acacia spp., Albizia spp., Combretum spp., Adansonia digitata, Diospyros mespiliformes, Ficus sycomorus, Kigelia africana, Lonchocarpus capassa, Trichilia emetica, Xanthocercis zambesiaca, and Xeroderris stuhlmannii (Marzoli 2007).

Dondo district is dominated by Sub-humid sub-Coastal Forest, Zambesian Woodland (see description above) and Coastal vegetation mosaics. The Sub-humid sub-Coastal Forest is specific to and occupies a relatively important area in the Provinces of Sofala and Zambézia. For example, it is well developed in the areas that stretches South from Beira (Cheringoma) to Inhambinga and Marromeu, and in the North, in the areas of Campo, Nicuadala, Namacurra and Maganja da Costa. The presence of this vegetation type is due to the relative abundance of coastal rainfall and also due to accumulation of water in the soil. Therefore, it is partially controlled edaphically. It is composed of mixed formations of dense and semi deciduous forests, at low altitudes, of Pteleopsis myrtifolia–Erythrophleum suaveolens with Hirtella zanguerica, forming a mosaic with chains of Brachystegia spiciformis–Julbernardia globiflora. Two main sub-groups can be defined: (i) Sub-coastal mosaic of Cheringoma, south of the Zambezi river (Sofala, e.g. including Dondo) and (ii) Sub-coastal mosaic of Zambézia, north of the Zambezi river and at the border with the delta area (Zambézia). Coastal vegetation mosaics are composed of vegetation types formed on recent dune formations or young soils shaped by wind. Newly formed dunes are first unstable and saline dense forests are colonized by pioneering plants of distinct gregarious and prostrate habit. Along the Mozambican coast, the most common pioneers are Sesuvium portulacastrum, Cyperus maritimus, Scaevola plumieri, Ipomoea pes-caprae, I. ficifolia, Canavalia maritima, Sophora tomentosa, S.inhambanensis, Tephrosia canescens, Launaea sarmentosa, Sporobolus virginicus, Dipcadi longifolium, Dactyloctenium aegyptiacum and Carpodratus jurtzi. These pioneers stabilize the sands creating favourable conditions for the establishment of Coastal Forests. The forests composition is influenced by the winds and generally consist of species with coriaceous leaves. Where the precipitation is locally high, the forests become tall and sometimes give rise to dense evergreen forests with many climbing plants. In the southern part of Mozambique, dense lowland forests are often dominated by Grewia occidentalis var. littoralis, Diospyros rotundifolia, Euclea atalensis, etc. or in some areas dominated by Mimusops caffra (Marzoli 2007). In Inhassoro, Miombo vegetation dominates. The
short closed miombo woodland and thicket vegetation is composed of the characteristic tree species *Julbernadia globiflora* and *Brachystegia spiciformis* and the grass cover includes *Panicum maximum, Schizachyrium sangineum* and *Sporobolus pyramidalis*. In Short Open Miombo Thicket Mosaic vegetation, characterised by shrubs and small trees with an open canopy, dominant tree species include *Julbernadia globiflora, Hyphaene coriacea, Mimusops caffra, Indigofera casuarina, Margaritaria discoidea, Ozoroa obovata, Ochna cf barbosae, Crotolaria monteroi, Strychnos spinosa, Strychnos madagascariensis, Olax dissitiflora* and *Dichrostachys cinerea*. In addition, riparian woodland of the Nhanganzo; the Cherimera and the Xivange coastal streams are dominated by dense stands of *Syzigium cordatum* interspersed with *Syzigium guineense, Garcinia livingstonei, Hyphaene coriacea* and *Ficus trichopoda*. (Golder Associates 2015). In this district, dune vegetation can be divided in Coastal Thicket and Dune Scrub and Costal Dune Forest. Coastal Thicket and Dune Scrub include pioneer Dune Communities such the characteristic pioneer grass *Halopyrum mucronatum*, found along with the common pioneer, *Scaevola plumieri*. On the higher and more stable dune slopes and on the more protected lee sides, costal thickets composed of common miombo species (*Julbernardia globiflora, Brachystegia spiciformis, Mimusops caffra and Strychnos madagascariensis*) are found. Compared to inland thicket, plants were slightly smaller and with an open canopy. Coastal Dune Forest vegetation type is characterised by its association with the tall frontal dunes, having emergent trees up to 15 m high, with closed canopy. Dominant species include: *Pterocarpus angolensis, Balanites maughamii* and *Suregada zanzibariensis* (Golder Associates 2015).

Previous studies have indicated that 786 known species distributed in eight biological groups are strictly endemic to the Coastal Forests. The highest rates of endemism are found in invertebrate's groups such as the millipedes, molluscs, and forest butterflies. Other endemic species include also birds, mammals, forest reptiles and amphibians. The vascular plant forest flora is also rich in endemic species and genera (Burgess and Clarke 2000). Areas of endemism have been delineated based on their species richness and endemic characteristics. These areas were further recognized as priority landscapes and sites to conservation (WWF-EARPO 2006). The studied districts include the following areas of endemism: Baixo Pinda Area, Mecufe/Baia do Lúrio, Inhamitanga/ Marromeu/ Cheringoma/ Dondo Area, Bazaruto Area (Error! Reference source not found.). In the studied districts, the south-eastern coast of Baixo Pinda Area is protected as a forest reserve and Bazaruto Area is a national park. Mecufe/Baia do Lúrio does not have any protection status and the protected areas located in the Inhamitanga/ Marromeu/ Cheringoma/ Dondo Area are located outside of Dondo district.
Figure 12 Area of endemism
Although consumption by indigenous large herbivorous is generally low, structural characteristics of the miombo makes it an excellent vegetation for a variety of herbivores such as the Waterbuck (Kobus ellipsiprymus), the Cape bushbuck (Tragelaphus scriptus), the Common eland (Taurotragus oryx), Sable antelope (Hippotragus niger) and the Lichtenstein’s Hartebeest (Alcelaphus buselaphus lichtensteini). Carnivores such as lions (Panthera leo), leopards (Panthera pardus) and necrophagous (e.g. hyenas, vultures) can also be found in this ecosystem. Avifauna is also rich and includes distinct species such as the African-Grey Penduline-tit (Anthoscopus caroli), the Sentinel Rock Thrush (Monticola Explorator) and the Shelley’s Sunbird (Nectarina Shelleyi). According to the IUCN Red List of Species, the status of this species are Least Concern (LT) except for the Near Threatened (NT) Shelley’s Sunbird and Vulnerable (VU) lion and leopard. About 80 percent of mammals in Mozambique are found in Miombo forests but the variety of insects and reptiles is generally rather low (Desanker, P.V., Frost et al. 1997; FAO 2005; Soto 2007).

Anthropogenic activities along the coast have modified this landscape in a mosaic of agricultural fields, with grassy fallow, palm wine production from Lala palm (Hyphaene coriacea) and orchards of exotic tree species such as coconut (Coco nucifera), cashew nut (Anacardium occidentale) and mango (Mangifera indica) (ERM 2015; Soto 2007).

3.1.1.2.2. Abiotic environment

Climatic conditions in the area of distribution of the eastern Africa Coastal Forests are characterized by the tropical monsoon climate of the Indian Ocean with a unimodal (south of Dar es Salaam) to bimodal (north of Dar es Salaam) mean annual rainfall of between 510 and 2’000 mm. Eastern African Coastal Riverine Forest may develop in areas with a lower mean annual rainfall of just 470 mm, since these forests depend on a river for their water supplies (Burgess and Clarke 2000).

Mozambican climate varies from tropical and sub-tropical in the north/central regions, to semi-arid and arid climates in the south. It is characterized by two well defined seasons, wet summer and dry winter. Geographically, temperatures are warmer near to the coast, and in the southern, lowland regions compared with the inland regions of higher elevation. Average temperatures in these lowland parts of the country are around 25-27°C in the summer and 20-25°C in winter. Rainfall varies widely from the coast (800-1’000 mm) decreasing inland to 400 mm at the border with South Africa and Zimbabwe. Rainfall decreases from the north/central regions (1’000-2’000 mm, NE monsoon) to the southern inland (500-600 mm) (Irish Aid 2018; Tadross and Johnston 2012).

The altitude also influences vegetation distribution Coastal Forests are found at altitudes ranging from sea-level to a maximum altitude which varies according to local ecological conditions, but is nowhere more than 1’100 m.

Mozambican territory is dominated by large plains (40%), with elevation under 200 m and extending inward from the eastern coast. North of the Zambezi River, the plains are between 60 km and 100 km wide. The plains become wider in the Zambezi Valley where they extend upstream about 600 km. South of the Zambezi River the plains are up to 100 km wide (Tadross and Johnston 2012).

Coastal Forests occur on a wide range of rock types and geomorphological features and soil types. The majority of inland territories of Mamba district is located on Precambrian formations (gneisses, migmatites, granitoids and related rocks) and carbonated rocks from Meso-Cenozoic formations. The coastal areas are dominated by alluvium deposits from the Quaternary. Eutric Leptosol (lithic soil) and Eutric Cambisol (shallow soil) cover the majority of Mamba district. Haplic Arenosol (coastal dune soil), Eutric Fluvisol (alluvial soil), Ferralic Arenosol, Calcaric Cambisol (shallow soil), Ferric lixisol (clay soil) are restricted to coastal areas and estuaries.

The underlying geology of Dondo district is largely Quaternary comprising mainly undifferentiated deposits and alluviums. The northern part of the district is the only exception, in this area sandstones, clays and related rocks from Karro/ Meso-Cenozoic dominate Ferralic Arenosol cover the majority of Dondo district. At the northern border, Stagnic and Haplic soils can be found locally. Nahmehinda water stream is characterized by Eutric Fluvisol aluviums and the whole coastal area is composed of Mollic Fluvisol alluviums.

Bazaruto island and the coast of Inhassoro district is located on Quaternary terraces. Inland district territories are dominated by carbonated rocks originating from Meso-Cenozoic formations. The northern border of the district is located on Quaternary undifferentiated deposits and alluviums. Bazaruto island and coastal area of Inhassoro district soils are mainly Arenosol / Haplic Arenosol. The rest of the district is dominated by clay soils classified as Chromic Luvisol. Glyric Arenosol and Eutric fluvisol are also found near the coastal region and in the north Ferralic Arenosol and Haplic Lixisol are locally presents.

Too few data are currently available to determine whether certain geological-geomorphic combinations do not support forest. Although, forest seems scarce to absent over planted surfaces composed of Precambrian Basement rocks. The entire range of geological substrate that is found in Africa is represented in the Coastal Forest Belt. The large range of substrate...
.types, geomorphological features (ancient plantation and plateaux, marine and lacustrine deposits, erosion features, river gullies, etc.) and the age of the surface contributes to the great diversity of the Coastal Forest (Burgess and Clarke 2000).

As aforementioned, miombo vegetation dominates the studied areas. Miombo geographical distribution suggests a lower tolerance to arid climates with large dry periods as it is replaced by other types of vegetation in drier regions of the country, mostly mopane and acacia savannahs (FAO 2005). Miombo woodlands can occur under a variety of climates (including dry climates) but it is mostly found in tropical moist regions. The dominant climatic feature for miombo forest development is the marked seasonality, characterised by a wet season and a dry winter. More than 95% of the 700-1'400 mm mean annual precipitation occur during a single 5-7-month period. Mean annual temperatures are within 18-23°C, with mean maximum temperatures in the 24-30°C range. This conditions result in marked seasonality of plant production, growth, reproduction, and decay (Desanker, P.V., Frost et al. 1997).

Miombo vegetation can develop on a variety of soils ranging from sandy soils with low fertility and water retention, loamy-sandy-clayed soils to red clay deep soils. Characteristic upland soils are predominantly alfisols, oxisols and ultisols - infertile, with low cation exchange capacities (2-18 cmolc kg-1), low total exchangeable bases (1-15 cmolc kg-1), high acidity (pH 4-6 in CaCl2), low available phosphorus (9-18 ppm), and a dominance of low-activity clays and sesquioxides. Bottomland soils are predominantly gleysols and vertisols (Desanker, P.V., Frost et al. 1997). Except for alluvial soils, Miombo forests were found on every soil types in Mozambique, with denser forests being located on red clay soils (FAO 2005). Soil composition might explain the absence of miombo in Dondo district.

3.1.1.2.3. Distribution

Stretching along the Indian Ocean coastline from Somalia to Mozambique (Figure 13), the largest remaining extent of Eastern African Coastal Forests is reported to be found in Mozambique (World Bank 2018). Miombo is the dominant forest type in several northern provinces, including Nampula where Membra district is located. It is not found in coastal areas of Dondo district, dominated by undifferentiated dry deciduous and sub-humid sub-Coastal Forests. Dry and average Miombo forest vegetation are found in Inhassoro (A. Sitoe, Salomão, and Wertz-Kanounnikoff 2012 citing MICOA (2008)). However, no updated cartography was found on forest cover by vegetation type. The current forest distribution (2017) was derived from remote-sensing analysis of Landsat images at a 30 m resolution. The developed algorithm allowed differentiation between: Dense and Open Forest (Figure 13).

Figure 13 Distribution of forest vegetation in studied areas

[Image: coastal_resilience_to_climate_change_baseline_coastal_and_marine_ecosystems_restoration_assessment.png]
3.1.1.2.4. Key processes and interactions (conceptual model)

Coastal Forests and their associated ecosystems provide a variety of services to local communities. Timber products provide jobs (forestry e.g. timber for domestic and exporting markets), firewood, charcoal but also raw material for the construction of a variety of tools and construction materials used in rural areas (ex: cooking utensils, poles, etc.). Non- timber products provide provisioning, regulating and cultural services such as food, medicinal plants, edible mushrooms, honey, bush meat (source of animal proteins), land for cropping, salt production, harvesting, water purification, pasture and fodder for animals, watershed protection, habitat for wildlife and ethnic communities, tourism attractions and assets, and cultural and religious groves. Indirect effects result from the exploitation of the forest resources either for subsistence (food, energy, building material) and or for income generating purposes. Agriculture sector also induces a large pressure on forests. Livestock and crops exploit land resources (soil and vegetation) inducing direct effects such as competition for land between forests and agriculture. (Soto 2007). Deforestation in Mozambique originates mainly from food crops such as corn, cassava and beans and cash crops such as sesame, tobacco and cotton. Given their nature, area cultivated for perennial crop (mainly copra, cashews and mango) have not changed significantly in recent years and therefore do not significantly influence forest cover change. Commercial agriculture in Mozambique is still very new and most of the small producers are from the family sector; in most cases working without inputs and using shifting cultivation (Sito, A. Salomao, A. and Wertz-Kanounnikoff 2012). Coastal Forests are also associated with mineral gas that contribute to national development (Soto 2007).

Fire is an important component influencing Miombo forests. It finds its origins in both natural and anthropogenic processes. Highly seasonal precipitation (varying between 650 and 1'400 mm per year) leave the vegetation dry for several months. As a result, thunderstorms at the start of the rainy season can easily set the vegetation alight. In addition to being naturally fire-prone, Miombo forests are also frequently burned by people (Country monitoring report on Mozambique, 2008). Slash-and-burn agriculture was identified as the main cause for burning forests with forest conversion to agriculture accounting for 65% of total deforestation (World Bank 2018). Fire is generally used prior to the rainy season for agricultural land preparation. Communities identified also rodent hunting as a cause for setting forest on fire. The decrease in larger mammals in the last 20 years has forced many hunters to resort to smaller mammals difficult to hunt in high vegetation. Fires are also used by loggers to clear paths and improve visibility to find precious wood, and by beekeepers accidentally while tending hives. Finally, fires are used by communities to clear undergrowth such as grasses that takeover paths and hinder movement in forest (Country monitoring report on Mozambique, 2008). It is noteworthy that uncontrolled fires are mainly of anthropogenic origin. According to FAO (2001) 90% of forests fires in Mozambique are caused by humans, 5% originate from natural cause and another 5% are of unknown origin. Forest fires do not directly produce deforestation and especially when they are part of the Miombo ecosystem, they can however degrade forests since they affect the processes of establishment and growth of trees (Sitoe, A. Salomao, A. and Wertz-Kanounnikoff 2012). In the non-fire resilient Coastal Forests (sensus stricto) they can be very damaging. However, the coastal strip with its evergreen to semi-evergreen coastal vegetation has the lowest burning intensity in the country but it is nonetheless very vulnerable to it (FAO 2001a). As described by A. Sito et al. (2012), the aforementioned activities are interdependent and closely influence land-use dynamics (Figure 15). The direct impact of deforestation results in direct conversion of forests to areas of permanent agricultural or shifting cultivation. The indirect impact on the forest includes a transition phase during which hardwood is extracted, followed by the extraction of firewood and charcoal in the areas that have become accessible. These areas are later used for agriculture, suggesting once more that agriculture and fuel-wood production work in combination to create forest-cover change. Fire is used to facilitate access in both logging and forest exploration, for production of firewood and charcoal, and for clearing land for agriculture (including slash and burn farming method). Figure 14 presents a simplified cause-and-effect conceptual model of the ecological processes most relevant to the Mozambican’s forest ecosystem risk assessment.
Figure 14 Dynamics of land-use and forest-cover changes (adapted from: Sitoe, A. Salomao, A. and Wertz-Kanounnikoff 2012))
Figure 15 Simplified cause-and-effect conceptual model of the ecological processes most relevant to the Mozambican’s forest ecosystem risk assessment
3.1.1.3. Threatening processes

Pressures in coastal areas are more significant than in any other regions, because coastal areas contain some of the most biologically diverse and ecologically important ecosystems (USAID 2008). A study conducted on Coastal Forests in Cabo Delgado in 2011 (Timberlake et al. 2011) concluded that the high proportion of range-restricted species, the limited extent of the forest patches, and the increased threat to the area show these forests to deserve international conservation concern (World Bank 2018). The following paragraphs describe threats to tropical biodiversity and tropical forest.

Habitat Fragmentation and Deforestation, resulting from conversion of natural forests to cropland, over-exploitation of forests, illegal exploitation, slash-and-burn practices, uncontrolled removal of vegetation, use of firewood as a source of energy, charcoal production, and uncontrolled bush fires (USAID 2008). Coastal Forests are increasingly being cleared for agricultural purposes including the expansion of commercial farming, shifting agriculture, livestock production and slash-and-burn method in search of soil that has not been leached of nutrients (Samoiys et al. 2015). As aforementioned, fire is not only restricted to agricultural activities, they are also used to clear land for cultivation and to provide access to resources (honey, precious wood, etc.), to maintain pastures for livestock, or to drive game animals to positions where they can be easily hunted (Ribeiro and Ribeiro 2008). Production of honey and beeswax is also a long tradition in Mozambique. Honey is used by local people to generate income, for brewing alcoholic drinks, preparation of medicines and as a sweetener. Traditional bee keeping is done with bark hives, which are produced by complete bark removal from the trunk of large trees, and in the process killing them. Collecting honey sometimes involves cutting trees in which a wild hive is located. Smoke and fire is always used to chase bees away from wild or bark hives, and uncontrolled fires can result from honey collection. Honey production is therefore also a factor that contributes to the destruction of forest (Byers et al. 2013).

Logging constitutes also one of the greatest threats to Coastal Forests. Unsustainable or illegal logging (reaching up to 93 percent of all logged wood in 2013) makes it difficult to accurately predict deforestation rate. In addition, more than half the volume of the commercial species harvested belongs to just three species (Environmental Investigation Agency UK Ltd. 2014): Afzelia quanzensis (chanfuta), Pterocarpus angolensis (umbila) and Millettia stuhlmannii (jambirre or panga-panga) and 90 percent of timber exports are restricted to only six species, including Combretum imberbe (mondzo), Swartzia madagascariensis (pau ferro) and Dalbergia melanoxylon (Pau preto) (Environmental Investigation Agency UK Ltd. 2014; Macqueen 2018).

Inhassoro is an area with high tourism development and more touristic areas are planned. Tourism activities can also induce considerable pressure on local ecosystems and mainly though fragmentation and deforestation resulting from the building of infrastructures.

Soil Depletion and Erosion as a result of poor land-use practices including deforestation of coastal and inland areas. Erosion takes different forms, including water erosion, wind erosion, physical compaction, salinization, and various forms of chemical degradation. In Mozambique, considerable erosion is due to extreme events like cyclones and heavy precipitation on unprotected surfaces (USAID 2008).

Pollution and Waste Disposal resulting from agricultural activities, mainly taking place along or close water bodies (e.g. river streams, lakes, etc.). Agrochemicals (pesticides and fertilizers) are transported by water and enter coastal and marine environments (USAID 2008). However in Mozambique, other direct threats are generally more important than pollution (Byers et al. 2013).

Mining that induce a loss of productive land, increase of water consumption and potential contamination of surface and groundwater and erosion and silting of rivers (USAID 2008). Mining activities might influence forest cover through combined processes: direct actions of mining activities, resettlement of populations in areas of mining concessions, and opening of access roads and construction of infrastructures (buildings, pipelines, etc.) (Sitoe, A. Salomao, A. and Wertz- Kanounnikoff 2012). To date, the influence of mining activities on forests is still limited. No planning of future prospections and exploitation activities exists. Therefore, measures must be taken to ensure that environmental impact assessments are conducted prior future developments and that suitable mitigation measures are implemented to prevent further degradations.

3.1.1.4. Ecosystem collapse

For spatial explicit criteria A and B, tree loss or degradation is the dominant pathway to collapse. For criterion A and B, Coastal Forests were considered collapsed when their mapped distribution declines to zero (100% loss). Pollution and fire were identified as the main threats that could influence abiotic processes and environment. However, the absence of quantitative data and monitoring of these threats did not allow to define collapse indicators for criterion C (see section 3.1.1.5.3). For criterion D, Coastal Forests were considered collapsed when the degradation of the first class and precious species stock reach 100%.
3.1.1.5. Assessment of ecosystem risk of collapse

3.1.1.5.1. Criterion A

No studies were found on forest cover changes by vegetation type. One of the main reasons for this is that the different national forest inventories used different ecosystem typologies, which makes direct comparisons difficult (Sitoe, A. Salomao, A. and Wertz-Kanounnikoff 2012). Forest cover changed was derived from remote-sensing analysis of Landsat images (30 m resolution), that allowed to define forest extent in 1996, 2003, 2010 and 2017. The developed algorithm was ultimately able to categorised forest vegetation in two classes: Open forest and Dense forest (Figure 16).

This analysis produced a difference of forest cover ranging from -73% to +11% over the 22 studied years. The criteria A1 assesses reduction in geographic distribution over the past 50 years. In the absence of homogenous dataset over a longer period, the abovementioned data was used. Forest cover losses never exceeded 25%, except for Memba where Dense Forest losses reached up to 73%. Dense Forests are therefore Endangered (EN) in Memba. On the opposite, Open Forests are assessed as Least Concern (LC) in this district as well as in Dondo. Dondo Dense Forests and Inhassoro & Bazaruto Dense and Open Forests declined by ~25% over a 22-year period which assign them to the Near Threatened (NT) risk category.

At the national level, forests exhibit a linear pattern of decline over the 1990-2015 period (R2=0.99). The 2014 National Forest report predicted an increase of the declining rate between 2015 and 2020 and a reduction between 2020 and 2030 (Timana et al. 2014). However, at district level and to the exception of Open Forests in Inhassoro & Bazaruto, fluctuations did not allow to derive predictions for the next 50 years nor for any 50-year period including the past, present and future, as requested under criterion A2.

![Figure 16 Change analysis of forest-cover in studied districts over the 1996-2017 period](image-url)
According to remote-sensing analyses, Dense Forest coverage in Memba dropped drastically between 2003 and 2010 and tend to plateau since 2010. For Open Forest, the increasing trend observed between 1996 and 2010 seems to be reversing since 2010 and decrease was observed over the 2010-2017 period. In Dondo, Dense and Open Forests seem to have reached a slower regression rate over the past 7 years. Finally, in Inhassoro & Bazaruto trends tend to indicate a decrease of both Dense and Open Forests over the 1996 – 2017 period. Considering the quasi-linear pattern of decline of Open Forest (R2=0.937) in this district, the absolute rate of decline was used to predict cover loss over the 1996 – 2046 period (IUCN 2017). This predicted a 60% decline of Open Forest over this 50-year period, which assigned Inhassoro & Bazaruto to the Endangered category under criterion A2b. If fluctuations of forest coverage did not allow predicting future trends under criterion A2 for the other districts, they provide intel on the evolutions of the forest changes and recent tendencies (2010-2017 period).

Due to the absence of historical data at district level, subcriterion A3 was assessed as Data Deficient (DD).
3.1.1.5.2. **Criterion B**

To inform subcriteria B1 following the IUCN RLE Guidelines v1.1, the extent of occurrence (EOO) of the 2017 forest distribution was assessed by measuring the area of the minimum convex polygon that encompasses all known occurrences of this ecosystem (IUCN 2017). The extent of the maximum convex polygons enclosing all occurrences (EOO) in the studied districts ranged between 3'130.3 km² and 6'348.7 km² (Table 3).

The above mentioned change analysis did not allow to identify strict continuing decline of the forest ecosystems over the 1996-2017 period, though trends are all converging toward loss of surface areas in the past 7 years (2010-2017). The national assessments of Mozambican forests indicated a continuing decline of forest cover due to multiple factors but mainly due to unsuitable exploitation of forest resources and the development of the agriculture. Conversion of land to agriculture, coupled with the related problematic of uncontrolled fire, together with the unsustainable use of forests for firewood,

Construction material and agroforestry are likely to cause continuing decline in geographic distribution, environmental quality and biotic interaction within the next 20 years. Forest vegetation in the three studied districts falls therefore under the Endangered (EN) risk category under criterion B1b.

Table 3 Extent of occurrence (EOO) and area of occupancy (AOO) of the Coastal Forest distribution

<table>
<thead>
<tr>
<th>Ecosystem class</th>
<th>Criteria</th>
<th>Memba</th>
<th>Dondo</th>
<th>Inhassoro &amp; Bazaruto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Forest</td>
<td>EOO [km²]</td>
<td>5'696.7</td>
<td>3'130.3</td>
<td>6'335.0</td>
</tr>
<tr>
<td></td>
<td>AOO</td>
<td>47</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Open Forest</td>
<td>EOO [km²]</td>
<td>5'697.3</td>
<td>3'139.6</td>
<td>6'348.7</td>
</tr>
<tr>
<td></td>
<td>AOO</td>
<td>56</td>
<td>30</td>
<td>44</td>
</tr>
</tbody>
</table>

The area of occupancy (AOO) was determined by applying a grid of 10 × 10 km cells and counting the cells in which the ecosystem covered more than 1% of the grid cell area (1 km²) (IUCN 2017). The AOO ranged from 30 to 56. As aforementioned observed threatening processes (conversion of land to agriculture and unsuitable use of forest resources) are likely to cause continuing decline in geographic distribution, environmental quality and biotic interaction within the next 20 years. All forest classes were therefore assessed as Vulnerable (VU) under criterion B2b, except Open Forests of Memba which fall under the Near Threatened (NT) risk category.

The studied ecosystems characteristics do not reach the thresholds of the B3 criterion. It was therefore assigned the Least Concern (LC) category for every district and ecosystem.

It is to be noted that criterion B evaluates risk based on ecosystem distribution extent. The present assessment focuses on ecosystem status within the studied districts, while ecosystems are not bounded to administrative boundaries. Although assessment at district level might be relevant for administrative purposes, limited extent of the ecosystems in the districts could ultimately lead to assign a higher risk category. Considering the whole extent of the ecosystem might indicate a lower risk because its larger geographic distribution makes it more resilient. As aforementioned Coastal Forests are spread along the coast between Somalia and Eastern Africa (3.1.1.2.3). National or international assessments could therefore provide a better understanding of the status of the ecosystem as whole. Nevertheless, assessment at district level is relevant to inform actions that need to be taken at local level and to evaluate the relative urgency of these interventions.
3.1.1.5.3. Criterion C

Pollution has been identified as a potential threat to forest loss. Uncontrolled waste disposal, untreated sewage discharge, contamination of soil and water by agrochemicals and industrial activities (ex: oil and gas extraction, etc.) have been previously identified as potential sources of pollutions (Byers et al. 2013; Report 2002; Samoilys et al. 2015; Soto 2007). It is also to be noted that forest fires could impact soil quality.

Impoverished soils produce less biomass and render natural regeneration less successful. Bare soils are more prone to erosion by torrential runoff that could affect upper layers. Lower infiltration capacity affects water table level, reducing the growth period and eliminating drought susceptible vegetation (FAO 2001a). The degradation of forests soils under agriculture requires the search for more forest land to access (and effectively) the next area of fertility. This phenomenon is particularly exacerbated by population growth.

However, to date there are no information regarding fire impact on soil properties in the study areas. Quantitative data and monitoring of pollution sources and fire-related issues in the study areas are lacking. It was therefore not possible to derive the status of the abiotic processes at this stage.

In the absence on relevant data to assess deterioration of abiotic processes, this criterion is classified as Data Deficient (DD).

3.1.1.5.4. Criterion D

No inventory describing plant nor animal species distribution and their status have been found for the studied districts. Similarly, little to no data exist on alien species and insect infestation (Timana et al. 2014). The only data available concern Inhassoro district. In this district, alien species were found locally around settlements and agricultural areas. Agave sisalana was recorded in the projected tourism development area and Melinis repens was recorded along the road verges and tracks. Lantana camara and Opuntia ficus-indica were noted around settlements in the south of the study area. Exotic agricultural plants such as cashew nut trees (Anacardium occidentale), mango trees (Mangifera indica) and casuarinas (Casuarina equisetifolia) occur in low numbers in disturbed areas (ERM 2015).

Although forest fires are a natural phenomenon in eastern Africa, the majority that occur are started by people and uncontrolled fires could also affect forest cover and species distribution. Over time and with frequent and intense burning, it is believed that lowland coastal forest and thicket vegetation is converted to
more fire-adapted vegetation types similar to Miombo woodlands (dominated by Brachystegia and Julbernardia species) (WWF-EARPO 2006). Natural regeneration is affected by fire which could prevent forest ecosystem to reach its climax. Increasing fire and logging intensity will considerably threaten a number of the narrowly endemic coastal forest specialist species e.g. Pterocarpus angolensis, Millettia stuhlmannii, Milicia excels, Androstachys jonsonii, Erythrophleum suaveolens, Brachystegia, Dalbergia melanoxylon, etc. and foster their replacement by wide-ranging species typical of Miombo (WWF-EARPO 2006). Fire management have a crucial role in the establishment and maintenance of woody vegetation. Ryan and Williams (2011) findings suggested that miombo woody biomass may be preserved or enhanced by burning in low-intensity conditions. As underlined by Laris and Wardell (2006), fire management should be adapted to the local context. While drastic reduction of woody biomass in some areas might require reducing fire, in others, well managed fire might be beneficial both for the local communities and biodiversity. When fire is properly timed, it could allow achieving a green flush of new perennial grass shoots (source of fresh fodder for domestic and wild animals). In addition, early-burning of low productive areas helps creating natural fire breaks. Patch-mosaic burning create an array of patch types that act as natural firebreaks limiting the spread of fire. Annual burning of selected areas can allow maintaining these fireguards, protecting particular vegetation patches. Although, indications are that forests are becoming less rich in species diversity, more fragmented and poorer in species associations, the absence of specie inventory and lack of knowledge on fire-related impact in our study areas, did not allow us to derive a precise assessment of this threat on forest ecosystems (FAO 2001a; WWF-EARPO 2006).

Another very concerning factor was that 85-90 percent of actual logging is focused primarily on only 5-6 species, putting substantial pressure on their stocks (Environmental Investigation Agency UK Ltd. 2014). Afzelia quanzensis (Chanfuta), Pterocarpus angolensis (Umbila), Millettia stuhlmannii (Jambirre or Panga-panga), Combretum imberbe (Mondo) and Swartzia madagascariensis (Pau ferro) are classified as “first class” based on their quality, uses and demand intensity. Export of first class timber in log form is banned and wood needs to be processed in Mozambique before leaving the country. Afzelia quanzensis (Chanfuta), Pterocarpus angolensis (Umbila), Millettia stuhlmannii (Jambirre or Panga-panga) and Dalbergia melanoxylon (Pau preto) logs, are classified as “Precious woods” in Mozambique and their exploitation is restricted by logging quotas by province and by license holder (Forest Legality Initiative 2016). However, recent studies indicate that these protective measures are not sufficient to offset the unsustainable consumption of these species. According to Environmental Investigation Agency UK Ltd. (2014), actual consumption (domestic consumption and global reported imports) rose by an average of 8 per cent per annum, between 2007 and 2013. Assuming that the consumption follows a continues increase at 8 percent per annum, the standing stock of the aforementioned first and precious class species would be completely logged out by 2029.

During the stakeholder consultation conducted onsite in November 2018, unsuitable forest exploitation was raised as a major threat to forests in the districts of Dondo and Inhassoro. In these districts, several forest concessions are registered (Figure 19). The Integrated Assessment of Mozambican Forests (AIFM), conducted in 2007, indicated that wood consumption locally exceeded potential forest production in every studied district (Marzoli 2007). However, the identified zones of unsustainable use of forests did not match with the forest concession holdings. These findings highlight that logging is not the sole important pressure. Domestic use for construction material and fuel production is also of great importance. In the domestic market, a slight wider use of species is accepted although preference is still given to the above-mentioned first class and precious species (World Bank 2018). The depletion of these species standing stocks appeared to be of great magnitude and concerning the whole ecosystem. This degradation of species characteristic of the native biota by an abiotic pressure could assign forests to the Critical Endangered (CR) risk category under criterion D2b, if its impact is confirmed at the district level.

Indeed, in the absence of specie inventory, it is difficult to assess the magnitude of this threat at local level. In the absence of robust evidence, criterion D2 was assessed as Data Deficient (DD).

Due to the absence of quantitative past and historical data at district level, subcriteria D1 and D3 were assessed as Data Deficient (DD).

For terrestrial ecosystems, protection of areas of endemism described in section 3.1.1.2.1 should be the priority. Inventories describing plant and animal species are needed to assess disruption of biotic processes and the status of forest vegetation under criterion D.
is still given to the above-mentioned first class and precious species (World Bank 2018). The depletion of these species standing stocks appeared to be of great magnitude and concerning the whole ecosystem. This degradation of species characteristic of the native biota by an abiotic pressure could assign forests to the Critical Endangered (CR) risk category under criterion D2b, if its impact is confirmed at the district level. Indeed, in the absence of species inventory, it is difficult to assess the magnitude of this threat at the local level. In the absence of robust evidence, criterion D2 was assessed as Data Deficient (DD).

Due to the absence of quantitative past and historical data at district level, subcriteria D1 and D3 were assessed as Data Deficient (DD).

For terrestrial ecosystems, protection of areas of endemism described in section 3.1.1.2 should be the priority. Inventories describing plant and animal species are needed to assess disruption of biotic processes and the status of forest vegetation under criterion D.

Figure 19 Location of forest concession in Mozambique
(source: Terra Firma, spatial database of timber operators (Muianga and Norfolk 2017))
3.1.1.6. Conclusion

Assessment of the reduction in geographic distribution (criteria A) of the dense and open forests in Memba, Dondo and Inhassoro & Bazaruto classified them respectively as Endangered (EN) and Least Concern, Near Threatened (NT) and Least Concern (LC) and Near Threatened (NT) and Endangered (EN) (Table 4). Conversion of land to agriculture and unsustainable use of forest resources threatened standing stocks. Under criterion B1b, forest vegetation was classified as Endangered (EN) in all districts. Under criterion B2b, all the forest vegetation types were assessed as Vulnerable (VU) except for Open Forests in Dondo which were characterized as Near Threatened (NT). The overall risk status of the ecosystem is assigned as the highest category of risk obtained through any criterion. The forest vegetation of the studied districts are therefore Endangered (EN) (Table 4).

### Table 4 RLE assessment summary for coastal forest vegetation (with criteria presenting the highest risk category in brackets)

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Forest</th>
<th>Criterion</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memba</td>
<td>Dense Forest</td>
<td>subcriterion 1</td>
<td>EN</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
<td>EN (A1 - B1b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 2</td>
<td>DD</td>
<td>VU</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>LC</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open Forest</td>
<td>subcriterion 1</td>
<td>LC</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
<td>EN (B1b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 2</td>
<td>DD</td>
<td>NT</td>
<td>DD</td>
<td>DD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>LC</td>
<td>DD</td>
<td>DD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dondo</td>
<td>Dense Forest</td>
<td>subcriterion 1</td>
<td>NT</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
<td>EN (B1b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 2</td>
<td>DD</td>
<td>VU</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>LC</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open Forest</td>
<td>subcriterion 1</td>
<td>LC</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td></td>
<td>EN (B1b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 2</td>
<td>DD</td>
<td>VU</td>
<td>DD</td>
<td>DD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>LC</td>
<td>DD</td>
<td>DD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhassoro &amp; Bazaruto</td>
<td>Dense Forest</td>
<td>subcriterion 1</td>
<td>NT</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
<td>EN (B1b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 2</td>
<td>DD</td>
<td>VU</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>LC</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open Forest</td>
<td>subcriterion 1</td>
<td>NT</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td></td>
<td>EN (A2-B1b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 2</td>
<td>EN</td>
<td>VU</td>
<td>DD</td>
<td>DD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>LC</td>
<td>DD</td>
<td>DD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.1.2. Mangrove

#### 3.1.2.1. Classification

IUCN Habitats Classification Scheme (Version 3.1) is a global typology of habitat types. The IUCN Habitats Classification Scheme is composed three hierarchic levels describing 18 habitats. The following habitats were identified in the studied districts: 1. Subtropical/Tropical Mangrove Forest Vegetation Above High Tide Level (level 1.7) and Mangrove Submerged Roots (level 12.7).

