Chapter 2

South Central Chibuto: the natural environment

2.1 Introduction

In this chapter, the biophysical and relevant socio-economic background to South Central Chibuto is traced, including the geology and mineral resources, soils, water and climate. Due to the magnitude of the impact of the year 2000 floods, the description of the physical dimensions of those floods is also undertaken when examining the climate of the study area. Finally, because of the impact of land-use suitability on the people's livelihoods, an outline of the existing strategies to cope with changes in the environment is highlighted.

2.2 The natural environment and resource base

Mozambique remains one of the poorest countries of the world with a low Human Development Index of between 0 and 0,5 (UNDP, 1991). Agriculture is one of the major economic activities contributing substantially to the economy. Although the country was ravaged by war for 16 years and has recently been buffeted by severe floods (Chapter 5), the country has shown remarkable resilience to such changes (UNDP, 1998; 1999; 2001).

Economic growth, that consistently exceeded population growth, has enabled a recovery of *per capita* economic income and a more positive Human Development Index. This index has shown a continuous growth from 0,310 in 1994 to 0, 378 in 2001(UNDP, 2001). Agriculture is the main economic activity in the country. It is estimated to account for 26, 9% of the GDP and employs over 80% of the working population (Instituto Nacional de Estatística, 2000).

Smallholder family farms of an average size of 1, 22 ha practicing traditional agriculture account for 97% of cultivated areas (Instituto Nacional de Estatística, 2002). Traditional agriculture constitutes a substantial basis for many livelihoods and is closely related to other uses of natural resources including cattle farming, poultry, gathering, hunting and fishing (Instituto Nacional de Estatística, 2002).

Since the colonial period, southern Mozambique and Gaza Province were classified as a ‘granary for the country’. The agricultural potential for cereal production including maize and rice has been substantial as will be shown in detail in subsequent sections (Wuyts, 1976; FRELIMO, 1977).

The South Central Chibuto region is located in the Chibuto District of Gaza Province in Southern Mozambique. The region covers approximately 400 km^2. The northern region is bounded by ancient dunes known as the *serra* (Portuguese) or *ntlava* (Shangana). The southern and western parts are bounded by a floodplain or *bila* (Shangana) of the Limpopo and Changane rivers, which are being intensively cultivated by the villagers of the study region. Because of the fertility of the soils and the presence of the town, the region is suitable for the use of aerial photographs and satellite images, because contours of commercial farms and communal villages’ blocks can be easily distinguished. As an urban fringe, the area is also suitable for the study of such themes as conversion, intensification and de-intensification of the use of the land that are being debated in the land-use and land-cover change literature (e.g. Lambin, 1997). The region thus provides an ideal case study for examining complex drivers of land use change such as physical, social and economic transformations.

South Central Chibuto is an old settlement and is located in a gradient landscape between:

- Plateau and river valley;
- Miombo forest and savannah riverine vegetation (Morais, 1988);
- Commercial irrigated farming and subsistence rain-fed farming, and
- Urbanized and rural areas (**Figs. 2.1 and 2.2**).

The study area lies in a large ecological region called the Lower Limpopo. The region of the Lower Limpopo (*Baixo Limpopo)* includes the valley between Chibuto and the mouth of the Limpopo River, as well as the upland area alongside the valley. The valley (10 to 20km wide) of the Limpopo River is almost flat, and lies on average 15 m above sea level. It is bordered by steep hills, some above 100 m high. At the foot of the hills, in a general a swampy zone is the *tsovo* or *livala* in Shangana language (Moçambique, 1986; Muchangos, 1992, 1999; Barradas, 1966).

In terms of economic geographic location, the region is situated in a transition belt between the agricultural regions of the Lower Limpopo River with an economy dependent mostly on the use of drained marshy lands of the left Limpopo riverbank. Rice, bananas and vegetables are the main agricultural commodity crops.

The economy of the Middle Limpopo agricultural region, an area from Chibuto upwards to the border with South Africa, is based on the use of large irrigation schemes where rice, maize, cotton vegetables and livestock farming are the main activities (Portugal, 1972, 1974). In the Middle Limpopo, there are a variety of food processing enterprises built during the colonial period. In this period, several thousands of Portuguese peasants were resettled to this region for agricultural development (Myres, 1994).

As will be illustrated in subsequent chapters, the agricultural history of the Lower Limpopo is strongly linked to a variety of government policies over the past forty years including:

- The forced cultivation of cotton and rice 1926-1961 (Roesh, 1991; Covane, 1996);
- The post-independence socialisation programme, initiated in 1977 until the policy of economic recovery which followed a structural adjustment policy of 1987 (Roesh, 1986, 1995; Araújo, 1988) and
- The war and the peace period of reconstruction initiated in the study area in 1983-1987 (Roesh, 1995; Vines, 1996; Ombe, 1991, Coelho, 1997).

