FINAL TECHNICAL REPORT

Geographic Information Systems (GIS) consultancy for the Blue Forests Project on the Mangroves of the Zambezi Delta.

Case Study: Chinde District, Province of Zambézia

SUBMITTED BY:

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ABBREVIATIONS AND ACRONYMS

ANAC – National Administration of Conservation Areas

CCP – Community Fisheries Center

DPTADER – Provincial Directorate of Lands, Environment and Rural Development

DIP – Digital Image Processing

DRR – Disaster Risk Reduction

EAME – East African Marine Ecosystem

ES – Ecosystem Services

ESCMC – High School of the Marine and Coastal Sciences

GEF – Global Environment Facility

GIS – Geographical Information System

GPS – Global Positioning System

IDPPE – Institute for Small Scale Fisheries Development

IIP – National Institute of Fisheries Research

IUCN – International Union for Conservation of Nature and Natural Resources

MAE – Ministry of State Administration

MCNR – Management Committee of Natural Resources

NRM – Natural Resources Management

SDAE – District Services of Economic Activities

UEM – Eduardo Mondlane University

UNDP – United Nations Development Programme

WWF – World Wide Fund for Nature

EXECUTIVE SUMMARY

Chinde is a district of the province of Zambézia, with its headquarters in the village of *Chinde*. It has a boundary, to the north with the district of *Mopeia*, to the west with the district of *Marromeu* in the province of Sofala, to the south and southeast with the Indian Ocean and to the northeast with the district of *Inhassunge*. The Chinde District, is a remote region in central Mozambique where the Blue Forests Project is located within the mangrove forests of the Zambezi Delta. The general objective of this study (GIS Consultancy) is to develop a comprehensive GIS database with all available data related to the Blue Forests Project located in Chinde District (Zambézia Province). Overall, in the District of Chinde (province of Zambézia), **2.250 ha** of mangrove forests were deforested over three years between 2010 (34.810 ha) and 2013 (32.560 ha) as a result of the anthropogenic pressure on such coastal forestry resources, where vast areas were established for charcoal production (ovens) with the sale of a charcoal bag for 150.00 mt (meticais). This also results from the strong demand for timber for construction of houses, whose main destination is the City of Quelimane and other villages such as Pambane, Chinde VIllage, Marromeu, Luabo. In Matilde community, the mangrove cutting is to send to Luabo, Marromeu, Quelimane and Micaune. Subsequently, there was a recovery or regeneration of **480 ha** of mangrove forests in the following three years between 2013 (32.560 ha) and 2016 (33.040 ha). Coastal erosion and charcoal production areas (ovens) are the main environmental impacts affecting the District of Chinde, with a lower intensity in terms of pressure on fishery resources, the impact of fishing gear such as beach seine net, longline and a local fishing gear with very fine mesh named *chicocota*; and finally unsustainable agricultural practices such as cassava production as the main crop. The lack of a Mangrove Monitoring and Management Program and fundamentally the implementation of a Reforestation Plan places such coastal forestry resources vulnerable to climatic changes and anthropogenic impacts. A total of 312.4 ha were identified as deforested areas during the field work and interpretation of aerial photos including approximately 294 ha in the proposed Community Conservation Area in the South Bank of the Zambezi Delta and 18.4 ha between Chinde and Nhaimbo community villages.

1. INTRODUCTION

To help the world address the challenges of an economic transition, the United Nations Environment Programme launched the Green Economy series. This effort seeks to pave a new way which will align economic development with the protection or even improvement of the globe's current environmental capital. The world's oceans and coasts – the Blue World – are key components of the planet's environmental capital, and indeed, it's economic capital. The path towards a Green Economy must address the unique challenges that face a global economy which relies critically on coastal and ocean ecosystems (UNEP, et. al; 2012).

Coastal and marine ecosystems, including mangrove forests, seagrass meadows and saltwater marshes, support livelihoods and wellbeing of across the globe. These "*blue forests*" are vital for coastal and island communities through the many services they provide, such as shoreline protection, providing essential habitat for fisheries and supporting marine biodiversity. They are also significant for our global climate by storing and sequestering atmospheric carbon; giving them additional value and significance in the global climate challenge (a concept also termed "*blue carbon*").

Mozambique has the second largest mangrove area in Africa, covering approximately 305.400 ha (Fatoyinbo & Simard, 2013) with the Zambezi river delta representing a large portion of the country's total mangrove area and the second largest continuous mangrove habitats in Africa (Barbosa, et al.; 2001).

World Wide Fund for Nature - Mozambique Country Office (WWF-MCO) is currently implementing a project entitled: "Mozambique Blue Forests Project", which is part of a global initiative funded by Global Environment Facility (GEF) which focus is the application of blue forests methodologies and approaches for valuing carbon and other Ecosystem Services (ES); and in the other hand, the project is managed by GRID-Arendal[1] to implement in Mozambique through WWF Mozambique. The intervention aims at improving the understanding of ES and carbon storage and sequestration for mangrove ecosystems in Mozambique, and to develop improved ecosystem management founded

[1] **GRID-Arendal is a collaborating centre of the United Nations Environment Programme (UNEP). Established in 1989 by the Government of Norway as a Norwegian Foundation, its mission is to communicate environmental information to policy-makers and facilitate environmental decision-making for change. This is achieved by organizing and transforming available environmental data into credible, science-based information products, delivered through innovative communication tools and capacity-building services targeting relevant stakeholders.**

upon that understanding. This small-scale intervention will help meet national priorities in coastal management, especially pertaining to the protection of mangrove ecosystems, and priorities in national climate change policy.

Chinde is a district of the province of Zambézia, with its headquarters in the village of Chinde. It has a boundary, to the north with the district of Mopeia, to the west with the district of Marromeu of the province of Sofala, to the south and southeast with the Indian Ocean and to the northeast with the district of Inhassunge. The Chinde District, is a remote region in central Mozambique where the Blue Forests Project is located within the mangrove forests of the Zambezi Delta.

1.1. OBJECTIVES

The general objective of this study (GIS Consultancy) is to develop a comprehensive GIS database with all available data related to the Blue Forests Project located in *Chinde* District (Zambézia Province) [Figure 2]. Specifically, the study comprised the following objectives:

a) To determine the status (current situation) of mangrove forests, including digital maps (at appropriate scales), information on biophysical and socio-economic issues and priority areas requiring attention;
b) To analyse the qualitative (based on expert opinion) and quantitative (based on data) status of the current situation (baseline);
c) To estabilish key recommendations to improve management of critical areas.

The results of this preliminar work will support basic decision making processes related to Mangrove Management and Planning, engagement with stakeholders and to support the Strategic Planning of the Blue Forests Project about spatial distribution of mangroves forests inside the boundaries of the project scope at the Chinde District (Figure 1).

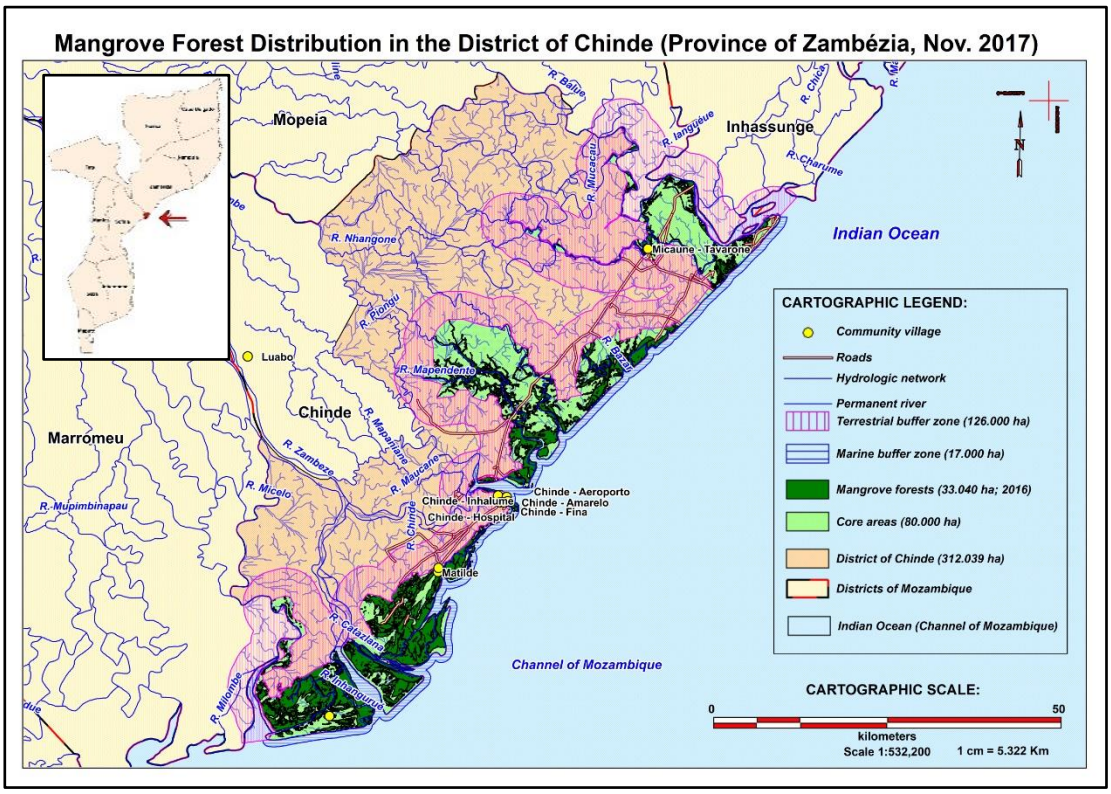


Figure 1: Functional strategic zoning to manage the forest resources in the District of Chinde, Zambézia province). **Cartographic Source:** MapInfo Professional.

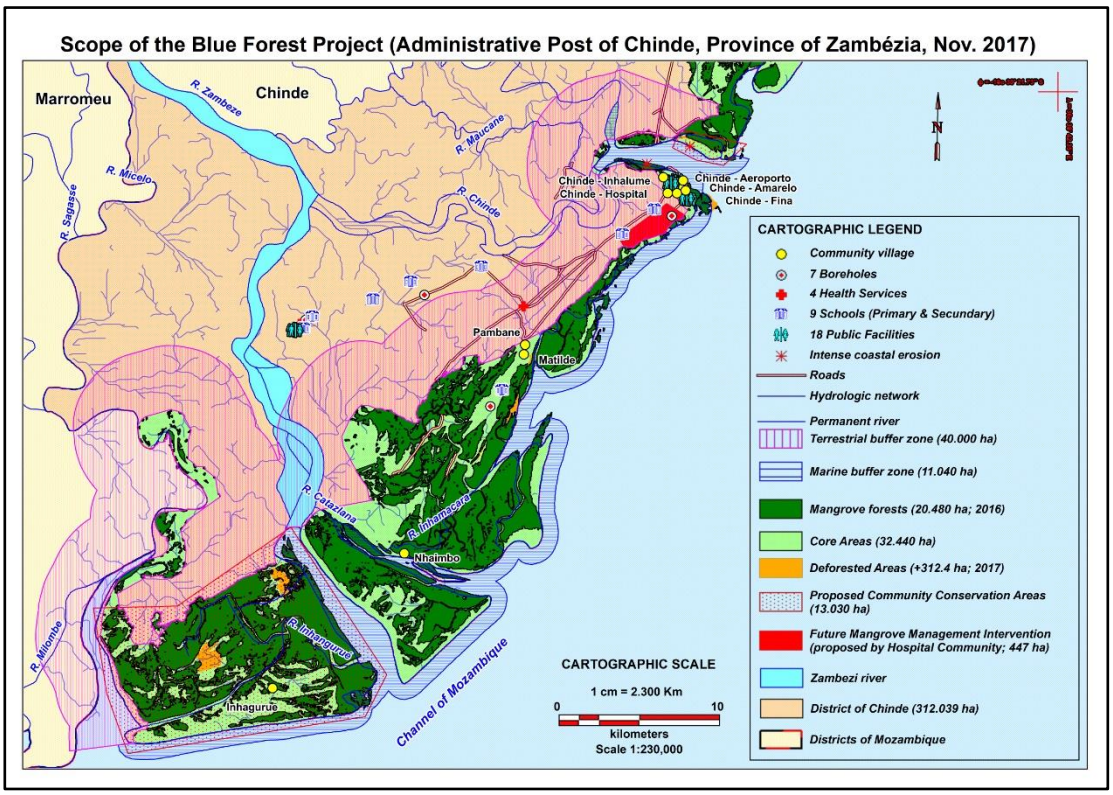


Figure 2: Location of the study area: Blue Forest Project scope (Administrative Post of Chinde, Zambézia province). **Cartographic Source:** MapInfo Professional.

2. BIOPHYSICAL CHARACTERIZATION

2.1. Location, Area and Population

The study area (Chinde District) is located in the heart of the Zambezi Delta, which is one of the most diverse and productive river-delta systems of the world, and the most important wetland on the Indian Ocean coast of Africa. The vast size of the Zambezi Delta and its unique juxtaposition of different landforms, vegetation types, and water bodies gives rise to immense biodiversity value, including Southern Zanzibar-Inhambane Coastal Forest Mosaic (associated with widely scattered wetland pans), diverse flooded grassland, woodland, and deep-water swamp communities of the Zambezi Delta plain (Zambezian Coastal Flooded Savanna ecoregion), and extensive coastal mangroves of the East African Mangrove ecoregion (all critically threatened ecoregions and global biodiversity conservation hotspots). The Zambezi Delta features diverse and abundant large mammal populations and the largest concentration of waterbirds in Mozambique. In addition to its rich biodiversity values, the Zambezi Deltas sustains a wealth of ecosystem services that are vital to food security and socio-economic development for more than 300,000 people that live in the region (Beilfuss et al. 2011).

The surface of the district[2] is 4.250 km^2 and its population is estimated at 130.000 inhabitants as of July 1st 2012. With a population density of approximately 30.5 inhab/km^2, the district is expected to reach 144.000 inhabitants by 2020.

The age structure of the district reflects an economic dependency ratio of 1:1, i.e for every 10 children or elderly there are 10 people of working age. With a young population (46%, below 15 years), it has a Masculinity Index of 92% (for each 100 female there are 92 male) and a district urbanization rate is 18%, concentrated in the Villages of Chinde and Luabo and peripheral areas of semi-urban matrix (MAE, 2014).

2.2. Climate and Hydrography

Two climatic seasons can be differentiated, based on temperature and precipitation - a rainy summer during which the climate is sub-humid and very hot and a dry winter in which the climate is semi-arid and hot - separated by a short transitional period.