#### 3.1.2.2. Ecosystem description

##### 3.1.2.2.1. Characteristic native biota

Mangroves are defined as characteristic littoral plant formation of tropical and subtropical sheltered coastlines (Hughes, Hughes, and Bernacsek 1992). In Mozambique, mangrove forests are dominated by 9 species: Avicennia marina, Bruguiera cylindrica, Bruguiera gymnorrhiza, Ceriops tagal, Heritiera littoralis, Lumnitzera racemose, Rhizophora mucronata, Sonneratia alba, Xylocarpus granatum (Tropical Coastal Ecosystems Portal 2018). The southern limit for Sonneratia alba and Heritiera littoralis is the River Save at around 21° S. Further south, mangrove trees are rarely taller than 4 m (Samoilys et al. 2015). To the best of our knowledge, no inventory of species has been specifically conducted in the studied areas. The only inventory found was produced by A. A. Sitoe, Mandlate, and Guedes (2014) who identified 6 of the aforementioned species in Sofala Bay near Dondo (Avicennia marina, Bruguiera gymnorrhiza, Ceriops tagal, Heritiera littoralis, Rhizophora mucronata and Xylocarpus granatum). Mangroves forests provide habitats to wide range of fauna, this include invertebrates, crabs, paenid prawns, fishes, reptiles and a variety of birds and mammals (see description in Annex 2).
3.1.2.2.2. Abiotic Environment

Mozambican coastline can be divided into three main regions; the coralline with coral limestone in the north, estuarine in the central region, and the sandy coastline in the southern region of the country (Spalding, Blasco, and Field 2015).

In the northern region, between River Ruvuma and the town of Mossuril, coastal plains are generally narrow due to highly indented and high relief of the highlands, locally approaching within 5 km of the coast. As a result, rivers are not tidal to any great distance and tidal forests are confined to the vicinities of stream mouths and to the shore of the bays. Mangrove forests are floristically well-developed but are seldom very extensive between their landward and seaward faces. However, the coasts present several large sheltered bays and are protected by numerous offshore islands and coral reefs offering a natural protection prone to the development of mangrove forests (Hughes, Hughes, and Bernacsek 1992). The study area of Mamba district constitutes the perfect example of this scalloped landscape. The 242 km shoreline comprise 4 large bays (Fernão Veloso, Simuco, Memba, Mamba and offshore from the city Gêba), and no more than 9 estuary areas populated with mangroves.

Between the south of the Zambezi and Beira, the alluvium from 18 rivers has produced a continuously deltaic coast. Mangroves occur on the open sea coast, in depressions behind frontal sand dunes and along the numerous channels that give the coast a scoloped appearance (Hughes, Hughes, and Bernacsek 1992). Dondo district, is characterised by a 28 km shoreline mainly composed of the alluvium transported by the Sangussi, Bumbo, Nhafupa, Nhamechinda and Savane rivers.

Between Bartolomeu Dias and Inhambane, no major rivers occur and the lack of silt and freshwater is reflected by the scarcity of tidal forests. In this section, the coast is strongly influenced by Agulhas Current flowing southward at the edge of the continental shelf. Inshore water temperature exceeding 21°C favourable to mangrove development are maintained by northern warm surface water, deflected northward as a consequence of Eddies generated at the boundary with the water over the continental shelf. The northward longshore resulting current and SE orientation of waves on beaches, transport vast quantities of sand northward between Inhambane and the Zambezi creating many northward pointing sandspits. The Inhassoro district, located in this area is crossed only by the Maurungane and Govuro rivers, flowing in the northward direction.

The Govuro river meets the Indian Ocean at the northern district border, in the Inhambane district. This district also includes the Bazaruto national park.

3.1.2.2.3. Distribution

Mozambican mangroves are among the best developed mangroves in terms of area, species diversity and forest structure (Spalding, Blasco, and Field 2015). With over 300'000 hectares, Mozambique has the largest tract of mangrove forest in Africa and ranks 13th in the world in terms of mangrove extent (WWF Deutschland 2018a).

Mangroves are ubiquitous along most of the Mozambican coast although differences are observed between the three above mentioned coastal regions. Mangroves tend to be more continuous in northern and central districts where offshore islands and reef- building corals offer a natural protection and become less common in the south (Hughes, Hughes, and Bernacsek 1992).

In Mamba district, mangroves are found in bays at the vicinity of stream mouths. In these bays, mangroves are sheltered from currents and the presence of coral-reefs in front of the bays offer a secondary protection. In the northern part of the district, mangrove forests occupied areas located around the mouths of the Lúrio and Mepoto rivers in the Fernão Veloso bay. The sandspit that close the southern part of the bay presents also mangroves at its extremity. The Meteca river and its affluent Muca meet the ocean in the bay of Simuco, 50 km north from Fernão Veloso bay. In this area, the mangrove cover occupies all the coastal area of the bay. The next mangrove is found in Merenge bay (10 km south), mainly on the northern and southern coast of the bay. Although the cover is not continuous, the largest surface area of mangrove is located around the Mamba bay. They occupied the northern coasts of the bay, in the vicinity of the Moendeze and Mecuburi rivers and the sheltered areas of the scalloped southern coast, including the mouth of the Sapite river. The southern extremity of the district also host a significant surface of mangrove on coastal areas located in the vicinity of the city of Gêba. The only mangroves that developed outside of the protection of the bays were located in the deltas of the Missangane and Naeco rivers. However, these mangroves seem to have disappeared over the past 25 years.

Over the 28 km shoreline of the Dondo district, 19 km are covered with mangroves. Starting from the bed of the Sangussi river delimiting the north-eastern extremity of the district, the coast presents a quasi-continuous mangrove on 15 km, implanted in the alluvium of the deltaic areas created by the Bumbo and Nhafupa rivers. The south-western mangrove is located on the left bank of the mouth of the Maria river.

As aforementioned, mangroves are less present in the southern part of Mozambique. A small extent of the mangrove of the Govuro river delta is included in the
Inhassoro district but the main mangroves are located in the southern area. Over the 58 km shoreline, only 8 km are populated with mangroves. This continuous coastal fringe is located at the interface with inland water and is protected by sandbanks that deflect the northward currents. Recent observations indicate that mangroves are located on the west coast of Bazaruto island. Prior 2001, patches were present on the east coast but they disappeared.

Figure 20 Distribution of mangrove forests in Memba district in 2017 (WWF Deutschland 2018b).
Figure 21 Distribution of mangrove forests in Dondo district in 2017 (WWF Deutschland 2018b).

Figure 22 Distribution of mangrove forests in Inhassoro & Bazaruto in 2017 (WWF Deutschland 2018b).
3.1.2.2.4. Key processes and interactions (conceptual model)

Mangrove forests present a bottom-up trophic regulation, with non-dominant species (fish, crabs, shrimps) (Marshall et al. 2018). Mangroves are mainly found in river mouths. The nutrients that flow downstream make these mangrove–estuarine systems highly productive. They provide nursery grounds and breeding areas for numerous important fishery species such as snapper, emperor, grouper, prawns, crabs and sea cucumber (Samoilys et al. 2015).

On the other side, mangroves are used as raw material in a wide range of anthropogenic activities. Local communities use *Avicenia marina* as timber for construction of bed, firewood and fodder; *Bruguiera gymnorrhiza* is harvested as poles for building materials and firewood; *Sonneratia alba* is mainly used for honey production, fire wood and boat building; *Ceriops tagal*, is used to make poles, firewood and timber for boat construction; *Sonneratia alba*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Bruguiera cylindrica*, *Heritiera littoralis*, *Xylocarpus granatum* are used as medicine as well as firewood (Soto 2007).

Besides exploitation of mangroves for production of wood materials, change in land-use was also identified as a major process affecting mangrove distribution. Increasing population is associated with the development of urbanization and agricultural activities. Poor soils of coastal east Africa do not easily support settled agriculture resulting in the widespread practice of shifting agriculture. Soils under forest cover are often more fertile and therefore face pressure to be converted for agriculture (WWF-EARPO 2006). Activities such as salt production and aquaculture ultimately lead to land clearing for accesses and building of infrastructures.

Extensive oil and gas exploration being conducted in the Mozambique Channel can also negatively impact mangrove development. Exploration and extraction requires land-clearing for accesses, construction of terminals, and the advent of shipping close to shore. In addition, although preventive measures are usually taken, accidental pollution (ex: oil spills) have the potential to damage coastal environments (Samoilys et al. 2015).

Finally, little is known on the effects of climate change and cyclones on mangroves in the studied areas. High cyclone frequency (Fitchett and Grab 2014) and change in abiotic processes and environment (sea level, hydroperiod and salinity) could ultimately result in reduced mangrove development.
Figure 23 Simplified cause-and-effect conceptual model of the ecological processes most relevant to the Mozambican's mangrove ecosystem risk assessment
3.1.2.3. Threatening processes

Historically, studies have identified major threats to the mangroves in Mozambique as: uncontrolled exploitation for firewood, charcoal and poles; clearance of mangroves for agriculture (mainly for rice fields) and salt production; pollution and decreased flow of freshwater to mangroves caused by construction of dams (Barbosa, Cuambe, and Bandeira 2001). Recent studies also point-out the importance of natural hazards, El Nino events and climate-related issues such as sea level rise, excessive flooding and increase sedimentation. These threats are not restricted to Mozambique but were found to be uniform across West Indian Ocean (WIO) with varying degree of intensity (Lee et al. 2017; UNEP-Nairobi Convention and WIOMSA 2015).

3.1.2.4. Ecosystem collapse indicators

Mangrove forests present a bottom-up trophic regulation, with non-dominant species (fish, crabs, shrimps). As proposed by Marshall et al. (2018), assessment of spatial and functional symptoms of collapse is therefore based on monitoring mangrove species, with mangrove loss or degradation being the dominant pathway to collapse. For criterion A and B, mangroves were considered collapse when their mapped distribution declines to zero (100% loss). Pollution and deforestation for production of construction material and fuel (firewood), were identified as the main threats that could influence abiotic and biotic processes. However, the absence of quantitative data and monitoring of these threats did not allow to define collapse indicators for criterion C and D (see section 3.1.2.5.3 and 3.1.2.5.4).

3.1.2.5. Assessment of ecosystem risk of collapse

3.1.2.5.1. Criterion A

To inform criterion A, the 1994, 2001, 2008 and 2015 mangrove distributions were compared to quantify declines in spatial distribution. These long term time series change were provided by WWF Deutschland (2018b). This dataset includes change in mangrove cover at the national scale over the past 25 years using highest resolution available. Landsat sensors providing imagery at 30 m resolution were used to derive mangrove areas prior 2015. Following the launch of Sentinel-2 in 2015, this sensor was used to gather further information at 10 m resolution. In order to ensure consistency in the data resolution and interpretation only Landsat data were considered in the present section (1994-2015 period).

Similar trends were observed in surface change over the past 25 years in the studied districts. Geographic distribution of mangroves were found to be dynamic rather than describing linear trends (continuous growth or decline). The 1994-2001 period is characterized by a slight decrease in mangrove cover, while coverage increased between 2001-2015 (Figure 24).

Ecosystem-risk analysis require detailed information and time series to generate robust results on the status of the ecosystem thus allowing to highlight areas that require urgent action, while better informing conservation and protection strategies accordingly. This type of analysis aiming to study ecosystems risk and vulnerabilities, from spatial and functional perspectives, more than two edges in the time have to be considered to interpret ecosystems’ trends and dynamics.

In the case of the CRCC project, long-term times series of changes generated by WWF Deutschland were considered to assess and compare mangrove spatial distribution from 1994 to 2015, which means within a long period of time (WWF Deutschland, 2018b). WWF data has been used in other comprehensive studies on mangroves vulnerability to climate change (Calvin, 2017). Except for Memba district surfaces covered by mangrove in 2015 exceeded 1994 estimates. For these districts, spatial explicit data did not suggest any decline in the next 50 years or any 50-year period including past present and future. Subcriteria A2a and A2b were therefore assessed as Least Concern (LC). For Memba the net change over the 1994-2015 period is estimated to 2%, classifying mangrove forests also as Least Concern (LC) for subcriteria A2a and A2b. As underlined by WWF Deutschland (2018b) these findings does not mean that mangroves are not affected by abiotic or biotic pressures but only that the gains are offsetting losses.

Due to the absence of quantitative past and historical data at district level respectively, subcriteria A1 and A3 were assessed as Data Deficient (DD).
3.1.2.5.2. Criterion B

To inform subcriteria B1, the extent of occurrence (EOO) of the 2018 mangrove distribution was assessed by measuring the area of the minimum convex polygon that encompasses all known occurrences of this ecosystem (Table 5). The area of occupancy (AOO) was determined by applying a grid of 10 × 10 km cells and counting the cells in which the ecosystem covered more than 1% of the grid cell area (1 km²) (IUCN 2017).

Mangrove distribution used was provided by WWF Deutschland (2018a) and consisted of the remote sensed estimation of the mangrove cover based on Sentinel-2 sensor imageries (10 m resolution).

Figure 24 Evolution of surface area (Ha) covered by mangroves between 1995 and 2015 in Memba and Dondo (A) and in Inhassoro & Bazaruto (B)
The EOO is no larger than 2,000 km² in every districts, but no evidence of continuous decline was identified for the ecosystem to be eligible under criteria B1a and B1b. Similarly, as no evidence of continuous decline was identified, the ecosystem was not eligible under criteria B2a and B2b.

Change in land use through urbanization and agriculture has been identified as the major threat during stakeholder consultation. Occurrence within proclaimed reserves are protected from this threat. The proximity of existing and expanding agricultural areas and urbanization/touristic projected areas constitute a direct threat to these restricted ecosystem patches. Mangrove ecosystem comprises 5 threat-defined locations in Memba, 1 in Dondo and 2 in Inhassoro & Bazaruto (including proximity of the projected touristic area). Based on this and considering the restricted values of EOO, mangrove forests are considered Critically Endangered (CR) under criterion B1c while considering AOO values, mangrove forests are considered Endangered (EN) in Memba and Dondo and Critically Endangered (CR) in Inhassoro & Bazaruto under criterion B2c.

As aforementioned, it is to be noted that criterion B evaluates risk based on ecosystem distribution extent. The present assessment focuses on ecosystem status within the studied districts, while ecosystems are not bounded to administrative boundaries.

Mangroves are spread all along the Mozambican coast. Although assessment at district level might be relevant for administrative purposes, limited extent of the ecosystems in the districts could ultimately lead to assign a higher risk category. Indeed, in the studied districts, mangroves occupied relatively restricted surface areas in the form of isolated patches. Under this configuration the ecosystem distribution is so restricted that they are at risk of collapse from the chance occurrence of single or few interacting threatening events. Mangroves are therefore assessed as Critically Endangered (CR) at district level. This underlines the urgency to take action for preventing this ecosystem to collapse in the studied areas. However, this does not mean necessarily that the ecosystem is threatened at a larger scale. Considering the whole extent of the ecosystem might indicate a lower risk because its larger geographic distribution makes it more resilient. National or international assessments could therefore provide a better understanding of the status of the ecosystem as whole. Nevertheless, assessment at district level is relevant to inform actions that need to be taken at local level and to evaluate the relative urgency of these interventions.

The studied ecosystems characteristics do not reach the thresholds of the B3 criterion. It was therefore assigned the Least Concern (LC) category for every district and ecosystem.

<table>
<thead>
<tr>
<th></th>
<th>Memba</th>
<th>Dondo</th>
<th>Inhassoro &amp; Bazaruto</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EOO [km²]</strong></td>
<td>1'043.43</td>
<td>1'092.64</td>
<td>794.87</td>
</tr>
<tr>
<td><strong>AAO</strong></td>
<td>9</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>
3.1.2.5.3. **Criterion C**

Pollution has been identified as a potential threat to mangrove loss. Uncontrolled waste disposal, untreated sewage discharge, contamination of soil and water by agrochemicals and industrial activities (e.g., oil and gas extraction, etc.) have been previously identified as potential sources of pollution (Byers et al. 2013; Samoilys et al. 2015; Soto 2007; Younge, Negussie, and Neil 2002). Unfortunately, quantitative data and monitoring of these sources of pollution in the study areas is lacking, it was therefore not possible to derive the status of the abiotic processes at this stage.

In the absence of relevant data to assess deterioration of abiotic processes, this criterion is classified as Data Deficient (DD).

3.1.2.5.4. **Criterion D**

To the best of our knowledge, no inventory of species exists in our study areas. It was therefore not possible to assess the impacts of identified threats (section 3.1.1.3) on species distribution.

In the absence of relevant data to assess deterioration of biotic processes, this criterion is classified as Data Deficient (DD).

3.1.2.6. **Conclusion**

Assessment of the spatial distribution of mangroves in Memba, Dondo and Inhassoro & Bazaruto assigned the Least Concern (LC) risk category to all districts under criterion A (able 6). Under criterion B, risk categories ranged from Endangered (EN) to Critically Endangered (EN). Restricted geographic distribution and the proximity of expanding agricultural, urban and touristic areas constitute a direct threat to these ecosystem patches. The overall risk status of the ecosystem is assigned as the highest category of risk obtained through any criterion (B1c – B2c). The mangrove forests of the studied districts are therefore Critically Endangered (CR) (able 6).
As stated above, the present assessment was conducted at district level. It indicated that due to the restricted geographical distribution of mangroves in the studied areas, the risk of collapse from the chance occurrence of single or few interacting threatening events is high. Mangroves are therefore assessed as Critically Endangered (CR) at district level and actions are needed for preventing this ecosystem to collapse in the studied areas. Assessment at district level is relevant to inform actions that need to be taken at local level and to evaluate the relative urgency of these interventions. However, this does not necessarily mean that the mangrove ecosystem in Mozambique would be assigned the same risk category. Evaluation at a larger scale (e.g. national level) would potentially yield different interpretations as accounting for larger surface areas and being more representative of the complete ecosystem dynamics. Assessment at larger scale could help defining the status of the ecosystem as a whole and inform actions and policy at the national level.

Table 6 RLE assessment summary for mangrove ecosystem (criteria with the highest risk category in brackets)

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Criterion</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memba</td>
<td>subcriterion 1</td>
<td>DD</td>
<td>CR</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
<td>CR (B1c)</td>
</tr>
<tr>
<td></td>
<td>subcriterion 2</td>
<td>LC</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>LC</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Dondo</td>
<td>subcriterion 1</td>
<td>DD</td>
<td>CR</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
<td>CR (B1c)</td>
</tr>
<tr>
<td></td>
<td>subcriterion 2</td>
<td>LC</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>LC</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Inhassoro &amp; Bazaruto</td>
<td>subcriterion 1</td>
<td>DD</td>
<td>CR</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
<td>CR (B1c–B2c)</td>
</tr>
<tr>
<td></td>
<td>subcriterion 2</td>
<td>LC</td>
<td>CR</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>LC</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

3.1.3. Coral reef

3.1.3.1. Classification

IUCN Habitats Classification Scheme (Version 3.1) is a global typology of habitat types. The IUCN Habitats Classification Scheme is composed three hierarchic levels describing 18 habitats. The classification of this ecosystem, using the IUCN habitats and classification scheme v. 3.1 is 9.9.8 Marine neritic; Coral Reefs.

Refined classification is possible with further studies.

While there are detailed descriptions available linked to coral species, substrates and types of corals, for the purposes of this district level assessment we were unable to conduct an assessment finer than two ecosystem types, northern corals (Memba district) and southern corals (Inhassoro district & Bazaruto archipelago). This is due to the lack of spatially explicit data on the distributions of the possible coral ecosystem types.

However, it is important to note that the northern and southern coral distributions respond differently to climate stressors that provoke bleaching, and ultimately impacts the diversity of corals and reef fish (McClanahan et al. 2011). This is one reason why the corals in Memba district and those in Inhassoro & Bazaruto are considered as two separate ecosystem types. Experts in the Global Coral Reef Monitoring network (GCRM) network have indicated that more investment in coral reef monitoring will be critical for Mozambique in the future, because these nationally (and globally) important ecosystems are exposed to further threats from offshore natural gas extraction.

3.1.3.2. Ecosystem description

3.1.3.2.1. Characteristic native biota

Bazaruto and Inhassoro’s corals go beyond the district limits and most descriptions are provided at the archipelago scale. It is reasonable to assume that the general descriptions of coral cover in the Bazaruto Archipelago is valid for the coral distribution in the Inhassoro district limits, including the Bazaruto island. In Obura et al. (2008), the corals in the Bazaruto archipelago
were described following the 2006 bleaching event, as part of the national monitoring system implemented since 1999 in Mozambique.

The main benthic coral genera include Acropora and Millepora, with acroporids being most susceptible to bleaching events, and these are found in the fringing reefs. The reef community is more mixed in the gulleys where sponges are also prominent, with a sparse community of black corals (Antipatharia) and sea fans (Anella). This wall forms part of the perimeter of a deep hollow (17 m) encircled by sand bars on the inner side of Bazaruto and is subjected to a strong tidal flux and is turbid. At the other end of the island, the corals found here are particularly sparse, consisting of the aherma types Dendrophyllia and Tubastrea and a few sediment-tolerant faviids, some small colonies of Porites and Pocillopora. The large bivalve, Hyotissa hyotis, is found in colonies of Dendrophyllia under overhangs (Schleyer and Celliers 2005). Everett and Schleyer (2008) indicate that the coral reefs in Bazaruto island, the principal island in the archipelago, and the zone of interest for this evaluation, are isolated from the coral reefs in northern Mozambique (including Memba district), furthering the argument to consider the districts’ distributions separately.

In Memba also, there is a higher proportion of hard corals, with wide depth, and Scleractinia is most represented, with four genera being dominant – Acropora, Porites, Echinopora, and Favites. In some places, the order Alcyonaceae, comprising of soft corals is also abundant, including the genera Sinularia and Lobophytum. These tend to dominate reef benthos (Pereira et al. 2014).

Both reefs are important for marine turtles. Mozambique is visited by five species of marine turtles, which have been observed in the Mamba corals and environs, as well as Inhassoro & Bazaruto. Bazaruto is also home to the most important population of the critically endangered dugong (Pereira et al. 2014), besides harbouring various species of cetaceans. Memba, situated between the Quirimbas archipelago, and the Primeiras e Segundas archipelago, is a critical site for nesting marine turtles, besides the diversity of tropical reef fish species, including bumphead parrotfish, and the Napoleon wrasse. These are but a few examples of the varied and interesting diversity present in the two districts, though district level sampling is rare.

3.1.3.2.2. Abiotic environment

The Inhambane province, where Inhassoro & Bazaruto are located, is under the influence of cyclonic and anticyclonic swirls. Experts suggest that the dynamic ocean currents are responsible for high mixing, and therefore productivity of the waters, resulting in high levels of plankton.

Consequently, they attract ichthyofauna as well as large aggregations of marine megafauna (Louro et al. 2018). However, the resulting cooling effect of the ocean currents on the waters also contributes to a relative lower diversity of corals in this area (Obura 2012). Bazaruto island has submerged sandstone reefs, dropping into fissures, gulleys, and lower walls. There is a shallower reef top as well, with mixed coral communities. Generally, in the Bazaruto archipelago, the reefs can be broadly divided into three, submerged sandstone reefs, submerged fringing reefs, and patchy reefs (Everett and Schleyer 2008).

The coral reef expanse in the north, which includes Mamba district, are fringing reefs which a product of biogenic accretion, and considered “true coral reefs”. According to McClanahan et al. (2014), the coral reef communities in the region where Memba’s reefs are situated are more temperature-sensitive

3.1.3.2.3. Distribution

In Mozambique, the coral cover in the national boundary ranges from the north in the Pebane district (Zambezia Province) to the Palma district (Cabo Delgado province), and in the south, in a discontinuous way, from Govuro district (Inhambane province) to Matutuíne district (Maputo province). There are no coral or seagrass ecosystems present in the Dondo district, or environs. The scope of the RLE risk assessment for coral reefs in the districts of interest is limited to the northern and southern limits of each district’s coastline. Figure 26 shows the full distribution of corals in Mozambique, beyond the two districts’ limits.
The northern coral ecosystem is essentially a coral coastline, comprising mostly of fringe reefs. In the south, they are described in high parabolic dunes, north-trending capes, barrier lakes with patchy coral reefs, more scattered than continuous (M. Pereira 2000). Figure 26 shows the district coastline for Inhassoro and Memba districts, and the coral cover corresponding to that area. Inhassoro’s analysis also included the Bazaruto Island, which is administratively in two districts (Inhassoro and Vilanculo).
3.1.3.2.4. Key processes and interactions (conceptual model)

Coral reefs are among the most biodiverse and productive ecosystems, and they are valued for the services they provide. Corals have a mutualistic relationship with algae: coral support photosynthetic algae providing a protected environment, and algae produce oxygen and help corals to remove wastes (Figure 28). Moreover, corals benefit from the photosynthesis products of algae (glucose, glycerol and amino acids). This corals-algae relationship facilitates the recycling of nutrients in nutrient-poor tropical waters. However, the coral/algae ratio is very delicate: if this is too low (i.e. the amount of algae is too high compared to corals), the vulnerability of corals to bleaching increases. In this context, fish are very important, because they feed on the algae and help regulating the coral/algae ratio (Figure 28). Corals support many human activities including fishing, which is among the main anthropogenic pressures that threaten coral reefs (Figure 28). Coral reefs provide shelter and nursery grounds to many fish species, therefore fishing alters the characteristic biota of this ecosystem, and alters the equilibrium among corals, algae and fish. Extensive fishing of species that feed on algae reduces the resistance of corals to bleaching. Moreover, corals need substrate to grow, and fishing contributes to destruction of substrates and corals. Climate change and ocean acidification are also threatening coral reefs (Figure 28). Other anthropogenic pressures to this ecosystem are urban pollution, sedimentation, coastal development and tourism.

Figure 27 Distributions of corals in two districts in Mozambique. Data generated from Landsat, 30 m resolution.
3.1.3.3. Threatening processes

At the national level, Mozambique began monitoring its reefs, discontinuously since 1999. However, monitoring sites have increased over time, permitting overall observations on reef health (Obura et al. 2017). The Global Coral Reef Monitoring network (GCRM), comprising of several conservation and research institutions conducts period evaluations on the status of coral reefs. Their 2017 report (idem) indicated that in Mozambique, nationally, coral cover has declined to 20 – 30% of its original extent, since monitoring began in 1999. This decline is attributed to mass bleaching events, flooding from terrestrial runoff, and unsustainable fishing.

While the corals and seagrass ecosystems are found in sympathy in the two districts, the seagrass ecosystems are more widespread, relative to corals. However, they are subject to similar threats and pressures, and many of the fauna depend on both habitats for their lifecycle. In the two districts of interest, local experts identified the following threats to both coral and seagrass ecosystems include fishing. The fishing techniques are varied, but include seine fishing, line fishing, surface & deep fishing, and cages. Most coastal fishing in Mozambique is artisanal, rather than industrial (Pereira et al. 2014), however there has been considerably over-exploitation, and lack of regulations in the fishing sector.

In Memba, our local experts specified that the main methods are seine beach fishing, and deep fishing. These practices not only affect the fish populations, but also have an impact on the coral reef structures themselves, and could perpetuate a vicious cycle of loss of habitat for fish coupled with overfishing. In the Inhassoro & Bazaruto district, similar information regarding fishing methods was not forthcoming, however, the local fisherman explained their observations on decreasing seagrass and coral surfaces. They also observed smaller sizes of fish catches, despite Bazaruto island being protected.

A future threat to coastal ecosystems in general, including corals, is offshore gas exploration and exploitation.

As explained before, considering the sympathy of coral and seagrass ecosystems, the threats to both are very similar, though the response rates and susceptibilities may vary between corals and seagrasses.
3.1.3.4. Assessment of ecosystem risk of collapse

3.1.3.4.1. Criterion A

Time-series data, covering a fifty-year span are not available to observe potential changes in the ecosystems’ distributions. At this stage, we are unable to project into the future, as this requires further expert input on the factors influencing potential future distributions of coral ecosystems. Moreover, due to the poor quality of the data for 2 out of the 4 years available, it wasn’t possible to build a trend on the coral distribution in Memba, Inhassoro & Bazaruto. Both coral ecosystems in Memba, and Inhassoro & Bazaruto are considered Data Deficient in criterion A and its sub-criteria.

3.1.3.4.2. Criterion B

Both ecosystems were evaluated under criterion B. The methods described in the IUCN RLE Guidelines v1.1. were used to calculate the Extent of Occurrence (EOO) and Area of Occupancy (AOO) (IUCN 2017). Figure 29 shows the minimum convex polygon enclosing all occurrences for Memba and Inhassoro & Bazaruto, with the 10km by 10km grid overlaid on the distribution.

Figure 29 Contrasting extents of occurrence of coral reefs between Inhassoro & Bazaruto, and Memba districts. Polygons with black lines show EOO.
Research on the fishing methods from other regions, particularly on seine fishing, suggests that the fisheries methods used in Memba and Inhassoro & Bazaruto caused more direct physical damage to coral (Mangi and Roberts 2006). Coral densities, size of coral colonies, and number of coral colonies was significantly higher in areas where beach seine fishing was not practiced, suggesting a direct negative impact of key fishing practices on the coral ecosystem. While this was not explicitly studied in the two districts in Mozambique, we can reasonably assume similar negative impacts, or continued threats to the coral quality in both ecosystems of interest.

However, if current fishing methods continue uncontrolled, to meet increased demands for fish protein, we can reasonably hypothesise a continual decline in the environmental quality of the coral ecosystems. A study conducted by Rare suggested that 88% of coastal fish stocks in Mozambique are over exploited, or fully exploited (Rare Mozambique n.d.), and that the trend is expected to continue if appropriate conservation and livelihood measures are not implemented (such as no-take zones, stricter enforcement of fishing regulations, seasonality, etc.).

During local consultations, the fisherman themselves indicated a decline in coral cover, seagrass extent, and fish stocks, which they attributed to unsustainable, growing fisheries practices.

Bleaching events have resulted in both coral and seagrasses mortality, in both districts, as recently as 2016 (CORDIO 2017). However, the recovery rates in the two districts vary considerably, suggesting that bleaching, linked to increased sea surface temperatures may be a more continued threat to coral ecosystems in Memba, compared to the south. Bleaching, while an important threat to coral ecosystems may not have as immediate impact on ecosystem quality, compared to the threats of fishing.

To summarise however, we can attribute continuous decline in coral cover quality, and fish stocks reliant on coral habitats. Considering continuous decline and restricted geographic distribution (EOO), corals are categorised as Critically Endangered (CR) in both districts under criteria B1b while under B2b, AOO values indicated that corals are only Endangered (EN)(Table 7).

However, the required data could not be obtained in time, and this criterion was not evaluated. The most complex aspect to evaluate criterion D will be identifying the collapse threshold, i.e. the point at which the coral ecosystem has lost its characteristic biota or interactions. This process requires expert input and validation, and is typically unique to each ecosystem. McClanahan and Muthiga (2017) could be an excellent source to determine the relative severity and extent of impact, based on biomass data that was collected in Northern Mozambique. Moreover, the abundance of algae in the coral reefs could be an indicator of the state of corals, because a too high proportion of algae relative to corals increases the vulnerability of corals to bleaching. However, district level data on the equilibrium between corals and algae could not be gathered. Criterion D was evaluated Data Deficient (DD).

### Table 7 Extent of occurrence (EOO) and area of occupancy (AOO) of the coral distribution

<table>
<thead>
<tr>
<th></th>
<th>Memba</th>
<th>Dondo</th>
<th>Inhassoro &amp; Bazaruto</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOO [km²]</td>
<td>1934</td>
<td>0</td>
<td>1181</td>
</tr>
<tr>
<td>AOO</td>
<td>14</td>
<td>0</td>
<td>13</td>
</tr>
</tbody>
</table>

#### 3.1.3.4.3. Criterion C

There are several abiotic features that could be identified to calculate the relative severity of various threats and pressures. Bland et al. (2017) identified four abiotic components of environmental processes that could affect coral cover for an ecosystem assessment in the Meso-American reef. These could be relevant for the districts of interest, and perhaps for the Western Indian Ocean reefs. They are, sea-surface temperature, ocean acidification, hurricane frequency/intensity, and pollution. For the purposes of this assessment, we could not gather adequate data, therefore criterion C was Data Deficient (DD).

#### 3.1.3.4.4. Criterion D

Similar to criterion C, there are indicators linked to fishing effort (CPUE), as well as species richness in the coral ecosystems which would help understand the level of degradation in biotic functions and processes.
3.1.3.5. Conclusion

Coral are not present in Dondo district. Restricted geographical distribution of coral and continuous decline in coral cover quality, and fish stocks reliant on coral habitats categorized this ecosystem as Critically Endangered (CR) under criterion B1b. Criterion B2b was assessed as Endangered. The overall risk status of the ecosystem is assigned as the highest category of risk obtained through any criterion (B1b). Corals in the studied districts are therefore Critically Endangered (CR) (Table 8).

Table 8 RLE assessment summary for coral ecosystem (criteria with the highest risk category in brackets)

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Criterion</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membra</td>
<td>subcriterion 1</td>
<td>DD</td>
<td>CR</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
<td>CR (B1b)</td>
</tr>
<tr>
<td></td>
<td>subcriterion 2</td>
<td>DD</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Inhassoro &amp; Bazaruto</td>
<td>subcriterion 1</td>
<td>DD</td>
<td>CR</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
<td>CR (B1b)</td>
</tr>
<tr>
<td></td>
<td>subcriterion 2</td>
<td>DD</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

3.1.4. Seagrass beds

3.1.4.1. Classification

IUCN Habitats Classification Scheme (Version 3.1) is a global typology of habitat types. The IUCN Habitats Classification Scheme is composed by three hierarchic levels describing 18 habitats. Seagrass ecosystems are classified as Habitat 9.9: 9. Marine Neritic, 9.9 Seagrass (Submerged).

3.1.4.2. Ecosystem description

3.1.4.2.1. Characteristic native biota

Seagrasses are marine angiosperms, monocotyledons that are adapted to live permanently submerged in seawater (Hartog and Kuo 2006).

Along the coast of Mozambique, 14 species of seagrass have been reported (Table 9, Bandeira and Björk 2001; Duarte, Bandeira, and Romeiras 2012), one of which, Zostera capensis, is listed as vulnerable (Bandeira 2014). Thalassodendron ciliatum and Thalassia hemprichii are the dominant subtidal seagrass species in Mozambique. Some species occur only in northern coast of Mozambique (see Table 9), while some species are pioneer species: Halophila ovalis and Halodule wrightii act as pioneer in exposed sandy areas, while Cymodocea serrulata in silted channels (Green and Short 2003).

Seagrasses generally occur in mixed seagrass stands, especially in intertidal areas, but can occur in pure stands, like the Z. capensis ones in the south of Mozambique (Green and Short 2003). The composition of the seagrass communities depends on the substrata. From north to south, the coastline of Mozambique changes from rocky limestone (until the Zambezi province) to estuarine (for 500 km between the Zambezi and the Save rivers), to sandy (Green and Short 2003).

- In the northern part of Mozambique, on limestone areas, seagrasses tend to occur with seaweed species (Bandeira and António 1996). Here, the most common community is composed by Thalassia hemprichii and Halodule wrightii, but Thalassia hemprichii also occurs mixed with species like Gracilaria salicornia, Halimeda spp and Laurencia papillosa, and Thalassodendron ciliatum mixes with Sargassum spp. H. wrightii also forms mixed beds with Z. capensis.
- On the sandy substrates further south the coast of Mozambique, mixed seagrass communities are formed by Thalassia hemprichii, Halodule wrightii, Z. capensis, Thalassodendron ciliatum and C. serrulata (Bandeira 1995). Seagrass beds are important as nursery, nesting and foraging sites for many species, and they act as shelter for juveniles animals (Harlin 1980; Larkum, McComb, and Shepherd 1989). They support a great biodiversity of marine vertebrates and invertebrates, and they increase the biodiversity of plants, animals, fungi etc. in the areas...
Seagrasses often occur in close connection with coral reefs and mangroves, and the state of each ecosystem is important for the other two. These three ecosystems work as a single system that keeps coastal zones healthy. While mangroves trap sediments and pollutants that would otherwise flow out to sea, seagrasses provide a further barrier to silt and mud that could suffocate coral reefs. Coral reefs, in turn, help protecting the seagrasses and the mangroves form strong ocean waves.

