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RESILIM : Resilience in the Limpopo River Basin Program

MAPPING OF MANGROVE VEGETATION COMMUNITIES AND DEGRADED AREAS IN THE LIMPOPO BASIN ESTUARY

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I.INTRODUTION

I.1 - Background

Mangrove forest in the Limpopo basin estuary is one of the most important livelihood resources for the Zonguene community. This resource occurs along the river banks and mud flats and provides an important breeding ground for fish and other marine resources important for local community as source of firewood and building material.

Mangroves are under constant flux due to both natural (e.g. erosion, aggradations) and anthropogenic factors. In the last three decades, forest losses because of anthropogenic factors have increased significantly (Giri et. al. 2010). The remaining mangrove forests are under immense pressure from clear-cutting, land-use change, hydrological alterations, chemical spill and climate change (Blasco et al., 2001).

The 2000 floods that hit Zonguene Administrative Post had a great negative impact in particular the destruction of vast areas of mangrove forest in Limpopo estuary, consequently affecting the local fisheries. During the vulnerability assessment exercise carried out in this community, it was also pointed that extensive patches of the mangrove have been destroyed by the 2000 floods and very poor regeneration is being observed. These observations are supported by a recent study by Jose (2009), who suggests as possible causes the changing in the structure and composition of the substrate and hydrological conditions.

Remote sensing and GIS are increasingly used in mangrove forestry change tracking worldwide to assist in gathering and analysing images acquired from aircrafts, satellites and even balloons (Aschbacher et al., 1995). The increasing use of remote sensing techniques in mangrove forest mapping is due to its higher reflectance values from forested areas in the near-infrared, moderate reflectance in the middle-infrared and low reflectance in the red spectral bands (Trisurat et al., 2000). Higher spatial resolution imageries (0.60 m) and its annual temporal resolution are great valuable resources for mapping mangrove natural resources and track their changes along different communities and times (Da Silva, 2005). The notable advantages of using GIS include the ability to update the information rapidly, to undertake comparative analytical work and making this information available as required (Silapathong and Blasco, 1992).

This study aims to map the mangrove degraded areas in Limpopo estuary to inform the conservation measures and form a basis to guide formulation of interventions under component II of the RESILIM Program, developing an adaptive management and responses to threats. Results generated from this study could provide an additional opportunity for a better understanding of mangrove forests geared towards their sustainable management.

I.2 – Objectives

The overall objective is to map the mangrove vegetation communities and degraded areas in the Limpopo basin estuary to inform the conservation measures and form a basis to guide formulation of interventions under component II of the RESILIM Program, developing an adaptive management and responses to threats.

The goal of this work is to provide a cartographic database of mangrove cover and surrounding land cover and land use setting; provide historical and current information about mangrove cover change and formulate a proposal for restoration area

I.2.1. **Specific objectives**

1. Coordinate data collection activities;
2. Perform imagery and aerial photos interpretation and analysis
3. Produce land cover and land use map (2005 and 2014)
4. Design, create and manage a mangrove cartographic database
5. Produce maps on mangrove location and distribution, mangrove patterns and densities (2005 and 2014)
6. Compare mangrove indicators in satellite imageries of 2 dates (2005 and 2014)
7. Estimate mangrove change rate in Limpopo Basin Estuary
8. Analyse the factors behind mangrove dynamics in different spaces
9. Identify and characterize the current mangrove degraded areas
10. Purpose the criteria for mangrove restoration in Limpopo Basin Estuary
11. Present the preliminary report in Zongoene
12. Edit the scientific quality to the final report

II.LITERATURE REVIEW

II. 1 - Definition and characteristics of mangrove

Mangrove is type of forest growing along tidal mudflats and along shallow water coastal areas extending inland along rivers, streams and their tributaries where the water is generally brackish (Melana et. al, 2000). This trees or shrubs develop best where low wave energy and shelter foster deposition of fine particles enabling these woody plants to establish roots and grow (Alongi, 2002). Characteristics and adaptations that make mangroves structurally and functionally unique include aerial roots, viviparous embryos, tidal dispersal of propagules, rapid rates of canopy production, frequent absence of an understory, absence of growth rings, wood with narrow, densely distributed vessels, highly efficient nutrient retention mechanisms, and the ability to cope with salt and to maintain water and carbon balance (Alongi, 2002).

II.2 – Distribution

Mangroves are globally distributed in the inter-tidal region between the sea and the land in the tropical and subtropical regions between approximately 30° N and 30° S latitude (Giri et al, 2010), with a total of 124 countries and areas identified as containing one or more true mangrove species (Tomlinson, 1986; Saenger, Hegerl and Davie, 1983; cited by FAO, 2007). According to Alongi (2002), the most diverse biogeographical regions are in the Indo-West Pacific (**Fig. 1**), and countries like Australia, Brazil, Nigeria and Mexico have roughly 48% of the 15.2 million hectares of mangroves worldwide in 2005 (FAO, 2007).

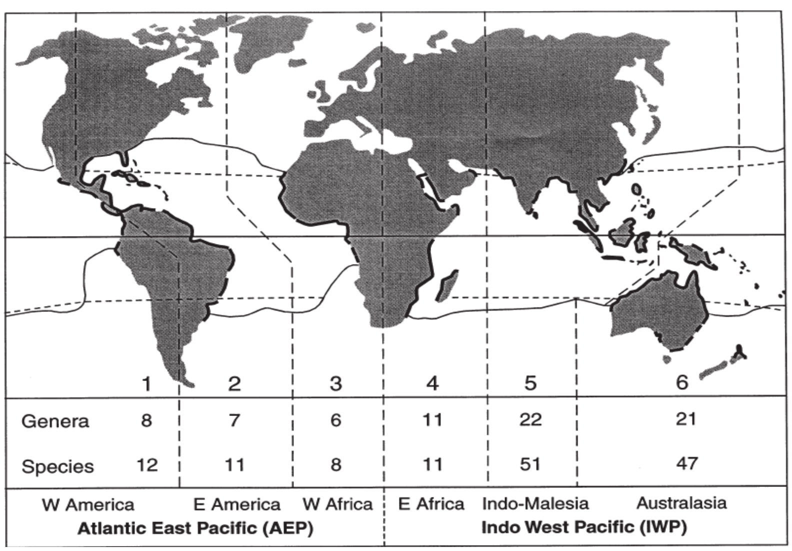


Figure 1: distribution and biogeographical provinces of the world's mangrove forests, together with the numbers of genera and species within each of the six provinces (Alongi, 2002, modified from Spalding et al., 1997 and Duke et al.,1998).

Mangroves cover about 3.5 million hectares on the African coastline (Chevallier, 2013) and are found in almost all countries along the west and east coasts of Africa, spreading from Mauritania to Angola on the west coast, and from Egypt to South Africa on the east coast, including Madagascar and several other islands (FAO, 2007). About 70 percent of all African mangroves can be found in just five countries: Nigeria, Mozambique, Madagascar, Guinea and Cameroon (**Figure 2**).

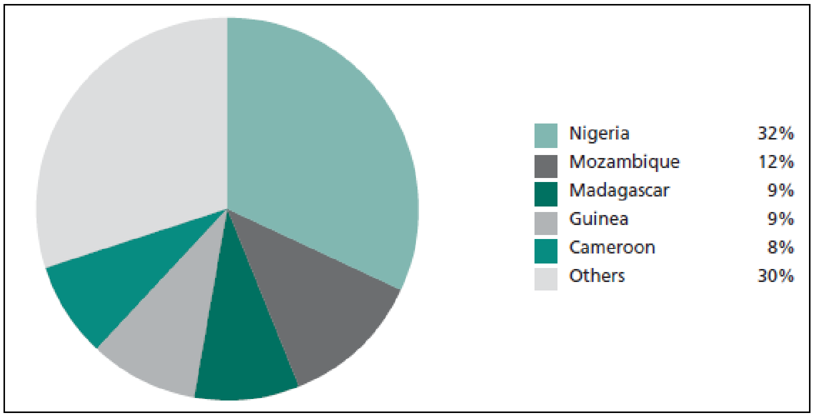


Figure 2 - Five African countries with the largest mangrove area in 2005 (FAO, 2007).

In Mozambique, mangrove are widespread along the coasts and cover an area of approximately 40,000 hectares (Barbosa et al, 2001; MICOA, 2006), usually occur along river mouths and in many sheltered shorelines, bays and lagoons (FAO, 2005). The largest mangrove forests occur in central region where large volumes of fresh water are discharged into the ocean, including the Zambezi, Púngue, Save and Búzi river deltas. The Zambezi Delta contains 50% of Mozambique's mangroves, extending for 180 kilometers along the coast and for 50 kilometers inlandand. This area contains 50% of Mozambique's mangroves and is one of the most extensive mangrove habitats in Africa (Chevallier, 2013).

Limpopo River is the only place where mangrove can be found in Gaza Province and the distribution of mangrove is limited in a small estuary of 6km length. In 1994 it represented the smallest mangrove area in Mozambique, with total of 387 ha and according to Saket and Matusse (1994), this area remained constant since 1972.

II.3 – Mangrove species

The mangrove flora consists of "true mangrove" and associated species. True mangroves grow in the mangrove environment; associated species may grow on other habitat types such as the beach forest and lowland areas (Melana et. al, 2000). According to Spalding *et al*. 1997, there are 9 orders, 20 families, 27 genera and roughly 70 species of mangroves; mostly located in the Indo-West Pacific (Alongi, 2002) (**Fig. 1**).

According to the list of Tomlinson, and the species listed by Saenger, Hegerl & Davie (1983) cited by FAO (2007), the mangrove species commonly found are:
Acanthus ebracteatus, *A. ilicifolius*, *A. xiamenensis*, *Acrostichum aureum*, *A. speciosum*, *Aegialitis annulata*, *A. rotundifolia*, *Aegiceras corniculatum*, *A. floridum*, *A. alba*, *A. bicolor*, *A.eucalyptifolia*, *A. germinans*, *A. integra*, *A. lanata*, *A. marina*, *A officinalis*, *A rumphiana*, *A schaueriana, Bruguiera cylindrica*, *B. exaristata*, *B.gymnorrhiza*, *B. hainesii*, *B. parviflora*, *B. sexangula*, *Camptostemon philippinensis*, *C. schultzii*, *Ceriops australis*, *C.decandra, C. somalensis, C. tagal*, *Conocarpus erectus*, *Cynometra iripa*, *C. ramiflora*, *Excoecaria agallocha*, *E. indica*, *Heritiera fomes*, *H.globosa*, *H.kanikensis*, *H. littoralis*, *Kandelia candel*, *Laguncularia racemosa*, *Lumnitzera littorea*, *L. racemosa*, *L. rosea*, *Nypa fruticans, Osbornia octodonta*, *Pelliciera rhizophorae*, *Pemphis acidula*, *Rhizophora annamalayana*, *R. apiculata, R. harrisonii*, *R. lamarckii*, *R. mangle*, *R. mucronata*, *R. racemosa*, *R. samoensis*, *R. selala*, *R. stylosa*, *Scyphiphora hydrophyllacea*, *Sonneratia alba*, *S. apétala*, *S.caseolaris*, *S. griffithii*, *S. gulnga*, *S. hainanensis*, *S.ovata*, *S. urama*, *Xylocarpus granatum*, *X. mekongensis*, *X.rumphii*.

About 8 mangrove species occur in Mozambique (FAO, 2005) and the main species consist of: *Rhizophora mucronata, Bruguiera gymnorrhiza, Avicennia marina, Ceriops tagal, Sonneratia alba, L. racemosa and Xilocarpus granatum* (MICOA, 2006; Barbosa *et al*, 2001). In Limpopo estuary the dominant species is *Avicennia marina* with about 99.5% (Balidy et al, 2005.) and other reported species include *Rhizophora mucronata* (Gove & Boane., 2001; Balidy et al, 2005), *Bruguiera gymnorrhiza*, *Ceriops tagal* and *Heritiera littoralis* (Dharani, 2002).

II.4 - Functions and uses of mangroves

Mangrove forests are among of the most productive and biologically important ecosystems of the world because they provide important and unique ecosystem goods and services to human society and coastal and marine systems.

According to the Millennium Ecosystem Assessment synthesis report (2006), they are four categories of environmental services, and mangroves perform almost all these functions namely:

- ***Regulating services*** (natural processes such as shoreline protection, atmospheric and climate regulation, human disease control, water processing, flood and erosion control);
- ***Provisioning services*** (goods and products that include wood and timber for cooking fuel, fish processing, salt production, charcoal, construction, and thatching);

- ***Cultural services*** (non-material benefits such as aesthetic value, recreation/tourism, sacred areas, ointments and traditional medicines); and
- ***Supporting services*** (natural processes that maintain other ecosystem services such as nutrient cycling, the provision of fish nursery habitats, sediment trapping, the filtering of water, and the treatment of waste).

Mangrove forests supplies a number of economically significant products including; timber, firewood, tannin, and honey. They help protect coral reefs, sea-grass beds and shipping lanes by entrapping upland runoff sediments. This is a key function in preventing and reducing coastal erosion and provides nearby communities with protection against the effects of wind, waves and water currents. They support the conservation of biological diversity by providing habitats, spawning grounds, nurseries and nutrients for a number of marine species and pelagic species (FAO, 2007), food and medicine for local communities (Giri et al, 2010).

Recent work on mangroves highlights the ecosystem benefits and ecological functions of coastal vegetation systems, including the carbon sequestration services provided by mangroves (Chevallier, 2013).

In Mozambique, mangroves are used for construction, firewood, charcoal production, tannins, fruit, fencing, fish traps and medicine. *Rhizophora mucronata* bark is used to dye fishing nets. Dugout canoes and beehives are made from *Avicennia marina* wood. Molluscs and crustaceans, such as mangrove crabs, *Scylla serrata*, mud creepers, *Terebralia palustris*, and shore crabs, *Matuta lunaris*, collected from mangroves represent an important source of protein for human populations in Mozambique, especially on Inhaca Island (Taylor et. al, 2003).

A mature mangrove forest also acts as a sediment trap, thereby assisting in the accretion of coastal sediments and further, adding to the protection of the low-lying inland areas. Mangrove forests also have a role in carbon sequestration with a capability of fixing an estimated 17 metric tonnes of carbon/hectare/year.

Further, economic benefits could be derived from mangroves through eco-tourism. There can be bird watching trips to observe rufous crab, hawk, and other uncommon birds of the coast, and intact stands of mangroves undoubtedly offer many opportunities for such activity.

Economic valuation figures suggest that the Matang mangroves in Malaysia provide timber and charcoal with a value of US$10 million ha^{-1} per year (Talbot and Wilkinson 2001 in UNEP-WCMC 2006). Annual commercial fish harvests from mangroves have been estimated from US$6,200 km^{-2} for the USA, US$60,000 in Indonesia to US$250,000 km^{-2} for managed mangroves of the Matang in Malaysia (UNEP-WCMC

2006). Economic valuation data on WIO mangroves is scanty and this may impair effective decision making by policy makers when choosing between conservation and development. Kairo et al (2009) identified major goods and services from a 12-year mangrove plantation as: firewood and building poles, coastal protection, ecotourism, research and education, carbon sequestration and on-site fisheries and estimated the net value of extractable wood products as at US$379.17/ha/yr. For non-extractable products, however, the net value ranged from US$44.42/ha/yr in carbon sequestration to US$1,586.66/ha/yr in coastal protection.

II.5. Natural Environment for Mangroves

Extensive development of mangrove occurs generally in the estuaries of large rivers flowing over shallow continental shelves. This development depends on a tropical climate, fine-grained alluvium, shores free of strong wave and tidal action, brackish water or saline conditions and a large tidal range. These factors influence the occurrence and size of mangroves, the species composition, species zonation, other structural characteristics and the functions of the ecosystem.
Light, temperature, rainfall and wind all have a strong influence on the mangrove ecosystem. Apart from playing a significant role in the development of plants and animals, they also cause changes in physical factors such as soil and water. Light is vital for photosynthesis and growth processes of green plants. It also affects the respiration, transpiration, physiology and physical structure of plants.

Tidal and wave action have a strong influence on the zonation of plant and animal communities and water salinity found within mangroves. Mangrove species are capable of tolerating only a certain degree of salinity. This tolerance of a saline environment varies with the species and several of them can withstand conditions of very high salinity.

Mangroves colonize sandy shores and corals, but the common soil substrates are clayey deposits. Mangrove soils are formed by the accumulation of sediment derived from coastal or river bank erosion or eroded soils from higher areas transported down along rivers and canals.

II.6. Mangrove vulnerability to ecological, climatic and anthropogenic factors

Global climate change specifically increases in temperature, sea level, and CO2, tropical storms, and precipitation, combined with anthropogenic threats such as conversion to agriculture, aquaculture, tourism, urban development and overexploitation, will threaten the resilience of mangrove ecosystems.

Rainfall changes are of greater significance to mangroves, particularly reduced rainfall, with drier coastal areas showing lower tree stature and biodiversity relative to humid

coastlines (Duke et. al, 1998). Reduced rainfall may change sediment inputs and salinity to affect productivity (Rogers et. al, 2005).
The intense rainfall has caused flooding, erosion and massive sedimentation.

Sea level rising will be affecting inundation period, productivity and sediment budgets to cause dieback from the seaward edge and migration landward, subject to topography, and human modifications (Ellison, 1993; Soares, 2009). Mangroves may adapt to changes in sea level by building peat and growing upward in place, or by expanding landward or seaward if adequate expansion space exists (Rodney et. al, 2008).

According to IPCC 2007, tropical storms are projected to be more intense in the future, with large peak wind speeds and more heavy precipitation. The species composition and structure of mangroves may change because of differences among species to tolerate storm waves and to regenerate (Roth 1997). Storm surges may flood mangroves, covering their aerial roots for prolonged periods, and cause them to drown (Ellison 2004). Tropical storms and floods have resulted in mass mortality in mangroves systems (Jimenez *et al.* 1985), thus compromising a mangrove systems ability to reorganize and recover (Rodney et. al, 2008).

In the last three decades, forest losses because of anthropogenic factors have increased significantly (Giri et. al. 2010). Mangrove habitats around the world have long been exploited for fuel, fishing and construction purposes, and have also been subject to various forms of pollution from industrial waste, mining, oil exploration and eutrophication. In the last decades, the conversion of large areas of mangrove for agriculture, aquaculture and urbanization has been largely contributing to the decline of this ecosystem.

The remaining mangrove forests are under immense pressure from clear-cutting, land-use change, hydrological alterations, chemical spill and climate change (Blasco et al., 2001). In the future, sea level rise could be the biggest threat to mangrove ecosystems (Giri et. al. 2010).

II.7. Impacts of mangrove dynamics on adjacent ecosystems and communities

Mangrove forests, seagrass beds, and coral reefs are tropical ecosystems that are highly productive, and provide many important biological functions and economic services. There are ecological interactions between these ecosystems that result from the mutual exchange of nutrients, organic matter, fish, and crustacean (Bosire, 2012).

Evidence of the connectivity between juvenile and adult habitats has been demonstrated by the faunal similarities between mangroves and seagrasses. The different life history stages of fish (egg, larvae, juvenile and adult) are often in distinctly different environments, requiring distinct resources and different ecological processes. De Troch et al (1996) established that some fish species within the mangroves were also found within nearby seagrass beds suggesting that many species of fish use mangroves for either feeding or shelter on a daily basis.

Some (economically important) species including fish and mud crabs have adopted a life strategy whereby they migrate from the coral reefs to seagrass beds and mangroves as they mature (Kimirei, 2012) indicating ontogenic habitat shifts. The shift in habitats from the adjacent coral reefs establishes a strong connectivity and energy transfer between the three ecosystems (Wakwabi, 1999).

There is also a social linkage between mangrove and community livelihoods. Traditionally, the coastal communities have depended on fisheries and mangrove exploitation for their livelihoods and income.

The socio-economic impacts of mangrove degradation include shortage of wood products, reduction in fisheries, as well as increased coastal erosion and the resilience of local people to climate change related effects.

The Zongoene hinterland bordering mangroves flood plain is steeper and observed land-use practices seem to be aggravating soil erosion and subsequent sedimentation downstream. As a result there may be continuous loss of the rich top soil leading to poor productivity which has significantly compromised the food security of the local people in the area.

Future impacts are projected to worsen as the temperature continues to rise and as precipitation becomes more unpredictable (Case 2006, IPCC 2007). One region of the world where the effects of climate change are being felt particularly hard is Africa (Mozambique) because of low economic development, dependence on agriculture as the mainstay of the economy and low institutional capacity (IPCC, 2001), thus mangrove degraded areas mapping is crucial for resources estimation and monitoring.

II.8 Mapping mangrove vegetation communities

Mapping vegetation is the identification of the distribution patterns of natural vegetation cover according to its spatial arrangement. Patterns, the spatial arrangement, texture and orientation of resources, refers to the shape and configuration (arrangement), size and spacing (texture) and direction (orientation) of resources (Anderson, 1982; Anselin, 1992; Robinson *et al*., 1995; ICRUM; 2006) and indicate location, spatial interactions, spatial structures and spatial processes at work, which order ecological communities (Wiens, 1989; Allen and Starr, 1982; Noss 1990; Anselin, 1992). Spatial arrangement can be natural or human, dispersed or concentrated. The natural arrangement is that resulted from the impact of topography, rainfall, hydrological fluxes while the human arrangement relates to the manmade objects such as plantations, urban development (Rydém and Chonguiça, 1994; Saket, Saket and Matusse 1994 and 1994).

Critical and often difficult task, of finding species distributions and assemblages is identifying the spatial scale at which those patterns occur (Sandler *at al.,* 1998), since they are many and vary accordingly to our capacities of detection (Spellerberg, 1991; Wiens, 1989). Thus, patterns of species distribution can be identified using GPS Real Time Tracking during field survey sampling and Remote Sensing Technologies.

In remote sensing the colors that appear on the satellite image reflect the various spectral levels recorded by the sensor (Robinson et al., 1995). These spectral levels can be understood using both digital and visual interpretation (Moreira, 2001) for low and higher spatial resolution satellite imagery, respectively.