[2] **Centro Nacional de Cartografia e Teledetecção http://www.cenacarta.com**

The region is limited by the annual average precipitation isohyet[3] of 1.200 mm. The duration of the rainy season varies according to the distance to the sea lasting about 6-7 months. In general, the rainy season begins abruptly in mid-November and lasts until April, sometimes until early May near coast, and decreases to 4-5 months as it moves inland and away from the sea, from November to the end of March/beginning of April.

Temperatures in the region along the delta and coastal strip are high, with the mean annual temperature around 25 °C to 26 °C and the average temperatures of the hottest months and those of the cooler, 27 °C - 28 °C and 20°C - 22 °C respectively. The mean maximum temperature varies between 34 °C and 36 °C during the warmer months with an average annual amplitude of 7.2 °C (27.7 °C in February and 20.5 °C in July). The annual average relative humidity is 75.4%, with the highest monthly average value of 81.0% in July and near the sea and the lowest of 68% in October, with the period from November to April considered as the most humid. Potential Evapotranspiration (PET)[4] values obtained using the Pennman formula indicate that this climatic element in the study region is 1.538 mm.

The climate of the region according to the *Thornthwaite* classification is of type C1 (dry sub-humid) transition between climates of the semi-arid type to that of the humid climates (MAE, 2014). The district's hydrographic network consists of twelve internal rivers (Figures 3 & 4) that originate from the great Zambezi river that runs through the District. The Zambezi river bathes with its waters, tributaries and its arms large extensions of the District, creating vast wetlands. The most important rivers and tributaries are: *Maria*, *N'seu*, *Chinde*, *Nhangulue*, *Chire*, *Namiara*, *Nahombe*, *Nhacatiua*, *Rimba*, *Pioncue*, *Mapangane* and *Lunguse* (DPTADER, 2016).

[3] **A line on a map or chart connecting areas of equal rainfall.**

[4] **Potential Evaporation or Potential Evapotranspiration (PET) is defined as the amount of evaporation that would occur if a sufficient water source were available.**

Figure 3: Spatial distribution pattern of the fluvial drainage network at Chinde Administrative Post. **Cartographic Source:** Global Mapper.

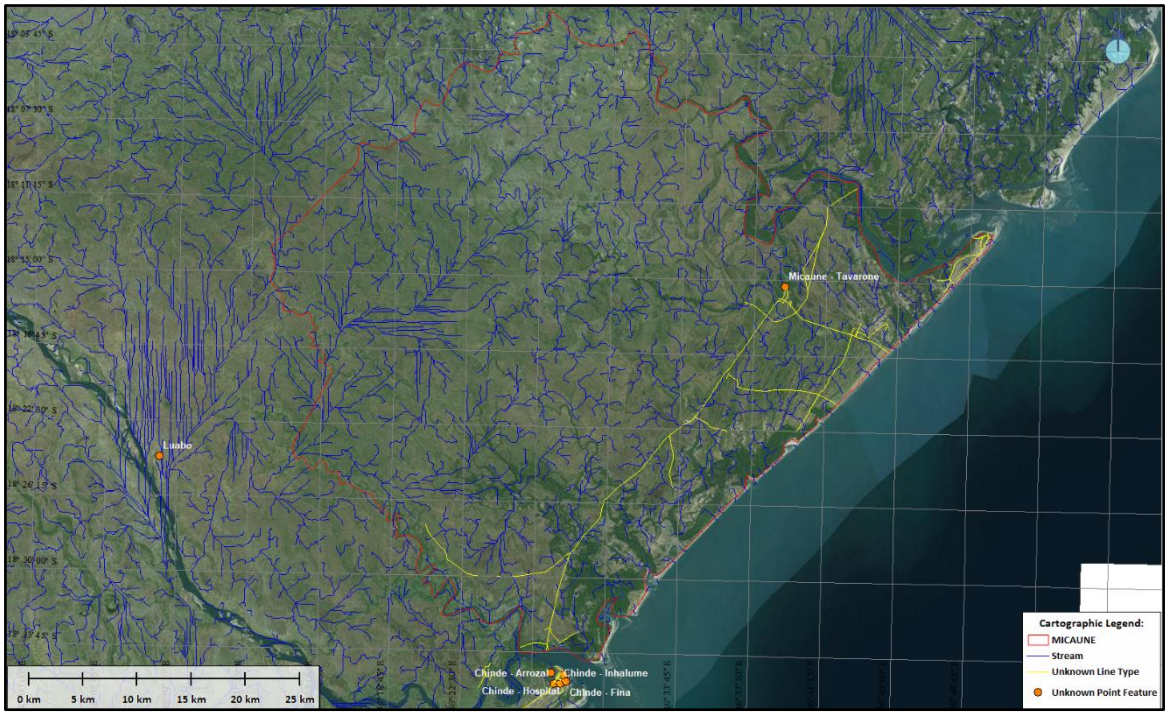


Figure 4: Spatial distribution pattern of the fluvial drainage network at Micaune Administrative Post. **Cartographic Source:** Global Mapper.

2.3. Geology and Geomorphology

The district is part of an important ecological and socio-economic region of the Zambezi river delta, more precisely the Lower Zambezi. The region is characterized by an extensive flood plain of the Zambezi river and its tributaries (Figures 3 & 4), and wetland systems are formed by alluvial plains of the rivers, extensive marshes, grasslands and hydromorphic depressions.

The Zambezi delta region begins in Mopeia approximately 120 km off the coast, and consists of the whole plain bounded by the Cuacuá River, a Zambezi channel, whose course drains at Quelimane on the Bons Sinais river, and the Zambezi itself whose course travels southeast towards the coast. It should be noted that one of the peculiarities of Chinde district is the complex and dense hydrographic network formed by numerous streams and river banks along the dense forest formations of mangrove, unique throughout the Zambezi Basin.

The Lower Zambezi region is part of the Urema System, considered to be an extension of the Rift Valley, formed by alluvial deposits on a stretch of coast between Beira and Quelimane, with about 200 km of coast, and to the confluence of the Chire more upstream of the Zambezi River.

The entire district occurs in a single geological formation of the Quaternary (recent formations), denominated by Deltaica Quaternary Plain, being the differentiation based on the degree of flood due not only to surface runoff and local drainage pattern, but also to the influence of the tides and the flooding caused by the Zambezi rivers and their tributaries.

In some areas, delta deposits of fine materials have been covered and separated on a series of fine sand beaches. There are also clayey materials associated with the flattening surfaces of the tops, partially related to terraces resulting from marine abrasion processes; sand-clay materials of fluvial origin, later covered by others of recent eolian origin and alluvial, and those clayey of fluvial-marine origin. Sand residual areas are linear dunes parallel to the current coastline, which is also very dynamic, as evidenced by the existence of more recent dunes cutting linear dunes. In the delta area there are old beach lines. Three large physiographic units are distinguished in the deltaic plain, namely: (i) the coastal plain (tidal influence area associated with mangrove occupancy); (ii) the floodplain (of hydromorphic features) seasonally flooded; and (iii) the system of raised terraces.

Most of the Zambezi Coastal and Deltaic Plain and the southern region is geologically characterized by the predominance of alluvial formations of the quaternary and recent pleistocenic sediments, commonly known as wetlands system due to the great dynamics of marine, estuarine and rainfall subsystems that determine the diversity of the material of superficial sedimentation and formation of the soils.

Morphologically, it is an extensive deltaic and coastal plain with altitudes between 5 - 20 m (Figures 5 & 6), flat relief to moderately corrugated with some convex-concave areas. In the zone of high beaches, fine dune sands dominate the dunes with microondulated relief of parallel dunes, while the smaller spots are represented by the coastlines and residual terraces of the pleistocene forming islands in the deltaic plain and slightly elevated pre-estuarine dunes. In the halomorphic zone, characteristics of the mangrove vegetation, predominate very juvenile and therefore undeveloped soils, remaining the original materials in the same conditions in which they were deposited, without occurring any pedogenetic processes (soil formation) on them. This is because much of the deposited material is saturated with water, whose level is strongly influenced by the alternation of the tides.

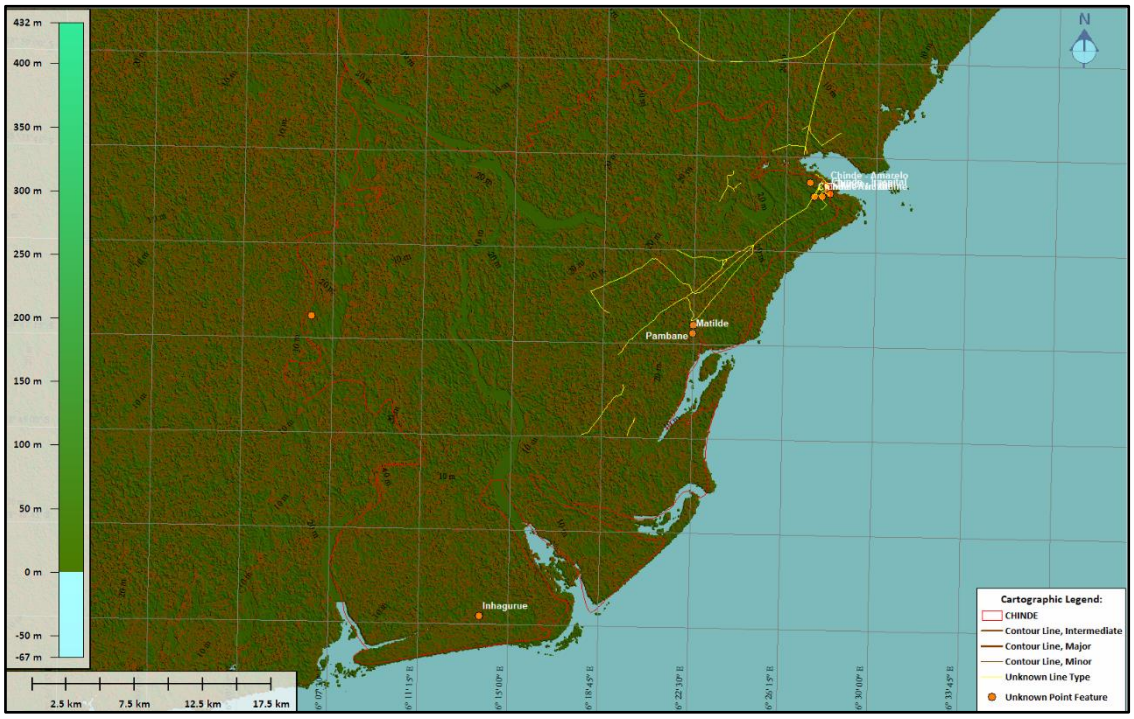


Figure 5: Digital Elevation Model (DEM) and hypsometry of Administrative Post of Chinde. **Cartographic Source:** Global Mapper, ASTER GDEM v2 Worldwide Elevation Data (1 arc-second resolution).

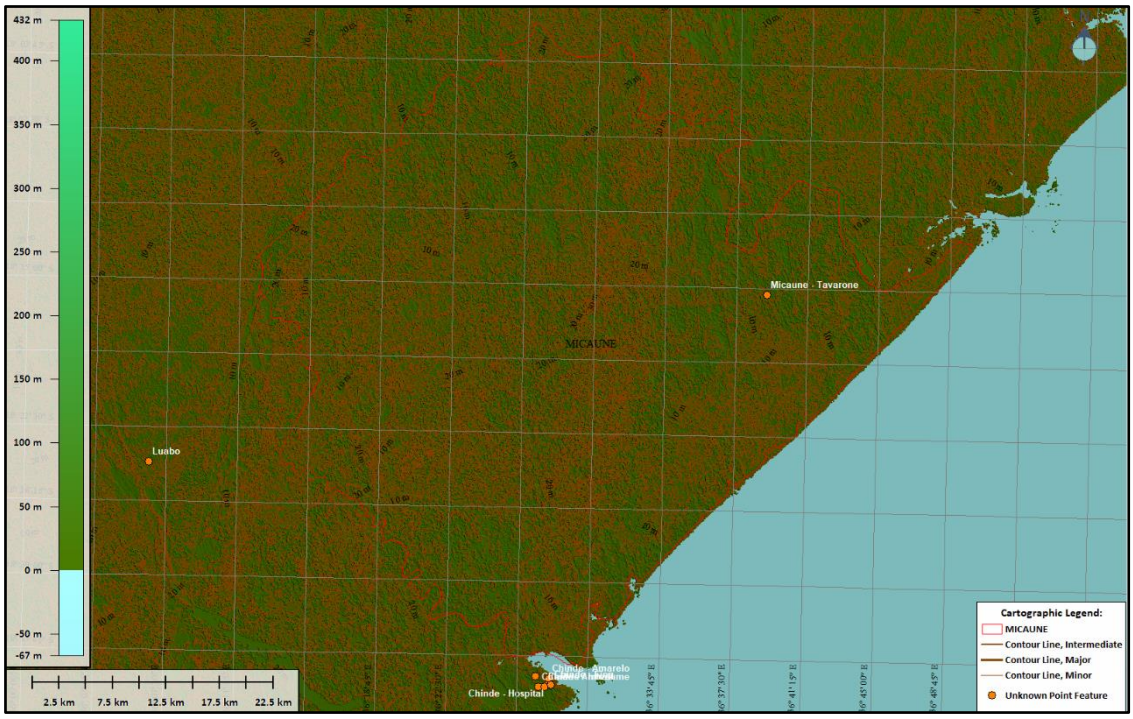


Figure 6: Digital Elevation Model (DEM) and hypsometry of Administrative Post of Micaune. **Cartographic Source:** Global Mapper, ASTER GDEM v2 Worldwide Elevation Data (1 arc-second resolution).

2.4. Soil and Vegetation

The region is characterized by alluvial valleys and mangrove swamps with dense mangrove vegetation and soil reach in clay. The Zambezi riverbed is made up of fine sand and mud, moving downstream and forming unstable banks and islands (MICOA, 1998 in WWF, 2017). From the coast towards inland, the soil is structured as follows: (a) clayey soils of alluvial deposits; (b) sand soils of mananga combined with yellowish sand soils in the interior dunes; (c) sand soils combined with hydromorphic soils; and (d) grey soils from sedimentary limestones. Along the river banks, there are sand sediments of alluvial deposits. And near the ocean there is a combination of marine and alluvial sands, being the clayey soils of estuary origin the dominant sediments, followed by alluvial clayey.

The vegetation is predominantly flooded savannah woodland. It comprises a combination of open grassland, woodlands, mangroves and freshwater swamp vegetation (Beilfuss, et al. 2000; Beilfuss and Brown, 2006; World Bank 2010 in WWF, 2017). The coastal zone is characterized by coastal dune vegetation.