Coupled to the structural influences on agriculture, sudden extreme events, including floods and droughts have also caused environmental change. In 1977 for example, a disastrous flood struck the area. Practically, the entire valley was flooded, except for areas, which were protected by dike. After the flood, most of the population left the valley, and communal villages (*Aldeias Comunais)* were formed in the hills (Roesh, 1986; Araujo, 1988; Macuacua, 2000). As is shown in more detail in subsequent chapters, this dislocation of people was a key factor shaping much of the land-use changes that occurred in the area.

2.2.1 Geology and mineral resources

South Central Chibuto is located in the southern Mozambican plain, which rises gradually from the coast to the steep slopes of the Lebombo (**Fig.2.5**). It is marked by undulating landscape, resulting from the sand accumulations formed into dunes, which in some places (e.g. Massinga) rise more than 200 meters above sea level. These dunes block the lower courses of some of the smaller rivers and form lagoons such as Bilene (Barradas, 1945, 1947, 1949; Wellington, 1955).

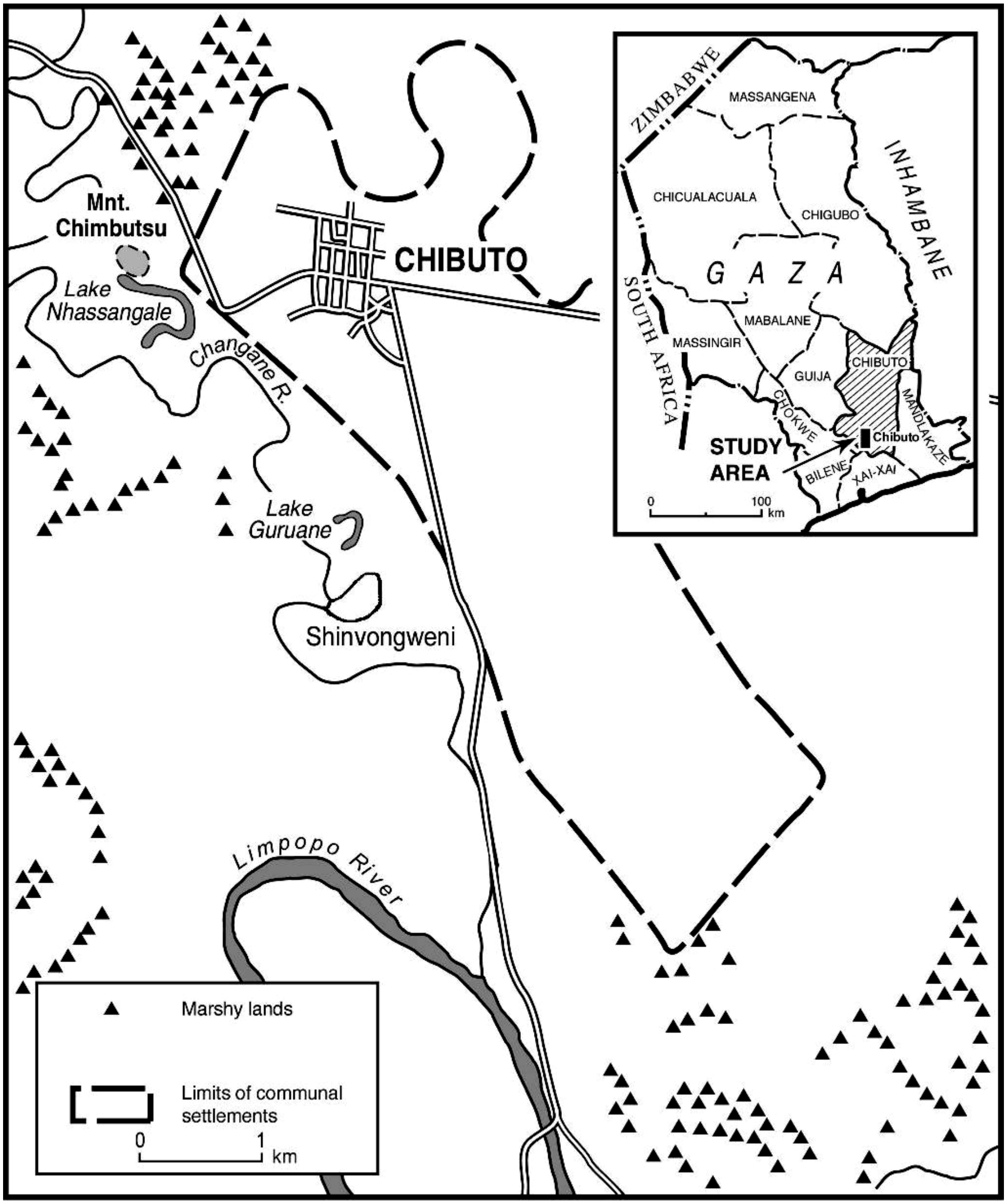

Fig. 2.1: The location of South Central Chibuto.
Source: Topographical map of Chibuto and aerial photographs.