Seagrass beds constitute important carbon storage (being responsible for about 15% of the carbon storage in the ocean; Duarte and Cebrián 1996, Duarte and Chiscano 1999); they play an important role in nutrient retention and recycling, they reduce bacterial pathogens and ocean acidification (Unsworth et al. 2012). Seagrasses trap nutrients (Gacia, Granata, and Duarte 1999) and promote their recycling, as seagrass decomposition is quite high (Newell et al. 1984; Ochieng and Erftemeijer 1999). Moreover, seagrasses act as important trophic links with other ecosystems, exporting on average 24.3% of their net production to adjacent land and seaward ecosystems (C. M. Duarte and Cebrián 1996; Menzies, Zaneveld, and Pratt 1967; Ochieng and Erftemeijer 1999).
3.1.3.5.1. Abiotic environment

Seagrasses need light to photosynthesize. Generally, they require an underwater irradiance in excess of 11% of that incident in the water surface for growth. This usually sets their depth limit. They are distributed from the intertidal zone to 40 m depth, depending on water clarity. The upslope limit of seagrasses is determined by their need of sufficient immersion in seawater, or tolerable disturbance by waves. Seagrasses often occur in intertidal zone where they are more protected from current and waves. Moreover, seagrasses require salinity in excess of 5‰ to develop and most of them a sandy to muddy sediment to grow, with organic contents <6% of the dry weight, sulphide concentrations <300 μM and redox potentials >-100 mV (Terrados et al. 1999; Hemminga & Duarte 2000; Koch 2001). Other than sandy and estuarine substrata, seagrasses can occur or rocky limestone substratum as well (Green and Short 2003).

3.1.3.5.2. Distribution

Among the three districts considered in this assessment, seagrasses are found only along the coast of Memba and Inhassoro districts, including the coasts of Bazaruto archipelago, while they do not occur along the coast of Dondo (Figure 30). Seagrasses are found from the intertidal zone down to about 40 m. Up to 2003 seagrasses were covering a total surface area of 43'900 ha in Mozambique (Bandeira and Gell 2003), with 2'500 ha at Inhassoro & Bazaruto Island, 3'000 ha at Mecufi-Pemba and 4'500 ha in the southern Quirimbas Archipelago (Bandeira and Gell 2003). Seagrasses were reported to cover half of the intertidal area around Inhaca Island (Bandeira 2002). Most are entirely marine and submerged, although some species (such as E. acoroides) cannot reproduce unless emergent at low tide (Short, Coles, and Pergent-Martini 2001). Mozambique is included in the Tropical Indo-Pacific bioregion defined by Short et al. (2007), which is the region with the largest number of seagrass species worldwide and a high species diversity of associated flora and fauna. Seagrasses’ distribution in depth depends on the availability of light for photosynthesis. In clear tropical waters, seagrass meadows can be found at up to 61 meters below sea surface. At the shallow edge, exposure (and associated high temperatures and drying at low tide), wave action and associated turbidity, low salinity from fresh water inflow determine seagrasses’ survival. In the inter-tidal zone, seagrass meadows are more common in sites that are protected from exposure, where they are sheltered from wave action or where there is entrapment of water at low tide.
3.1.3.5.3. Key processes and interactions (conceptual model)

Seagrasses support a high biodiversity. Of particular importance for the 2 districts of Mozambique (Memba and Inhassoro & Bazaruto) is the diversity of fish and invertebrates that find shelter or grow on seagrass beds (Figure 31). The accumulation of smaller organisms and the seagrasses themselves attract bigger herbivorous and piscivorous species. Among these, the endangered dugong feeds on seagrasses around Bazaruto, and this seems to be one of the most important population of dugongs remaining in the world. Marine turtles including the critically endangered hawksbill turtle have nesting sites around Bazaruto and along the coast of Memba. Seagrasses are also known as the lungs of the sea, because of the high amount of oxygen that they generate every day through photosynthesis.

Moreover, seagrasses equilibrate the amount of nutrients in the water: seagrass leaves absorb nutrients, capture sand, dirt and silt particles, and in nutrient poor regions seagrasses act as nutrient pump, helping nutrient cycling (taking up nutrients from the soil and releasing them into the water through their leaves). Furthermore, their roots stabilize the sediment, which in turns improves water clarity and quality, reduces erosion and buffers coastlines against storms. Various effects of climate change impact seagrasses negatively. Usually seagrasses can recover after natural disasters such as floods, cyclones and storms (Bandeira and Gell 2003). However, the frequency of these natural disasters is increasing, and this might not give enough time to an affected meadow of seagrass to recover.

Increased water and air temperature might also affect the extension of seagrasses. Seagrasses adapt quite well to a changing environment, they adapt their habitat colonizing new suitable area. However, if changes happen too quickly, this might not give enough time to seagrasses to colonize new suitable habitats. Humans can also have a direct impact on seagrasses. Through coastal development, for example, human activity alters the flow, content and clarity of water. Seagrasses needs light to grow, therefore activities that cause a limitation of irradiance negatively impact seagrasses (for example through sedimentation).
3.1.3.4. Threatening processes

Local consultations identified fishing as one of the possible causes of seagrasses degradation in Memba. However, fishing would mainly affect seagrasses close to the coast, while widespread loss of seagrass meadows has been observed also far from the coast. A disease affecting seagrasses, like the wasting disease observed in Florida (Robblee et al. 1991), might be the cause of this loss, but additional research is needed to confirm this hypothesis. In Inhassoro the main threats are tourism, mining activities, gas and oil extraction, plastic marine pollution and fishing. Indeed, tourism and coastal development are quite intense in Inhassoro. In Memba, coastal development and tourism are less intense.

Mozambique’s coastline sustains an economy and people dependent on fisheries for jobs and proteins. It also contains amazing biodiversity, classified by many experts as the second most biodiverse spot in the world after the coral triangle. Unfortunately, overfishing and destructive fishing techniques have contributed to declining fish catches and degraded ecosystems.

Fish catch data show a steadily decrease of landings. Fishermen report species that no longer show up in their nets and the overall size of catch is declining.

The overall of artisanal catch has been estimated to have declined nearly 30% since 25 years ago (Rare Mozambique n.d.). According to Rare, the growth of human population and the decline in fish supply will result in a 70% decrease in protein availability by 2030 as compared to 1995, when fish supply peaked. In the next 15 years it is estimated a 1.8 million-ton food gap.

3.1.3.6. Assessment of ecosystem risk of collapse

3.1.3.6.1. Criterion A

Seagrasses are declining in Mozambique. Despite the unavailability of precise data, a decrease from 7 Km to 200 m along the coast of Inhassoro has been reported by local communities. Other sources report a loss of 40% of the area of seagrass in Inhassoro & Bazaruto (Bandeira and Gell 2003).
Historical data on seagrass distribution are not available, and predictions on the future distribution of seagrass in the districts considered in this assessment are not possible. As for the coral reef data, although some spatial data from past years could be gathered thanks to remote sensing, these could not be used because of their quality. Identifying seagrasses distribution (and marine ecosystems in general) through remote sensing is very challenging, and the techniques to obtain high quality data through remote sensing are improving. However, it is not yet possible to achieve a high enough certainty to consider the data valid for the assessment. Therefore, Criterion A cannot be assessed for seagrass ecosystems in Memba, Inhassoro & Bazaruto. Criterion A and its sub-criteria are Data Deficient (DD).

3.1.3.6.2. Criterion B

Seagrass ecosystems were evaluated under criterion B, in all three locations considered for this assessment. In order to achieve this, the distribution of seagrasses produced by the ROAM team was used. The distribution of seagrass used here is obtained through the analysis of Landsat image with a 30 m resolution, from 2017.

This data was also improved with GPS data gathered during the validation workshop. The extent of the minimum convex polygon enclosing all ecosystem occurrences in Memba has an area of 1'984 Km2, while in Inhassoro & Bazaruto is of 1'230 Km2 (Table 10 and Figure 32). The AOO is 19 for Memba and 9 for Inhassoro and Bazaruto (Table 10 and Figure 32). In both Memba and Inhassoro & Bazaruto, the seagrass beds at the edge district formed a continuous meadow that exceeded the administrative border. In order to remain consistent with the administrative border, the ecosystem had to be cut at the border. This adjustment to the district border, however, does not influence the conclusions for criterion B1. Criterion B2 would have not been affected by an extended area of the ecosystem outside the administrative border either.

Seagrass experts and local people have identified a continuous decline in seagrass distribution in Inhassoro, as well as a decline in the amount of fish they can find in seagrass habitat; corals’ productivity is also declining. Moreover, in Memba and Inhassoro the use of fishing techniques that are harmful to seagrass has been reported (information from locals, experts, and Bandeira and Gell 2003). The fishing effort has been increasing over the years, and there has not been any indications of intents to reduce it. Additionally, coastal development and mining is currently happening along the coast of Inhassoro, altering the environmental quality appropriate to the ecosystem.
We can conclude that there is a continuous decline of seagrasses in Memba, Inhassoro & Bazaruto, as well as a continuous decline of the environmental quality appropriate to the characteristic biota of seagrasses. This is due to the increase of the disruption of the biotic interactions appropriate to seagrass and of threatening processes to seagrass distribution. For both Memba and Inhassoro & Bazaruto, the EOO is lower than 2'000 km². Therefore, for criterion B1b the ecosystem is assessed as Critically Endangered (CR). For both districts, the AOO is lower than 20, therefore, the ecosystem is assessed as Endangered (EN) under criterion B2b.

The ecosystem is assessed as Critically Endangered (CR) for criterion B in the districts of Memba, Inhassoro & Bazaruto. This conclusion needs to take in consideration that the assessment is conducted at the district level, and the area of assessment is small per se. Considering the ecosystem at the district level, can be a limitation, because the area of the assessment is relatively small.

However, the ecosystem at the district level is declining, therefore solutions need to be taken if it’s continuous reduction (and eventual disappearance) want to be avoided. Conducting an assessment at the district level allows for specific information on the local threats to ecosystems, but it is more challenging to gather district-level spatial data. Extending the assessment at the national (or international) level, would allow to consider the ecosystem as a whole (ecosystems are not restricted by administrative boundaries), and the result of the assessment could be different. Indeed, even though the ecosystem is probably threatened all along the coast, its area of extension is probably higher. The outcome might therefore be less dramatic.

Table 10 Extent of occurrence (EOO) and area of occupancy (AOO) of the seagrass beds in Memba, Inhassoro and Bazaruto.

<table>
<thead>
<tr>
<th></th>
<th>Memba</th>
<th>Dondo</th>
<th>Inhassoro &amp; Bazaruto</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOO [km²]</td>
<td>1'984</td>
<td>-</td>
<td>1'230</td>
</tr>
<tr>
<td>AOO</td>
<td>19</td>
<td>-</td>
<td>9</td>
</tr>
</tbody>
</table>
3.1.3.6.3. **Criterion C**

Several abiotic processes threaten seagrass distribution. The most important ones for the seagrass of Memba, Inhassoro & Bazaruto are salinity, sea-surface temperature, nutrient content, cyclones, floods and storms. Data on the values or frequency of these abiotic processes could not be gathered at the district level. Gas and oil extraction on the coast Inhassoro can affect seagrasses because they alter the water, but the impact of these activities could not be quantified at the district level. Although an attempt to gather adequate data was made, this were not available. Criterion C is therefore data deficient (DD).

3.1.3.6.4. **Criterion D**

The increase of fishing effort and the use of harmful fishing technique (e.g. beach seine) are partially threatening seagrasses. However, district-specific data could not be gathered, and these factors would not explain the decline of seagrass observed far from the coast. An estimation of the collapse threshold of seagrasses due to the disruption of the biotic environment is also missing. Consultations with experts and locals could help in gathering the missing information needed to assess criterion D. Moreover, the occurrence of a disease affecting seagrasses, such as the wasting disease that caused massive seagrass loss in Florida, might be causing the disappearance of seagrass beds far from the coast. Available information on possible threats to seagrasses and their quantification has been reviewed, but more information is required to determine their risk status. Specific data at the district level could not be gathered, therefore criterion D results data deficient (DD).

### Conclusion

Seagrass beds are not present in Dondo district. Restricted geographical distribution and inferred threatening processes, such as continuous decline in seagrass cover and continuous disruption of biotic interactions influencing processes that drive seagrass distribution, categorized seagrass beds as Critically Endangered (CR) in the other two districts (Table 11). Seagrasses are assessed as Critically endangered for criterion B1b, and Endangered for criteria B2b, in both district (Memba and Inhassoro & Bazaruto). The overall risk status of the ecosystem is assigned as the highest category of risk obtained through any criterion (B1b). The seagrass beds in the studied districts are therefore Critically Endangered (CR) (Table 11).

The reader needs to keep in mind that this assessment is conducted at the district level. Although a continuous decline in seagrasses was identified by local experts, the small scale at which the assessment was conducted might influence the result for criterion B, which is strongly affected by the scale. An assessment on seagrasses at the national level would clarify the condition of this ecosystem in Mozambique. This issue is explained in more detail at the end of the assessment for criterion B.

### Table 11 RLE assessment summary for seagrass beds ecosystem (criteria with highest risk category in brackets)

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Criterion</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memba</td>
<td>subcriterion 1</td>
<td>DD</td>
<td>CR</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
</tr>
<tr>
<td></td>
<td>subcriterion 2</td>
<td>DD</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
</tr>
<tr>
<td>Inhassoro &amp; Bazaruto</td>
<td>subcriterion 1</td>
<td>DD</td>
<td>CR</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>NE</td>
</tr>
<tr>
<td></td>
<td>subcriterion 2</td>
<td>DD</td>
<td>EN</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>subcriterion 3</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>DD</td>
<td>-</td>
</tr>
</tbody>
</table>
3.2. Mapping trends of coastal and marine ecosystems

In this section, we present the baseline scenario of the various land use categories in the study area. Specifically, here we highlight the output from available mapping exercises and scientific literature. An understanding of the baseline scenarios was important in identifying the spatial data needs and in choosing appropriate processes that can augment existing methods.

i. Baseline analysis of mangrove forests

Mozambique boasts of the largest tract of mangrove forests in Africa, hosting approximately 300,000 hectares of mangrove forest. The most extensive and recent evaluation of the changes in geographic distribution of mangrove forests in the coastlines of Mozambique was carried out by the WWF (WWF Deutschland 2018a). Specifically, the assessment was based on the analysis of high resolution optical imagery to document the changes from 1995 to 2018. In particular, Landsat Thematic Mapper (TM), Enhanced Thematic Mapper (ETM) and Optical Land Imager (OLI) provided the long term change mapping at 30m resolution while Sentinel-2 data was used mapping at 10m resolution in the years after 2015.

From the results of these image analysis, there was significant decline in the coverage of mangrove forests in the period between 1994 and 2008. The most drastic decline were recorded in the shorelines around Maputo bay. In the period from 2008 to 2015, a positive trend was recorded in most of the provinces.

Figure 33: Spatial extent of mangrove forests in Mozambique as at 2015. The inset images cover the three study districts of Dondo in Sofala province, Inhassoro district in Inhambane province and Memba district in Nampula province.
Commonly, mangrove forests are cleared to make room for agricultural land, human settlements and salt farms. Mangrove trees are also used for firewood, construction wood, and charcoal production.

ii. Existing maps of forest cover dynamics in the study areas

Between 2001 and 2017, Mozambique lost approximately, 2.88Mha of her forest cover (Global Forest Watch, 2018). This was equivalent to 9.9% of the total forest cover in the country. Like Mangrove forests, other coastal forests are an important part of the livelihoods of the communities living in the coastal regions of Mozambique. The forests serve as a source of timber, firewood and charcoal production. The forest areas are also regularly cleared to make way for agricultural land, such as small scale cassava farms.

Commonly, the use of fire is preferred for clearing the forests, thereby affecting larger portions of natural forests in the coastal areas and contributing to the degradation of vital ecosystems. Consequently, the main threats to the coastal forests in Mozambique have been uncontrolled fires, urbanization and human settlement, agriculture, encroachment, grazing and unsustainable harvesting of forest resources for timber, fuel and medicine. The maps in Figure 32 highlight the baseline geographic variation of tree cover in the three study districts of Dondo, Inhassoro and Memba together with the locations that have experienced tree cover loss in the period between 2000 and 2017. The maps were derived from the archival data by the Global Forest Watch.

Figure 34: Baseline distribution of tree cover in Dondo, Inhassoro and Memba districts as at the year 2000. The pixels which are shared in red color highlight the areas that have experienced loss of tree cover in the 17 years from the year 2000.
iii. Historical evolution of seagrass and coral reefs in Mozambique

The area under seagrass is on a steady decline. A study of the trend of changes in seagrass beds in Inhambane bay showed that sea grasses reduced by over 50% in the 20 year period between 1992 and 2013 (Mabuto et al, 2018). Major damages on the sea grasses were attributed to cyclones. However, in such cases seagrass recovered naturally after some time. Human activities that lead to changes in marine environment remain a major threat to sea grasses, at time leading to permanent loss particularly when artificial structures are developed on habitats of sea grass colonies. In particular, waste disposal from domestic and industrial sources, destructive fishing practices, sediment alternation, construction activities, changing water regimes through damming or deviation of rivers and estuaries and unsustainable farming practices are some of the human activities that have been pointed out as the major threats to sea grasses (Gullström et al, 2002).

Among the countries in Eastern Africa, Mozambique has the longest coastline consisting of fringing and island reefs towards the Tanzania border in the north and high latitude reef closer to the border with South Africa to the south (Obura et al, 2002). Coral reefs provide the first barrier against ocean currents and strong waves. They face numerous threats and are therefore on a decline. Overfishing, accumulation of sediments, mining, pollution, and poor land management practices are principal threats to the reef ecosystem. On the global scale, increasing surface temperatures from climate change lead to coral bleaching, and often their permanent destruction or death.

There have been a few attempts to map sea grasses in the coastal areas of Mozambique. The main challenge being that the sea grasses occur beneath the water surface hence making it difficult to be captured by conventional image analysis methods.

iv. Croplands and human settlement areas

The areas under cropland and human settlement are on a gradual increase. This increase can be attributed to population growth and the process of urbanization particularly in the coastal regions. Agriculture is mainly rain-fed in Mozambique and therefore cropland areas are largely seasonal, often alternating from agricultural land use to grassland, or appearing within wooded areas. Areas of human settlement remain fairly constant particularly for communities that lead a sedentary way of life like farmers or fishermen who are the largest majorities in the coastal zones of Mozambique. However, due to urban sprawl, the areas which are considered as human settlement can expand over a duration of time. In each of the three case study districts, cropland is a significant part of the land cover of each district.

In Dondo district, traditionally, the main cropland areas are found in the Southwestern regions particularly in flood plains and estuaries where Dondo River joins the Indian Ocean. In Inhassoro district, the main farming areas are within the coastal zone in the eastern part of the district. Due to the seasonality of the farming activities, the croplands can sometimes with grassland areas. In Memba district, the southern regions around Memba town are the most cropped.
v. Wetlands and riparian vegetation

Wetlands and riparian vegetation in the study area have not exhibited a drastic decline, even though their general trend is reduction. This mainly due to the sparse human population density in most coastlands of Mozambique. The effects of global climate change are hard-hitting on the many sub-classes of wetlands. Furthermore, threats from herding, cultivation and fishing are compounded by the effects of global warming to add pressure on areas under wetland.

vi. Baseline characteristics of shrublands and grasslands

These areas are less threatened and in some cases even benefit from deforestation and forest degradation. Grassland areas often regrow even after a wildfire. There are instances of clearing of these areas for agricultural land, even though the coastal areas are not known for being cropland baskets due to limited freshwater sources. In all the three case study districts grasslands are a dominant land cover type appearing as a transition class between forested areas and croplands.

3.2.1. Baseline profile of Memba district in Nampula Province

In the period of analysis, forest cover classes were a significant part of the land cover characteristics of Memba district, with dense and open forest categories occupying almost one third of the land area in each period of analysis. Apart from the forest classes, the other major land cover class was shrubland, expanding substantially from 1996 to 2017. The increase of shrubland particularly in the area around Memba town and also around forests could be an indication of the degradation of the forest cover categories as a result of increased demand for land for farming and settlement. Of note also is the expansion of the areas under settlement, especially around the larger urban centers. The net reduction of grass may be indicative of the systematic conversion of the same to agricultural areas.
Apart from the maps, the table below outlines the changes in the vital land cover classes in Memba district from 1996 to 2017. Specifically, the table highlights the changes in Mangrove forests, other coastal forests, shrubland and grassland. Of note is the consistent rise in the areas under human settlement, increasing from 263 hectares in 1996 to more than 900 hectares in 2017.
accounting for almost 200% increase in the area under human settlement in 20 years. The apparent increase in forest cover between 1996 and 2003 is consistent with other studies which have shown an increase in woodlands in some districts in the neighboring Niassa province between 1989-2005 (Temudo and Silva, 2011).

### 3.2.1.1. Coral reefs in Memba district

While the classification schema appeared to show a consistent geographic distribution of coral reefs in Memba district, the variation in the area of coverage may be due to the variation ocean conditions at the time of imaging, including water column, turbidity, salinity and temperature may influence the health detectability of corals beneath the water surface (Besselle-Browne et al, 2017). Even then, the results show a stable existence coral reef from 2006 to 2017, averaging a summation area of about 11,000 hectares. It appears to increase by about 2500 hectares between 2006 and 2017, even though this might actually signify a reduction in live corals, since corals whiten on bleaching thereby becoming easily detectible by remote sensing energy. In principle, when corals are stressed by increasing temperature conditions or changes in penetrating light, or nutrients, they push out the symbiotic algae living in them, causing them to turn white. A combination of high resolution satellite image analysis, physicochemical surveys and extensive field work is recommended to improve the assessment of the status of the live corals in the district. Fig. 38 below is a map showing the distribution and coverage trend of corals between 1996 and 2017. The trends indicates some parts of seagrass areas in 1996 being colonized by corals in the later years. This is possibly due to high levels of variability in abiotic conditions within seagrass areas relative to neighboring reefs (Riegler, 1999; Perry and Larcombe, 2003; Yates et al., 2014; Camp et al., 2016a).

### Table 12 Variation in selected land cover classes in Inhassoro district between 1996 to 2017

<table>
<thead>
<tr>
<th>MEMBA</th>
<th>Area in Hectares (Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1996</td>
</tr>
<tr>
<td>DENSE FOREST</td>
<td>75,190.32</td>
</tr>
<tr>
<td>OPEN FOREST</td>
<td>67,410.72</td>
</tr>
<tr>
<td>MANGROVE</td>
<td>3,574.88</td>
</tr>
<tr>
<td>SHRUB LAND</td>
<td>279,873.00</td>
</tr>
<tr>
<td>OPEN GRASSLAND</td>
<td>17,898.84</td>
</tr>
<tr>
<td>CROPLAND</td>
<td>8,419.50</td>
</tr>
<tr>
<td>SETTLEMENT</td>
<td>263.88</td>
</tr>
<tr>
<td>BARELAND</td>
<td>6,838.38</td>
</tr>
</tbody>
</table>
While the classification schema appeared to show a consistent geographic distribution of coral reefs in Memba district, the variation in the area of coverage may be due to the variation in ocean conditions at the time of imaging, including water column, turbidity, salinity and temperature which may influence the health detectability of corals beneath the water surface (Besselle-Browne et al., 2017). Even then, the results show a stable existence of coral reef from 2006 to 2017, averaging a summation area of about 11,000 hectares. It appears to increase by about 2500 hectares between 2006 and 2017, even though this might actually signify a reduction in live corals, since corals whiten on bleaching thereby becoming easily detectible by remote sensing energy. In principle, when corals are stressed by increasing temperature conditions or changes in penetrating light, or nutrients, they push out the symbiotic algae living in them, causing them to turn white. A combination of high resolution satellite image analysis, physicochemical surveys and extensive field work is recommended to improve the assessment of the status of the live corals in the district.

Figure 38 below is a map showing the distribution and coverage trend of corals between 1996 and 2017. The trends indicate some parts of seagrass areas in 1996 being colonized by corals in the later years. This is possibly due to high levels of variability in abiotic conditions within seagrass areas relative to neighboring reefs (Riegl, 1999; Perry and Larcombe, 2003; Yates et al., 2014; Camp et al., 2016a).

Figure 37: Variation in the area of coral reef coverage type in Memba district in Mozambique between 2006 and 2017

The map below highlights the snapshots of areas of concentration of seagrass beds and coral reefs in Memba district in 1996 and in 2017.

Figure 38: Map depicting the geographic distribution of seagrass and coral reef classes along the coast of Memba district.
3.2.1.2. Seagrass beds in Memba district

Due to the poor quality of the images around 1996 and 2010, attempts were made to find alternative images for mapping the seagrass beds, however, even the best image in 1996 and another in 2008 could not yield hypothesized results due to ocean water characteristics during those epochs. An analysis of the changes in seagrass beds in Memba was thus evaluated by comparing the images between 2006 and 2017. From the evaluation, there was a marginal reduction of about 3% of the quantity of seagrass in the district within the decade of 2006 to 2017. Seagrass in Memba reduced from 18,200 to 17,600 hectares. It is possible that the damage to seagrass does not make it disappear completely from the areas, and it also regenerates rather quickly. Interviews with residents in the district showed that over the years, seagrass beds have reduced tremendously. There could also be breaks within the seagrass beds, which were not detected by remote sensing and requires further field studies in the future. (Poursanidis, D., et al. 2018).

Generally, this quantity of seagrass is higher than other global and regional studies have estimated. Besides the scale of mapping which would detect smaller patches of seagrass without filtering, further field visits and verification in future studies are recommended. Geographically, the seagrass beds occupy a thin strip along the entire coastline of Memba district.

3.2.1.3. Mangrove forests in Memba district

From the mapping results, there were net reductions in the area covered by mangrove forests in Memba district. In 1996, the total area of mangrove forests was about 3600 ha which initially reduced to approximately 2800 ha over seven years by 2003. The reduction may be attributable to uncontrolled logging and the flooding associated with the El-Nino phenomenon during this period. The coverage then increased to approximately 3200 hectares by 2010. This can be attributed to stable weather conditions in the preceding seven years and enhanced enforcement of the law in conserving mangroves. The validation workshop dialogue indicated that despite a growing population in the district awareness about the importance of conserving mangroves and enforcing related legislation was more significant over the last decade. However, the coverage reduced again drastically between 2010 and 2017, to approximately 2300 hectares. Validation dialogue with residents in the district showed that over the years, mangrove forests have reduced tremendously. There could also be breaks within the mangrove forests, which were not detected by remote sensing and requires further field studies in the future.
residents and government officials showed that coupled with the growing demand for mangrove poles, there is a natural phenomena that causes the mangroves to dry up. In addition, increased erosion can massively increase the amount of sediment in rivers, affecting the mangroves areas.

In summary, over a 20 year period there was a loss of 1400 ha, representing a reduction of approximately 38% in mangrove coverage in Memba district between 1996 and 2017.

3.2.1.4. Coastal forests in Memba district

In Memba district, apart from mangrove forests, other forest typologies including closed and open forests are the dominant land classes covering more than two thirds of the land surface. However, in the last decade it appears the forest classes have undergone drastic changes with the areas which were initially occupied by forests increasingly becoming shrublands and grasslands. Between 1996 and 2017 there has been a reduction of approximately 40000 hectares in the combined forest categories signifying a 40% fall. This is an annual deforestation rate of 2% which is very high. The trend also shows that the closed forests are increasingly being disturbed into open ones, especially due to fire and timber harvesting. Coastal forest in Memba district is estimated to be about 30% of the remaining 95000 hectares, and is as such highly threatened by this trend.
3.2.2. Baseline profile of Dondo district in Sofala Province

From the results of the image analysis, the dominant land cover class in Dondo district in the last two decades was shrubland followed by open forest and closed forest categories and then grassland. The main forest classes are located in the eastern and northeastern part of the district. In the west of the district, particularly in the area around Dondo city, the surrounding areas are predominantly used as cropland. Mangrove forest categories are located in three main patches in the shorelines of the district. In contrast to the other two districts, coral reefs and seagrass categories were not present in Dondo district shorelines. These were neither in the satellite imagery nor were they observed during the initial field exercise after the inception workshop.

Figure 40: Variations in the area of mangrove forests in Memba district from 1996 to 2017

Figure 41: Variation in the area of open and closed forest categories in Memba district between 1997 and 2017

3.2.1.4. Coastal forests in Memba district

In Memba district, apart from mangrove forests, other forest typologies including closed and open forests are the dominant land classes covering more than two thirds of the land surface. However, in the last decade it appears the forest classes have undergone drastic changes with the areas which were initially occupied by forests increasingly becoming shrublands and grasslands. Between 1996 and 2017 there has been a reduction of approximately 40000 hectares in the combined forest categories signifying a 40% fall. This is an annual deforestation rate of 2% which is very high. The trend also shows that the closed forests are increasingly being disturbed into open ones, especially due to fire and timber harvesting. Coastal forest in Memba district is estimated to be about 30% of the remaining 95000 hectares, and is as such highly threatened by this trend.
From the statistics of land cover categories, the main anthropogenic drivers of land cover change in the district appeared to be the demand for land for settlement and for agricultural activities. The area under cropland increased significantly from approximately 16,000 hectares in 1996 to over 23,000 hectares in 2017. On the other hand the areas under settlements increased from 1500 hectares in 1996 to approximately more than 6300 hectares in 2017. The table 12 below outlines the dynamics of land cover change in Dondo district from 1996 to 2017.

From the variation of the dominant land cover classes in Dondo district showed that areas under cropland and those under human settlements increased progressively from 1997 to 2017. On the other hand, there was a net reduction in the forest classes, and shrubland.
3.2.2.1. Mangrove forests in Dondo district

As has been highlighted previously, coral reefs and seagrass classes were not located in the district. On the other hand the mangrove classes appeared to be relatively stable, within the range of 2000 ha to 2400 ha. In 1996, the mangrove coverage was approximately 2300 hectares before declining by about 250 ha over 7 years to about 2050 hectares by 2003. Thereafter, the coverage of mangrove forests increased to about 2400 hectares in 2010 before once again reducing drastically to about 2100 hectares in 2017. The increase in the year 2010 was a trend also witnessed in Memba district, and can as such be linked to favorable climatic conditions that enabled natural regeneration. Furthermore, the government has been more vigilant in enforcing conservation laws over the last decade as it becomes clear that the mangroves are threatened, according to validation discussions with stakeholders. In overall, this indicated only a net loss of about 200 hectares in the 20 years or 8% of initial cover. This loss is widely linked to the growing urban population within the major urban centers that require supply of building poles and charcoal, which are extracted from mangroves. Woollen et al., (2016) observed that charcoal business is more lucrative around major towns and cities in Mozambique, which then become deforestation hotspots.

Table 13 Variation in area of coverage of land cover classes in Dondo district in Mozambique from 1996 to 2017

<table>
<thead>
<tr>
<th>DONDO</th>
<th>Area in Hectares (Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1996</td>
</tr>
<tr>
<td>DENSE FOREST</td>
<td>42,920.55</td>
</tr>
<tr>
<td>OPEN FOREST</td>
<td>28,274.13</td>
</tr>
<tr>
<td>MANGROVE</td>
<td>2,309.22</td>
</tr>
<tr>
<td>SHRUB LAND</td>
<td>121,993.11</td>
</tr>
<tr>
<td>OPEN GRASSLAND</td>
<td>29,297.52</td>
</tr>
<tr>
<td>CROPLAND</td>
<td>16,652.88</td>
</tr>
<tr>
<td>WETLAND</td>
<td>158.85</td>
</tr>
<tr>
<td>SETTLEMENT</td>
<td>1,528.20</td>
</tr>
<tr>
<td>BARELAND</td>
<td>390.96</td>
</tr>
<tr>
<td>WATERBODY</td>
<td>2,600.55</td>
</tr>
</tbody>
</table>

Figure 43: Variation in the area of coverage of mangrove forests in Dondo district in Mozambique from 1996 to 2017
3.2.2.2. Coastal forests in Dondo district

From the analysis of other forest categories in Dondo district, there appeared to be considerable steady loss in both the dense and open forest categories over the two decade study period. While this is not necessarily the trend for coastal forest as it is a representation of all forest within the vast district, it gives a clear indication of the coastal forest containment. The combined forest reduced from about 70000 ha to about 60000 ha over the 20 years, representing about 15% forest loss. There were significant temporary changes of forest that were followed by regeneration or conversion from closed to open forest, indicating that most of the clearance is usually not for permanent land use change. Field validation showed the use of fire to clear land for cultivation, and cassava farming within the forested areas.

![Graph showing variation in area of closed and open forest cover classes in Dondo district Mozambique from 1996 to 2017](image)

3.2.3. Baseline profile of Inhassoro district in Inhambane Province

The result of remote sensing analysis showed that, historically, Inhassoro district is covered predominantly shrub land cover classes. The main forested areas in the district are situated in the central part of the district. Main human settlements are found in close proximity to the shores. Of the three case study districts, Inhassoro boasts of the largest coverage of coral reefs and seagrass colonies particularly around the islands. Farming is minimal in the district.
Between 1996 and 2017, the areas covered by human settlements in Inhassoro district increased threefold from 658 hectares to 2130 hectares. This trend is consistent with the World Bank collection of development indicators, usually compiled from officially recognized data sources that put urban population growth in Mozambique at 3.8% in 2016 (UNECA, 2017). Similarly, the areas under grasslands expanded from about 6655 hectares in 1996 to about 22000 hectares in 2017.
3.2.3.1. Coral reefs in Inhassoro district

The size of coral reef in the district of Inhassoro was just over 17,000 hectares in 2007 as well as in 2017. While, the average coverage of corals from the image analysis was above the average by other global scale data and regional studies which put it just over 5000 hectares. Field validation around the island of Ilha de Santa Carolina showed that the area is rich in coral reefs. These are represented in this study, but there are no coral reefs in this area according to other regional studies. It is therefore likely that global and regional datasets are too generalized for smaller scale studies, as they may only map the larger coral reefs with little verification data or clear procedure.

Geographically, majority of the coral reefs and seagrass beds are located on the eastern shorelines of Bazaruto island and also in the area within 10km of radius of Inhassoro mainland shorelines. This agrees with previous observations (Golder Associates, 2015)
3.2.3.2. Seagrass bed in Inhassoro district

While two mapping years (1996 and 2010) did not appear to yield hypothesized results due to image quality, there was a small reduction in the quantity of seagrass in the district within the decade of 2007 to 2017. Seagrass in Inhassoro reduced from about 8,900 hectares to about 8,200 hectares. This represents a very marginal loss of only about 6% over ten years. It is possible that the damage to seagrass does not make it disappear completely from the areas, and it also regenerates rather quickly. Previous studies have indicated that there is about 8800 ha of seagrass beds in Inhassoro (Findlay et al 2011). Interviews with residents in Inhassoro revealed that over the years, seagrass beds have reduced tremendously. There could also exist breaks within the seagrass beds, which were not detected by remote sensing and requires further field studies in the future.

Generally, this quantity of seagrass is lower than other global and regional studies have estimated. Besides the scale of mapping which would detect smaller patches of seagrass without filtering, further field visits and verification in future studies is recommended.

Figure 47: Distribution seagrass and coral reef habitats in the coastal water of Inhassoro district between 1997 and 2017

Figure 48: Variation in the area of sea grass land cover classes in Inhassoro district in Mozambique between 2007 and 2017
3.2.3.3. Mangrove forests in Inhassoro district

In the period between 1996 and 2017, the area covered by mangrove forests in Inhassoro district reduced steadily by approximately 25% from about 340 hectares in 1996 to about 255 hectares in 2017. Unlike in the other two districts where the coverage increased by the year

2010, here it still reduced marginally compared to 2003. The reduction is attributed to the continuous harvesting of mangrove poles and the growing population which further compounds the loss. There was little evidence of natural attrition of mangrove trees from the field validation interviews and sampled visits.

![Figure 49: Variation in the area of mangrove forests in Inhassoro district in Mozambique between 1996 and 2017](image)

3.2.3.4. Coastal forests in Inhassoro district

Between 1996 and 2017, there was a net loss in the in both categories of forest, and the overall loss was 30000 ha from an initial estimate of 120000 to the 2017 estimated cover of 90000 hectares. This represented a 40% loss or a 2% annual loss. The loss was steady over the years, indicating consistent factors such as clearing for settlement and cultivation as well as timber harvesting and forest fires.

![Figure 50: Variation in the areas of open and closed forest categories in Inhassoro district, Mozambique between 1997 and 2017](image)
3.2.4. Changes in the status of coastal ecosystems from the results of image analysis

In order to evaluate the variation in the status of the coastal and marine ecosystems, change detection analysis was carried out on the results of image analysis. In particular, change detection processes reveal both the quantitative and the geographic characteristics of the changes in the land cover characteristics. In this evaluation, both the change detection matrices and the maps for individual coastal ecosystems are presented. The change detection matrices show the relative quantitative shifts in the land cover classes whereas the maps of the changes in the individual ecosystems highlight the potential degradation hotspots and regeneration locations and can guide mitigation efforts to reverse the negative trends of ecosystem degradation.

