Literature review of climate resilience in the Mozambique portion of the Limpopo/Olifants river basin

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USAID: RESILIENCE IN THE LIMPOPO BASIN PROGRAM (RESILIM) – OLIFANTS

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1 Introductory Note

This document is a review of the Mozambican part of the Limpopo Basin river system. It also forms part of the work being conducted by Verde Azul Consult through a contract with AWARD (Association for Water and Rural Development), lead consultant for the RESILIM-O project.

This project is part of a program called RESILIM - Resilience in the Limpopo Basin funded by USAID, with a duration five years and objective of supporting resilience strategies in South Africa and Mozambique.

The focus of the RESILIM-O project is the Olifants River, mostly located in South Africa. However, due to the approach of the project, the target area also includes the area of confluence with the Limpopo River in Mozambique until its mouth in Xai-Xai district, Gaza Province.

The main focus of this document is the analysis of the Limpopo River Basin in Mozambique with some consideration of the Olifants River Basin. This review complements that of the Olifants River Basin conducted by AWARD in order to obtain an overview of the project implementation area.

2 Location of the Limpopo River Basin

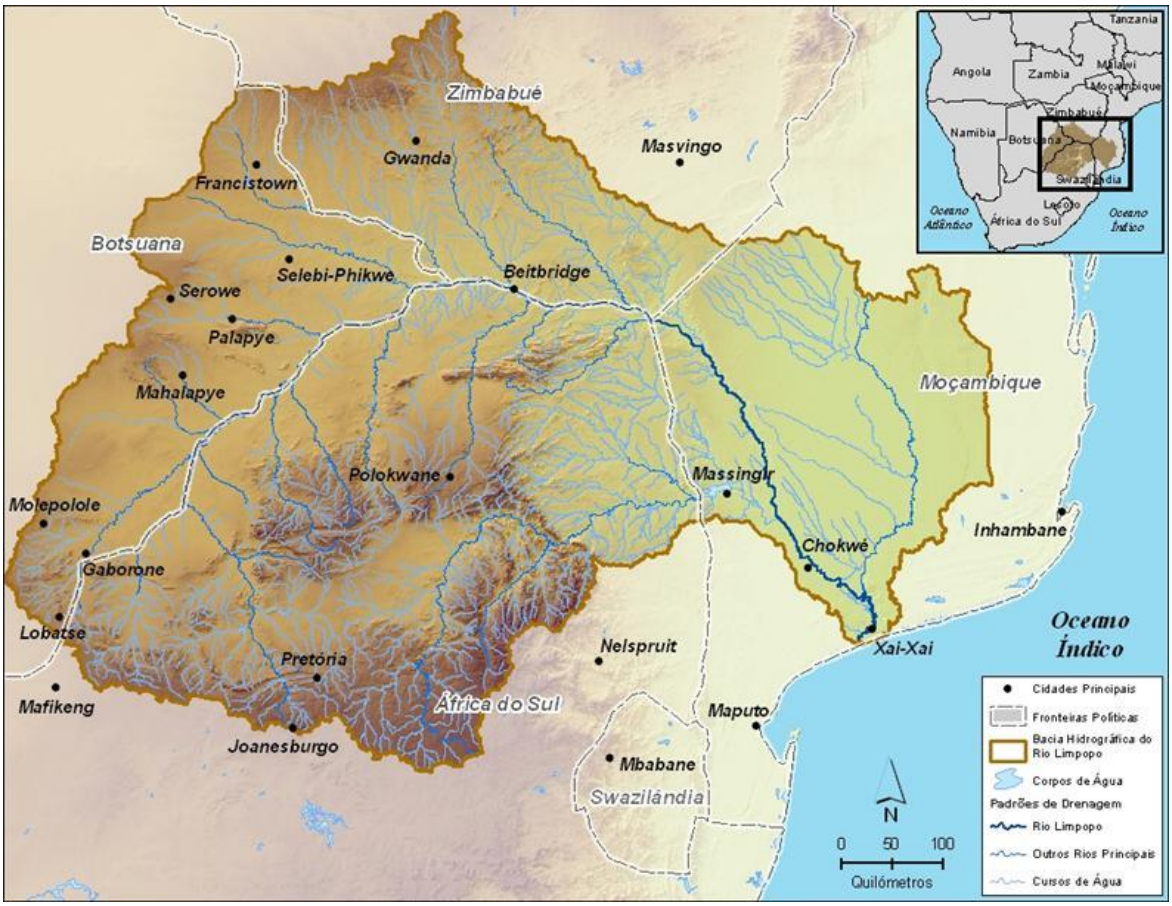

Figure 1: Map showing the location of the Limpopo River Basin (Hatfield, 2010, LIMCOM site)

The Limpopo River Basin is located approximately latitudes 22° and 26° Southand longitudes 26° e 35° East. The Limpopo Basin covers about 412 000Km^2 and straddles four countries in southern Africa. The South African portion of the basin has the largest area with around 193 500 km^{2}which is 47% of the total area. Next is the Mozambican portion with a 79 600 km^2 extension or 19,3% followed by Botswana with 76 300 km^2 or 17,3% of the basin and lastly, Zimbabwe with the smallest portion at 66 000 km^2, or 16%. There is no doubt that upstream water management has a serious effect on downstream conditions inside Mozambique.

The Limpopo River Basin is divided into three parts namely (INGC;UEM& FEWS NET, 2003):

- Upper Limpopo, which goes until the confluence with the Shashe River, at the border between South Africa, Botswana and Zimbabwe.
- Mid Limpopo, between the Sache River confluence and the confluence with the Luvuvhu River at the border of South Africa, Zimbabwe and Mozambique in Pafuri; and
- Lower Limpopo, which extends from Pafuri until the mouth of the river on the Indian Ocean.

The Basin supports large urban centres such as Francistown, Gaborone, parts of Pretoria, Polokwane and Johannesburg – all with a major contribution to pollution (Estuaries[1]: a Lifeline of Ecosystem Services in the Western Indian Ocean. Salif Diop, Peter Sheren, Jonh Machiwa).

The part of the basin in Mozambican territory is located between parallels 21° and25° South and meridians 31° e 35° to the east. In Mozambique, the Limpopo River Basin is bordered on the north by the Save River, to the south by the Komati River, to the east by the Indian Ocean coast and to the west by South Africa (DNA, 1996). According to DNA (1996), the Limpopo River Basin has four main tributaries flowing inside Mozambican territory namely: the Nuanedzi River to the north of the Basin which comes from Zimbabwe, flowing inside Mozambique for about 60 km, the Shingwedzi River which comes from South Africa which joins the Olifants River, the Changane River with its source very close to the border with Zimbabwe which joins the Limpopo close to its source on the coast of Xai-Xai, and the Olifants River which joins the Limpopo after the Massingir Dam/.

The Olifants River is the Limpopo River's most important tributary in Mozambique. With an extension of 6.900 km^2 from its origins in the Highveld, the river flows east passing through the provinces of Mpumalanga and Limpopo until its confluent with the Limpopo River in Mozambique which empties into the Indian Ocean. In this area of the basin the Olifants River is classified as perennial and rarely dry (except in exceptional cases) and one of Letaba River's main tributaries. The other main tributary of the Limpopo River is the Changane River with a length of 43 000 km^2 and is located in an area with an arid and semi-arid climate.

The length of the river, including the Olifants River, the Limpopo River and the two most important tributaries (the Changane and Shingwezi River) is 450 km, which is 31% of the total length total of the river.

[1] *Local irrigation using groundwater in organic soils of wetlands in floodplains or water from springs adjacent to dunes (Ducrot, 2011)*

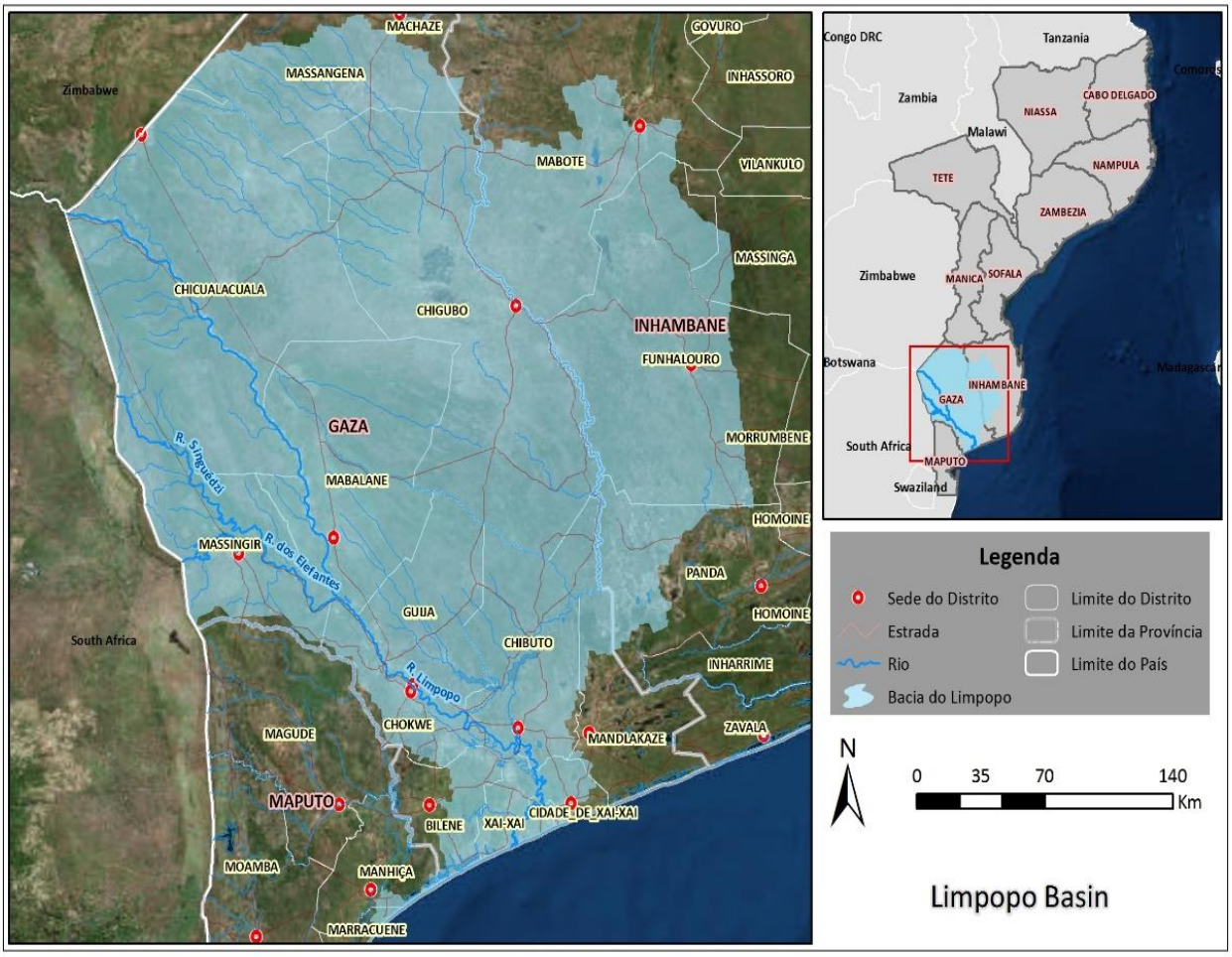

Figure 2- Map showing the location of the Limpopo River Basin in Mozambique (Verde-Azul, 2016)

3 Biophysical Features of the Limpopo River Basin

3.1 Climatic Conditions

The climate of the Basin varies considerably due to the fact that it is located at the transition of major climatic zones. According to the Köppen's classification, (FAO-SAFR, 2004 citing Köppen, 1918), the Basin's climate is predominantly semi-arid, dry and hot, with a generally Tropical climate, which varies from the coast to the interior.

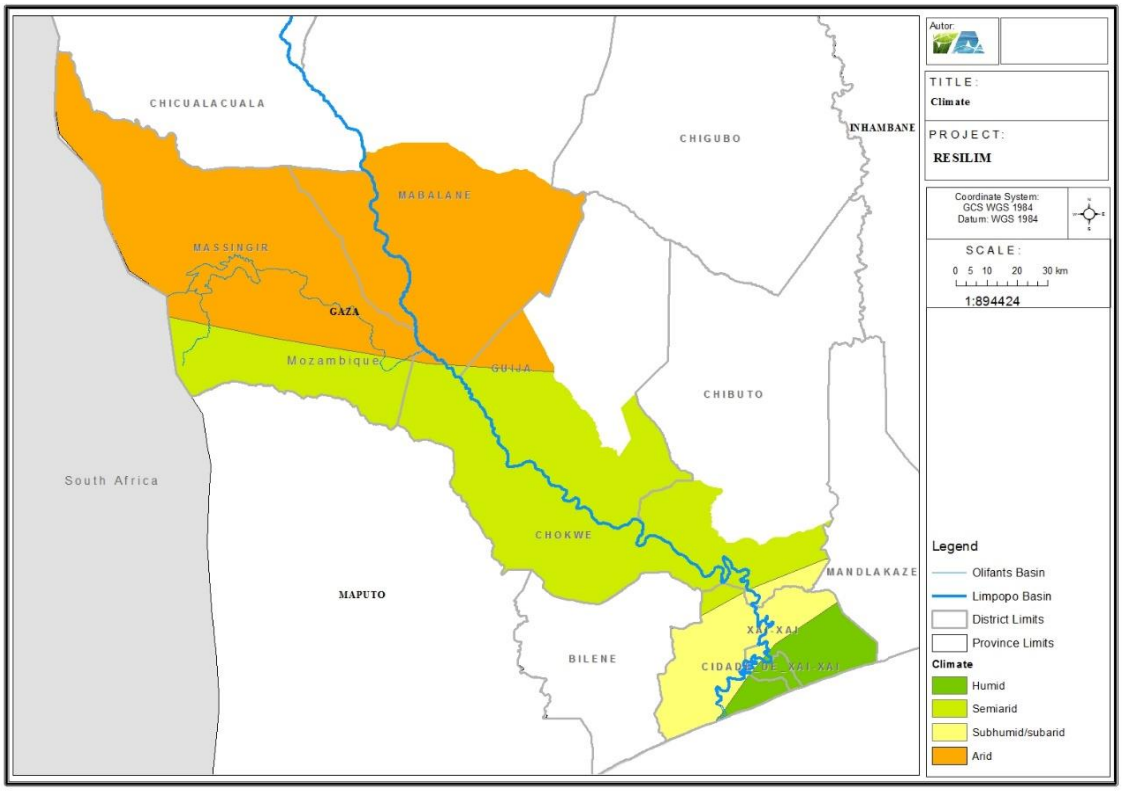

Figure 3: Climate Map of the Limpopo River Basin (Verde-Azul, 2016)

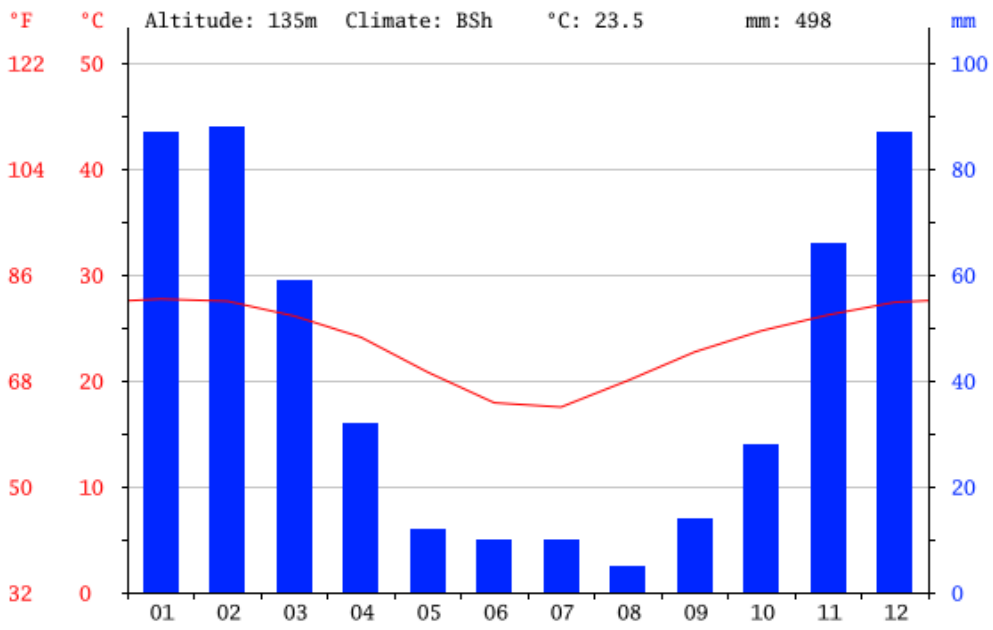

Figure 4: Graph showing weather variations in the Limpopo River Basin (Fonte: Fews Net)

3.1.1 Temperatures

The Basin's temperature generally averages between 23°C and 26°C with similar precipitation, from the coast to the interior (INGC;UEM& FEWS NET, 2003). The maximum daily temperature in the Limpopo River Basin varies between 30° C e 35 ° C during the hottest month (January) and a minimum of 9° C to 12° C during the coldest month (June). High temperatures mostly occur in summer, from the coast to the interior, respectively.