The savannah woodlands are dominated by Acacia, palms and semi-deciduous forest combined with miombo forest, with *Julbernardia globiflora* and *Androstachys johnsonii* tree species (Wild e Barbosa, 1967 in WWF, 2017). Grasslands include swamp mosaics with areas of phragmites and papyrus. The coastal dunes consist of thickets and woodlands on sandy ridges, with pockets of coconut groves (Beilfuss, et al. 2000 in WWF, 2017). Along the river and tidal creeks there is dense mangrove vegetation.

According to Smith (1992) and Moll and Werger (1978) the distribution and composition of mangroves are dynamic and directly related to geomorphological changes occurring as a function of coastal erosion and sedimentation processes. The mangrove forest of the Zambezi delta, according to Shapiro et al. (2015), is composed by the eight species found in Mozambique as follows: *Avicennia marina*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Heritiera littoralis*, *Lumnitzera racemosa*, *Rhizophora mucronata*, *Sonneratia alba* and *Xylocarpus granatum*.

2.5. Wildlife

According to Bento and Beilfuss (2003) the wildlife includes large mammals, such as reedbuck and migrating eland; carnivores such as lion (*Panthera leo*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), spotted hyena (*Crocuta crocuta*) and side-striped jackal (*Canis adustus*). There are migratory waterbirds including pintails, garganey, African openbill (*Anastomus lamelligerus*), saddle-billed stork (*Ephippiorhynchus senegalensis*), wattled crane (*Bugeranus carunculatus*), and great white pelican (*Pelecanus onocrotalus*). Reptiles include Nile crocodile (*Crocodylus niloticus*), Nile monitor lizard (*Varanus niloticus*) and African rock python (*Python sebae*), the endemic Pungwe worm snake (*Leptotyphlops pungwensis*) and three other snakes that are nearly endemic; floodplain water snake (*Lycodonomorphus whytei obscuriventris*), dwarf wolf snake (*Lycophidion nanus*) and eyebrow viper (*Proatheris*) and several endemic butterflies (WWF, 2017).

3. SOCIO-ECONOMIC CHARACTERIZATION

3.1. Demography

It is estimated that there is about 188.206 people, of which 95.211 are women, representing a proportion of about 50.5%, living in the delta and gaining their livelihood out of the resources in the delta, or related activities. This population of the delta is mainly distributed in the Districts of Marromeu, in Sofala Province and Chinde, in Zambézia Province (WWF, 2017).

The population is predominantly rural at a figure corresponding to 86.9% (INE, 2007). The most prominent age group is the economically active population (15-64 years), which corresponds to 53.2% and the least salient is the elderly population (over 65 years old) of 2.4% of the population of the District. The economic dependency ratio is 46.8%, corresponding to the percentage of the population aged 0-14 and 65 and over the total population of the District (INE, 2007 in DPTADER, 2016).

Infant mortality indicators point to levels of 182.9 per thousand live births, 191.1 for boys and 174.4 for girls per thousand. The post-infant mortality is 152.2 per thousand, which concludes that the level of infant and post-infant mortality, ie in childhood (0-5 years), is 306.2 per thousand live births (INE, 2007). The average number of households is four (4) persons, 3.6 in the rural area and 3.9 in the urban area. Life expectancy is 35 years, 34.5 for men and 36.4 for women, and the masculinity rate is 94, or for each group of 100 women there are 94 men. A large part of the labor force is linked to the agricultural sector, which absorbs around 76% of the labor force (INE, 2007).

Table 1: Geographical positions of the visited villages during the fieldwork (Oct., 2017).

Nr.	Village	Geographical Coordinates	
		Latitude Sul (-φ)	**Longitude Este (λ)**
1	Chinde – Aeroporto	φ_1 = -18º 34’ 46.56’’ S	λ_1 = 36º 27’ 15.88’’ E
2	Chinde – Hospital	φ_2 = -18º 35’ 06.44’’ S	λ_2 = 36º 27’ 58.72’’ E
3	Chinde – Amarelo	φ_3 = -18º 34’ 52.56’’ S	λ_3 = 36º 27’ 57.84’’ E
4	Chinde – Arrozal	φ_4 = -18º 35’ 18.48’’ S	λ_4 = 36º 27’ 25.92’’ E
5	Chinde – Fina	φ_5 = -18º 35’ 12.48’’ S	λ_5 = 36º 28’ 04.01’’ E
6	Matilde	φ_6 = - 18º 40’ 49.44’’ S	λ_6 = 36º 22’ 27.84’’ E
7	Pambane	φ_7 = - 18º 40’ 30.00’’ S	λ_7 = 36º 22’ 30.00’’ E

Figure 7: Human settlements and neighborhoods of the Chinde headquarter. **Cartographic Source:** Global Mapper.

3.2. Agricultural Resources

The district of Chinde has enormous potential for the development of the agrarian sector due to the privilege of possessing enormous amounts of water resources mainly of the Zambezi river and its tributaries, irrigable arable land and forest and fauna resources, with emphasis on the reserve of Maimba. Most of the population of the District lives mainly in the rural area and their survival depends on agriculture. Agricultural production depends on sustainable land management and rainfall, as well as tidal influence of rivers and the technical aspects that are disseminated to communities through an interaction between agricultural technicians and producers.

Of the 44.286 ha planned for various food crops for the crop year 2016, 44.877 ha were planted and sown, which represented a 100% increase, representing a growth of 15% when compared to the area under cultivation (38.964 ha) in the campaign agricultural sector. Despite drought losses due to drought, this growth was due to the increasing population and rise of areas explored by family in addition to the opening of new fields of sweet potato and cassava (Figure 48) production as alternatives to losses of cereal crops due to the dry season.

Regarding production, the District planned to produce 175.171 tons of miscellaneous products by the end of the fourth quarter of the 2015/2016 crop year, producing 92.186 tons, representing an execution of 53%. The low run was due to the scarcity of rain that was felt throughout the campaign. From the beginning of the Agricultural Campaign 2015-2016 up to the present time, damages caused by the scarcity of rain in the order of 10.678 ha of diverse crops (rice, maize, millet, sesame and cassava) and affecting 8.897 producers.

The District has two main irrigation systems (Sombo and Chacuma), with a total of 1.200 ha potentially irrigable. However, due to their high state of degradation they are paralyzed despite the existence of some producers to reuse the areas (DPTADER, 2016).

3.3. Industry and Commerce

The industrial network during the period of 2015 – 2016 did not grow. There were waxing of 2 milling industries due to lack of raw material (rice and corn). Regarding the commercial network, the District currently has a total of three conventional markets and 248 fixed banks. Compared to the same period of last year there was an increase in the order of 50% and 7.6% respectively.

3.4. Livestock

According to the list of livestock, 825 cattle, 6.505 goats, 55 sheep, 525 pigs and 41.035 were registered, corresponding to an overall execution of 94.8%.

3.5.Fisheries

The Zambezi delta is located in the central Sofala bank, the major fisheries ground of Mozambique. The major fisheries comprise shrimp, small pelagic and demersal fish species. According to Brinca and Palha de Sousa (1984) the main shrimp species are of Penaeidae family (Figure 46), being *Penaeus indicus* and *Metapenaeus monoceros* the most abundant species (Saetre e Paula e Silva, 1990). These are shallow water shrimp captured in depths less than 25 m, hence in coastal waters. Further, they spend the larval up to juvenile stage in estuaries and mangrove creeks. In the mangrove creeks there are crabs of specie *Scylla serrata* (Piatek, 1981).

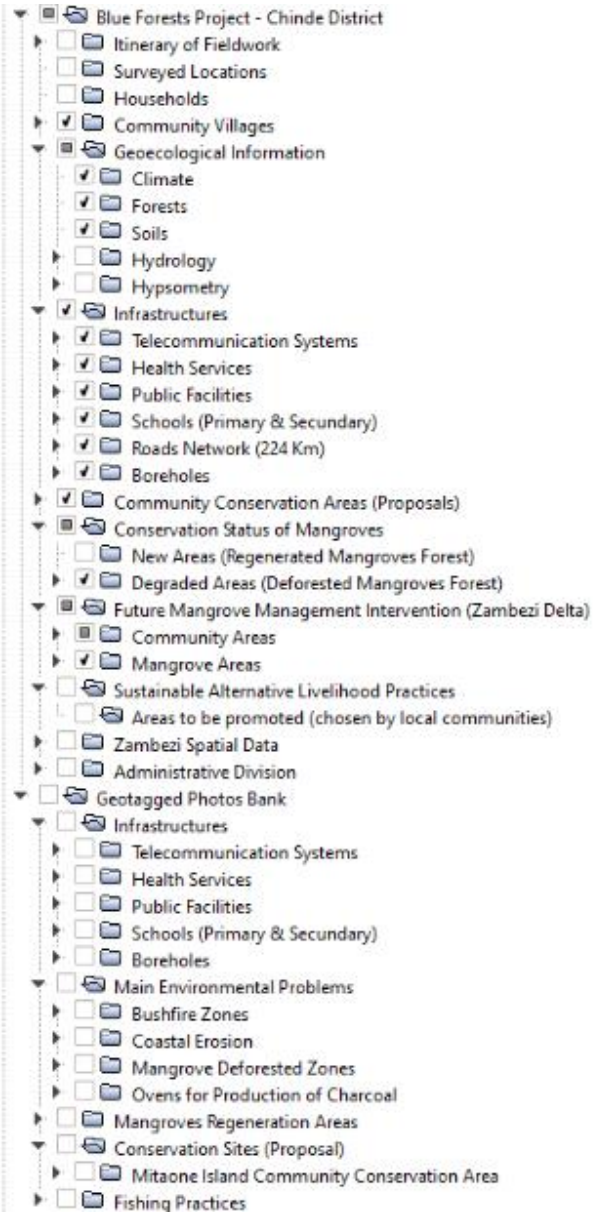
The small pelagic fish species include the scads and mackerel, where the main species are *Decapterus russelli* and *Rastrelliger kanagurta* (Brinca et al, 1983), captured in 20 to 90 m depths, sometimes entering the estuaries and mangrove creeks; the anchovy, with the main species *S.*

punctifer and *S. heterolobus* and sardines with the main species *Pellona ditchela* and *Thryssa vitrirostris*; the magumba also known as malola, *Hilsa kelee*, and as patanas, *Leiognathus equulus* and *Secutor insidiator*; xaréu malabárico, *Carangoides malabaricus*, and *Ariomma indica*. The demersal fish species includes the species of Lutjanidae family, *Lutjanus bohar*, *L. sanguineus* e *L. gibbus*. The large pelagic fishes include *Scomberomorus commerson* (Saetre and Paula e Silva, 1979) [WWF, 2017].

According to statistical data from the National Census of Artisanal Fisheries held in August 2012, the District has 2.183 fishermen, with 980 fishing gear and 850 vessels used for fishing in 22 fishing centers, 12 of which are in shore waters and 10 inland waters. However, fishing is more practiced with rowing boats and has recently been practiced by some fishermen with motor power.

4. RESULTS & DISCUSSIONS

The geodatabase was designed as a native data structure for a GIS Mapping Project, which is the primary data format used for editing and data management. While a GIS software works with geographic information in numerous GIS file formats, it is designed to work with and leverage the capabilities of the geodatabase. It is the physical store of geographic information, primarily using a Database Management System (DBMS) or file system. GIS users can access and work with this physical instance of a collection of datasets of mangroves forests either through a GIS software or through a database management system using SQL. Geodatabases have a comprehensive information model for representing and managing geographic information. This comprehensive information model is implemented as a series of tables holding feature classes, raster datasets, and attributes as follow.



4.1. Priority areas requiring attention

The main areas that require special attention to be prioritized for a correct rehabilitation and management are the following:

4.1.1. Areas affected by coastal erosion

There have been reports of slow but chronic erosion in the delta of Zambezi. The village of Chinde in the northern end of the Delta is one of the most affected areas. According to Ronco et al. (2010) in WWF (2017), reasons of this persistent erosion are not yet well known, but environmentalists suspect to be the consequence of the reduction of runoff due to the upstream regulation of the Zambezi River. In fact there are two major dams constructed for production of electricity: the *Cahora Bassa* dam, in Mozambique and the *Kariba* dam, in Zimbabwe, beside several smaller dams and dikes built to trap water for irrigation, spread along the Zambezi river basin.

The sediment budget in the estuaries is mostly dependent on the input of sediments from the river and from the adjacent seas, and the sediment dynamics is governed by the river runoff and tidal currents. Under normal natural conditions a steady state balance should prevail. This means that there should be no net sediment fluxes in a given portion of the estuary if averaged throughout relatively long periods. However, when the sediment input from the river is reduced, persistent erosion in the delta may occur (Roco et al. 2010 in WWF, 2017). The consequences on the coastal ecosystems and infrastructures can be enormous. The Chinde Village, an historical village that used to be an important center of trade between the highland communities (Zimbabwe, Zambia, Malawi up to Zaire) and the Asians before Europeans, is eroding (Figures 26 & 27).

Shoreline changes induced by erosion are natural processes that take place over a range of time scales. They may occur in response to smaller-scale (short-term) events, such as storms, regular wave action, tides and winds, or in response to other large-scale (long-term) events.

The case of the sandy shoreline of Amarelo community (Chinde) was eroded around 1 Km the last 13 years, losing 10 ha of land. Local old resident households explained that a long time ago, maybe 15 years or more, there were houses that were usurped by the sea. There is concern by the Chinde district government regarding severely affected families living within a few meters of the impact zone of the coastal erosion (Figures 8 & 9).

Figure 8: Future Coastal Zone Management Intervention. Figure shows old physiographic configuration of the coastal zone in 2004 (Chinde - Amarelo Community). **Cartographic Source:** Google Earth Pro.