3.2.4.1. Overall land cover change in Memba district

A summary of change detection results is presented in the Table 14, and represents a comparison of the study's start year of 1996 and the end year of 2017. From the table the net gaining classes were; cropland, settlement, open forest and shrubland, while the classes that lost acreage were; dense forest, mangrove forest grassland and bareland.

By looking at the individual coastal ecosystems of interest, the dense forest classes mainly changed to shrublands, open forest classes and to croplands. The shift to shrubland may be due to the effect of fires which is the common method for clearing forests to create room for farmlands. Similarly, the open forest classes shifted to shrublands, grasslands and to croplands. Of note also is that in the duration of analysis, at least 3000 acres of open forests changed to dense forest classes in the district. This can be attributed to the various management effects that have been adopted.

The mangrove forest classes in Memba district reduced by about 30%, signifying an annual rate of change of about 1.5%. The shift was mainly bareland and shrublands. In addition, areas which were previously occupied by mangroves have been taken over by water, indicating the potential effects of shoreline and tidal changes on the mangrove ecosystem in the district.

3.2.4.2. Changes in the distribution of coastal forests in Memba district

In order to analyse the changes in the coastal forests, the open and dense forests were combined into a single class. From the map of changes in the coastal forest (Figure 49), it is evident that Memba district has faced significant spatial and temporal changes in her temporal characteristics. With the locations of degradation spreading across the district. The remaining stable forest are found in the north-western part of the district. It is also positive to note that there have been efforts to reverse the trend of degradation particularly in the coastal zones resulting in a marginal gain of the forest in the southern areas towards Memba town.
Figure 51: Geographic distribution in the changes in the coastal forests highlighting stable, degraded and regenerating forest areas
3.2.4.3. Changes in the distribution of mangrove forests in Memba district

From the map of the distribution of mangroves, the most vulnerable mangrove forests were those occupying thin stripes along the coastline, these may particularly be vulnerable to tidal changes in the oceans. In addition, most of the degradation occurred at the edges of the mangrove forests. This may be due to the ease of accessibility to the edges. Management efforts should therefore consider placing barriers at the edges of the forests to limit access to the vulnerable ecosystems.

3.2.4.4. Stability of corals and seagrass beds in Memba district

To visualize the stability of sea-based classes over the period of analysis in Memba district, arithmetic sum of the respective surfaces of the corals and seagrasses in the four epochs of analysis was computed. Locations where corals or seagrass beds, depending on the class under analysis was available for each of the four epochs was considered to be the most stable habitat of the respective ecosystem. On the other hand, locations where, the respective ecosystem was only detectable in one epoch was considered to be least stable. This assumption was motivated by the fact that detecting corals and seagrasses is highly dependent on the turbidity and tidal characteristics of the ocean. High turbidity and sedimentation may also affect the sustainability of corals and seagrass beds (Erftemeijer et al, 2012). At the same time, corals and seagrass beds in such surfaces are also least detectable. Based on this assumption, the map in figure 53 highlights that geographic distribution of the stability of corals and seagrass beds in Memba district. The least stable locations are are potentially the most vulnerable. From these analysis, on a particular coral, the most vulnerable locations are the edges as this are more prone to disturbances from tidal events and from sediment loading. The sinuous form of the shorelines in Memba district may be providing protection to seagrass beds with the most stable seagrass beds being in the most sinous locations. The most vulnerable location for both corals and seagrass beds in Memba in the district are in the southern parts in the areas around Memba bay and Chepa.
Figure 53: Spatial distribution of the variability in the stability of corals (a) and seagrass beds (b) in Memba district.
Table 15: Land cover change (in hectares) in Memba district between 1996-2017

<table>
<thead>
<tr>
<th>New land cover classes (2017)</th>
<th>Dense Forest</th>
<th>Open Forest</th>
<th>Mangrove Forest</th>
<th>Shrubland</th>
<th>Grassland</th>
<th>Cropland</th>
<th>Settlement</th>
<th>Bareland</th>
<th>Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Forest</td>
<td>6729.39</td>
<td>3937.68</td>
<td>20.43</td>
<td>7915.32</td>
<td>1048.41</td>
<td>223.02</td>
<td>514.98</td>
<td>0.9</td>
<td></td>
<td>20392.92</td>
</tr>
<tr>
<td>Open Forest</td>
<td>19823.76</td>
<td>19187.19</td>
<td>18.36</td>
<td>32554.62</td>
<td>2037.78</td>
<td>343.62</td>
<td>406.26</td>
<td>0.63</td>
<td></td>
<td>74376.81</td>
</tr>
<tr>
<td>Mangrove</td>
<td>282.6</td>
<td>5.22</td>
<td>1890.18</td>
<td>90.72</td>
<td>1.71</td>
<td>0.18</td>
<td>2.61</td>
<td>0.27</td>
<td></td>
<td>2273.49</td>
</tr>
<tr>
<td>Shrubland</td>
<td>45443.7</td>
<td>42528.87</td>
<td>74.88</td>
<td>219500.7</td>
<td>13161.96</td>
<td>4782.69</td>
<td>1909.08</td>
<td>1.17</td>
<td></td>
<td>327465.1</td>
</tr>
<tr>
<td>Grassland</td>
<td>902.25</td>
<td>560.97</td>
<td>21.6</td>
<td>3985.2</td>
<td>281.88</td>
<td>108.36</td>
<td>443.7</td>
<td>1.62</td>
<td></td>
<td>6317.73</td>
</tr>
<tr>
<td>Cropland</td>
<td>1352.34</td>
<td>943.11</td>
<td>11.88</td>
<td>11856.78</td>
<td>1123.29</td>
<td>1905.66</td>
<td>386.91</td>
<td>0</td>
<td>17595.99</td>
<td></td>
</tr>
<tr>
<td>Settlement</td>
<td>38.52</td>
<td>30.42</td>
<td>0.09</td>
<td>513.72</td>
<td>37.8</td>
<td>110.34</td>
<td>30.24</td>
<td>0</td>
<td>911.43</td>
<td></td>
</tr>
<tr>
<td>Bareland</td>
<td>193.5</td>
<td>72.72</td>
<td>122.22</td>
<td>1989.9</td>
<td>142.74</td>
<td>713.79</td>
<td>2050.83</td>
<td>0.27</td>
<td>5300.55</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>227.79</td>
<td>26.91</td>
<td>1233.18</td>
<td>664.92</td>
<td>11.79</td>
<td>91.17</td>
<td>1.35</td>
<td>745.2</td>
<td>19.71</td>
<td>3022.02</td>
</tr>
<tr>
<td>Total</td>
<td>74993.85</td>
<td>67293.09</td>
<td>3392.82</td>
<td>279071.9</td>
<td>17847.36</td>
<td>8278.83</td>
<td>6489.81</td>
<td>24.57</td>
<td></td>
<td>158816.0</td>
</tr>
<tr>
<td>Changes</td>
<td>-54600.9</td>
<td>7083.72</td>
<td>-1119.33</td>
<td>48393.18</td>
<td>-11529.6</td>
<td>9317.16</td>
<td>647.64</td>
<td>-1189.26</td>
<td>2997.45</td>
<td></td>
</tr>
</tbody>
</table>

The land use change matrix presents the dynamics of the changes within a particular land cover class. Total coverage of each class at the base line or reference year (1996 in this case) is shown in the second row from the bottom. While the total coverage in the latter year (2017 in this case) is show on the furthest column on the right. The entries in each of the other cells moving from top to bottom show the areas of a particular land use which have shifted from the initial land cover class to another class in the follow up year. On the other hand, the entries from left to right show the new acrages that have been gained by a class in the follow up year. The values at the intersection of the same class between initial and follow-up year show the stable areas that have not shifted in the two epochs of analysis. Changes are computed by subtracting the totals of a particular land cover class in the initial year (vertical sums) from the total coverage in the latter epoch (horizontal totals). Negative changes (shaded in orange), imply a reduction in coverage of the respective class from the baseline year of 1996 to the follow-up year of 2017 while the positive changes (shaded in green) signify an increase in the coverage of the respective class. It therefore follows that in Memba district, (Table 14), dense forest class, mangroves, grasslands and bareland reduced in coverage while the other classes increased in coverage.
3.2.4.5. Overall land cover changes in Dondo district

From the land cover change matrix for Dondo district (Table 15), there were net losses in the forest, mangrove and shrubland land cover classes between 1996 and 2017. Conversely there appeared to be gains in the grassland, cropland, settlement and barelands. Of the focus ecosystems in this study, the most significant changes were in the dense forest classes which lost nearly a quarter of the coverage in the 20 years of analysis. Mangrove forest classes in the district less than 10% of the coverage.

By looking at the individual ecosystems, the forest classes mainly shifted to shrublands, grasslands and croplands while the mangrove classes changed to other forest classes, grasslands and shrublands. This reveals the systematic change in the forest classes to shrublands, grasslands, croplands and ultimately to settlements and barelands. From the same analysis, it is also noteworthy that settlements specifically emerged from areas that were initially shrublands, grasslands and croplands.

3.2.4.6. Geographic distribution in the change of status of coastal forest in Dondo district

Geographically, the hotspots of degradation of coastal forests in Dondo districts are towards the north-western part of the district that has traditionally hosted most of its dense forests. In addition, other vulnerable areas are the coastal areas towards the shoreline. This particularly due to the high concentration of populations in these areas. It is also evident that there is pressure on the forest classes from Beira and Dondo towns in the South Western parts of the district. Potential areas of regeneration are in the wetlands and the estuarine parts towards the western boundaries of the district. Due to the dominant croplands and grasslands to the southwest, agroforestry could provide a potential alternative for improving the tree cover in the district.

Figure 54: Geographic distribution of the changes in the status of coastal forests in Dondo district
3.2.4.7. Geographic distribution in the change of status of mangrove forests in Dondo district

The main mangrove forests in Dondo have traditionally been in the eastern shorelines of the district. From 1996-2017, the main stable stands of mangrove forest were found to be along the same shorelines. In the western shorelines towards Beira town, the mangroves have largely been degraded. Apart from human influence on the eastern mangrove forests, their being in an estuarine area also exposes them to other influences including flooding and sediment load from Dondoriver.

The degradation pattern of mangroves in Dondo district are not limited to the edges of the forest but shore extensive degradation into the forests, resulting in potential mangrove forest fragmentation.

Figure 55: Geographic distribution of changes in the mangrove ecosystem in Dondo district
Table 16: Land cover change (in hectares) in Dondo district from 1996-2017

<table>
<thead>
<tr>
<th>New land cover classes (2017)</th>
<th>Dense Forest</th>
<th>Open Forest</th>
<th>Mangrove Forest</th>
<th>Shrubland</th>
<th>Grassland</th>
<th>Cropland</th>
<th>Wetland</th>
<th>Settlement</th>
<th>Bareland</th>
<th>Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Forest</td>
<td>16361.82</td>
<td>6198.39</td>
<td>225.72</td>
<td>7465.41</td>
<td>1286.73</td>
<td>122.85</td>
<td>19.08</td>
<td>3.87</td>
<td>0.27</td>
<td>373.14</td>
<td>32057.28</td>
</tr>
<tr>
<td>Open Forest</td>
<td>10881.9</td>
<td>6675.84</td>
<td>82.35</td>
<td>7683.39</td>
<td>2048.58</td>
<td>243.72</td>
<td>16.92</td>
<td>4.23</td>
<td>0.45</td>
<td>69.93</td>
<td>27707.31</td>
</tr>
<tr>
<td>Mangrove</td>
<td>123.03</td>
<td>24.84</td>
<td>1741.5</td>
<td>83.52</td>
<td>13.95</td>
<td>4.77</td>
<td>0</td>
<td>0</td>
<td>0.63</td>
<td>112.05</td>
<td>2104.29</td>
</tr>
<tr>
<td>Shrubland</td>
<td>10646.19</td>
<td>10552.68</td>
<td>78.03</td>
<td>71458.92</td>
<td>10741.23</td>
<td>2457.36</td>
<td>7.47</td>
<td>57.87</td>
<td>29.25</td>
<td>96.12</td>
<td>106125.1</td>
</tr>
<tr>
<td>Grassland</td>
<td>3877.74</td>
<td>3971.79</td>
<td>104.94</td>
<td>23598.09</td>
<td>9371.52</td>
<td>2567.07</td>
<td>52.47</td>
<td>21.78</td>
<td>33.75</td>
<td>145.62</td>
<td>43744.77</td>
</tr>
<tr>
<td>Cropland</td>
<td>707.58</td>
<td>678.78</td>
<td>3.06</td>
<td>8296.38</td>
<td>3836.79</td>
<td>9445.68</td>
<td>13.77</td>
<td>70.56</td>
<td>0</td>
<td>84.87</td>
<td>23137.47</td>
</tr>
<tr>
<td>Wetland</td>
<td>81.18</td>
<td>20.07</td>
<td>3.78</td>
<td>284.58</td>
<td>1077.48</td>
<td>29.79</td>
<td>41.94</td>
<td>0.09</td>
<td>0</td>
<td>57.69</td>
<td>1596.6</td>
</tr>
<tr>
<td>Settlement</td>
<td>82.17</td>
<td>66.51</td>
<td>0.18</td>
<td>2697.93</td>
<td>587.79</td>
<td>1581.75</td>
<td>0</td>
<td>1369.35</td>
<td>0.99</td>
<td>0</td>
<td>6386.67</td>
</tr>
<tr>
<td>Bareland</td>
<td>0.9</td>
<td>1.71</td>
<td>9.63</td>
<td>107.1</td>
<td>3.06</td>
<td>5.76</td>
<td>0</td>
<td>0.36</td>
<td>313.47</td>
<td>21.78</td>
<td>463.77</td>
</tr>
<tr>
<td>Water</td>
<td>98.1</td>
<td>11.25</td>
<td>54.45</td>
<td>94.23</td>
<td>69.57</td>
<td>104.76</td>
<td>0</td>
<td>0</td>
<td>11.25</td>
<td>1592.1</td>
<td>2035.71</td>
</tr>
<tr>
<td>Total</td>
<td>42860.61</td>
<td>28201.86</td>
<td>2303.64</td>
<td>121769.6</td>
<td>16563.51</td>
<td>151.65</td>
<td>1528.11</td>
<td>390.06</td>
<td>2553.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes</td>
<td>-10803.3</td>
<td>-494.55</td>
<td>-199.35</td>
<td>-15644.4</td>
<td>14708.07</td>
<td>6573.96</td>
<td>1444.95</td>
<td>4858.56</td>
<td>73.71</td>
<td></td>
<td>-517.59</td>
</tr>
</tbody>
</table>

Once again the classes with the negative changes (shaded in orange) have reduced in coverage from the baseline year in 1996 to the follow-up year in 2017 while the positive changes (shaded in green) increased in coverage over the period of analysis. Consequently, there was a net reduction in coastal forest classes, mangroves and shrublands in Dondo district in the period between 1996 and 2017. In addition, due to anthropogenic activities, climate change and tidal fluctuations, amount of open water surfaces in the district also reduced.
3.2.4.8. Overall land cover change in Inhassoro district

From the land cover change matrix of Inhassoro district (Table 16), net losses were recorded in coastal forest classes and in mangroves in the period from 1996-2017. Since Inhassoro traditionally has had the least coverage of mangrove forest of the three study districts, a loss of approximately 70 hectares of mangroves in the 20 years under analysis was approximately more than 20% loss of mangrove cover in the district. Of all the three forest classes, the main shift was towards shrublands and to grasslands. For the mangrove forests, the effect of tidal and shoreline changes of the 20 years was also evident as a section of the previous mangrove forests particularly in the northern shores was taken up by water.

Of note also is the expansion of the areas under settlement, particularly taking over areas that were initially occupied by forests, shrublands and grasslands. Similarly, there was also a four-fold expansion in the areas under

3.2.4.9. Distribution of changes in the coastal forests in Inhassoro district

Geographically, the hotspots of forest degradation in the mainland areas of Inhassoro district appear to be on the eastern parts of the district towards the shoreline (Figure 53). In Bazaruto island, there is consistent spatial distribution of degradation locations along the lengths of the island. The main stable forest classes appear to be in the area approximately 20km from the shoreline. Because of the relatively low concentration of human settlements in the western interiors of the district, most regenerated forests appear towards the western part of Inhassoro district.
3.2.4.10. **Distribution of changes in the mangrove forests in Inhassoro district**

In both mainland Inhassoro district and in Bazaruto Island, there have been significant losses in the mangrove classes. The spatial pattern of the loss of the mangroves appears to be concentrated in the forest towards the north-eastern part of Inhassoro district and also in Bazaruto Island. Areas of regeneration are particularly in the southern patch closer to Inhassoro town.

![Distribution of changes in the mangrove forests in Inhassoro district](image)

3.2.4.11. **Stability of corals and seagrass beds in Inhassoro district**

To visualize the stability of sea-based classes over the period of analysis in Inhassoro district, an arithmetic sum of the corals and seagrass classes in the four epochs of analysis was computed. Locations where corals or seagrass beds, depending on the class under analysis was available for each of the four epochs was considered to be the most stable habitat of the respective ecosystem. On the other hand, locations where, the respective ecosystem was only detectable in one epoch was considered to be least stable. This assumption was motivated by the fact that detecting corals and seagrasses is highly dependent on the turbidity and tidal characteristics of the ocean. It therefore follows that highly turbid and turbulent ocean surfaces are the least suitable for the sustainability of corals and seagrass beds. At the same time, corals and seagrass beds in such surfaces are also least detectable. Based on this assumption, the map in figure 57 highlights

![Stability of corals and seagrass beds in Inhassoro district](image)
that geographic distribution of the stability of corals and seagrass beds in Inhassoro district. The least stable locations are potentially the most vulnerable.

From the analysis, the most stable corals in Inhassoro are those that are deep within the sea while the corals around the coastlines both for the mainland areas and those in close to the shores of Bazaruto island are the most vulnerable. In addition, the thin line of seagrass to the northern shores of the mainland district also appear to be unstable. This may be due to the flat form of the shoreline that exposes the seagrass beds to the tidal influences from the ocean while also making the flat shorelines easily accessible to humans.

Figure 58: Spatial distribution of the variability in the stability of corals (a) and seagrass beds (b) in Inhassoro district
From the change detection statistics (Table 16), there was a net loss (shaded in orange) in the coastal forest classes and in the barelands in Inhassoro district. On the other hand the land cover classes that appeared to have had major increases in coverage in the district for the period between 1996 and 2017 were shrublands, grashlands, croplands and settlements indicating the potential influence of human activities in changing the forests and barelands into the other classes.
3.3. Socio-economic results and interpretations

This section summarises socio-economic inputs for all the three districts. Socio-economic situation analysis acts as a cross-cutting theme, as many of these domains overlap and affect all coastal ecosystems both terrestrial and marine. They also impact other ecosystems such as intertidal mud and sandflats which women are significantly dependent on for the shellfish fishery.

Table 18 Links between socio-economic behaviours and ecosystems

<table>
<thead>
<tr>
<th>Institutions and practices</th>
<th>Coral Reefs</th>
<th>Seagrass Beds</th>
<th>Mangrove forests</th>
<th>Coastal forests</th>
<th>Sand Dunes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutions and culture</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Environmental economics</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Fishing practices</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Forest harvesting practices</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Agriculture practices</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Fire practices</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

The section starts with a review of two key previous projects as well and then outlines the Success Factor Analysis (SFA). This is a central part of the socio-economic analysis of the baselines. It then discusses the general socio-economic linkages to each of the ecosystems analysing some factors in more depth. It then highlights specific relevant elements in each district, including results from stakeholder interactions before providing inputs into the community plans. Recommendations have been generated throughout the text as appropriate and collated in the recommendations section 4.

3.3.1. Review of previous projects and studies

3.3.1.1. Project document and district profiles

The Coastal Resilience to Climate Change (CRCC) project document and its annexes, especially the district profiles (IUCN, 2017, Annexes a, b &c.), were particularly important inputs into the social assessment. There is a rich source of district level socio-economic information contained in these documents that has not been repeated here but referred to as appropriate.

3.3.1.2. Sofala Bank Artisanal Fisheries Project (SBAFP)

In recent years there have been two important projects in coastal fisheries management both supported by IFAD. These were the Sofala Bank Artisanal Fisheries Project (SBAFP), (IFAD, 2016) and the Artisanal Fisheries Promotion Project (ProPESCA), which started in 2012 and is still ongoing (IFAD. 2012). The Sofala Bank Project was an important milestone in the development of the artisanal fishery sector. This is attributed to its integrated livelihood approach, which delivered tangible development in remote and complex fishing areas and beyond the fisheries sector. The project had impacts at the household, institutional and policy levels (IFAD, 2016). This included better incomes and assets among beneficiaries, enhanced human and social capital, improved access to social and market infrastructure, as well as better participation in grass-roots institutions and in particular in savings and credit groups. The project made an important contribution to policy formulation and legislation favouring the artisanal fishery subsector and helped strengthen institutions in the subsector. The development of the National Strategic Plan for the Artisanal Fishery Sector (Plano Estratégico para o Sector da Pesca Artesanal (PESPA 2006–2016), was one of the
project’s highest achievements. Importantly, the project helped fishery communities organize into groups and also promoted a culture of savings and credit, which continues under the ProPesca project. This provides a good basis upon which to start new activities under CRCC. The impact evaluation reported a remarkable impact on the access of the artisanal fishery communities to informal microfinance (through accumulating savings and credit associations - ASCAs), which led to increased personal savings and improved investment capacity in the artisanal fishery subsector (IFAD 2016).

The project recorded improved engagement in women with the ASCAs which is in common with the lessons for this kind of project.

The review commented that:

“All in all, the effectiveness of this component shows mixed results. Even if the project succeeded in mobilizing ASCAs at community level, it did not succeed in realizing their full social and economic potential by linking these savings groups with formal financial institutions and commercial banks for productive credit and other forms of financial services for livelihood enhancement. It did not put enough emphasis on value-addition, promotion of market linkages as well as creation of micro-enterprises.”

It went on to say:

However, the linkages with the formal financial sector and private sector actors along the fishery value chain remain weak and constrain impact on productivity and on the income base of artisanal communities. The evidence suggests that ASCAs are still mainly used by individuals for savings. The evaluation did not find much evidence that these groups have been federated into viable institutions with greater voice and capability to link to formal and/or commercial financial institutions. Both the quantitative and qualitative analysis found that the amounts invested in productive activities, which could have been financed by taking credit from ASCAs, are very small. This indicates that by and large ASCAs remained weakly linked to fisheries activities and did not manage to promote higher investments in fisheries technological innovations, which require the availability of bigger amounts of financial capital for acquisition and maintenance over the years.”

It should be noted, however, the VSLA type of ASCA is not supposed to be federated especially if this increases the operational costs and interest rates as the group independence keeps costs manageable by community members, neither are they aimed a large scale commercial enterprise focusing mostly on women’s economic empowerment. Thus, strong private sector linkages are likely to be inappropriate. Later we discuss more plausible linkages to ecosystem governance.

Recommendation: Link with and build upon the ASCA work that has been undertaken by SBAFP and ProPesca.

Post harvesting activities: SBAFP did some groundwork towards the diversification of the economic base of the rural poor through improved post-harvesting activities and the project’s training activities led to improved post-harvesting activities (e.g. salting and drying) and its infrastructure development component created better access to markets, which indirectly contributed to better incomes. However, diversification activities but it did not fully achieve their objective. The involvement of the private sector and the development of small and medium-sized fishery enterprises and relevant linkages according to the impact evaluation report (IFAD 2016) remained at an embryonic level, and this would appear so today.
Recommendation: Assess whether supporting post-harvesting activities as a CRCC project activity will have a value addition for the management of ecosystems

3.3.1.2.1. Institutional analysis

In summary, the evaluation commented “In terms of impact on institutions and policies, the project culminated in the adoption of PESPA. Yet, there were shortcomings in the co-management approach and enforcement process of the management measures stemming from PESPA. PESPA recognized the importance of developing linkages to formal microfinance institutions and markets, but it did not promote any conducive policies. Grassroots institutions are weak because by and large they have not been federated into apex organizations. This would have given them more leverage in policy dialogue with government authorities and resource allocation processes”.

Recommendation: CRCC to consider strengthening the conducive policies towards linking microfinance institutions with ecosystem management

3.3.1.2.2. Environment and natural resources management.

Overall, the SBAFF evaluation assesses that the impact on natural resources management was limited. However, the role of the project in preparing the ground for the long-term sustainable management of marine resources of the Sofala Bank was valuable. This was achieved by the adoption of PESPA and the co-management approach which were key to promoting an enabling environment and set the basis for sustainable management of the marine resources of the Sofala Bank. However, this was not the same as “reducing unsustainable practices that threaten the natural resource base in the project area” as foreseen. Despite improvements in fishers’ awareness and capacity to fish more sustainably, the adoption of different and more targeted fishing techniques than those used at the start of the project appears to be less widespread than expected given the thrust of the project in this regard.

Recommendation: CRCC to promote the adoption of more sustainable and ecosystem-friendly fishing techniques

3.3.1.3. ProPESCA project

The ProPESCA project is a large IFAD / OFID investment of USD 43.5 million over seven years on the whole coastline, with IFAD financing USD 21.1 million and the Opec Fund for International Development (OFID) USD 13.5 million (IFAD, 2012). The development goal is to improve incomes and livelihoods of households involved in artisanal fisheries. Its purpose is to increase the volume of high value fish on a sustainable basis and increase the returns obtained from traded fish. Some 26 growth poles, in 7 provinces along the coast line, were identified within 24 districts to participate in ProPESCA, representing about half of the 51 coastal districts of Mozambique. ProPESCA started in March 2011. The OFID loan was declared effective in January 2012 and is ongoing. The project is making investments in the fish value chain at the participating growth poles. These will include strengthening fisher capacity, fish market and related infrastructure, input and output traders and community as well as national and district government capacities to manage artisanal fisheries sustainably. There are four components – Supporting development of Higher Value Fish; Improving Economic Infrastructure; developing Financial Services and Institutional Strengthening, Policy Initiatives and Project management. The project is continuing the work of supporting ASCAs and microfinance.

Parallel to and linked to ProPESCA, IFAD administers a grant from the Belgian Fund for Food Security (BFFS) for the Coastal HIV/Aids Prevention and Nutrition Improvement Project (CHAPANI), effective from May 2012, with the overall goal to improve food security and livelihoods of households involved in artisanal fisheries. The grant recipient Associação Moçambicana Ajuda de Povo para Povo (ADPP). ADPP is IUCN’s partner in the SUSTAIN project. It will mobilise people in the fishing communities to increase their knowledge of and change risky sexual behaviour and (as of the second year) diversify their regular diet.

Recommendation: Coordinate closely with the Ministry (or ProPESCA project) including the savings and credits schemes as well as the nutrition and food security component as it relates to coastal resilience
Figure 59: Fishing communities supported by Propesca (IFAD 2012)
3.3.2. Success factor analysis

The results of the success factor analysis, which was carried out during the provincial workshops as a group exercise, indicates the perception of project participants of the status of the 32 key success factors in the project area. The success factors are based on the analysis of a wide range of restoration projects.

The absence of success can be caused by barriers which may need to be removed before progress can be made. One of the key benefits of the success factor analysis is that it facilitates a discussion by the project participants over, and learning about the factors that will lead to project success. These factors can be built into the project monitoring and evaluation framework and revisited for example every 6 months or annually on the project. The project team can also be clear about which factors it is attempting influence, or remove barriers.

With regards to the results during the provincial workshops it can be seen the different provincial teams had different perceptions about the extent to which certain success factors were in place. In some cases there would be expected provincial differences but in other (e.g. the legal situation) it would be expected to be the same. Overall the facilitation team felt that the teams were being overly optimistic about which of the success factors were already in place. The pattern expected at the beginning of such a process is that there would be less greens and more yellows and red boxes than is shown in the project sites from this exercise.
Coastal Resilience to Climate Change Baseline; Coastal and Marine Ecosystems Restoration Assessment

Table 19: Preliminary restoration success factor analysis

<table>
<thead>
<tr>
<th>Theme</th>
<th>Feature</th>
<th>Key success factor</th>
<th>Provincial-level Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Restoration (marine &amp; terrestrial) generates social benefits</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Restoration (marine &amp; terrestrial) generates environmental benefits</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td>b. Awareness</td>
<td>Benefits of restoration are publicly communicated</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Opportunities for restoration are identified</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td>c. Crisis events</td>
<td>Crisis events are leveraged</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td>d. Legal requirements</td>
<td>Law requiring restoration exists</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Law requiring restoration is broadly understood and enforced</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td>Enable</td>
<td>e. Ecological conditions</td>
<td>Marine (coastal, inshore and ocean) and terrestrial (soil, water, climate, and fire) conditions are suitable for restoration</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Marine or terrestrial plants and animals that can impede restoration are absent</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Native seeds, seedlings, or sources populations are readily available</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td>f. Market conditions</td>
<td>Competing demands (e.g., food, fuel) for degraded coastal and forestlands are declining</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Value chains for products from restored areas exists</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td>g. Policy conditions</td>
<td>Land and natural resource tenure are secure</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Policies affecting restoration are aligned and streamlined</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Restrictions on clearing remaining natural forests or damaging coastal habitats (wetlands mangrove, dune, seagrass, coral reef) exist</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coastal habitat clearing and damage restrictions are enforced</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td>h. Social conditions</td>
<td>Local people are empowered to make decisions about restoration</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Local people are able to benefit from restoration</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cultural factors support and do not impede restoration</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td>i. Institutional conditions</td>
<td>Roles and responsibilities for restoration are clearly defined</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Effective institutional coordination is in place</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td>Implement</td>
<td>j. Leadership</td>
<td>National and/or local restoration champions exist</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sustained political commitment exists</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td>k. Knowledge</td>
<td>Restoration “know how” relevant to candidate landscapes exist</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Restoration “know how” transferred via peers or extension services</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td>l. Technical design</td>
<td>Restoration design is technically grounded and climate resilient</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Restoration limits “leakage”</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td>m. Finance and incentives</td>
<td>Positive incentives and funds for restoration outweigh negative incentives</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Incentives and funds are readily accessible</td>
<td>Memba: Partially</td>
</tr>
<tr>
<td></td>
<td>n. Feedback</td>
<td>Effective performance monitoring and evaluation system is in place</td>
<td>Memba: Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Early wins are communicated</td>
<td>Memba: Partially</td>
</tr>
</tbody>
</table>

**KEY:**
- **GREEN= IN PLACE**
- **YELLOW= PARTLY IN PLACE**
- **RED= NOT IN PLACE**
Generally looking at the patterns of analysis it can be seen that in terms of “motivation” it is considered that the benefits of restoration are understood. The presence of cyclones as climate related crisis events has helped focused efforts towards restoration, although in Dondo it was felt that these lessons were not being fully learnt. There was a feeling that information around restoration was not fully communicated and that the legal position related to restoration was not fully understood. In terms of an enabling environment for restoration this showed a mixed picture with many of the factors of success being present in Inhassoro, although this would seem to be only a partial picture) and less present in Memba and Dondo. The project should pay attention to those factors showing contradictory results for example, competing demands for food and fuel, the security of tenure to carry out restoration activities, the alignment of policies and restrictions and enforcement on habitat removal or damage. This latter point is particularly important as the cost or restoring ecosystems is more, considerably more in some cases, than keeping those same ecosystems intact and continuing to provide goods and services.

Thus the balance of investment must be in retaining intact ecosystems rather restoring in one area, while another area degrades. In terms of the implementation of restoration the project can help support local champions to emerge as well as increasing and transferring the restoration “know how”.

This latter issue is particularly important in mangrove restoration as many of the current efforts have led to failure. The project will have to pay attention to funds and incentives, monitoring and communications.

Recommendation: It is recommended that the success factor analysis is carried out at the district level and repeated periodically during the project. It is a relatively quick exercise but enables a deeper reflection of the processes, barriers and successes attendant with restoration and can form part of the projects monitoring effort.

3.3.3. Institutions and culture

3.3.3.1. Traditional authorities – Régulo

The Régulo are the traditional authorities of the area and a key institution that the project needs to engage with. This is a hereditary position based on clan succession and an integral part of Mozambique social, cultural and political fabric. The position of the Regulo is recognised by the Government of Mozambique especially since Law 15/2000 which allows for integration of the traditional authority in state governance through a legitimating process. Thus the traditional authorities, have to some extent, to represent the state at community level (IUCN 2017). Nevertheless, the Ministry of State Administration does not recognize the regulado and even the village as administrative units and yet it is at these levels where the community-based natural resource management is genuinely sustained.

Each regulo has a clear geographical area of responsibility (regulado). The structure of traditional authority is legitimized and recognized by state representative. Within the regulado there are the villages and bairros. The bairros and villages are Frelimo administrative units. That means in terms of traditional authority structure, each regulado is further subdivided in cabos (GDM 2015). In Memba, for example, there are about 689 regulos of first, second and third categories to govern a total population of 268,602 inhabitants More details on the Regulo and allied institutions for each of the project districts can be found in the District profiles appended to the project document (IUCN, 2017) In addition to social responsibilities the Regulo has ecological responsibilities being responsible for a geographical area and has custodianship of certain ecologies within his or her jurisdiction (see below). The Regulo recorded for the project coastal areas are found in Table 13.
In the project area that perform this numina function. In the project areas these sites are under a collective community responsibility with the Regulo taking overall individual leadership for their care. These sites are often quite small but in some cases can be extensive. In many cases these sites have a relationship with other areas in the landscape as these are often locations for decision-making on societal and land management matters. Some traditional leaders refer to them as ‘acupuncture points’ in the landscape indicated their importance in the cultural landscape in as acupuncture points are in the body. Thus they are not just isolated places but ‘punch above their weight’ in terms of cultural influence in the landscape. The same has been seen for biodiversity with many sacred natural sites remaining local concentrations of biodiversity in the landscape (Verschuuren et al. 2010), where other areas have lost their biodiversity. Sacred natural sites can, therefore, be considered an institution in their own right, and in some jurisdictions have been given their own legal persona.

In the project districts a list of 11 sacred natural sites were recorded (Table 14). Of those where data was provided 2 were forests, 2 sand dunes and 1 was a coral reef. In Dondo and Inhassoro they are small of 1-2ha but in Membga they are large with a collective size of over 100ha. The majority are degraded and would be good targets for restoration efforts. It is recommended that the project works with the restoration of sacred natural sites as an entry point and a means of engaging the Regulo as a champion of restoration the wider areas under their stewardship.

### Table 20 Regulo in the project area

<table>
<thead>
<tr>
<th>SN.</th>
<th>Name of Regulo</th>
<th>Location</th>
<th>Number of SNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jaime Alicora</td>
<td>Memba</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Maguacua</td>
<td>Dondo-Chonamaco-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ndo</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Chibo</td>
<td>Chibo</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Fequete Queixa</td>
<td>Inhassoro sede</td>
<td>3</td>
</tr>
</tbody>
</table>

**Recommendation:** The project needs to work proactivity with the Regulo of the project area and supporting them to become champions for ecological restoration. This effort should start first with the sacred natural sites under their custodianship several of which have become degraded.

Gender note on traditional authorities. Like many traditional societies the Regulo has been a male dominated institution that have customarily given weight to the opinion of male elders. They have not been either gender or youth responsive although there are usually mechanism where the voice of women are heard (The role of the Queen Mothers in these systems are particularly important). To retain relevance in the modern and increasingly equitable gender and youth dispensation these institutions need to, and in-fact in many cases are, becoming more gender and youth responsive. Projects like CRCC can help these intuitions understand the ways in which they can adapt to the changing realities of gender expectations and mores.

**Recommendation:** Support the institution of the Regulo to support gender equity in the cultural management and restoration of traditional land and sea domains.

### 3.3.3.1 Sacred Natural Sites

Culturally most communities in Mozambique, and indeed sub Saharan Africa have special places to venerate and intercede with the spirits of the ancestors, hold ceremonies or bury their dead. These are often natural places such as forests, lakes, rivers, mountains, rocks. In fact almost any natural feature can take on these properties, technically known as ‘numina’ (Verschuuren et al. 2010), for example there are sand dunes and coral reefs, as well as forests such as...
2.3.3.2. Culture and restoration

From the application of the 10 questions on culture (Wild, 2016) to five Regulo came the detailed answers below. Generally is can see culture can have an influence on restoration, that working with the Regulo is important and they can be a champion for restoration. There is cultural change under way. See gender note above.

10 Questions on culture for Forest Landscape Restoration – Integrated Coastal Zone Management (ICZM). Each bullet represents an answer from a different Regulo.