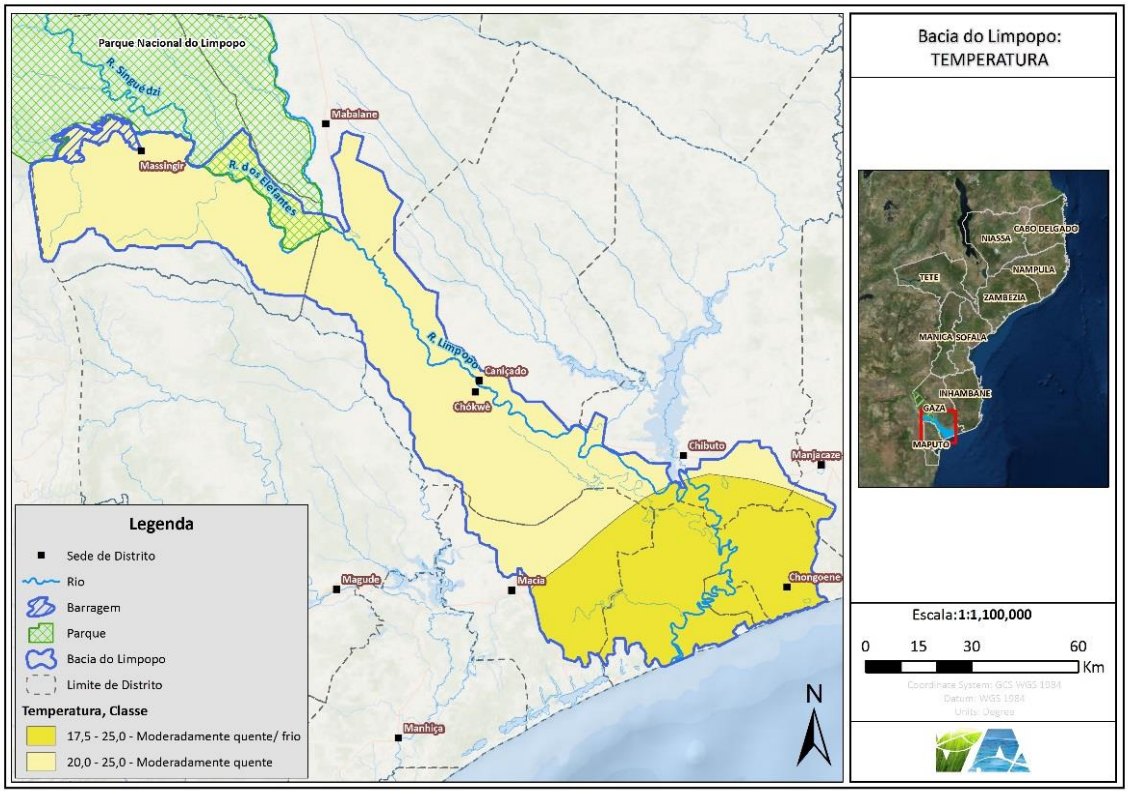

Figure 5: Map showing temperatures in the Limpopo River Basin (Verde-Azul, 2016)

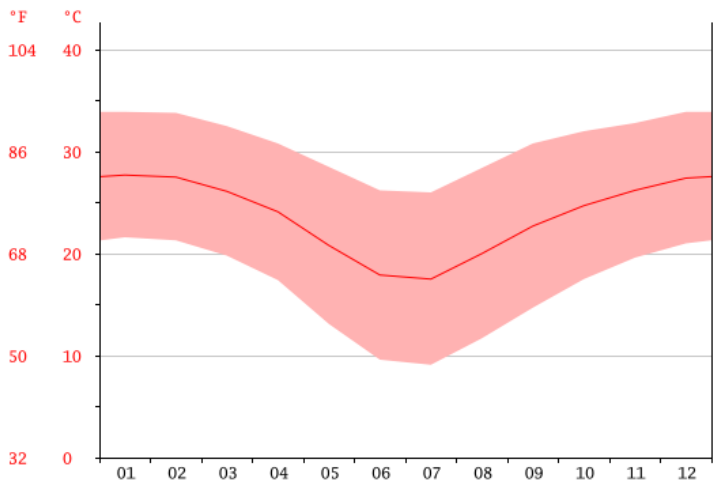

Figure 6: Graph showing temperature variations in the Limpopo River Basin (Fews Net, 2015)

3.1.2 Precipitation

The average annual precipitation in the Mozambican part of the Limpopo River Basin varies between 1000 mm along the coast and 350 mm in Pafuri, presenting a major variation inter-annual, with a coefficient variation of around 40% (INGC;UEM& FEWS NET, 2003).
Most of the Limpopo River Basin receives less than 500 mm of rain per year. The seasonal nature of rainfall during both summer (October to March) and in winter (April to September) is explained by the presence of anti- cyclonic conditions over the entire southern African region. Evaporation averages 1.970 mm, varying between 800-2400 mm per year, meaning it varies at a higher rate than precipitation. (Chilundo, 2007).

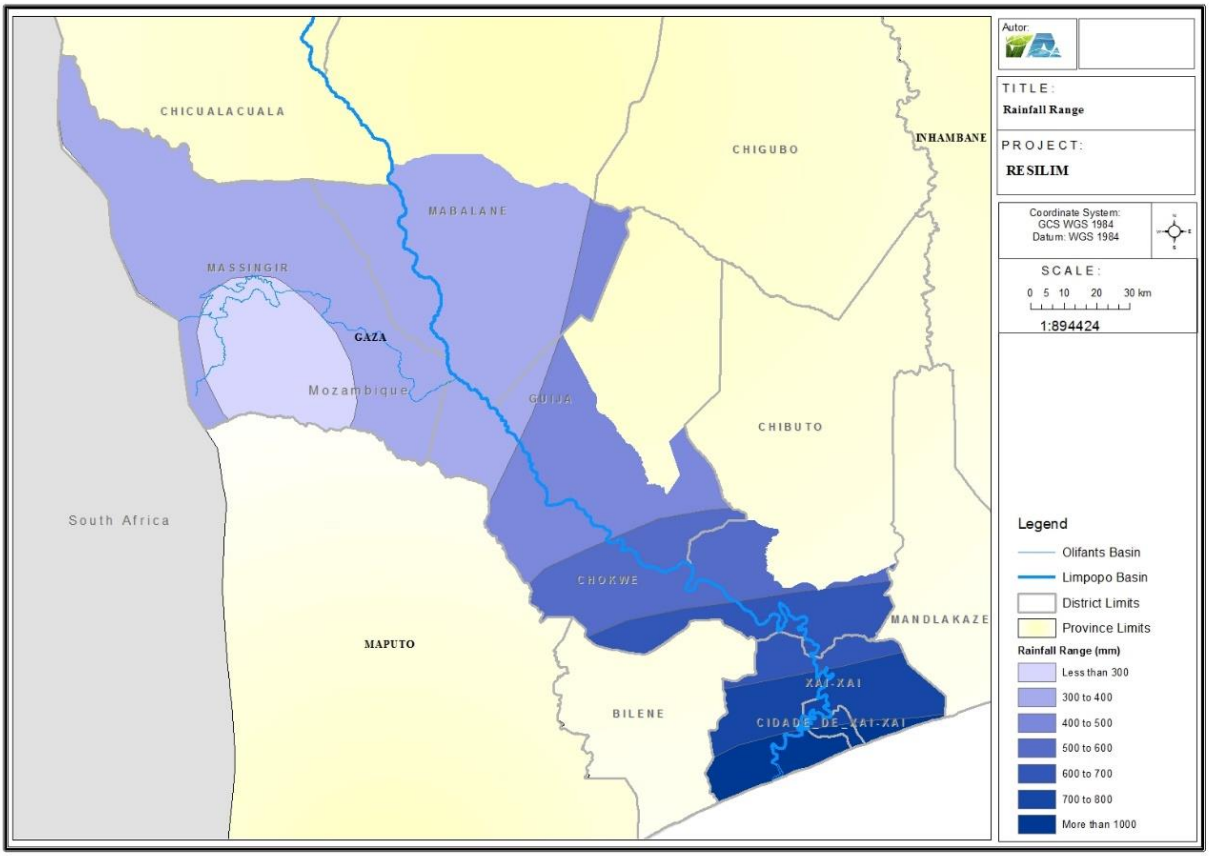

Figure 7: Map showing precipitation in the Limpopo River Basin (Verde-Azul, 2016)

3.2 Topography

In Mozambique, the Limpopo River Basin is essentially made up of flat land gently undulating with slopes not exceeding 5 ° to 8 °. The average slope of the river Limpopo between Pafuri and Xai -Xai is 0.35/km. In this area the altitude is less than 400m, and generally less than 100m. The Limpopo River flows through a fluvial plain with terraces which are 1 to 3 km wide between Pafuri and the confluence with the Olifants River, increasing to a width of 2 to 5 km after this confluence. The area in Mozambique is characterized by vast floodplains along the Limpopo and Changane Rivers (Brito *et al*,2009).

3.3 Geology

The Limpopo River Basin is bordered to the far west by volcanic rocks of the Great Karoo, rhyolites and basalts of the Lebombo mountain range (Brito *et al*, 2009). Most of the Limpopo River Basin in Mozambique is made upofthick deposits of marine sediments of Pleistocene known as "Manangas" located in relatively high areas and by sandy deposits along the coast (FAEF, 2001). This region has a sandy loam texture with a high percentage of coarse sand. Tectonically the central and eastern parts of the basin are cut into several blocks, bordered by faults facing the east-north west and west south-east. Faults face the North-South direction, covering the length of the East African Rift system. The extension to the North Tectonic Deep-Marine Valley on thecoast of Natal to the coastal area of the Limpopo Basin, is also made up ofa wide alluvial and deltaic sequence in the lower basin (DNA, 1996).

The Limpopo River Basin is divided into 5 main geological areas namely (DNA, 1996): (i) Dune Valley, (ii) main alluvial valleys, (iii) old alluvial plains, (iv) Erosion plains and valleys (v) the Libombo mountain range.

- The Dune Valley is located in the coastal area of the basin, with dunes formed by sands of average grain size that contain little clay. They are especially found in Macia/Xai -Xai, while the main alluvial valleys are located in the Limpopo and Olifants Rivers. They are well developed and characterized by gravel and coarse sand and in some cases mixtures of clay can be noted.
- Old alluvial plains are generally formed by ancient riverbeds. With the presence in the Limpopo River Basin of the interfluvial plain of the Limpopo, Incomati (downstream of the confluence of the Limpopo and Olifants) and the Limpopo - Changane inter-fluvial plain located on the left bank of the Limpopo River.
- Erosion plains and valleys dominate the entire plain with 2 to 20m of alluvial cover from loamy sands and sandy clays over tertiary sedimentary and cretaceous rocks. There is also the Lebombo Range which is composed of basalts, in the northwestern part Basin in Pafuri and of rhyolites in the west of the Basin and south of Pafuri, in the border area between the Republic of South Africa and Zimbabwe.

Four formations can be observed within the geological areas of the Limpopo River Basin, located in the alluvial and erosion plains, namely (DNA, 1996):

- Mazamba Formation: this is found on the river bank, from the town of Mabalane untilt the confluence of the river with the Nuanedzi River.
- Cheringoma Formation: located on the left bank of the Olifants River, it is characterized by limestone and sandstone based limestone.
- Olifants Formation: located on the right margin of the Olifants River and parallel to the Cheringoma formation, also notable in Massingir. This formation is characterized by reddish sandstone, conglomerates and siltstones
- Sena Formation: starts at the confluence of the Limpopo and Nuanedzi Rivers until Pafurim, south west of Massangene and north of Chicualacuala. This formation is characterized by conglomerates and pebbles of Karoo volcanic rocks.

3.4 Soils

Soils in the Limpopo River Basin are characterized by a vast sandy coverage, with the exception of rich alluvial deposits on river floodplains (DNA, 1996). Normally, the soils have a sandy texture or sand-clay, are white in colour on the coastal dunes and generally light red from the coast to the interior and on interior dunes.

With regards to geomorphology, in the areas next to the great Limpopo and Olifants Rivers, soil formation generally corresponds to fluvial terraces (DNA, 1996). Soil distribution in Mozambique generally follows physiographic characteristics. In the southern region as coastal plains are made up of sandy soils, with the exception of rich alluvial deposits along main rivers and streams.

Soil composition is of great importance as far as the agricultural potential of the land. In general, the Limpopo River Basin is naturally fertile, particularly along the great river (Limpopo, Changana and Olifants) where fluvial sediments have been deposited. However, there are problems with salinity and sodicity, particularly in plains and depressions (Brito *et al.*, 2009).

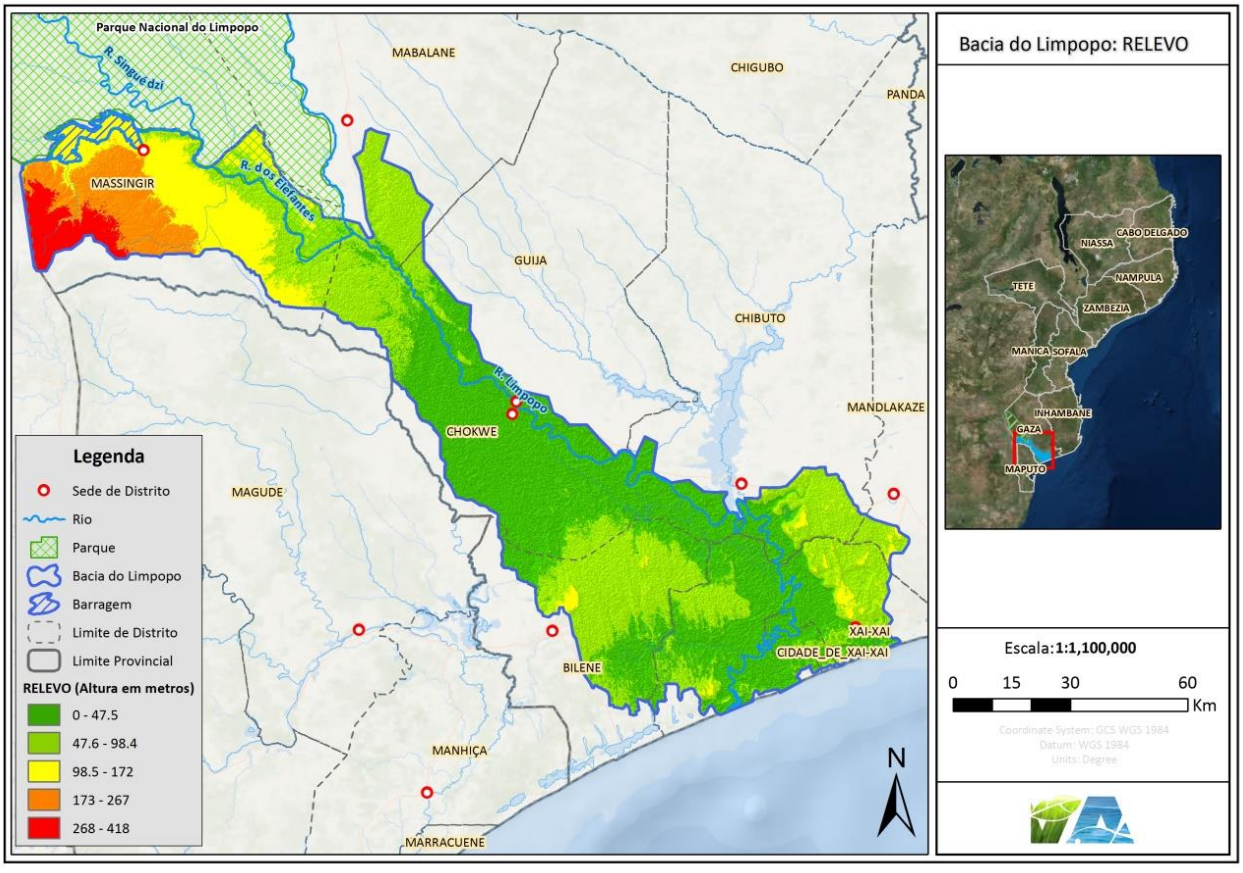

Figure 8: Relief Map for the Limpopo River Basin (Verde-Azul, 2016)

4 Water Resources

Mozambique is a country located downstream of the great hydrographical network it is part of, sharing nine out of fifteen international rivers in the Southern African Development Community (SADC). Rivers are the main carriers of the country's water resources, more than 50% of which originate in countries which are upstream. The Limpopo River is an important source of water for economic development in all four countries, especially seeing as it passes through a region which is affected by extreme climatic conditions, forcing the countries to mitigate these effects.