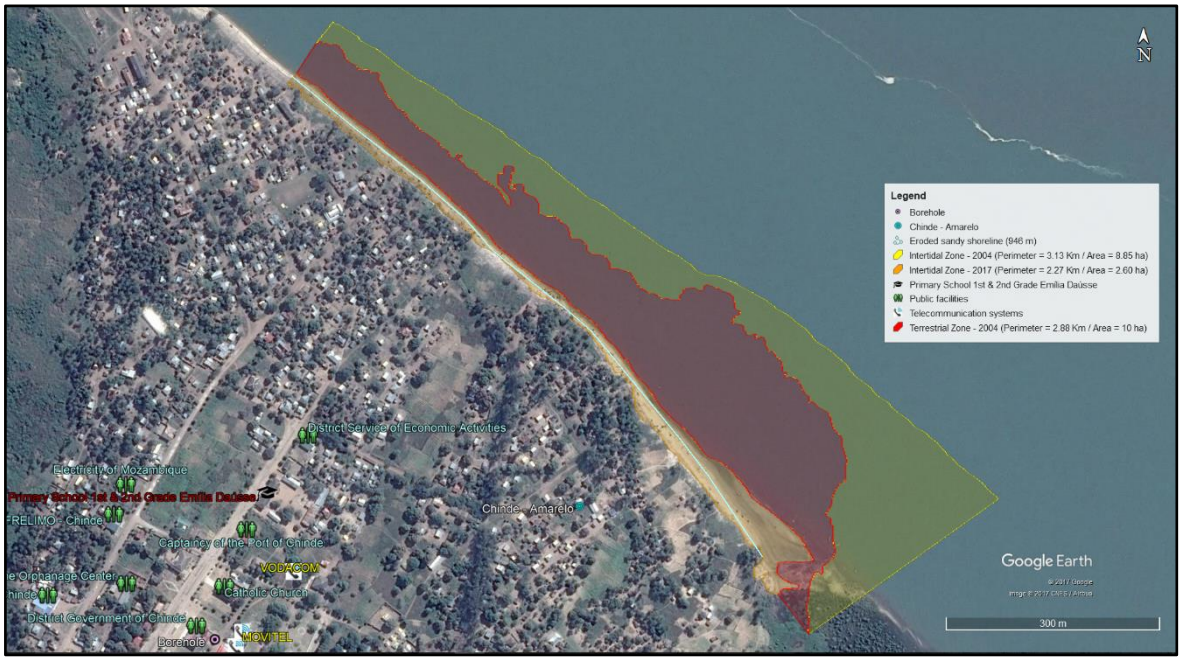


Figure 9: Future Coastal Zone Management Intervention: Current physiographic configuration of the coastal zone in 2017, losing 10 ha of land along 13 years due to the impact of the coastal erosion. **Cartographic Source:** Google Earth Pro.

4.1.2. Areas affected by deforestation

In the present study, deforested areas were identified in two ways: the first one was through interpretation of aerial photos in Google Earth Pro (more than 294 ha) in the proposed Community Conservation Area in the South Bank of the Zambezi Delta, and the second was, as shown in the figure below, between Chinde and Nhaimbo (18.4 ha), observing that the community villages of Pambane, Matilde and Nhaimbo have left important anthropogenic impacts in their peripheral mangrove forest.

Figure 10: An example of deforested areas (18.4 ha surveyed areas during the fieldwork and 294 ha by aerial photography interpretation). **Cartographic Source:** Google Earth Pro.

4.1.3. Areas designated by local community for reforestation

With the establishment of a proposed mangrove management system and sustainable exploitation of mangrove tree products such that sustainable harvesting, it will be strong recommended 13 trees per hectare per month for fuelwood and charcoal production in Bairro Amarelo in Chinde Sede and Pambane. Such exploitation is recommended to a household per hectare and controlled by the Community Mangrove Management Committees (Figure 11).

In muddy coastal environments or within the tidal zones of estuaries, mangrove forest and other indigenous shrub species are commonly found. Most erosion in these zones is attributable to the removal of the mangroves and other trees. To overcome this problem, replanting is necessary because these trees can regenerate and serve as coastal defence structures.

Planting vegetation species relative to their correct elevation in mudflat environments is important. At low- and subtidal deltas below the high water mark, saltmarsh species are recommended. Saltmarshes are typically zoned according to elevation, the zones being controlled by the frequency and duration of tidal inundation. Within this area, mangroves are also recommended and can be planted easily. If the area already has a serious erosion problem, then special seeding techniques are needed.

A combination of species is suggested to reduce pest damage; however, the choice should be well planned in order to avoid competition. The mangrove forest should have a minimal width of 300 m, densities of at least 0.5 metre and be planted in staggered alignment. Numerical studies show that mangrove forest and other coastal vegetation of certain density can reduce wave height considerably and protect the coast from erosion, as well as effectively prevent coastal sand movement during strong winds. Healthy coastal forests such as mangroves and saltmarshes can serve as a coastal defence system where they grow in equilibrium with erosion and accretion processes generated by waves, winds and other natural actions (Figure 12).

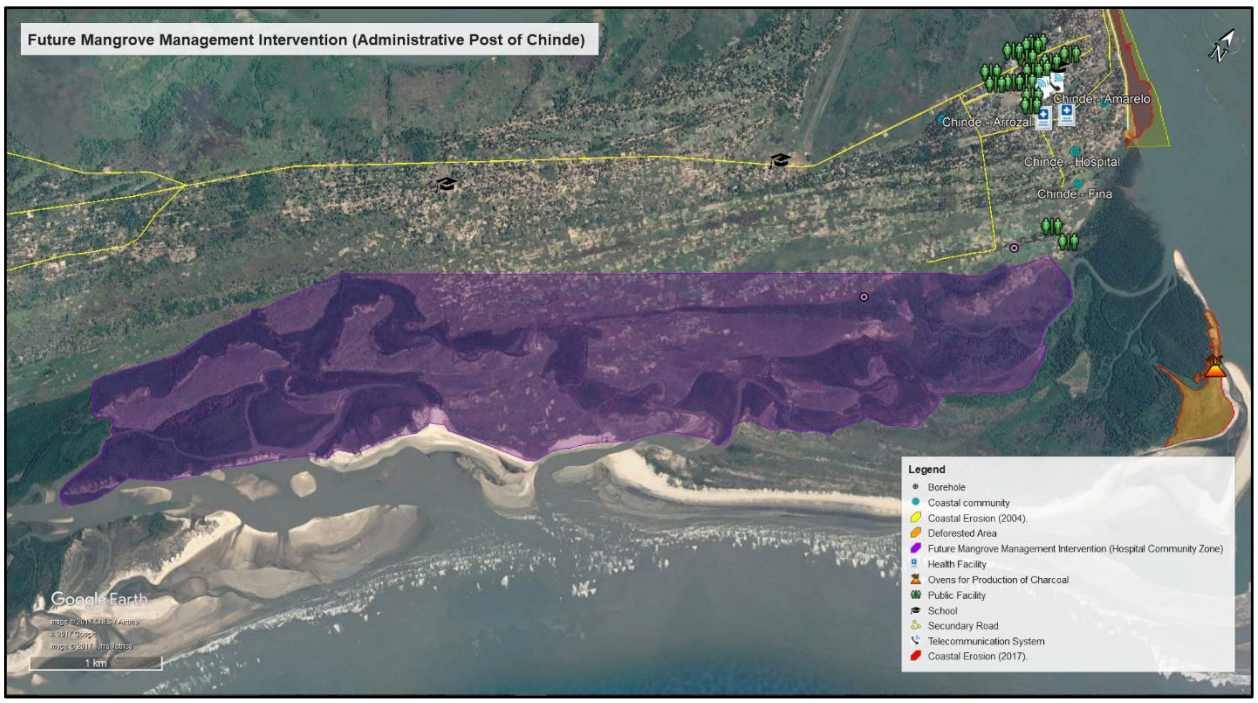


Figure 11: Coastal revegetation proposal zone in a muddy coastline environment (tidal zones of estuaries) linked to the Future Mangrove Management Intervention Program at the Hospital Community. **Cartographic Source:** Google Earth Pro.

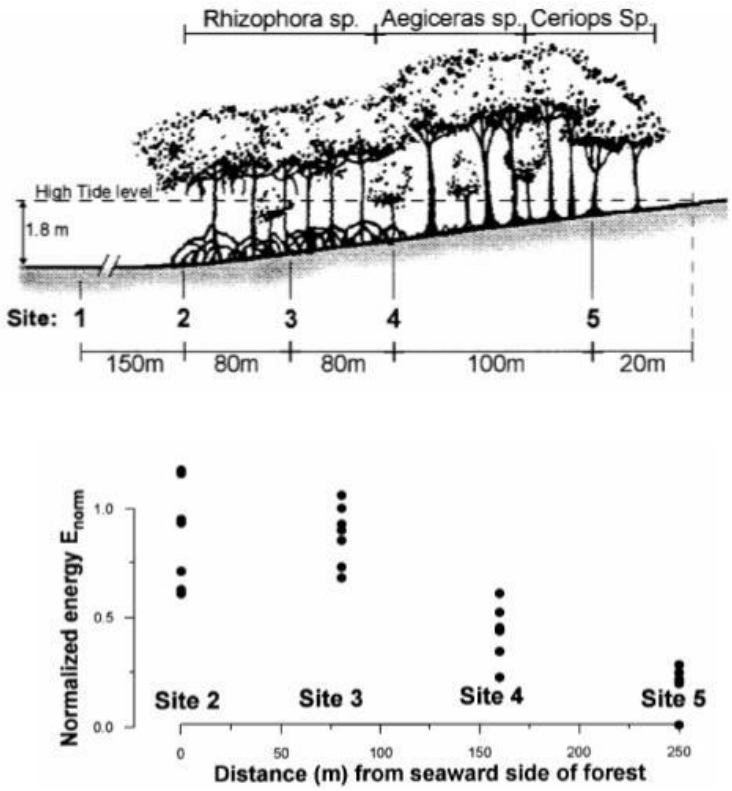


Figure 12: Wave attenuation by mangrove forest (*Rhizophora* sp., *Aegiceras* sp., *Ceriops* sp.) at Cocoa Creek, Australia is obvious; measurements at sites 2–5 show the decline in wave energy transmission through the mangrove forest. The incoming wave was measured at site 1 (Massel et al., 1999). **Website:** http://www.fao.org/docrep/010/ag127e/AG127E09.htm

4.1.4.- Proposed areas for protection and conservation

It is highly recommended to propose a deep study to **Mitaone Island** and especially the **South Bank of the Zambeze River Delta** as a protected areas with management category of Community Conservation Area based on the Conservation Law # 16/2014 (Figure 13). These pristine mangrove areas have high natural potentialities, forest resources well preserved, and amazing scenic landscapes. They are being threatened by mangrove cutting to build houses (Figures 42 & 43): Mitaone Island and the South Bank of the Zambeze River Delta had been loosing more than 12.05 ha and 354 ha respectively deforested (Figures 14 & 15).

The Mozambican Conservation Law also addresses some aspects of interest in Article 22, which defines the Community Conservation Area Management Category as "*a conservation area for sustainable use of the delimited community public domain under the management of one or more local communities, where they have the right to use and improvement of land, for the conservation of fauna and flora and the sustainable use of natural resources*". The same Article mentions other main characteristics that define it as a Community Conservation Area:

1) The Community Conservation Area aims at achieving the following objectives:
   a) To protect and conserve existing natural resources in the area of customary community use, which includes conserving natural resources, sacred forests and other sites of historical, religious, spiritual and cultural use to the community;
   b) To ensure the sustainable management of natural resources in a way that results in local sustainable development;
   c) To ensure access and durability of plants for medicinal use and biological diversity in general.

2) Licensing for the exercise of activities of exploitation of resources to third parties can only be done with prior consent of the communities, after a process of auscultation, which culminates in the conclusion of a partnership agreement;

3) The management of natural resources in the Community Conservation Area is done according to the usual rules and practices of the respective resident communities, but without prejudice to compliance with national legislation.

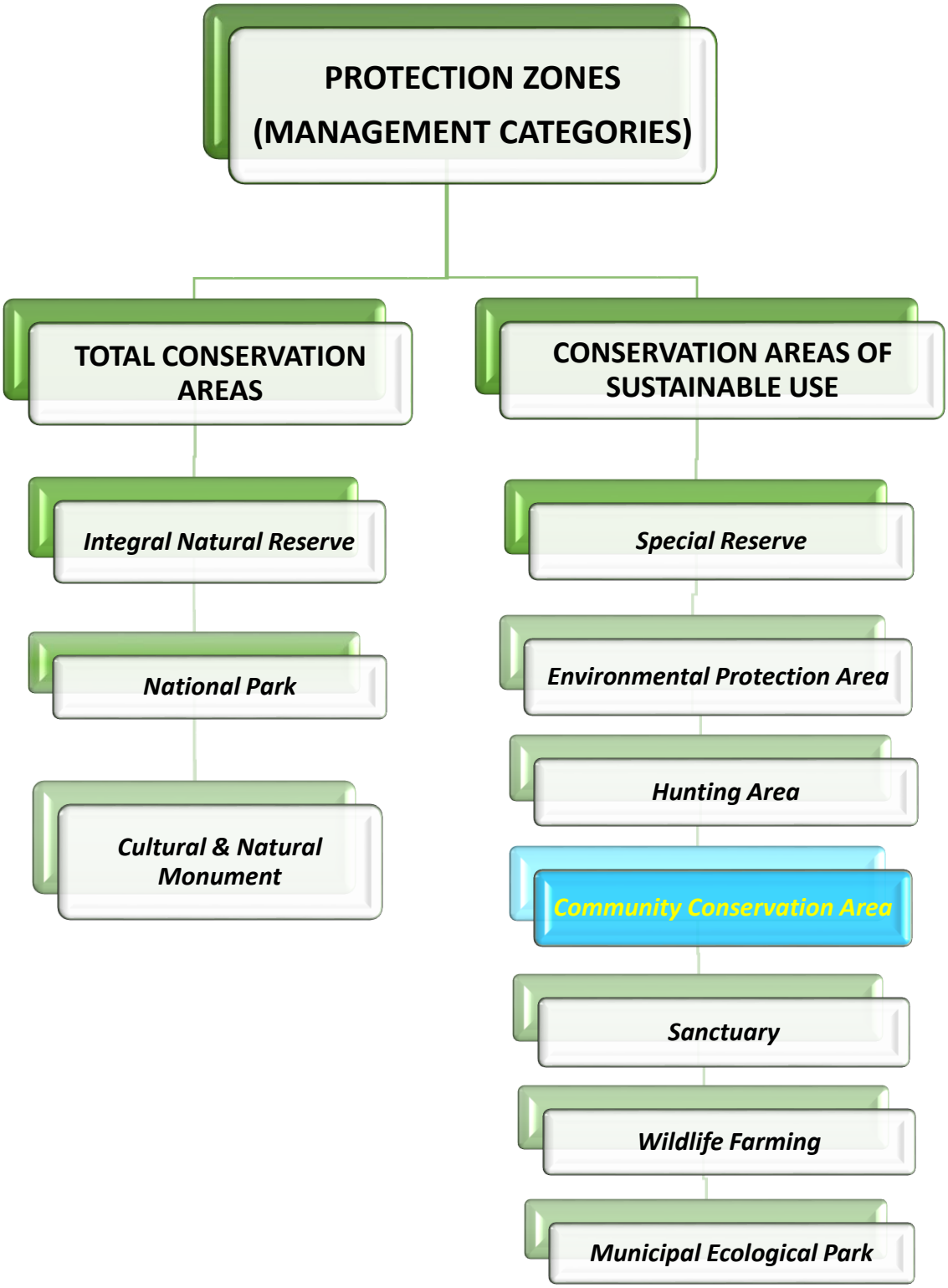


Figure 13: Classification of Protection Zones and Categories of Management of Conservation Areas of Mozambique. The Community Conservation Area Category will be analyzed and proposed for strategic conservation zones of mangroves in pristine conditions. **Source:** Conservation Law # 16/2014.