In visual interpretation, the combination of colors may denote the structure and types of vegetation and vary according to the season. The evergreen leaf are depicted in the band 5 of Landsat TM in red or dark red while the deciduous forests are represented by red in March/April imageries and dark brown or red in July/August imageries of TM5 (Steven et al. 1990).

The grassland in the wet season is represented by a bright red to light red and when there is insufficient soil organic matter appears to bluish white (Saket and Matusse 1994).

The mangrove vegetation cover due to its almost constant reflectance of radiation throughout the year is very distinct from the surrounding vegetation types. In many cases, mangrove appears in TM5 images represented by dark red color (FAO, 1994).

In higher spatial resolution imageries (Quickbird, Ikonos) mangrove vegetation cover appears in green color, arranged in mosquito texture along estuarine brackish waters.

However, studies show that visual interpretations based on the colors are difficult to interpret because they depend not only by physical factors but also on physiological and psychological human factors (Junior, 1998 and Moreira, 2001).

Moreira (2001) illustrates the latter situation through correspondence between the wavelength and color, in which blue (1 = 440 nm); Green (1 = 550 nm) and red (1 = 700 nm). It also shows that for example all electromagnetic radiation located between 400 and 500 nm cause sensation of blue color in the human brain, although pure blue color (monochrome) is that of a wavelength of 440 nanometers (nm).

Rimsten (1994) stresses the influence of physical factors and refers that the same mangrove vegetation communities can appear in different colors depending on its spatial location. Da Silva (2005) when comparing the spatial location of open scrub vegetation and coconut palms in areas under the influence of salt water found that had the dark red color the same as mangrove vegetation cover in Landsat TM5.

Junior (1998) shows that the difference between the crown of the tree layers results in different color intensities and variations in the intensity of the color are a consequence of the objects patterns, for example vegetation may take various sizes, spacing and this will cause a secondary color.

To minimize difficulties arising from the visual interpretation based on colors, the combination of visual interpretation elements such as shape, pattern, density, slope, position, proximity and digital interpretation is made. Such elements are validated in the field using spatial sampling framework.

III. MATERIALS AND METHODS

III.1. Study Area

Limpopo basin estuary is located in Zongoene between latitude 25º 18’ and 25º 48’ S and Longitude 33º 19’ and 33º 48’ E, south of Xai-Xai District, Gaza province (**Figure 3**. The climate is humid tropical and characterized by two distinct seasons, with a hot and rainy, occurring from November to March and cold and drought that occurs from April to October (Boane & Gove, 2001). The precipitation range between 500-600mm/annum and the soils are mostly alluvial to sand-clay loan on front dunes which support extensive grain production as well as vegetables.

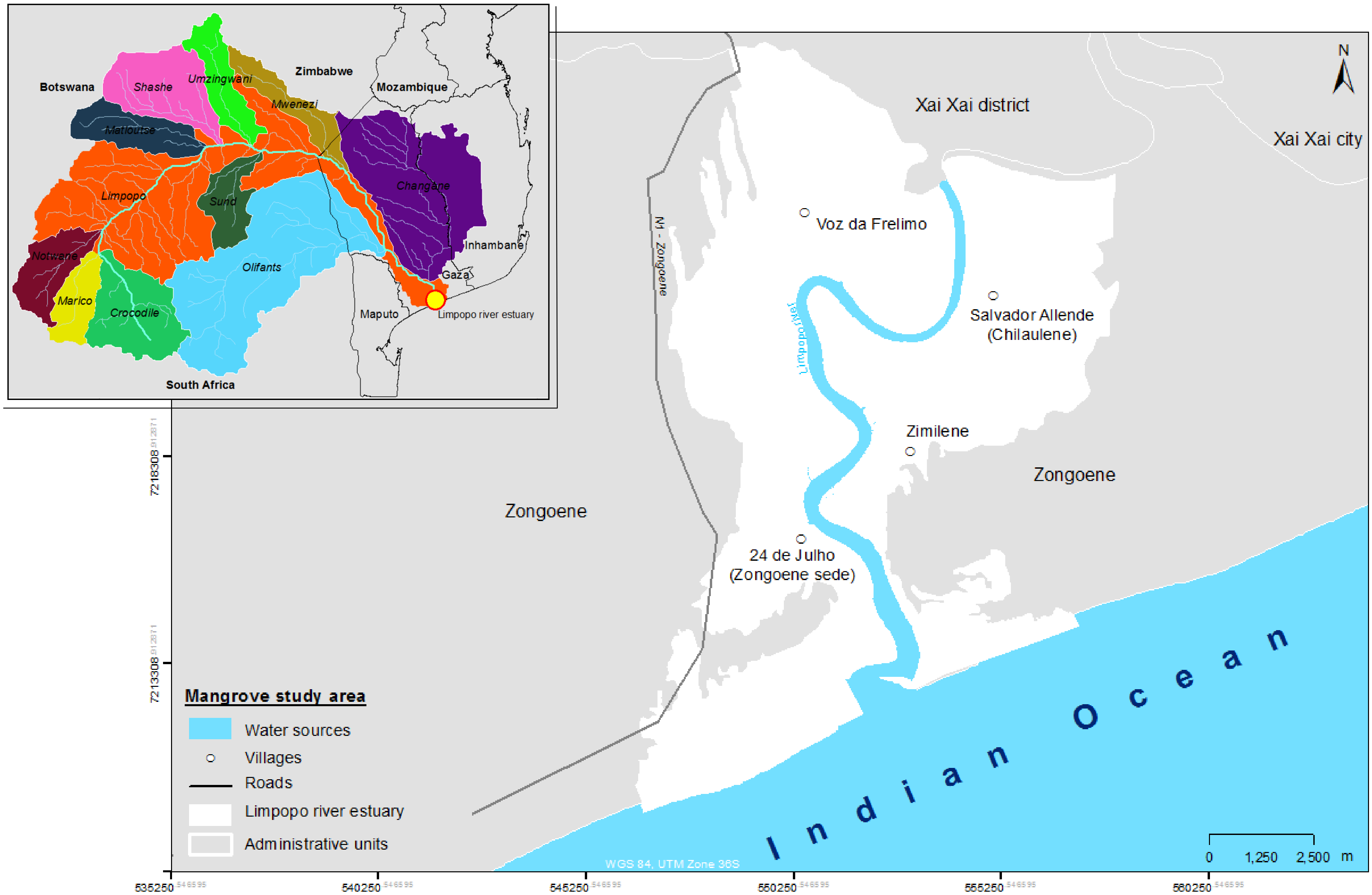


Figure 3: Limpopo basin estuary location

Table 1: Activities and milestone's verification

	Activities	Milestone's verification
		Goal 1: Mangrove cartographic database
1	1.1. Coordinate data collection activities 1.1.1.mapping; *by means of quick bird and aerial photos, participatory mapping, quadrats and GPS Real Time Tracking Technology*; current mangrove vegetation communities and associated mangrove biodiversity; 1.1.2.visual and digital interpretation of Quick bird satellite imageries (2014) and aerial photos (2005) in order to obtain mangrove communities status (degraded, dispersed and dense) 1.1.3. mapping, by means of Quick bird satellite imagery interpretation and GPS Real Time Tracking Technology, mangrove adjacent land cover/ land use in 2014; 1.1.4.mapping, by means of visual and digital interpretation of Quick bird satellite imageries (2014) and aerial photos (2005), the flow patterns in 2005 and 2014; 1.1.5. Compilation of mangrove cartographic database	1.1. Map of mangrove vegetation communities and associated biodiversity ▪ Mangrove vegetation communities zonation ▪ Area and size of mangroves ▪ Presence (type) and absence of species ▪ Abundance of species ▪ Dominance of species ▪ Diversity of species 1.2. Map of mangrove vegetation communities status (2005 and 2014) ▪ Degraded mangrove (area previously populated by mangrove and nowadays influenced by flow patterns. In this category also included mangrove under regeneration and replantation)) ▪ Dispersed mangrove (mangrove under stress or with low regeneration rates, patches of bare soil are mixed with mangrove vegetation communities) ▪ Dense mangrove (mostly dwarf mangrove) 1.3. Map of water flow patterns (main river, channels, fish ponds, lakes, flood plains) 1.4. Map of mangrove contiguous land cover/use Land cover ▪ Coastal dunes vegetation ▪ Primary dunes ▪ Non mangrove trees ▪ Grassland ▪ Water sources Land uses ▪ Settlements ▪ Agriculture ▪ Fish ponds ▪ Aerodrome

		Goal 2: Historical and current information about mangrove cover change
2	2.1. Production of maps on mangrove location, distribution, patterns and densities (2005 and 2014) 2.2.Comparing mangrove spatial indicators (location, distribution and extent) in Quickbird imageries and aerial photos of 2014 and 2005, respectively; 2.3. Estimation on mangrove change rate in Limpopo Basin Estuary 2.4. Analyse the factors behind mangrove dynamics in different spaces	2.1. Map of mangrove location, distribution, patterns and densities in 2005 and 2014 2.2. Map showing the spatial correlation of mangrove indicators (location, pattern and extent) in 2005 and 2014 2.3. Tables and charts on mangrove biostatistics ▪ Mangrove extent (2005 and 2014) ▪ Mangrove recovering rate (2014) ▪ Change rate (2014 to 2005) ▪ Relative change rate ▪ Annual change rate
		Goal 3: Purpose the criteria for mangrove restoration in Limpopo Basin Estuary
3	3.1.Examination of the factors behind mangrove dynamics in different spaces 3.2.Identification and characterization of the current mangrove degraded areas 3.3. Criteria for mangrove restoration in Limpopo Basin Estuary	3.1. Map of mangrove degraded areas (bare land, natural regeneration and replantation) 3.2. Extent of mangrove degraded areas 3.3. Charts, adjusted R square between mangrove degraded areas and physical and anthropogenic factors 3.4. Map of mangrove suitability analysis
4	4.1. Presention of the preliminary report in Zongoene 4.2. Edition of the scientific quality to the final report	4.1. Presentation of the preliminary report in Zongoene 4.2. Editing of the scientific quality of the final report 4.3. Submission of the final report

Source: authors based on the scope of the project

III.2-Sampling and sampling frame

Integrated spatial sampling was used to achieve the results of this study. Integrated spatial sampling consisted on survey of mangrove vegetation, adjacent land cover and land use and mangrove associated biodiversity in the Limpopo basin estuary to ensure the mangrove cartographic database. Transects, GPS, Base maps and Plots/subplots were also combined in order to provide mangrove location, distribution, density and species composition. Belt transects (91.674 to 1,589 meters) running perpendicular to the shoreline and pre-determined sites from quick bird satellite imageries of 2014 were used to ensure representativeness of the samples.

Mangrove vegetation cover plots of 10x10m separated in a distance of 75 m from each plot were used during the low tide for sampling mangrove vegetation communities. In each plot of 10x10m, a random subplot of 1x1m was positioned in order to estimate the mangrove associated fauna, and observations were made to identify species occurring in the mangrove subplot. GPS coordinates were taken in each plot as shown on **plate 1**.

Plate 1: integrated spatial sampling of mangrove. The plate shows different materials and methods used in capturing mangrove realm in the Limpopo basin estuary. Scientists of diverse fields such as geography, mangrove ecology, mangrove environment, indigenous mangrove knowledge were joined to discuss and map the unique remained mangrove patches in Zongoene. Knowledge sharing remarked daily sessions of field mangrove samples.

Quick bird satellite images of 2014 were validated by means of GPS Real Time Monitoring Platform that integrated the satellite signals, pre- classified imageries, base map and the field mangrove reality and at once displayed in a mini-computer laptop.

Geographic interoperability helped us in delineating the confusing mixed categories of mangrove and non-mangrove trees. For example, dispersed mangrove had the same spectral signals as of *Acacia xanthophloea; Phoenix reclinata and Phragmites autralis (*see plate 2*).*

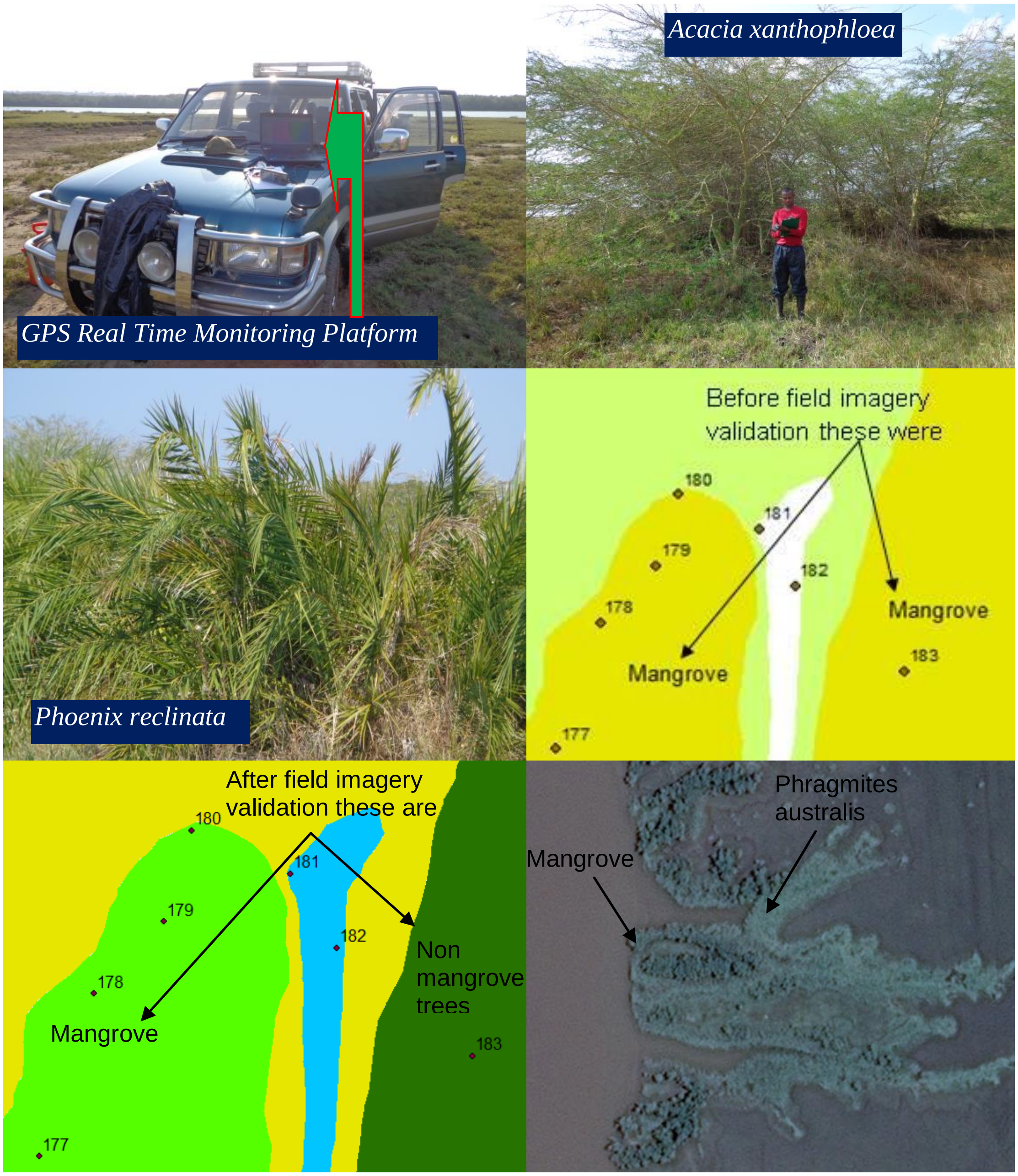


Plate 2: Mangrove habitat alteration is mainly characterized by emerging new mangrove associated plant species that emit spectral signals similar to mangrove. This needed integrated field imageries validation.

Pattern and composition of natural regeneration and replantation in the degraded mangroves were assed using linear regeneration techniques (plate 3). GPS track tool was used to record the replantation area. The recovering mangrove area mixed with old disperse mangrove trees was detected using its patchy mud spectral reflectance and spatial location. The presence of negative spectral signals mixed with higher positive normalized difference vegetation index (NDVI) was used to map the poor regenerating status of mangrove.

Sites of mangrove vegetation cover recovery within the degraded mangrove sites were digitalized in the field in order to avoid physiological errors. Because manual linear correlation could decrease the accuracy of the results, GPS data was downloaded and transformed to KML (Keyhole markup language) and later integrated into Google Earth for validation of the mangrove recovery polygons, tides inundated areas and grassland river banks (plate 4). Dead/cut trees were counted in each plot of 10 x 10 m to access the degradation rate. A GPS coordinate was taken in each recorded plot center. Father degradation rate estimators such as the size of the cut/dead mangrove trees were accessed in order to determine the severity of the degradation and its spatial variation as shown on plate 4.

Plate 3: mapping of degraded mangrove area (natural regeneration and replantation) still challenging when it comes to comparing the costs of higher resolution imageries and field samples intensification. The issue behind mapping these areas is mixed spectral signals of bare soils and small sparse mangrove plants.

Mangrove surface sampling in dense, disperse and degraded sites where taken based on three sediment cores randomly taken using a hand corer to a depth of 5 cm into the soil at low tide. Samples were located using a GPS in each plot, and later were weighed and dried at 105 C for 24 hours for analyses of soil texture and percent organic matter. Water salinity, pH and temperature were measured in each plot, using a multimeter placed in a hole in which water were left to accumulate during the surface sampling.

III.3- Cartographic database design and implementation

Secondary data were collected according to various geopolitical institutions and mangrove geodatabase needs attributes as shown on **table 2**:

Table 2: mangrove cartographic database sources

Type of data	Source of data
Topographic maps and DEM	CENACARTA (National Center of Remote Sensing)
Administrative boundaries	MAE (Ministry of State Administration)
Quick bird satellite imagery (2014) and aerial photos (2005)	CDS- Xai Xai, CENACARTA, GEO DATA DESIGN AND GOOGLE EARTH
Meteorological data	INAM (National Institute of Meteorology)
Tides, hydrologic and bathymetric data	DNA (National Directorate of Water)
Sediments and soils	IIAM (National Institute of Agro Research)
Socio-economic data	Questionnaire Survey (CDS Xai-Xai)

Source: authors based on visited geopolitical institutions

Questionnaire survey was also administrated to 242 households distributed unequally in Salvador Allende 98 (40.5%), Zimilene 62 (25.6%), Voz da Frelimo 46 (19.0%) and 24 de Julho 36 (14.9%). Results on questionnaire survey where codified, digitized and mined in SPSS (Statistical Package for Social Sciences) (see appendix 1). Charts and cross tables where processed and then joined to spatial data for analysis.

Mangrove Cartographic Geodatabase design and creation was compiled considering the structure, the diagrams illustrating, the data base logical groups and the unified modelling language.

III.4- GIS and statistical analyses

Mangrove location, distribution and extent were based on imagery interpretation based on interactive supervised classification methods and visual interpretation validated in using the google earth and the field survey sampling. Imagery classification was extensive to mangrove adjacent land use/cover. The Normalized Difference Vegetation Index-NDVI (a measure of photosynthetic status) was computed and categorized in 3 classes (degraded, dispersed and dense) to reflect different status of mangrove. Overall data was extracted, converted and integrated into the geodatabase. Within the same feature dataset shapefiles were projected to WGS 84 UTM Zone 36S and topologically validated to ensure the relationships between spatial entities. Mangrove patches, mangrove degraded patches, mangrove regenerated patches, mangrove dense area and land use/cover shapefiles extent calculation was based on calculate geometry tool present in ArcGIS ArcInfo 10.

Calculation on mangrove change rates was based on 2014 year using the estimators applied by FAO (1994), Saket and Matusse (1994) and later by De Boer (2000), where:
The change rate (T_{Dt1et2}) is the sum of the recovery rate of the compare year ($Area_{rejt2}$) with the difference between the area in 2014 ($Area_{t2}$) and 2005 ($Area_{t1}$).

$$T_{D_{t_1}et_2} = Area_{t_2} - Area_{t_1} + Area_{rej_{t2}} \quad (1)$$

The relative change rate ($TM_{t1\ et2}$) between 2005 (t_1) and 2014 (t_2) is the partition between the degradation rate and the mangrove cover area in 2014 (t_2).

$$TM_{t_1et_2} = \frac{T_{D_{t_1}et_2}}{Area_{t_2}} * 100\% \quad (2)$$

The period separating the two years in duty (T_{t1et2}) is the difference between 2014 (t_2) and 2005 (t_1).

$$T_{t1et2} = t2 - t1 \quad (3)$$

Thus, the annual change rate on mangrove (TM_{anual}) is the partition between the relative change rate between 2005 (t_1) and 2014 (t_2) taking into consideration the time that splits the two years in analysis (T_{t1et2}).

$$TM_{anual} = \frac{TM_{t_1et_2}}{T_{t_1et_2}} \quad (4)$$

However, various scale levels influence on different mangrove change rates. On a larger scale Landsat imageries was not able to detect small degraded patches of mangrove that cumulatively influence on large mangrove dynamic. Thus a cocktail of different spatial resolutions of satellite imageries provides detailed results and higher accuracy which in turn helped in better decisions making towards improvement of our conservation measures. Thus, spatial correlation and comparative analysis based on

the same scales and control geographic sites were used in satellite images of 2005 and 2014 for the case of comparisons.
The comparison was based on satellite images of 2005 and 2014 with reference to selected locations and along with homogenous mangrove species. In that regard was important to note that during the comparison was not enough to say that there was a reduction in 0.07%. This was added by the term in benefit of grassland, agriculture for example. Such kind of short reports helped us on production and interpretation of land cover land use change linkages, important information needed to set management measures.

Degradation rate classification was based on three classes (low, moderate and severe) depending on the size of the patchy. The attributes of each category where provided by means of identity tool used to overlay different maps. The significance of the degradation rate between geographic sites was tested using a t-test.

Proximity analysis such as buffer, near distance helped on analysis of the linkages between mangrove degradation and the location of adjacent land cover/use or other independent factors (altitudinal gradients, slope, flow pattern, tidal heights, temperature, socio-demographic data). The linkages were weighted in an uninterrupted combination in order to find out control variables and priority areas for intervention.