To what extent is culture an important factor that can influence ICZM in the area?
- It is high because the community respects its culture and traditions, so the intervention must take into account these aspects
- There is respect for those areas that are cultural sites. For example certain cultural areas forest cannot have any develop any activities within them. The project also has to respect these areas.
- The social and cultural factors influence integrated
management of coastal areas, because, for example, the forests are conservation areas, and the holy sites serve the community for worship when there are problems such as scarcity of rain or poor fish catches.

- Social and cultural factors can influence the integrated management of coastal zones, as each place has its way of life and obeys habits, rules and local behavior.

2. What are the main themes or domains where culture influences FLR?

a. Related to land, land tenure, governance and rights:
   i. On land tenure the government approves individuals to buy a piece of land. To make it official they authorise transactions in the government land office.
   ii. Land can return to community and government can reissue it to someone else (Has that happened?) It has happened once Are there any regulations regarding the marine and inter-tidal habitats. No there is not specific regulations. How does government recognise the authority of the Regulo? The government provide with them a monthly stipend and a uniform.
   vii. Could he as regulo create an area to designate a degraded area as no-go area or as a sacred area? This can be done, but his own area is not much degraded, but in areas of destruction the Regulo can help to restore.
   viii. Can a community develop a plan? Yes the community can develop and the Regulo can support.

b. Related to specific landscapes, features in the landscape, and/or specific sites (forest or non-forest) e.g. sacred natural sites.
   i. Lake fresh water called Casinhenga near the sea (cemetery). Forest called Ziziwa-Galasse 1.5ha. Sacred sites in the dunes (used for cemetery). Dues some of the cemetery is being eroded due to sea level rise. No SNS in the marine areas.
   ii. (Praia de Farol-tremor de terra - Beach of Lighthouse - earthquake)

b. Related to specific plant and animal species:
   i. Food: fish, vegetables
   ii. Taboos and beliefs does not exist
   iii. Medicines does not exist
   iv. Construction mixed
   v. Others
   a. Arts and crafts: there is a school for arts and crafts
   d. Related to institutions and cultural leadership: - Yes related to Regulo.

3. What are the main themes or domains where societal culture influences ICZM?

- Governance and rights; natural and sacred sites; food; Institutions and cultural leaderships and spirituality and religion
- The fishermen think that the female presence in the fishing centers influences the low and bad catches and even the onset of bad weather. The solutions for this are:
   - The use of domestic utensils (Washing dishes, pots and pans) is not allowed in fishing centers, i.e. on the beach, using sea water;
   - Prohibition of the presence of women in fishing centers.

4. In your opinion is culture an opportunity for, or a barrier to, ICZM in the area?
- It is a barrier (x2)
- It is an opportunity (x1)

a. If a barrier how?
   - Barrier, because at some extent it delays development.

b. If it is an opportunity how?
   - Because at one time among people in the community, women were forbidden to be close to men, especially in the meetings, they were forced to isolate themselves, they had no voice. Today with the approach of several cultures, these myths have been abandoned.

5. How does culture influence gender and youth regard to ICZM?

- Culture influences gender. Nowadays everyone (man and woman) practices fishing for food, selling and for their subsistence, the same applies equally to young people.
- Existence of selective activities where only men participate and practice
- Culture does not influence gender and youth

Subsidiary question: How is the institution of the Regulo adapting to the constitutional requirement of women's empowerment?
- Traditionally the issue of gender – has pushed man in front of everything – the government is pushing women in all activities this is giving them a new mind set – as women can now be engaged with.

6. Does the overarching group culture of the area lead predominantly lead to restoration or degradation?

- Prior to the establishment of the CCP in the zone the system of degradation was predominated due to lack of knowledge; in recent years has been to moving restoration.
- There is a behaviour of change especially from fishing community – used use very destructive gears – even scuba diving and a destroying culture now they are no longer doing that. Community now has a new mind.
set. There has been a huge campaign and the regulo is the focal point for reducing bush fires, make sure they open fire breaks etc.

- It leads to restoration

7. Are their cultural or religious institutions that are particularly important for ICZM?
- Yes, they are important because at some point they educate even though the message is not always received.
- They are very important

8. In what way should the ICZM programme (CRCC) that is currently being implemented take into account culture, and can a restoration culture be developed? If yes How?
- Through gender equity, women must be involved in all processes in the community and outside the community.
- In the case of the Dondo District, restoration activity has not yet started
- Yes. Through behavior change and environmental education

9. Is any relevant culture or cultural services recognised in existing national laws, conservation or science programmes e.g. National cultural laws or policy, World Heritage Convention, Living Cultural Heritage Convention, National Biodiversity Strategy and Action Plan?
- No answers.

10. Which is the government department that is responsible for working with Regulo.
- Reglos deal with district localities. Ministry of state administration.

3.3.3.3. Community Councils for Fishers (CCP) and fisheries co-management committees.

The Community Council for Fisheries (CCP – Conselho Comunitario de Pescas) is a local co-management structure established under the Marine Fisheries Regulations, 2003 with responsibility of supporting the sustainable management of the artisanal fisheries resources and with the right to establish the boundaries of the fishing area of the community, develop use and access rights (Swennenhuis 2011). Key informant interviews were held with leaders of the CCP in Memba, Dondo and Inhassoro.

<table>
<thead>
<tr>
<th>Districts</th>
<th>Memba</th>
<th>Dondo</th>
<th>Inhassoro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of CCP’s</td>
<td>4</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Number of Fish centers</td>
<td>37</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>Number of fisher-Total</td>
<td>2949</td>
<td>1835</td>
<td>368</td>
</tr>
<tr>
<td>Men</td>
<td>2167</td>
<td>1829</td>
<td>no data (ND)</td>
</tr>
<tr>
<td>Women</td>
<td>782</td>
<td>6</td>
<td>ND</td>
</tr>
</tbody>
</table>

*This data was collected through a direct interview with the CCPs focal points in the districts and may not necessarily match what is indicated in fishery census. From this data it shows that in Memba District women are 26.5% of the total number of fishers while in Dondo District women are 0.33% of the total number of fishers. No data were provided in Inhassoro District.*
Recommendation: The project pays greater attention to female foot fishers in areas of coral reefs and associated sand and mud flats. In the community reserve in Mamba, Baixo Pinda Fishing Center, the community to could be encouraged to use the reserve mechanism to expand to the adjacent shellfish fishery to restore its productivity.

The CCP’s have now been established for over 15 years in general they are seen to function well although not at full capacity. Non-the-less they are playing an important role in fisheries and marine management. It was recognised that one of the main strengths of the CCP is to mobilize the community as the government cannot interact with the fishers by themselves. The main challenges are not sufficient transport to go and visit the fishing centres and so do this community mobilisation.

The CCP do cooperate with each other and fishers that reside in one CCP can fish in the area of another CCP if they inform the host CCP either by phone or on paper. While the advent of mobile phones has made this relatively easy it is less likely that a paper system works in reality. This does, however, fulfill and important principle of community management that there are boundaries to the resources and harvesters can be held accountable across those boundaries.

One problem is to ensure that all fisheries have licenses, as a number of fishers operate without them, and, therefore, do not follow the rules, an issue raised by government staff. Even licenced fishers may not follow the rules. In Inhassoro the focus group claimed that 85-90% of fishers follow the rules. At the time this was considered highly unlikely and subsequent data indicated 50%, however, this will need to be validated during the establishment of the project monitoring and evaluation system.

In the context of the project it seems that the CCP are not comprehensively addressing ecosystem protection, management and restoration. This may be the case with mangroves but it is not clear with other ecosystems. It is important that governance is undertaken across the whole value chain right back to the ecosystem. For example the ProPESCA project is dealing with many parts of the fishing value chain but it is not clear that it is undertaking maintaining ecosystem health and productivity. This is potentially a role that the CCRC can play in supporting the ProPESCA activities to more strongly link to ecosystem health and productivity.

An example of the linkages to the ecosystem was with the mangrove swimming crab (Scylla serrata) fishery in Dondo District. It was reported in one of the fishing camps that foreign buyers send trucks daily to buy mangrove crabs for live export to China. This high demand and uncontrolled harvesting is leading to declining crab catches, at the same time there has been significant losses in the area of mangroves due to felling and coastal erosion probably caused, at least in part, by sea level rise.

Figure 60: Governance linkages along the value chain

Figure 61: Simplified value chain for the exports of live mangrove swimming crab
3.3.3.4. Environment committees

Very little information was gathered regarding environmental committees. In general these appear to function less well than the CCP. They did not appear to be in place in all project areas and the relationship with the CCP was not clear, for example over the management of mangroves. It was highlighted that the fishing community need wood products especially for boats and fish drying and, therefore, there needs to be coordination between the different committees.

Recommendation: CRCC project support the enhanced coordination and cooperation between the key coastal zone management institutions including government agencies, the Reglo, CCP and the environment committees.

3.3.3.5. Savings and loans groups

Poupança e Crédito Rotativo – PCR, which are Accumulating savings and credit associations (ASCAs). In general in Mozambique these are developed on the Care International model known as Village Savings and Loans Associations (VSLA). PCR/VSLA are one of Africa’s success stories in terms of community solidarity-based savings and lending mechanisms. The SBAFP final evaluation recommended that these have a stronger link to fisheries activities and this has now been taken up in the ProPESCA project. Thus the CCP are associated with PCR which are supporting their activities. The SBAFP final evaluation had also suggested that it was a project failure to scale these associations up to a tertiary level and to strongly link these to private sector value chains. This is likely to have been asking too much of these savings groups that are often most popular with women. They are not designed to strongly federate nor to play strong private sector functions. The scale of savings generated and the fees/levels of interest charged is much more at the household and livelihood level than for commercial activity. They are, however, critically important savings institutions and an important part of financial infrastructure and the fact they are operational in the CRCC project area is a great plus.

One of the limitations of the PCR/VSLA model was that they address the double bottom line not the triple bottom line, thus strongly addressing the economic and social but not the environmental pillars of development. Over the past seven years IUCN has developed an innovation on the model to address the environmental (IUCN, 2013, Kakuru and Masiga, 2016, IUCN, 2017). This is to link the community fund established in a PCR/VSLA group with a community environmental action plan, for example a CRuRAP. The concept is that the community commits to and develops a community land-use or resource/
3.3.4. Environmental economics and cost-benefit analysis

In addition to institutional and cultural aspect, economic values are very important in supporting or preventing degradation. As described in the methodology, an element of environmental economics and cost-benefit analysis was attempted. Unfortunately the rapid nature of the baseline assessment did not allow for a detailed data collection that would have supported a full cost benefits analysis.

3.3.4.1. Economic value of mangrove forest, coral reef and seagrass

This analysis was based on global figures on the ecosystem monetary benefits and localized GIS mapping done during this assessment on the degraded mangrove, coral reef and seagrass beds ecosystems. Due to the challenges with getting verifiable localized monetary data, these figures are indicative and illustrates the economic losses when the ecosystems in subject are degraded. These figures can be found in table 24 below with details for each district in tables 25 to 26.

Table 23: PCR groups in the project districts

<table>
<thead>
<tr>
<th>District</th>
<th>Number of groups</th>
<th>Total number of members</th>
<th>Male</th>
<th>Female</th>
<th>Fishers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memba</td>
<td>no data (ND)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Dondo</td>
<td>7</td>
<td>318</td>
<td>157</td>
<td>161</td>
<td>142</td>
</tr>
<tr>
<td>Inhassoro</td>
<td>62</td>
<td>1523</td>
<td>262</td>
<td>1261</td>
<td>ND</td>
</tr>
</tbody>
</table>

From the data received from the districts there are 62 PCR groups in Inhassoro where their membership consist of 81% being women and 17% being men. The average group size is 24. This profile is typical for PCR groups in many parts of sub-Saharan Africa. There is no information on how many fishers form these groups although the total number of fishers in Inhassoro was 368 but with no gender breakdown. ProPESCA project focal point confirmed that due to increased demand for membership they have expanded the PCR support to other community members and it was unfortunate that the number of fishers supported by PCR is not being tracked. The data for Dondo district indicates a much smaller number of 7 PCR groups, and has an atypical pattern, with a much larger group size of 45 per group of which 49% were men and 45% were fishers. The very small number of female fishers recorded for Dondo would indicated that most if not all the fishers in the PCR groups were men, which is unusual for PCR. Given the data from elsewhere in the report it does seem that the number of female fishers is being under recorded. These figures can be found in table 24 below with details for each district in tables 25 to 26.

Table 24 Total estimated annual economic losses from selected ecosystems in the CRCC project area

<table>
<thead>
<tr>
<th>Ecosystem/District</th>
<th>Economic (Monetary) value (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Memba</td>
</tr>
<tr>
<td>Coral reef</td>
<td>4,890</td>
</tr>
<tr>
<td>Seagrass</td>
<td>358,666</td>
</tr>
<tr>
<td>Mangroves</td>
<td>424,809</td>
</tr>
<tr>
<td>Total annual economic loss due to degradation</td>
<td>$788,367</td>
</tr>
</tbody>
</table>

Recommendation: Pilot the IUCN MaliVerde (Mkuba) solidarity evolution of the PCR – in the project area. This model has been specially designed to incentivise the development and implementation of community resource management plans such as the CRuRAPs.
Mangroves, for example, provide habitat, food and nutrients for 1300 animal species, many which are commercially important fish and shrimp. The Millennium Ecosystem Assessment gave sea food from mangroves a market value ranging from $7,500 to $167,500/km²/year (Wells, S., & Ravilious, C., 2006). Due to these economic and ecological importance, the United Nations Environment Programme World Conservation Monitoring Center (UNEP-WCMC) in 2006 has estimated the total economic value of mangrove forests at USD 100,000 and USD 600,000 per km² per year (Wells, S., & Ravilious, C., 2006; Laurans, Y., & et al., A. 2013; Fatoyinbo, et al., 2008). Despite these significant benefits, the global mangrove cover has decreased by 35% from 1980 to 2000 (Fatoyinbo, et al., 2008). Bryan Dewsbury (2014), estimated the total economic value of seagrass at USD 1749.81 per ha.

From the above table, Memba district encountered the deforestation of mangrove forests, seagrass and coral reefs. The average annual loss was estimated at USD 788,367 from deforestation of seagrass, mangrove forest and coral reefs.

**Table 25 Loss from degradation of Mangrove forests, seagrass and Coral reefs in Memba District**

<table>
<thead>
<tr>
<th>Land cover class</th>
<th>1996</th>
<th>2003</th>
<th>2010</th>
<th>2017</th>
<th>Average degradation per year (ha)</th>
<th>Average TEV per year /ha ($)</th>
<th>Average annual loss per year (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangrove forest</td>
<td>4152</td>
<td>3076</td>
<td>3565</td>
<td>2530</td>
<td>-77</td>
<td>5500</td>
<td>(424,809)</td>
</tr>
<tr>
<td>Seagrass</td>
<td>11450</td>
<td>9298</td>
<td>-102.4761905</td>
<td>3500</td>
<td>(358,667)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coral reefs</td>
<td>2854</td>
<td>2795</td>
<td>-2.80952381</td>
<td>1740</td>
<td>(4,891)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average annual loss</td>
<td>5500</td>
<td>(788,367)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From the above table, Memba district encountered the deforestation of mangrove forests, seagrass and coral reefs. The average annual loss was estimated at USD 788,367 from deforestation of seagrass, mangrove forest and coral reefs.

**Table 26 Loss from degradation of Mangrove forests, seagrass and Coral reefs in Dondo District**

<table>
<thead>
<tr>
<th>Land cover class</th>
<th>1996</th>
<th>2003</th>
<th>2010</th>
<th>2017</th>
<th>Average degradation per year (ha)</th>
<th>Average TEV per year /ha ($)</th>
<th>Annual loss per year per ha ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangrove forest</td>
<td>2646</td>
<td>2277</td>
<td>2523</td>
<td>2259.73</td>
<td>-18</td>
<td>5500</td>
<td>(101,357)</td>
</tr>
<tr>
<td>Seagrass</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>3500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coral reefs</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>1740.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average annual loss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(101,357)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In Dondo District, only information on mangrove could be obtainable by GIS & mapping team. As shown the table, there were a degradation of mangrove forest cover from 1996 to 2003. From 2003 to 2010, mangrove forest cover increased and then reduced in 2017. Generally, from 1996 to 2017, there is an average degradation of 18.4 ha per year. Using total economic value estimated by UNEP-WCMC in 2006, the average annual loss from mangrove forest degradation is estimated at USD 101,357.

### Table 27 Loss from degradation of mangrove forests, seagrass and coral reefs in Inhassoro District

<table>
<thead>
<tr>
<th>Land cover class</th>
<th>1996</th>
<th>2003</th>
<th>2010</th>
<th>2017</th>
<th>Average degradation per year (ha)</th>
<th>TEV per year/ha</th>
<th>Annual loss per year (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangrove forest</td>
<td>1002.392</td>
<td>1326.6</td>
<td>1131.57</td>
<td>851.13</td>
<td>-7.2</td>
<td>5500</td>
<td>-39616.238</td>
</tr>
<tr>
<td>Seagrass</td>
<td>928</td>
<td>338</td>
<td>420</td>
<td>664</td>
<td>-12.6</td>
<td>3500</td>
<td>(44,000.00)</td>
</tr>
<tr>
<td>Coral reefs</td>
<td>2340</td>
<td>897</td>
<td>2589</td>
<td>803</td>
<td>-73.2</td>
<td>1740.81</td>
<td>(127,410.71)</td>
</tr>
<tr>
<td>Average annual loss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(211,027)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Considering the business as usual, mangrove forest cover has increased from 1996 to 2003 and decreased from 2010 to 2017. Both seagrass and coral reef have decreased from 1996 up to 2003 and have increased in 2010 then decreased in 2017. Considering the total economic value of both classes, the average annual degradation loss is calculated at USD 211,027 in Inhassoro District as shown in the above table.

#### 3.3.4.2. Cost Benefit analysis

As described in the methodology section, the restoration opportunity assessment methodology (ROAM) uses cost-benefit analysis (CBA) that is applied to identify restoration transitions. Usually this process is done right at the end of the ROAM process when the transitions have been well identified, the areas to restore are fully delimited and sufficient cost and benefits data (analysed by hectare of ecosystem) has been collected. The lighter version or ROAM as carried out in this assessment did not fully allow for this process. Thus the data presented here is only indicative of what might be achieved.

Table 23 provides some preliminary ecosystem management and restoration transitions. These transitions can be subjected to cost-benefit analysis to gauge which are most likely to bring the appropriate level of return. This does not mean that CBA is the only criteria used in deciding the transitions to pursue as some may be essential despite high cost but it can inform project choices. In the case of all ecosystems, the project is unlikely to be able to reduce the climate change impact on them, however, it is known, for example, that reducing human impacts on reef will help their resilience to climate change, and the same is considered true of other ecosystems.
### Coral Reef Transitions

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over-harvested fish populations</td>
<td>Healthy fish populations</td>
<td>Reduced fishing pressure or increased net mesh sizes to build up populations of reef fish e.g. parrot fish that eat and keep reefs healthy.</td>
</tr>
<tr>
<td>Use of physically damaging fishing gear</td>
<td>Use of benign or low impact fishing gear</td>
<td>No use of traps or drag nets in reef areas, to reduce physical damage to the reef structures</td>
</tr>
<tr>
<td>Coastal pollution</td>
<td>Reduced coastal pollution</td>
<td>Control of sources of pollution, plastic bags etc. to reduce pollution impacts on coral.</td>
</tr>
<tr>
<td>Open access fishing</td>
<td>Locally-managed fishing</td>
<td>e.g. Locally control of gear types, locally managed marine reserves (LMMA/TURF reserves etc.)</td>
</tr>
</tbody>
</table>

### Seagrass bed Transitions

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of physically damaging fishing gear</td>
<td>Use of benign or low impact fishing gear</td>
<td>Fishing gear is likely to have minimal impact on seagrass. Beach seine nets may have some impact on the shallowest seagrasses but more attention is needed to look at the loss of seagrass (especially in Inhassoro)</td>
</tr>
<tr>
<td>Economically vulnerable fishers</td>
<td>Less economically vulnerable fishers</td>
<td>It may be that the project may not be able to have direct impact on the ecosystem health of seagrass beds. If this is the case then the project should focus on building economic resilience of fishers who are suffering as a result of seagrass declines.</td>
</tr>
<tr>
<td>Open access fishing</td>
<td>Locally-managed fishing</td>
<td>Locally control of gear types, may help seagrass beds – but this needs examining. Locally managed marine reserves (LMMA/TURF reserves etc.)</td>
</tr>
<tr>
<td>Coastal pollution</td>
<td>Reduced coastal pollution</td>
<td>Pollution may be having an impact so the control of sources of pollution may be important e.g. assessing impact of oil and gas industry.</td>
</tr>
</tbody>
</table>

### Mangrove

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncontrolled uses of all mangroves</td>
<td>Identification and protection of mangroves with critical coastal protection values</td>
<td>Not all areas of mangroves have the same coastal protection function. Those areas with the highest protective function need to be identified and given special attention</td>
</tr>
<tr>
<td>Over harvesting of Mangroves</td>
<td>Sustainable harvesting of Mangroves</td>
<td>In general mangroves can be harvested sustainably, however, overharvesting will lead to weakening of individuals and so sustainable harvesting regimes need to be promoted.</td>
</tr>
</tbody>
</table>

### Coastal Forests

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsustainable use of fire</td>
<td>Proper use of fire</td>
<td>Fire is generally overused in the coastal forest types. Some ecosystems are fire vulnerable and others are fire resilient. Community Based Fire management should be supported to manage fire such that the ecosystems are not compromised.</td>
</tr>
<tr>
<td>Protection of high value coastal forests</td>
<td>Clearing of coastal forests for charcoal and agriculture</td>
<td>The most valuable areas of high biodiversity value forests should be identified and managed on sustainable basis.</td>
</tr>
</tbody>
</table>
Cost-benefit analysis can, then, be applied to these different transitions. An interesting case study is the community reserve established in Memba. It is suggested a cost-benefit analysis is carried out on this well-established reserve. Knowing the cost-benefit ratios will also help structure the government and project support to these transitions. For example a transition with a high return on investment for communities may need less government initial investment than a transition with a low return on investment for communities.

3.3.5. Socio-economic dimensions of coral reefs

- Climate change impacts on coral reefs (sea temperature rise, subsequent bleaching and mortality, and sea water acidification) are seen as the greatest current human derived impacts on coral reefs. The 2017 bleaching and subsequent death of large areas of Australia’s Great Barrier Reef has dramatically highlighted the vulnerability of this ecosystem to climate change. Subsequent global analysis on resilient coral reefs (WWF Resilient Reefs analysis) has indicated some limited number of reefs areas have a natural resilience to climate change. One such area is Northern Mozambique along with Tanzania. This indicates the CRCC project activities to support the coral reef ecosystems is particularly important.
- Coral reefs are one of the more prominent ecosystems in Memba district, and are likely to be a key focus for that district. Unfortunately during this assessment there was not the time to visit the reefs themselves, and most interaction was through the fishing community, although it must be said that of all the ecosystems, the information gained from local stakeholders about coral reefs was the lowest. This was limited to some indication of degradation and the fact that at least one coral reef is a culturally important sacred natural site.
- Coral reef fish, however, form a key part of the artisanal fishery. Different fishing practices have different impacts upon the reefs, traps and seine nets, for example, can cause physical impacts, and overfishing of some fish groups (e.g. parrot fish) can reduce the grazing function and hence allow damaging algal growth. Thus managing human impacts on the coral reefs is likely to be one of the best actions that can be undertaken by the project.
- Other causes of coral reef damage were not observed (e.g. pollution) however, the field visits were not comprehensive enough to detect pollution impacts.

**Recommendation:** Seek a greater understanding of the sacred dimension of the coral reef sites, as well as documenting in detail the impact of local fishing practice on both the health of the ecosystem and the constituent target fish species.

Recommendation: Expand the successful community reserve in the community to areas of coral reef

3.3.6. Socio-economic dimensions of seagrass beds

- Seagrass beds are important ecosystems from a climate change perspective. They have important fisheries values. They are seen generally as a resilient ecosystem. In the project area seagrasses are most extensive in Inhassoro district with 88km2 of seagrass bed in the area between the mainland and the offshore islands.
- In the Inhassoro area there is an important local fishery based on seagrass fish species. Fisher leaders reported to the survey team the widespread loss of seagrass in this area in recent years. The losses have been so great that they have requested that the government hold a period of mourning for the loss of the beds. This would seem to be a strong local expression of (actual or near) ecosystem collapse. These local stakeholders expressed that they felt this was a very high priority action for the CRCC project.
- Fishers consider that the oil and gas industry may be responsible for this loss. Localized disturbance from operations or more widespread pollution events may have impacts on seagrass but none of these are known to occur in Inhassoro in the oil development thus far. Other causes like disease and temperature increase may have impacts, but it is important to understand the widespread loss of this ecosystem.

**Recommendation:** Carry out an in depth joint scientific and participatory study with stakeholders (fishers and diver operators) into the reported widespread loss of seagrass beds in Inhassoro district.

3.3.7. Socio-economic dimensions of mangrove forests

3.3.7.1. Historical background of mangrove forests in Mozambique

Mangroves provide a number of valuable ecosystem services that contribute to human wellbeing, including provisioning services (timber/construction material, fuelwood and charcoal); Regulating (flood, storm and erosion control: prevention of salt water intrusion), habitat (breeding, spawning and nursery habitat for commercial fish species, biodiversity) and cultural services (recreation, aesthetic, non-use). Mangroves ecosystem services have characteristics of public goods and level of consumption of some of these services by one beneficiary does not reduce the level of service received by another (mangroves play the role of coastal protection and storm buffering) (Barbosa, F.et al., 2001). This makes private sector less involved and the management of mangrove
forests becomes harder due to the open access, unless common pool management regime is put in place. There is a market failure as mangrove ecosystem services are under supplied by market system. Consequently, mangroves are generally undervalued in both private and public decision making relating to their use, conservation and restoration. Lack of understanding and information on the economic value of mangrove ecosystem services has generally led to their omission in public decision making. Without evidence of the economic value of mangroves that can be compared with alternative public investment, the importance of mangroves as natural capital is likely to be ignored (Barbosa, F.et al., 2001).

There are nine mangrove species in Mozambique and the major use is for building materials, firewood, fencing, fish traps and medicinal purposes. Ecologically mangroves play a role as nursery and feeding grounds of many important commercial fish and crustacean species. Forest and land legislation act in Mozambique envisages community participation in the protection of natural resources including mangrove forests. However, there are still some pressures to mangroves, including uncontrolled exploitation for firewood, clearing of mangrove for solar salt production; uncontrolled influx of people from interior region to the coast; charcoal production and pole harvesting pollution and decreased flow of freshwater to mangroves caused by constructions of dams, uncontrolled coastal migration and business growth along the coast. The rate of mangrove deforestation in Mozambique was estimated as 18821 hectares per year and it was high in Maputo and Beira. The development of large scale aquaculture in Mozambique results in negative impact like depletion of mangrove regions, pollution of mangrove habitats and depletion of fauna resources traditionally used in small scale fisheries. (Barbosa.et al., 2001). Coastal sand deposition has also been indicated as one of the causes of significant mangrove mortality (Sitoe. et al., 2014).

The area of mangrove forest in Mozambique decreased from 408,000 ha in 1972 to 357,000 ha in 2004, resulting in a deforestation rate of 15.9 km2 year−1. In 2001, mangrove forests in Mozambique had an area of approximately 396,080 ha located mostly in sheltered shorelines and river estuaries (Barbosa, F.et al., 2001) and only 26 123 ha were in conservation (Macamo, C. & A. Sitoe 2017; Herr, D. et al., 2017).

### Table 28 Summary of mangrove forest cover trends

<table>
<thead>
<tr>
<th>Years</th>
<th>Mangrove forest cover (ha)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>396080</td>
<td>Barbosa, F.et al., (200); Fatoyinbo et al., (2008)</td>
</tr>
<tr>
<td>2013</td>
<td>300000</td>
<td>Macamo, C. &amp; A. Sitoe (2017); Herr, D. et al.,(2017);</td>
</tr>
</tbody>
</table>
From the figures in table 24; mangrove forest cover was reduced from 408000 ha in 1972 to 300000 ha in 2013 (108,000ha in 41 years). This makes an average deforestation rate of 2,571.4 ha per year. FAO (2015) in the global forest resource assessment estimated the deforestation rate of mangroves forests to be 2644ha per year from 2005 to 2010 and this was likely to be the same deforestation rate from 1990 to 2015. This is also compared with an annual mangrove deforestation rate for Africa of 274000 ha per year as stated by (Valiela, et al., 2001).

- Mangroves are where marine and terrestrial management systems overlap. They are harvested for construction materials as well as being productive fisheries (e.g. live crab exports) and nurseries for inshore and pelagic fish. They are also a key part of the coastal defences, which when compromised have severe impacts (e.g. Dondo district). They are a locus for critical management actions across different institutions potentially complicating management.

- What became apparent during the assessment was the lack of detailed knowledge of re-establishment of mangroves through natural regeneration, appropriate engineering works and where appropriate, planting of mangroves. It was reported that current replanting efforts had largely failed requiring reflection on the methodologies utilised.

Recommendation: Provide improved information on the current best practices in mangrove re-establishment. This may require the establishment of clear tenure for specific communities, so that management responsibilities are known.

Recommendation: Mangrove management is used as a testing ground for integrated institutional coordination where the CCP, Environment Committees, Regulo and government support institution’s work in concert.

3.3.7.1.1. Mangrove restoration costs

It proved difficult to get economic information for the establishment of costs and benefits. Table 25 sets out the estimated costs of the restoration of one hectare of mangrove forests. This estimate is adapted from the literature and stands at about USD 7000/ha
### 3.3.7.1.1 Mangrove restoration costs

It proved difficult to get economic information for the establishment of costs and benefits. Table 25 sets out the estimated costs of the restoration of one hectare of mangrove forests. This estimate is adapted from the literature and stands at about USD 7000/ha.

<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
<th>Cost per unit ($)</th>
<th>Number of units</th>
<th>Total cost ($)/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior level staff time</td>
<td>One day per Month</td>
<td>119</td>
<td>12</td>
<td>1428</td>
</tr>
<tr>
<td>Middle-level staff time</td>
<td>One day per Month</td>
<td>68</td>
<td>12</td>
<td>816</td>
</tr>
<tr>
<td>Junior level staff time</td>
<td>Twice a month</td>
<td>42</td>
<td>24</td>
<td>1008</td>
</tr>
<tr>
<td>Planning cost</td>
<td>Meetings</td>
<td>50</td>
<td>3</td>
<td>150</td>
</tr>
<tr>
<td>Maintenance cost (monitoring)</td>
<td>year</td>
<td>100</td>
<td>10</td>
<td>1000</td>
</tr>
<tr>
<td>Travel cost and communication</td>
<td>year</td>
<td>71</td>
<td>10</td>
<td>710</td>
</tr>
<tr>
<td>Transport of seedlings</td>
<td>Truck rental</td>
<td>96</td>
<td>1</td>
<td>96</td>
</tr>
<tr>
<td>Planting cost</td>
<td>Person-days</td>
<td>116</td>
<td>1</td>
<td>116</td>
</tr>
<tr>
<td>Seedlings production cost</td>
<td>Plants</td>
<td>0.29</td>
<td>2500</td>
<td>725</td>
</tr>
<tr>
<td>Seedlings maintenance</td>
<td>Months</td>
<td>45</td>
<td>6</td>
<td>270</td>
</tr>
<tr>
<td>Safety equipment</td>
<td>Boots, masks, gloves</td>
<td>74</td>
<td>1</td>
<td>74</td>
</tr>
<tr>
<td>Boat rental</td>
<td>Boat rental</td>
<td>116</td>
<td>1</td>
<td>116</td>
</tr>
<tr>
<td>Plastic bags for seedlings</td>
<td>bags</td>
<td>0.03</td>
<td>2500</td>
<td>75</td>
</tr>
<tr>
<td>Hydrological restoration – Material and equipment</td>
<td>Total cost</td>
<td>232</td>
<td>1</td>
<td>232</td>
</tr>
<tr>
<td>Hydrological restoration – Labor</td>
<td>Total cost</td>
<td>141</td>
<td>1</td>
<td>141</td>
</tr>
<tr>
<td>Maintenance after restoration</td>
<td>Total cost</td>
<td>31</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>6988</strong></td>
</tr>
</tbody>
</table>

Source: Adapted table from Tulika N. et al., 2017
3.3.8. Socio-economic dimensions of coastal forests

- Coastal forests are complex mosaic ecosystems for a number of reasons.
  o Firstly they are very high in both structural and biological diversity. Within what looks like extensive woody vegetation types in the coastal area, are in reality a multitude of different vegetation types. Some of this variety is a result of differing geological, soil and groundwater conditions, but there are important anthropogenic or human caused elements.
  o Secondly coastal forests are not well studied generally and especially in Mozambique, thus there is limited literature to refer to, and investment in the basic ecological and taxonomic studies is very low.
  o Thirdly there is not widespread scientific consensus on a) how to describe these forests; (terms for forests and other woody vegetation are diverse and defined in multiple ways. Examples are forests, woodland, wood, thicket, scrub, bushland, shrubland wooded savannah etc. Even official definitions have their limitations), and b) some of the basic ecological processes (especially with regard to the role of fire and grazing), as well as over long-term human interactions and management – often via community manipulation of fire and grazing. Confusion and misperceptions in academia are amplified among development professionals and the wider community.
  o Fourthly forests, which form mosaics within themselves, also form mosaics with other ecosystem types especially grasslands, wetlands and high saline ecosystems at the coast (salt marshes, flats, mangroves, dunes etc). The relationship with grasslands can be particularly problematic. The role and impact of fire in forest ecosystems can be very different requiring nuance fire policies. Importantly is the little documented phenomenon of what can be called ‘old-growth anthropogenic forests’ where human communities have suppressed fire in grassland/forest transition zones over long periods of time (several centuries) leading to the emergence of high biodiversity old growth forests. Colonial observers misunderstood these to be remnant primary/climax forests in savannah ecosystems, leading to perverse policy outcomes (Fairhead and Leach, 1996). This perception remains widespread today.
  o Finally forest lands have been targeted for human agriculture (both for crops and livestock) and other uses over long periods using fire as a tool. The agricultural purpose has been to exploit the fertility (often mining) of the forest generated humic soils, while all sorts of wood and non-wood products have also been used for human fuel, construction and tools. The subsequent patterns of land use, both long-established and recent add a further layer of complexity.

Figure 52 for Inhassorro, is a depiction of some of this variety in the project area, adapted to indicated the ecosystems that are fire-resilient and non fire resilient (due to their tidal nature fire is not a feature of mangrove forests). All of the project districts have transitions

---

5 Given the and the non-steady state of ecosystems and the widespread anthropogenic influence on them the concepts of ‘primary’ and ‘climax’ vegetation types currently have less value
- Even in fire-resilient ecosystems (e.g. Miombo woodlands) the overuse of fire is damaging. Fire resilient and fire dependent miombo woodland will collapse completely under an annual burning regime, a common agricultural practice. Grasslands, however, will thrive under an annual burning regime and high biodiversity ‘old-growth grassland’ require fire to maintain the biodiversity and control the invasion of low biodiversity tree and shrub species.
- We learnt from the Reglo of Dondo district that there has been a campaign in recent years to reduce the amount of use of fire in agriculture. Modern conservation agriculture practices emphasise the build up of soil humus by reducing the use of fire and by mulching crop wastes.
- Community-Based Fire Management (CBFiM) is an approach taken in a number of countries e.g. in Ghana (MoLNR, 2011) that could be considered for the CRCC project.

Recommendation: The ecological dimension of fire in the project terrestrial ecosystems and vegetation types needs to be properly assess and a nuanced fire policy, tailored to each vegetation should be produced and promoted, through Community-Based Fire Management approaches

Recommendation: The project should assist the identification and sustainable management of high conservation value forests where fire is not normally a feature – through a stakeholder engagement process
- The majority of the boats observed being used inartisanal fishing were either dug-out canoes or wooden clinker built vessels (launch). Some locally grown agricultural timbers such as cashew are used, where the supply is likely to be sustainable if ongoing planting of cashew is maintained. Access to indigenous wood will thrive under an annual burning regime and high biodiversity ‘old-growth grassland’ require fire to maintain the biodiversity and control the invasion of low biodiversity tree and shrub species.

For policy (and project activities) particularly important is the correct use and management of fire in fire-resilient and the prevention or suppression in non fire-resilient ecosystems. The use of cutting and fire (slash burn agriculture causes the transformation of non fire-resilient forests into other types with great loss of biodiversity and structural complexity (Figure 53). In this process coastal forest is transformed over a period of time to Cashew, Man- go and Cassava parkland. The bottom line ecologically, policy wise and for the project is that the use of fire is ‘okay’ in some ecosystems’ and ‘not okay’ in others! High biodiversity old-growth grasslands and woodlands need fire, old growth high forests – need no fire.

The use of fire in transition zones (high forest - woodland) also has cultural dimensions, with farmers, hunters and beekeepers using fire for different purposes and having different cultural elements. In some societies the burning of large areas prior to the planting season is a sign of male status (R. Wild pers.obs.).