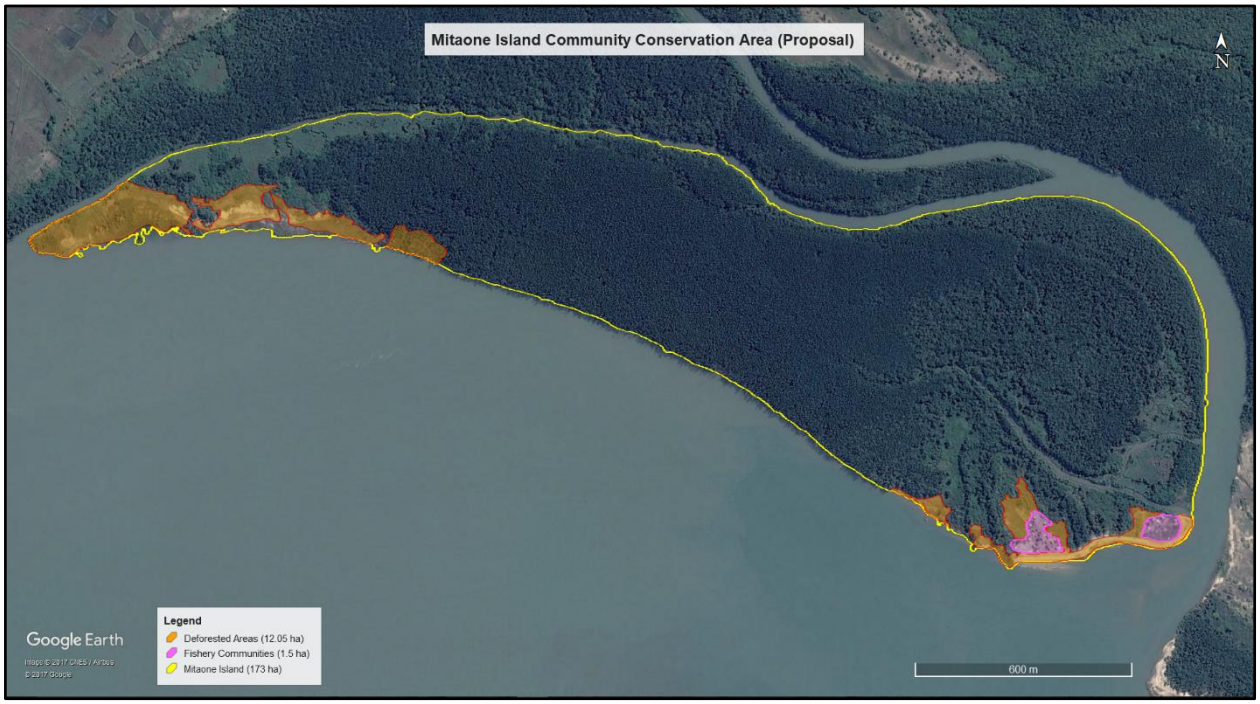


Figure 14: Mitaone Island Community Conservation Area (Proposal). **Cartographic Source:** Google Earth Pro.

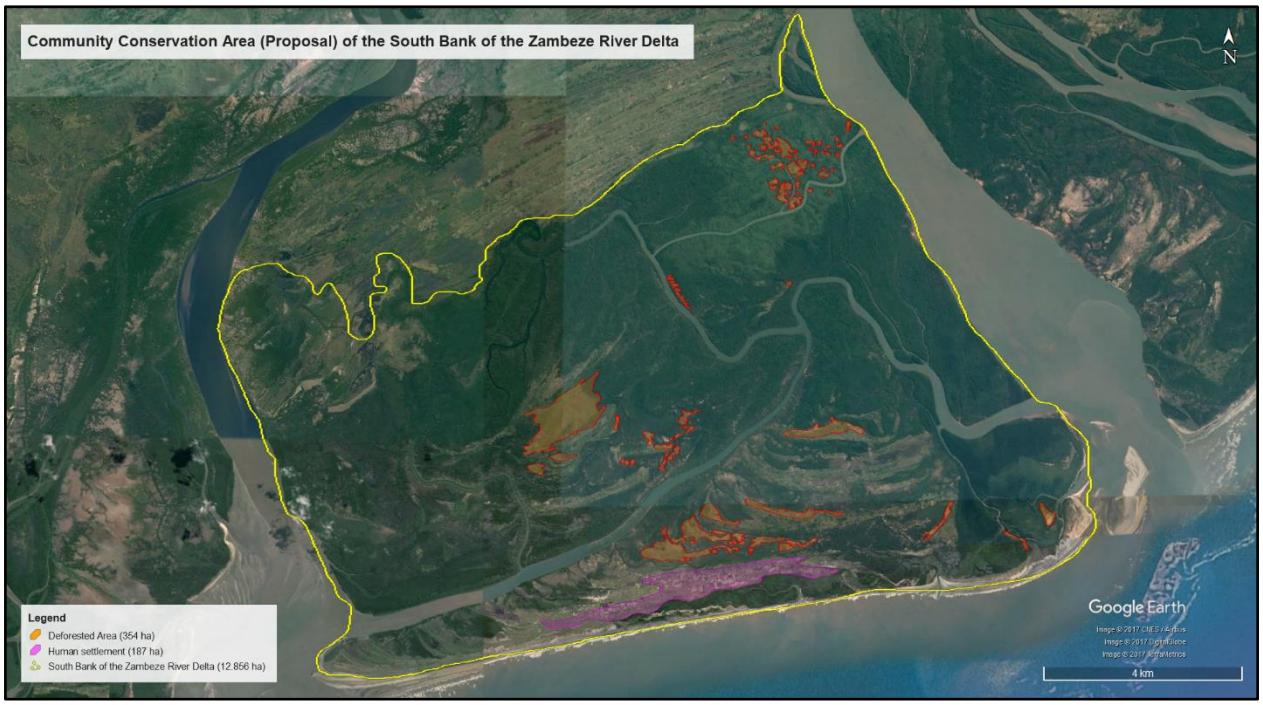


Figure 15: Community Conservation Area (Proposal) of the South Bank of the Zambeze River Delta. **Cartographic Source:** Google Earth Pro.

4.1.5.- Proposed buffer zones

It is highly suggested to propose a deep study to designe in more details a buffer zones system [terrestrial buffer zone (126.000 ha) / marine buffer zone (17.000 ha)] surrounding the core areas (80.000 ha) where are settles the spatial distribution of mangroves forest resources (33.040 ha) in the District of Chinde (Figures 1 & 2).

The Mozambican Conservation Law also speeches some aspects of interest in Article 40 (Section V), which defines the buffer zone as "*a territorial portion bounded around the conservation area, forming a transition band between the conservation area and the multiple use area in order to control and reduce impacts resulting from activities incompatible with the conservation of biological diversity, both inside and outside of the conservation area".*

The same Article mentions that creation of a buffer zone aims to:

a) Formation of a buffer zone around of a conservation area that minimizes the pressures of various human activities;
b) Protection of courses and other sources of water, safeguarding their quality and quantity;
c) Promotion and maintenance of the landscape in general and the development of tourism, with the participation of the private sector and local communities;
d) Promotion of environmental education, serving as a basis for consolidating the attitude of respect for activities and needs related to conservation and quality of life;
e) Containment of continuous and disorderly urbanization;
f) Consolidation of appropriate uses of complementary activities to the Management Plan proposal of the conservation area;
g) Extend conservation measures to promote the sustainable use of natural resources;
h) Provide the function of ecological corridors in order to ensure the maintenance of biological structure and processes, habitat connectivity as well as the movement of genetic material between conservation areas.

1) In the buffer zone, any activity likely to affect its biotic must be previously approved by the implementing agency of the conservation areas and subject to environmental licensing, based on the Assessment of the Environmental Impact, under the terms of specific legislation;
2) The creation of the buffer zone must obey the same assumptions of Article 39, on the approval, modification or extinction of conservation areas.

4.2.- Status of Mangrove Forests

All satellite images (Table 2) used to this study were subject to Unsupervised Classification of Digital Image Processing (DIP), where the mangrove class was extracted and converted to shapefile, and the mangrove cover area estimated through geoprocessing analysis.

Table 2: Available Catalog of Satellite Images of the study area (District of Chinde).

Image ID	Image Date	Satellite	Sensor	Spectral Band	Spatial Resolution (m)
LC08_L1TP_166073_20160906	09/06/2016	Landsat	OLI 8	2-7	30
LC08_L1TP_166073_20130626	06/26/2013	Landsat	OLI 8	2-7	30
LT05_L1TP_166073_20090611	06/11/2009	Landsat	TM5	1-5,7	30

Overall, in the District of Chinde (province of Zambézia), **-2.250 ha** of mangrove forests were deforested over three years, between 2010 (34.810 ha) and 2013 (32.560 ha) product of the anthropogenic high pressure on such coastal forestry resources, establishing vast areas of charcoal production (ovens) with the sale of 150.00 mt the price of the charcoal bag, as well as also in response to strong demand for timber for construction of houses , whose main destination is the City of Quelimane and other villages such as Pambane, where the main use of the mangrove is for the construction of houses too, whose destination is the town of Chinde (Headquarter), Marromeu, Luabo, while in Matilde the mangrove cutting is to send it to Luabo, Marromeu, Quelimane and Micaune. Subsequently, there was a recovery or regeneration of **+480 ha** of mangrove forests in the following three years between 2013 (32.560 ha) and 2016 (33.040 ha) for cause the impact of environmental awareness policies on protecting and conserving mangroves forest, among other factors. Therefore, it is concluded that it was more what was lost in the last 16 years, than what was gained in the Chinde District.

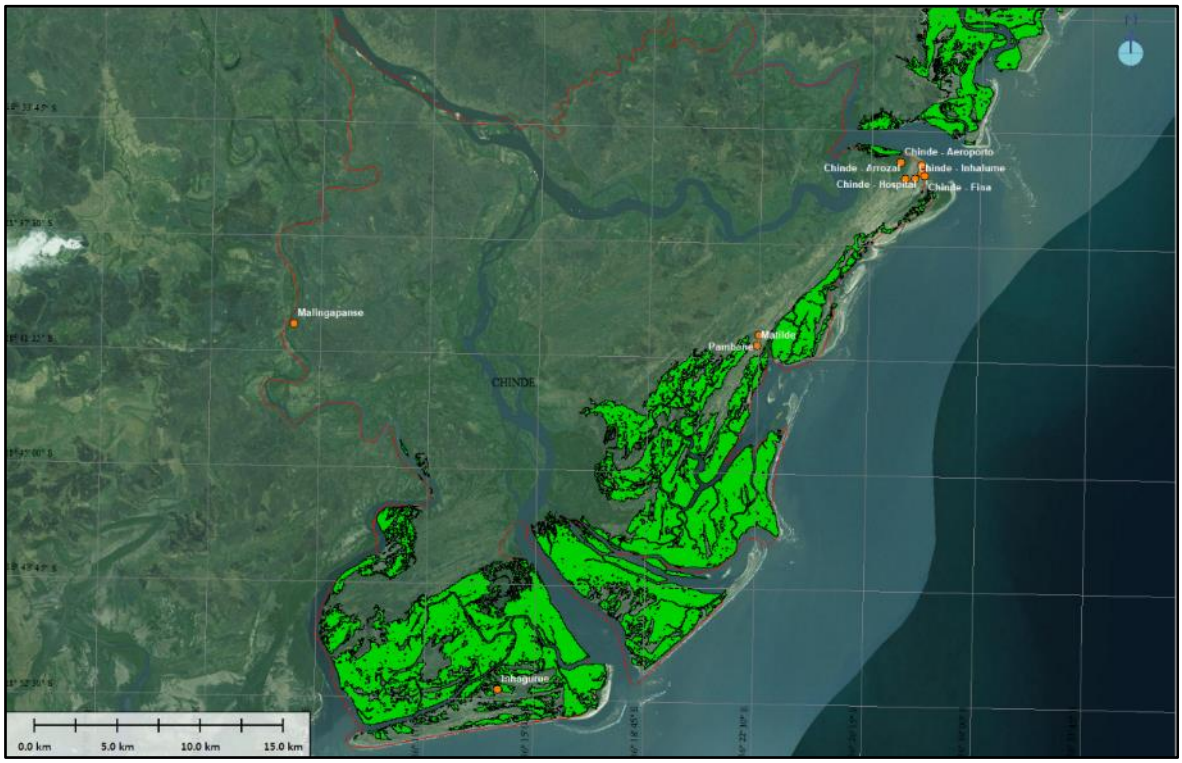


Figure 17: Spatial distribution of 20.450 ha of mangrove forests (2010) in the Administrative Post of Chinde (District of Chinde). **Cartographic Source:** ENVI / Global Mapper.