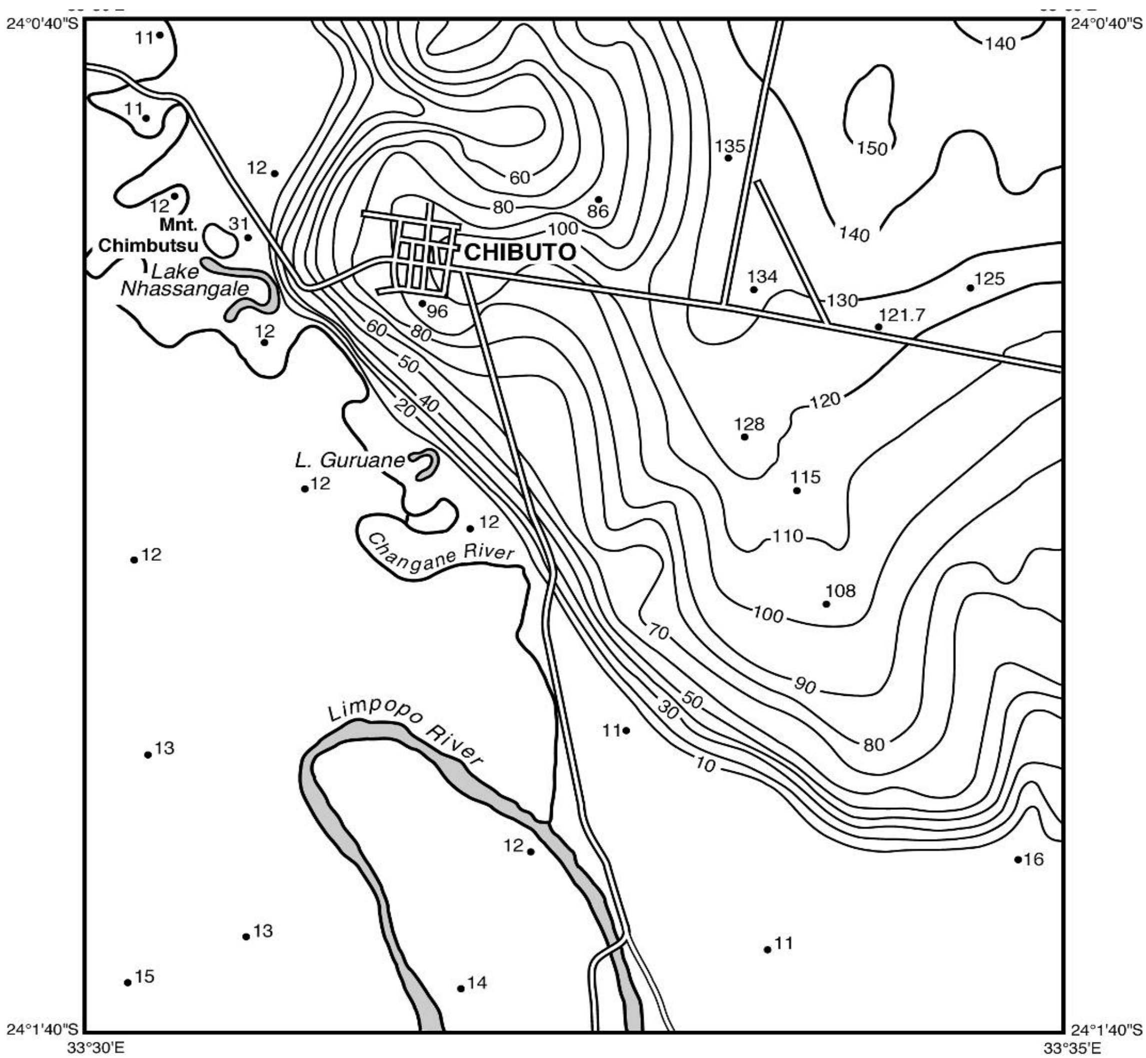

Fig. 2.2: The landforms of South Central Chibuto as a gradient zone (e.g. plateau, slopes and floodplain).
Source: Topographical map of Chibuto.