Thus, from data on proximity analysis multiple regression analysis (linear and nonlinear) where r (spearman coefficient of correlation) R square (coefficient of multiple determination) and Adjusted R square (standardized R square based on the sample size and degrees of freedom) were computed in SPSS (Statistical Package for Social Science). This helped us to know whether the distribution of mangrove degradation area vary over a range of values of the different independent parameter (land use/land cover, altitudinal gradients, slope, flow direction and accumulation, rainfall, temperature, tide heights, hydrology, sediments parameters, socio-economic variables). In addition, Adjusted R square denoted how much any factor explains the variability on another.

Care was taken in interpreting adjusted R square, as a casual relationship is not necessary implied; the underlying, causal agent governing the mangrove degradation distribution could be a different factor. For instance, the mangrove degradation distribution in Zambeze Delta river may be more strongly related to the availability of fresh water than to the presence of salt water filling the Zambezi river during drought times (Da Silva, 2005). In that respect, once it was discovered that, for example, sedimentation is the factor of core mangrove degradation; further multivariate regression analysis and Analysis of Variance (ANOVA) were performed in order to understand which sediment parameter is most important. Further the factors related to the influencing cause were computed.

The use of parameters description, multiple regression analysis and analysis of variability of different factors affecting mangrove in different sites helped us to identify site critical factors and the recommend smart mangrove species. For example, for areas were the critical factor was brackish water availability, the mangrove species such as *rhizophora mucronata* were not recommended for replantation. In areas were the density of crabs was higher, management measures such as shown on **plate 4** were recommended.

Plate 4: successful mangrove replantation depends on critical factors analysis and a design of quality and low cost management technologies was urgent for tackling the density of crabs, availability of water as provided by tidal inundation, river banks, grassland utilization by cattle.

IV. RESULTS

IV.1-Mangrove vegetation communities

Mangrove in the Limpopo basin estuary is found within a relative distance of 15.96 km from the south patchy to north patchy, on proximities of Limpopo River and effluents. Along the main river, mangrove vegetation is located in V shaped areas in a total number of 8 interrupted homogeneous patches viewed at the scale of 1:1000 (**see figure 4**). Three distinct mangrove communities can be identified in mangrove areas of Limpopo basin estuary:

- Dispersed mangrove: Tall and old mangrove trees, located near (2 to 500 meters) of the Limpopo river margins;
- Dense mangrove: mostly dwarf, found above 500 meters of the main river;
- Regeneration: New seedlings, ranging from 0.5 to 1 meter high.

In 2014, the major mangrove patchy is found in 24 de Julho village (5,825 meters from the Indian ocean) and its size is about 136.1692 ha while the smallest patchy measures 0.015321 ha and its located in Zimilene village within a distance of 6,226 meters from the Indian ocean (see **figure 4**).

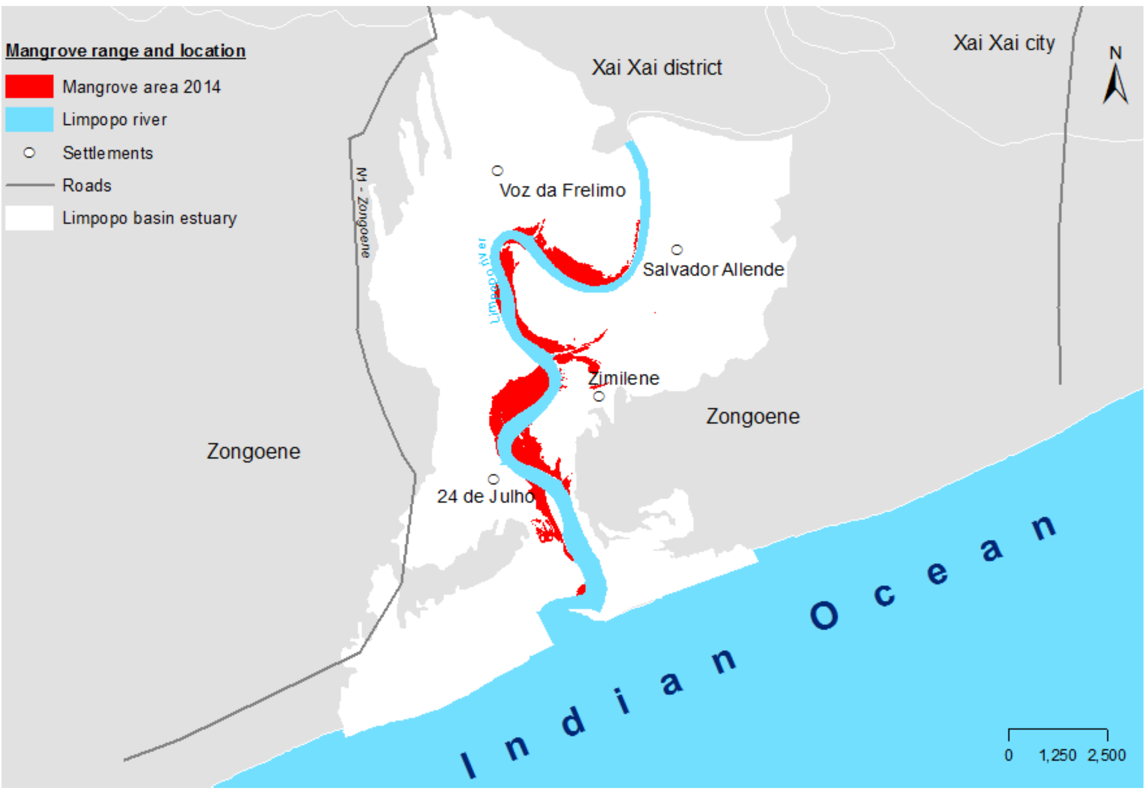


Figure 4: Mangrove location, range and distribution in Limpopo basin estuary

IV.2 - Vegetation Structure

Five species of mangrove were recorded in Zomgoene basin estuary: *Avicennia, marina, Rhizophora mucronata, Ceriops tagal, Brugiera gymnorhiza, and Xylocarpus granatum*. The last three species were mostly found in reforestation areas of Zimilene (Mahielene) community, in a juvenile stage as shown on t**able 3.**

Table 3: Mangrove species found in the Limpopo basin estuary

Mangrove species	Sampling site
Avicennia marina	24 de Julho and Zimilene
Rhizophora mucronata	24 de Julho and Zimilene
Bruguiera gymnorrhiza	Zimilene
Ceriops tagal	Zimilene
Xylocarpus granatum	Zimilene

Source: Field work, 2014

The most abundant specie was *Avicennia marina* with 566 trees, which represent 93% of the all trees measured and the least abundant species was *Xylocarpus granatum* with 1 tree, representing 0.2% of all trees measured (**figure 5**).

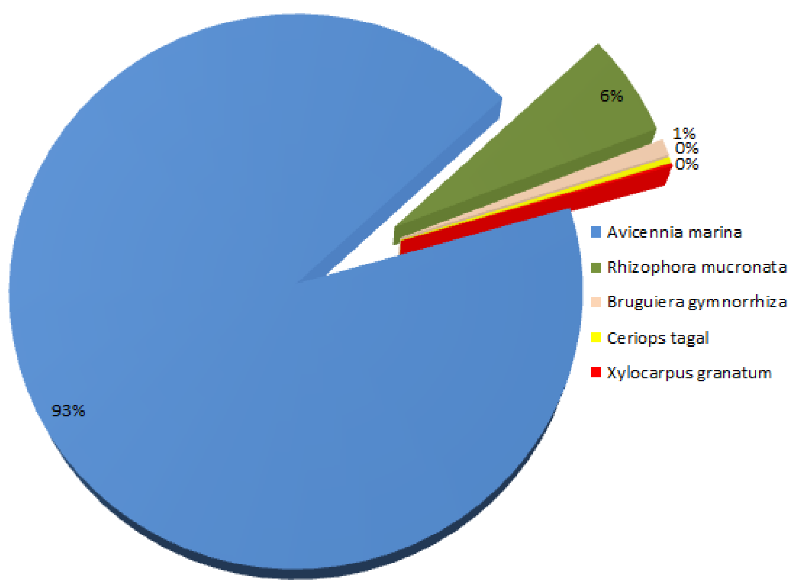


Figure 5: Distribution of sampled mangrove species in Limpopo basin estuary

These findings confirm previous descriptions of species abundances in Limpopo basin estuary (Jose, 2009; Balidy *et. al*, 2004). A summary of patterns of occurrences is presented in **table 4.**

Table 4: Patterns of occurrence of the five mangrove species in Limpopo basin estuary

Family	Species	Sampling sites: 24 de Julho N/ha	Sampling sites: Zimilene N/ha	Total	Percentage (%)
Avicenniaceae	*Avicennia marina*	362	204	566	92.5
Rhizophoraceae	*Rhizophora mucronata*	23	14	37	6.0
Rhizophoraceae	*Bruguiera gymnorrhiza*	0	6	6	1.0
Rhizophoraceae	*Ceriops tagal*	0	2	2	0.3
Meliaceae	*Xylocarpus granatum*	0	1	1	0.2
Total		**385**	**227**	**612**	**100.0**

Source: Field Survey, 2014 N=Number of trees; ha=hectare

Tree height and diameter were only measured for the two most abundant species (*Avicennia marina* and *Rhizophora mucronata*) given that the other three species (*Bruguiera gymnorrhiza, Ceriops tagal* and *Xylocarpus granatum*) were not representative and occur in a juvenile stage.

The distribution of the diameter at breast height (DBH) was skewed to the small classes in Zimilene. In all plots, both *Avicennia marina* (10.1~15cm), and *Rhizophora mucronata* (0~5cm), exhibited the lowest DBH compared to 24 de Julho. The DBH of all sampled trees showed reverse J-shaped distributions (**figure 6**).

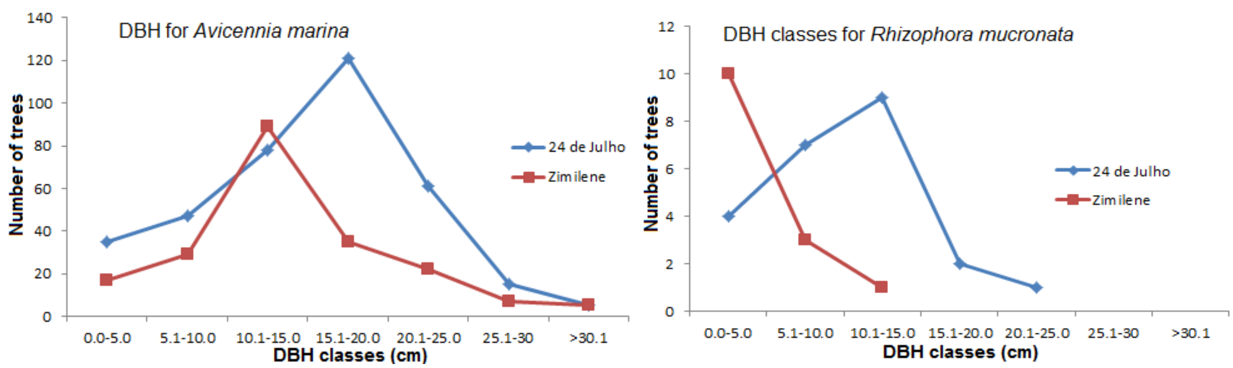


Figure 6: frequency distribution of the diameter at breast height (DBH) for *Avicennia marina* and *Rhizophora mucronata* classed in all sampled plots.

The frequency distributions for H of *Avicennia marina* showed normal distribution and were slightly skewed to the small (2.1~3.0) and medium (3.1~4.0 m) classes and *Rhizophora mucronata* was skewed to the smallest classes of 1~2.0 m (**Figure 7)**.

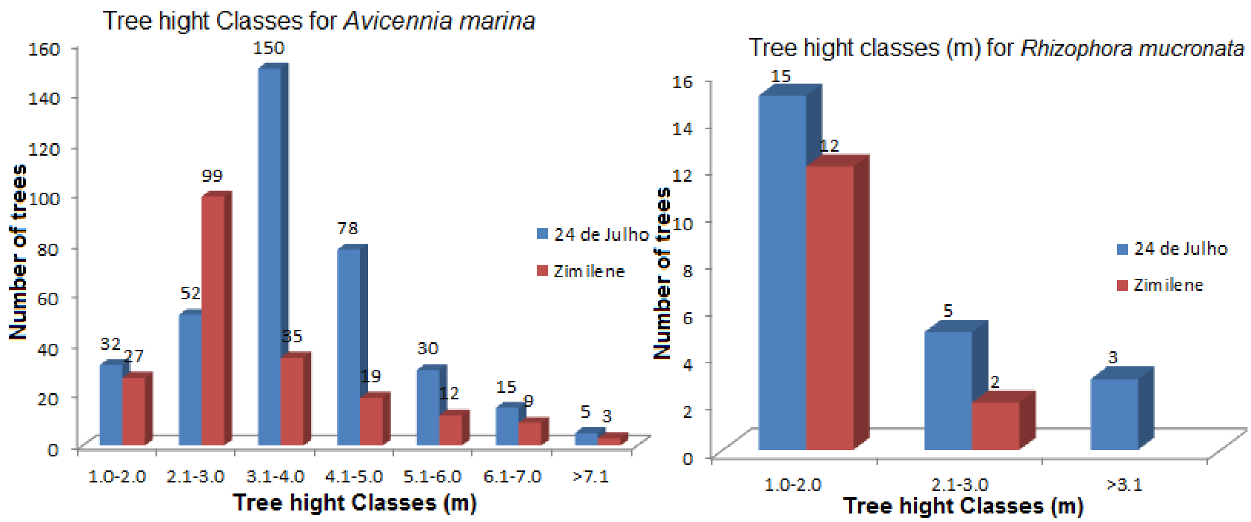


Figure 7: frequency distributions of the tree height (H) for *Avicennia marina* and *Rhizophora mucronata* classed in all sampled plots

IV.3 - Mangrove fauna

More than 120 species of fish belonging to 52 families have been recorded from estuarine waters of Limpopo basin. The Carangidae, Cerranidae, Sparidae, Lutjanidae and Sciaenidae are the most representative (see f**igure 8**), contributing to local fishery. Common fish species include *Caranx heberi, Leiognathus equulus* and *Secutor insidiator*.

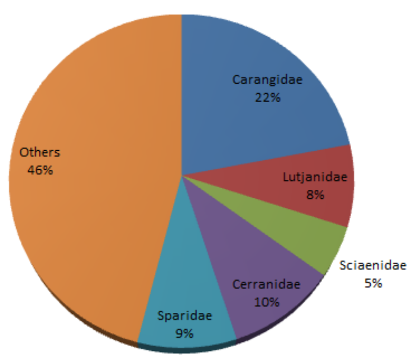


Figure 8: fish catch composition in Limpopo basin estuary

Mangrove associated fauna in Limpopo basin estuary also include crabs and molluscs. Upper zones are inhabited by marsh crabs, *Sesarma spp*., and closer to shore fiddler crabs, *Uca spp*., are dominant. Giant mud crabs, *Scylla serrata*, hermit crabs, prawns and shrimp are all mangrove residents in Limpopo basin estuary.

Fiddler crabs in particular play an important role in the cycling of nutrients in mangrove ecosystems as they feed on detritus or micro-organisms living on detritus. Giant mud crabs predate on molluscs and smaller crab species and are harvested for food.

Filter feeders such as rock oysters, *Saccostrea cucullata*, and barnacles, *Balanus amphitrite*, secure themselves to lower stems or pneumatophores in lower intertidal areas, enabling them to filter plankton and nutrients from surrounding waters.
Mud creepers, *Terebralia palustris*, mud whelk, *Cerithidea decollata*, and *Strombus spp*. are all mangrove molluscs as it's shown in Plate 5.

Plate 5: Common mangrove associated fauna in Limpopo basin estuary

When villagers were asked if they have seen some mangrove associated fauna, within 242 (100.0%) about 208 (85.95%) responded to this question.

Among 208 (85.95%) respondents, Crab and shrimp 134 (54.03%) were the most seen in mangrove area and unequally distributed. About 49 (23.56%) were observed in Salvador Allende mangrove patches; 40 (19.23%) in Zimilene; 23 (11.06%) in 24 de Julho and 22 (10.58%) in Voz da Frelimo (**see table 5**).
Shrimp 39 (15.73%) was more expressive 22 (10.58%) in Salvador Allende (Chilaulene); 8 (3.85%) in Zimilene; 7 (3.37%) in Voz da Frelimo and 2 (0.96%) in 24 de Julho. While *crabs* 14 (6.73%) represented 6 (2.88%) in Salvador Allende; 3 (1.44%) in 24 de Julho (Zongoene sede) and 2(0.956%) in Zimilene (**see table 5**).

Table 5: village distribution of mangrove associated fauna

	24 de Julho	Salvador Allende	Voz da Frelimo	Zimilene	Total
Crab	3	6	3	2	14
Percent	1.44	2.88	1.44	0.96	6.73
Caridean shrimp	2	22	7	8	39
Percent	0.96	10.58	3.37	3.85	18.75
Mussel	0	1	0	0	1
Percent	0.00	0.48	0.00	0.00	0.48
Crab and shrimp	23	49	22	40	134
Percent	11.06	23.56	10.58	19.23	64.42
Crab and mussel	0	1	3	0	4
Percent	0.00	0.48	1.44	0.00	1.92
Shrimp, Lobster and Crab	3	2	0	3	8
Percent	1.44	0.96	0.00	1.44	3.85
Crab, shrimp and mussel	0	4	0	0	4
Percent	0.00	1.92	0.00	0.00	1.92
Shrimp and mussel	0	1	0	1	2
Percent	0.00	0.48	0.00	0.48	0.96
Crab, shrimp, lobster and mussel	1	0	0	0	1
Percent	0.48	0.00	0.00	0.00	0.48
Crab and Lobster	0	0	0	1	1
Percent	0.00	0.00	0.00	0.48	0.48
Total	32	86	35	55	208
Percent	15.38	41.35	16.83	26.44	100.00

Source: CDS-Questionnaire Survey 2014

As it's shown in table 6, *crab* and *shrimp* are the more abundant mangrove associated species in Limpopo basin estuary particularly in Salvador Allende. Concurrent villages to such abundant species distribution are Zimilene and 24 de Julho. The spatial distribution variability of mangrove associated fauna might be related to the status of mangrove vegetation communities.

IV.4-Mangrove vegetation communities status

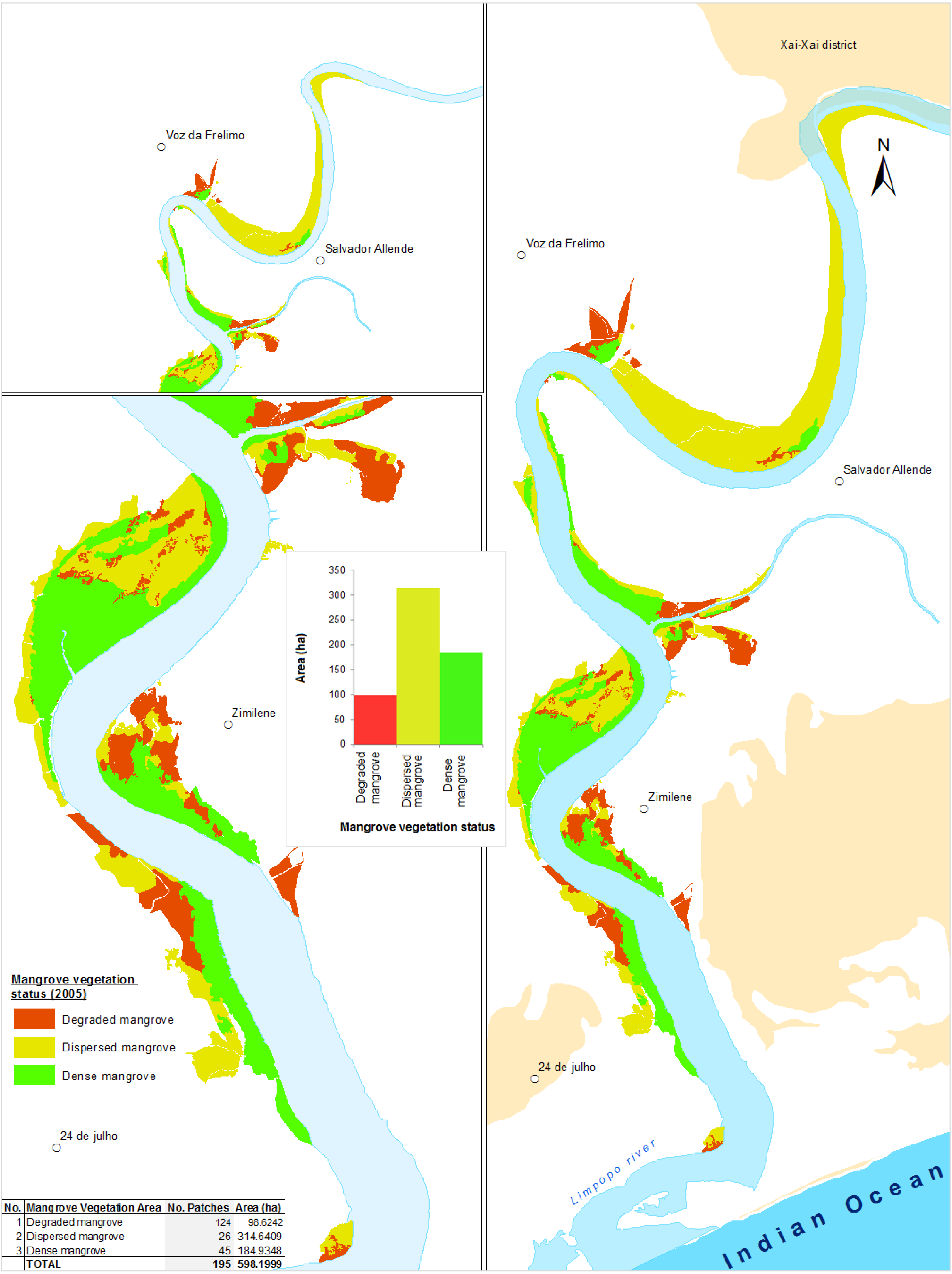
Mangrove vegetation communities status varied from degraded, disperse and dense with clear trend to poor conservation status (**see table 6, figures 9 and 10**).