4.1 Water Quantity

The flow of the Limpopo River varies during the year, with lowest levels in the dry season, significantly reducing from the Macarretane Dam until the Zongoene River mouth, due to the construction of reservoirs and dams in the upstream countries (over 47 dams of over of over 12 Mm^3 have been constructed in the Basin, only one is located in Mozambique (Elmi, 2014)). Though an agreement to establish a committee to manage the Limpopo exists between the four countries which share the river (Limpopo Basin Permanent Technical Committee, now known as Limpopo Basin Commission, LIMCOM), there are no specifications on the minimum flow to be respected at the border between South Africa and Mozambique. The only official document which proposes equal division of water resources is the Memorandum of Agreement (1989) between Botswana and South Africa, with an allocation of 116.67 Mm^3 for each country. As such, no consideration is given to the needs of Zimbabwe and Mozambique. As far as the economic development of the region (Zimbabwe, Botswana and South Africa are three of the four most economically developed countries in the SADC region)) resulting in a reduction in the amount of water available for new activities, the absence of a minimum flow at the border presents a threat to the development of Mozambique in the Limpopo River Basin.

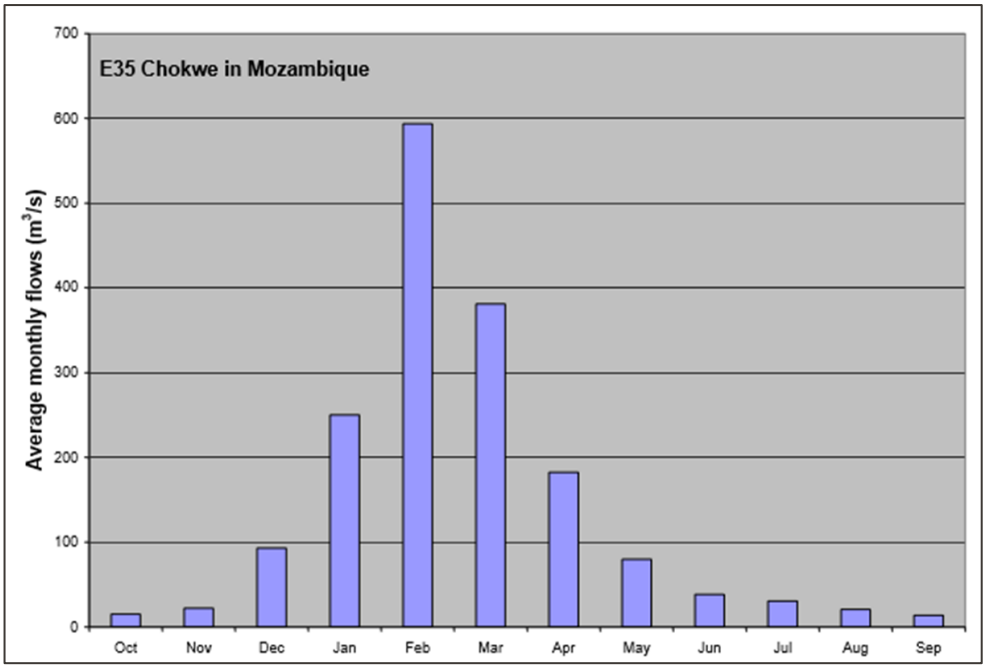

Figure 9- The average flow distribution of the Limpopo River in Chokwe (LBTC, 2011)

With regards to the Olifants River, though its fluctuations are lower than the Limpopo, they are significant, making the regulation of the Massingir necessary to permit intensive use of water in the Lower Limpopo (Profile of Chokwe, 2005).

Based on available data, the total runoff is about 216 km^3/year, 100 km^3 (46%) of which are generated in the country. (Council of Ministers, 2007The annual availability of surface water per season is 1 119,4.106 m3 in the dry season, and 2 110,2.106 m3 in the rainy season (Mastinhe , 2011) . In fact, the capacity of the bed of the Limpopo River after the confluence with the river Elephant is around 1 500 m3/s.

Generally over flow rates do not cause major flooding. However, the flow rate of the Limpopo varies greatly throughout the year as shown in Figure 8.

Historic flow records made at only two hydrometric stations of Limpopo in Chokwe and Xai- Xai reveal that between 1955 and 2000 higher flow rates of more than 3639 m3/s were recorded at the Chokwe hydrometric (E -35), with equivalent figures at the Xai-Xai hydrometric station.

TABLE 1- GRAPH SHOWING HISTORIC FLOW (WATERNET, 2009) [FLOW (M^2/S)]

YEAR	CHOKWE	XAI-XAI
1955	5050	3310
1958	4870	2270
1966	3890	2220
1967	4190	2670
1972	5210	3150
1975	5190	3520
1977	5810	4350
1981	4490	3090
2000	19 967	—

In addition, the flow also has a variability in the medium and long term. Based on annual records over a period of 50 years between 1950 and 2008, the Combomune Station in Chokwe noted that based on flood alert levels set for each hydrometric station, floods occur every 1.6 years in Limpopo. Analysis of the alert levels conducted uding past flow rates based on river level indicators in Mozambique show that there are extended wet and dry phases that can last for 20 years or more.

In the 2012 – 2013 rainy season Limpopo had an above normal hydrological regime, reaching the highest runoff and warning levels in the past 10 years, only surpassed by recored levels seen in 200, according to the charts below. In terms of flow, it reached around 8.000m3/s on 21 January 2013, both on the main course (Beitbdrige station) and in the Olifants River resulting from heavy rainfall occurred in the upstream countries (MPD 2013).

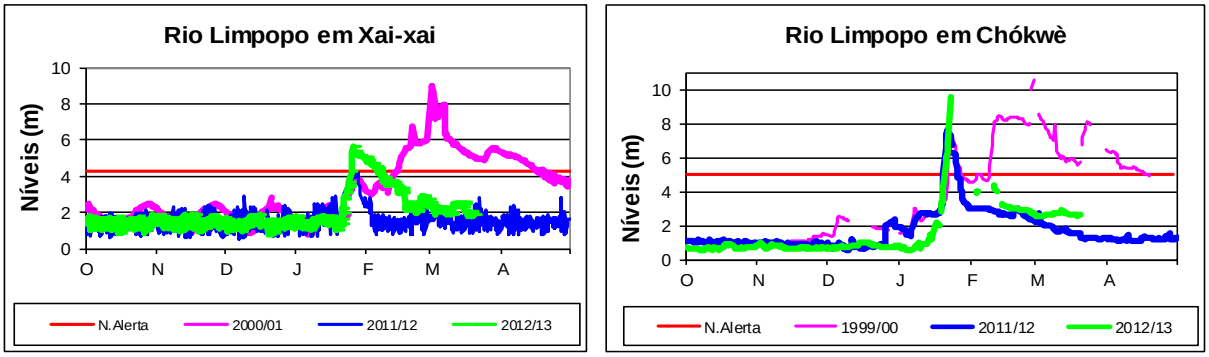

Figure 10: Hydrological Regimes in different months of 2011 to 2013 (MDP, 2013)

4.2 Water quality

Aquifers in the Limpopo River Basin are of poor quality due to salinity. Floodplains (bordering the dunes), erosion plains and erosion valleys (shallow alluvial cover, sandy clay over the entire land area) have highly mineralized groundwater (FAO, 2004). However, some of the alluvial aquifers have good water quality, such as recent coastal dunes, alluvial deposits along the river and the erosion plains along the streams (FAO, 2004).

The overall mineralization of groundwater is not very high, but the variability is, especially in the mining areas of the Basin. The water's chemical problems are similar across the countries in the Basin (salinity, nitrates and metals) limiting the amount of groundwater that can be used. This was an important issue in the past because of numerous mines in South Africa and Zimbabwe near the border. The signs of pollution related to this source are now casual (Ducrot, 2011). However, we must make reference to recent studies conducted by our partner AWARD in the South African part of the Limpopo River Basin in Hoedspruit and Phalaborwa, which show alarming signs of toxins resulting from mining activity and contamination from untreated sewage.

There are problems of severe salinity and sodicity in most alluvial soils, especially in the lower lying areas of the Limpopo River (FAO, 2004). This is caused by the presence of saline deposits and estuaries, under the alluvium. The invasion of saline water can be heard more than 55 km above the mouth, even reaching 80km in dry periods (Anon. 200 & Mozambique).

4.3 Environmental Flow

In South Africa, historic water management strategies were generally highly developed and geared towards the exploration of natural resources, mainly for agriculture and industry.

The dual pressures of limited water resources and need for economic growth, along with changing attitudes towards environmental, social and institutional issues at global level which led to a general shift in policies on the sustainable use of natural resources began with the Earth Summit held in Rio de Janeiro in 1992. This is how the concept of environmental flow, also known as ecological flow was born, based on the principle that the flow of water along the riverbed helps to maintain riverine ecosystems in a good state.

4.3.1 Definition

Reserves can be defined as the quantity and quality of water required to meet human needs and protect aquatic ecosystems, with the objective of securing sustainable ecological development and relevant use of water resources. Thus, reserves consist of two parts, reserves for basic human needs and ecological reserves, as represented by ecological flow.

Basic human needs include water for drinking, food preparation and personal hygiene. According to the World Health Organization, this translates to a minimum volume of 50 to 100 litres per person per day.

The concept of ecological reserves does not cover the protection of aquatic ecosystems, preventing the development, but the security level of protection for water resources and associated ecosystems by enabling sustainable development.

As such, ecological flow is generally defined as an absolutely necessary flow rate for the rivers keep their properties, needing to vary throughout the year taking into account the needs of species during their life cycle. In certain rivers both droughts and floods are part of the ecological cycle. The environmental flow must be considered as the amount of water that takes precedence over all other uses. According to LBTC (2010), the flow should be reserved for the conservation of delicate ecological system in the estuary, conservation areas such as the Limpopo National Park containing unique biome with several endangered species and contribute significantly to the economies in the basin river through tourism.

4.3.2 Considerations in Mozambican Legislature

The *National Water Policy* provides for the allocation and use of this resource in an equitable and sustainable manner, prioritizing basic human needs while making allowances for the protection of associated ecosystems (Council of Ministers, 2007). Although the national water management policy implicitly focuses onthe management of water resources, for the maintenance of environmental flow maintenance, we found in our review a strategy or concrete studies that can determine the specific water needs for the conservation of ecosystems in the Limpopo Basin. However, the Water Act (1991) firmly places the ecological flow as the mainitem after household use.

4.3.3 Practical Considerations

There are methods to determine the environmental flow (Johet, 1997) such as: using historical flow records as basis; analysing the relationship between the flow rate and hydraulic parameters; or the relationship between the habitat and the flow rate. In its 2010 study, the LBTC used the a different model to those already known, developed by South Africa (South African Desktop Model) to estimate the flow resulting from the environmental welfare in two places in Limpopo (10 km downstream of Massingir and 30 km downstream of the confluence of the Limpopo river and river of Elephants). Based on the South African model, the two parts of the river were classified as C / D, which means they undergo important changes with a negative impact on the environment (not enough flow and degraded quality). However, there is no other accurate study or measurements to know what flow rate should be maintained by the environment along the river and in the estuarine zone.

Moreover, there is no clear evidence of use, capacity and interventions that guide the institution (The Limpopo River Basin Management Unit, UGBL) in the management of water resources for these purposes. UGBL currently focuses more on water management for irrigation systems in the district of Chokwe and Xai -Xai, downstream of the river.

This being the case, the management of environmental flows is done in a generic based on the control of the dry flow or flood son the Massingir Dam, in connection with the Macarretane Dam, Indirectly controlling the need for water to maintain of ecosystems. There is still opportunity for the development of infrastructure to increase the efficiency of water use.

Apart from variations in river flow due to the weather and the fact that Mozambique is downstream, the flow of the river is also affected by infrastructure (dams) in the countries that share the river with Mozambique.

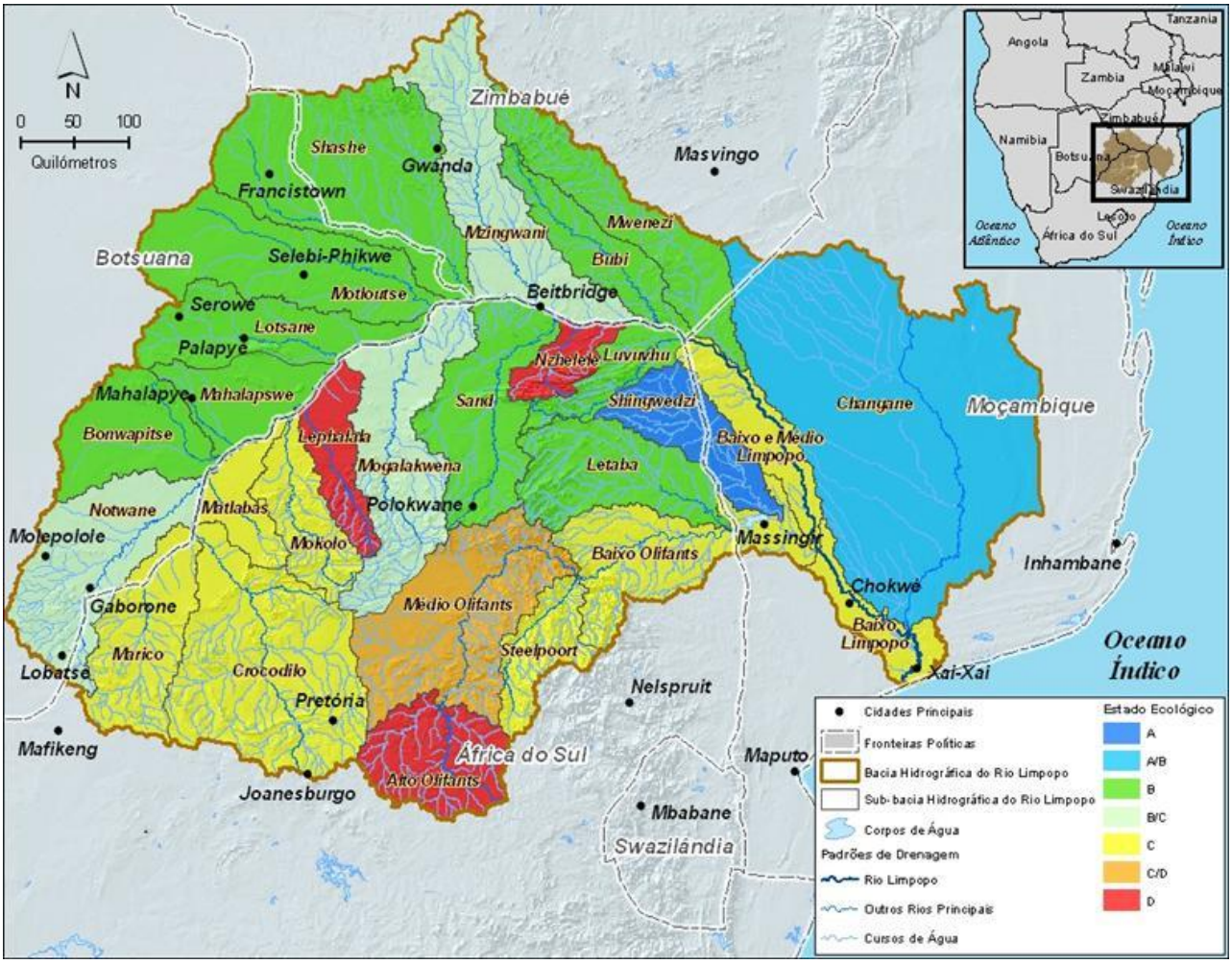

Figure 11: Ecological state of the sub-basin of the Limpopo River (A: natural - D: significantly altered) (LBTC, 2010)

The LBTC report indicates that the analysis of data on water quality shows that the river is already negatively affected, especially along the Olifants River where a lot of agricultural and industrial activities take place. The ecological state of rivers in the Limpopo River Basin ranges from natural (in national parks) to highly modified (for example, the number of elephants). There is potential for the deterioration of water quality and habitats in urban areas and along the river because of these unsustainable practices which should be contained.

The challenges and opportunities described above show that the joint management of the transboundary river basin is needed to achieve equitable and sustainable use of the water resources of the Limpopo River Basin. Mutual benefit and equitable sharing of resources are fundamental approaches to water management in the Limpopo River basin.

4.4 Water degradation factors

In Mozambique, the main sources of pollution in the river Limpopo include, among others, commercial farming activities in the Chokwe area (use of fertilizers and pesticides), compounded by poor water drainage. In addition, high levels of salts and other contaminants drain into the river.