The majority of the boats observed being used in artisanal fishing were either dug-out canoes or wooden clinker built vessels (launch). Some locally grown agricultural timbers such as cashew are used, where the supply is likely to be sustainable if ongoing planting of cashew is maintained. Access to indigenous wood will thrive under an annual burning regime and high biodiversity ‘old-growth grassland’ require fire to maintain the biodiversity and control the invasion of low biodiversity tree and shrub species.

For policy (and project activities) particularly important is the correct use and management of fire in fire-resilient and the prevention or suppression in non fire-resilient ecosystems. The use of cutting and fire (slash burn agriculture causes the transformation of non fire-resilient forests into other types with great loss of biodiversity and structural complexity (Figure 53). In this process coastal forest is transformed over a period of time to Cashew, Man- go and Cassava parkland. The bottom line ecologically, policy wise and for the project is that the use of fire is ‘okay’ in some ecosystems’ and ‘not okay’ in others! High biodiversity old-growth grasslands and woodlands need fire, old growth high forests – need no fire.

The use of fire in transition zones (high forest - woodland) also has cultural dimensions, with farmers, hunters and beekeepers using fire for different purposes and having different cultural elements. In some societies the burning of large areas prior to the planting season is a sign of male status (R. Wild pers.obs.).

The majority of the boats observed being used in artisanal fishing were either dug-out canoes or wooden clinker built vessels (launch). Some locally grown agricultural timbers such as cashew are used, where the supply is likely to be sustainable if ongoing planting of cashew is maintained. Access to indigenous wood will thrive under an annual burning regime and high biodiversity ‘old-growth grassland’ require fire to maintain the biodiversity and control the invasion of low biodiversity tree and shrub species.

For policy (and project activities) particularly important is the correct use and management of fire in fire-resilient and the prevention or suppression in non fire-resilient ecosystems. The use of cutting and fire (slash burn agriculture causes the transformation of non fire-resilient forests into other types with great loss of biodiversity and structural complexity (Figure 53). In this process coastal forest is transformed over a period of time to Cashew, Man- go and Cassava parkland. The bottom line ecologically, policy wise and for the project is that the use of fire is ‘okay’ in some ecosystems’ and ‘not okay’ in others! High biodiversity old-growth grasslands and woodlands need fire, old growth high forests – need no fire.

The use of fire in transition zones (high forest - woodland) also has cultural dimensions, with farmers, hunters and beekeepers using fire for different purposes and having different cultural elements. In some societies the burning of large areas prior to the planting season is a sign of male status (R. Wild pers.obs.).

The majority of the boats observed being used in artisanal fishing were either dug-out canoes or wooden clinker built vessels (launch). Some locally grown agricultural timbers such as cashew are used, where the supply is likely to be sustainable if ongoing planting of cashew is maintained. Access to indigenous wood will thrive under an annual burning regime and high biodiversity ‘old-growth grassland’ require fire to maintain the biodiversity and control the invasion of low biodiversity tree and shrub species.

For policy (and project activities) particularly important is the correct use and management of fire in fire-resilient and the prevention or suppression in non fire-resilient ecosystems. The use of cutting and fire (slash burn agriculture causes the transformation of non fire-resilient forests into other types with great loss of biodiversity and structural complexity (Figure 53). In this process coastal forest is transformed over a period of time to Cashew, Man- go and Cassava parkland. The bottom line ecologically, policy wise and for the project is that the use of fire is ‘okay’ in some ecosystems’ and ‘not okay’ in others! High biodiversity old-growth grasslands and woodlands need fire, old growth high forests – need no fire.

The use of fire in transition zones (high forest - woodland) also has cultural dimensions, with farmers, hunters and beekeepers using fire for different purposes and having different cultural elements. In some societies the burning of large areas prior to the planting season is a sign of male status (R. Wild pers.obs.).

The majority of the boats observed being used in artisanal fishing were either dug-out canoes or wooden clinker built vessels (launch). Some locally grown agricultural timbers such as cashew are used, where the supply is likely to be sustainable if ongoing planting of cashew is maintained. Access to indigenous wood will thrive under an annual burning regime and high biodiversity ‘old-growth grassland’ require fire to maintain the biodiversity and control the invasion of low biodiversity tree and shrub species.
artisanal fishing were either dug-out canoes or wooden clinker built vessels (launch). Some locally grown agricultural timbers such as cashew are used, where the supply is likely to be sustainable if ongoing planting of cashew is maintained. Access to indigenous wood for boat building is becoming more constrained and the prices higher. The source for boat building logs in both Memba and Dondo was at least 30-50km removed from the communities that use them. It would be advisable to secure long-term supplies of such timber by careful and sustained local forest management. Substitution with fibreglass boats is possible but less desirable as it severs the community link with the ecosystem and reduces an income stream for the timber producing community.

Recommendation: Carry out a detailed assessment of the timber species used in boat construction in the project districts including sources and quantities of supplies. Carrying out critical habitat assessments are a productive part of the EIA process. Studies that have been carried out in the context of coastal development (e.g. Oil and Gas) have wider utility in the building of ecosystem based climate resilience. An example is shown in Figure 53. In this figure the area of Critical Habitat was provisionally defined during the 2014 EIA for the expansion of the Sasol project. The area shown as a zone of tourism development potential comprises the INATUR tourism development area, which coincides with a Zone of Tourism Interest (ZIT), defined in studies on behalf of INATUR in 2010. The location of proposed oil wells, known at the time of the EIA, is also shown (EOH, 2015).

Figure 63: Map of critical habitat in Inhassoro District
### 3.3.9. Socio-economic dimensions of sand dunes

- Sand dunes are characteristic features of the Mozambique coast and several of the project districts. They are geologically linked to other areas of sandy substrate that have not necessarily been thrown up into dunes. Biophysically, dunes have a progressive evolution from the coast where landward blown sea sand is piled into low hills, termed ‘dunes’. Over a period of time, these sand hills become vegetated initially with shrubs and thicket and eventually forests. In the dips between the dunes where the water table is high, a wetland feature termed a ‘dune slack’ can form complete with its own vegetation type. Dunes themselves act as coastal protection but are vulnerable to wind erosion. If the vegetation cover is removed (overharvesting, agriculture & fire), long-stable dunes can start moving once more and can become destructive of other ecosystems and human infrastructure.

- High levels of economic development, settlement development and tourism can compromise dune stability. With the increasing unpredictable weather events, cyclones and sea-level rise, Mozambique will need to maintain the coastal protection that the existing dunes provide. The maintenance of vegetation cover on dunes is an important policy decision.

- Sand substrates, both dune and non-dune, are less attractive for agriculture, but this does not prevent the expansion of agriculture into these sub-optimal habitats. Where old-growth sand forests, which can be high in biodiversity, have developed, they can be vulnerable to resource overharvesting.

- Localised damage to sand dunes can occur simply from foot traffic, which in a situation of high winds can initiate the process of dune erosion and collapse. Installing wooden walkways in such vulnerable situations can reduce the risk of dune erosion.

**Recommendation:** Develop policies and land-use plans that maintain effective vegetation cover on sand dunes such that their stability is not compromised. Ensure planning departments do not allow the development of unplanned settlements where they damage sand dunes, and prevent local damage through the use of appropriate infrastructure.

---

**Figure 64: Summary diagram of ecological services and sensitivities in Inhassoro District.** (from EOH, 2015)
3.3.10. Gender observations

The project is undertaking a full gender analysis and these comments are limited to observations encountered during the field work. Data shows women to outnumber men as fishers. Yet the project is not addressing key ecosystems of interest to women (mud and sand flats). They fish the less charismatic, lower value shellfish and do not generally go to sea. There is a prostitution risk at temporary fish landing stations (this maybe outside the scope of the project but it should be aware of this dynamic). Role of women in fire management needs to be better understood.

Consideration of gender and traditional authorities (see section 3.3.3.2)

3.3.11. Supplementary social information Memba district

Table 30 Example details of main fisheries from Sirissa CCP

<table>
<thead>
<tr>
<th>SN</th>
<th>CCP Name</th>
<th>Name of Fishing centre</th>
<th>No. Fishers (m/f)</th>
<th>Fishing gear type/fishery</th>
<th>Target fishery and trends</th>
<th>Ecological conditions</th>
<th>Institutional conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sirissa</td>
<td>820 (230m/590w)</td>
<td>Line, gill, hunting (spear or foot fishing?), drag net (beach seine?), camboa (?), surface gill nets.</td>
<td>Horse mackerel, stone fish, octopus, anchoveta, pompano, fuzileiro and others.</td>
<td>mangrove and coral reefs are in a degraded state</td>
<td>The management level is good; the fisheries are successful in that they ban the destruction of corals and mangroves as well as the use of mosquito nets in fisheries. The challenge of the CCP is to further increase awareness so that all people in the community are aware.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Mutacaua</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Lúrio</td>
<td>270 (70m/200w)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Sala</td>
<td>320 (120m/200w)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Muambacaia</td>
<td>402 (90m/312w)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Chaunde</td>
<td>382 (82m/300w)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2194* (592m/1602w)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 31 Source timber for boat construction in Memba

<table>
<thead>
<tr>
<th>Boat types</th>
<th>Timber sp. used</th>
<th>Who makes</th>
<th>Source of timber</th>
<th>Cost</th>
<th>Longevity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Canoe, dugout from the trunk of one tree, used for line (and small net fishing?).</td>
<td>Cashew tree</td>
<td>Local communities</td>
<td>From the villages (not in the forest)</td>
<td>5,000 to 6,000 Metical</td>
<td>5 to 7 years</td>
</tr>
<tr>
<td>2. Launch, made from planks by a boat-builder/carpenter used for larger net fishing</td>
<td>-Umbila (Pterocarpus angolensis D.C.), Jambire (Milletia stuhlmannii Taub.)*</td>
<td>Local communities</td>
<td>Mazua and Shipenhe (near Memba HQ)</td>
<td>200,000 to 300,000 Metical</td>
<td>5 to 10 years (depending on maintenance)</td>
</tr>
</tbody>
</table>

*Sources: Memba informant Mr. Abdul, scientific names from Mate, et al. 2014.

Figure 65: Fishing Centers in the District of Memba (Source: Impacto, 2012, in IUCN 2017)
Landing site Baixo Pinda CCP

The team interviewed leaders from the Baixo Pinda CCP which was established in 2001. In this settlement fishing is the main activity with agriculture second. The main fish caught are line fish and seine netting. The fisher leaders stated although there was no cooperative there was a fishers association, a fact disputed by young fishers who joint the interview later. The success of the CCP were that fishing was now more sustainable, they had created a community reserve, they carry out patrolling and they had stopped the community openly defecating on the beach. The main challenges were that the CCP were few (20 people) and the numbers of fishers high.

Baixo Pinda Community Reserve establishment.

The community, with a support project set up a community reserve in 2003. The objective of the reserve was to look after the population of small fish. The reserve is in a shallow bay adjacent to the community and specifically for beach seine. The reserve is open only for 3 days a month only and they use a 4cm (2 finger) mesh size. The benefits they report is that they have a high quantity of fish, and they fish they catch are of bigger size. Although the quantity of fish that they catch per fisher is about the same now (2 boxes per month) there are many more fishers now and the income is higher. The young male fishers were welcome to join fishing in the reserve as long as they followed the rules. Traders now come specifically to the village when they are harvesting the reserve. Trading is carried out by individual negation with traders and not by auction (which might be more lucrative for the fishers). Interestingly the fish market constructed by the government was not used as the community had rejected it. The reason for this could not be established. It would be very interesting to carry out a cost benefit analysis (CBA) on the reserve establishment as it seems the investment in establishing the reserve has been returned many times over in the last 15 years. We did not learn which project supported the establishment of the reserve.

This reserve might be an idea situation to try increasing net mesh sizes to increase over fish catch size (Sary, 1997).

Adjacent to this small bay reserve is an extensive area of sand flats with an active women’s foot fishery for shellfish. Interestingly this area was not within the reserve and there were no limitations established for this area (other than those set by the spring and neap tides). It might be worth exploring if a similar reserve approach could increase shellfish catches and reduce women’s catch effort.

3.3.12. Supplementary social information Dondo district

Beira workshop: Participants highlighted the low survival rates of planted mangroves in the district (around 10%) mainly due to poor evaluation of ecological conditions and they asked about preconditions put in place to avoid such failure in the CRCC project.

During the field work in Dondo district (22.11.18) a number of key features were recorded.

- Sacred forest managed by the Regulo
- High conservation value forests
- Old growth grasslands with high biodiversity
- Invasion into the grassland by a Eucalyptus sp.
- Patches of riverine and what appeared sand forests
- Low grade agriculture in poor soils
- Burning of forest areas

Widespread transporting of charcoal from Dondo forests to Beira Meetings were held in Tsengo and Praia Nova fishing centres (see annex 3 for full details). A meeting was held with fishing community in Tsengo fishing centre, including 3 fishers, 5 traders and one farmer and a Regulo/fishers leader, of these 2 were women.

The community reported that between 1962 to 1963 the sea and the river where far apart, but that 2005 coastal erosion started and the casuarinas that protected the soil were uprooted this allowed the sea to enter and quite a large area of the village and also mangroves were lost. They also reported that earlier their canoes were small, but now they have improved ones, and the fishing gears are improved including the crab cages. Tsengo is largely a temporary fishing centre and that most of fisherman have their houses and families in the Tsengo headquarters and Beira, where they have schools, hospitals and other services.

Crab fishing: One of the fishers had been crab fishing for 2 years. He and other crab fishers use thin wire mesh cage to crabs. He reported an increase in crab prices with the November 2017 being 100MT/kg but since January 2018 it has been 120MT/kg. He also reported a decline in catch. In terms of community organisation the fisherman are part of a CCP and some are part of a revolving fund group.

Fish catches: In late nineteenth the minimum amount of 30kg per fisherman in two hours of fishing. Currently the minimum amount after 5 hours of fishing is 10kg per fisherman. This is caused not only by the reduction in the fish quantity in the sea but also by the increase on the number of fisherman. The number of traders also increased.
Meeting with secretary of the CCP of Tsengo in Praia Nova - Mr. Custodio. The roles of the CCP are the following:

1. mangrove protection,
2. conflict resolution
3. patrolling the fishing gear
4. collection of license fee
5. and control the fishing closed period - the closure period is from December to March

There are 250 fishermen in Praia Nova who use the following techniques:

1. line fishing - 15kg to 30kg daily for fisherman
2. palangre fishing - 10 kg to 40 kg daily for fisherman
3. surface fishing - 10kg to 40kg daily for fisherman
4. deep-sea fishing - 1 to five box daily for fisherman

After 15 years the main successes of the CCP are regarding conflict resolution and control of mangrove degradation, while the main challenges are regarding the collection of license fee, control of closed period - the fisherman do not want to stop fishing in the period.

The PCR has 20 members and the now defunct IDPP (Institute for Development of Small Fishing) supported their creation. The timber for canoes construction comes from Zavane area and, it is becoming more difficult to acquire the timber as the prices are increasing now.

It should be noted that Dondo is included in the list of high biodiversity value forests in the Eastern Africa Coastal Forests Ecoregion - Strategic Framework for Conservation 2005 – 2025. (WWF-EARPO. 2006) Figure 56 and Table 28.
Table 32 High priority conservation landscapes in the coastal forests of Mozambique (including Dando)

<table>
<thead>
<tr>
<th>Priority Site</th>
<th>Priority Landscape</th>
<th>Area (km²)</th>
<th>Status</th>
<th>Strict plant endemics</th>
<th>Strict vertebrate endemics</th>
<th>Threat type</th>
<th>Threat level</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quirimbas National Park</td>
<td>Cabo Delgado area</td>
<td>7,500</td>
<td>NP</td>
<td></td>
<td></td>
<td>L, Ag, F</td>
<td>High</td>
<td>WWF</td>
</tr>
<tr>
<td>Nairote Area</td>
<td>Cabo Delgado area</td>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td>L, Ag</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>Palma</td>
<td>Cabo Delgado area</td>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td>Ag, L</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>Nangade</td>
<td>Cabo Delgado area</td>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td>Ag, L, F</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>Mecufi-Baia do Lurio</td>
<td>Cabo Delgado area</td>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td>F, L</td>
<td>Very high</td>
<td>None</td>
</tr>
<tr>
<td>Matibane</td>
<td>Nampula</td>
<td>199</td>
<td>FR</td>
<td></td>
<td></td>
<td>L, Ag, C</td>
<td>Very high</td>
<td>None</td>
</tr>
<tr>
<td>Baixo Pinda</td>
<td>Membra area</td>
<td>196</td>
<td>FR</td>
<td></td>
<td></td>
<td>L, Ag, F</td>
<td>Very high</td>
<td>Angoche</td>
</tr>
<tr>
<td>Mossuril Complex</td>
<td>Mossuril</td>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td>Ag, F</td>
<td>Very High</td>
<td>None</td>
</tr>
<tr>
<td>Gile Reserve area</td>
<td>Zambezia</td>
<td></td>
<td>PA</td>
<td></td>
<td></td>
<td>F</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>Maganja da Costa</td>
<td>Zambezia</td>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td>L, Ag, F</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>Moribane FR</td>
<td>Manica</td>
<td>53</td>
<td>FR</td>
<td></td>
<td></td>
<td>Ag, L</td>
<td>Very high</td>
<td>None</td>
</tr>
<tr>
<td>Inhamitanga/Marrom, Cheringoma/Dondo/Gorongosa</td>
<td>Sofala area</td>
<td>7,000</td>
<td>NP, FR &amp; other</td>
<td>L, Ag, F</td>
<td>Very high</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bazaruto</td>
<td>Inhambane area</td>
<td>1,600</td>
<td>NP</td>
<td></td>
<td></td>
<td>Ag, F</td>
<td>Very high</td>
<td>WWF/ FNP</td>
</tr>
<tr>
<td>Pomene</td>
<td>Inhambane</td>
<td>200</td>
<td>Reserve</td>
<td></td>
<td></td>
<td>F, Ag</td>
<td>Very high</td>
<td>None</td>
</tr>
<tr>
<td>Chirindzene</td>
<td>Xai-Xai area</td>
<td></td>
<td>SR</td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
<td>None</td>
</tr>
<tr>
<td>Matutuine/Licuati</td>
<td>Maputo</td>
<td>19</td>
<td>FR</td>
<td></td>
<td></td>
<td>L, C</td>
<td>Very high</td>
<td>None</td>
</tr>
<tr>
<td>Maputo Reserve</td>
<td>Maputo</td>
<td>700</td>
<td>Reserve</td>
<td></td>
<td></td>
<td>F, L, Ag, G</td>
<td>Very high</td>
<td>None</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>17,467</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.3.13. Supplementary social information
Inhassoro district

3.3.13.1. Decline in sea grass beds Inhassoro District.

The topic of discussion with the group around social context, culture, gender and finance was introduced. Fisher leaders, however, wanted to focus on the seagrass decline and so the focus of the discussion was adapted. CCP leader, Filipe Viegas Hopack CCP Fequete. "I agree fishers have a special culture, however our biggest issue is that since 2015 we have experienced a widespread loss of seagrass with a white colour all over the place. (note. Possibly caused by the sand becoming visible with the loss of sea grass/or from whitening of seagrass leaves) the consequences is that fish population has dropped and our incomes have declined. It is so serious that we requested the government to declare a period of mourning for our seagrass beds. If this new project does not do something about the seagrass it has done nothing. We wonder what has happened to it. None of it has washed up on the shore. When we had the 2000 cyclone much seagrass washed upon the shore line. For about 3-4 years after the cyclone we had strange fish from Sofala in our sea-grass beds. After 3 years the sea grass recovered.

CCP leader, Mário Feliciano de Sousa, CCP Petane, confirmed the situation and said he discussed with the divers operators who reported the sea grass physically shrinking. The fishermen mentioned the impact of the reduction of sea grasses: the corals productivity is reducing and as well the fishing production. This is an opportunity to the restoration through the project, said the director of the SDAE.

The quantity of fish they get now is too small. The line of sea grasses now is to narrow, maybe 200 meters, before it was about 7km. The question is where are the sea grasses now?

The project should first look at what is happening in the sea, because the community depends on the fishery to survive. The group decided to produce a map the seagrass beds.

Discussion: One of the fisher leaders thought that the gas drilling was to blame and a discussion ensued. The baseline team said that it was important to draw this kind of event to the government. The strength of description was appropriate, however, it was advised not to jump to conclusion on the cause.
Team comments: Several causes for the decline were conjectured including:

Gas exploration. This was considered unlikely as impact, if any, would most likely be only proximate to the drilling sites. This issue should be referred to the relevant EIA processes. It was noted there is hostility between the fishers and the company. Physical damage from beach seine nets. The team observed at the same day significant damage to seagrass beds from beach seines. However, this impact is localized to the shoreline and not to the deeper water where the declines are reported.

Physical damage from other sources was considered unlikely. Climate change, it was speculated that increase in temperature may have an impact but this is not reported in the literature.

Disease. A possible cause is wasting disease as observed in other sea grass beds (Robblee et.a. 1991)

3.3.13.2. Recommended Actions

- See if the satellite image series pick up the SG reduction.
- Interview dive operators / get contracts.
- Carry out a loss of income case study from seagrass decline E.
- Carry out an ecological study on the seagrass beds including more detailed participatory documentation of the pattern of loss with fishes.
- Confirm the drivers of decline and develop action plan to resolve

Recommendation: The CRCC project works with dive operators who are the “experts” under the water by setting up a dive operator contact group.
Figure 67: CCP in Inhassoro district visited during the project scoping mission in 2017.
3.3.13.3 Fishers institutions in Inhassoro District

- Each village has a CCP that were formed a long time ago. The objective of the CCP is to promote sustainable use of the fishing.
- The main strengths of the CCP is to mobilize the community as the government cannot interact with the fishers by themselves. CCP has also created awareness on different issues. For example there has been a lot of awareness on the need to conserve sea turtles. However, due to the loss of sea grass beds there is no option for fishermen other than to fish turtles.
- The main challenges are not sufficient transport to go and visit other communities.
- There is also a problem to ensure that all fisheries have licenses.
- Q. Can fishers that reside in one CCP fish in the area of another CCP?
  A. Yes fishers can fish in another CCP area but will need to inform that CCP either by phone or on paper.
- Ms. Judite Paceli of SDAE-Inhassoro made the comment that some fishers are not part of the CCP and do not follow the rules.
- Q. What percentage of fishers follow the rules?
  A. 85-90%
  (It was felt by the team this level of compliance was unusually high and may be exaggerated) These communities do have PCR (VSLA). A discussion ensued about the MITADER fund which was to pay for engines but the fishermen were not happy (the reason was not clear). The district focal point though the programme was still continuing although there was an institution change from IDPP – IDPA.
- It was reported by government staff in the provincial workshop in Inhambane that

Figure 68: Map of CCP areas from Inhassoro from community CRCC consultation meetings 2017
Inhassoro district is facing deep changes in last years, and there is exploitation of oil and gas. In the last years (from 2014), it is observed the degradation of seagrass, which is the ecosystem that ensure the conservation of the general biodiversity, accompanied of low level of fish captures. Close to Inhassoro there is the Bazaruto National Park, created to protect dugongs and turtles, and it is observed that these animals are changing their hotspots, and now they are seen outside the park, and close to fisher zones. This could be for grazing. There is a reduction of mangrove, seen in the south and north. The most important ecosystems are coral reefs and seagrasses.
### 3.3.14. Inputs into the community-based ecosystem management and restoration plans

The following plan inputs identifies actions that communities can take against the appropriate project results.

<table>
<thead>
<tr>
<th>Plan activities against results 3-7.</th>
<th>Districts</th>
<th>Responsibility</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Result 3: Baseline studies conducted and utilized to develop the Programme ‘took kit’ to guide activity design, implementation and monitoring:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Develop the programme toolkit content per ecosystem</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1 Coral reefs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Participatory assessment of reef-damaging current practices integrated with the RLE Create methodology for local innovation and linking with global best practices and</td>
<td>Memba</td>
<td>Communities with project team</td>
<td>2019</td>
</tr>
<tr>
<td>1.2 Develop the project ‘coral reef tool kit’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2. Seagrass beds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Communities collaborate with national and international scientists by forming and Action Learning Group and researching into the extensive loss of seagrass beds</td>
<td>Inhassoro</td>
<td>Communities with project team</td>
<td>2019</td>
</tr>
<tr>
<td>2.2 With the inputs from the ALG, global science and best practice develop ‘seagrass tool kit’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3. Mangroves</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 Mangrove conservation and re-establishment (ensuring no further decline and restoration of those areas that are feasible. The level of degradation in some mangroves may be such that they can no longer be restored</td>
<td>Dondo,</td>
<td>Communities with project team</td>
<td>2019</td>
</tr>
<tr>
<td>3.2 Carry out an assessment on international best-practices on mangrove management and re-establishment to develop a ‘mangrove tool kit’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Coastal forests</td>
<td>4.1 Develop fire control protocols for different kinds of terrestrial ecosystems; agricultural land, grasslands (focusing on old-growth grasslands), fire-dependent woodland, fire non-dependent high forests. Put this information in to a ‘fire management tool kit’</td>
<td>Dondo, Memba (north)</td>
<td>Communities with project team</td>
</tr>
<tr>
<td>4.2 Participate with project staff to identify and map non fire-resilient and fire resilient forests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.3 Contribute to developing the 'coastal forests tool kit'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Sand dunes</td>
<td>5.1 Participate with project staff to identify vulnerable sand dunes and create a 'sand dune tool kit'</td>
<td>Communities with project team</td>
<td>2019</td>
</tr>
<tr>
<td>Result 4: Community resilience strengthening actions carried out in an inclusive and participatory manner involving men and women and resulting in tangible benefits and positive changes in governance, natural resource management and local level livelihoods;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 General and cross-cutting: CRuRAPS</td>
<td>6.1 20 selected communities in the project area each develop CRuRAPS for each appropriate ecosystem type which will be matched with a MaliVerde mechanism.</td>
<td>Memba</td>
<td>Communities with project team</td>
</tr>
<tr>
<td>6.2 Each community identifies a set of community level bylaws for each ecosystem types to be endorsed by the district authorities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.3 Implement the bylaws (effectively implementing the CRuRAPS) monitoring and reporting on the numbers of infractions and the use of the fine monies.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Establishment of TURF reserves (local marine management areas):</td>
<td>Self-identification of communities that wish to set up local marine (or terrestrial) management areas.</td>
<td>Memba</td>
<td>Communities with project team</td>
</tr>
<tr>
<td>8 Mangroves</td>
<td>8.1 Mangrove forest co-management groups ensure the protection and sustainable harvesting of mangroves through CRuRAPS</td>
<td>Dondo, Memba (north)</td>
<td>Communities with project team</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>9 Coastal forests</td>
<td>9.1 Training of community members in, and the implementation of fire management and prevention techniques and plans.</td>
<td>Dondo, Memba (north)</td>
<td>Communities with project team</td>
</tr>
<tr>
<td></td>
<td>9.2 Monitor for sustainable harvesting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Sand dunes</td>
<td>10.1 Implement sand dune restoration actions such as the maintenance of vegetation cover</td>
<td></td>
<td>Communities with project team</td>
</tr>
<tr>
<td></td>
<td>10.2 Install wooden raised walkways to access the beach where there is risks of wind erosion to sand dunes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Result 6: Enhanced awareness and understanding of the wider community on the importance of sustainable natural resource use, the role of ecosystems and nature based solutions and the impacts of climate change for resilience livelihoods;</td>
<td></td>
<td></td>
<td>Communities with project team</td>
</tr>
<tr>
<td>11 General and cross cutting</td>
<td>11.1 Community participation programme supported by “Resilience Radio Programme” - propose collaboration with Farm Radio International</td>
<td>All districts</td>
<td>Communities with project team</td>
</tr>
<tr>
<td></td>
<td>11.2 Learning-visits between communities to successful intervention implementation e.g. the community beach seine reserve in Memba</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11.3 Awareness raising about the MaliVerde mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Result 7: Innovative conservation finance mechanisms established to ensure longer term investments in and sustainability of resilience and adaptation action.</td>
<td></td>
<td></td>
<td>Communities with project team</td>
</tr>
<tr>
<td>12 MaliVerde mechanism – general and cross cutting</td>
<td>12.1 Proactively establish within each CCP the MaliVerde mechanism as a linkage between PCR groups (both operated by ProPesca and other NGOs) as an incentive mechanism to improve the development and implementation of the CRuRAPS.</td>
<td>All districts</td>
<td>Communities with project team</td>
</tr>
</tbody>
</table>
4. RECOMMENDATIONS AND CONCLUSIONS

The combination of both IUCN methodologies ROAM and RLE is a pioneering participative approach that allows the implementation of a robust and coherent socio-ecological analysis of the coastal and marine ecosystems. Results from the different community consultations underpin science-based findings of the ecosystem risk assessments for the 3 districts. Combining an ecosystem and a social approach has added great value in understanding the increasing challenges that coastal communities face as a result of climate change and providing recommendations and providing recommendations on how increase their social, ecological and climate resilience. Long term and sustainable solutions can be then identified only by analysing the issues from both perspectives, socio-economic and ecological. A joint approach, however, requires strong coordination and communication efforts, to ensure a coherent output of results and recommendations. Despite the challenges and barriers that both teams have encountered and overcome this combined approach provides the required baseline and understanding for conducting additional socio-economic analysis and identifying best practices to reinforce the resilience of the targeted coastal communities.

Data generated from ROAM and RLE can feed into ecosystem services scenario modelling software, such as InVEST, to help prioritising investments and developing sustainable portfolios focusing in nature conservation (conservation investments).

Results from this project could potentially be used as a framework for mainstreaming ecosystem risk assessments and ecosystem on district strategies and plans; besides this framework could be-scale up and replicate thus informing strategies, plans and policies at the national level, such national biodiversity action plans (NBAP) or national adaptation plans (NAP).

4.1.1. Ecological recommendations and conclusions

The complexity of ecosystem dynamics and interactions goes beyond administrative boundaries. Therefore, large-scale assessments provide a more holistic overview of ecosystem conservation status. However, the scope of this project was limited to district administrative boundaries, thus potentially affecting the final result of the RLE evaluations described in section 3.

Considering the restricted geographical distribution of ecosystems and above mentioned study area restriction, the four ecosystems were classified as Critically Endangered (CR) (Table 33). It is to be noted that the present evaluation reflects ecosystem status at the district level. Evaluation at a larger scale (e.g. national level) would potentially yield different interpretations as accounting for larger surface areas and being more representative of complete ecosystem dynamics.

Table 33 RLE assessment summary for coastal ecosystems in study areas

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Memba</th>
<th>Dondo</th>
<th>Inhassoro &amp; Bazaruto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Forest</td>
<td>CR (D2b)</td>
<td>CR (D2b)</td>
<td>CR (D2b)</td>
</tr>
<tr>
<td>Mangrove</td>
<td>CR (B1c)</td>
<td>CR (B1c)</td>
<td>CR (D2b)</td>
</tr>
<tr>
<td>Coral reef</td>
<td>CR (B1b)</td>
<td>--</td>
<td>CR (B1b)</td>
</tr>
<tr>
<td>Seagrass beds</td>
<td>CR (B1b)</td>
<td></td>
<td>CR (B1b)</td>
</tr>
</tbody>
</table>
In all four ecosystems, ensuring that community members’ livelihoods are protected and/or enhanced, while implementing an ecological approach will require on-the-ground and policy actions. Spatial data for all four ecosystems assessed in the three districts will benefit from ground-truthing of satellite images. This may not easily furnish historical trends; though secondary sources can prove valuable to consider the spatial criteria.

One key conclusion from this project is the need for more, and better quality data on marine ecosystems, both in terms of distribution, as well as ecological processes. Although it is becoming more precise, classification of marine ecosystems using remote sensing still has limitations. A great number of datasets is available at the national level however, the quality and amount of data available decreased when downscaling from national to district level. The interpolation of available data appears as one of the major challenge that both teams have faced along the process.

For Mozambique, few datasets on corals and seagrass are available via the public domain. This calls the need for a project to first ascertain whether data has been collected, but not public, and then prioritise data collection on an as-need basis. Seagrass beds are particularly underrepresented in ecosystems studies probably due to the lack of awareness on their importance, despite the value they represent for coastal communities and their future generations.

When talking about seagrasses, local fishermen are aware of the connections among these marine ecosystems and consequently of the services provided, e.g. food. They greatly value seagrass and take their loss very seriously, to the point of requesting a period of mourning for the loss of seagrasses. Moreover, a need for tracking and quantifying the fishing catch and techniques used by local communities and other actors is needed. This is a first step towards understanding/ estimating the damage to coral reefs and seagrass beds due to fishing.

With the appropriate data, it would be possible to estimate threshold values of collapse from unsustainable fishing, by quantifying it as an indicator to criterion D (biotic processes), or possibly even criterion C as a proxy to damaged substrates. This will allow the implementation of long term solutions for a sustainable fishing activity in the area. A key recommendation is to assess the potential or actual barriers to addressing unsustainable fishing practices, which is identified as a key threat to both coral and seagrass ecosystems in both districts. The responses could range from participatory sustainable fisheries management plans, considering seasonality, number of permits, duration of fishing period, and self-monitoring plans. Barriers to acquiring more sustainable methods for fishing could involve an active programme to support the community by removing inappropriate fishing gear and considering a low-pay mechanism for better technology. Supplementary livelihoods, surrounding eco-tourism or community tourism may also provide a diversified income source, which may limit threats from fishing.

Issues surrounding by-catch, no or limited take zones, and community managed marine areas could also be locally-determined solutions that can inform policy makers. A similar conclusion can be drawn for coastal forests and mangroves. Considering coastal forests, in the three districts the principle threat identified was conversion for agriculture, and unsustainable slash and burn agriculture. Restoration measures that consider agro-forestry systems could present a social and ecological solution to some parts of degraded coastal forest areas.

Additionally, understanding the historical dynamics of slash and burn, to ensure recovery of fallow lands may be a suitable response. A policy-oriented solution could consider threats from the extractive sectors. It is important to understand whether communities are in favour of and/or benefit from such extractive activities, as on-the-ground measures may require assessing alternative income sources if community members are hired or paid off by industry. Overharvested forest and timber species must be given priority when considering restoration efforts, as depletion in their stocks can influence ecosystem characteristics and functionality. Typically, hardwood trees are climax species and can be an indicator of older forests that are more likely to harbour higher levels of diversity.

4.1.2. Socio-economic recommendations

General recommendations

- Ecosystem management and restoration. Do not allow in-tact areas to slide into degradation while attempting to restore others. Restoration is more expensive than conservation and sustainable use. There is no point and it is very costly to restore in one place and let another area degraded to be re-stored later.
- Increasingly use environmental economics tools and cost benefit analysis to make the case for restorative development practices. Develop specific case studies, for example the Baxia Pinda community fishing reserve, Memba district, to make the case to decision-makers to increase investment in these approaches.
- Establish radio programmes for public awareness of restoration in the project areas as has been undertaken by IUCN and Farm Radio International in Malawi and Uganda (e.g. Farm Radio International (2015)).
**Specific recommendations**

1. Recommendation: Link with and build upon the ASCA work that has been undertaken by SBAFP and ProPESCA.

2. Recommendation: Assess whether supporting post harvesting activities as a CRCC project activity will have a value addition for the management of ecosystems.

3. Recommendation: CRCC to consider strengthening the conducive policies towards linking microfinance institutions with ecosystem management.

4. Recommendation: CRCC to promote the adoption of more sustainable and ecosystem friendly fishing techniques.

5. Recommendation: Coordinate closely with the Ministry (or ProPESCA project) including the savings and credits schemes as well as the nutrition and food security component as it relates to coastal resilience.

6. Recommendation: It is recommended that the success factor analysis is carried out at the district level and repeated periodically during the project. It is a relatively quick exercise but enables a deeper reflection of the processes, barriers and successes attendant with restoration and can form part of the projects monitoring effort.

7. Recommendation: The project needs to work proactivity with the Regulo of the project area and supporting them to become champions for ecological restoration. This effort should start first with the sacred natural sites under their custodianship several of which have become degraded.

8. Recommendation: Support the institution of the Regulo to support gender equity in the cultural management and restoration of traditional land and sea domains.

9. Recommendation: Support the institution of the Regulo to support gender equity in the cultural management and restoration of traditional land and sea domains.

10. Recommendation: CRCC project work proactively with communities and Regulo on the conservation of degraded sacred natural sites.

11. Recommendation: The project pays greater attention to female foot fishers in areas of coral reefs and associated sand and mud flats. In the community reserve in Memba, Fishing Center, the community to could be encouraged to use the reserve mechanism to expand to the adjacent shellfish fishery to restore its productivity.

12. Recommendation: Engage with the foreign exporters of Crab in Dondo district to support mangrove crab management by reducing pressure on small size of crabs.