Table 6: Mangrove vegetation community's status (2005 and 2014)

		Status of mangrove community			
		2005		2014	
No.	Status category	Patches	Area (ha)	Patches	Area (ha)
1	Degraded mangrove	124	98.6242	735	133.3399
2	Dispersed mangrove	26	314.7613	8	269.6789
3	Dense mangrove	45	184.9348	11	62.6635
	TOTAL	**195**	598.3203	754	465.6823

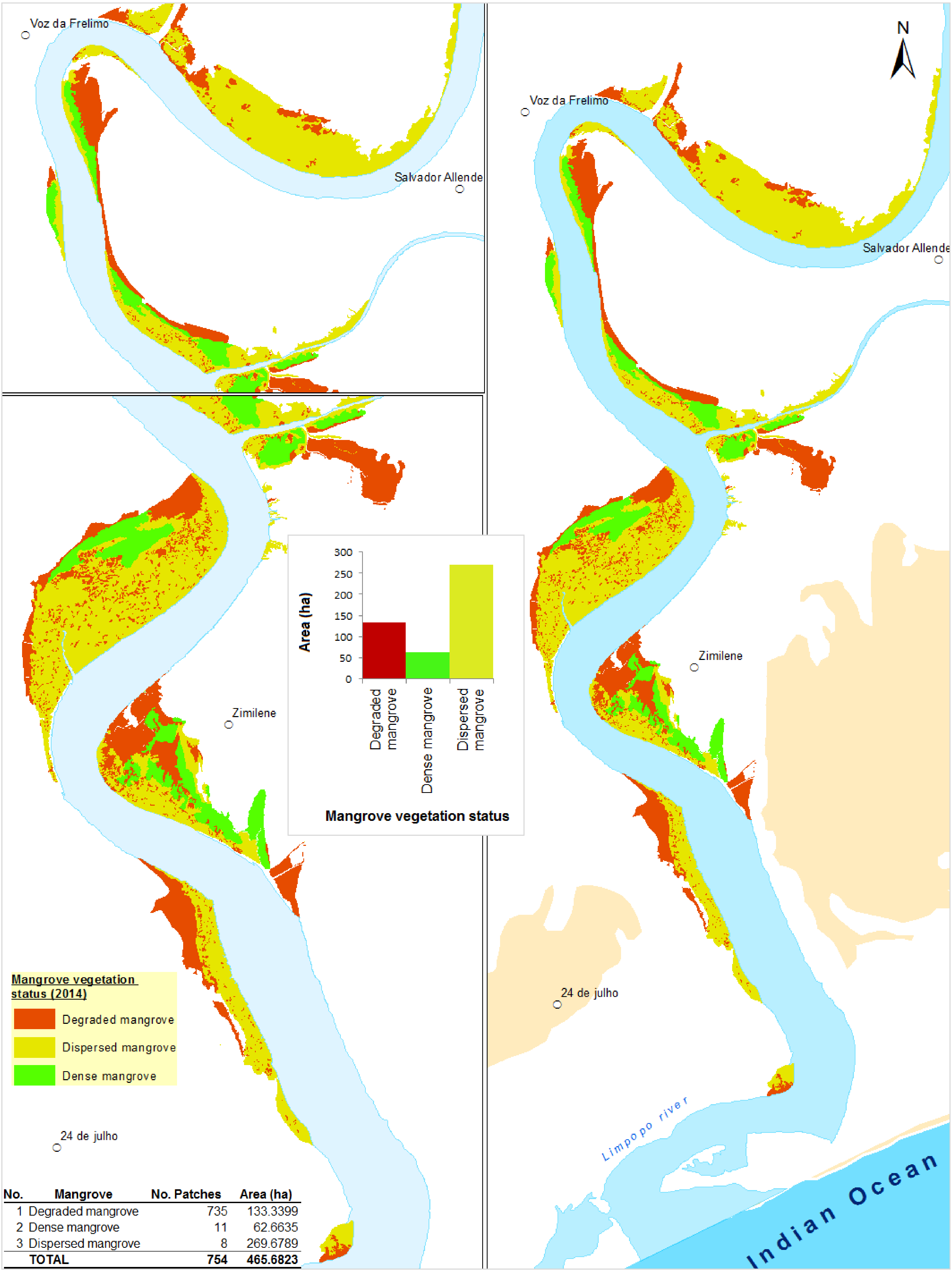
Source: aerial photos (2005) and Quickbird imagery (2014)

Figure 9: Mangrove vegetation status distribution in 2005



No.	Mangrove Vegetation Area	No. Patches	Area (ha)
1	Degraded mangrove	124	98.6242
2	Dispersed mangrove	26	314.6409
3	Dense mangrove	45	184.9348
	TOTAL	195	598.1999

Figure 10: Mangrove vegetation status distribution in 2014



No.	Mangrove	No. Patches	Area (ha)
1	Degraded mangrove	735	133.3399
2	Dense mangrove	11	62.6635
3	Dispersed mangrove	8	269.6789
	TOTAL	754	465.6823

In 2005, mangrove area was 598.3203 ha, majority composed by disperse mangrove (314.7613 ha), dense mangrove (184.9348 ha) and degraded mangrove (98.6242 ha). After approximately 9 years, mangrove conservation status showed new and less figures (465.682 ha), being disperse (269.6789 ha), degraded (133.3399) and dense (62.6635 ha). Among these figures, special attention is given to the presence of large mangrove patches (8 dispersed patches) within interior irregular patches (735) of degradation.

- Degraded mangrove was classified as the area previously populated by mangrove and actually (2014) still influenced or not by a large tidal amplitude. Degraded mangrove includes: 1-bare land, 2-replantation and 3- recovering. The density of mangrove varies from 0 (bare land), 7 plants/m2 (replantation) and more than 27 plants/m2 (recovering) as shown in **plate 7**.

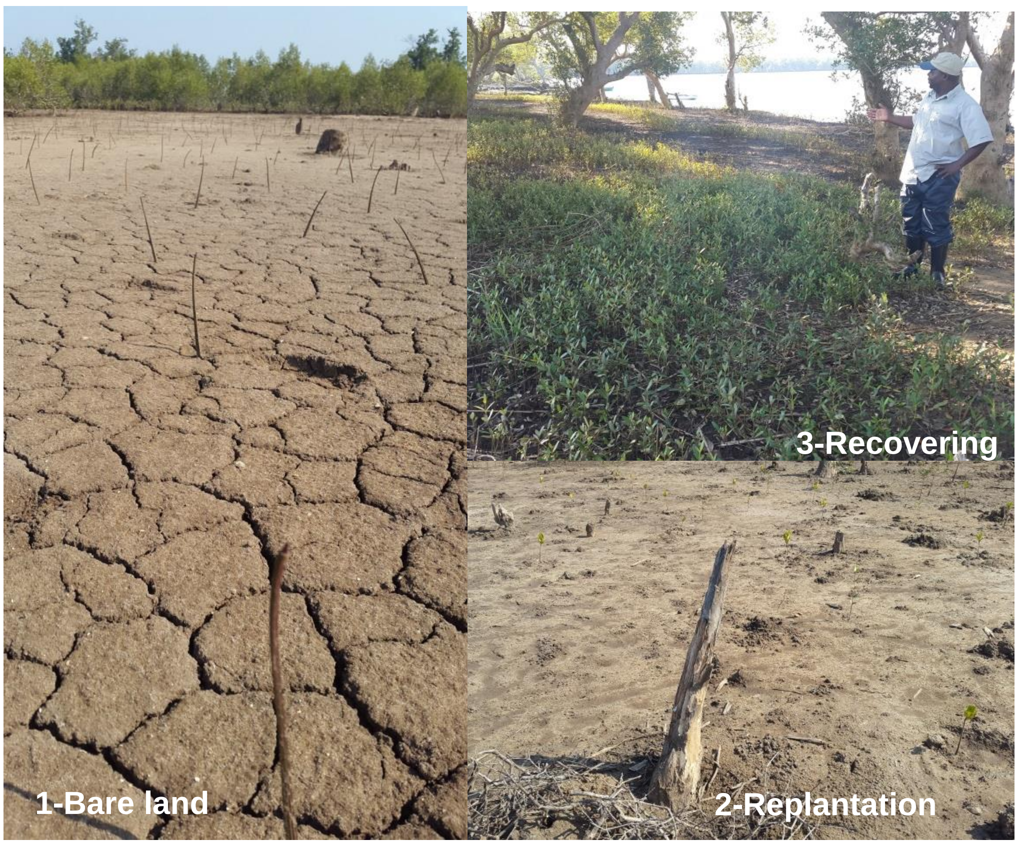


Plate 6: Degraded mangrove area lost its critical landscape-level functions related to the regulation of fresh water, nutrients, and sediment inputs into the intertidal mangrove forest wetlands, in that regard this category is red colored in our maps and charts.

Within a total mangrove forest area (598.1999 ha) about 124 patches of degraded mangrove area represented 16.49% (98.6244 ha) in 2005. Nine (9) years past, the same category occupied about 735 patches representing 28.63% (133.3399 ha) of the total mangrove area (**465.6823** ha) in 2014.

Degraded mangrove area has a clear spatial and temporal variability.

In 2005, the community of Zimilene had 48.6827 ha degraded, 24 de Julho (24.4554 ha), Voz da Frelimo (16.6757 ha) and Salvador Allende (8.8103 ha). After 9 years, Zimilene continued with higher mangrove degraded areas (47.7746 ha), 24 de Julho (44.4250 ha), Salvador Allende (27.1223 ha) and Voz da Frelimo (14.0179 ha) with the lowest rate as shown in **table 7**.

Table 7: Mangrove degraded area spatio-temporal variability

		MANGROVE DEGRADED AREA (HA)	
No.	**Village**	**2005**	**2014**
1	24 de julho	24.4554	44.4250
2	Salvador Allende	8.8103	27.1223
3	Voz da Frelimo	16.6757	14.0179
4	Zimilene	48.6827	47.7746
	TOTAL	**98.6241**	**133.3398**

Source: aerial photos (2005) and Quickbird imagery (2014)

When a mangrove degraded area naturally recovers successful, it creates a dense mangrove cover. In Quick bird satellite imageries such areas are represented by homogenous lighting green arranged linearly at the bordering of the patchy. Higher densities (more than 27plants/m2) of mangrove competing for river dominated (strong outwelling) lower water capacity carrying of the habitat results on scrub mangroves (dwarf) normally setting along the flat fringes (1 m altitude) and sandy sediments of the Limpopo river channels. The presence of diurnal unsatisfactory inundation on dense fringe mangrove areas is resulting in dominance of dwarf *Avicennia marina* (**see plate 7**).

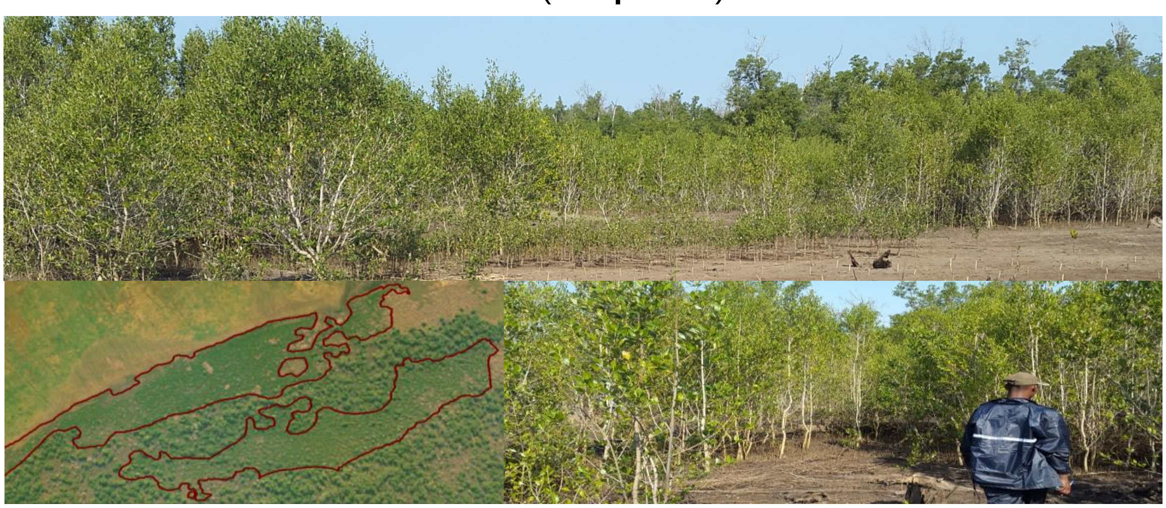


Plate 7: Scrub *Avicennia marina* as resulted by inadequate diurnal water inundation and sandy sediments down moved from upland dunes.

In 2005 dense mangrove represented 30.92% (184.9348 ha) dropping in 45 patches and in 2014 it covers an area of 62.6635 ha (13.4563%) within 11 patches.

Such mangrove class in 2005 was more concentrated in 24 de Julho community (109.7653 ha), Salvador Allende (36.2291 ha), Zimilene (31.6956 ha) and disperse in Voz da Frelimo (7.2448 ha).

In 2014, Zimilene community had the largest area (28.6394 ha), followed by 24 de Julho (17.3305 ha) and last by Salvador Allende (16.6937 ha). None dense mangrove area was found in Voz da Frelimo (0.0000 ha), indicating the scope of mangrove forest evolution (**see table 8**).

Table 8: Spatio-temporal variability of dense mangrove area

		DENSE MANGROVE AREA (HA)	
No.	**Village**	**2005**	**2014**
1	24 de Julho	109.7652	17.3305
2	Salvador Allende	36.2291	16.6937
3	Voz da Frelimo	7.2448	0.0000
4	Zimilene	31.6956	28.6394
	TOTAL	**184.9347**	**62.6636**

Source: aerial photos (2005) and Quickbird imagery (2014)

One of the characteristics of dense mangrove forest evolution in 2014 is the presence of juvenile mangroves that through time might become trees or not. If the combined factors (brackish waters, mud sediments, river flow patterns, and mangrove fauna) remain in equilibrium, it is expected that such juveniles will become older trees. Older trees are majority interlaced with patches of *Avicennia marina* recovering mangrove that unfortunately less adapts to lack of solar radiation. Thus, patches of recovering *Avicennia marina* located within the major patches of older trees are condemned to disappear. When it occurs frequently, old mangrove trees are mixed with irregular patches of poor recovering indicating the scope of disaggregation of mangrove forest area. And if the evolution continues, older mangrove mixed with poor recovering will result in degraded mangrove area due to the impact of the increase of direct solar radiation, increase of surface temperature and disequilibrium in chemical and physical aspects of mangrove sediments. Such areas are classified as dispersed mangrove or mangrove near to die (degraded) as shown on **plate 8**.

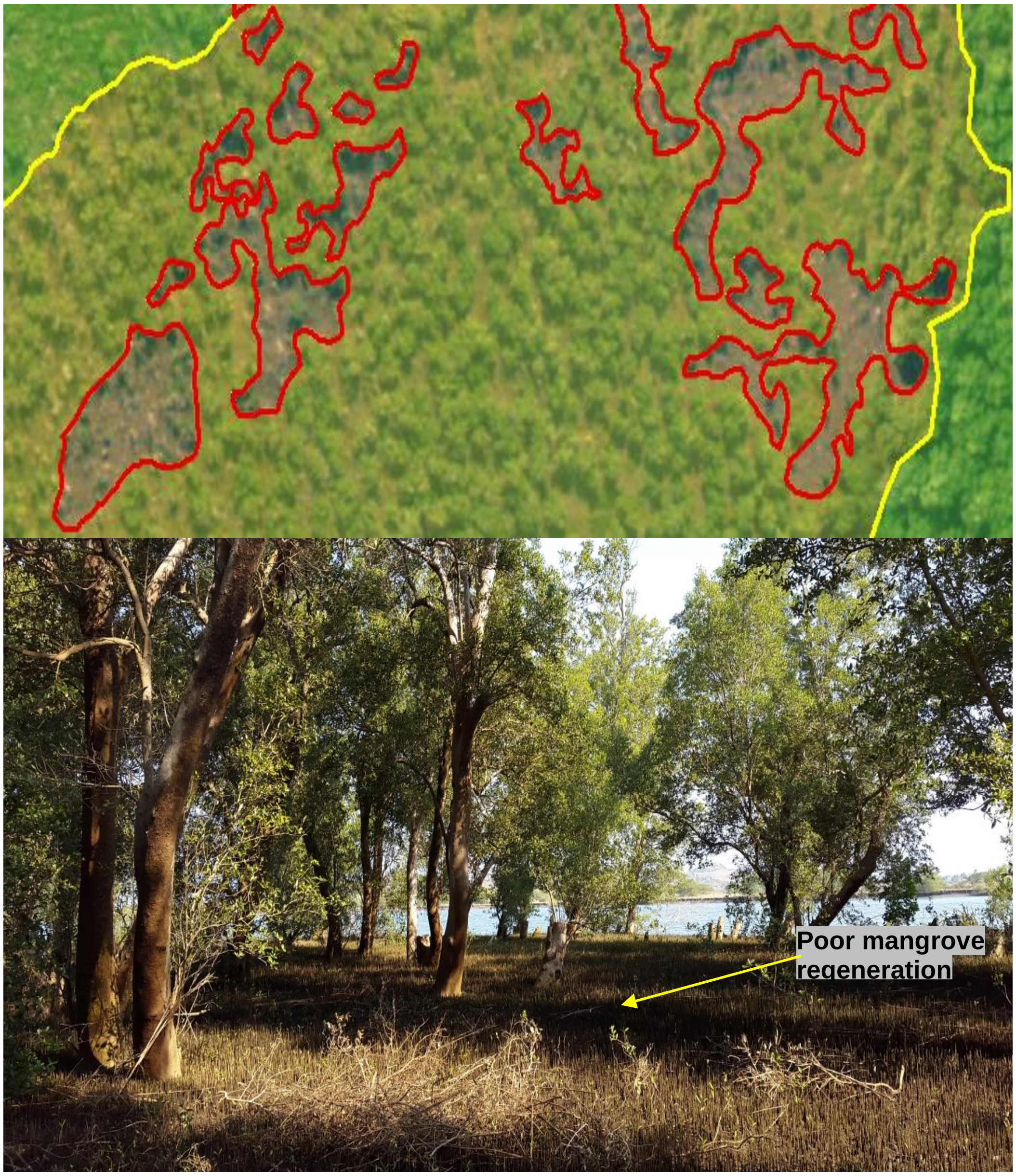


Plate 8: dispersed mangrove category as it's characterized by older trees and poor recovering rate. Although the area is daily inundated poor solar radiation and compacted *Avicennia marina* sediments limits other competing mangrove species.

Table 9: Spatio-temporal variation of disperse mangrove area

		DISPERSE MANGROVE AREA (HA)	
No.	**Village**	**2005**	**2014**
1	24 de Julho	63.9671	117.5193
2	Salvador Allende	230.3145	41.9394
3	Voz da Frelimo	5.9111	70.931
4	Zimilene	14.4483	39.2893
	TOTAL	**314.6410**	**269.6790**

Source: aerial photos (2005) and Quickbird imagery (2014)

Dispersed mangrove varied in space and time. In 2005, the community of Chilaulene (Salvador Allende) observed the higher figures of mangrove with trends to degradation (230.3145 ha), the same as 24 de Julho (Zongoene Sede) (63.9671 ha). Low figures of disperse mangrove were documented in Voz da Frelimo (5.9111 ha) and Zimilene (14.4483 ha). In 2014, the community of Chilaulene was the one registering low rates of disperse mangrove (41.9394 ha) the same as Zimilene (39.2893 ha). In the same period, Zongoene sede had 117.5193 ha and Voz da Frelimo (70.931 ha). Since disperse mangrove is characterized by old trees with patches of poor regeneration, the shift of 230.3145 ha (2005) to 41.9394 ha (2014) in Chilaulene Community might be an indicator of mangrove dynamic, the reason for documenting mangrove history.

IV.5-History and current information about mangrove vegetation and contiguous land use/cover

Results from classification of aerial photos (2005) and Quickbird satellite images (2014) show that there are 10 land cover/use types in the Limpopo basin estuary (figures 11 and 12), namely:

- Aerodrome (identified by its linear pattern with grey tones indicating the presence of low spectral reflectance)
- Agriculture (regular pattern indicating the presence of commercial farms and small irregularly dispersed subsistence yields of small holder farmers based on maze, rice, banana, horticulture)
- Coastal dunes vegetation (distinguished by their location on higher altitudes and sometimes interlaced with whitish small patches of denuded coastal dunes sandy)
- Mangrove (distinct by its mosquito arrangement in V shaped river areas where diurnal inundation is frequent. The presence of mud sediment results on lower spectral reflectance of mangrove degraded area. The dark green in mosquito pattern differentiates mangroves from the light green of *Phragmites australis.* The presence of *Acacia xanthophloea was differentiated from mangrove due to its location within grass land area).*
- Fish ponds (differentiated by the presence of water in a regular format. Their spatial proximity suggests manmade objects and the presence of light green within the regularly structured objects represents the occurrence of *Phragmites autralis in fish ponds*)
- Grassland (*Grasslands are distinguished by whitish color when are dry and located on sandy soils and grey when are located in mud inundated area*. Most dominant grass lands are *Cynodon dactylon* and when are located in an inundated area its greenness confuses with mangrove seedling. Apart of *Cynodon, Phragmites autralis grassland is distinguished by* light green on sedimentation area).
- None mangrove trees (*Acacia xanthophloea, Phoenix reclinata are of* bright to deep green and occur in associations).
- Primary dunes (are recognized by their whitish color arranged in a horse format near the shoreline)
- Settlements (regular format to urban areas as resulted by good planning and mosquito pattern for dwellings occupying areas of undefined structure) and
- Water sources (linear and meandering pattern due to uniform topography) as shown in Table 11

The overall trend of change in each land cover type is also detailed. In particular, decreases land cover/use types has been witnessed for mangrove, grassland and water sources, with large decrease for mangrove (annual change rate loss of 3.5%), followed by grassland (annual change rate loss of 1.2%) (table11).