Salinity is also impacted by the geological formation of the river bed (for example, Changane River), erosion and low permeability of the predominant soils (Mananga) (DNA/ARA-Sul, 2006). However, a proven phenomenon is that saline intrusion now extends for many kilometres upstream due to a reduction in existing fresh water flows in the Limpopo. The upstream abstraction of water has a significant effect on salt water intrusion.

According to DNA / ARA-Sul (2006) for the Massingir dam in particular, drained water has low salt concentrations. It is however accepted that in the event of reduced flow in the Olifants River, water quality may deteriorate.

A reduction in water availability (quantity) may have effects further downstream of the Basin, impacting the much needed water supplies for human consumption, aquatic wildlife, recreation, irrigation, and industrial use. This impact could worsen the degradation of wetlands, coastal ecosystems and mangroves on the banks of the Limpopo (Louw e Gichuki, 2003).

The basin supports large urban centres like Francistown, Gaborone, parts of Pretoria, Polokwane and Johannesburg - all with significant contributions to pollution (Estuaries: a Lifeline of Ecosystem Services in the Western Indian Ocean. Salif Diop, Peter Sheren, Jonh Machiwa).

Between 40,000 and 60,000 hectares of floodplain above the estuary is extensively cultivated by local farmers (Louw and Gichuki 2003).

4.5 Main Infrastructure in the Limpopo River Basin

Due to weather variations, irrigation in the Limpopo River Basin is essential for food security (crops and livestock) and broader rural development. During the colonial period, the basin was equipped with efficient irrigation systems but misuse, followed by the struggle for liberation and civil war resulted in the almost complete destruction of much of the infrastructure, and salinization of soils.

Today, there are four main sets of infrastructure supporting the irrigation systems in the Limpopo and Olifants River basins. The first is the Massingir Dam on the Olifants River and the second is the Macarretane Dam.

The Massingir Dam has a capacity of 2,844 million m3, but its potential is not fully explored due to infrastructure problems. The dam only utilizes about 1,300 million m3 of its capacity (van der Zaag et al., 2010). Built in the colonial period between 1972 and 1977, this dam forms part of the Limpopo Valley irrigation system, increasing the irrigation capacity of small and large farmers.

It is intended to control the flow of the river downstream, ensuring water supply for irrigation in Chokwe and mitigating saline intrusion especially at the mouth of the Limpopo River.

The Macarretane Dam has a storage capacity of 4 million m3. This dam was built between 1953 and 1955 to raise water levels and feed the Chokwe irrigation system. There are an additional 22 small dams for agricultural and livestock purposes in the central and northern parts of Gaza Province. In dry regions like this one, this strategy can result in more environmentally friendly which result in little water to evapotranspiration.

The third piece of infrastructure is the Chokwe irrigation system, also known as "Eduardo Mondlane", the largest in the country. It is located in Gaza about 200 km north of Maputo and covers an area of about 31,000 hectares. It has a length of about 8 to 50 km upstream and downstream of the Macarretane Dam, and is between 3 and 18 kilometres wide (DNA, 1996).

The fourth infrastructure is a gravity fed irrigation system in the Lower Limpopo, also known as “the Xai-Xai Irrigation”, located in Gaza Province, covering an area of 2,970 hectares between the city of Chibuto and Xai -Xai (DNA, 1996).

There are no large dams on the Limpopo as yet, meaning water resources in the Massingir Dam are heavily used.

NGOs, the PNL through the Community Support Program, the National Institute of Social Action (INAS) through direct funding or food security programs, and the national PRONASAR program, have supported and continue to support the development of small irrigation systems which make a contribution at both communal and individual level. Many of these were established in recent years (Ducrot, 2013). Similarly, there has been a great effort to support the sinking of boreholes in villages.

4.6 Water Availability

There is limited data on water use in Mozambique. According to the van der Zaag (2010), these uses are relatively small. They include:

- Irrigation in the Chokwe area. In recent years, rehabilitation projects have resulted in significant increases in the area under irrigation. However, thousands of hectares cannot be cultivated due to salinity and sodicity problems.

  According to van der Zaag et al. (2010) a maximum of 58 000 hectares can be irrigated in a sustainable manner in the Mozambican part of the Limpopo River Basin without causing tensions among different users (in the case of operating the dam at full capacity), or only 44 000 hectares should the dam continue operating at its current capacity. An agreement for the rehabilitation of the project was signed with foreign investors in 2015.

- Daily use to meet the basic needs of rural populations. No water license is required. This use includes the irrigation of small plots of land (less than 1ha) or *machongo*[2].
- Water supply to cities

Less water than is available is currently being used. There are no major conflicts in the basin, except some at the local level among peasants, or between small scale and large scale farmers during severe droughts (Matsinhe, 2011). The main challenge is the management and sharing of water throughout the year.

5 Climate Change and Risk of Natural Disasters

5.1 Overview

In Africa, Mozambique is the third most vulnerable country to risks associated with climate change, having experienced 68 natural disasters in 50 years (Heila Lotz - Sisitka and Penny Urquhart, 2014). The location of the country makes it particularly vulnerable to climatic hazards such as drought, flooding and cyclones.

The following table presents some weather events that have occurred over time in the country (including the Limpopo River Basin), including the number of affected:

TABLE 2 - LIST OF WEATHER EVENTS THAT OCCURRED IN THE COUNTRY (INCLUDING THE LIMPOPO RIVER BASIN) SINCE 1980 (VERDE-AZUL, 2016)

Year	Event	Affected Areas	Number of people affected
2015-2016	Drought		
2013	Floods	Limpopo River Basin	
2002-2006	Drought	43 in the south and central parts of the country affected	800,000 affected
2000	Floods	Limpopo River, Maputo, Umbeluzi, Nkomati, Buzi and Save caused by 3 cyclones	More than 200 million people affected and 700 deaths recorded
1996	Floods	Todos rios do sul de Moçambique incluindo o Limpopo	200,000 people affected
1991-1992	Drought	Afectou todo o pais	1,32 million peope affected;
1985	Floods	Maiores Cheias até a data dos últimos 50 anos em 9 rios do sul de Moçambique incluindo o Limpopo após 4 anos de seca severa	500, 000 peope affected
1983-1984	Drought	Maior parte do país afectado	Registo de mortes pela seca, guerra e cólera endémica
1981-1983	Drought	Sul e centro do pais	2,46 Milhões de pessoas afectadas
1981	Floods	Rio Limpopo	500,000 peope affected
1980	Drought	Sul e centro do país	Data not available

[2]*Local irrigation using groundwater in organic soils of wetlands in floodplains or water from springs adjacent to dunes (Ducrot, 2011)*

Periodic droughts and occasional floods caused by excessive rainfall are associated with a phenomenon known as El Niño Southern Oscillation (ENSO). The La Niña phase of ENSO is a global ocean temperature anomaly with annual rainfall variability from year to year. The El Niño phase of ENSO causes drought conditions (Lindesay J. A. and C. H. Vogel, 1990).

Climate change projections show that in the absence of strategies and mechanisms for adaptation, Mozambique could lose up to 4,850 km2 of land by 2040, or even 0.6 % of its land area. This may affect 2.3% of the population, which may be forced to migrate away from the coast (UNFCCC, 2003).

According to the same source, the effects of climate change are significant and can in the following ways:

- An increase in average air temperature between 1.8 and 3.2 ° C
- A 2% to 9% reduction in rainfall
- A 2% a 3% increase in solar radiation
- A 9% para 13% increase in the evapotranspiration rate.

This scenario can affect the population in different ways. In Mozambique, the main sectors likely to be affected by climate change are (UNFCCC, 2003):

- Agriculture
- Forests and grazing lands
- Livestock
- Water
- Coastal areas and resources
- Infrastructure
- Health
- Fisheries

5.2 Droughts

The Limpopo River Basin is affected by droughts which in turn has a direct impact on people and ecosystems. Droughts and upstream water extraction in South Africa often reduces the flow of the river at the end of the dry season.

In recent years, the trend has been weather conditions which are drier and warmer than normal, raising evapotranspiration rates, which in turn contributes to recurrent droughts and has negative effects on water resources particularly in mountainous regions.

Severely dry conditions were experienced in the Limpopo River Basin between 1953 and 1995 when a drought occurred in 1961 – 1973 and another from 1982 – 1994 (DNA, 1996). There were periods in which the flow of water in the river was relatively low, extending from one to eight months.

The vulnerability of the population is in part a result of its dependence on rainfall for its main activity (agriculture). The lack of rainfall not only contributes to a reduction in crop production but to poverty. Another effect of droughts is the reduction in the quantity and quality of grazing lands, reducing the amount and quality of grazing lands and negatively affecting food availability and income. There are also potential repercussions on soil conditions, vegetation and nutritional value, increasing the risk of disease and malnutrition.

According to Parkisson (2013), droughts pose between 48-73% of the risk of loss of crops in Mozambique. In instances where droughts last for long periods, sometimes consecutive years, according to FAO (2012), households and even public authorities experience water shortages, a situation that is aggravated by water quality management problems and lack of water storage and distribution capacity.

During periods of food insecurity as a result of a drought, people adapt by increasing their activities to ensure they generate enough money to buy food. Activities are varied, local, short-term, and depend mainly on social capital, each household's work output, and environmental and infrastructural characteristics of the area (Osbahr, et al., 2008).

5.3 Floods

The high incidence of floods in the Limpopo River Basin is due to two factors. First, it is related to tropical cyclones that form in the southwest Indian Ocean, concentrated on the coast of the country. Few of these cyclones reach the ground (they create strong winds, heavy rains), with an average of three or four getting close enough each year. Second, Mozambique is a'downstream' country,through which nine major river systems in south east Africa, pass through before draining into the Indian Ocean.

Em segundo lugar, Moçambique é um país «a jusante» onde nove grandes sistemas fluviais das vastas áreas do sudeste da África, atravessam o país para drenar as águas no Oceano Indico.

Mozambique has to manage the effects of the rain which falls downstream beyond its own basins. It is estimated that 50% of the water in rivers Mozambique comes from outside the country. According to DNA (1996), the Limpopo River is prone to cyclical floods that are sometimes catastrophic. The effects are even greater when there is a peak in the flow of the Limpopo and Olifants River, and convergence associated with high levels of rainfall in national and foreign territory.

About 80% of Mozambique's population works in the agriculture and fisheries sector, with most settlements located in floodplains, areas which are highly vulnerable to flooding. For example, during the 2000 floods in Xai-Xai and Chokwe at least 700 people died. It is estimated that 350,000 animals were lost and about 650,000 people were displaced.

It is said that since the floods of 2000, early warning systems have been improved and the number of victims decreased dramatically. Traditional knowledge of the indicators in nature was and remains important (Ducrot, 2011).

5.4 Cyclones

In Mozambique, cyclones normally occur from November to April. The cyclones that hit the country are formed to the east of Madagascar and in the Mozambique Channel (MICOA, 2006).

Cyclones formed in the east of Madagascar tend to cause strong winds that intensify when they reach the warm waters of the Mozambique Channel. Those formed in the Mozambique Channel are usually accompanied by heavy rains, sometimes causing flooding. According to MICOA (2006) cyclones can cause gusts of winds of 125,299 kilometres, strong enough to destroy homes, buildings and industrial infrastructure.

In Mozambique, cyclones occur on average three times a year. In the first quarter of 2000 there were four cyclones. Cyclones Eline and Huddah caused widespread damage affecting the economy, especially communications infrastructure. They were part of the risks ofthe effects of the 2000 floods in the Limpopo River Basin.

5.5 Weather Forecasts

In 2012, the National Institute for Disaster Management (INGC) led a project on climate change in the Limpopo River Basin. Using a variety of scenarios and the seven Global Circulation Models to two scales, its climate projections are the most extensive produced for Southern Africa. Climate change simulations predict that there will be a reduction in water availability. Since it is a region with weather variations, extreme precipitation will occur more often, increasing the risk of flooding, as water will be available more erratically. According to De Wit, M., & Stankiewicz, J. (2006), "a possible further reduction in rainfall could lead to a sharp decline in drainage density, causing permanent drought in many small rivers or their tributaries." Temperatures will also become more variable resulting in a hardening of the soil, reducing its ability to absorb water from the rain, which will negatively impact agricultural activities.

Over 90% of crops in the Limpopo River Basin rely directly on rainfall. Crop security is ameliorated by unpredictable rainfall. The risk of loss of agricultural production and of loss of income is most important in the middle of the basin and could reach more than 70%, since most of the population depends on rain-fed agriculture. Thus, the development of an integrated irrigation systems presents the best way to guarantee harvests over time.

6 Biological feature of the Limpopo River Basin

6.1 Types of vegetation

Vegetal coverage is mostly constituted by 57,67 % of shrub savannah of the type *Colophospermum mopane*. Along the coastal zone of the basin, forests are mixed with coastal dunes, having a share of 13,76 % of the vegetation coverage in the basin. Acacia savannah accounts for 10,74 % and occurs in saline lands. In the Pafuri region, where the Limpopo River enters Mozambican territory, the Chigubo, Mabalane and Chicualacuala Districts are mostly constituted of arboreal savannah, accounting for about 7,09 % of the

basin's vegetation. Near the Changane River, vegetation is of the shrub savannah type, from the Chiguto to the Chibuto District, with a share of 6,06 % of the vegetation coverage of the basin (MOPH, 1996:19).

Forests of the *miombo* type are located at the mouth of the Limpopo in Xai-Xai, and at the coastal region between Xai-Xai and Chibuto Districts, accounting for 1.11 % of the vegetation. Shrub savannah and woods account for 0,98 % and thicket forests account for 0,09 % of the vegetation coverage (MOPH, 1996:19).

The main biome in Gaza Province is the dry savannah/eutrophic, which lies between rainfall areas of 400 and 600mm. It is characterized by the predominance of Acacia spp. and Colophospermum Mopane and Caesalpinioideae and Combretaceae in leached soils. The Miombo also typifies the wet savannah/dystrophic of the region.

One can distinguish the three main eco- climatic zones from the upstream to downstream (FAO, 2004):

- From the border, crossing 100 km downstream to the confluence with the Olifants River, the sandy plateau is dominated by an arid sand vegetation and dense vegetation communities dominated by shrubby forest. The mopane and Acacia *Colophospermum* are found on the slopes, dominated by a community of more open forests (due to antropogenismo) with acacia forests, *Commiphora and Terminalia* at lower altitudes. In floodplains, woods and open forests of acacia (*xanthophloea, tortilis and nilotica*) with shrubs/Salvadora persica forests can be found. The *xanthophloea* acacia is a flat-topped tree with yellow bark, growing where its roots finds water easily. The presence of *Salvadora persica* is an indicator of saline-alkaline soils that are seasonally flooded near the river banks. Acacia *tortilis* is a salt-tolerant tree found in the more permeable soils (FAO, 2004).
- Downstream, in the sub-humid area, about 100 km to the coast and near the Indian Ocean, are open forests with thickets. There is continuous chopping of wood in this region. The floodplain supports acacia forests. On the deposits of dike along the Limpopo River, there are dense thickets of *Ficus, Diospyros and xanthocercis*. Around the Chokwe irrigation scheme, there are considerable reductions in wood biomass, except in the west, where dense forests and Acacia forests remain. (FAO, 2004).
- The coastal are is characterized by a humid tropical climate with physiognomic composition of vegetation patterns that reflect anthropogenic changes. *Terminaliasericea* and *rhigozum* sp. are the dominant species in the deep yellowish-brown sand (ferralic arenosols) along with *Nardostachys johnsonii* and some *Commiphora, Grewia and Combretum*. In soils with high clay content, *Colophospermummopane* is dominant (FAO, 2004).