13. Recommendation: CRCC project support the enhanced coordination and cooperation between the key coastal zone management institutions including government agencies, the Reglo, CCP and the environment committees.

14. Recommendation: Pilot the IUCN MaliVerde (Mkuba) solidarity evolution of the PCR – in the project area. This model has been specially designed to incentivise the development and implementation of community resource management plans such as the CRuRAPs.

15. Recommendation: Cost-Benefit analysis is carried out on different restoration transitions to examine those which project-based investments likely to bring appropriate returns.

16. Recommendation: Seek a greater understanding of the sacred dimension of the coral reef sites, as well as documenting in detail the impact of local fishing practice on both the health of the ecosystem and the constituent target fish species.

17. Recommendation: Expand the successful community reserve in the community to areas of coral reef.

18. Recommendation: Carry out an in depth joint scientific and participatory study with stakeholders (fishers and diver operators) into the reported widespread loss of seagrass beds in Inhassoro district.

19. Recommendation: Provide improved information on the current best practices in mangrove re-establishment. This may require the establishment of clear tenure for specific communities, so that management responsibilities are known.

20. Recommendation: Mangrove management is used as a testing ground for integrated institutional coordination where the CCP, Environment Committees, Regulo and government support institution's work in concert.

21. Recommendation: The ecological dimension of fire in the project terrestrial ecosystems and vegetation types needs to be properly assess and a nuanced fire policy, tailored to each vegetation should be produced and promoted, through Community-Based Fire Management approaches.

22. Recommendation: The project should assist the identification and sustainable management of high conservation value forests where fire is not normally a feature – through a stakeholder engagement process.

23. Recommendation: Carry out a detailed assessment of the timber species used in boat construction in the project districts including sources and quantities of supplies.

24. Recommendation: Develop policies and land-use plans that maintain effective vegetation cover on sand.
dunes such that their stability is not compromised. Ensure planning departments do not allow the development of unplanned settlement where they damage sand dunes, and prevent local damage through the use of appropriate infrastructure.

25. Recommendation: The CRCC project works with dive operators who are the “experts” under the water by setting up a dive operator contact group

4.1.3. Socio-economic conclusions

Mangrove forests, seagrass and coral reefs are coastal ecosystems that provided significant economic good and services. These ecosystems are critical and contribute to the livelihood of many people in Mozambique. Historically, these resources have gradually degraded from 1996 up to 2018. Considering the economic value of these resources, the three District of study loose an annual average of USD 1,898,372.79 from degradation of mangrove forests, coral reef and seagrass ecosystems. This also represent the cost of inaction as these resources will keep declining in business as usual. In other words, conservation of existing resources will annual loss of 1,898,372.79 in the three Districts. Seagrass was the most degraded ecosystem in Inhassoro and Memba Districts. This is caused by inappropriate fishing techniques that disturb the seagrass ecosystem. Ndondo is the least vulnerable District in terms of coastal resources degradation. Lack of complete information on the impact of reduced ecosystems like historical information of fish catch, sources ecosystem of each category of fishes and exact number of people who are involved in fishing industry were among the challenges for economic analysis and prediction of future scenarios. Lack of data related to the establishment of community reserve was also a challenge to estimate the cost of actions (interventions) that may help to restore or conserve the degraded ecosystems.
5. REFERENCES


Bandeira, Salomão. 2014. “Zostera Capensis a Vulnerable Seagrass Species.”


Socio-economic references


Coastal Resilience to Climate Change Baseline; Coastal and Marine Ecosystems Restoration Assessment

IUCN. 2013. Practical guidelines for establishing a Community Environment Conservation Fund as a tool to catalyse social and ecological resilience. IUCN Uganda Country Office.


IUCN and WRI. 2014b. Forest landscape Restoration opportunity Assessment for Rwanda. Minirena (Rwanda). Vi+51ppl


IUCN 2018. Forest Landscape Restoration Opportunities Assessment: 10 Districts of Zambezia and Nampula Report submitted to MITADER and SUSTENTA>


MITADER 2018. Forest Landscape Restoration Opportunities Assessment: 10 Districts of Zambezia and Nampula Provinces.


Wild, R.G. et al (multiple authors) 2010. The social values of Cultural, Sacred and Religious forests: Opportunities, Threats and Recommendations for policy and field level action. A submission to inform the UN Secretary General’s Report on “Social and Cultural Aspects of Forests” For International Year of Forests 2011 by IUCN Specialist Group on the Cultural and Spiritual Value of Protected Areas - CSVPA


Valiela, I., Bowen, J. L., & York, J. K. (2001). Mangrove Forests: One of the World’s Threatened Major Tropical Environments: At least 35% of the area of mangrove forests has been lost in the past two decades, losses that exceed those for tropical rain forests and coral reefs, two other well-known threatened environments. AIBS Bulletin, 51(10), 807-815.


Additional references


6. APPENDIX

6.1. Appendix A. Summary of the five criteria (A-E) used to evaluate the risk status of an ecosystem

### A. Reduction in geographic distribution over ANY of the following time periods:

<table>
<thead>
<tr>
<th></th>
<th>CR</th>
<th>EN</th>
<th>VU</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Present (over the past 50 years)</td>
<td>≥ 80%</td>
<td>≥ 50%</td>
</tr>
<tr>
<td>A2a</td>
<td>Future (over the next 50 years)</td>
<td>≥ 80%</td>
<td>≥ 50%</td>
</tr>
<tr>
<td>A2b</td>
<td>Future (over any 50 year period including the present and future)</td>
<td>≥ 80%</td>
<td>≥ 50%</td>
</tr>
<tr>
<td>A3</td>
<td>Historic (since 1750)</td>
<td>≥ 90%</td>
<td>≥ 70%</td>
</tr>
</tbody>
</table>

### B. Restricted geographic distribution indicated by EITHER B1, B2 or B3:

<table>
<thead>
<tr>
<th></th>
<th>CR</th>
<th>EN</th>
<th>VU</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Extent of a minimum convex polygon enclosing all occurrences (Extent of Occurrence) AND at least one of the following (a-c):</td>
<td>≤ 2,000 km²</td>
<td>≤ 20,000 km²</td>
</tr>
<tr>
<td>(a)</td>
<td>An observed or inferred continuing decline in EITHER:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>a measure of spatial extent appropriate to the ecosystem; CR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii.</td>
<td>a measure of environmental quality appropriate to characteristic biota of the ecosystem; EN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii.</td>
<td>a measure of disruption to biotic interactions appropriate to the characteristic biota of the ecosystem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>An observed or inferred threatening processes that are likely to cause continuing declines in either geographic distribution, environmental quality or biotic interactions within the next 20 years.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>Ecosystem exists at … AND at least one of a-c above (same subcriteria as for B1).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>The number of 10 × 10 km grid cells occupied (Area of Occupancy)</td>
<td>≤ 2</td>
<td>≤ 20</td>
</tr>
<tr>
<td>B3</td>
<td>A very small number of locations (generally fewer than 5) AND prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and thus capable of collapse or becoming Critically Endangered within a very short time period (B3 can only lead to a listing as VU).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### C. Environmental degradation over ANY of the following time periods:

<table>
<thead>
<tr>
<th></th>
<th>Extent (%)</th>
<th>Relative severity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>The past 50 years based on change in an abiotic variable affecting a fraction of the extent of ecosystem and with relative severity, as indicated by the following table:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CR</td>
<td>EN</td>
</tr>
<tr>
<td>≥ 80</td>
<td>CR</td>
<td>EN</td>
</tr>
<tr>
<td>≥ 50</td>
<td>EN</td>
<td>VU</td>
</tr>
<tr>
<td>≥ 30</td>
<td>VU</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>The next 50 years, or any 50-year period including the present and future, based on change in an abiotic variable affecting a fraction of the extent of the ecosystem and with relative severity, as indicated by the following table:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CR</td>
<td>EN</td>
</tr>
<tr>
<td>≥ 80</td>
<td>CR</td>
<td>EN</td>
</tr>
<tr>
<td>≥ 50</td>
<td>EN</td>
<td>VU</td>
</tr>
<tr>
<td>≥ 30</td>
<td>VU</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>Since 1750 based on change in an abiotic variable affecting a fraction of the extent of the ecosystem with relative severity, as indicated by the following table:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CR</td>
<td>EN</td>
</tr>
<tr>
<td>≥ 90</td>
<td>CR</td>
<td>EN</td>
</tr>
</tbody>
</table>
Appendix B. Accuracy assessment procedure and results

The accuracy assessment process should follow consistent and proven representative sampling procedure that reduces uncertainties and limitations encountered during the mapping process. This project avoided the methods that estimate land cover areas from maps alone as then there is no indication that mapping best practices are met, as inevitable classification errors are unaccounted for. Instead, it was decided to employ a common practice and compare the classified map classes against carefully selected reference or ground truth data, to provide such assurance. The ground truth data, also called the reference data, helps to correct for systematic map classification errors and provides the information necessary for estimating the uncertainty of map classes and the creation of confidence intervals in an error matrix. Random sample points, averaging 300 in number were generated in ArcGIS 10.3 and interpreted in imagery basemap within the software as well as Google Earth, both of which provide high resolution satellite data. These were then overlaid onto the 2017 map and values of the classified raster extracted to points. Each point therefore had a raster value and a corresponding ‘ground truth point’. A frequency table was then generated using the frequency tool, to show the distribution of points per class. All the classes had a majority of points corresponding to their respective classes, as a few others were matched elsewhere.

A pivot table was then generated to create an error matrix and the percentage field added and calculated. The table was exported to Microsoft Office Excel and formatted to calculate the overall accuracy.

The results showed an overall accuracy of 85.1% for Inhassoro 2017 map, 81.1% for Membia 2017 map, and 84.3% for Dondo 2017 map. Most of the smaller classes with smaller sample points, including bareland, settlement and open water had 100% accuracy, while the larger classes with larger sample points, including the forest classes and grassland, had lower accuracy between 50% and 90%.
### Accuracy assessment for Memba district 2017 land cover map

<table>
<thead>
<tr>
<th>Classnames</th>
<th>Dense forest</th>
<th>Open forest</th>
<th>Mangrove</th>
<th>Shrubland</th>
<th>Grassland</th>
<th>Cropland</th>
<th>Settlement</th>
<th>Bareland</th>
<th>Wetland</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification data</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>72.73</td>
</tr>
<tr>
<td>Open forest</td>
<td>2</td>
<td>41</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>79.53</td>
</tr>
<tr>
<td>Mangroves</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.00</td>
</tr>
<tr>
<td>Shrubland</td>
<td>1</td>
<td>12</td>
<td>0</td>
<td>165</td>
<td>10</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>84.18</td>
</tr>
<tr>
<td>Grassland</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>60.00</td>
</tr>
<tr>
<td>Cropland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50.00</td>
</tr>
<tr>
<td>Settlement</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.00</td>
</tr>
<tr>
<td>Bareland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.00</td>
</tr>
<tr>
<td>Wetland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.00</td>
</tr>
<tr>
<td>Overall accuracy</td>
<td>81.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Accuracy assessment for Inhassoro district 2017 land cover map

<table>
<thead>
<tr>
<th>Classnames</th>
<th>Dense forest</th>
<th>Open forest</th>
<th>Mangrove</th>
<th>Shrubland</th>
<th>Grassland</th>
<th>Cropland</th>
<th>Wetland</th>
<th>Settlement</th>
<th>Bareland</th>
<th>Open water</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification data</td>
<td>16</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>64.0</td>
</tr>
<tr>
<td>Open forest</td>
<td>4</td>
<td>23</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>67.6</td>
</tr>
<tr>
<td>Mangrove</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Shrubland</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>96</td>
<td>21</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>75.0</td>
</tr>
<tr>
<td>Grassland</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>81.6</td>
</tr>
<tr>
<td>Cropland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>73.3</td>
</tr>
<tr>
<td>Wetland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Settlement</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Bareland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Open water</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Overall Accuracy</td>
<td>85.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Accuracy assessment for Dondo district 2017 land cover map

<table>
<thead>
<tr>
<th>Classnames</th>
<th>Dense forest</th>
<th>Open forest</th>
<th>Mangrove</th>
<th>Shrubland</th>
<th>Grassland</th>
<th>Cropland</th>
<th>Wetland</th>
<th>Settlement</th>
<th>Bareland</th>
<th>Open water</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification data</td>
<td>10</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>66.7</td>
</tr>
<tr>
<td>Open forest</td>
<td>3</td>
<td>10</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>58.8</td>
</tr>
<tr>
<td>Mangrove</td>
<td>1</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>87.5</td>
</tr>
<tr>
<td>Shrubland</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>22</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>84.6</td>
</tr>
<tr>
<td>Grassland</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>72.2</td>
</tr>
<tr>
<td>Cropland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>86.7</td>
</tr>
<tr>
<td>Wetland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Settlement</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>88.9</td>
</tr>
<tr>
<td>Bareland</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Open water</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Overall Accuracy</td>
<td>84.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 6.2. Appendix C. Example of species associated with mangrove ecosystem

<table>
<thead>
<tr>
<th>Invertebrate</th>
<th>Crab</th>
<th>Paeneid prawns</th>
<th>Fish</th>
<th>Reptile</th>
<th>Birds</th>
<th>Mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpheus</td>
<td>Uca</td>
<td>Metapeneus monocer</td>
<td>Ambassia salga</td>
<td>Crocodilus niloticus</td>
<td>Halcyon senegaloides</td>
<td>Dolphin</td>
</tr>
<tr>
<td>Upogebia</td>
<td>Sesarma</td>
<td>Penaeopsis hilarus,</td>
<td>Anguilla bicolor</td>
<td>Varanus niloticus.</td>
<td>Merops superciliosus</td>
<td>Atta paludinosus</td>
</tr>
<tr>
<td>Saccostrea</td>
<td>Scylla serrata</td>
<td>Paeneus canaliculatus,</td>
<td>A. mossambica</td>
<td>Caretta caretta</td>
<td>Zosterops senegalensis</td>
<td>Cephalophus monticola</td>
</tr>
<tr>
<td>Balanus</td>
<td>P. indicus</td>
<td>Belonichthys fluviatilis</td>
<td>Dermochelys coriacea</td>
<td>Alcedo semitorquata</td>
<td>C. natalensis</td>
<td></td>
</tr>
<tr>
<td>Cerithidia</td>
<td>P. monodon</td>
<td>Clarias gariepinus</td>
<td></td>
<td>Ceryle rudis</td>
<td>Cercopithecus albogula</td>
<td></td>
</tr>
<tr>
<td>Littorina scali</td>
<td>P. semisulcatus</td>
<td>Clenopoma ctenotis</td>
<td></td>
<td>Corythornis cristata</td>
<td>C. pygerythrus</td>
<td></td>
</tr>
<tr>
<td>Oecophyllum</td>
<td>Eleotris melanosoma</td>
<td>Gobius nebulosus</td>
<td></td>
<td>Halcyon albiventris</td>
<td>Dugong dugon</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kuhlia rupestris</td>
<td></td>
<td>Annea cinerea</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oreochromis placidus</td>
<td></td>
<td>A. golth</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Periophthalmus kalolo</td>
<td></td>
<td>A. purpurea</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Platygobius sp.</td>
<td></td>
<td>Bubulcus ibis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Syngnathoides baculeal</td>
<td></td>
<td>Butorides striatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Therapon jarbua</td>
<td></td>
<td>Egretta garzetta</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tilapia sparmanci,</td>
<td></td>
<td>Halaeetus vocifer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P. indica</td>
<td></td>
<td>Nictiorax nictiorax</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pandion haliaetus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Scopus umbretta</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Scotopelia plesi</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Actitis hypoleucos</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Calidris minuta</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Calidris testacea</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Charadrius hiatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C. marginatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C. pecuanus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Corvus albus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Drama ardea</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pelecanus rufescens</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Phalacrocorax carbo</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P. africanius</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pluvialis squatarola</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tringa nebularia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Xenus cinereus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Weaver</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Phoenix</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estrilda astrild</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lonchura cucullata</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quela erythrops</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vidua macroura</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.3. Appendix D. Fieldwork summary information

Team composition

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robert WILD</td>
<td>IUCN staff</td>
<td>FLR financing expert</td>
</tr>
<tr>
<td>Alain NDOLI</td>
<td>IUCN staff</td>
<td>Senior programme officer - FLR</td>
</tr>
<tr>
<td>Ephrem IMANIRAREBA</td>
<td>IUCN staff</td>
<td>FLR economist</td>
</tr>
<tr>
<td>Joseph NJUE</td>
<td>IUCN staff</td>
<td>GIS officer</td>
</tr>
<tr>
<td>Maria MATEDIANE</td>
<td>IUCN staff</td>
<td>Senior program officer - Forest</td>
</tr>
<tr>
<td>Jaffer Ababu WAKHAYANGA</td>
<td>IUCN consultant</td>
<td>Remote sensing Expert</td>
</tr>
<tr>
<td>Manuel MENOMUSSANGA</td>
<td>IUCN staff</td>
<td>Senior program officer - Coastal Marine</td>
</tr>
<tr>
<td>Silene BILA</td>
<td>IUCN staff</td>
<td>Programme assistant - Forest</td>
</tr>
</tbody>
</table>

Workshop Agenda

<table>
<thead>
<tr>
<th>Tempo</th>
<th>Evento</th>
<th>Interveniente</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.00-08:30</td>
<td>Registo de participantes</td>
<td>Todos</td>
</tr>
<tr>
<td>08:30 – 08:40</td>
<td>Notas de boas vindas</td>
<td>CRCC ponto focal</td>
</tr>
<tr>
<td>08:40 – 08:55</td>
<td>Discurso de abertura</td>
<td>Director provincial, DPMAIP</td>
</tr>
<tr>
<td>08:55 – 09:00</td>
<td>Apresentacao dos participantes</td>
<td>Todos</td>
</tr>
<tr>
<td>09:00 – 09:05</td>
<td>Apresentacao da agenda do workshop</td>
<td>Manuel</td>
</tr>
<tr>
<td>09:05 – 09:20</td>
<td>Intervalo de café</td>
<td>Todos</td>
</tr>
<tr>
<td>09.20 – 09:30</td>
<td>Apresentacao de ROAM &amp; RLE : Objectivos, abragencia/ou componentes.</td>
<td>Joseph</td>
</tr>
<tr>
<td>09:30 – 09:40</td>
<td>Visão geral sobre os factores de mudança / ameaças e possível risco para o ecossistema - biofísico (exemplo de ROAM)</td>
<td>Joseph &amp; Alain</td>
</tr>
<tr>
<td>09:40 – 10.00</td>
<td>Apresentação sobre as tendências socioeconómicas, institucionais e culturais que afetam as paisagens costeiras e marinhas/marinhas (com exemplos da ROAM)</td>
<td>Rob, Maria, Ephrem &amp; Alain</td>
</tr>
<tr>
<td>10:00 – 10:30</td>
<td>Apresentação sobre o mapeamento de degradação/ regeneração de ecossistemas, Análise multicritério e oportunidades de restauração, serviços ecossistémicos e RLE.</td>
<td>Joseph, Jaffer</td>
</tr>
<tr>
<td>10:30 – 12.00</td>
<td>Perguntas e respostas/ trabalhos em grupo para levantamento de dados / fontes de informação/</td>
<td>Todos membros da equipa</td>
</tr>
<tr>
<td>12.00 – 12:15</td>
<td>Considerações finais</td>
<td>DPMAIP</td>
</tr>
<tr>
<td>12:15 – 13.00</td>
<td>Almoço</td>
<td>Todos</td>
</tr>
</tbody>
</table>

ROAM - Restoration Opportunity Assessment Methodology (Metodologia de Avaliação de Oportunidades de Restauração)
RLE – Red List of Ecosystem (Lista vermelha de Ecossistemas)
Work Plan from 19 to 24 November

<table>
<thead>
<tr>
<th>Activity</th>
<th>Date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half Day workshop</td>
<td>19th November</td>
<td>Inhambane</td>
</tr>
<tr>
<td>Half day control survey</td>
<td>20th November</td>
<td>Inhambane</td>
</tr>
<tr>
<td>Half Day workshop</td>
<td>21st November</td>
<td>Beira</td>
</tr>
<tr>
<td>Half day control survey</td>
<td>22nd November</td>
<td>Dondo</td>
</tr>
<tr>
<td>Half Day workshop</td>
<td>23rd November</td>
<td>Nampula</td>
</tr>
<tr>
<td>Half day control survey</td>
<td>24th November</td>
<td>Memba</td>
</tr>
</tbody>
</table>

6.4. Appendix E. Information gathered from provincial workshops and district surveys.

Introduction

From 19th to 24th November a multidisciplinary team from IUCN undertook three seminars and field work for data collection, for the Coastal Resilience to Climate Change (CRCC) baseline mapping (team composition in annex 1). The seminars were done in Inhambane, Beira and Nampula Cities, and the complementary filed work in the districts of Inhassoro, Dondo and Memba (annex 2).

The workshops had the participation of key stakeholders from the province, district and community level.

A. From the province level there were representatives of:
   a. Provincial Directorate for the Sea, Inland Waters and Fisheries (DMAIP),
   b. Provincial Directorate of Land, Environment and Rural Development (DPTADER),
   c. Provincial Directorate of Agriculture and Food Security (DPMASA),
   d. Provincial Services for Geography and Cadastre (SPGC),
   e. Provincial Directorate of Tourism (DPCT),
   f. Provincial delegation of National Fisheries Research Institute (IIP),
   g. Provincial delegation of National Institute for Disaster Risk Management (INGC).
   h. Civil Society Organizations such as ADEL Sofala (Local Development Agency of Sofala), Malhalhe, AENA, Ocean Revolution Bitonga Divers, and Community Land Initiative (ITC).

B. From the district and community level:
   1. District Services for Economic Activities,
   2. District Service for Planning and Infrastructures,
   3. Local leaders,
   4. Extensionists,
   5. Members of Community Fishery Council

The data collection followed the same structure in the three provinces, a half day workshop followed by field work in the target districts. Summary of the Workshops The workshops followed the same programme (see above). The provincial focal points for the CRCC project, were in charge of the moderation of the workshops.

Presentation were made by the Restoration Opportunity Assessment (ROAM) and Red List of Ecosystem (RLE) team, to introduce the participants to concepts of both methodological approaches that are being used in the Exercise of Restoration Assessment and for the coastal Marine Ecosystem in Inhassoro, Dondo and Memba Districts. After presentation followed a clarification section, group work, presentation of group work to the plenary and clarifications of the group work.

6.4.1.1. Opening session

In Inhambane the opening and closure were made by the Delegate of the IIP, in Beira it was done by the focal point from DPMAIP and in Nampula by the Provincial Director of DMAIP. All of them mentioned the importance of the workshop due to the challenges faced in the provinces and districts in particular, to preserve the coastal and marine resources. In Nampula, were mentioned mangrove degradation, use of harmful fishing arts and coral reef degradation as examples of threats to the ecosystem. Was mentioned that, health ecosystems will lead to a better development, improvement of communities’ livelihoods, a better economy for the country and improvement of tourism and country development.

After the opening sessions and presentations of the participants, the CRCC project manager reminded the participants the objectives of CRCC project, districts involved, steps already done in the project and the objectives of the workshop. He mentioned the mapping of the marine and coastal ecosystems as the main result of the workshops and field work, as well as the
identification of areas for restoration and the costs and benefits for each identified intervention.

6.4.1.2. Presentations in the workshops

Presentation 1: Overview ROAM and RLE Process - CRCC Assessment

ROAM - Restoration Opportunity Assessment Methodology

The project intends to evaluate restoration opportunities in Dondo, Inhassoro and Memba. One of the tools to be used is ROAM, which helps to understand where to do restoration and how to involve the community in this process. It is a participatory process that involves various stakeholders. ROAM is done in three main steps:

1. Preparation - This meeting is for the participants to understand the methodology and help to identify the status of the landscapes.
2. Data collection and data analysis - In this workshop data are collected, to understand the level of preparation for restoration. The Cost and benefits analysis is done in this stage.
3. Results and recommendations - Next year a report will be compiled and presented to the partners for feedback, to improve the results of the evaluation and identify strategies to be developed, based on the results.

RLE - Red List of Ecosystems

The tool will be used to monitor and evaluate the processes of change in the ecosystems along the project lifetime. For example: Coral reefs, coastal forests and seagrasses. The main objective is to evaluate the state of the ecosystems and the needs to improve them. The tool will help to analyze the risk of collapse of the ecosystems. e.g. mangroves in Dondo, may be classified as vulnerable, in the beginning of the project and at the end of the project (as a result of the interventions in the project), evaluate if the mangrove changed its status, for instance from vulnerable to Least Concern).

Biophysical & Social economic Drivers of Degradation and the Restoration Diagnostic Assessment. The drivers used depend on the actual situation of each region. They can be biophysical or socio-economic vectors. Examples of vectors that may be relevant for mangroves include: fires, sea level and increasing infrastructures in the coastal zone.

For the diagnosis of restoration opportunities, it is used the Restoration Diagnostic Assessment Tool. The tool comprises 32 success factors (which can be seen as well as barriers) divided in three main themes, motivation, capacity and implementation. To evaluate each factor, it is used a traffic light color system (green, yellow and red) and throughout the project it is possible to evaluate how the colours change.

To undertake the economic and social analyses, one of the tools is the cost and benefits analyses. Normally the costs are higher in the first years of the intervention and the benefits are higher in the last years. It is important to identify who will be paying the costs and the investment. Normally the communities are the first investors, they invest land, time and other resources.

The analyses will include gender analysis and its contribution to build resilience in the coastal area. It is also important to evaluate the contribution of the youth and the benefits they can have from restoration. Youths are the biggest group in the communities. The cultural dimension should also be looked at, since its importance may affect the development. Degradation Opportunities and Interventions & Multi Criteria Analysis

The study will make an analysis in the specific districts over years (20 years), for 11 aspects, e.g. mangrove cover. It was explained how to get the degradation maps, prioritization and identification of opportunities for restoration. It was given an example of the analyses made in 10 District ROAM in Nampula, Zambezia and explained that, the criteria analysis may vary. The expectation from these workshop was to identify the interventions relevant for each district based on the participants’ experience.

Questions and answers after the presentations in Inhambane (19.11.2018)

1. Q: How is the multi-criteria analysis done and how to define the criteria?
2. Q: The satellite images show many mangroves, but there are other types of ecosystems, such as coastal dunes, marine reserves; will other ecosystems be considered in the study? A: Yes
3. Q: Inhassorro district has in place a land use plan and tourism master plan. It would be good to consider existing tools when implementing the tools presented in the workshop. It is important to involve the communities to have information about the changes in the site area, e.g. fisherman, local fisheries committees.
4. Q: i) Has any study in Inhassoro district already been done to identify the ecosystems to be restored? ii) Is mangrove the only ecosystem to restore? If yes, what is the current stage? iii) In relation to other marine and coastal ecosystems, will remote sensing be sufficient? There are trained personnel to do seagrass and coral reef evaluations in deep areas.
Answer: The study is based on previous studies in the area. A biophysical data collection will not be done at this time, but information from other studies will be used to inform on the state of marine ecosystems.
5. Inhassoro is facing deep changes in last years, and...
we have exploitation of oil and gas. In the last years (from 2014), it is observed the degradation of seagrass, which is the ecosystem that ensure the conservation of the general biodiversity, accompanied of low level of fish captures. Close to Inhassoro there is the Bazaruto National Park, created to protect dugongs and turtles, and it is observed that these animals are changing their hotspots, and now they are seen outside the park, and close to fisher zones. This could be for grazing. There is a reduction of mangrove, seen in the south and north. The most important ecosystems are coral reefs and seagrasses.

**Group work in Inhambane (19.11.2018)**

**Group 1 Factors of success**

Comment: Involvement of communities, through the direct contact with local leaders.

**Questions/Answers group 1**

Q: What is the status of the campaigns for planting trees called “one student, one tree” and “one leader, one forest”?

A: The campaigns are still going on. The SDPI in partnership with SDAE take advantage of commemorative dates (e.g. environment day) to encourage schools to plant trees. It is recommended that schools plant fruit trees and shade trees. The leaders already have forests, at the moment the work is to increase the planted areas. At the moment the focus is to plant fruit trees and not native forest species, especially in the cities.

**Group 2 Mapping (Inhambane)**

1. What are the land use/Environmental/Socio-Biophysical challenges (risks/threats) in the target districts?
   - Development in the coast: increase number of people living in the coast
   - Food insecurity
   - People are more active in fishery

**Biophysical:**
- Coastal erosion
- Loss of vegetation
- Reduction of biodiversity
- Environmental pollution
- Tourism development

**Socioeconomic:**
- Development in the coast
- Social exclusion
- Reducing access to resources

2. What are major social-economic challenges that could be addressed through Forest Landscape Restoration?
   - Increase access to resources
   - Food security
   - Employment

3. What are the provincial and district goals/targets in environmental protection? (These must be aligned with the CRCC programme goals)?
   - In the Mozambique Sustainable Development Plan, there are targets for the province and districts to: 300ha up to 2022 in Inhambane; Inhassoro 20ha up to 2022
   - Reduce marine pollution by plastic

4. What Type of Restoration Interventions (shown in appendix 1) can be adopted to reduce/eliminate socio-economic-environmental challenges and meet provincial/district/national socio-economic-environmental Goals/targets?
   - Ecosystems restoration and environmental education

5. What are some of the factors to consider when mapping potential areas for new mangroves and seagrasses?
   - Local history,
   - Community involvement,
   - Auscultation of stakeholders,
   - Environmental characteristics

6. List some of the GIS data/layer that could be useful for this assessment.
   - Landsat images
   - Data may be found at provincial services on Geography and
   - CENACARTA (Maputo)

7. For climate change vulnerability please provide indicator for each of the risk components (See appendix 3).
   - Exploration of hydrocarbons,
   - Coastal development,
   - Reduction of vegetation and use of wood fuel

8. How would the maps be useful at your district/provincial level for implementation?
   - Source of information to the public;
   - Location of resources;
   - For comparison in time and season

9. List some of the interventions (describing practices) that could be used for restoring degraded areas at the same time improving the livelihood of the inhabitants.
   - Mangrove replanting,
• Sea grasses,
• Radio program, TV, lectures in schools

10. In each of the intervention, state the criteria that could be used to map their potential areas (please see appendix 2).
• Existence of bad practices to the environment.
<table>
<thead>
<tr>
<th>Restoration Project Title</th>
<th>Restoration Practices/Activities</th>
<th>Year Start-End</th>
<th>Admin post</th>
<th>Contact Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDS (Sustainable Development Centers) Costal zones – by the ministry of environment</td>
<td>Soil erosion mitigation measures using low cost measures e.g. Cement bricks to protect cost, combined with vetiver grass,</td>
<td>2007-2012</td>
<td>Inhassoro and other districts</td>
<td>Manuel (IUCN)</td>
</tr>
<tr>
<td>Climate Change Project</td>
<td>Climate change local adaption plans (e.g. coping strategies at district level)</td>
<td></td>
<td>Inhassoro</td>
<td>Afonsina (844141058)</td>
</tr>
<tr>
<td>Ministry of Agriculture/SDAE</td>
<td>Plant mangrove native tree species specially.</td>
<td></td>
<td>Inhassoro</td>
<td></td>
</tr>
<tr>
<td>Skill sharks</td>
<td>No information, call Anuario</td>
<td></td>
<td>Inhassoro</td>
<td>Anuario (848918848)</td>
</tr>
<tr>
<td>District land use plan</td>
<td>GIS analysis for land cover etc. Zonation for conservation, tourism, settlements, etc</td>
<td></td>
<td>Inhassoro</td>
<td>Manuel (IUCN)</td>
</tr>
<tr>
<td>General Urbanization plan for Inhassoro (on-going)</td>
<td>Plan well, with the coming of oil and gas company (SASOL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A project increasing the river bed of Mutamba River which provide water to Inhambane</td>
<td>Success: Involvement of community leaders,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ana Isabel – SDPI Inhambane</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taigo Cherene - SPGC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cremildo Carlos Zacarias - SPFFB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Contact Information:

- Ana Isabel – SDPI Inhambane: 846506407 amacucha@gmail.com
- Taigo Cherene - SPGC: 844684260 chmiron8@yahoo.com.br
- Cremildo Carlos Zacarias - SPFFB: 842171887 mrcsiban-da@gamil.com
Questions and answers after the presentations in Beira (21.11.2018)

Main questions

1. Caetano Gimo (agricultura)
   a. Comment: the presentations are complementary
   b. Is it possible to have the presentations?
   c. In the districts, the focal point will be there, but he thinks the focal points in the district will need assistance from focal point at province level. How the results in the district will have a follow-up?
2. District focal point: the communities will take part in the activities of mangrove restoration?
   a. What really means benefit of restoration? if the restoration cost is high then the benefits we are not going to restore?
3. Provincial focal point: the province do not have the exactly information on the extension mangrove area to be restored. However there is other ecosystems to be considered. Will the project focus only in mangroves?
4. Community leader of Chinamacondo. What are the concrete actions to be implemented in the district? In the district there are areas of agriculture and fisheries and exploitation of mangrove. It is important to know the real areas to be addresses. How the community leaders will be involved. Actores to be involved na provincial e no distrito;
5. Adel sofala. There is a specific strategy for mangrove, and one of the element is mapping. How is this mapping is aligned with the strategy. What is the level of coordination?
6. Community leader of Tsengo. Welcome the project and community is open to the support which will come with the project
7. Junito Amade: Want to understand about mapping and if the project will involve OCBs and community leaders will be involved in this process.
8. Eugenio Sigauque: MIMAIP is elaborating a mangrove strategy that plan to map the mangroves. Is there any coordination between this mapping exercise and the mapping that is being planned in the strategy?
   a. The project areas were chosen based on the specific ecosystems?
9. One of the problems that make people cut mangroves, is the socio-economic situation. How to overcome this socio-economic issues. What are examples of other countries?
10. When the project will start to implement restoration in the communities? This year.

Main Answers

1. Co-participation of community in costs and benefits. For instance: if the issue is mangrove restoration, the community will help in that.
   a. First is that it is more expensive to restore than to maintain an ecosystem. If it is too expensive to restore, the priority will be on the benefit and not on the cost to restore. When making our project costs, it is important to find the cost of restoration and find ways to cover that costs. E.g. give incentives for restoration and pay for restoration services; if a cyclone hit, the government must give assistance to the community, it would be better to give money before and restore the mangrove.
2. The project will work with 4 ecosystems: coral reefs, mangroves, coastal forest and seagrasses; the project is marine and terrestrial, agriculture and other land uses will be used.
   a. The project will support all income generation activities in the coastal area not only fishing.
   b. The elaboration of mangrove strategy is an ongoing process, and it is not finished. Though as MIMAIP is partner in this project this will be addressed. The mapping being performed in the project will be aligned with the strategy. Depending on the scale of the mapping planned by MIMAIP there will be no need to re-map the mangroves in these three districts.
3. Restoration is a slow process that bring result in a long-term. The project will focus in strengthen the institutions in techniques and means that may address the mangrove degradation.
4. The project will work with 4 ecosystems: coral reefs, mangroves, coastal forest and seagrasses; the project is marine and terrestrial, agriculture and other land uses will be considered. The project will not focus only on restoration, but also in conservation of the health areas (mapping). For the degraded areas, the project will prioritize the areas for restoration. The degradation of mangrove happens due to various aspects: economic, social, legal, etc. The process of mapping is done looking at all the other aspects that results in mangrove degradation. From the study it will be identified the main activities to deal with this degradation. Sometimes the problem may come from outside the community, community may cut mangrove for domestic uses, while people from outside cut for commerce. It is important to identify the causes to address correctly the problems.
5. The socio economic issues is critical. Because people develop by degrading ecosystem. All ecosystems can be managed to be productive and this is a challenge.
6. There is great experience in this area, in forest, wood-
land, mangrove, grazing areas, wet lands, farm lands (grazing and threes). There are examples from Niger and Ethiopia, initiated by the community themselves, i) Will brings benefits to community, iii) the best examples are from Africa and; iv) communities initiate by themselves.

7. Uganda as an example of community involvement in restoration. A revolving fund was create as incentive for communities to restore. E.g. the communities create their own plans and laws and, make a commitment to adhere to the laws and, a grant is given to the communities. The fund is available for all community members. Anyone can have access to the credit if prove that is contributing to restoration.

8. The mangrove strategy is an ongoing process, and it is not finished; but because the MIMAIP is a partner of the project this will be addressed. It will be necessary to see the scale of mapping in the strategy and in CCRC mapping.


1. What are the land use/Environmental/Socio-Biophysical challenges (risks/threats) in the target districts?
Answer: Natural causes: Erosion, Cyclones and floods

2. What are major social-economic challenges that could be addressed through Forest Landscape Restoration?
Answer: Improved livelihoods, increase of marine flora and fauna.