Table 10: Mangrove vegetation and adjacent land cover/use (2005 and 2011)

No.	Land Use Land Cover C	AREA (ha)		Recovering area (ha)	Change rate (2014 to 2005)	Relative change rate (%)	Annual change rate (%)
		2005	2014				
1	Aerodrome	4.1165	4.1165	0	0	0	0
2	Agriculture	5819.161	5989.6342	0	170.4734	2.8461	0.3162
3	Coastal dunes vegetation	1644.203	1644.205	0	0.002	0.0001	0
4	**Mangrove**	598.1999	422.0047	43.6776	-132.5176	-31.4019	-3.4891
5	Fish ponds	0	9.397	0	9.397	100	11.1111
6	Grassland	600.4623	541.411	0	-59.0513	-10.9069	-1.2119
7	None mangrove trees	50.2643	72.7994	0	22.5351	30.9551	3.4395
8	Primary dunes	425.697	425.697	0	0	0	0
9	Settlements	1175.437	1175.437	0	0	0	0
10	Water sources	1007.814	999.1597	0	-8.6545	-0.8662	-0.0962
	TOTAL	11325.36	11283.8615	-	-	-	-

Source: aerial photos (2005) and Quickbird imagery (2014)

As shown in table 10 overall extent of mangroves reduced in the last decade, from a total area of 598.2ha in 2005 to 422.0 ha in 2014 (relative change rate of 31.4% and change rate loss of 3.5% per year), although the variation of change rates was different between locations. The decline in mangrove vegetation may be associated with the blocking of drainage canals, hence the decrease of water flow. The frequency of floods in the mangrove and the estuary area was overwhelmed by a large volume of sediment that altered soil conditions for the mangrove development. When such conditions area created mangrove areas are colonized by mangrove associated species and later on by agriculture. The significant increase of none mangrove trees (*Acacia xanthophloea, Phoenix reclinata*) and agriculture, with annual rate of increase of 3.4% and 0.3%, respectively was documented (table 10).

Although significant aerial dynamic was observed between the 9 years in the Limpopo basin estuary, different spaces in various times documented different change rates as shown on table 11:

Table 11: spatio-temporal variation of LCLU

	TOTAL		24 de Julho		Salvador Allende		Voz da Frelimo		Zimilene	
	AREA		AREA		AREA		AREA		AREA	
Land Use Land Cover Category	**2005**	**2014**	**2005**	**2014**	**2005**	**2014**	**2005**	**2014**	**2005**	**2014**
Aerodrome	4.1165	4.1165	4.1165	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Agriculture	5819.1608	5989.6342	413.9509	1317.139	4455.7399	2067.68	197.9680	2363.28	751.5020	241.5374
Coastal dunes vegetation	1644.2030	1644.2050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1644.2030	1644.2050
Mangrove	598.1999	422.0047	131.9268	164.1305	289.0960	83.3835	20.5271	78.6802	156.6500	95.8107
Mangrove recovering	0.0000	43.6776	0.0000	15.1443	0.0000	2.3719	0.0000	6.2686	0.0000	19.8928
Fish ponds	0.0000	9.3970	0.0000	6.9693	0.0000	0.0000	0.0000	0.0000	0.0000	2.4277
Grassland	600.4623	541.4110	5.3913	50.3951	166.8578	13.1441	156.4802	109.375	271.7519	368.4969
None mangrove trees	50.2643	72.7994	3.4218	6.2383	46.8425	48.8578	0.0000	0.0000	0.0000	17.7033
Primary dunes	425.6970	425.6970	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	425.6970	425.6970
Settlements	1175.4370	1175.4370	862.0280	862.0280	313.4090	313.4090	0.0000	0.0000	0.0000	0.0000
Water sources	1007.8142	999.1597	20.5914	170.9073	863.4795	203.412	1.1355	132.358	122.6935	492.484
TOTAL	11325.3550	11327.5391	1441.4267	2592.9518	6135.4247	2732.2572	376.1108	2689.9645	3372.4974	3308.2548

Source: aerial photos (2005) and Quickbird imagery (2014)

Table 12: LCLU change in 24 de Julho community

Land Use Land Cover Category	TOTAL AREA 2005	TOTAL AREA 2014	24 de Julho AREA 2005	24 de Julho AREA 2014	Change rate (2014 to 2005)	Relative change rate	Annual change rate
Aerodrome	4.1165	4.1165	4.1165	0.0000	-4.1165	0.0000	0.0000
Agriculture	5819.1608	5989.6342	413.9509	1317.139	903.1881	68.5720	7.6191
Coastal dunes vegetation	1644.2030	1644.2050	0.0000	0.0000	0.0000	0.0000	0.0000
Mangrove	598.1999	422.0047	131.9268	164.1305	47.3480	28.8478	3.2053
Mangrove recovering	0.0000	43.6776	0.0000	15.1443	0.0000	0.0000	0.0000
Fish ponds	0.0000	9.3970	0.0000	6.9693	6.9693	100.0000	11.1111
Grassland	600.4623	541.4110	5.3913	50.3951	45.0038	89.3019	9.9224
None mangrove trees	50.2643	72.7994	3.4218	6.2383	2.8165	45.1485	5.0165
Primary dunes	425.6970	425.6970	0.0000	0.0000	0.0000	0.0000	0.0000
Settlements	1175.4370	1175.4370	862.0280	862.0280	0.0000	0.0000	0.0000
Water sources	1007.8142	999.1597	20.5914	170.9073	150.3159	87.9517	9.7724
TOTAL	11325.3550	11327.5391	1441.4267	2592.9518			

Source: aerial photos (2005) and Quickbird imagery (2014)

Table 13: LCLU change in Salvador Allende community

Land Use Land Cover Category	TOTAL AREA 2005	TOTAL AREA 2014	Salvador Allende AREA 2005	Salvador Allende AREA 2014	Change rate (2014 to 2005)	Relative change rate	Annual change rate
Aerodrome	4.1165	4.1165	0.0000	0.0000	0.0000	0.0000	0.0000
Agriculture	5819.1608	5989.6342	4455.7399	2067.679	-2388.0607	-115.4947	-12.8327
Coastal dunes vegetation	1644.2030	1644.2050	0.0000	0.0000	0.0000	0.0000	0.0000
Mangrove	598.1999	422.0047	289.0960	83.3835	-203.3406	-243.8619	-27.0958
Mangrove recovering	0.0000	43.6776	0.0000	2.3719	0.0000	0.0000	0.0000
Fish ponds	0.0000	9.3970	0.0000	0.0000	0.0000	0.0000	0.0000
Grassland	600.4623	541.4110	166.8578	13.1441	-153.7137	-1169.4502	-129.9389
None mangrove trees	50.2643	72.7994	46.8425	48.8578	2.0153	4.1248	0.4583
Primary dunes	425.6970	425.6970	0.0000	0.0000	0.0000	0.0000	0.0000
Settlements	1175.4370	1175.4370	313.4090	313.4090	0.0000	0.0000	0.0000
Water sources	1007.8142	999.1597	863.4795	203.4117	-660.0678	-324.4984	-36.0554
TOTAL	11325.3550	11327.5391	6135.4247	2732.2572			

Source: aerial photos (2005) and Quickbird imagery (2014)

Table 14: LCLU change in Voz da Frelimo community

Land Use Land Cover Category	TOTAL AREA 2005	TOTAL AREA 2014	Voz da Frelimo AREA 2005	Voz da Frelimo AREA 2014	Change rate (2014 to 2005)	Relative change rate	Annual change rate
Aerodrome	4.1165	4.1165	0.0000	0.0000	0.0000	0.0000	0.0000
Agriculture	5819.1608	5989.6342	197.9680	2363.284	2165.3155	91.6232	10.1804
Coastal dunes vegetation	1644.2030	1644.2050	0.0000	0.0000	0.0000		0.0000
Mangrove	598.1999	422.0047	20.5271	78.6802	64.4217	81.8779	9.0975
Mangrove recovering	0.0000	43.6776	0.0000	6.2686		0.0000	0.0000
Fish ponds	0.0000	9.3970	0.0000	0.0000			0.0000
Grassland	600.4623	541.4110	156.4802	109.3745	-47.1057	-43.0683	-4.7854
None mangrove trees	50.2643	72.7994	0.0000	0.0000	0.0000		0.0000
Primary dunes	425.6970	425.6970	0.0000	0.0000	0.0000		0.0000
Settlements	1175.4370	1175.4370	0.0000	0.0000	0.0000		0.0000
Water sources	1007.8142	999.1597	1.1355	132.3577	131.2222	99.1421	11.0158
TOTAL	11325.3550	11327.5391	376.1108	2689.9645			

Source: aerial photos (2005) and Quickbird imagery (2014)

Table 15: LCLU change in Zimilene community

Land Use Land Cover Category	TOTAL AREA 2005	TOTAL AREA 2014	Zimilene AREA 2005	Zimilene AREA 2014	Change rate (2014 to 2005)	Relative change rate	Annual change rate
Aerodrome	4.1165	4.1165	0.0000	0.0000	0.0000	0.0000	0.0000
Agriculture	5819.1608	5989.6342	751.5020	241.5374	-509.9646	-211.1328	-23.4592
Coastal dunes vegetation	1644.2030	1644.2050	1644.2030	1644.2050	0.0020	0.0001	0.0000
Mangrove	598.1999	422.0047	156.6500	95.8107	-40.9465	-42.7369	-4.7485
Mangrove recovering	0.0000	43.6776	0.0000	19.8928	0.0000	0.0000	0.0000
Fish ponds	0.0000	9.3970	0.0000	2.4277	2.4277	100.0000	11.1111
Grassland	600.4623	541.4110	271.7519	368.4969	96.7450	26.2540	2.9171
None mangrove trees	50.2643	72.7994	0.0000	17.7033	17.7033	100.0000	11.1111
Primary dunes	425.6970	425.6970	425.6970	425.6970	0.0000	0.0000	0.0000
Settlements	1175.4370	1175.4370	0.0000	0.0000	0.0000	0.0000	0.0000
Water sources	1007.8142	999.1597	122.6935	492.484	369.7905	75.0868	8.3430
TOTAL	11325.3550	11327.5391	3372.4974	3308.2548			

Source: aerial photos (2005) and Quickbird imagery (2014)

Figure 11: Mangrove vegetation communities adjacent land cover/use (2005)

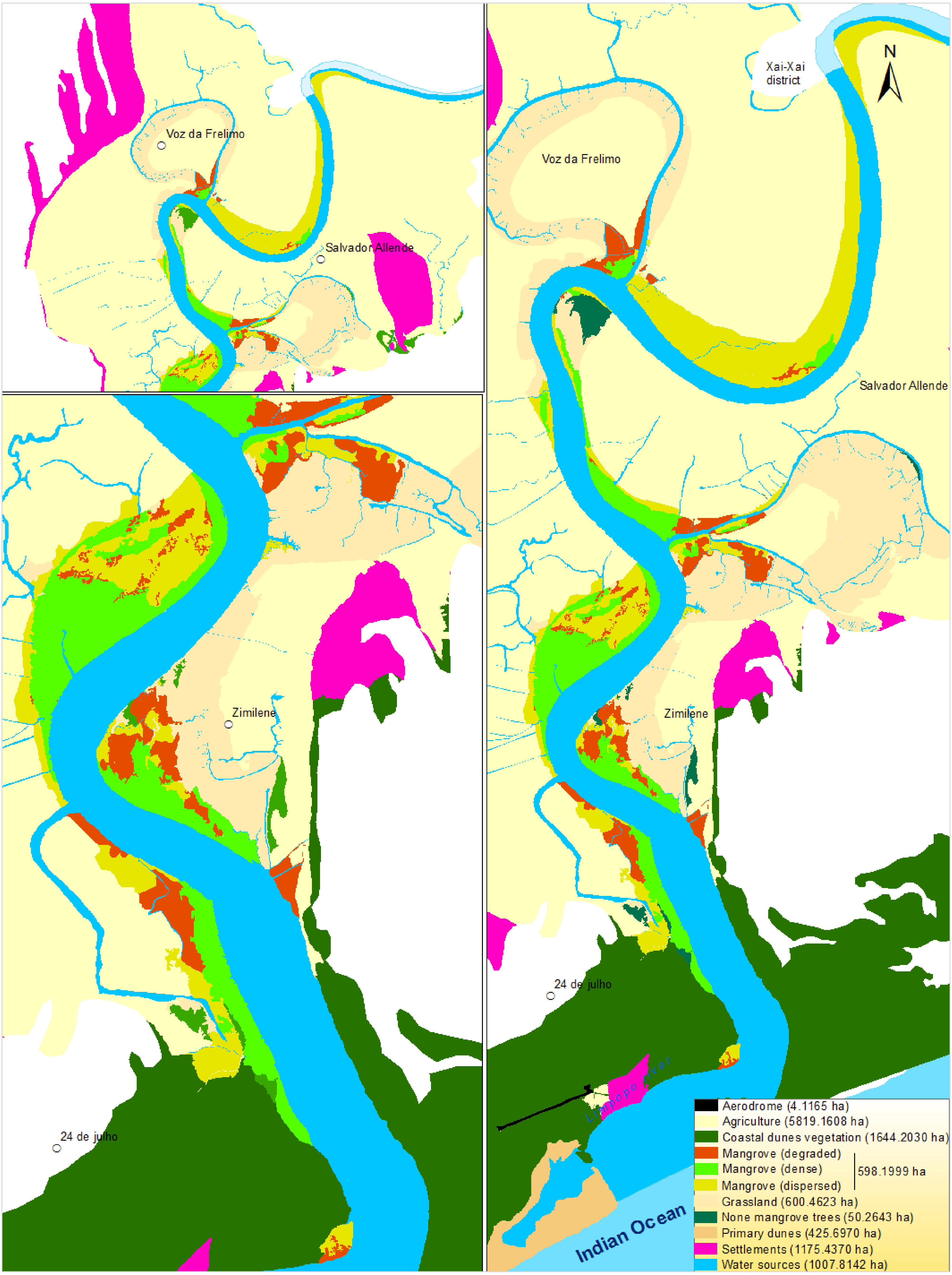
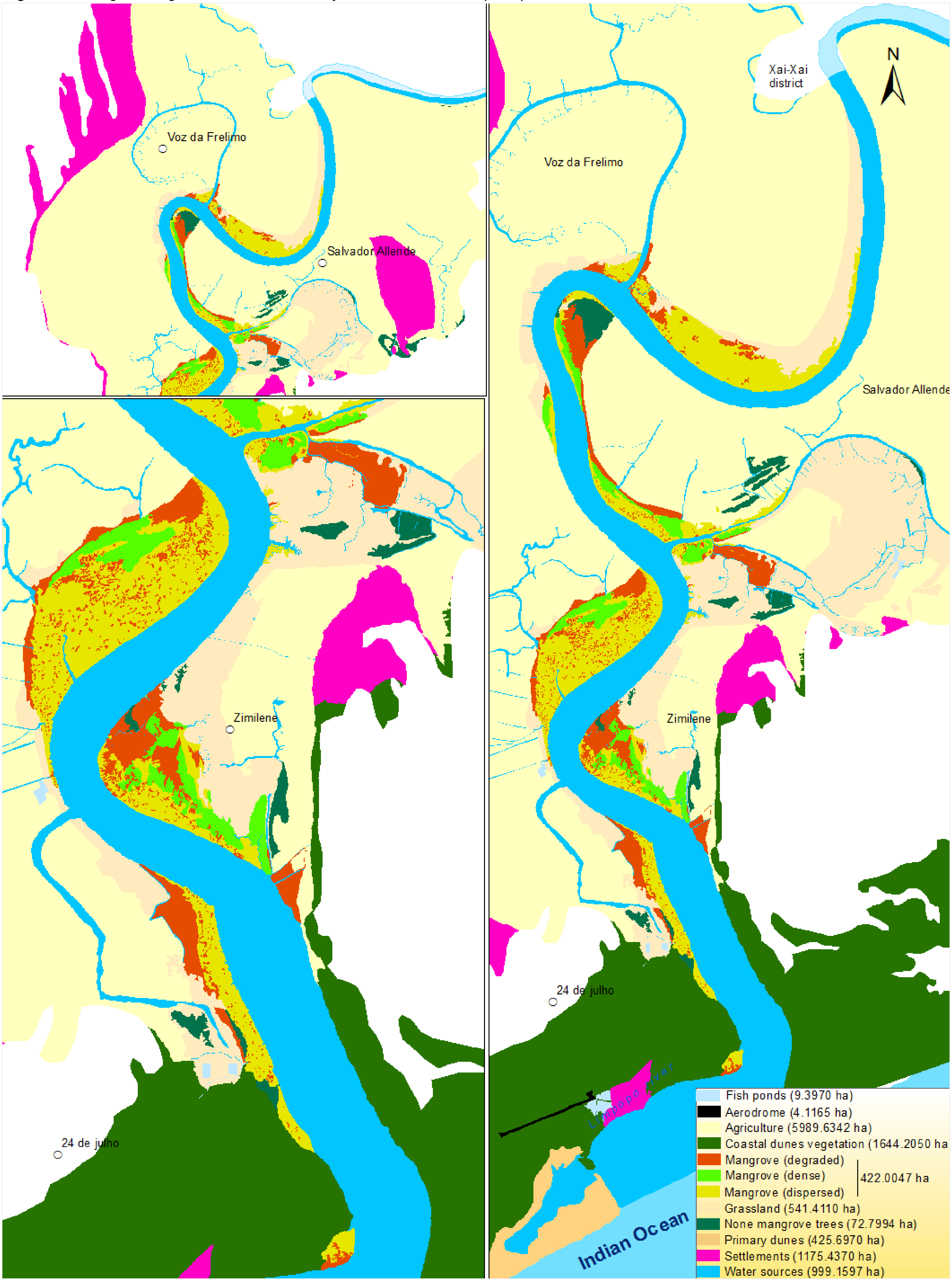


Figure 12: Mangrove vegetation communities adjacent land cover/use (2014)



Mangrove annual extent relative rate loss during the 9 years in the Limpopo basin river is 3.5% as resulted by mangrove area of 598.2 ha in 2005 to 422.0 ha in 2014 and a recovery area of 43.6776 ha.
However, different spaces had different magnitudes of annual relative rate. In 24 de Julho the mangrove cover annual relative rate has increased in 3.2% as resulted by mangrove area increase of 131.9268 ha in 2005 to 164.1305 ha in 2014 and a recovery area of 15.1443 ha. In Salvador Allende the annual relative rate loss is 27.09% as caused by the reduction of 289.0960 ha in 2005 to 83.3835 ha in 2014 and a recovery area of 2.3719 ha. In Voz da Frelimo the mangrove cover annual relative rate has increased in 9.09% as resulted by the increase of 20.5271 ha in 2005 to 78.6802 ha in 2014 and a recovery area of 6.2686 ha. In Zimilene the mangrove cover annual relative rate loss is 4.75% as caused by the decrease of 156.6500 ha in 2005 to 95.8107 ha in 2014 and a recovery area of 19.8928 ha (tables 12, 13, 14 and 15).

VI-DISCUSSION

a) The diameter (DBH) and tree height are important structural parameters that affect the density and influence the spatial distribution of the individuals in a certain plant community. In this study, tree height, diameter and density for *Avicennia* marina and *Rizophora mucronata* differed between 24 de Julho and Zimilene in the Limpopo basin estuary. The shorter trees and smallest DBH are mostly found in Zimilene, indicating that this mangrove is in active process of regeneration. Tree height and DBH also decreased with the distance from river bank, however, this distance increased the mangrove density, e.g. large-sized trees (more than 30.1 cm in DBH) were dispersed mangrove occurred within 1m from the river bank, and trees located at 500m from the river bank were short and stunted, with the highest density (27 trees/m^2), indicating that mature mangrove is concentrated along the river margins or edges. According to Schaeffer-Novelli & Cintrón 1986, the density of forests is a function between age and maturing, due to the competition within the canopy for space. Thus, during a forests development, they go through a period in which land is occupied by a large density of trees, as such in the case of the interior mangroves, with reduced diameter, to a phase of higher maturing, when volume is made up by a few trees of large tonnage and volume as in river margins mangrove. Thus, density is reduced through the forests' maturing.

b) Frequency distribution for tree height of both *A. marina* and *R. mucronata* had a normal distribution and was slightly skewed to the smaller classes. The distribution of DBH was also skewed to the smaller classes, all sampled trees showed reverse J-shaped distributions. These results were similar to the findings by Jose, 2009, suggesting active regeneration in these populations.

c) Mangrove associated fauna in Limpopo basin estuary also include crabs and are major predator on mangroves as they consume mangrove propagules. Predation on mangrove seeds has been widely recognized to contribute how a mangrove community will grow. In Kenya, Dahdouh-Guebas et. al. (2002) found that there was a direct correlation between crab distribution and mangrove distribution. The consumption of the propagules by crabs greatly affects the natural regeneration of mangroves, affecting their distribution across the intertidal zone (Alongi, 1992).

d) Mangrove cover extent is clearly increasing in the communities of Voz da Frelimo and 24 de Julho located at the side of the Zongoene headquarters and drastically decreasing to the rates of extinction in the another side of Limpopo river (Salvador Allende and Zimilene);
e) Although higher rates of mangrove area recovery (19.8928 ha) were observed in Zimilene community, the mangrove degraded area continues (47.7746 ha) minimizing both efforts of natural recovery and replantation, indicating the scope of dominance of older mangrove tree (14.4483 ha in 2005 to 39.2893 ha in 2014) and a need of it's replacement;
f) Higher rates of mangrove recovery (15.1443 ha) and a positive dynamic of mangrove (3.2%) are observed in 24 de Julho. Such positive patterns are encouraging mangrove conservation activities and this might be related to upstream geographic barrier that protects the area from the negative impacts of floods. Although efforts, the observed increasing of farming annual rate of 7.6% as caused by the increase of 413.9509 ha in 2005 to 1317.139 ha in 2014 is currently creating sandy sedimentation of mangrove area, hence grass land *(Phragmites autralis* and *Cynodon dactylon*) had an annual relative increase of 7.6% as resulted by 413.9509 ha in 2005 to 1317.1390 ha in 2014) and consequently an increase of dispersed mangrove area from 63.9671 ha in 2005 to 117.5193 ha in 2014. Dispersed mangrove (old trees) in areas where the agricultural irrigation channels drain waters, is being removed by fluvial erosion;
g) An embarrassing question was made in the field by a Chilaulene women collecting mangrove firewood for distillation of sugar cane dry gin when she asked: should we talk on mangrove in this area? I think you are trying to sprout the wrong target, she said sniggering. At that time (field work) was a joke but currently results indicate the highest annual relative loss of 27.09% and the lowest mangrove recovery of 2.3719 ha in Chilaulene. Sidewise, water sources registered an annual relative rate loss of 36.0554% as caused by the decrease of 863.4795 ha in 2005 to 203.4117 ha in 2014. Small holder farmers are shifting from agriculture to concentrate in other activities (distillation of sugar cane dry gin). Chilaulene agricultural area annual relative loss is 12.83% as resulted by decrease of 4455.7399 ha in 2005 to 2067.6790 ha in 2014.
h) Observed patterns of mangrove annual change rate (3.5%) in Limpopo basin estuary might be found in geomorphologic and hydrological patterns (figures 12, 13).