TABLE 3- TYPES OF FORESTS AND THEIR RESPECTIVE CLASSIFICATIONS (FAO, 2004)

Types of woodlands and land use classification	Total (ha)
High forests	25 338 (ha)
Low forests	635 923(ha)
Thickets (high density area)	4 014 494(ha)
Prairie	1 868 244(ha)
Mangrove	387(ha)
Dune Vegetation	20 833(ha)
Agriculture	1 067 568(ha)
Irrigated Agriculture	27 590(ha)
Total productive forest	1 437 162(ha)

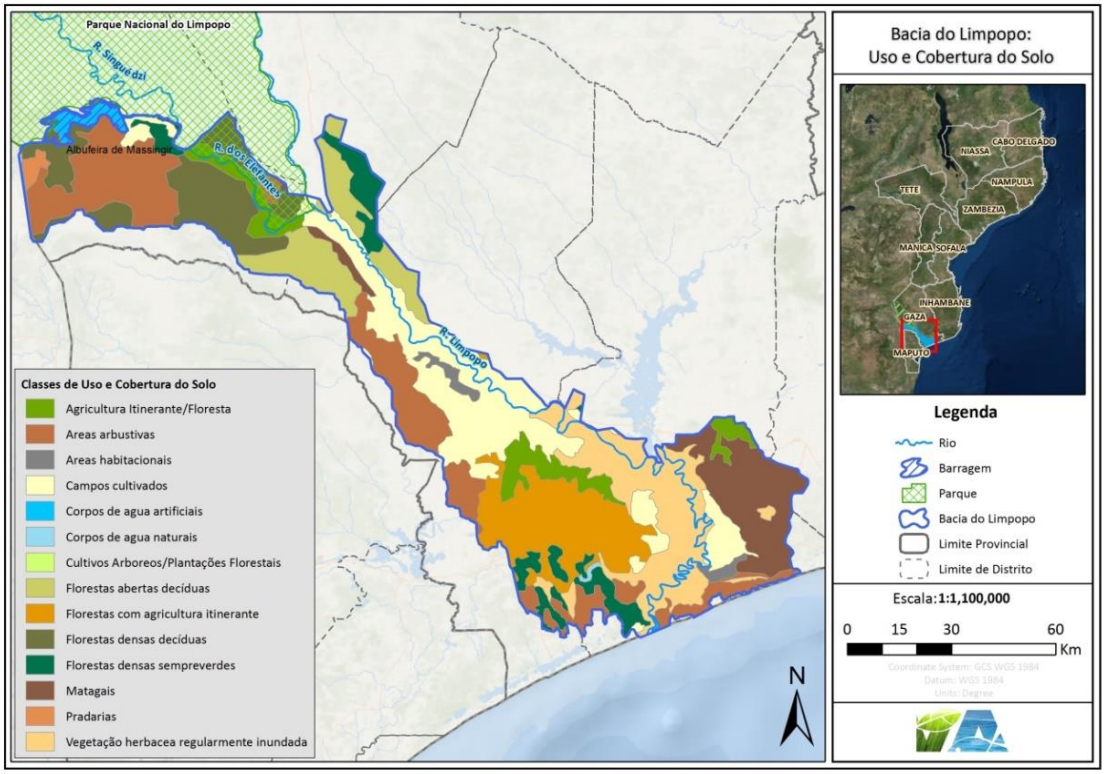

Figure 12- Map showing coverage of land use in the Limpopo River Basin(Verde-Azul, 2016)

6.2 Biodiversity and weather

An endemism called Maputoland can be identified throughout the Limpopo River Basin. Maputoland - Tongoland is an eco- region that stretches from the Drakensberg foothills in Port Elizabeth (34° S) in South Africa, to the Limpopo River estuary (25° South) in a strip along the coast ranging from 240 km and 8 km in width from north to south (Council of Ministers, 2003).

6.2.1 Ecology and climate of the Maputoland-Tongoland endemism centre

The eco region experiences relatively seasonal dry weather. In most of the ecoregion, precipitation is less than 800 mm per year, with 75 % of it in the hot summer months between October and March (Council of Ministers, 2003). Temperatures range between 12° and 26°C.

The Maputoland – Tongoland endemism centre comprises:

- Inselbergs,
- Marine and Coastal Ecosystems: Coral coast, Costa coastal wetlands
- Parabolic dunes, deltas, mangroves.

6.2.2 Biodiversity and the endemism centre of Maputoland - Tongoland

This is an extraordinary place, notable for its high level of biological diversity, characterized by a mosaic of low and high thickets predominantly along watercourses that flow into the Indian Ocean, reaching one of the most complex floral areas of Africa, even though levels of endemism are relatively low.

The floristic and physiognomic composition isevident in this ecoregion. Between 6.000 and 7.000 plant species occur in the ecoregion (Council of Ministers, 2003).Dominant tree species include *Diospyros dichrophylla, Euphorbia triangularis, Rhus dentata, and Senecio deltoids*.

Faunal diversity is moderate, although the white rhino (*Ceratotherium simum*) and Black Rhinoceros (*Diceros bicornis*), along with other globally endangered species are found in this ecoregion. Due to the porosity of the region and the consequent free movement of many species in this eco region, the number of endemic species is generally low.

The diversity and endemism of reptiles and amphibians is relatively high. Two of the almost endemic reptiles: the *Bradypodion thamnobates* and *Kinixys natalensis* are considered rare, while two amphibians, the *Hyperolius pickersgilli* and *Leptopelis xenodactylus* are considered common.

6.3 Classification of eco-regions

The Mozambican part of the Limpopo River Basin is made up of two terrestrial eco-regions namely: the Miombo Woodlands and the Zambezian Halophytes.

6.3.1 The Miombo Woodlands

The Miombo Woodlands[3] is a protected eco-region dominated by Central African Plateau. One of the region's main charcteristics is the presence of large expanses of rolling savanna woodland on a gently undulating plain, interspersed with grassy drainage lines in a regular catenary sequence. The area is very important because of the diversity of species found in it.

Species include: Mopane trees that can grow to over 25 meters (80 feet) if the soil is rich, though these trees are adaptable and can also grow in poorly drained or clay soils.

It comprises a wide range of large mammals, including giraffes, elephants, rhino and the largest African elephant population (Loxodonta africana), with parts of these plant and animal communities relatively intact.

Bird species such as the black-faced waxbill *Estrilda erythronotus*), the Miombo Rock Thrush (*Monticola angolensis*), and the Miombo Pied Barbet (*Tricholaema frontata)*.

[3]*Ver: http://wwf.panda.org/about_our_earth/ecoregions/central_eastern_miombo_woodlands.cfm*

6.3.2 Zambezian Flooded Savannas

The Zambezian Flooded Savannas[4] is an eco-region with a rich diversity of birds and which supports large populations of mammals, such as the African elephant (*Loxodonta africana*).

Many African mammals move seasonally with the rise and fall of floodwaters, following changing vegetation.

Bird species include the Slaty egret (*Egretta vinaceigula*), Wattled Crane (*Grus carunculatus*), and the Pygmy goos (*Nettapus auritus*). Among endemic reptiles are Barotse water snakeand the striped swamp snake (*Limnophis bicolor*).

Threats to the Zambian Flooded Savannas are a result of human activity in the area of cattle ranching and contamination from heavy metals, insecticides and agricultural runoff.

6.4 National Marine Ecosystem Priority Areas in the Limpopo River Basin

Mozambique has the third longest maritime coast on the African continent, extending about 2 700 km^2 along the Inidian Ocean, and characterized by a wide range of ecosystems such as estuaries, dune, mangroves, coastal lagoons, swamps, coral reefs and sea weeds. These ecosystems provide habitats for several species of great ecological importance and economic value for the country in general, and local communities in particular. In the Limpopo River Basin, ecosystems that are prioritised for conservation include: all regions that have been declared conservation areas, mangroves and wetlands.

Marine Ecosystem National Priority Areas in the Limpopo Basin.

6.4.1 Mangroves

In Mozambique, mangroves are common along the coast, covering approximately 40,000 hectares (Barbosa et al, 2001; MICOA, 2006). They usually occur along river mouths and protected coastlines, in bays and lagoons (FAO, 2005) where salt water flows and freshwater reflux ensure the survival of the mangrove ecosystem. The Limpopo River is the only place where mangroves can be found in the province of Gaza, where they are limited to a small estuary about 6 km in length.

About 8 species of mangroves occur in Mozambique (FAO, 2005) with the main species being: *Rhizophoramucronata*, *Bruguiera gymnorrhiza*, *Avicennia marina*, *Ceriops tagal*, *Sonneratiaalba*,*L. racemosa* and *Xylocarpus granatum* (MICOA, 2006; Barbosa et al., 2001). In the estuary of the Limpopo River Basin, the dominant species is Avicennia marina, at about 99.5 % (Bailey et al., 2005). Related species include Rhizophora mucronata (Gove & Boane , 2001; Balidy et al , 2005) Bruguiera gymnorrhiza , tagal Ceriops and Heritiera littoralis (Dharani, 2007).

[4] *Ver: http://wwf.panda.org/about_our_earth/ecoregions/zambezian_flooded_savannas.cfm*

Mangroves play a key role in the livelihoods of local communities. They are used in construction, for firewood, production of charcoal, tannins, fruit, fencing, hunting equipment and medicine.

The bark of the *Rhizophora mucronata* is used to dye fishing nets, while canoes and beehives are made from *Avicennia* wood. Molluscs and crustaceans, concentrated in the mangrove area are an important source of protein for communities in Mozambique. (Da Silva, A. *et al*. 2014).

The floods that hit the Zongoene administrative post in 2000 had a massive negative impact, in particular, the destruction of vast mangrove forests in the Limpopo estuary, especially on the right, affecting local fishing activities.

6.4.2 Wetlands

Wetlands are another important water resource in the Limpopo River Basin in Mozambique, generally distributed in swamps along the river, for example, the swamps after the confluence with the Changane River (Chilundo, 2007).

Three main types of wetlands can be identified (Madra, 2005) in the Limpopo River Basin namely:

- Coastal wetlands: with brackish lagoons and simple lakes;
- Continental wetlands: with 5 types of permanent lakes, permanent rivers, a seasonal lake, seasonal rivers and the “Ox Bow Lagoon "
- Man-mad wetlands, which fall into two categories: canalsand irrigated lands.

TYPES OF VEGETATION IN WETLANDS

Different species of vegetation and fauna can be found in different classes of wetlands. In plant species, we have short grasses that occur in all wetlands.

Most of the continental wetland consists essentially of high grasses (reeds/cattails), short grass (*Cyperus javanicus*), or a mixture of both in open flooded areas.

Coastal wetlands are made up mainly of short grass and bare sand. The class of tall grasses consists of *Typha spp, Phragmites spp , Scirpus spp , Juncus spp , Panicum spp and Urochloa spp*.

The classification of forests can be divided into dense mangrove forest that is only found in the estuary of the River Limpopo, open forest and shrubs composed of *Acacia spp* and *Artiplex spp* (Madra, 2005).

WETLANDS FAUNA

Certain bird species dominate the fauna of wetlands. According to Madra (2005), there are a total of 64 species, with the most common in the area being: *Himantopus himantopus maridionals, Tachybaptus ruficollis capensis, Bubulcus ibis, Plectropterus gambensis, Ardea melanocéfala Ardea Goliath & Phalacrocorax carbo Egrena intermedia & Pelecanus rufescens and Anas eryhrorhyncha*.

Rare species include *Circaeus pectoralis*, *Circus ranivorus* and *Geronicus calvus*, and those on the Red List are prioritized for conservation including: *Phoeniconais minor* (endangered), *Gyps coprotheres* (vulnerable), *Ephippiorhynchus senegalensis*, *Sagittarius* and *Halcyonsenegaloides* (all locally endangered) (Madra , 2005).

Wetlands also have a great local importance as they are economically beneficial to communities through things such as fishing, sugarcane plantations, maize plantations, extraction of sand and water consumption and ecotourism (Madra, 2005).

7 Governance in the Limpopo River Basin

In the context of a project aimed at reducing the vulnerability of communities and ecosystems, it is critical to understand governance in the Limpopo River Basin in three related areas: water, land (including foods security and access to infrastructure and public services) and climate change.

7.1 Overview

In Mozambique, governance is decentralized all the way to district level. The Limpopo River Basin is located mainly in the province of Gaza and a bit in Inhambane province. Mozambican government is structured in a hierarchical manner, with provincial governments dependent on the central government even though it has some autonomy. There is, to a large extent, a lot of duplication in lines of hierarchy. This because there is a provincial government (administrative) and ministerial government (sectorial and more technical). In addition, there is also a municipal government. Municipal governments have their own structure with no hierarchical ties to the two other governments, but in certain cases with fiscal dependence on the central government.

The Limpopo River passes through 10 districts (Chicualacuala, Massingir, Massengena, Mabalane, Funhaloura, Mabote, Guija, Bilene, Xai-Xai and Chibuto) - the last level of administration at which government officials are found - and some municipalities (Chokwe, Chibuto, XaiXai). In terms of administration and planning, each district develops its own Strategic District Development Plan though not all districts through which the Limpopo River passes have SDDPs (Ducrot, 2011). In many cases, SDDPs have no influence and are not used in the daily operations of the districts.

Despite the *Local Authorities Act* of 2003 and national projects such as PRONASAR (*National Program for Water Supply and Rural Sanitation*), the main challenge faced by local government authorities in the decentralization process is the skills development for government officials. The *National Action Plan for the Reduction of Poverty*(2015-2019) also makes reference local authorities, infrastructure, equipment and mechanisms for internal controls. The dearth of capacity in the municipalities and lack of skills transfer remains a cause for delays.

Districts consist of administrative posts, towns, villages and settlements. At community level, there are different types such as chiefs and headmen (inherited from the colonial era) and ward councillors, some of whom are elected through local elections (Ducrot, 2011). Advisory Councils, established at district, administrative post and town level in line with the Local Authorities Act, allow interaction between local and government authorities. They are composed of traditional chiefs, government and civil society representatives. Only elected officials are part of local councils.

They play a key role in planning at a local level and in the selection of projects that receive funding from the District Development Fund (DDF). The DDF was established to fund projects aimed at poverty reduction (Ducrot, 2013).

According to Spierenburg *et al.* (2008), an NGO forum was established to co-ordinate services and help communities with resource management. The forum is made up of 7 local NGOs (Rural Organization for Mutual Assistance or ORAM, Forum for Nature at Riskor FNP– secretary of the Forum, National Union of Peasantsor UNAC; Caritas - Chokwé, Justice and Peace Xai Xai, Civil Service for Peace and Rebuilding Hope) and 3 international NGOs (African Wildlife Foundation, International Union For Nature Conservation, and Mozambique VETAID - Veterinarian Aid).

LIMPOPO NATIONAL PARK

The Limpopo National Park (LNP) project between Mozambique, South Africa and Zimbabwe was started by NGOs in 1998, but due to disagreements between the various role players on whether to create a conservation area or park, only officially established in 2001. The parties eventually decided to go for the second option, and since then, the park is managed by a Project Management Unit.

People are not allowed to permanently settle in the park. But on the insistence of funders and local communities, over 27 000 people were allowed to live in the LNP. On the Mozambican side, the LNP is located in the district of Mabalane. Around 6 000 people live in the Shingwedzi River Basin and more than 16 000 along the Limpopo, adjacent to the LNP (Nhancale, 2007). The management of the LNP is aimed at two objectives, to ensure the conservation and protection of biodiversity, while improving the livelihoods of communities which rely on natural resources.

According to Nhancale (2007), Management Committees were created to enable each community to participate in the management process, but in reality, local authorities at district level are not properly integrated in the governance of the LNP. Communities are encouraged to leave the LNP. Past attempts at resettling in people have been in vain.

7.2 Governance for Water Management

7.2.1 Legal Aspects

Mozambique is a member of the Southern African Development Community (SADC), where the waters of the Limpopo River Basin are managed in line with the *SADC protocol on the sharing of Water Resources,* signed in 2003. This document supports member states in the management of international waters. It was established in line with other international legal instruments such as the *United Nations Convention on the Law of the Non-navigational Uses of International Watercourse* (UN, 1997).

For water resource management, Mozambique has the Water Act (1991) and the National Water Policy (2007) which are being implemented through the National Water Resource Management Strategy. Several decrees were enacted, strengthening the law.

7.2.2 Key institutions

The end of the apartheid regime in South Africa in the early 90s led to better co-operation in the Southern African region. Before that, the management of water resources was restricted to bilateral agreements. The Limpopo Basin Permanent Technical Committee (LBPTC) was established in 1986, in 2003, it became a committee (LIMCOM). It officially began operating when Zimbabwe signed the agreement in 2011.

At national level, water management is the responsibility of the National Water Directorate (DNA), and focuses on the following issues: development and management of policies, strategy and investment mobilization, water supply in rural and urban areas, management of water resources, planning of water projects. It also manages agreements on the sharing of water resources in transfrontier basins. The DNA is an institution which falls under the Ministry of Public Works, Housing and Water Resources (MOPH). The MOPH is responsible for decision making with regards to water (issuing of permits for water consumption).

The DNA is further divided into Regional Water Administrations (ARAs). ARA-South manages the Limpopo River Basin, among others, and also manages dams in this water system. The Limpopo River Basin Management Unit (UGBL) represents ARA-South in the Limpopo River Basin.

The Limpopo River Basin Committee (CLP) brings together users and their representatives with organizations that manage irrigation, land and water. This committee allows co-ordination among all role players in the Basin and is an advisory body to the director of the UGBL. The organization has been operational since 2004, members meet twice a year or more if necessary (Ducrot, 2011). However, according to Matsinhe (2011), farmers are still under represented.

At district level, the government provides water management services through the District Office for Planning and Infrastructure (SDPI), which is responsible for public infrastructure including water; and the District Service for Economic Activities (SDAE), which is responsible for activities related to food production including irrigation and fisheries.

At local level, there is a Water Committee established for each borehole. It is however possible to find more than one committee per village. The committee is responsible for the maintenance of equipment and collection of rates (Ducrot, 2013).