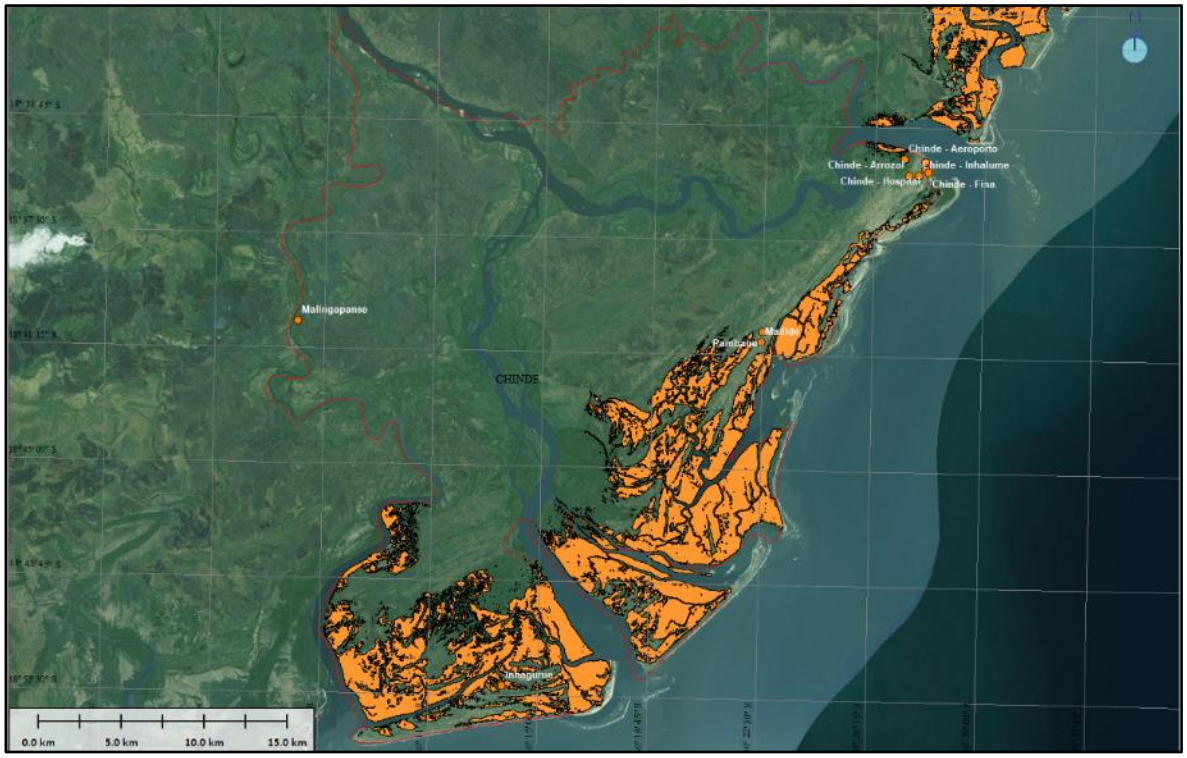


Figure 16: Spatial distribution of 18.540 ha of mangrove forests (2013) in the Administrative Post of Chinde (District of Chinde). **Cartographic Source:** ENVI / Global Mapper.

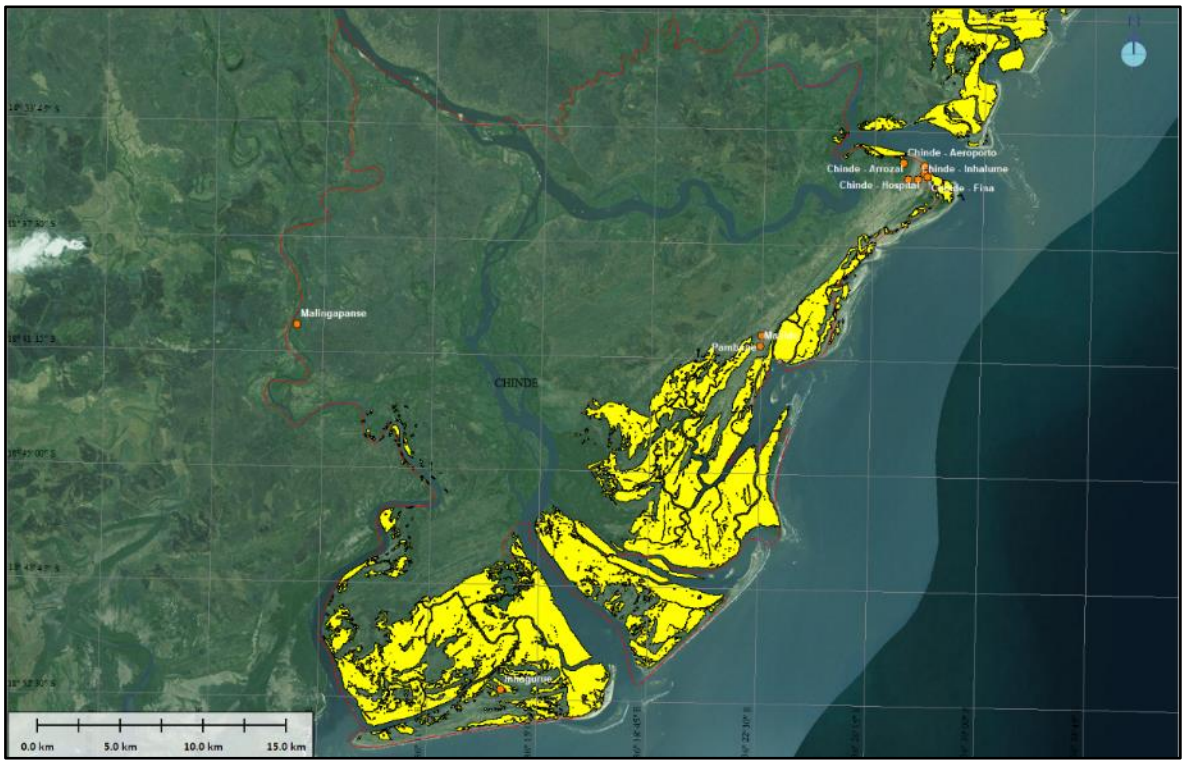


Figure 19: Spatial distribution of 20.480 ha of mangrove forests (2016) in the Administrative Post of Chinde (District of Chinde). **Cartographic Source:** ENVI / Global Mapper.

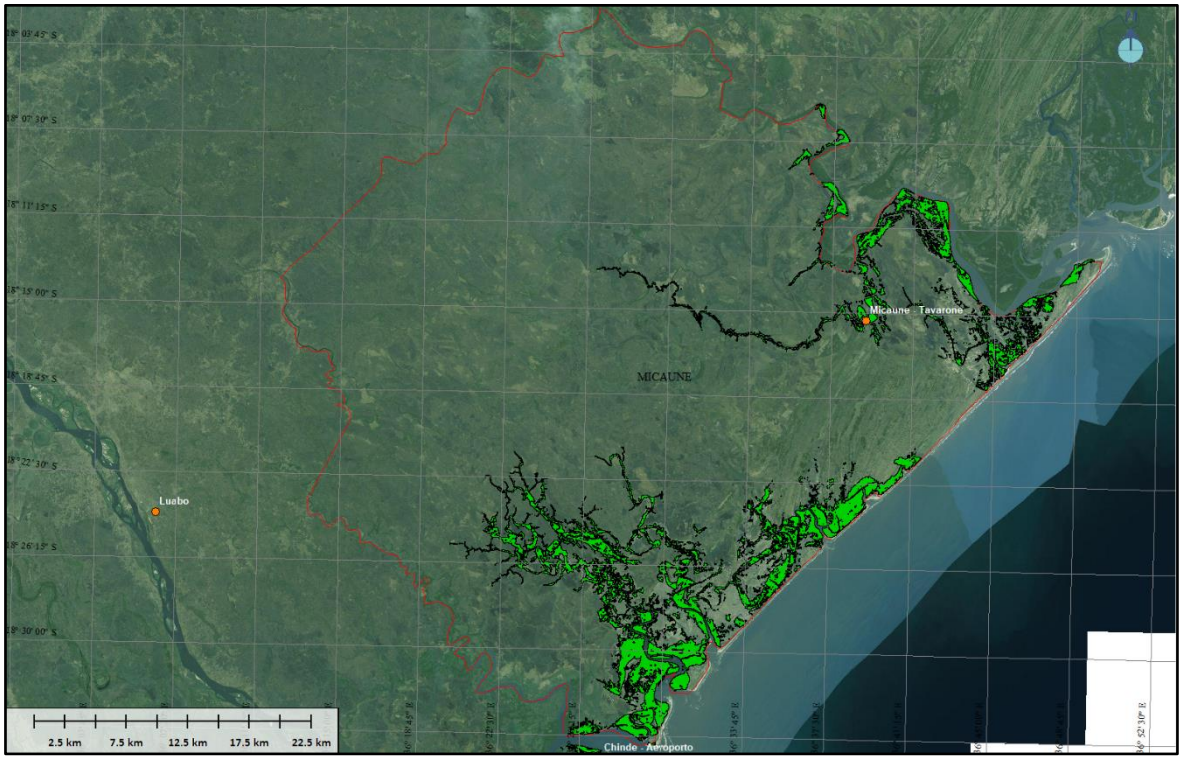


Figure 18: Spatial distribution of 14.360 ha of mangrove forests (2010) in the Administrative Post of Micaune (District of Chinde). **Cartographic Source:** ENVI / Global Mapper.

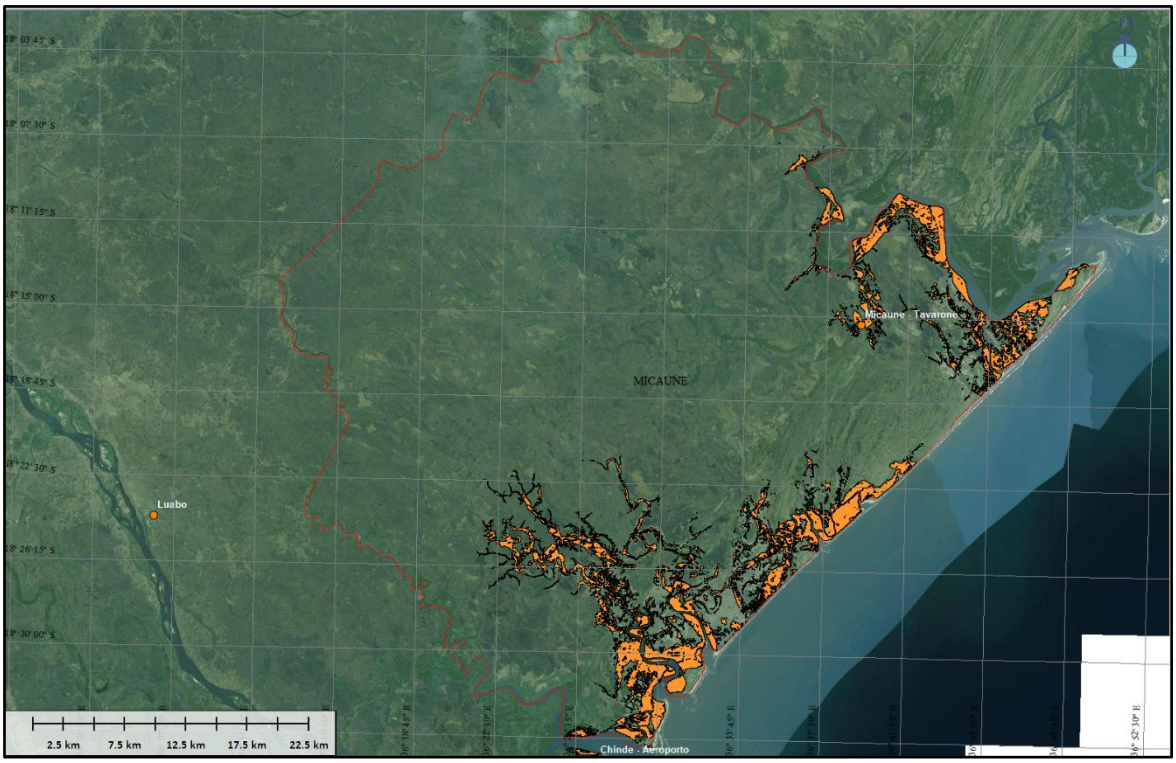


Figure 20: Spatial distribution of 14.020 ha of mangrove forests (2013) in the Administrative Post of Micaune (District of Chinde). **Cartographic Source:** ENVI / Global Mapper.

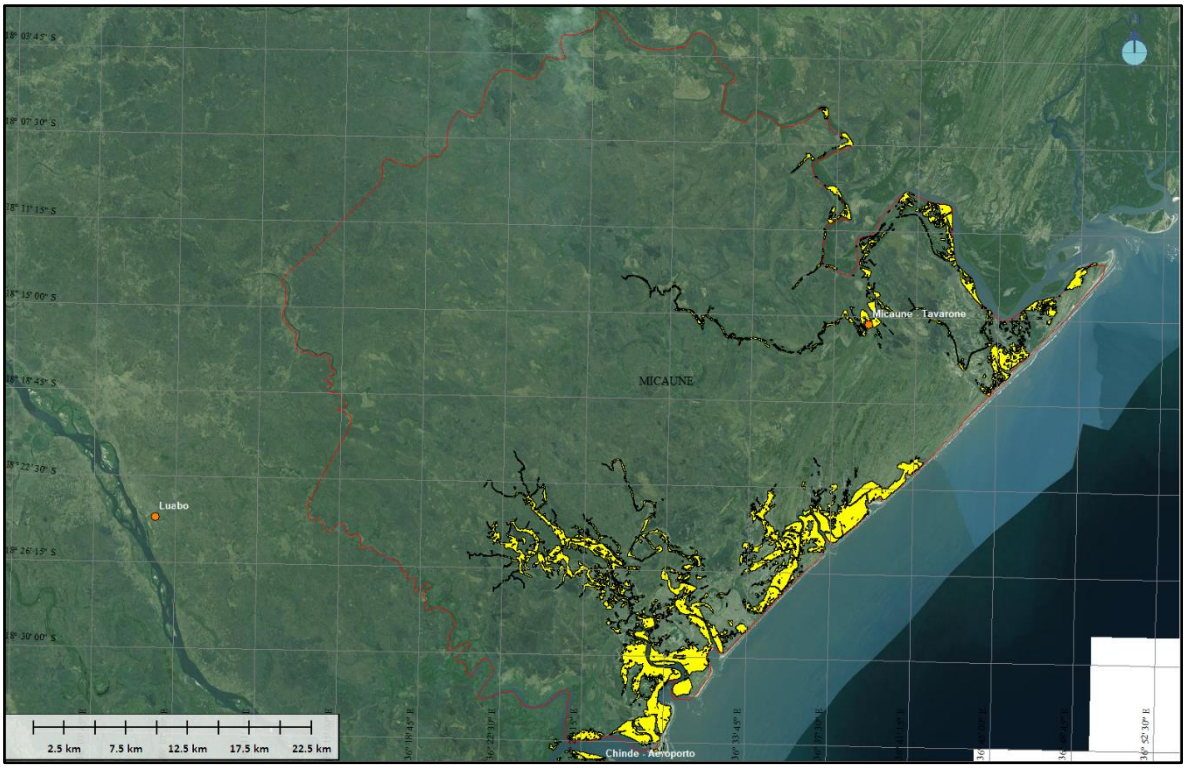


Figure 21: Spatial distribution of 12.560 ha of mangrove forests (2016) in the Administrative Post of Micaune (District of Chinde). **Cartographic Source:** ENVI / Global Mapper.