3. What are the provincial and district goals/targets in environmental protection?(These must be aligned with the CRCC programme goals).
Answer: i) decrease the rate of coastal erosion; ii) increase in biodiversity (flora and fauna)

4. What Type of Restoration Interventions (shown in appendix 1) can be adopted to reduce/eliminate socio-economic-environmental challenges and meet provincial/district/national socio-economic-environmental Goals/targets?
Answer: i) mangrove reforestation; ii) strengthen the protection of resources; iii) Empowering communities with alternative sources of income

5. What are some of the factors to consider when mapping potential areas for new mangroves and seagrasses.
Answer: i) type of soils; ii) Soil moisture iii) Vulnerability; iv) Cost / benefit issues

6. List some of the GIS data/layer that could be useful for this assessment.
Answer: i) Population density map; ii) Satellite image; iii) Agro ecological zones

7. For climate change vulnerability please provide indicator for each of the risk components (See appendix 3).
Answer: i) population pressure; ii) Gender imbalance; iii) Low schooling index

8. How would the maps be useful at your district/provincial level for implementation?
Answer: i) Ease of project implementation process ii) Identify the phases of implementation

9. List some of the interventions (describing practices) that could be used for restoring degraded areas at the same time improving the livelihood of the habitants.
Answer: i) reforestation of mangrove ii) alternative source of income

10. In each of the intervention, state the criteria that could be used to map their potential areas (please see appendix 2).
Answer: i) salinity and soil acidity; ii) Water flow; iii) costs/benefits (measuring the benefit of intervention)
<table>
<thead>
<tr>
<th>Restoration Project Title</th>
<th>Restoration Practices/Activities</th>
<th>Year Start-End</th>
<th>Admin pos</th>
<th>Localities</th>
<th>Contact Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCR (Promotion of saving with the CCPs Sengo, Farol, Moziza and Praianova)</td>
<td>Only the promotion of saving and crediting groups for community council of fish (CCP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion of mangrove restoration government (a campaign)</td>
<td>Campaign of tree plantation in mangroves monitored by Natural Resource Management Committee CGRN (equivalent to CCP on forest)</td>
<td>Continuous</td>
<td>Savane</td>
<td>Sengo</td>
<td>Amelia Chaves – 829121497 (DPTADER) Jose Chivunvuro – 2995432 (DPMAIP)</td>
</tr>
<tr>
<td>PROMEC – Economic Promotion of smallholder farmers. Funded Austrian development Agency</td>
<td>Supporting Cassava production and processing (Soil is sandy and can only tolerate cassava and very limited maize). Avoid bush burn, leave all the organic matter on ground – Zero tillage</td>
<td>Ended 8 years (lasted for 5 ye</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-management promoted by DPMAIP</td>
<td>Teaching CCPs best practices avoiding degradation of seagrasses</td>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROPESCA sponsored by FIDA and European Union</td>
<td>Support small scale fishermen, awareness raising on best finish practices friendly to marine and coastal ecosystems</td>
<td>Started: 2010 End: March 201</td>
<td></td>
<td></td>
<td>Eugenio 848295451</td>
</tr>
<tr>
<td>SwioFISH</td>
<td>Inspection of fishing activities and punishing bad practices, interventions with PCR groups fisheries management inspections (strengthen inspection capacity, awareness) statistics. Investigation (biodiversity of shrimps, and other species)</td>
<td>2017-2021</td>
<td></td>
<td></td>
<td>Cesar 842405490</td>
</tr>
</tbody>
</table>

**Group members names**

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. Amelia Chaves</td>
<td>829121497 <a href="mailto:Melitachaves012@gmail.co">Melitachaves012@gmail.co</a></td>
</tr>
<tr>
<td>Jose Chivunvuro</td>
<td>84 2995432 <a href="mailto:Jcandue01@gmail.com">Jcandue01@gmail.com</a></td>
</tr>
<tr>
<td>Barnete Caetano Gimo</td>
<td>846316165 <a href="mailto:edyjojo@yahoo.com.br">edyjojo@yahoo.com.br</a></td>
</tr>
<tr>
<td>Stauti Janeiro Luis</td>
<td>862151988</td>
</tr>
</tbody>
</table>
Questions/Answers group 3

About the promotion of mangrove restoration. From the comments it was said that: i) 90% of the seeds planted died; ii) the reforestation was done without a previous evaluation of the ecological conditions of the place; iii) for the current project, in case of mangrove restoration, communities and technicians will learn appropriate restoration techniques for zoning, establishment of the nursery, planting, management, etc. In addition it was emphasized that i) any type of reforestation is difficult because species may not be suitable, areas may have had no mangrove before, etc; ii) restoration is more expensive than protection; iii) when the mangrove is devastated, the soil also degrades, erosion may occur and the conditions for mangrove growth get deteriorated.

Questions and answers after the presentations in Nampula (23.11.2018)

Q. When will be the validation seminar?
A. It is expected to be by the end of January.

Q. In the district of Memba it is notorious the issue of cutting of mangroves. Degradation is both caused by natural reasons and by the action of man. He could see in the presentations many details about mangroves, but hardly nothing on coral reefs, which is the predominant ecosystem in the north of Nampula. He mentioned that in some areas fisherman use harmful practices to the coral reefs.
A. Yes, coral reefs are important and will be part of the study.

Q. I would like a demonstration on how the costs of mangrove degradation will be assessed. In addition to the mangroves restoration, another issue is erosion. I would like to know if the project will have a component linked to the roads. Or if there may be coordination with the provincial director of public works.
A. There will be no training on cost and benefit analysis, but for further information Ephrem can assist. Regarding the infrastructures the project does not have the same approach as the PROPECSA project.

Group Work in Nampula (23.11.2018)

Factors of success Mapping (Nampula)

1. What are the land use/Environmental/Socio-Biophysical challenges (risks/threats) in the target districts?
   Answer: Environmental
   • Mangrove cutting risk;
   • Erosion-bare land;
   • Changes the climate and affects precipitation

   Socio-economic:
   • Disappearance of fishing resources,
   • Disappearance of mangrove forest,
   • Reduction of income of families

2. What are major social-economic challenges that could be addressed through Forest Landscape Restoration?
   Answer:
   • Reproduction of marine species
   • Increased protection of resources and
   • Increased productivity

3. What are the provincial and district goals/targets in environmental protection? (These must be aligned with the CRCC programme goals).
   Answer: No answer

4. What Type of Restoration Interventions (shown in appendix 1) can be adopted to reduce/eliminate socio-economic-environmental challenges and meet provincial/district/national socio-economic-environmental Goals/targets?
   Answer: i) mangrove reforestation; ii) casuarina reforestation

5. What are some of the factors to consider when mapping potential areas for new mangroves and seagrasses?
   Answer: i) Economic, environmental and cultural issues

6. List some of the GIS data/layer that could be useful for this assessment.
   • Geographical coordinates,
   • Altitude in relation to sea level,

7. For climate change vulnerability please provide indicator for each of the risk components (See appendix 3).
   Answer: i) Exposure: temperature and rain
   ii) Adaptability: Land tenure, land ownership and existence of institutions

8. How would the maps be useful at your district provincial level for implementation?
   Answer: Control of risk areas, awareness work, future consultations

9. List some of the interventions (describing practices) that could be used for restoring degraded areas at the same time improving the livelihood of the habitants.
   Answer: Mangrove reforestation

10. In each of the intervention, state the criteria that could be used to map their potential areas (please see appendix 2).
    Answer: i) Meetings with local governments, ii) community consultation, iii) Community awareness and implementation of activities
## Group 3. Stock taking Memba

<table>
<thead>
<tr>
<th>Restoration Project Title</th>
<th>Restoration Practices/Activities</th>
<th>Year Start-End</th>
<th>Target Area (Ha)</th>
<th>Estimated Area Treated (Ha)</th>
<th>Admin post</th>
<th>Localities</th>
<th>Contact Person</th>
</tr>
</thead>
</table>
| CARE project – implemented by INGC | 1- Open field for improved seed multiplication  
2- Community awareness of forest fires | 2014 - 2017  | NA              | Na              | Simuco  
Baixo Pinda  
The activity 2 was implemented in all Memba coast | Geba  
Simuco  
Serissa | Macadica – 84 7215471 |
| GEREN – Natural Resources Management Project implemented by SNV | 1- Community awareness on sustainable management of natural resources | 2001 - 2008  | NA              | Na              | Memba sede  
Mazua  
Lurio | Geba  
Simuco  
Serissa | Macadica – 84 7939789 |
| PPANNCD – Artisan Fishing and Climate Change adaptation project in North of Nampula and Cabo – Implemented by IDPPE and SDAE | 1- Awareness raising to address the use of harmful fishing arts; participative management of resources and coastal protection; | 2007 - 2013  | NA              | NA              | All Memba coastal zone | 84 7939789 |
| Create Agriculture and Livestock and Mining association – financed by community Land Initiative (ITC) implemented by AENA | 1. Training on associativism and community mobilization on the creation of agriculture and mining association | 2015 - 2017  | NA              | NA              | Mazua |  |

There was a comment on the presentation and was suggested to include the names of the organizations in charge of the projects and not the partners from the government. For example, SDAE in Memba undertook many activities such as: conservation agriculture, extensionism, soil conservation. That is why it appear in the table as a project.
The fishermen mentioned the impact of the reduction of sea grasses: the corals productivity is reducing and as well the fishing production. This is an opportunity to the restoration through the project, said the director of the SDAE.

During the discussions it was pointed that other causes, such as climate change might be the reason, and it was advised that the fishermen and communities register everything that happens.

All communities have Community Fishing Councils (CCP). The CCPs have the function of monitoring / controlling the use of marine resources, raise awareness about bad practices (harmful fishing gear, fishing at night), and sensitize people to pay licenses.

**Main successes / strengths of the CCP:**

- In Inhassoro people were not aware about theimporth of some species, the CCPs helped to spread this awareness about turtles for instance.
- The CCPs inform communities about laws.Inhassoro CCPs, has a lot of experience in this work, and participate in exchanges of experience of experience with other provinces

**PCR (promoted by IDPPE):** each CCP has one PCR. Years back there was the District Local Development Fund (commonly called 7 million). The fisherman and other people in the district could access to the fund, but it was no well-conceived and did not have expected results.

### 6.5 Field Work in Beira (Dondo), 22.11.2018

Meeting with fishing community in Tsengo

- Community Members Presents
  - Nelinho Joao - Trader
  - Albino Joaquim - Fisherman
  - Ben Joaquim - trader
  - Pedro Pacro - trader
  - Juliao evaristo - trader
  - Joao Muchaque - crab fisherman
  - Armando Martinho - fisherman
  - Armando Castro - trader
  - Memora Armando - trader - woman
  - Gisela Kaido - farmer - woman
  - Daureel Jose Bcemdaze - Community Leader of Tsengo - fisherman

**Question:** Tell us the history of your village

Between 1962 to 1963 the sea and the river where far. but in 2005 the erosion started the casuarinas that were protecting the soil the casuarinas that protected the soil were uprooted by the erosion. Before our canoes were small, but now we have improved ones, all our fisher arts are improved including the crab cages.
Most of fishermen have their houses and families in the Tsengo headquarter and Beira, where they have schools and hospitals.

Question to the crab fisherman - where you fish crabs and give more information on your activity?

I fish crabs for two years. the price of crabs is hore in January (120MT/Kg). But in November it cost 100MT/kg. We use thin mesh cage to crabs.

Q- Community organization

In terms of community organisation the fisherman are part of a CCP and some are part of a revolving fund group.

Q- Mangrove stage of conservation

The mangrove have suffered with the erosion.

Q- Daily fish quantity

In late nineties the minimum amount of 30kg per fisherman in two hours of fishing. Currently the minimum amount after 5 hours of fishing a minimum amount of fishing is 10kg per fisherman. This is caused not only by the reduction in the fish quantity in the sea but also by the increase on the number of fisherman.

The number of traders also increased.

Q- The kinds of fish Corvina (.... sp) - 80Mt/kg
Malola (... sp) -
Garoupa (...sp) - 100Mt/kg
Big Serra (....sp) - 80 Mt/kg - small serra 20Mt for four to five fishes.
Q - Marine ecosystems where they fish
Muddy bottom - normally fish malola, Bague and Mapute
Rocky bottom - is the favorite for the fisherman, due to the high quality of fish. Here they fish garoupa [grouper sp.], red fish [red snapper], and peixe pedra. [Manuel to help with the scientific names of these species]
Sand bottom - here they fish garoupa, red fish, peixe pedra and corvina

The fishery has declined and fishermen are forced to fish in the high seas

Q- Forest species used to produce canoes, houses species used to produce the canoes
Canoes - Mussassa, Mpepe, Mbau Stick Houses - kanda, Mtuodage
Firewood and charcoal - Mussassa, tongole, mkute, nfunvo

Meeting with secretary of the CCP of tsengo in praianova - Mr. Custodio [second name]

Q- Role of the CCP

6. Mangrove protection,
7. Conflict resolution
8. Patrolling the fishing gear
9. Collection of license fee
10. And control the fishing period/entrance - the closure period is from December to March

Q- How the fishermen leave in the closure period

1. In the closure period there still allowed to do line fishing and the surface fishing

Q- Number of fisherman in praia nova 250 fishermen in praia nova

Q- Main fishing types

5. Line fishing - 15kg to 30kg daily for fisherman
6. Palangre fishing - 10 kg to 40 kg daily for fisherman
7. Surface fishing - 10kg to 40kg daily for fisherman
8. Deep-sea fishing - 1 to five box daily for fisherman

Q- Successes and challenges of the CCP

After 15 years the main successes of the CCP were on conflict resolution and control of mangrove degradation and conflict resolution.

The main challenges were regarding the collection of license fee, control of closed period - the fisherman do not want to stop fishing in the period. The means of work are personals

Q- How many members in the group of community revolving funds groups (PCR) and who support the creation?

The PCR has 20 members and IDPP (extinct institute for Development of Small Fishing) support the creation.

Q- Where the acquire the timber for canoes construction

It comes from Zavane area and, it is becoming more difficult to acquire the timber as the prices and raising now.

Field Work in Nampula (Memba), 24.11.208

It started with an informal meeting with the head of the Locality of Geba. In the meeting he mentioned that he expects that the project classifies the status of the mangrove, and with that information build awareness about utilization and conservation of mangrove in Memba.

He mentioned the location of fire free forests in Memba: baixo Pinda, Fica, Nwepane, Nakapa and Metemane (in this area, there are saline and tuna is available). There are CCPs in Memba, and one of the tasks of the CCPs is to collect harmful fish gear.

Meeting with the President of CCP - Mr. Assan and secretary of the CCP - Mr. Amissa
Q: What are the main source of income for the community of baixo pinda?
1. Agriculture - cashew nut; sesame, maize, cassava
2. Fish - is the most important source of income all households fish
Q: The fishing arts used and type of fishing techniques
1. Line fish
2. Surface and deep fishing
3. Cages
4. Seine beach fishing
5. Marine hunting
6. Catch fishing - octopus, oysters and clams
Q: Do you fish in groups?
1. Seine beach fishing is done in groups of 30 to 40 fishermen
2. Surface and deep fishing - groups of 7 to 9 fishermen
3. Line fishing - a group of 3 fishermen
Q: Is there any fishermen cooperative?
There is no a cooperative but an association. Note: when a group of youth fisherman join in the meeting they declared that there is no any fishermen association in the community.
Q: What are most important fishing type?
The most important fishing type are seine beach fishing and deep fishing.
Q: How long was the CCP created? The CCP was created in March 2001
Q: Success of the CCP
1. The fishermen are aware on the sustainable fishing practices;
2. The creation of community reserve in 2003
3. Reduction of the fecalims in the beach
4. Patrolling - the fishermen fish every 12 days, for one day
Q: Challenges of the CCP
The number of active members reduced, when they perceived the CCP was a nonprofit community organization
Q: More information on the community marine reserve?
Within marine reserve the fishing is every 30 days for 3 day using seine beach fishing with a fishing net of 2 to 2,5 inches. Each fisherman fish 2 boxes of a mixed fish per day.
The CCP ensure the accomplishment of the community reserve rules. Whoever does not comply with the law pays the fine or goes to the police.
During the visit it was possible to see some species there: seagrasses, algae, starfish, sea urchin, sea cucumber, Ombe,
Q: Involvement of women in fishing
The women are doing catch fish. The men do not see any advantage on this type of fish.
The table below shows the type of fish men and women catch, and the difference in prices in 10 years interval.
Meeting with permanent secretary of Memba in headquarters 24/11/2018
Number of fishermen per administrative post including men and women
1,349 - Memba headquarter
1,003 - Simuca
1,112 – Sirica
Fishing in Memba District

Fishing is one of the main economic income generating activities. Both male and female are involved in fishing activity in Memba District.

Table 6-1 Fish prices reported by male fisheres for Memba district

<table>
<thead>
<tr>
<th>Species</th>
<th>Historical prices (MTC)</th>
<th>Fish catch (kg/month)</th>
<th>Fishing type (Gear type)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010 (or near date)</td>
<td>2015(or near date)</td>
<td>2018</td>
</tr>
<tr>
<td>Peixe pedra</td>
<td>50.00</td>
<td>70.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Fusilier</td>
<td>50.00</td>
<td>70.00</td>
<td>80.00</td>
</tr>
<tr>
<td>Pompano</td>
<td>50.00</td>
<td>70.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Horse mackerel</td>
<td>45.00</td>
<td>60.00</td>
<td>70.00</td>
</tr>
<tr>
<td>Anchoveta</td>
<td>50.00</td>
<td>150.00</td>
<td>250.00</td>
</tr>
<tr>
<td>Octopus</td>
<td>25.00</td>
<td>40.00</td>
<td>60.00</td>
</tr>
<tr>
<td>Others</td>
<td>25.00</td>
<td>35.00</td>
<td>40.00</td>
</tr>
</tbody>
</table>

The above table summarize the historical price and fish catch of fishing sector in Memba. A general remark from the above table, the prices have increased for all type fishes but the fish catch has decreased. This might be due to several reasons including the degradation of source ecosystem (seagrass, mangrove and coral reefs) and changes in climatic conditions. More than 1000 people are involved in fishing of each of the above mentioned category species.
Table 6-2 Fish prices reported by female fishers for Memba district

<table>
<thead>
<tr>
<th>Species</th>
<th>Historical prices (MTC)</th>
<th>Fish catch (kg/month)</th>
<th>Source ecosystem</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010 (or near date)</td>
<td>2015 (or near date)</td>
<td>2018</td>
</tr>
<tr>
<td></td>
<td>2010 (or near date)</td>
<td>2015 (or near date)</td>
<td>2018</td>
</tr>
<tr>
<td></td>
<td>2010 (or near date)</td>
<td>2015 (or near date)</td>
<td>2018</td>
</tr>
<tr>
<td>Octopus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clam</td>
<td>20.00</td>
<td>25.00</td>
<td>30.00</td>
</tr>
<tr>
<td></td>
<td>2010 (or near date)</td>
<td>2015 (or near date)</td>
<td>2018</td>
</tr>
<tr>
<td>Seagrass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anchoveta (6 kgs)</td>
<td>50.00</td>
<td>150.00</td>
<td>250.00</td>
</tr>
<tr>
<td></td>
<td>2010 (or near date)</td>
<td>2015 (or near date)</td>
<td>2018</td>
</tr>
<tr>
<td>Coral, reef, mangrove</td>
<td>Sea cucumber a)</td>
<td>25.00</td>
<td>35.00</td>
</tr>
<tr>
<td></td>
<td>Shells b)</td>
<td>15.00</td>
<td>20.00</td>
</tr>
<tr>
<td></td>
<td>1st grade shells</td>
<td>25.00</td>
<td>35.00</td>
</tr>
<tr>
<td></td>
<td>2nd grade shells</td>
<td>15.00</td>
<td>20.00</td>
</tr>
<tr>
<td></td>
<td>3rd grade shells</td>
<td>10.00</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>sea cucumber</td>
<td>1st grade sea cu-</td>
<td>15.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd grade sea cu-</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1st grade sea cu-</td>
<td>15.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd grade sea cu-</td>
<td>10.00</td>
</tr>
</tbody>
</table>

Similarly to the previous male fisher table, the prices of fish increased from 2010 to 2018 while the fish catches decreased except for Anchoveta species. The increase in fish catch for Anchoveta might be due to the current fishing type where a mosquito net is being used as fishing gear type (which is not sustainable).

Table 6-3 Additional information on shell prices

<table>
<thead>
<tr>
<th>Shells classification</th>
<th>2010</th>
<th>2015</th>
<th>2018</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st grade shells</td>
<td>25.00</td>
<td>35.00</td>
<td>5.00</td>
<td>In 2018, the demand was lower due to the situation of the market</td>
</tr>
<tr>
<td>2nd grade shells</td>
<td>15.00</td>
<td>20.00</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>3rd grade shells</td>
<td>10.00</td>
<td>5.00</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>sea cucumber</td>
<td>15.00</td>
<td>35.00</td>
<td>40.00</td>
<td></td>
</tr>
<tr>
<td>1st grade sea cucumber 1st (each)</td>
<td>15.00</td>
<td>35.00</td>
<td>40.00</td>
<td></td>
</tr>
<tr>
<td>2nd grade sea cucumber 1st (each)</td>
<td>10.00</td>
<td>30.00</td>
<td>40.00</td>
<td></td>
</tr>
</tbody>
</table>
### List of participants

**Inhambane 19 November 2018**

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Telephone</th>
<th>E-mail</th>
<th>gende</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avene Eduardo Uetima</td>
<td>Instituto de Investigacao Pesqueira</td>
<td>823063276</td>
<td><a href="mailto:aveneeduardo@gmail.com">aveneeduardo@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Sandra A. Nhacoungue</td>
<td>DPTADER</td>
<td>849117717</td>
<td><a href="mailto:mairahilaria@gmail.com">mairahilaria@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Vanda M.A.E. Massing</td>
<td>Mahalhe</td>
<td>846394684</td>
<td><a href="mailto:vandam.massingue@gmail.com">vandam.massingue@gmail.com</a></td>
<td></td>
</tr>
<tr>
<td>Stella Mariza</td>
<td>DPCULTURI</td>
<td>847803333</td>
<td>stellamarizaferrã<a href="mailto:o@gmail.com">o@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Frank Ussivane</td>
<td>DPASAI</td>
<td>847276421</td>
<td><a href="mailto:frank.ussivane@gmail.com">frank.ussivane@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Pelaciro Malhaieie</td>
<td>UEM-ESHTI</td>
<td>823958508</td>
<td><a href="mailto:paydakany@gmail.com">paydakany@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Cremildo Carlos Zacari</td>
<td>SPFFB.DPTADER</td>
<td>842871887</td>
<td><a href="mailto:mercibanda@gmail.com">mercibanda@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>José Felisberto Gujam</td>
<td>DPTADEPMAIP</td>
<td>825325740</td>
<td><a href="mailto:josegujamo@yahoo.com.br">josegujamo@yahoo.com.br</a></td>
<td></td>
</tr>
<tr>
<td>Tiago M. Chenehe</td>
<td>DPTADER-SPGC</td>
<td>844684260</td>
<td><a href="mailto:chiminone8@yahoo.com.br">chiminone8@yahoo.com.br</a></td>
<td>x</td>
</tr>
<tr>
<td>Ana Isabel Macucha</td>
<td>GDI-SDAE</td>
<td>846506407</td>
<td><a href="mailto:amacucha@gmail.com">amacucha@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Fernando Uaene Macique</td>
<td>GDI-SDAE</td>
<td>846459416</td>
<td><a href="mailto:fumacique@gmail.com">fumacique@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Horácio José</td>
<td>ORM/Bitonga Divers</td>
<td>845506206</td>
<td><a href="mailto:madivadenajose@gmail.com">madivadenajose@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>António Cabral</td>
<td>ORM/Bitonga Divers</td>
<td>825147877</td>
<td><a href="mailto:toneco@oceanrevolution.org">toneco@oceanrevolution.org</a></td>
<td></td>
</tr>
<tr>
<td>Jaffer Wakhanganga</td>
<td>Geopsy Research</td>
<td></td>
<td><a href="mailto:w.jaffer@yahoo.com.br">w.jaffer@yahoo.com.br</a></td>
<td>x</td>
</tr>
<tr>
<td>Dr Alain Ndoli</td>
<td>IUCN</td>
<td></td>
<td><a href="mailto:alain.ndoli@iucn.org">alain.ndoli@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Silene Bila</td>
<td>IUCN</td>
<td>846035949</td>
<td><a href="mailto:silene.bila@iucn.org">silene.bila@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Pelle Bagersund</td>
<td>IUCN</td>
<td></td>
<td><a href="mailto:per.matin.bagersund@iucn.org">per.matin.bagersund@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Maria Julieta Martinho</td>
<td>IUCN</td>
<td>824770170</td>
<td><a href="mailto:julia.martinho@iucn.org">julia.martinho@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Joseph Njue</td>
<td>IUCN</td>
<td>0785186361</td>
<td><a href="mailto:joseph.njue@iucn.org">joseph.njue@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Ephraim Imanirareba</td>
<td>IUCN</td>
<td>0788822950</td>
<td><a href="mailto:ephraim.imanirareba@iucn.org">ephraim.imanirareba@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Robert Wild</td>
<td>IUCN</td>
<td></td>
<td><a href="mailto:robert.wild@iucn.org">robert.wild@iucn.org</a></td>
<td>x</td>
</tr>
</tbody>
</table>

**20th November 2018, Inhassoro, Focus group discussion**

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Telephone</th>
<th>E-mail</th>
<th>gende</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benedito Pedro Mabote</td>
<td>Substituto do Chefe da Localidade</td>
<td>847106409</td>
<td><a href="mailto:beneditamabote02@gmail.com">beneditamabote02@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Alberto Zuanze</td>
<td>SDAE-Inhassoro</td>
<td>848378572</td>
<td><a href="mailto:herculenochadrequ83@gmail.com">herculenochadrequ83@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Herculano P. Chadreque</td>
<td>SDAE-Inhassoro</td>
<td>848735599</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Mário Feleciano de Sous</td>
<td>Pescador CCP petane</td>
<td>845717260</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Felipe Viegas Holack</td>
<td>Pescador CCP Pequete</td>
<td>848385080</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Judite David Paceli</td>
<td>SDAE-Inhassoro</td>
<td>847032287</td>
<td><a href="mailto:jucapaceli@yahoo.com.br">jucapaceli@yahoo.com.br</a></td>
<td>x</td>
</tr>
<tr>
<td>Manuel Luis Gerente</td>
<td>SDPI- Inhassoro</td>
<td>845407043</td>
<td><a href="mailto:gerente20@yahoo.com.br">gerente20@yahoo.com.br</a></td>
<td>x</td>
</tr>
<tr>
<td>Belmio Marrengula</td>
<td>SDPI- Inhassoro</td>
<td>848470410</td>
<td><a href="mailto:belmirodavizo@gmail.com">belmirodavizo@gmail.com</a></td>
<td>x</td>
</tr>
</tbody>
</table>
### Beira 21 November 2018

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Telephone</th>
<th>E-mail</th>
<th>gende</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jonito Amade</td>
<td>DPMAIP</td>
<td>865521689/84894713</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staute Janeo Luís</td>
<td>CCP Farol Dondo</td>
<td>821544729/86215198</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silene Bila</td>
<td>IUCN</td>
<td>846035949</td>
<td><a href="mailto:silene.bila@iucn.org">silene.bila@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Jaffer Wakhanganga</td>
<td>IUCN</td>
<td>846035949</td>
<td><a href="mailto:w.jaffer@iucn.org">w.jaffer@iucn.org</a></td>
<td></td>
</tr>
<tr>
<td>Joseph Njie</td>
<td>IUCN</td>
<td>785786361</td>
<td><a href="mailto:joseph.njue@iucn.org">joseph.njue@iucn.org</a></td>
<td></td>
</tr>
<tr>
<td>Pelle Bagersund</td>
<td>IUCN</td>
<td>8247737598</td>
<td><a href="mailto:per.matin.bagersund@iucn.org">per.matin.bagersund@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Feliciano Domingos Jôs</td>
<td>DPMAIP</td>
<td>862154945</td>
<td><a href="mailto:felicianomequejose@gmail.com">felicianomequejose@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Daniel José Bendzane</td>
<td>Sengo</td>
<td>879641449</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eugenio Sigauque</td>
<td>ADEL</td>
<td>840475864</td>
<td><a href="mailto:esigauque14@gmail.com">esigauque14@gmail.com</a></td>
<td></td>
</tr>
<tr>
<td>Ricardo Luis Denco</td>
<td>Sec de Chinamacond</td>
<td>863627621</td>
<td><a href="mailto:richardoluisdenco@gmail.com">richardoluisdenco@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Domingos M. Antônio</td>
<td>SDAE-Dindo</td>
<td>848648642</td>
<td><a href="mailto:dominogomissasse@gmail.com">dominogomissasse@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Jorge Luis Mabingo</td>
<td>DPMAIP-SOFALA</td>
<td>847712636</td>
<td><a href="mailto:jorge.luis.mabingo@gmail.com">jorge.luis.mabingo@gmail.com</a></td>
<td></td>
</tr>
<tr>
<td>Amélia Cumbi</td>
<td>DPTADER Sofala</td>
<td>829121497</td>
<td><a href="mailto:melitachaves012@gmail.com">melitachaves012@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>José Chivamusso</td>
<td>DPMAIP-Sofala</td>
<td>842995432</td>
<td><a href="mailto:jcanidaino2@gmail.com">jcanidaino2@gmail.com</a></td>
<td></td>
</tr>
<tr>
<td>Barnete Caetano Gimo</td>
<td>DPASA Sofala</td>
<td>825857676</td>
<td><a href="mailto:edyjojo@yahoo.com.br">edyjojo@yahoo.com.br</a></td>
<td></td>
</tr>
<tr>
<td>Ephraim Imanirareba</td>
<td>IUCN</td>
<td>078882950</td>
<td><a href="mailto:ephraim.imanirareba@iucn.org">ephraim.imanirareba@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Dr Alain Ndoli</td>
<td>IUCN</td>
<td></td>
<td><a href="mailto:alain.ndoli@iucn.org">alain.ndoli@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Ephraim Imanirareba</td>
<td>IUCN</td>
<td>078882950</td>
<td><a href="mailto:ephraim.imanirareba@iucn.org">ephraim.imanirareba@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Maria Julieta Martinho</td>
<td>IUCN</td>
<td>824770170</td>
<td><a href="mailto:julietamartinho@iucn.org">julietamartinho@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Graça Raquel Chaleco</td>
<td>SDPI-Dondo</td>
<td>845275054</td>
<td><a href="mailto:gracachaleco@gmail.com">gracachaleco@gmail.com</a></td>
<td>x</td>
</tr>
</tbody>
</table>

### Nampula 23 November 2018

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Telephone</th>
<th>E-mail</th>
<th>gende</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celestino João</td>
<td>DPC Turismo</td>
<td>844946446</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inocência Armando Joaquim</td>
<td>DPTADER</td>
<td>846412220</td>
<td><a href="mailto:inocenciajoaquim@gmail.com">inocenciajoaquim@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Ali Omar</td>
<td>INGC NPL</td>
<td>840657669</td>
<td><a href="mailto:aiomarys09@gmail.com">aiomarys09@gmail.com</a></td>
<td></td>
</tr>
<tr>
<td>Benedita Rosa Ricardo</td>
<td>SDPI</td>
<td>842877434</td>
<td><a href="mailto:ricardobeneditarosa@gmail.com">ricardobeneditarosa@gmail.com</a></td>
<td></td>
</tr>
<tr>
<td>Mario José Vacene</td>
<td>DPMAIP</td>
<td>864037718</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paulo Mário Avelino</td>
<td>DPMAIP</td>
<td>865262804</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muireque Variano</td>
<td>DPMAIP</td>
<td>847364744</td>
<td><a href="mailto:vareanomureque@gmail.com">vareanomureque@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Maria Julieta Martinho</td>
<td>IUCN</td>
<td>824778170</td>
<td><a href="mailto:maria.matediane@iucn.org">maria.matediane@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Ephraim Imanirareba</td>
<td>IUCN</td>
<td>0788822950</td>
<td><a href="mailto:ephraim.imanirareba@iucn.org">ephraim.imanirareba@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Pelle Bagersund</td>
<td>IUCN</td>
<td></td>
<td><a href="mailto:per.matin.bagersund@iucn.org">per.matin.bagersund@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Jaffer Wakhanganga</td>
<td>Geopsy Research</td>
<td><a href="mailto:w.jaffer@yahoo.com.br">w.jaffer@yahoo.com.br</a></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Dr Alain Ndoli</td>
<td>IUCN</td>
<td></td>
<td><a href="mailto:alain.ndoli@iucn.org">alain.ndoli@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Name</td>
<td>Organization</td>
<td>Phone</td>
<td>Email</td>
<td>Note</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------</td>
<td>------------------</td>
<td>----------------------</td>
<td>------</td>
</tr>
<tr>
<td>Manuel Menomussunga</td>
<td>IUCN</td>
<td>8249991570</td>
<td><a href="mailto:manuel.menomussanga@iucn.org">manuel.menomussanga@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Roberto L. livia</td>
<td>SDAE memba</td>
<td>841877725</td>
<td><a href="mailto:robertolivra@gmail.com">robertolivra@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Gilberto Aiuba</td>
<td>CCP Angoche</td>
<td>843122805</td>
<td><a href="mailto:gaajamal@gmail.com">gaajamal@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Félix Viegas</td>
<td>DPTADER</td>
<td>844769691</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Rufina Domingos</td>
<td>DPASA</td>
<td>828882830</td>
<td><a href="mailto:rfordo@yahoo.com.br">rfordo@yahoo.com.br</a></td>
<td>x</td>
</tr>
<tr>
<td>Razaque António</td>
<td>Extensao DPMAIP</td>
<td>861631371</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Silene Bila</td>
<td>IUCN</td>
<td>846035949</td>
<td><a href="mailto:silene.bila@iucn.org">silene.bila@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Mahamude Sunate</td>
<td>DPMAIP NPL</td>
<td>850144350</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Zacarias Tair</td>
<td>DPMAIP NPL</td>
<td>847829837</td>
<td><a href="mailto:zacariastaiar@gmail.com">zacariastaiar@gmail.com</a></td>
<td>x</td>
</tr>
<tr>
<td>Joseph Njue</td>
<td>IUCN</td>
<td>0785186361</td>
<td><a href="mailto:joseph.njue@iucn.org">joseph.njue@iucn.org</a></td>
<td>x</td>
</tr>
<tr>
<td>Casimiro Ussene</td>
<td>DPMAIP NPL</td>
<td>846018143</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Jumesy João</td>
<td>AENA</td>
<td>840655902</td>
<td><a href="mailto:jud.vivi@hotmail.com">jud.vivi@hotmail.com</a></td>
<td>x</td>
</tr>
</tbody>
</table>
QUESTIONNAIRES USED

Culture

Community finance

ROAM CRCC: Community financing questionnaire for restoration

District: Inhassoro Name of respondent: Provincial focal point (name?). Date:

1. Are most households in the district able to save money? If so how?
   Yes

2. Are most households in the district able to borrow money? If so how?
   Yes, from friends.

3. In case of household emergencies, food purchase, health issues or paying school fees how to most household find cash resources? (tick all that apply)
   a. Borrow from friend or relative üf
   b. Borrow from microfinance institution or bank
   c. Exploit natural resources (e.g. make charcoal/fishermen) üCharcoal making far from the forest, or going fishing.
   d. Wage labour from other community members
   e. Government cash or food for work programmes
   f. Money lender (ajiota/loan shark)
   g. Community or group savings
   h. Otherselling livestock üf

4. Which is the most commonly used?
   Going fishing or doing trading

5. What proportion of households in the district depend on paid wage labour by neighbours for a sizable portion of their income?
   a. Less that 20%
   b. 20-50%
   c. More than 50%
   Does not know

6. What proportion of households in the district depend on government safety net (e.g. cash or food for work) for a sizable portion of their income?
   a. Less that 20%
   b. 20-50%
   c. More than 50%
   No government safety nets
7. What are the main financial institutions as the village level?
   a. Formal banks – no banks accounts at village level \(\ddot{U}\) No banks at the village level
   b. Microfinance banks
   c. Cooperatives – \(\ddot{U}\) there are no cooperatives but there are fishers associations.
   d. Solidarity groups (e.g. CARE International village savings and loans associations). \(\ddot{V} \text{SLA/PCR}\)
   e. Traditional rotating savings groups \(\ddot{V} \text{e.g. Xitike}\)
   f. Money lenders. there are few but not many
   g. Mpesa/mobile account. \(\ddot{U}\)
   h. Others?

8. Are there any financial institutions at the village level focused on climate? If yes describe.
   \(\checkmark\) PCR working with CCP

9. Are there any financial institutions at the district level focused on soil, land or forest restoration? If yes describe.
   At district there is fund for 7million MT which people (groups and individual) can make projects and apply to borrow funds and pay back. Most people do not actually pay back. This is not specially for poor people and the focus on agriculture, fishponds, livestock, tourism etc. There is some social security for the poorest elderly.

10. What are your recommendations for supporting local financial institutions to provide incentives village level restoration?