Hidráulica do Chókwè (HICEP) was established in 1997 and manages hectares of land under irrigation and other cultivated areas (with or without irrigation) in the Chokwe region. This institution has been responsible for the proper management and maintenance of infrastructure, and distribution of water to rural communities and land access since 2009. The Lower Limpopo Irrigation System (RBL) is responsible for irrigation in the Xai-Xai area.

These two institutions supported the Associations of Water Users (ASU) which was created around the same time. ASUs are in charge of the management of secondary and tertiary water canals along with conflict resolution. They are also responsible for the management of land under irrigation and receive Land Rights (DUAT) on behalf of their members.

7.3 Governance of land

7.3.1 Access to land

Access to land for customary use, occupation in good faith and tribal rights are recognized in law. For Mozambicans, this means freedom, sovereignty and social security. Since land belongs to the State, land use is about more than just property and should contribute to the economic well-being of its occupants. Currently, there is a package on land which includes different legal instruments. According to the latest version of the *Constitution of the Republic* (2004), the land is State property. It has been 7 years since the government put in place the DUAT policy through the Massive Land Regularization (RMT) program.

At the moment, the GOM intends to regularize the land occupied by more than 5 million people and around 5 000 tribal land permits. The National Land Policy ((Resolution n°10/95) and *Implementation Strategy* provided guidance in the legislative changes to the Land Act (Law n°19/97). Point 18 of the Land Policy guarantees «the rights of Mozambicans over land and other natural resources, including the promotion of investment and sustainable and equitable use of these resources» and introduces the question of tribal rights. The regulation of the Land Act established in 1998 specifies that the Land Act is not applicable in areas managed by municipalities.

According to the Land Act, DUAT can be obtained in three ways:

i. «Occupation in line with customary norms practices - Occupation by individuals or local communities, in line with customary norms and practices. This mean individuals and local communities can obtain a DUAT for land occupation based on local traditions such as inheritance. They will however require approval from the traditional chief.

ii. Good faith occupation of land – Occupation by individuals who, in good faith, have been using the land for at least 10 years. This type of occupation is onlu applicable to Mozambican nationals.

iii. Through the granting of a permit through an application to the State as outlined in land legislation. This is the only way through which foreign nationals and entities can obtain land rights[5]» (SPEED, GIZ e ACIS, 2012)

Land use agreements also exist between families (Ducrot, 2011). For economic activities, a DUAT is valid up to 50 years, renewable for the same period. The institution responsible for the issuing of DUATs depends on the size of the land.

- Less than 1.000 ha: Provincial Government
- Between 1.000 and 10.000 hectares: the Ministry of Land, Environment and Rural Development (MITADER)
- More than 10 000 ha: The Council of Ministers

[5] *"Pessoa Singular" is the legal term used to refer to an individual and the term "Legal Person" is used to refer to the bodies set up under the law, such as companies and other organizations*

The Mozambican government specifies that «the approval of a DUAT application does not grant permits or other authorization, as required by relevant legislation, for other economic activities (agriculture, livestock or agro-processing, industry, tourism, retail, fishing, mining and environmental protection)».

A key aspect in the application for a DUAT is consultation with local communities. The current Land Act stipulates that in the absence of public consultations, an application is considered invalid. The regulation also strengthens the participation of local communities in land management. Local authorities have the discretionary authority to revoke a provisional DUAT if they feel it is not justified. This complicates private investments, against the wishes of the government, which decided to promote investments, particularly in the agriculture sector, by implementing reforms through the New Alliance for Food Security and Nutrition. As it stands, less than 15% of arable land in Mozambique is cultivated (MOSCA *et al.*, 2012). There is enormous potential for agricultural development.

A conflict regarding access to land recently took place in the Limpopo River Basin. In 2008, 30 000 hectares of land in the Massingir area were leased by a project called ProCana with the objective of producing sugar case for ethanol production, primarily for South Africa. The problem was that local communities were already using the land, which is their main source of livelihood, and part of that land has already been allocated by the LNP for resettlement.

The government also authorized the use of 750 million m3 of water for irrigation, which will negatively impact local communities (Suárez e Seufert, 2011). This project was abandoned in 2009 but this case is a good example of the risks associated with the negotiation process for land use for more intensive purposes, and the potential negative impact on the environment and society. Intensification of land use should be managed in Mozambique, especially in the Basin where large scale projects should not exhaust the water resources beyond what is agreed.Land should also be secured for customary and government economic development initiatives.

7.3.2 Use of Land

LEGAL ASPECTS

The legal framework for the use and management of the environment is outlined in the *EnvironmentalAct* (Decree 20/97), in the Forestry and Wildlife Act (Law n°10/99) and its regulations, in line with various international conventions and/or ratified by the Mozambican government. It also covers the issue of pollution and how it should be handled.

There is a *Regulation on Environmental Impact Assessment* (Decree 42/2004 amended to Decree 42/2008) which «applies to all public and private activities which can, directly or indirectly, influence the environment according to Article 3 of the Environmental Act.» (ERM, 2014). The regulation defines three categories of activities and outlines a list of activities included in each. Based on the category of the proposed project, there may be a need for an Environmental Impact Assessment or Basic Impact Assessment.

As such, all applications for the authorization of any economic activity after the granting of a DUAT fall under this legislation.

7.3.3 Key institutions

The Ministry of Lands, Environment and Rural Development (MITADER) is the main ministry in the management of natural resources. It is responsible for regional planning, management of land and protected

areas, the use of forests, natural resources and fauna, and the planning and coordination of rural development. It is the key ministry for rural communities in the country, and has an integrated and sustainable development policy.

The Ministry of Agriculture and Food Security (MASA) is responsible for the management of land linked to agriculture. Its mission is: "to contribute to improved food security and poverty reduction by supporting the family sector, the private sector, government agencies and non-governmental organizations in order to increase agricultural productivity, agro-processing and marketing within the principles sustainable exploration of natural resources." The Government established the Technical Secretariat for Food Security and Nutrition (SETSAN) to coordinate interventions related to food security.

At provincial level, *ad-hoc* Directorates handle applications for permits for different economic activities (Gaza Provincial Directorate for Fisheries, Gaza Provincial Directorate for Agriculture, etc.).

In the Limpopo River Basin, there are some farmer or fishermen Associations but most people conduct their economic activities individually.

On environmental affairs, communities organize themselves formally, but not automatically, in Committees for Natural Resource Management (CGRN). Where CGRNs exist, communities receive 20% from forest and wildlife exploration activities in their area, in line with the Ministerial Decree n° 93/2005. However, in general, CGRNs facilitate and co-ordinate environmental projects and activities in their area. They also have an important role in the mitigation and resolution of conflict. There is no concrete data on the number of CGRNs that exist in the Limpopo River Basin.

In the LNP, communities do not receive the 20% directly, and can only do so through FDD (Ducrot, 2013).

7.4 Governance in the management of climate change

The issue of resilience to climate change is complex and requires an integrated approach. In the case of this project, this involves various sectors, especially water, agriculture/food security and infrastructure as described above. There is no one ministry dedicated to this issue which comprises various social, political, technical, environmental and climate issues. This part deals specifically with the response of institutions managing climate change and linked policies and strategies.

7.4.1 Development of climate change response institutions

The Council for the Prevention, Coordination and Combat of Natural Disasters (CCPCCN) was created through the Presidential Decree nº 44/80 of September 3, 1998. Its executive arm, the Department of Prevention of Natural Disasters (DPCP) was mandated with providing humanitarian assistance to refugees, the internally displaced and people affected by the drought.

In 1999, with the coming into effect of the National Policy on the Management of Disasters, the DPCCN was replaced by the National Institute for Disaster Management (INGC) by the Minister of Foreign Affairs. This change reflected the dependence of the country on foreign aid for disaster response. In 2006, the INGC was authorized to create a National Centre for Emergencies (CENOE) – to coordinate the emergency operations and humanitarian assistance; and a Civil Protection Unit (UNAPROC) with the primary responsibility of conducting rescue operations.

The legal standing of the INGC is further reinforced by its statute (2007 & 2008) and its adoption by the Council of Ministers (2009). Three regional directorates of the INGC were created, one in the north, one in the central part of the country and another in the south of Mozambique. There are also provincial offices to ensure the presence of the institution to risk areas as indicated in Figure 13.

There are entities in charge of disaster risk management at provincial and district level, such as District Committees. At community level, great strides have been made, as illustrated by the Advisory Councils and Technical Committees for the Management of Disaster Risk (CTGRC). There are still challenges of them not being properly equipped but the capacity to respond to emergencies improves each year, thanks to improvements in the legal and institutional framework.

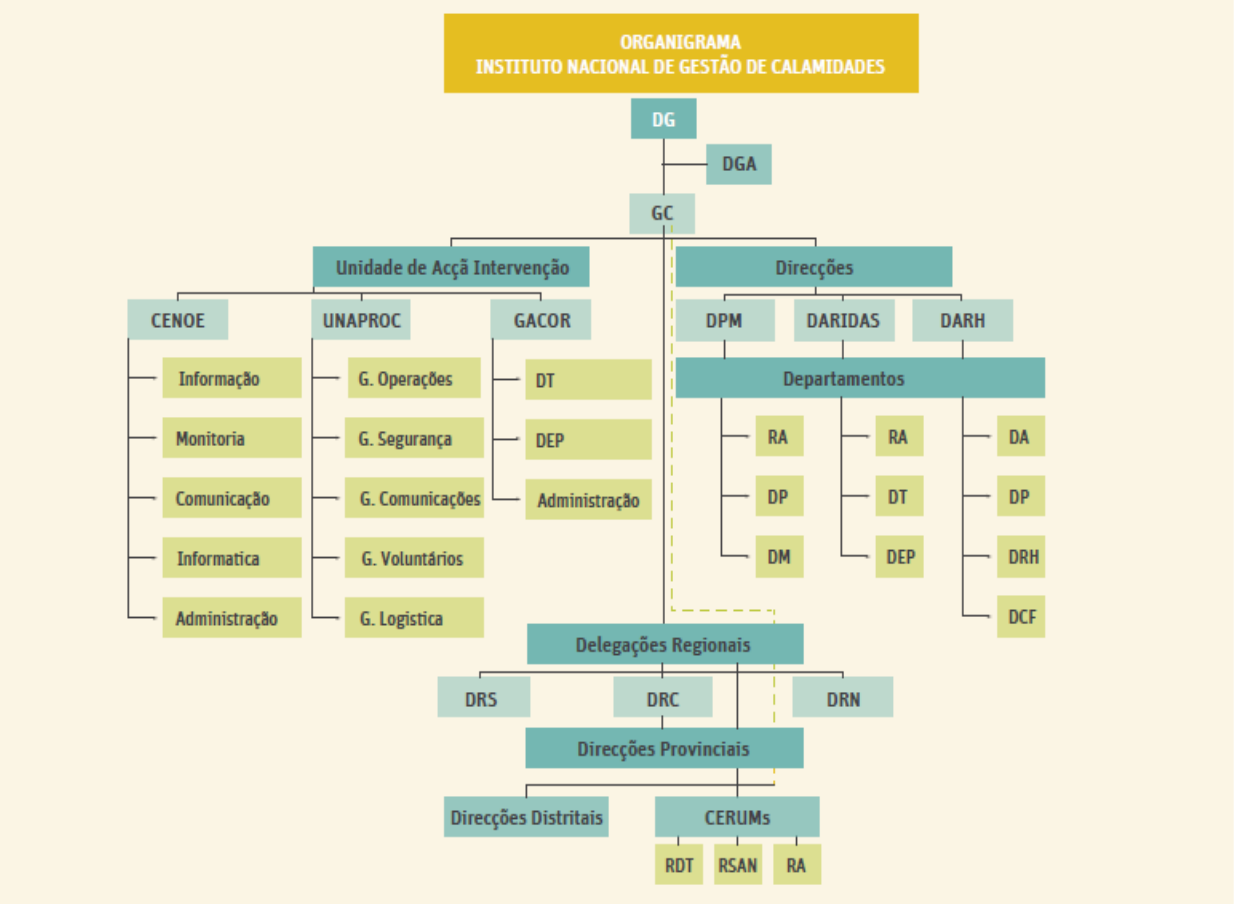

Figure 13: Organigram of the INGC

7.4.2 Climate change policies and strategies

After independence in 1975 Mozambique was affected by various disasters. There was flooding in the Limpopo River Basin in 1977 and in 1978-1979. Furthermore, widespread drought occurred in 1982/83. The government responded to each disaster, depending on international aid.

With the adoption of a *Disaster Management Policy* in 1999, the Government of Mozambique began to introduce proactive measures for disaster management through the use of early warning systems and community participation (GFDRR, 2014). The government also allocated funds for contingencies and supported the recovery of livelihoods of people affected by disasters. This policy was part of a broader strategy of post-independence development based on change in the government's approach. The distribution of aid focused on the provision of services, based on efficient decision making and management systems within the community.

After the 2000 floods, there was an increase in relief and capacity building projects - both at government and local level - such as the USAID funded *Capacity Building for Disaster Preparation*.

From 2005, the spirit of "self-reliance" gained ground as the main guiding principle for national development. This spirit has changed the government's approach to disaster management, with less focus on foreign aid. Although funding continues to be raised from external sources, local institutions have started becoming more proactive in their reaction to events.

The National Master Plan for Prevention and Mitigation of Natural Disasters (2006 – 2014) was the key document in the management of disasters in Mozambique (GFDRR, 2014). This plan clearly outlines the link between mitigation and recovery, poverty and reduction of vulnerability in the context of an agriculture based economy. For example, the management of water resources which supply irrigation systems in the control of water levels to mitigate the impact of floods and droughts on agricultural production (GFDRR, 2014).

Considerations on food safety included in this plan have extended beyond strategic reserves of seed and emergency supplies, promoting the introduction of drought-resistant crops that can be grown commercially and change the rural economy in semi-arid areas. It also focuses on disaster preparedness based on early warning systems, information management, communication and technical skills in rescue operations.

In 2007, the first *National Plan for Resettlement and Reconstruction* which was the government's strategy to resettle communities living in flood risk areas with potential for economic growth took place. This was followed by the *National Action Program for Adaptation to Climate Change2008-2018* (NAPA) and the *National Action Plan to Combat Drought and Desertification 2008-2018* (PANCOSEDE).A *National Strategy on Adaptation and Mitigation of Climate Change* was drafted for the period 2013-2025, affirming the need for decentralization and local technical training and materials. It establishes guidelines on building resilience. Since April 2014, Mozambique now has a legal instrument which requires all sectors to develop disaster risk management measures, Law 15/2014 (*Duties and rights of the user of health services*), signed by the president, created an opportunity to clarify the policies and responsibilities in the recovery phase.A list of the main legal instruments directly or indirectly linked to climate change follows:

- National Environment Policy (1995)
- National Strategy on Biofuels (1997)
- National Water Policy (2007)
- Resolution n°10/2009 approving the New Energy Policy (2009)
- Policy on Development of New and Renewable Energies (2009)
- National Strategy on Adaptation and Mitigation of Climate Change2013-2025 (2012)
- Law n°15/2014 National Strategy on Adaptation and Mitigation of Climate Change(2013-2025) (2012)