Limpopo channels down dunes are composed by grain sandy soils. These soils might be resulted by dunes migration in the direction of estuarine channels, which promotes the formation of sandy banks that are accumulated in the mangrove area (figures 12, 13).

Such banks cause the increase of altimetry and the reduction of river and channels batimetry as well as the reduction of daily inundation amplitude. Presumable the documented accumulation of sandy sediments in the mouth of Limpopo river (see profile 3) is reducing the diurnal amplitude of tidal inundation. As a result fluvial channels (including in the near future the Limpopo river) are being converted into lagoons and coastal ponds.

New mangrove seedling in areas affected by marine amplitudes flow patterns was observed. Thus, daily marine inundation and annual flood cycle are critical to the life cycle completion of mangrove with seeds dispersing during higher water amplitudes and germinating as water levels recede. Such flow patterns affect the breeding and feeding behaviors of fish. For areas where the topography is above 1 m such daily tidal inundation does not spread and might be resulting in disruption of reproductive patterns for fish and wildlife species as documented by local population the decrease of 76.4%.

During the fluvio-marine flow these structures (lagoons and ponds) are reconnected but when flooding time arrives, due to higher fluxes of upstream macaretane dam the hydrological connection between Limpopo river and floodplain structures is disrupted. Such higher fluxes are represented by a yellow line in figure 13 and are mostly critical since when accumulation is made in the north area of Chilaulene and then confined to small channel for discharge, their speed increases creating temporal water channels in mangrove area that increase the grain sandy in contrast to silt. Such fluxes when continue down to Zimilene are blocked by the presence of dunes in the mouth of Limpopo river (figure 12, profile 3). The immediate result is the accumulation of water in Zimilene mangrove for a long period of time, which consequently decreases water salinity and a die out of large mangrove areas.

Observed adverse effects of reduced and regularized flood flows is reduced silt deposition and nutrient availability as documented by the increase of sandy sediments and grasslands in a rate of 2.92% (Zimilene) and 9.9% (24 de Julho). In addition, Limpopo channel degradation is documented by water loss rate of 36.05% in Salvador Allende. Reduced habitat heterogeneity is also observed particularly by the dominance of *Avicennia marina (92.5%)* and increase of Avicennia marina habitat fragmentation of 8.24% as resulted by 195 patches in 2005 to 754 patches in 2014. Moreover, there is a serious displacement of wetland vegetation by upland species by an annual increase rate of 3.44% as caused by the increase of 50.2543 ha in 2005 to 72.7994 ha in 2014. And the most and not undoubtable impact of flow patterns change is the loss of coastal mangroves in an annual rate of 3.50% with risk of extinction in Chilaulene community.

During drought events the Limpopo river, lagoon and lake flows remain blocked conditioning poor drainage to mangrove area.

When poor drainage is prolonged solar radiation incidence increase and in turn results in soil cracks and surface salt concentration. In higher resolution aerial photos (0.6m) of drought season these areas appear in whitish interlaced with small

Citroen Yellow indicating the presence of *Bruguiera gymnorrhiza* located in a mangrove degraded of Zimilene community. While in Quick bird satellite imageries of rain season such sites are differentiated by the presence of meandering inundation down small dispersed 30% gray sandy banks.

In areas where channels still well-draining waters (daily ocean inundation), soil surface is silt and soft mainly populated by mosquitos, crabs and shrimps on the intermediate upstream channel zone and small patches of *rhizophora mucronata* are located within a distance of 2 to 5 m from these channels.

Figure 13: Mangrove area topographic profiles

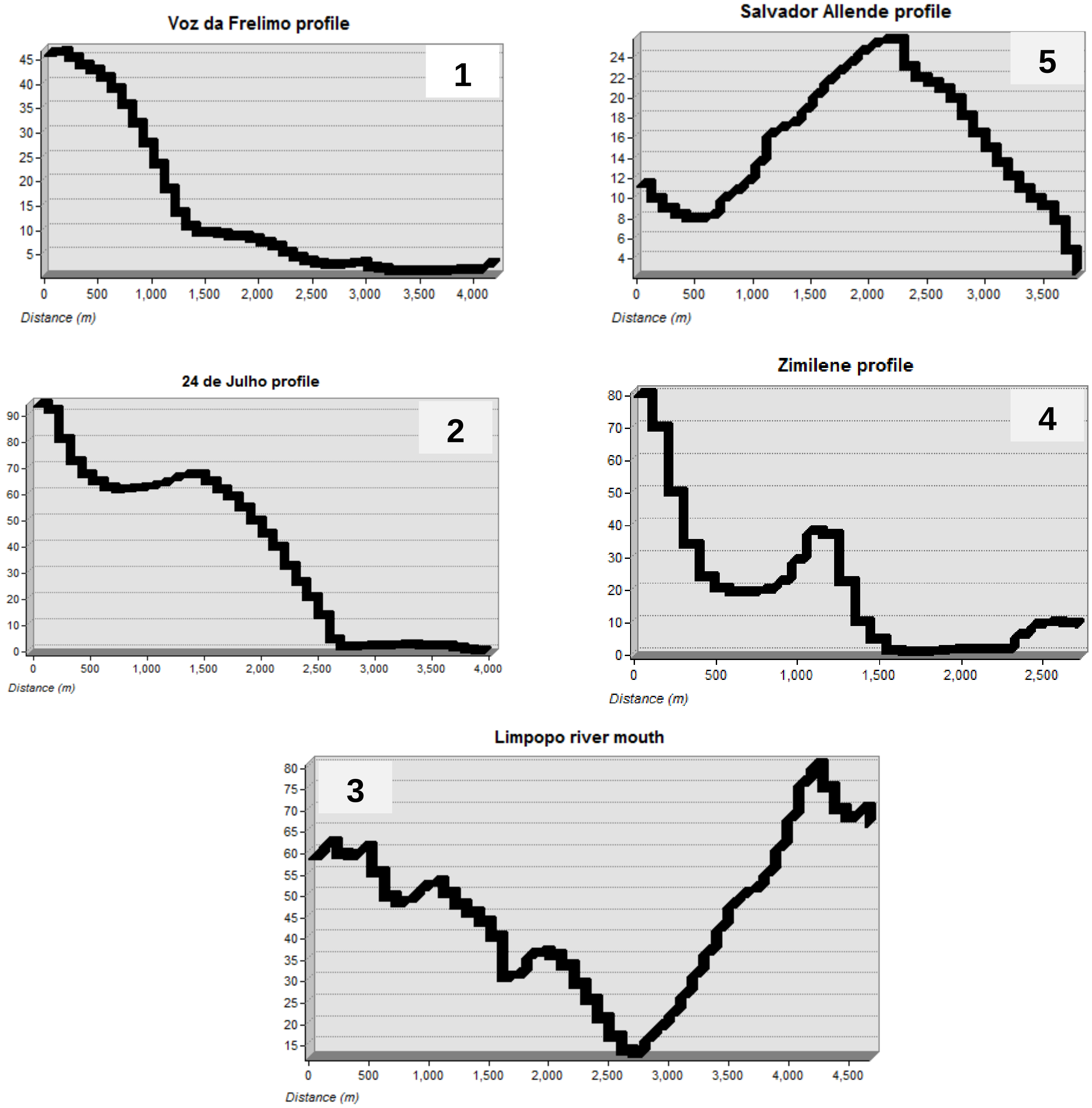
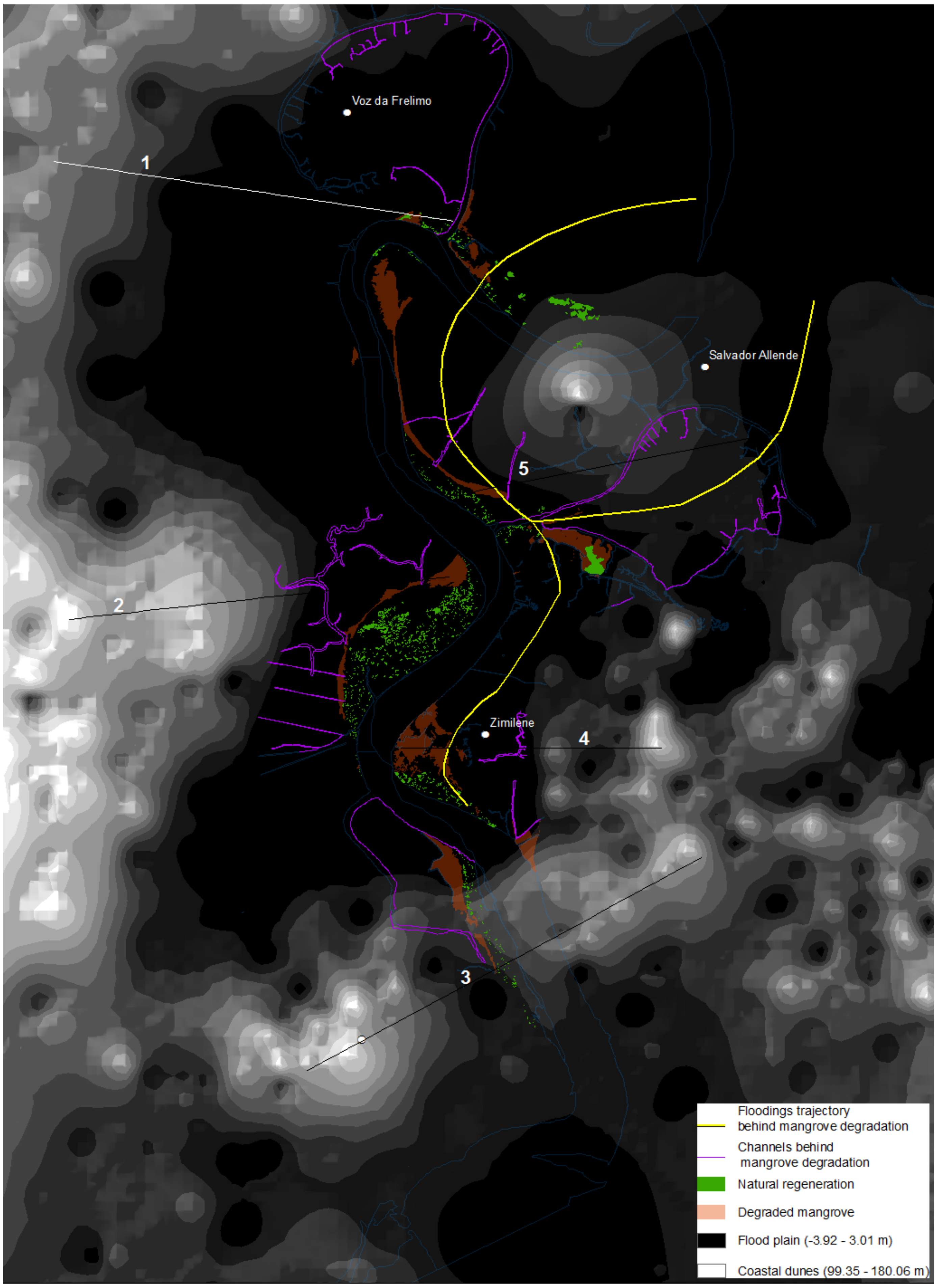


Figure 14: spatial model for mangrove conservation in the Limpopo basin estuary



VII-PROPOSAL FOR MANGROVE RESTORATION

Mangrove restoration is the regeneration of mangrove forest ecosystems in areas where they have previously existed. The issue of restoration is critical today since mangrove forests are being lost very quickly and this study in particular estimate Limpopo basin estuary mangrove area in 2014 at 422.0ha - down from 598.2ha in 2005 (change rate loss of 3.5% per year).

Before the restoration start, there is a need to clearly evaluate the necessary conditions for seedling survival. Unfortunately, many mangrove restoration projects move immediately into planting of mangroves without determining why natural recovery has not occurred, often resulting in major failures of planting efforts. Some factors like poor site selection, specie selection, lack of understanding mangrove ecology and hydrology, lack of community consultation and participation, short project duration, lack of follow-up and monitoring may lead to the failures in mangrove restoration projects.

Because mangrove forests may recover without active restoration efforts, we recommend that restoration planning should look at the potential existence of stresses, before attempting restoration:

- Propagule distribution
- Hydrologic patterns
- Pressures and threats to mangrove area

VII.1.Propagule distribution

Natural recovery is slowed due to a lack of natural mangrove propagules being available to a damage site. Propagule limitation in Limpopo basin estuary is caused by a loss of adult trees capable of producing propagules and by hydrologic restrictions or blockages of canals, which prevent natural waterborne transport of mangrove propagules to a restoration/damage site, prevents secondary succession from occurring.

VII.2. Hydrologic patterns

Understanding the hydrologic patterns (depth, duration and frequency of tidal inundation, and of tidal flooding) of existing natural mangrove plant communities (a reference site) is important for a successful mangrove restoration project. Each mangrove species thrives at a different substrate level which in some part dictates the amount of exposure of mangrove to tidal waters. Many degraded areas in Limpopo basin estuary are located in relative high topography (above 1 m) of the substrate from a nearby healthy mangrove forest and not regularly inundated by daily tides (Figure 13).

The higher topography might result from dune soils migrating in the direction of mangrove area, which promotes the formation of sandy banks increasing the altimetry. This phenomenon is also responsible for blockages of canals, affecting the irrigation of restoration areas, important for the distribution and successful establishment and growth of targeted mangrove species. Thus, any plans for mangrove restoration in Limpopo basin estuary must first consider the stresses such as blocked tidal inundation that prevent secondary succession from occurring, and it has to be removed before attempting restoration.

VII.3.Pressures and threats to mangrove area

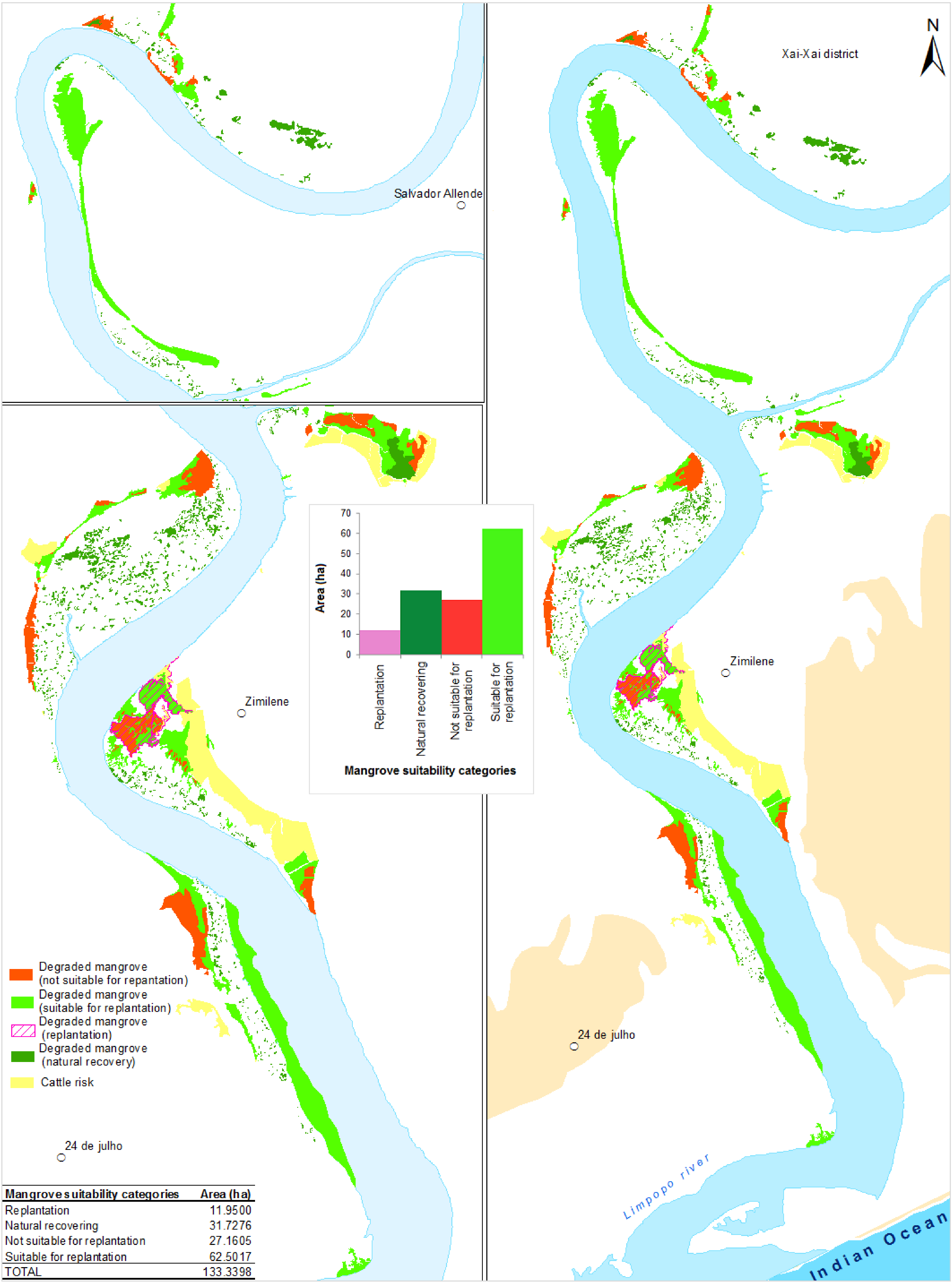
Some problems to consider which may affect the progress of restoration are:

- Threats from local domestic animals (see figure 14)
- Crab and barnacle infestations

It can be concluded that the successful mangrove restoration in Limpopo basin estuary will require careful analyses of a number of factors in advance of attempting actual restoration (Figure 13):

- For a given area of mangroves or former mangroves, the existing watershed needs to be defined, and any changes to the coastal plain hydrology that may have impacted the mangroves documented;
- Careful site selection must take place factoring into account the history of the site;
- Given that there have been prior efforts to restore mangroves in the area, there is a need to access the results in terms of successes and failures and lessons learned from these prior efforts. The restoration methodology must reflect an acknowledgement of the history of routine failure in attempts at mangrove restoration and proposed use of proven successful techniques;
- After the initial restoration activities are complete, the proposed monitoring program must be initiated and used to determine if the project is achieving interim measurable success to indicate whether any mid-course corrections are needed.
- Based on these critical factors, the map of mangrove replantation suitability is shown in figures 14 and 15. Mangrove replantation area was estimated in 62.5017 ha in 2014. Principal factors to consider in each site are documented in figures 14 and 15 but geomorphology and hydrological pattern fluxes are the determinant of both natural dispersal of seeds and replantation. Abundance of crabs and potential trampling by cattle feeding in grassland can be minimized basing on nature friendly management tools such as shown on plate 4.

Figure 15: Proposed areas for mangrove replantation (light green)



Mangrove suitability categories	Area (ha)
Replantation	11.9500
Natural recovering	31.7276
Not suitable for replantation	27.1605
Suitable for replantation	62.5017
TOTAL	133.3398

VIII. LESSONS

a) The activities for mapping of mangrove vegetation communities and degraded areas in the Limpopo basin estuary mainly consisted on review of existing information in the Limpopo basin estuary, preliminary interpretation of satellite imagery and aerial photos, development of mangrove socio-economic database, mangrove field survey, cartographic database creation, GIS and statistical data analysis and report writing.

b) Imagery analysis was based on digital and visual interpretation to produce the land cover/use (LCLU) map of the two dates (2005 and 2014). Field imagery validation by means of real time monitoring technology supported the idea of no exhaustive imagery interpretation and classification is made completely in the office. A field survey is needed in order to clarify confusing categories such as mangrove and adjacent non-mangrove trees.

c) Mainly 10 LCLU are found in the Limpopo basin estuary namely: 1. Coastal dunes vegetation (1644.203 ha in 2005 to 1644.205 ha in 2014), 2. Primary dunes (425.697 ha in 2005 to 425.697 ha in 2014), 3.Non mangrove trees (50.2643 ha in 2005 to 72.7994 ha in 2014), 4.Grassland (600.4623 ha in 2005 to 541.411 ha in 2014), 5. Water sources (1007.814 ha in 2005 to 999.1597 ha in 2014), 6.Settlements (1175.437 ha in 2005 to 1175.437 ha in 2014), 7.Agriculture (5819.161 ha in 2005 to 5989.6342 ha in 2014), 8.Fish ponds (0 ha in 2005 to 9.397 ha in 2014), 9.Aerodrome (4.1165 ha in 2005 to 4.1165 ha in 2014) and 10.Mangrove (598.1999 ha in 2005 to 422.0047 ha in 2014). Agriculture was the land use occupying the largest area (5819.1608 ha) in 2005 and 2014 (5989.6342 ha). The lowest area was occupied by non-mangrove trees 50.2643 ha in 2005 and 72.7994 ha in 2014. New spatial entity was observed in 2014, the fish ponds occupying 9.3970 ha.

d) Overall LCLU and mangrove socio-economic database were modeled and integrated in a spatial geodatabase (GDB) according to unified modelling language (UML). The structure and contents of the GDB facilitated the production of maps on mangrove location, distribution, status, patterns and extent.

e) It was found that mangrove in the Limpopo basin estuary extents in a relative distance of 15.96 km from the south patchy to north patchy and is located in V shaped areas in a total number of 8 non heterogenic patches. In 2014, the major mangrove patchy is found in 24 de Julho village and its size was about 136.1692 ha while the smallest patchy measures 0.015321 ha in Zimilene community.

f) Five species of mangrove were recorded in Limpopo basin estuary: 1.*Avicennia marina (92.5%), 2.Rhizophora mucronata (6.0%), 3. Ceriops tagal (0.3%), 4.Brugiera gymnorhiza (1.0%), and 5.Xylocarpus granatum (0.25)*. Results of this study indicated that the size-class distribution of *A. marina* and *R. mucronata* mangrove in Zimilene had a reverse J shape, which suggested active regenerations.

g) Mangrove species are associated to more than 120 species of fish belonging to 52 families and Carangidae, Cerranidae, Sparidae, Lutjanidae and Sciaenidae are the most representative.

h) Mangrove vegetation communities' status was also mapped, ranging from dense, disperse and degraded. In 2005, most of mangrove area was disperse (314.7613 ha) and after approximately one decade (10 years), mangrove conservation status continued disperse (269.6789 ha) indicating the scope of mangrove trend.