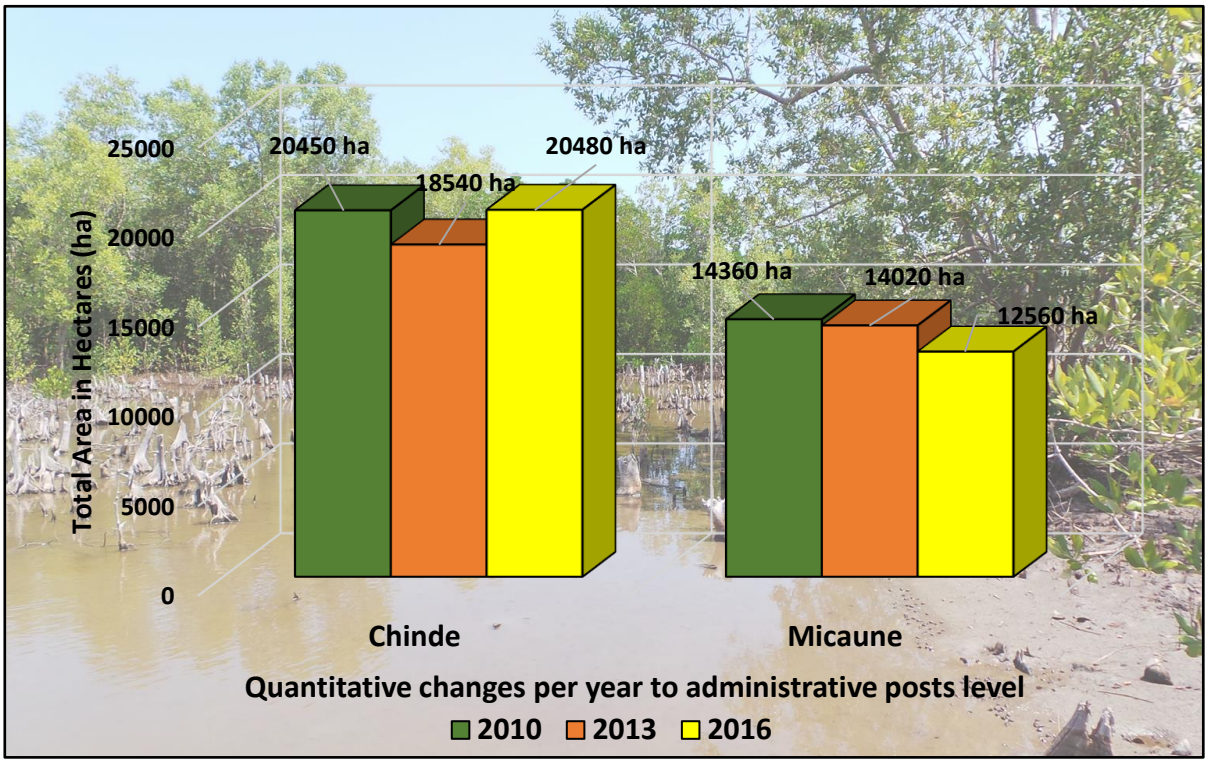


Figure 22: Mangrove forests surface extension per year (2010 – 2013 – 2016) in the Administrative Posts of Chinde & Micaune (District of Chinde).

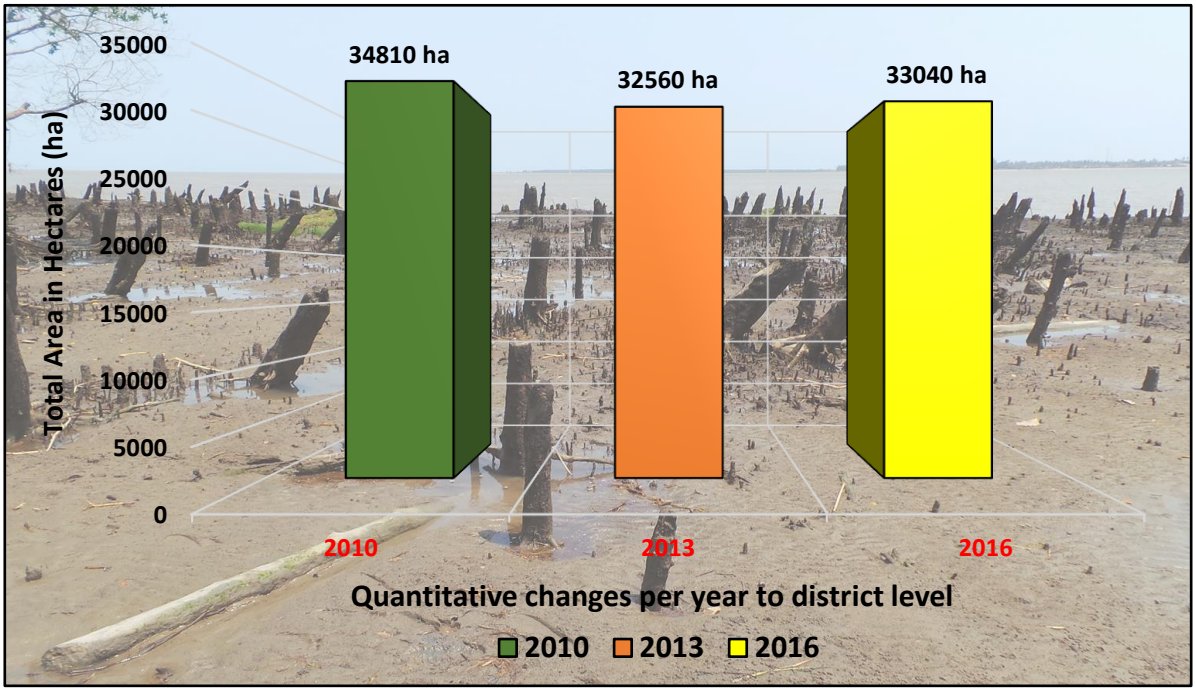


Figure 23: Mangrove forests surface extension per year (2010 – 2013 – 2016) in the District of Chinde (Zambézia province).

5.- CONCLUSIONS

- The District of Chinde (province of Zambézia) lost **-2.250 ha** of mangrove forests (deforested areas) over three years, between 2010 (34.810 ha) and 2013 (32.560 ha) product of the anthropogenic high pressure on such coastal forestry resources;
- Subsequently, there was a recovery or regeneration of **+480 ha** of mangrove forests in the following three years between 2013 (32.560 ha) and 2016 (33.040 ha) for cause the impact of environmental awareness policies on protecting and conserving mangroves forest, among other factors;
- The main destination of the mangrove wood is the City of Quelimane and other villages such as Pambane, where the main use of the mangrove is for the construction of houses too, whose destination is the town of Chinde (Headquarter), Marromeu, Luabo, while in Matilde the mangrove cutting is to send it to Luabo, Marromeu, Quelimane and Micaune;
- Coastal erosion and charcoal production areas (ovens) are the main environmental impacts affecting the District of Chinde. About coastal erosion, the actual physiographic configuration of the coastal zone of Amarelo neighborhood lost 10 ha of land along 13 years affecting seriously such local communities;
- Other environmental impacts affecting the District of Chinde with a lower intensity in terms of pressure on fishery resources, are the impact of fishing gear such as beach seine net, longline and *chicocota*; and finally unsustainable agricultural practices such as cassava production as the main crop;
- The lack of a Mangrove Monitoring and Management Program and fundamentally the implementation of a Reforestation Plan places such coastal forestry resources vulnerable to climatic changes and anthropogenic impacts;
- The main mangrove species more used by local communities for different used: extraction of charcoal, construction, etc. are: *Rhizophora mucronata*, *Avicennia marina*, *Sonneratia alba*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Xylocarpus granatum*, *Heritiera littoralis* e *Lumnitzera racemose*;
- Were designated two strategic proposed coastal protected areas with the management category of Community Conservation Area: Mitaone Island (173 ha) and the South Bank of the Zambeze River Delta (12.856 ha);
- In the fieldwork, were georeferenced in the Administrative Post of Chinde: 4 Telecommunication Systems, 4 Health Services, 18 Public Facilities, 9 Schools (Primary & Secundary) and 7 boreholes (Table 3).

6.- RECOMMENDATIONS (TO IMPROVE MANAGEMENT OF CRITICAL AREAS)

- Establishment of a mangrove management system and sustainable exploitation of mangrove tree products such that sustainable harvesting is set at 13 trees per hectare per month is allowed for fuelwood and charcoal production in Bairro Amarelo in Chinde Sede and Pambane. Such exploitation be attributed to a household per hectare and controlled by the Community Mangrove Management Committees;
- It is considerable that the severe erosion problems on the sandy coast that sufer the coastal community of Amarelo are usually due to human activities such as dam of Cahora Bassa that decreases the Zambezi river sediment supply to the coast, vegetation clearance in beach woodlands, offshore mining, and building inappropriate coastal structures. In terms of erosion generated by vegetation clearance, revegetation of the area using indigenous vegetation is the only option. Other coastal protection options should be considered in combination with revegetation if the erosion problem is attributable to multiple factors;
- It is strongly recommended the management of the Cahora Bassa dam as to mimic the natural seasonal cycle as maximum as possible;
- Promotion of incoming generating agriculture in the District of Chinde as an alternative livelihood activity to mangrove cutting;
- Support of fish processing and trade, to reduce post-harvest losses, add value to fish product and increase income in Bairro Hospital, Bairro Amarelo and Bairro Aeroporto, in Chinde Sede and in Matilde and Pambane;
- Promotion of crab fattening to increase income and reduce pressure on wild stocks and ecosystems in Bairro Hospital, Bairro Amarelo and Bairro Aeroporto, in Chinde Sede and in Matilde and Pambane;
- Promotion of beekeeping in mangrove forests in Faina and Arrozal neighborhoods, in Chinde Sede, in Matilde, Pambane, Inhagurue and Malingapasse;
- Promotion of the use of bricks, taking advantage of abundant clay, for building houses as an alternative to mangrove timber and poles in the Chinde District;
- Establishment of a sustainable Human Resettlement Strategic Plan that can improve the quality of life of affected families, protecting their social, family and livelihood relationships;
- Design and creation of a Spatial Planning and a Land Cover Use detailed project of the Chinde District;
- Continue the Digital Image Processing with special reference to satellite images of 2010 – 2013 – 2016 applied to human settlement spatial pattern evolution linked to mangrove critical areas

trends using Mangrove Watch Africa by integrating optical (LandSat, Sentinel 2) and SAR (ALOS, Sentinel 1) remote sensing products to produce high quality up-to-date cartographic products as follow:

- Mangrove extent (1996 - now);
- Mangrove extent annual updates;
- Annual mangrove change;
- Near real-time mangrove monitoring;
- Mangrove biomass;
- Mangrove height;
- Pressures and threats;
- Potential restoration.

- It is highly recommended to propose a deep study to analyze and design a Regional Network of Protected Areas based on the structure tree of Classification of Protection Zones and Categories of Management of Conservation Areas of Mozambique from the Conservation Law # 16/2014 with the propose to identify new protected areas and designate new management categories to protect and conserve them from anthropogenic threats;
- The necessity to reinforce the capabilities of all Community Fishery Centers and the Management Committees of Natural Resources of Chinde District related to a coastal revegetation proposal zone by the Hospital neighborhood (Future Mangrove Management Intervention Program). Furthermore, the need to have more information about existence and functionality of these committees.

7.- ACKNOWLEDGMENTS

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9.- APPENDICES

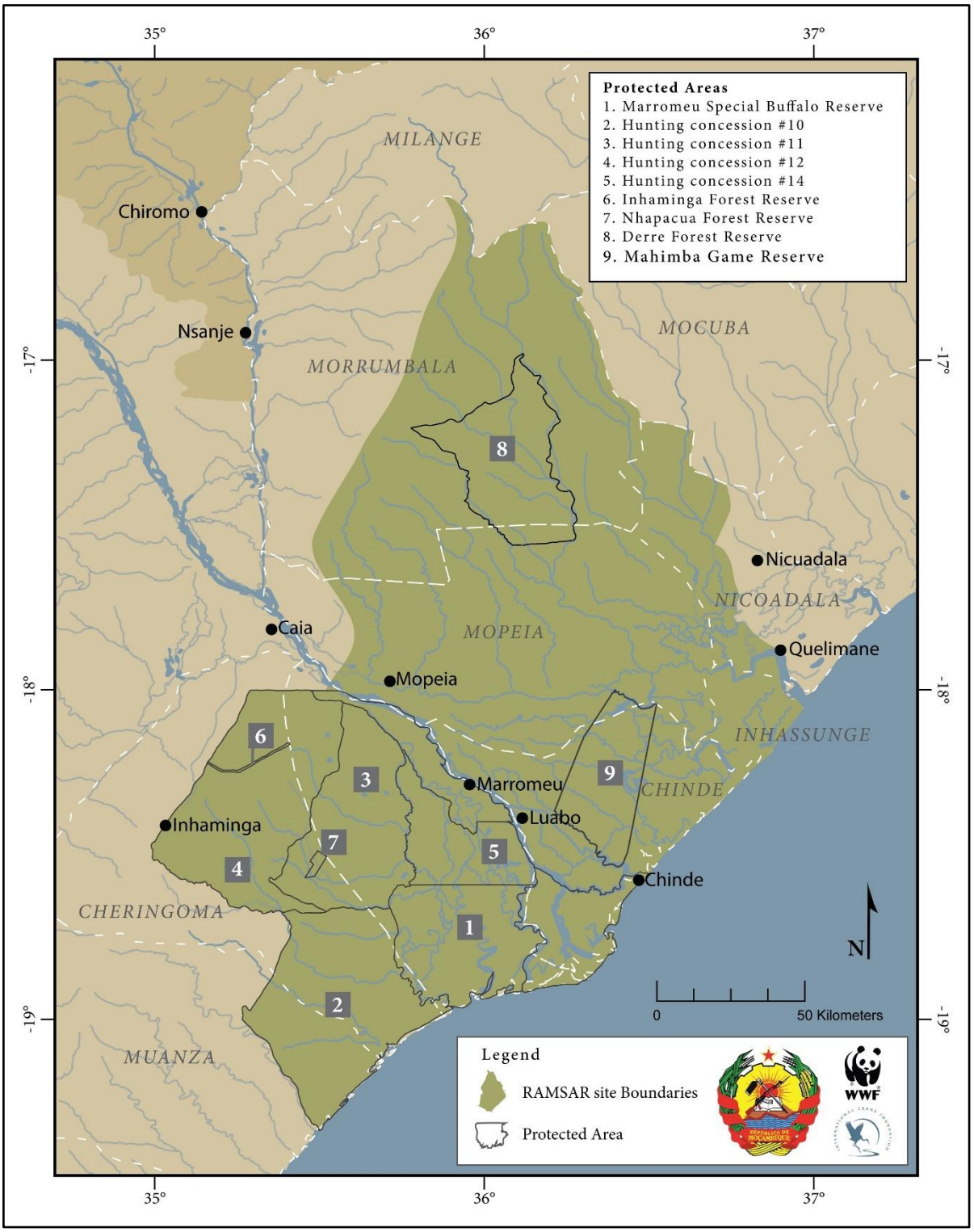

Figure 24: Protected Areas in the proposed Zambezi Delta Ramsar Site.
Website: https://www.ramsar.org/search?search_api_views_fulltext=mozambique