8 Socio-economic aspects of the Basin

8.1 Socio-demographic aspects

8.1.1 Population distribution in the Basin

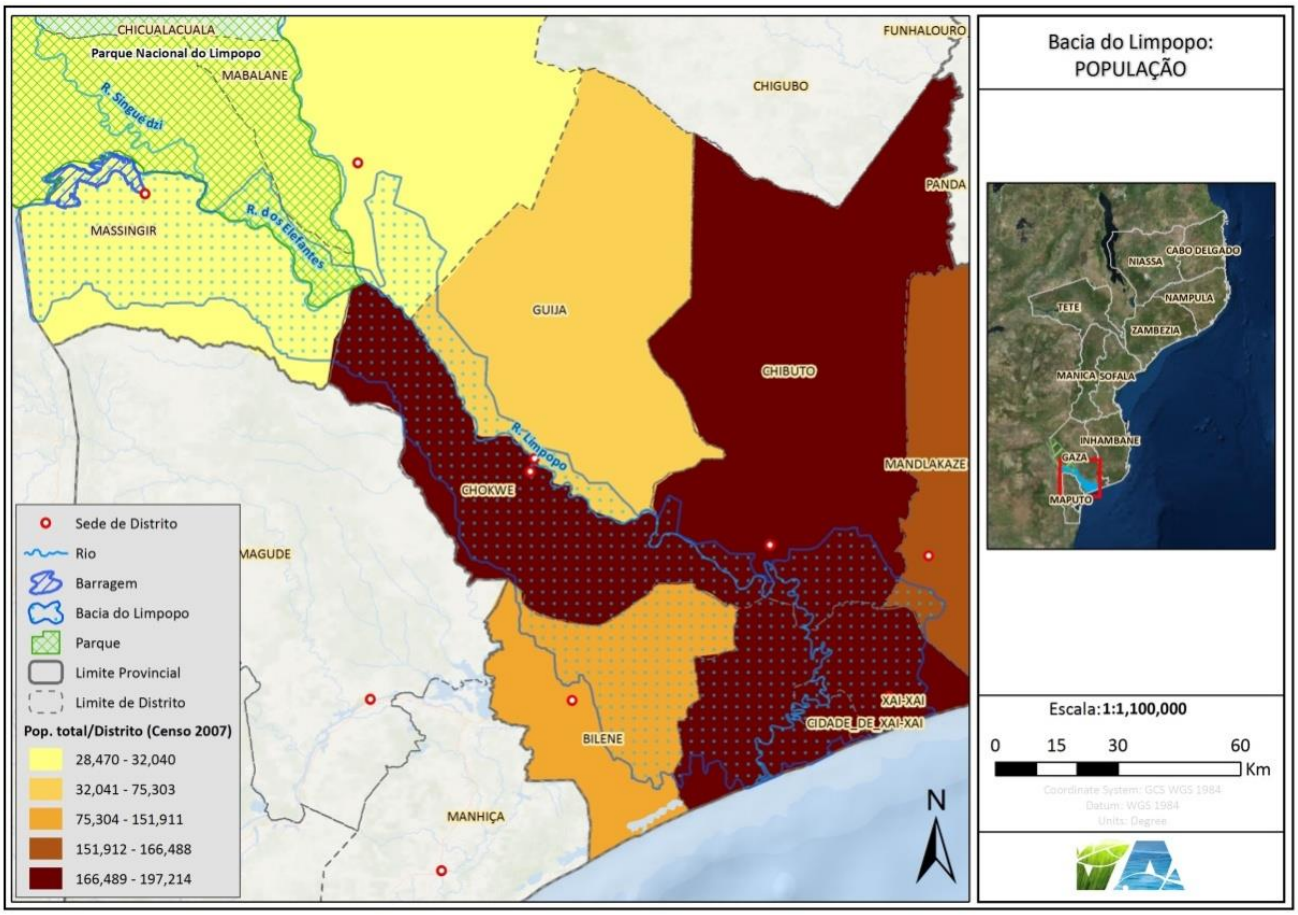

Figure 13 -Map showing population density in the Limpopo River Basin (Verde Azul, 2016)

Most of the Limpopo River Basin in Mozambique is located in Gaza Province, with a small part in Inhambane Province. According to the 2007 Census, Gaza has a population of 1 236 284 inhabitants. The Basin, including neighbouring countries along the river, has a population of 1 300 000 inhabitants (INGC, 2012).

Of the figure mentioned above, 80% of the population lives in rural areas while the remaining 20% live in urban areas. According to INGC;UEM& FEWS NET (2003), the distribution of the population in the Basin is mainly influenced by agro-ecological features and economic infrastructure. Population density varies from one person per square kilometre in the district of Chigubo to 100 people per square kilometre in the rural district of Xai-Xai.

The population is concentrated on the southern bank of the Basin where the climate is less arid, reducing rapidly into the interior, towards an arid climate as illustrated in Table 4.

TABLE 4- TABLE SHOWING POPULATION DISTRIBUTION PER DISTRICT IN THE PROVINCE OF GAZA

District	Estimated Population (2015)	Administrative Posts
Chibuto	216 431	Malehice Chibuto Chaimite
Chokwe	205 572	Macarretane Chokwe Lionde Xilembene
Guija	93 890	Mubangoene Caniçado Chivongoene
Mabalane	38 707	Ntlavene Mabalane
Massingir	35 224	Mavodze Massingir Zulo
Xai-Xai	252 864	Cidade De Xai-Xai Chicumbane Chongoene Zongoene

The manner in which the population is distributed along the river is a result of reliance on agricultural activities, seeing as these areas are conducive for agriculture and people live in traditional homes without water or electricity.

In terms of population distribution by gender, there are less men, especially in the age group 20 -24. This factor can be partially explained by high levels of male migration to work in South African mines (Brito et al, 2009). The population in the Basin grows an average of 2,5% each year (INGC;UEM& FEWS NET, 2003). The average age in the Basin is 17,5 years and 95% of the people are considered dependants, aged less than 15 or older than 64.

8.1.2 Household Profile

The majority of households in Gaza province are female headed, with an estimated 54% overall (INE, 2009). A comparative study between the districts of Xai- Xai and Chokwe (comparison between urban and rural areas) on Gender and Poverty conducted by Tvedten (2010) shows that the majority of male heads of households are married (traditionally , formally or informally), while most female heads of households are made up of widows. A large proportion of widows is related to the premature deaths of men and HIV & AIDS. (Tvedten, Paulo & Montserrat 2008).

TABLE 5- HOUSEHOLD PROFILE

Head of Household	Gaza Province	Chókwè	Xai-Xai
Male Headed Households	46	48	44
Female Headed Households	54	52	56

Data provided by INE (2009) shoes that the average household has 4.9 members. A study conducted by Tvedten (2010) shows that these households have approximately double the number of members at around 7 people. In Chokwe, 67% of households are male headed and have more than 7 members, with 53% in Xai-Xai. Female Headed Households are smaller (at 43% to 37%).

8.1.3 Education in the Limpopo River Basin

TABLE 6- ILLITERACY RATES DISAGGREGATED BY SEX, AGE AND AREA

	Illiteracy Rates (%) Total			Illiteracy Rates (%) Urban			Illiteracy Rates (%) Rural		
Age	Total	Men	Women	Total	Men	Women	Total	Men	Women
Total	38.5	23.5	48.8	24.4	13.5	32.4	43.6	27.3	54.4
15-19	14.3	13.0	15.6	7.6	6.9	8.3	17.1	15.5	18.7
20-24	25.0	17.0	30.6	14.4	9.8	17.9	29.7	20.4	36.0
25-29	32.5	21.9	40.0	19.1	12.6	24.2	37.9	26.0	46.1
30-39	36.6	24.4	44.6	22.7	14.1	28.6	41.7	28.3	50.4
40-49	45.4	22.8	59.3	30.9	12.7	43.2	50.8	26.9	64.9
50-59	62.7	35.3	78.8	49.7	23.6	67.9	66.2	38.9	81.6
60 +	74.0	45.9	88.8	66.4	35.9	83.3	75.6	48.0	90.0

The Limpopo River and its tributary the Olifants River are mainly located in the province in Gaza. As such, the education analysis will be focused on the province. According to the 2007 Census, literacy levels in the various age groups vary based on sex and area of residence.

Data shows that in the province, 38.5% of the population aged 15 and above does not know how to read or write. This signifies a reduction of about 14% when compared to data from the 1997 Census where the literacy rate was 52.7%.

Rural areas have higher rates of illiteracy when compared to urban areas, with a rate of 43.6% against 24.4%. Differences based on age and sex are noted in both urban and rural areas,and more pronounced among women, whose rates of illiteracy are higher than those of men.

8.1.4 Health in the Limpopo River Basin/Gaza

Residents of the Limpopo River Basin are exposed to a range of diseases linked to water or lack of sanitation. The population in the lower Limpopo, in humid areas are generally low, for the most part due to the high density of carriersof three common diseases such as malaria, cholera and bilharzia.

The incidence of these diseases peaked between 2000 and 2008. During the 2000 floods, which happened in February and March, over 800 people died and caused severe damages with effects on public health such as dysentery. There was also an increase in the number of malaria cases and water-borne diseases. In 2008, residents of the Limpopo River Basin was affected by cholera.

The HIV & AIDS epidemic is also another cause of premature deaths among men, mothers and infants. According to a UNAIDS report, Gaza Province has the highest prevalence in the country at 25.1% in 2009. The provinces of Gaza and Maputo, in the south of the country, have a higher rate of children under 18 who are orphaned (19%), having lost a mother, father or both parents (Sitefante, 2011). The proliferation of the virus in the south of the country is linked to the migration patterns of men to South Africa, a country with the highest number of people living with HIV in the world. The high rates are also a result of polygamy, low condom use and other practices such as "kutchinga"[6]

8.2 Economic activities

8.2.1 Employment and occupation per sector

Given the fact that 80% of the population in Gaza lives in rural areas and the rest in urban areas as explained in previous chapters, the rate of formal employment in the Limpopo River Basin is relatively low.

The low rate of employment can be understood from the analysis of the occupations of the main members of households, in line with data from the Household Budget Survey (2015). The survey shows that the main

occupation of heads of households in the province of Gaza (normally made up of people in the active age group) is subsistence farming, with a representation of 58.6%.

TABLE 7 : PERCENTAGES OF HOUSEHOLD IN GAZA PROVINCE PER OCCUPATION

DISTRIBUIÇÃO PERCENTUAL DE CHEFES DOS AGREGADOS FAMILIARES POR OCUPAÇÃO PRINCIPAL, SEGUNDO CARACTERÍSTICAS SELECCIONADAS. MOÇAMBIQUE, 2014/15													
	Altos dirigentes	Técnicos universitários	Técnicos não universitários	Administrativos	Operários não agrícolas	Artesão independente	Pequeno comerciante	Pessoal de serviço	Empregados domésticos	Camponesa	Operários agrícolas	Outras ocupações	Total
Gaza	1,0	1,7	2,6	1,7	12,8	0,0	10,4	3,8	0,4	58,6	5,3	1,6	100,0

[6] *"kutchinga"- a traditional practice or ritual in southern Mozambique through which widows have sexual relations with a relative of the deceased husband (preferably his brother). Widows are used as a form of purification to ward off the spirit of the dead husband, and prevent him from haunting because he thinks she still belongs to him.*

8.2.2 Main areas of activity

According to a study by FEWS-NET (2001), maize, cassava, peanuts, beans, sorghum, millet and rice are the main subsistence crops. Historically, the province of Gaza had a lot of potential in agro-processing, mainly producing rice, cotton and flour, and with some factories for agro-processing. Most of these factories are currently not in operation, but there are Mozambican and South African owned companies at the forefront of what the authorities call the 'gradual recovery' of the commercial agriculture sector. As such, subsistence farming remains the main economic activity in rural areas in the Limpopo River Basin. Agriculture is dependent on rainfall which flows through the Limpopo River.

The Limpopo Valley has the natural conditions and infrastructure it needs to attract investment in irrigation and increase agricultural production. Only around 15% of the population relies on irrigation, 26% in Upper Limpopo, 69% in Mid Limpopo, mainly in the district of Chokwe and 5% in Lower Limpopo (Matshinhe, 2011). Gaza is a province with an extensive irrigation network (50 323 ha), around 17,5% (8 825 ha) of which are currently under irrigation. 30 000 of the land under irrigation is part of the Eduardo Mondlane Irrigation System in the Chokwe District. At the moment, only 7 500 ha are being used.

TABLE 8: OCCUPATION PER SECTOR ACROSS DIFFERENT YEARS

Sector	2004	2006	2008
Agriculture	63,5	51	61,8
Livestock	0,3	0,4	0,4
Forestry	0,4	0,1	0,1
Fishing	0,3	1,4	1,0
Industry	0,4	0,3	0
Electricity and Water	0,4	0,3	0
Retail	26,1	30,7	20,0
Restaurants and Hotels	0	0,1	0,5
Transport and Comunication	9,0	15,0	14,3

Livestock and other domestic animals are important, both from a cultural and economic perspective. Generally, richer households are involved in both livestock production and farming. Fishing is mainly artisanal and concentrated along the beaches of Xai-Xai, Bilene and Dingoine, with some activity in river and lakes.

Tourism is developing but remains concentrated in coastal areas.

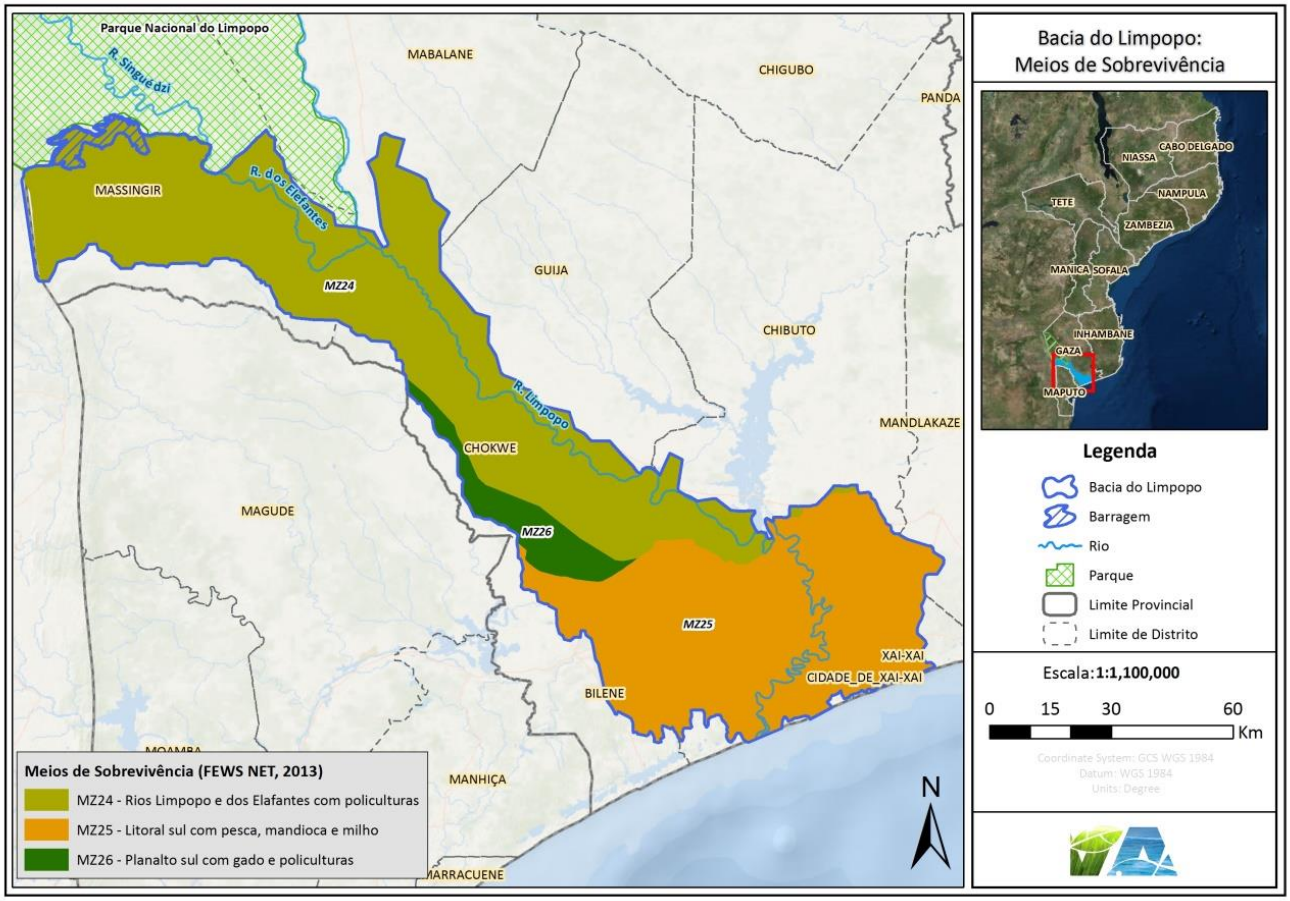

Figure 14: Mapshowing methods of subsistence in the Limpopo River Basin (Verde-Azul, 2016)

8.2.3 Sources of income for families

Migrant work in South African mines is the main source of income for families living in the Limpopo River Basin (FEWS-NET, 2001). Since colonial times, the province of Gaza Province, in particular, has been considered a supplier of migrant labour to South African mines. The practice of men leaving their families to go and work in mines or on commercial farms is rooted. However, some large farmers with more than 5 hectares of land in the Lower Limpopo do not look for this type of work as they are able to gain better returns from agriculture. Other sources of income include the sale of crops, hiring out and selling livestock to families which are better off, the sale of traditional beer, working in the local agricultural sector and lastly, monetary donations to poor families.

Commercial crops include surplus harvests of maize, cassava and tomatoes, from upstream to low lying areas. According to FEWS -NET (2001), cassava sales contribute between 40% - 60% of cash income for middle and upper class households upstream of the river. For lower Limpopo areas, tomato sales make up 40-80 % of the total cash income for middle and upper class households. As such, the sale of these products is a lucrative source of income for better off households.

Local labor for seasonal work in production and harvesting is also an income generating activity for some of the poorest families, although not as significant in terms of financial returns. Another important source of money for poor families is the production and sale of traditional beverages. Poor women typically take part in this activity, producing around 100 liters per month on average (FEWS -NET, 2001).