I) Decrease on land cover/use types have been witnessed for mangrove, grassland and water sources, with large decrease for mangrove (annual change rate loss of 3.5%), grassland (annual change rate loss of 1.2%) and water sources (-0.0962%). Although significant aerial dynamic was observed between the 9 years in the Limpopo basin estuary, different spaces in various times documented different mangrove change rates.

j) In 24 de Julho the mangrove cover annual relative rate has increased in 3.2% as resulted by mangrove area increase of 131.9268 ha in 2005 to 164.1305 ha in 2014 and a recovery area of 15.1443 ha. In Salvador Allende the annual relative rate loss is 27.09% as caused by the reduction of 289.0960 ha in 2005 to 83.3835 ha in 2014 and a recovery area of 2.3719 ha. In Voz da Frelimo the mangrove cover annual relative rate has increased in 9.09% as resulted by the increase of 20.5271 ha in 2005 to 78.6802 ha in 2014 and a recovery area of 6.2686 ha. In Zimilene the mangrove cover annual relative rate loss is 4.75% as caused by the decrease of 156.6500 ha in 2005 to 95.8107 ha in 2014 and a recovery area of 19.8928 ha.

K) Changes in mangrove extent were influenced by geomorphology and water flow patterns in the Limpopo basin estuary. The findings demonstrated that soil from sand dunes migrate in the direction of mangrove area, which promotes the formation of sandy banks resulting in the change of substrate and increase of altimetry. Changes in water flow pattern may be associated with reduction of tidal inundation amplitude as resulted by increased altimetry (above 1 m), which is blocking drainage channels connection and in turn creating lagoons. Infestation of crabs and potential trampling by cattle are already managed based on nature friendly management tools (plate 5). Such factors are critical for setting mangrove replantation criteria.

J) Given that there have been prior efforts to restore mangroves in the Limpopo basin estuary (11.9500 ha), but there is a need to access the results in terms of successes and failures and lessons learned from these prior efforts. The restoration methodology must reflect an acknowledgement of the history of routine failure in attempts at mangrove restoration and proposed use of proven successful techniques. After the initial restoration activities are complete, the proposed monitoring program must be initiated and used to determine if the project is achieving interim measurable success to indicate whether any mid-course corrections are needed.

L) Based on that, the map of mangrove replantation suitability is shown in figure 15. Mangrove replantation area was estimated in 62.5017 ha in 2014. Determinant factors at smaller scale are documented in figures 14 (geomorphology and hydrological flow patterns) and at large scale infestation of crabs and potential cattle trampling are important for both natural dispersal of seeds and success of replantation. Note that ongoing crabs infestation management tools seem to be efficient (see plate 4) hence less crab negative impact was observed in mangrove replanted sites and cattle trampling is a potential factor since during research period the shift of agriculture was being replaced by grassland and consequent cattle grazing in a mangrove contiguous area.

IX. Limitations

a) Detailed mapping of replanted and recovering mangrove (each propagule) was not achieved in this research due to satellite imagery spatial resolution (0.6m) available in the commercial market. This will require a future accurate mapping of propagule for monitoring mangrove replantation efforts and natural recovering speed. If detailed mapping of propagules is ensured, this will indicate to which extent replantation is crucial in contrast to natural recovering;

b) Such mapping scale issues have also failed to precisely determine geomorphologic dynamic, which is crucial for site sediments dragging prioritization and opening of irrigation channels. This has influenced on reduced availability of future mangrove rehabilitation area. However, a cost-effective survey of to which extent such sediments are profitable for construction industry is recommend;

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X. APPENDICES
A-QUESTIONNAIRE SURVEY

Variables 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
24 de Julho	Raquilir Jose Sitoe	.	4	2	4	2	.	1	2	.	2	.	.	.	3	Chiconela	1	2	.	.	3	.	1	64	.	.	1	1	1	2	1	2	2	6	1	2	6	.	2	3	.	3	.	2	3	1	1	.
24 de Julho	Alice Nduvane	15.05.2014	3	2	1	2	.	1	1	.	1	.	1	.	3	Zonguene	.	1	1	.	8	.	4	.	.	.	.	1	1	3	2	4	2	6	1	3	6	.	1	2	.	2	.	2	5	1	.	1
24 de Julho		22.05.2014	3	1	.	2	.	.	1	.	2	.	.	.	.	Cumbane	.	2	.	.	3	.	7	.	48	47	3	1	1	.	1	.	2	6	1	2	6	.	1	2	7	2	6	2	3	2	7	1
24 de Julho	Albino Mula	15.05.2014	2	1	99	2	.	2	3	.	2	.	.	.	3	Zongoene sede B1	.	1	1	.	14	.	4	.	.	.	3	.	1	1	1	1	99	51	1	99	.	.	.	2	18	2	.	2	.	1	15	1
24 de Julho	Leonor Mutamba	19.05.2014	3	2	1	2	.	2	2	.	2	.	.	.	3		.	1	1	.	3	34	1	.	.	50	1	7	1	.	1	.	1	45	1	1	6	.	.	.	.	.	.	.	.	.	.	1
24 de Julho	Maholele	19.05.2014	2	2	1	2	.	1	2	.	2	.	.	.	2	Chicumbane	.	2	.	.	3	.	1	.	.	31	1	7	1	.	1	.	2	45	1	2	6	.	.	.	.	.	.	.	.	.	.	.
24 de Julho	Marta Mussava	19.05.2014	3	2	1	2	.	2	1	.	2	.	.	.	3		.	1	2	.	1	31	.	.	.	.	1	7	1	.	1	.	4	46	1	4	6	.	3	3	.	3	.	3	.	3	.	.
24 de Julho	ILda Mutamba	19.05.2014	2	2	1	2	.	2	1	.	2	.	.	.	3		.	1	1	.	3	31	4	.	.	.	1	7	1	.	1	.	4	21	1	4	1	.	2	3	.	3	.	3	.	1	10	.
24 de Julho	Carla Mussane	19.05.2014	2	2	1	2	.	2	1	.	2	.	.	.	3		.	1	1	.	3	31	4	.	.	.	1	7	1	.	1	.	4	21	1	4	6	.	2	3	.	3	.	3	.	3	.	.
24 de Julho	Matilde Uamusse	19.05.2014	4	2	4	2	.	3	3	.	2	.	.	.	3	Zongoene sede B1	.	2	.	.	13	31	4	.	.	.	3	7	1	3	1	.	3	61	1	3	6	.	1	2	4	2	2	2	4	2	4	1
24 de Julho	Isabel Mathe	15.05.2014	4	2	1	2	.	3	1	.	2	.	.	.	3		.	.	.	.	15	.	7	.	70	65	1	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24 de Julho	Salomao Mulate	.	3	1	1	2	.	1	1	.	2	.	.	.	3		.	2	.	.	1	.	7	.	55	.	1	7	1	.	1	.	3	24	1	3	6	.	1	2	4	2	5	2	6	1	3	.
24 de Julho	Maria Sitoe	.	2	2	1	2	.	2	1	.	1	.	1	.	3	Zongoene sede B2	.	1	1	.	8	.	7	.	37	35	.	7	1	14	1	13	2	15	1	2	6	.	1	2	.	2	.	2	6	2	3	.
24 de Julho	Meldina	17.05.2014	4	2	4	1	.	1	2	.	2	.	.	.	3		.	1	1	.	1	29	2	.	.	.	1	7	1	.	1	.	3	24	1	3	2	.	3	3	.	3	.	3	.	1	3	.
24 de Julho	Maria Machango	17.05.2014	3	2	1	2	.	2	1	.	2	.	.	.	3		.	1	2	.	1	31	1	.	.	.	1	.	1	.	1	.	3	24	1	4	6	.	99	3	.	3	.	3	.	3	.	.
24 de Julho	Maria Mucavele	17.05.2014	2	2	2	1	.	1	1	.	2	.	.	.	3		.	1	2	.	1	29	1	.	.	.	1	.	1	.	1	.	4	24	1	3	6	.	1	2	4	2	5	2	6	1	3	.
24 de Julho	Alda	17.05.2014	3	2	1	2	.	2	1	.	2	.	.	.	3		.	1	2	.	1	31	4	.	.	.	1	7	1	.	1	.	4	35	1	4	6	.	3	3	.	3	.	3	.	1	10	.
24 de Julho	Paulina	17.05.2014	3	2	1	2	.	2	1	.	2	.	.	.	3		.	1	2	.	1	27	4	.	.	.	1	7	1	.	1	.	4	35	1	4	6	.	1	2	4	2	5	2	.	1	10	.
24 de Julho	Moises Mutambe	17.05.2014	2	1	1	3	.	2	1	.	2	.	.	.	.	Zongoene sede B2	.	1	1	.	9	.	7	.	.	38	3	7	1	.	1	.	4	62	1	4	11	.	1	2	10	2	5	2	6	2	17	.
24 de Julho	Almerinda	17.05.2014	2	2	1	2	.	1	1	.	1	5	.	1	3	Zongoene sede B2	.	1	1	.	1	40	11	.	.	34	1	7	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24 de Julho	Angelina Chilaule	17.05.2014	4	2	4	2	.	1	2	.	99	.	.	.	3	Chimodzo	.	2	.	.	3	33	1	.	.	.	1	7	1	.	1	.	3	28	1	2	.	.	.	.	.	.	.	.	.	.	.	.
24 de Julho	Atalia Cossa	17.05.2014	2	2	1	2	.	2	2	.	1	4	.	1	3		.	1	1	.	3	40	1	.	.	31	1	7	1	.	1	.	2	63	1	2	6	.	.	.	.	.	.	.	.	.	.	.
24 de Julho	Bernadino Uamusse	17.05.2014	4	1	4	3	.	1	1	.	2	.	.	.	3	Zongoene sede B2	.	1	1	.	14	.	1	.	.	.	3	7	1	.	1	.	4	63	1	4	6	.	1	2	10	2	4	2	6	1	3	.
24 de Julho	Julieta Tivane	17.05.2014	3	2	4	2	.	2	2	.	2	.	.	.	3		.	2	.	.	1	.	11	.	.	60	1	7	1	.	1	.	3	24	1	2	8	.	1	2	4	2	5	2	6	1	3	.
24 de Julho	Miguel Chau	17.05.2014	3	1	1	3	.	2	1	.	2	.	.	.	3		.	1	2	.	9	.	7	.	40	36	3	7	1	3	1	4	4	64	1	4	8	.	1	2	4	2	5	2	6	1	3	.
24 de Julho	Vasco Mula	17.05.2014	3	1	1	2	.	3	1	.	2	.	.	.	3		.	1	2	.	15	.	9	.	.	.	3	7	1	1	1	1	4	16	1	3	8	.	1	2	4	2	5	2	6	1	7	1

2	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Raquilir Jose Sitoe	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	1	1	3	7	.	1	6	.	2	.	14	.	.	13	.	.	.	.	.	.	.	.
Alice Nduvane	2	2	1	3	3	.	.	.	.	.	.	.	.	.	.	1	1	.	.	3	3	.	.	.	.	.	.	7	2	1	1	.	7	.	1	7	.	2	.	15	.	.	14	.	.	.	.	.	.	.	.
	.	2	.	.	.	.	.	.	.	.	.	.	.	8	.	1	.	.	.	.	.	.	.	.	.	.	.	7	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Albino Mula	7	2	8	3	6	4	2	5	3	6	4	7	5	8	1	1	1	2	3	3	4	4	5	5	7	6	6	7	2	1	1	5	7	.	1	7	.	4	.	48	.	.	.	.	.	.	.	.	.	.	.
Leonor Mutamba	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	11	.	1	8	.	2	.	16	.	.	.	.	.	.	.	.	.	.	.
Maholele	.	2	8	.	.	.	.	.	.	.	.	.	.	.	.	1	7	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Marta Mussava	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ILda Mutamba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carla Mussane	.	2	8	.	.	.	.	.	.	.	.	.	.	.	.	1	7	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Matilde Uamusse	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	6	.	.	.	.	.	.	.	.	.	.	.	.	1	1	3	7	.	1	8	.	4	.	30	.	.	22	.	.	10	250	30	.	.	.
Isabel Mathe	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salomao Mulate	.	2	8	3	7	.	.	.	.	.	.	.	.	8	5	1	7	.	.	.	.	4	6	.	.	.	.	7	7	1	1	3	8	.	1	6	.	2	.	45	.	.	.	.	.	.	.	.	.	.	.
Maria Sitoe	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	8	.	1	8	.	2	.	45	.	.	14	.	.	.	.	.	.	.	.
Meldina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	2	.	.	99	.	.	.	.	.	.	.	.	.	.	.	.	.
Maria Machango	.	2	8	.	.	.	.	.	.	.	.	.	.	.	.	1	7	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	8	.	.	.	.	2	.	1	.	.	1	.	.	.	.	.	.	.	.
Maria Mucavele	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	11	1	.	2	.	.	2	.	1	.	.	1	.	.	.	.	.	.	.	.
Alda	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	99	.	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paulina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	26	1	.	.	.	.	2	.	1	.	.	1	.	.	.	.	.	.	.	.
Moises Mutambe	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	27	1	.	1	6	.	4	.	25	.	.	16	.	.	.	.	.	.	.	.
Almerinda	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	1	.	.	.	.	.	.	30	.	.	.	.	.	.	.	.	.	.	.
Angelina Chilaule	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Atalia Cossa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	6	1	.	.	.	.	2	.	23	.	.	.	.	.	.	.	.	.	.	.
Bernadino Uamusse	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	3	8	.	1	6	.	4	.	12	.	.	13	.	.	.	.	.	.	.	.
Julieta Tivane	.	2	8	.	.	.	.	.	.	.	.	.	.	.	.	1	7	.	.	.	.	.	.	.	.	.	.	7	5	1	1	2	1	.	1	6	.	2	.	27	.	.	.	.	.	.	.	.	.	.	.
Miguel Chau	.	2	8	.	.	4	5	.	.	.	.	.	.	.	.	1	7	.	.	.	.	.	.	.	.	.	.	7	7	1	1	3	8	.	1	6	.	2	.	14	.	.	10	.	.	.	.	.	.	.	.
Vasco Mula	7	2	8	3	7	4	6	.	.	.	.	.	.	8	5	1	7	.	.	.	.	4	5	5	4	.	.	7	6	1	1	3	7	.	1	8	.	4	.	45	.	.	.	.	.	.	.	.	.	.	.
Adnercia Nhaule	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	28	.	.	1	8	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Daniel Chave	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	1	8	.	4	.	15	.	.	10	.	.	.	.	.	.	.	.
Cremildo Mazuze	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	16	.	.	1	8	.	2	.	15	.	.	13	.	.	.	.	.	.	.	.
Aldai Macie	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	13	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Artimiza	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	29	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Inacio Mavungue	.	2	8	3	5	.	.	.	.	.	.	.	.	.	.	1	7	.	.	3	6	.	.	.	.	.	.	7	7	1	1	25	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salomao	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Flavia Massingue	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	1	6	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Luis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	16	8	.	1	8	.	.	.	19	.	.	.	.	.	.	.	.	.	.	.
Constantino Massar	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	3	.	1	8	.	4	.	15	.	.	10	.	.	.	.	.	.	.	.
Manuel Chilaule	.	2	8	3	7	.	.	.	.	.	.	.	.	8	6	1	7	.	.	.	.	.	.	.	.	.	.	7	6	1	1	3	8	.	1	6	.	2	.	14	.	.	.	.	.	.	.	.	.	.	.
Ernesto Chilaule	.	2	8	3	7	.	.	.	.	.	.	.	.	8	6	1	7	.	.	.	.	.	.	.	.	.	.	7	6	1	1	3	8	.	1	6	.	2	.	14	.	.	.	.	.	.	.	.	.	.	.
Isaias Pelembe	1	2	2	3	3	.	.	.	.	.	.	.	.	8	4	1	1	.	.	3	2	.	.	.	.	.	.	.	.	1	1	.	8	.	1	7	.	4	.	18	.	.	13	.	.	.	.	.	.	.	.
Marta Boca	2	2	1	3	3	4	4	5	5	6	6	7	7	8	8	1	1	2	3	3	2	4	4	5	5	6	7	7	6	1	1	3	7	.	1	4	.	4	.	40	.	.	25	.	.	.	.	.	.	.	.
Domingos Manhica	3	2	2	3	1	4	4	5	5	6	6	7	7	8	8	1	3	2	4	3	1	4	5	5	2	6	6	7	7	1	1	.	8	.	2	.	.	2	.	41	.	.	21	.	.	.	350	.	.	.	.
Carlos Boca	3	2	4	3	1	4	2	5	5	6	6	7	7	8	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	20	8	.	1	7	.	4	.	23	.	.	21	1	.	10	.	15	10	.	.
Samuel Manave	2	2	1	3	3	4	4	5	6	6	5	7	7	8	8	1	2	2	4	3	1	4	5	5	3	6	6	7	7	1	1	3	8	.	1	4	.	4	.	26	.	.	26	.	.	30	400	15	.	.	.
Heringues Chilaule	3	2	1	3	2	4	4	5	5	6	6	7	7	8	8	1	1	2	3	3	4	4	5	5	2	6	6	7	7	1	1	10	7	.	.	.	.	.	.	30	.	.	29	.	.	25	400	15	.	.	.

2	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
Raquilir Jose Sitoe	.	.	50	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	3	.	1	3	1	1	1	4	1	1	2	.
Alice Nduvane	.	.	35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	3	.	99	.	1	3	1	4	1	3	1	2
	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	7	1	5	1	7
Albino Mula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leonor Mutamba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	1	33	1	1	1	5	2	.	2	.
Maholele	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Marta Mussava	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	4	.	1	10	.	.	.	.	.	.	.	.
ILda Mutamba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	4	.	1	10	.	.	.	.	.	.	.	.
Carla Mussane	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	2	.	2	.	2	.	2	.	2	.
Matilde Uamusse	.	.	.	80	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	4	.	1	8	1	1	1	6	2	.	2	.
Isabel Mathe	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salomao Mulate	.	.	.	.	.	.	10	.	70	.	.	.	10	.	17	.	.	2	.	2	.	.	.	1	.	1	.	.	2	.	.	5	4	1	8	1	6	1	1	1	8	2	.
Maria Sitoe	20	.	30	40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	3	.	1	8	1	1	1	2	2	.	2	.
Meldina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	8	.	.	.	.	.	.	.	.
Maria Machango	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	7	.	.	.	.	.	.	.	.
Maria Mucavele	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	3	.	1	8	.	.	.	.	.	.	.	.
Alda	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	1	.	.	.	.	.	.	.	.
Paulina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	5	4	1	37	2	.	2	.	1	15	2	.
Moises Mutambe	.	.	.	80	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	5	16	1	8	1	1	1	6	.	.	.	.
Almerinda	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Angelina Chilaule	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Atalia Cossa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bernadino Uamusse	90	.	.	100	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	2	.	1	8	1	1	1	6	.	.	.	.
Julieta Tivane	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	2	.	.	5	4	99	8	1	6	1	1	1	10	1	9
Miguel Chau	.	.	.	100	.	.	.	.	.	.	.	.	.	.	.	20	.	.	.	.	.	.	.	.	.	.	2	.	2	.	.	5	4	1	8	1	1	1	1	1	2	1	4
Vasco Mula	.	.	.	100	.	.	.	.	.	.	.	.	100	.	200	200	.	.	.	.	.	.	.	2	.	2	2	.	1	15	1	5	4	1	8	1	16	1	1	2	.	2	.
Adnercia Nhaule	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	17	.	.	.	1	17	2	.	1	1	2	.	2	.
Daniel Chave	.	.	100	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.	.	1	8	1	1	2	.	2	.	2	.
Cremildo Mazuze	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	8	.	.	.	.	.	.	.	.
Aldai Macie	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	6	.	.	.	.	.	.	.	.
Artimiza	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	8	.	.	.	.	.	.	.	.
Inacio Mavungue	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	8	.	.	.	.	.	.	.	.
Salomao	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	8	.	.	.	.	.	.	.	.
Flavia Massingue	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	8	2	.	2	.	1	15	2	.
Luis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7	.	.	.	.	.	.	.	.
Constantino Massar	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	5	4	1	17	.	.	.	.	.	.	.	.
Manuel Chilaule	.	.	.	.	.	.	10	.	50	.	.	.	50	.	30	.	.	2	.	2	.	.	.	2	.	2	.	.	2	.	.	5	4	1	3	1	6	1	1	1	10	2	.
Ernesto Chilaule	.	.	.	.	.	.	10	.	15	.	.	.	10	.	5	.	.	2	.	2	.	.	.	2	.	2	.	.	2	.	.	5	4	1	8	1	6	1	1	1	10	1	9
Isaias Pelembe	50	.	90	80	.	.	1	.	1	.	.	.	3	.	4	80	.	1	.	1	.	.	.	1	.	1	1	.	1	9	6	5	4	1	9	1	4	1	4	1	11	1	5
Marta Boca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Domingos Manhica	.	.	.	40	.	.	.	3	.	.	.	.	.	.	.	10	.	.	1	.	.	.	.	.	.	.	1	.	1	.	7	2	.	1	18	1	1	2	.	2	.	2	.
Carlos Boca	100	.	.	80	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2	.	1	19	1	12	1	6	1	2	2	.
Samuel Manave	.	.	20	40	.	.	5	1	10	.	.	.	.	.	3	8	.	1	1	.	.	.	.	.	.	1	1	.	1	11	3	2	.	1	7	1	2	1	6	1	2	.	.
Heringues Chilaule	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	.	.	.	.	.	.	.	.