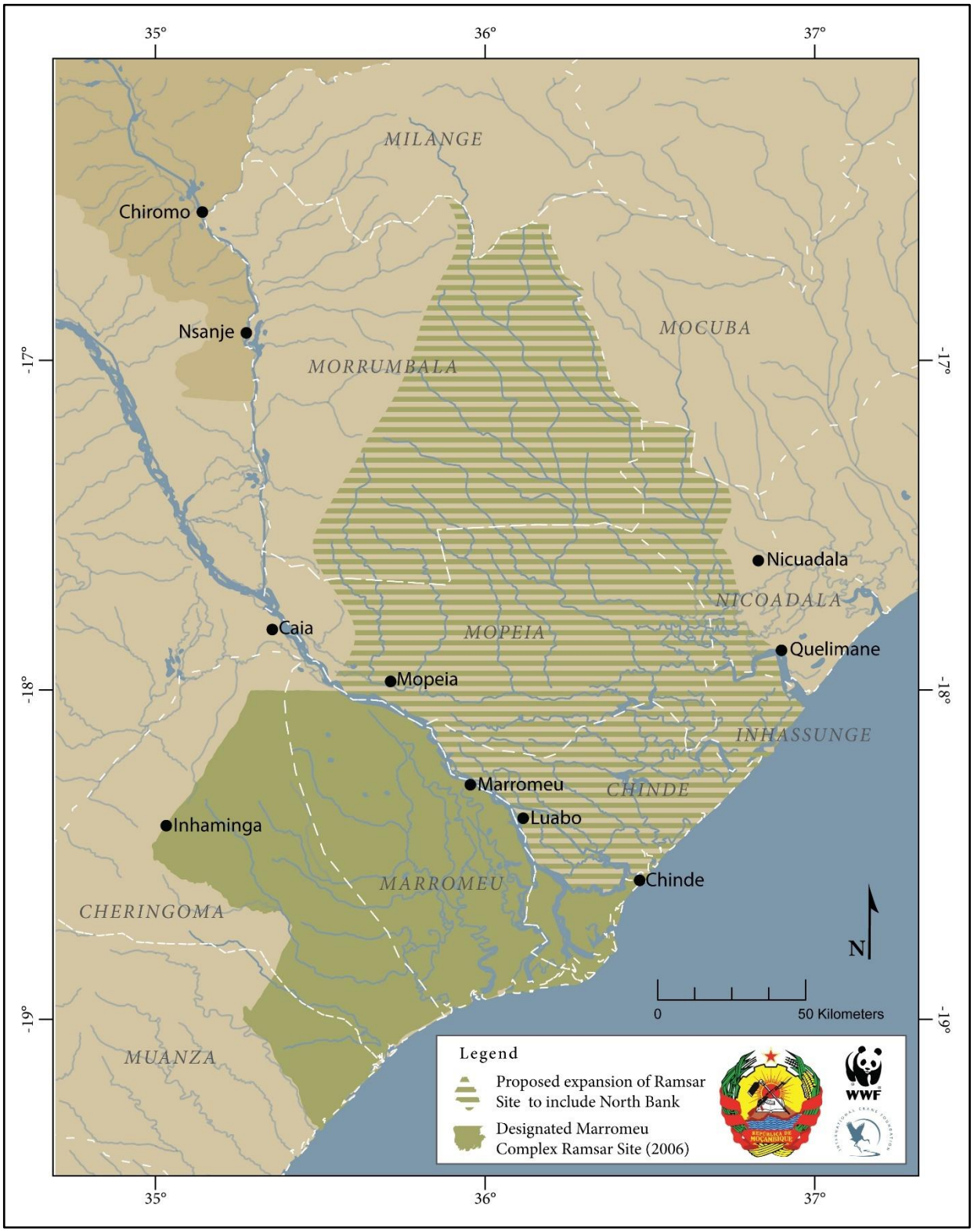

Figure 25: Marromeu Complex Ramsar Site (designated 2006) and proposed North Bank expansion to establish the Zambezi Delta Ramsar Site.
Website: https://www.ramsar.org/search?search_api_views_fulltext=mozambique

Table 3: Geographical positions of the surveyed infrastructures during the fieldwork (Oct., 2017).

Nr.	INFRASTRUCTURE	NAME	Geographical Coordinates	
			Latitude Sul (-φ)	Longitude Este (λ)
1	Telecommunication Systems	*MCEL*	**φ =** -18°34'58.94"S	**λ** = 36°27'41.40"E
		MCEL	**φ =** -18°39'57.03"S	**λ** = 36°14'39.85"E
		VODACOM	**φ =** -18°34'55.52"S	**λ** = 36°27'44.15"E
		MOVITEL	**φ =** -18°34'58.28"S	**λ** = 36°27'41.70"E
2	Health Services	*George Health Center*	**φ =** -18°39'12.61"S	**λ** = 36°22'25.49"E
		Chinde Health Center	**φ =** -18°35'4.08"S	**λ** = 36°27'47.07"E
		Matilde 8 of March Health Unit	**φ =** -18°39'56.71"S	**λ** = 36°14'31.47"E
		Maternity	**φ =** -18°35'0.00"S	**λ** = 36°27'51.45"E
3	Public Facilities	*Administrative Post - Chinde Headquarters*	**φ =** -18°35'3.42"S	**λ** = 36°27'43.02"E
		District Government of Chinde	**φ =** -18°34'58.44"S	**λ** = 36°27'39.50"E
		District Service of Education, Youth and Technology of Chinde	**φ =** -18°35'6.14"S	**λ** = 36°27'33.52"E
		District Service of Economic Activities	**φ =** -18°34'49.79"S	**λ** = 36°27'44.83"E
		District Service of Planning & Infrastructure	**φ =** -18°35'4.45"S	**λ** = 36°27'30.79"E
		District Health Service of Woman & Social Action of Chinde	**φ =** -18°35'5.50"S	**λ** = 36°27'44.10"E
		Headquarters of the District Committee of the Party FRELIMO - Chinde	**φ =** -18°34'53.37"S	**λ** = 36°27'35.55"E
		Police of the Republic of Mozambique	**φ =** -18°35'1.40"S	**λ** = 36°27'39.63"E
		House of Culture	**φ =** -18°35'3.29"S	**λ** = 36°27'37.06"E

Nr.	INFRASTRUCTURE	NAME	Geographical Coordinates	
			Latitude Sul (-φ)	Longitude Este (λ)
		Catholic Church	**φ =** -18°34'56.65"S	**λ** = 36°27'40.84"E
		Captaincy of the Port of Chinde	**φ =** -18°34'54.06"S	**λ** = 36°27'41.90"E
		Mother Magdalene Orphanage Center	**φ =** -18°34'56.52"S	**λ** = 36°27'36.16"E
		Mapex Fishing Center	**φ =** -18°35'27.64"S	**λ** = 36°28'11.96"E
		Mapex Lighthouse	**φ =** -18°35'26.83"S	**λ** = 36°28'6.21"E
		Electricity of Mozambique	**φ =** -18°34'52.02"S	**λ** = 36°27'36.12"E
		Central Market of Chinde	**φ =** -18°34'57.05"S	**λ** = 36°27'32.39"E
		Matilde's Fish Market	**φ =** -18°40'6.41"S	**λ** = 36°14'19.34"E
		Headquarter of the Matilde Locality	**φ =** -18°40'7.23"S	**λ** = 36°14'23.33"E
4	**Schools (Primary & Secundary)**	*Primary School 1st & 2nd Grade Emília Daússe*	**φ =** -18°34'51.99"S	**λ** = 36°27'42.90"E
		Primary School 1st & 2nd Grade Feira Muemba	**φ =** -18°39'1.06"S	**λ** = 36°17'5.71"E
		Primary School 1st & 2nd Grade Kenneth Kaunda	**φ =** -18°41'59.44"S	**λ** = 36°21'42.36"E
		Primary School 1st & 2nd Grade Maguiguane Muemba	**φ =** -18°38'23.91"S	**λ** = 36°18'25.00"E
		Primary School 1st & 2nd Grade Nhacumba Matilde	**φ =** -18°39'37.97"S	**λ** = 36°14'57.65"E
		Complete Primary School September 7th Matilde	**φ =** -18°40'1.92"S	**λ** = 36°14'39.35"E
		Complete Primary School Filipe Samuel Magaia	**φ =** -18°36'40.23"S	**λ** = 36°25'51.06"E
		Complete Primary School Samora Machel Sombo	**φ =** -18°37'50.72"S	**λ** = 36°20'53.66"E
		General Secondary School of Chinde	**φ =** -18°35'49.20"S	**λ** = 36°26'57.98"E

Nr.	INFRASTRUCTURE	NAME	Geographical Coordinates	
			Latitude Sul (-φ)	Longitude Este (λ)
5	Boreholes	*District Government of Chinde*	**φ =** -18°34'58.57"S	**λ** = 36°27'40.43"E
		-	**φ =** -18°36'4.57"S	**λ** = 36°27'35.47"E
		-	**φ =** -18°38'53.07"S	**λ** = 36°18'54.78"E
		Primary School 1st & 2nd Grade Kenneth Kaunda	**φ =** -18°41'59.24"S	**λ** = 36°21'43.26"E
		-	**φ =** -18°42'35.60"S	**λ** = 36°21'19.00"E
		Located between MCEL and Primary School 1st & 2nd Grade Nhacumba Matilde	**φ =** -18°39'48.11"S	**λ** = 36°14'43.72"E
		-	**φ =** -18°35'33.98"S	**λ** = 36°27'59.95"E

Figure 26: Participation of the District Government of Chinde through Administrator Pedro A. A. Vírgula in awareness of local environmental problems (coastal erosion) that strikes the Chinde - Amarelo Community (Díaz P., I.; Oct. 2017).

Figure 27: Broad impact of the accelerated erosion on the coastal fringe of Chinde - Amarelo community (Chinde river mouth) (Díaz P., I.; Oct. 2017).

Figure 28: Destruction of soil organic matter and consequent loss of fertility due to bushfires (Díaz P., I.; Oct. 2017).

Figure 29: Deforestation of mangroves (Ponta Liberal, coastal bar of Chinde river mouth) [Díaz P., I.; Oct. 2017].

Figure 30: Deforestation of mangroves (Ponta Liberal, coastal bar of Chinde river mouth) [Díaz P., I.; Oct. 2017].

Figure 31: Deforestation of mangroves (Ponta Liberal, coastal bar of Chinde river mouth) [Díaz P., I.; Oct. 2017].

Figure 32: Localization and pre-assessment of the ovens for production of charcoal: 130 bags x 150,00 mt = 19.500,00 mt (317 USD) (Ponta Liberal, coastal bar of Chinde river mouth) [Pita, R.; Oct. 2017].

Figure 33: Bags of charcoal ready to be sold (Ponta Liberal, coastal bar of Chinde river mouth) [Díaz P., I.; Oct. 2017].

Figure 34: Field of ovens for production of charcoal (Ponta Liberal, coastal bar of Chinde river mouth) [Díaz P., I.; Oct. 2017].

Figure 35: Field of ovens for production of charcoal (Ponta Liberal, coastal bar of Chinde river mouth) [Díaz P., I.; Oct. 2017].

Figure 36: Single oven for production of charcoal. [Díaz P., I.; Oct. 2017].

Figure 37: Usually, charcoal producers dig channels around the oven connected to a local stream. Once the charcoal material has been removed, they use the water from the peripheral channel to extinguish the oven [Díaz P., I.; Oct. 2017].

Figure 38: Traditional canoes used to transport wood mangroves and charcoal through small rivers to supply the needs of the local communities [Díaz P., I.; Oct. 2017].

Figure 39: A house frame built with *Ceriops tagal* poles (Village of Pambane) [Díaz P., I.; Oct. 2017].

Figure 40: External structure of a local church made of mangrove wood (Chinde Headquarter) [Díaz P., I.; Oct. 2017].

Figure 41: Biogenic shoreline at risk by coastal erosion at Mitaone Island (Proposal of Mitaone Island Community Conservation Area) [Díaz P., I.; Oct. 2017].

Figure 42: Timber traders preparing the mangrove wood from Mitaone Island to Quelimane city (Díaz P., I.; Oct. 2017).

Figure 43: Current deforestation at Mitaone Island (Proposal of Mitaone Island Community Conservation Area) [Díaz P., I.; Oct. 2017].

Figure 44: Small watercourses are used at high tide to transport mangrove and/or charcoal wood for home construction (Díaz P., I.; Oct. 2017).

Figure 45: Mangrove cutting at Pambane village (Díaz P., I.; Oct. 2017).

Figure 46: Collecting clams on a sandbank of the Zambezi river (Chinde) and fisherman in canoe to prepare the mosquito net to capture krill and anchovies (Díaz P., I.; Oct. 2017).

Figure 47: Cat-fish (*Arius spp*) [Díaz P., I.; Oct. 2017].

Figure 48: Local fisherman showing his catch of a reticulate whipray or honeycomb stingray (*Himantura uarnak*) at Mapex Fishing Center (Chinde-Fina). This specie was assessed as Vulnerable by IUCN (Díaz P., I.; Oct. 2017).

Figure 49: Large specimen of Giant Tiger Prawns (*Penaeus monodon*) at Mapex Fishing Center (Chinde-Fina) [Díaz P., I.; Oct. 2017].

Figure 50: Cropland of maize (Díaz P., I.; Oct. 2017).

Figure 51: Cropland of cassava (Díaz P., I.; Oct. 2017).

Figure 52: Cropland of beans (Díaz P., I.; Oct. 2017).

Figure 53: Goat cattle breeding and poultry (Díaz P., I.; Oct. 2017).

Figure 54: Fluvial erosion destroying a cropland of bananas (Díaz P., I.; Oct. 2017).

Figure 55: Fluvial erosion destroying a pathway (Díaz P., I.; Oct. 2017).