9 Priority areas for the implementation of P-RAP (Particpatory- Resilience Assessment Process)

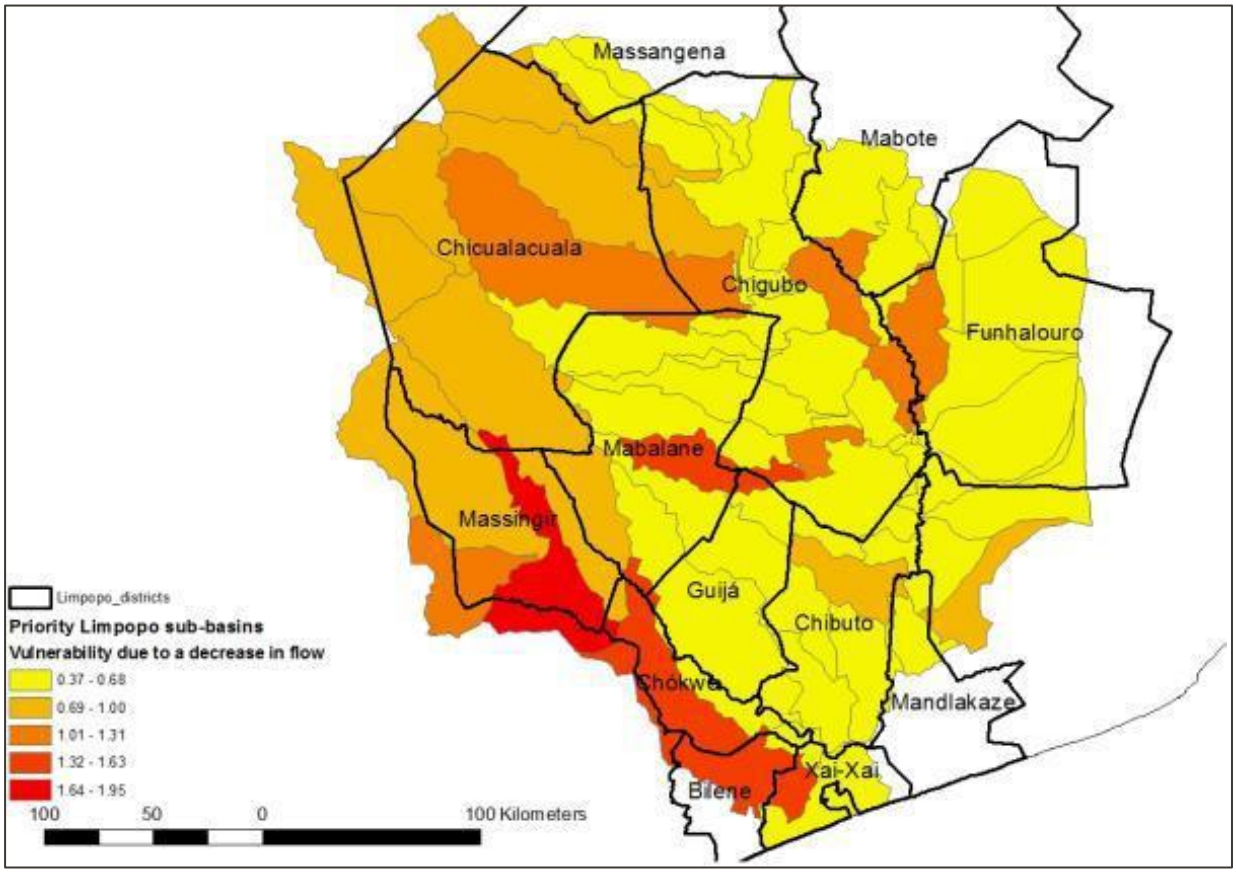

Figure 15- Map illustrating areas with the highest social vulnerability to reductions in flow

Risk management within the RESILIMO-O project will be developed in the three areas of the Limpopo River Basin most likely to be affected by phenomena associated with climate change and other human factors namely: the coast of Xai-Xai (Zongoene administrative post), mid Limpopo in Chokwe district (Lionde administrative post), and in Massingir District in the lower Olifants (Massingir administrative post). Based on a study conducted by UNEP (2013), which analysed the social vulnerability in the Limpopo River Basin, three areas within the RESILIM-O target area with high rates of vulnerability have been identified, as mentioned

above. While recognizing that the concept of social vulnerability is subjective, a vulnerability index has been developed, with the following indicators:

- Wealth (Average value of livestock);
- Access to capital (Proportion of disposable income spent on food); Ratio of dependancy dependência (Ratio of household dependancy); (Average income of those not involved in agriculture); and
- Social welfare (Average assistance received).

In this context, social vulnerability is not considered the main determinant for the selection of Massingir, Chockwe, e Xai-Xai, as it explicitly focuses on the demographic and socio-economic factors that amplify the impact of events on local communities (Tierney et al 2001; Center Heinz 2002). Resilience is incorporated into the RESILIM-O project during the process of outlining the vulnerability of a socio-ecological system, the capacity of target communities and of the ecosystem to adapt to climate risks and human factors. The diversity of elements is taken into consideration, as described below.

9.1 Coastal Areas of Limpopo - Zongoene

Xai -Xai District is located in the Lower Limpopo and has an area of 1908 km2, with an estimated population of 252,864 inhabitants, according to the 2007 census. The district has three administrative posts: Zongoene, Chicumbane and Chongoene (MAE, 2015). Its climate is influenced by cyclones originating in the Indian Ocean. Rainfall occurs in summer, peaking in January and February. The average annual rainfall ranges from 825 mm to 1145 mm and decreases from the coast inland. The average evapotranspiration is slightly higher in the interior compared to the coast due to lower rainfall.

An assessment will be conducted in the Zongoene administrative post, located at the base of the Limpopo, where the river flows into the Indian Ocean. The administrative post is made up of three localities and has 18 villages/settlements. The total population is 27 404 inhabitants around 55, 27% of which are women. More than 50% of the population is not involved in any income generating activity, with only 25% formally employed. More than half the population does not know how to read, write or speak Portuguese (they only speak the local language: Changana). Income ranges between 500 and 2000 meticais (Balidy e Mahumane, 2008).

In the area, the traditional system of governance is executed in coordination with the current system. This means that for certain decisions, the heads of the administrative post have to consult the community leaders.

The main sources of income include agriculture, fishing and livestock. Agriculture is practiced mainly in the lowlands along the Limpopo where peaty soils are highly fertile, but also on coastal and inland dunes that have low fertility. Though the climate is favorable, only 50% of the land is used for agriculture. The main crops are maize, cassava, rice and sweet potatoes. The area has high agricultural potential. There is an ancient irrigation and drainage system inherited from colonial times that was abandoned and could be renovated. To this point, agriculture remains of a subsistence nature and is not done at a large scale. Fishing is focused mainly on fish, prawns and crabs. With Zongoene's strategic location along the coast and at the mouth of the Limpopo River, fishing is another activity with high potential. Fishing is practiced only at household level, and each household owns livestock mainly cattle (Balidy e Mahumane, 2008). There is some infrastructure in place for the development of this activity (dip tanks) and good grazing lands.

On the other hand, given the proximity to Xai-Xai, Bilene Beach and the LNP, along with easy access via the N1, tourism could be an alternative economic activity. As such, the Zongoene administrative post has development potential that can benefit local communities. They however need to find ways to mitigate the lack of agricultural inputs and high occurrence of pests (Balidy e Mahumane, 2008). Further, Zongoene is still located in a region that is adversely affected by climate change, with irregular rainfall and risks of flooding and erosion. This phenomenon is noted in the constant changes in the ecosystem.in 2000, part of the area was silted and completely destroyed by floods.

9.2 Lower Limpopo- Chockwe

Chokwe District is located in the Gaza Province and the Limpopo River also passes through it. It has an area of 2,466 km2 and based on the 2007 census, a population of 205 572. The district has four administrative posts: Chókwè-Sede, Macaretane, Lionde and Chilembene (MAE, 2015). In terms of climate, it is a semi-arid area, with precipitation occurring during the summer season, peaking in January and February. The average annual precipitation ranges from 500mm to 800mm, and temperatures range from 22ºC to 26ºC. The average rate of evapotranspiration is 1,400 mm to 1,500 mm.

The Limpopo River passes through most of the district which has one of the largest irrigation systems in Mozambique. Most of the land in the region is used for commercial and subsistence agriculture. It is interesting to note that rates in the area incentivize the production of sugarcane while penalizing other food crops (Gonho and Woodhouse, 2014). The Macarretane and Massingir dams were built to manage the supply of water to agricultural lands located in the region. The resilience assessment will be conducted in Lionde, an area prone to and with areas which are irrigated and a zone which is not irrigated.

9.2.1 Area under irrigation

Villages in this area are close to the rivers and the Limpopo irrigation systems in both districts. The irrigation system was built along the Limpopo during the Portuguese colonial era, and covers an area of about 31,000 hectares.

The area predominantly on a plain, merging into the lower Limpopo valley and wetlands. The main type of soil is made up of sand, with sandy clay and alluvial deposits in many parts, and relatively high fertility (irriS -NET, 2011). Rains begin slowly in October and November, extending through February and March. The average annual rainfall is 700-800mm with temperatures in relatively elevated areas ranging from 30-35 ° C.

The main sources of income for households in the area include the sale of agricultural produce and livestock, as well as casual labor and manufacturing homemade beverages. The area is also characterized by the production of rice, maize, tomato, onion, cabbage, lettuce, cauliflower, cucumbers and peppers, especially in the low lying irrigated areas (FEWS-NET, 2011). In the highlands, households produce cassava and sweet potatoes. Bananas, citrus, cashew and mango are also produced. Proximity to the river offers a special advantage not only for agriculture under irrigation, where rice and vegetables are profitable crops, wetlands allow artisanal fishing which is also profitable. Although cattle and other animals are reared, the sale of agricultural produce is the main source of income.

Access to markets is favorable because most of the villages are located along or near the main road from Chokwe with direct access to Maputo and other major cities like Xai-Xai and Macia.

Access to these irrigated areas is the main determinant of wealth differences between households as it allows for an increase in crop diversity. Wealthier households have greater access to these irrigated areas and consequently higher yields, particularly for rice which relies on irrigation (FEWS-NET, 2011). There are vast differences among farmers in the area. Some produce only for their own consumption. Most of those have access to land through the quota system, with land sizes of less than 10 hectares, and very little security. Very few have access to facilities through which they can store their produce (barns, kraals, etc.) and do not have mechanized equipment such as tractors. To increase income, they usually practice other activities. Livestock farming is conducted mainly by the rich. According to a study by Amilai (2008), these farmers are insecure about their futures. On the other hand, rural entrepreneurs have larger pieces of land (over 50 hectares) and equipment such as tractors. The latter grow rice for export (national or international) and generally practice livestock farming.

The main problem faced in the area of livelihoods is the lack of rain. Although there are irrigation canals, the infrastructure is extremely dilapidated, and most agricultural production relies on rainfall. This presents a threat to crop production and grazing for livestock. The presence of insects, pests and crop diseases also reduces the quantity and quality of produce. The death of cattle and goats from crocodile attacks is also a problem, along with loss of livestock to diseases such as foot and mouth, anthrax, swine flu etc.

In the area under irrigation, the allocation of land and water rights are managed by Hidráulica do Chókwè (HICEP).

9.2.2 Area not under irrigation

This area lies within the Gaza Province, covering parts of Xai-Xai, Bilene, Chokwe, Chibuto and Guija districts. The area straddles the Limpopo River, but excludes a few coastal villages that are part of the areas under irrigation. The area is predominantly low lying, with high temperatures 30-35 ° C in December and January (FEWS-NET, 2011). The average rainfall is about 800 mm per year, decreasing between the months of November and March. The main type of soil is sandy with alluvial clay in many parts and reasonably high fertility. It is a fairly easily accessible area.

The main subsistence activities are crop production, animal husbandry, casual work and self-employment as well as the sale of alcoholic beverages. The main crops produced include maize, beans, peanuts, pumpkin, vegetables such as tomatoes, onions and cauliflower. Cashew, *mafurra*, banana, mango, citrus and guava are also important crops. In the highlands, crops produced include cassava and sweet potato (FEWS-NET, 2011). The main crops sold by households to the Maputo, Xai-Xai, Chibuto and Macia markets are maize, tomatoes, beans, onions and cauliflower. This is despite people located far from the main road and railway line face difficulties in sending their produce to market.

Livestock production includes the rearing of cattle, goats, pigs and chickens. Considering the fact that this area is not on the riverside, livestock production is more lucrative for wealthier households (FEWS-NET, 2011).

The main problems which impact livelihoods in the area are pests; animal diseases and crocodiles which attack livestock and other animals close to the river during watering; and human diseases such as malaria affecting productivity during the cultivation period (November and December). In addition, the area is prone to drought.

Households respond to these challenges in various ways including increased consumption of wild plants, increased demand for formal employment, the sale of animals and cultivation of drought resistant crops etc.

As previously mentioned, the process of allocating land rights (DUATs) includes a local community consultation. According to S and Woodhouse (2014), local authorities (both traditional leaders and the provincial governor) in the area try to influence communities in favor of investors, providing preliminary project assessments and conflict resolution.

9.3 Lower Olifants - Massingir

In Gaza province, the subsistence is concentrated near the Olifants River, at the point where it meets with the Limpopo River. This area extends far to the north of the river and is located mainly in Massingir district in Gaza. Massingir district has an area of 5,893 km2 with an estimated population of 35,224 based on the 2007 census. The district has three administrative posts: Mavodze, Massingir and Zulo (MAE, 2015). The population density is very low with only about 5 people per square kilometer, the area is relatively isolated from commercial centers within the country and the road network beyond the main road to the village is poor and often impassable during the rainy season. More than 80% of the Massingir district population lives in poverty (FEWS-NET, 2011). This is an area with a semi-arid climate, gently rolling plains, with some more mountainous areas towards the border with South Africa to west (FEWS-NET, 2011).

Part of the area is covered by the Limpopo National Park. Vegetation is composed mainly of bush, predominantly Mopani. Rainfall occurs in summer, peaking in January and February, but it is irregular. The average annual rainfall is 600 mm and temperatures are around 30 ℃. The average evaporation is about 1500 mm. Droughts and floods are common in this area. It essentially has the highest agricultural, livestock and charcoal production. The main food crops produced are maize, beans, groundnuts and sweet potatoes. Natural vegetation provides an abundance of wood for processing into charcoal, most of which is destined for urban markets (FEWS-NET, 2011).

Livestock farming is common in this region, focusing mainly on goats and chickens, with a reduction in pig farming. Poorer families have less cattle due to lack of money to invest in new animals and the pressure to sell animals to buy food. Based on the conditions in the area, production for consumption is not sufficient and affects poorer households the most. Most households derive their income from work in South African mines, especially in years in which harvests are poor.

Para além disso, as pessoas mais pobres procuram emprego localmente na terra dos agregados familiares mais ricos, e às vezes parte do pagamento é feito pelo empréstimo dos bois para usarem nas áreas de sua produção agrícola. Dos animais comercializados, gado é mais rentável embora os cabritos e galinhas também sejam vendidos ao longo do ano. As culturas mais comercializadas são batata-doce em primeiro lugar, depois o amendoim e hortícolas especialmente em Junho e Agosto. As outras formas de rendimento constituem a venda de lenha e carvão, e bebidas de fabrico caseiro. Especificamente será implementado a avaliação de resiliência em Massingir-Sede, devido a possibilidade de trabalhar com grandes partes interessadas da região.

Furthermore, poorer people seek employment locally, working the land of wealthier households. Sometimes part of the payment is made through the loaning of livestock for cultivation. Of the animals that are sold, cattle are the most lucrative although goats and chickens are also sold during the year. The most traded crops are sweet potatoes, peanuts and vegetables especially in June and August. Other forms of income include the sale of firewood and charcoal, and home-made beverages. A resilience assessment will be conducted in Massingir-Sede as there is a possibility of working with major stakeholders in the region.

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The *Association for Water & Rural Development [AWARD]*

AWARD is a non-profit organisation specializing in participatory, research-based project implementation. Their work addresses issues of sustainability, inequity and poverty by building natural-resource management competence and supporting sustainable livelihoods. One of their current projects, supported by USAID, focuses on the Olifants River and the way in which people living in South Africa and Mozambique depend on the Olifants and its contributing waterways. It aims to improve water security and resource management in support of the healthy ecosystems to sustainlivelihoods and resilient economic development in the catchment.

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About USAID RESILIM-O

USAID: RESILIM-O focuses on the Olifants River Basin and the way in which people living in South Africa and Mozambique depend on the Olifants and its contributing waterways. It aims to improve water security and resource management in support of the healthy ecosystems that support livelihoods and resilient economic development in the catchment. The 5-year program, involving the South African and Mozambican portions of the Olifants catchment, is being implemented by the Association for Water and Rural Development (AWARD) and is funded by USAID Southern Africa.

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