Source: CDS-Field Survey 2014

Salvador Alle	Amelia Joao	24.05.2014	2	2	1	1	.	1	1	.	1	.	1	1	3	Chilanlene B4	.	1
Salvador Alle	Marta Chicavele	22.05.2014	3	2	1	2	.	2	1	.	2	.	.	.	3		.	1
Salvador Alle	Isilda Maria	22.05.2014	2	2	1	2	.	2	2	.	2	.	.	.	3		.	1
Salvador Alle	Alberto Mazoe	.	3	1	1	1	.	2	1	.	2	.	.	.	3	Mahilene	.	.
Salvador Alle	Helena Mula	22.05.2014	2	2	1	2	.	2	1	.	2	.	.	.	3		.	1
Salvador Alle	Olga Francisco	22.05.2014	2	2	1	2	.	1	1	.	2	.	.	.	3		.	1
Salvador Alle	Salmina Mboane	22.05.2014	3	2	1	2	.	2	1	.	2	.	.	.	3		.	1
Salvador Alle	Jonas Macondzo	22.05.2014	3	1	1	6	3	2	1	.	2	.	.	.	3		.	1
Salvador Alle	Celeste Macondzo	22.05.2014	2	2	2	2	.	1	4	.	.	.	.	.	3		.	1
Salvador Alle	Rosita Mulungo	22.05.2014	3	2	1	2	.	2	1	.	.	.	.	.	3	Mahilene	.	2
Salvador Alle	Jose Nhandzime	22.05.2014	3	1	1	3	.	2	1	.	2	.	.	.	.	Mahilene	.	1
Salvador Alle	Marta Bila	22.05.2014	2	2	2	2	.	1	4	.	.	.	.	.	.	Mahilene	.	1
Salvador Alle	Amerio Guenha	22.05.2014	3	1	2	4	2	1	5	2	2	.	.	.	3		.	1
Salvador Alle	Acacio Nhanengue	22.05.2014	3	1	1	2	.	1	1	.	2	.	.	.	3		.	1
Salvador Alle	Sonia Zaida	22.05.2014	3	2	1	2	.	1	2	.	2	.	.	.	3		.	1
Salvador Alle	Gertrudes	22.05.2014	3	2	1	2	.	1	2	.	2	.	.	.	3		.	1
Salvador Alle	Agostinho Nhandzim	22.05.2014	3	1	1	2	.	2	1	.	2	.	.	.	.	Mahilene	.	1
Salvador Alle	Jaime Junior	22.05.2014	3	1	1	2	.	2	1	.	2	.	.	.	.	Mahilene	.	2
Salvador Alle	Helena	22.05.2014	4	2	3	2	.	1	2	.	2	.	.	.	.	Mahilene	.	2
Salvador Alle	Maria Machava	22.05.2014	4	2	4	2	.	1	2	.	2	.	.	.	.	Zonguene	1	2
Salvador Alle	Rosalia Zimila	25.05.2014	3	2	1	2	.	2	1	.	1	.	2	1	3	Xai xai	5	2
Salvador Alle	Raquel Mazuze	24.05.2014	2	2	2	2	.	.	1	.	1	.	1	1	3	Xai xai	5	1
Salvador Alle	Eugenio	24.05.2014	3	1	1	2	.	2	1	.	2	.	.	.	3	Magombane	5	1
Salvador Alle	Lazaro	24.05.2014	2	1	2	3	.	2	1	.	1	.	1	1	3	Xai xai	5	1
Salvador Alle	Narciso	24.05.2014	2	1	2	6	4	3	1	.	1	.	3	.	3		5	1
Salvador Alle	Ecelina	24.05.2014	3	2	1	1	.	1	1	.	2	.	.	.	3	Bilene	5	1
Voz da Frelir	Florencia Bernardo	15.05.2014	3	2	1	2	.	99	1	.	1	.	1	.	3	4 Bairro	.	1
Voz da Frelir	Mario	16.05.2014	99	1	4	.	.	1	1	.	2	.	.	.	3		.	2
Voz da Frelir	Filomena Fuguana	.	3	2	2	2	.	1	2	.	2	2	.	.	.	Chicumbane	2	1
Voz da Frelir	Bernardo Markel	.	4	1	1	1	.	2	1	.	2	.	.	.	3	B4	.	1
Voz da Frelir	Joao Markel	15.05.2014	.	1	1	3	.	2	1	.	2	.	.	.	3	B4	.	1
Voz da Frelir	Caldir Maudluio	.	3	2	4	2	.	3	2	.	2	.	.	.	3	B 4	.	2
Voz da Frelir	Jose Mazuse	.	3	1	1	2	.	2	1	.	2	.	.	.	3	B 4	.	1
Voz da Frelir	Flora M. Mazive	15.05.2014	3	2	4	2	.	99	2	.	2	.	.	.	3	B4 Maboi	.	2
Voz da Frelir	Utilia Ndove	15.05.2014	3	2	1	2	1	1	1	.	1	1	1	.	3	B 4 Maboi	.	2
Voz da Frelir	Hortencia Malaunde	.	3	2	4	2	.	1	2	.	2	.	.	.	3	B 4 Maboi	.	1
Voz da Frelir	Maria A. Matavel	15.05.2014	.	2	1	1	.	2	1	.	2	.	.	.	3	B4 Maboi	.	2
Voz da Frelir	Jose D.Mulhanga	15.05.2014	4	1	1	2	.	1	1	.	2	.	.	.	3	B4	.	1
Voz da Frelir	Ana Math	16.05.2014	2	2	4	2	.	1	2	.	2	.	.	.	3	B4	.	1
Voz da Frelir	Pedro Mussuei	.	3	1	1	6	1	2	.	.	1	.	.	.	3	B4 Maboi	.	1
Voz da Frelir	Sonia David Mulhan	.	3	2	1	2	.	3	1	.	1	.	1	.	3	Zonguene	.	1
Voz da Frelir	Adelia Mutambe	15.05.2014	3	2	1	2	.	2	1	.	1	1	.	.	3	B4 Maboia	.	1
Voz da Frelir	Orlando Duvane	15.05.2014	2	1	1	1	.	2	1	.	2	.	.	.	.	B4 Maboia	.	1
Voz da Frelir	Alzira Simango	15.05.2014	3	2	1	2	.	2	2	.	2	.	.	.	.	B4 Maboia	.	1
Voz da Frelir	Carlos Balate	15.05.2014	3	1	1	1	.	2	1	.	2	.	.	.	3	B4 Maboia	.	1
Voz da Frelir	Isabel Bento	16.05.2014	4	2	4	2	.	1	2	.	2	.	.	.	3	Manjacaze	3	1
Voz da Frelir	Carlos Mahanuco	.	3	1	1	5	.	2	1	.	2	.	.	.	3		.	1
Voz da Frelir	Ester Mahanuque	16.05.2014	3	2	4	2	.	1	2	.	2	.	.	.	2	Mahanuque	.	1
Voz da Frelir	Celia Leonardo	16.05.2014	3	2	1	2	.	1	1	.	1	2	.	.	2	Gutsuine	.	1
Voz da Frelir	Samaria Zumbane	16.05.2014	3	2	2	2	.	1	2	.	2	.	.	.	3	Goine	.	1
Voz da Frelir	Samaria Zumbane	16.05.2014	3	2	2	2	.	1	2	.	2	.	.	.	3	Goine	.	1
Voz da Frelir	Angelica Mboane	15.05.2014	2	2	1	2	.	2	1	.	1	1	1	2	2	Zonguene	1	1
Voz da Frelir	Amelia Machave	15.05.2014	99	2	1	2	.	1	1	.	2	.	.	.	3	Bilene	.	1
Voz da Frelir	Maria Cossa	16.05.2014	3	2	4	2	.	1	2	.	2	.	.	.	3		.	2
Voz da Frelir	Ofelia Mussane	16.05.2014	3	2	2	2	.	1	2	.	2	.	.	.	1		1	1
Voz da Frelir	Mario Nave Cossa	16.05.2014	99	1	4	2	.	1	1	.	2	.	.	.	3	Chibuto	2	2
Voz da Frelir	Raimundo Sozinho	18.05.2014	4	1	1	4	.	3	1	.	2	.	.	.	3		.	1
Voz da Frelir	Belino Molheia	16.05.2014	3	1	.	4	.	2	1	.	1	.	.	.	2		.	1
Voz da Frelir	Alice Bunga	16.05.2014	2	2	1	1	.	2	5	1	2	.	.	.	1	Zonguene B3	1	1
Voz da Frelir	Flora Nguenha	16.05.2014	3	2	1	5	.	1	1	.	1	.	1	.	3	Voz da Frelimo	.	1
Voz da Frelir	Natercia Mate	16.05.2014	3	2	1	2	.	3	2	.	.	.	.	.	3	B4	.	2
Voz da Frelir	Domingos Joaquim	.	3	1	1	2	.	2	1	.	1	1	1	.	3	Voz da Frelimo B1	.	1
Voz da Frelir	Feliciana Mula	16.05.2014	3	2	1	2	.	2	1	.	1	.	.	.	.		.	1
Voz da Frelir	Paula Malheia	16.05.2014	2	2	1	2	.	2	1	.	1	1	1	1	3		.	1
Voz da Frelir	Rosita Moiane	16.05.2014	3	2	1	2	.	2	2	.	2	.	.	.	3		.	2
Voz da Frelir	Agostinho Macuche	16.05.2014	3	1	1	3	.	3	1	.	2	.	.	.	.		.	2
Voz da Frelir	Olinda Markel	16.05.2014	3	2	1	2	.	1	4	.	.	.	.	.	3		.	1
Voz da Frelir	Salome Markel	16.05.2014	4	1	4	2	.	3	2	.	.	.	.	.	3		.	2
Voz da Frelir	Elsa Vembane	16.05.2014	2	2	1	2	.	2	1	.	2	.	.	.	2	Chibuto	.	1
Voz da Frelir	Alice Bunga	16.05.2014	2	2	1	1	.	2	5	1	2	.	.	.	1	Zonguene B3	1	1
Voz da Frelir	Flora Nguenha	16.05.2014	3	2	1	5	.	1	1	.	1	.	1	.	3	Voz da Frelimo	.	1
Voz da Frelir	Jaime Tete	16.05.2014	99	1	1	2	.	1	1	.	2	.	.	.	3	Voz da Frelimo B5	.	2
Voz da Frelir	Francisco Mahumar	16.05.2014	4	1	1	2	.	1	1	.	2	.	.	.	3	Voz da Frelimo B5	.	1
Zimelene	Lizete Homo	22.05.2014	3	2	4	2	.	1	2	.	.	.	.	.	3	Cumbane	.	2
Zimelene	Joao Zimila	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.
Zimelene	Alberto Chilaule	19.05.2014	3	1	4	2	.	1	1	.	2	.	.	.	3		.	2
Zimelene	Victorino Moiane	16.05.2014	2	1	4	2	.	2	1	.	2	.	.	.	3	Zongoene	.	.
Zimelene	Alda Mula	16.05.2014	3	2	1	2	.	2	2	.	1	1	1	1	3	Nhacutse	1	1
Zimelene	Salmina Mula	16.05.2014	3	2	1	1	.	.	1	.	2	.	.	.	3	Bairro 1	.	.
Zimelene	Narciso Licuze	19.05.2014	2	1	1	2	.	2	1	.	2	.	.	.	3		.	1
Zimelene	Manuel	19.05.2014	4	1	1	2	.	1	1	.	2	.	.	.	3		.	1
Zimelene	Fatima	19.05.2014	3	2	2	5	.	1	2	.	2	.	.	.	1	Bairro 1	.	2
Zimelene	Regina	19.05.2014	2	2	1	2	.	2	1	.	2	.	.	.	3	Bairro 1	.	1
Zimelene	Milagre Maulele	19.05.2014	2	1	1	6	2	2	1	.	1	.	.	.	3	Bairro 1	.	1
Zimelene	Benjamim	19.05.2014	3	1	1	6	2	2	1	.	1	.	.	.	3	Bairro 1	.	1
Zimelene	Manuel Nhabanga	19.05.2014	3	1	1	6	2	2	1	.	1	1	4	.	3	Bairro 1	.	1
Zimelene	Amelia Zimba	19.05.2014	3	2	1	2	.	1	2	.	2	.	.	.	3		.	1
Zimelene	Beniasse Machai	15.05.2014	3	1	4	2	.	1	1	.	2	.	.	.	3		.	1
Zimelene	Juliao Mathe	15.05.2014	2	1	2	3	.	1	1	.	2	.	.	.	2	Xai xai	6	1
Zimelene	Aron Manhengue	15.05.2014	3	1	2	3	.	2	1	.	1	4	1	1	1		6	1
Zimelene	Alzira Mula	15.05.2014	3	2	3	2	.	1	2	.	2	.	.	.	3	Manjacaze	4	2
Zimelene	Carlos Mula	16.05.2014	3	1	1	5	10	1	1	.	1	2	1	1	3		.	1
Zimelene	Manuel Chilaule	16.05.2014	3	1	1	2	.	1	1	.	2	.	.	.	3		.	1
Zimelene	Rute Chilaule	16.05.2014	3	2	4	2	.	1	2	.	2	.	.	.	3		.	2
Zimelene	Maria Milambo	16.05.2014	3	2	3	2	.	1	2	.	2	.	.	.	3		.	1
Zimelene	Estevao Mazuze	16.05.2014	3	1	99	3	.	1	1	.	2	.	.	.	3		.	1
Zimelene	Mariana Sitoe	16.05.2014	3	2	3	4	.	1	2	.	2	.	.	.	2	Macia	2	1
Zimelene	Isabel Mulane	16.05.2014	3	2	4	2	.	1	2	.	2	.	.	.	3		.	1
Zimelene	Joao Antonio	16.05.2014	4	1	1	2	.	1	1	.	3	.	.	.	3		.	2
Zimelene	Etelvina Mula	16.05.2014	3	2	2	2	.	1	2	.	99	.	.	.	3		.	2
Zimelene	Herminia Muthamba	16.05.2014	3	2	4	2	.	2	2	.	2	.	.	.	3		.	1
Zimelene	Gina Joaquim	16.05.2014	3	2	1	2	.	1	1	.	1	1	.	1	1	Mahelene	1	2
Zimelene	Carlota Macarringue	16.05.2014	3	2	2	2	.	1	2	.	2	.	.	.	3		.	1
Zimelene	Elio Mula	16.05.2014	3	1	1	2	.	1	1	.	2	.	.	.	3		.	1
Zimelene	Jose Ussimane	16.05.2014	3	1	1	2	.	2	1	.	1	3	5	1	3		.	1
Zimelene	Alberto Timane	15.05.2014	3	1	1	3	.	2	1	.	2	.	.	.	2	Xai xai	.	2
Zimelene	Rene	15.05.2014	2	1	2	6	1	1	1	.	1	3	.	.	1	Xai xai	2	1
Zimelene	Francisco Antonio	15.05.2014	2	1	.	6	1	1	5	5	2	.	.	.	1	Xai xai	2	1
Zimelene	Joao Mariquel	15.05.2014	4	1	4	2	.	2	1	.	99	.	.	.	3		.	99
Zimelene	Antonio Matavel	16.05.2014	3	1	3	2	.	1	1	.	2	.	.	.	2	Macia	6	2
Zimelene	Maria Matavel	15.05.2014	4	2	4	2	.	2	3	.	1	.	1	1	3	Chokwe	1	99
Zimelene	Maria de Lurdes	17.05.2014	3	2	4	2	.	1	2	.	2	.	.	.	3		.	1
Zimelene	Assucena Massang	17.05.2014	4	2	4	2	.	1	2	.	2	.	.	.	3	Bairro 3	.	1
Zimelene	Helena Zimila	17.05.2014	3	2	1	2	.	.	1	.	2	.	.	.	3		.	2
Zimelene	Joaquim	19.05.2014	3	1	.	2	.	1	1	.	2	.	.	.	.	Bairro 4	.	1
Zimelene	Domingos Alberto	19.05.2014	3	1	1	2	.	1	1	.	2	.	.	.	3	Bairro 4	.	2
Zimelene	Maria	12.05.2014	4	2	4	2	.	2	3	.	2	.	.	.	3	Bairro 4	.	2
Zimelene	Rosita Machava	19.05.2014	4	2	4	2	.	1	2	.	2	.	.	.	3	Bairro 4	.	2
Zimelene	Veronica Nfumo	19.05.2014	99	2	4	2	.	1	2	.	.	.	.	.	3		.	2
Zimelene	Belinha Nhabanga	19.05.2014	2	2	1	2	.	1	2	.	.	.	.	.	.		.	1
Zimelene	Raulina Mbalane	19.05.2014	4	2	4	2	.	1	2	.	2	.	.	.	2		.	2
Zimelene	Alice Mussane	19.05.2014	3	2	2	2	.	1	2	.	2	.	.	.	3		.	1
Zimelene	Salmina Nhazima	19.05.2014	3	2	4	2	.	2	2	.	2	.	.	.	3		.	2
Zimelene	Raulina Mula	19.05.2014	3	2	2	2	.	1	2	.	2	.	.	.	3	Bairro 4	.	1
Zimelene	Gimpede Mussane	19.05.2014	2	2	1	2	.	2	1	.	1	1	1	.	3	Bairro 4	.	1
Zimelene	Flora Mandleia	19.05.2014	3	2	1	2	.	2	1	.	1	1	1	.	3	Bairro 4	.	1
Zimelene	Marta	19.05.2014	2	2	1	2	.	2	1	.	2	.	.	.	3	Bairro 4	.	1
Zimelene	Armando Bila	19.05.2014	3	1	1	2	.	1	1	.	2	.	.	.	3		.	2
Zimelene	Elisa Tamele	19.05.2014	3	2	4	2	.	1	2	.	2	.	.	.	3		.	2
Zimelene	Olinda Deve	19.05.2014	3	2	4	2	.	2	2	.	2	.	.	.	3		.	2
Zimelene	Delfa Zimila	19.05.2014	2	2	1	2	.	1	2	.	2	.	.	.	3		.	1
Zimelene	Juvencia	19.05.2014	2	2	1	2	.	1	1	.	2	.	.	.	3		.	1
Zimelene	Bernadete	19.05.2014	3	2	1	2	.	2	1	.	2	.	.	.	3		.	1
Zimelene	Jorge	19.05.2014	3	1	2	.	.	1	1	.	2	.	.	.	3		.	1
Zimelene	Carlota Matsinhe	15.05.2014	3	2	2	2	.	1	2	.	2	.	.	.	3	Chirambene B1 Z5	.	1
Zimelene	Aurelio Fabiao	16.05.2014	4	1	3	2	.	1	1	.	2	.	.	.	3	Chirambene B1 Z5	.	1
Zimelene	Domingos Manjate	16.05.2014	3	1	3	2	.	1	1	.	2	.	.	.	3	Chirambene B1 Z5	.	1

Source: CDS-Field Survey 2014

1	Aldeia
2	Nome
3	Data
4	Idade
5	Sexo
6	ECivil
7	Profi
8	ProfiOutro
9	AF
10	ChefeF
11	ChefeFOut
12	ChefeFTem
13	SimTempo
14	SimOnde
15	SimActiv
16	TemReside
17	Natural
18	CausaMorar
19	FEscola
20	Nivel
21	NivelOut
22	Actividade
23	Cultura
24	ActiPessoa
25	ActIdade
26	IdadeH
27	IdadeM
28	ActiFinal
29	ActImport
30	ActiAlim
31	ActiRend
32	FFiavelAgri
33	FFiavelRend
34	TemPeixe
35	TipoPeixe
36	Mariscos
37	TempMarisc
38	TipoMarisc
39	MariscOutro
40	Mudanca
41	Tamanho
42	CausaTam
43	Quantidade
44	CausaQua
45	Mangal
46	CausaMang
47	Utilizador
48	CausaUtil
49	Importante1
50	NivelImport

51	Importante2
52	NivelImport2
53	Importante3
54	NivelImport3
55	Importante4
56	NivelImport4
57	Importante5
58	NivelImport5
59	Importante6
60	NivelImport6
61	Importante7
62	NivelImport7
63	Importante8
64	NivelImport8
65	ActivImport1
66	NiveImport1
67	ActivImport2
68	NiveImport2
69	ActivImport3
70	NiveImport3
71	AtivImport4
72	NiveImport4
73	ActivImport5
74	NiveImport5
75	ActivImport6
76	NiveImport6
77	ActivImport7
78	NiveImport7
79	CoMangal
80	Importancia
81	SimImport
82	Utilidade
83	OutroUtil
84	Organismo
85	SimEspecie
86	OutroEspec
87	Destino
88	OutroDest
89	ProdConsum
90	ProdCOutr
91	ProdCOutro2
92	ProdVend
93	ProdVOutr1
94	ProdVOut2
95	PrecoLenha
96	PrecoCarv
97	PrecoEst
98	PrecoMedic
99	PrecoTint
100	PrecoOut

101	PrecoCaran
102	PrecoCarac
103	PrecoCamar
104	PrecoPeix
105	PrecoOutr
106	PrecOutr
107	QLenha
108	QCarvao
109	QEstaca
110	QMedic
111	QTinta
112	QOutro
113	QCarang
114	QCarac
115	QCamar
116	QPeixe
117	QOutr
118	TemLenh
119	TemCarv
120	TemEstac
121	TemMedic
122	TemTinta
123	TemOut
124	TemCaran
125	TemCarac
126	TemCamar
127	TemPeix
128	TemOutr
129	OutNegoc
130	SimOutr
131	Rende
132	MangalDestr
133	IndiqOutro
134	ProtMangal
135	Finalidad
136	TrabHome
137	IndicarH
138	TrabMulhe
139	IndicarM
140	TrabRapa
141	IndicaRapa
142	TrabRapari
143	IndicaRapar