The dunes are partly covered with dense bush, grass, settlements and agricultural fields where palm trees and cashew trees are the main plants of this region. The most fertile parts of the plain are the wide floodplains of larger rivers (such as the Limpopo River and its tributary the Changane, Incomati and Umbeluzi Rivers), which contain extensive areas of alluvial and swamp soils (Barradas, 1960; Romano, 1963). Quaternary sands underlay the area in the eastern and northern parts of the region.

The western parts consist of alluvium of the Limpopo and Changane Rivers (Barradas, 1960; Bouman, 1983).

The geologic characteristics of South Central Chibuto are related to the turbulent character of the Quaternary period with its eustatic movements causing successive marine transgressions and regressions (Barradas, 1945, 1947). The transgressions and regressions were accompanied by climatic changes with dry and wet spells (Barradas, 1945, 1947; Koch, 1964). Ancient or inland dunes, for example, are a consequence of dry spells coinciding with regressions where the sea floor is exposed and the sands are subjected to speedy winds, which result in dune formation.

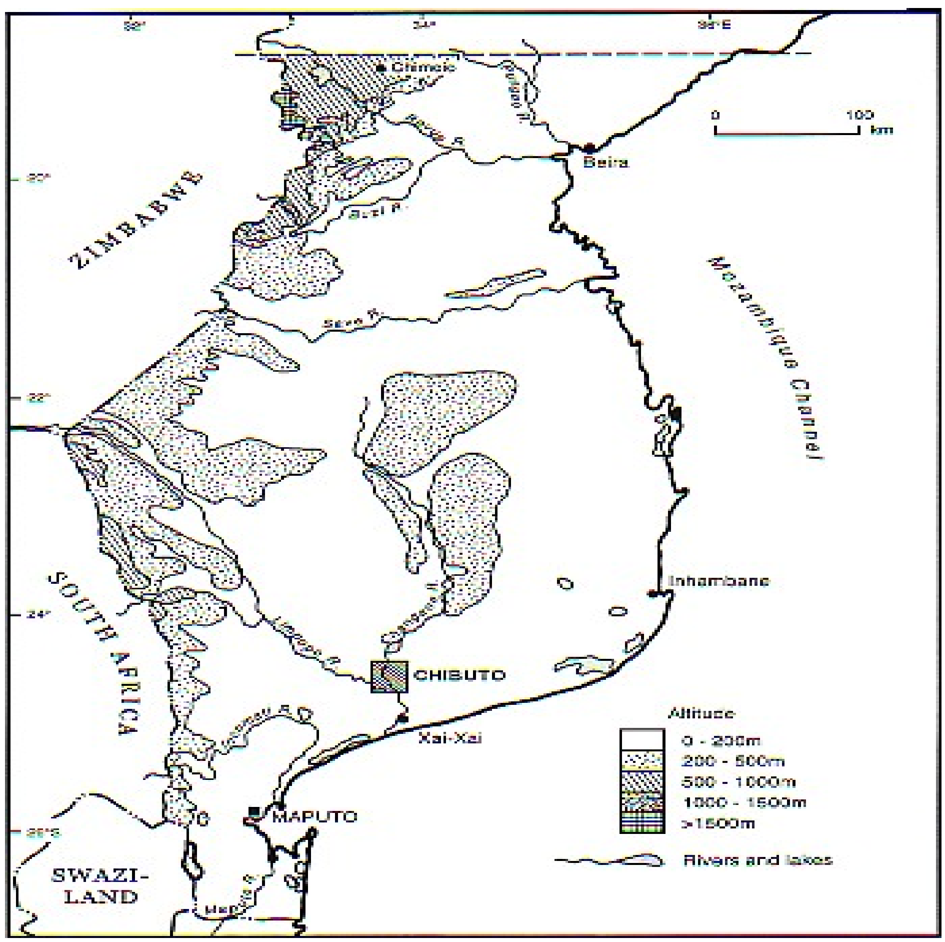

Fig. 2.3: **The** relief of Southern Mozambique.
Source: Bouman (1983, 10).

The stratigraphy of this region comprises sands, clays and clayed limestone that were laid down under marine shallow water, terrestrial and fresh water lacustrine conditions in the later Pleistocene and recent time due to more prolonged weathering. Some of the most prolonged sandy dune ridges are reddish-brown in colour (Barradas, 1955; Bouman, 1983; Moçambique, 1983) (**Fig.2.4**).

In terms of petrography, the area is situated within Mozambican sands. The 'sandiness' of the environment, where Tsonga culture has developed is such that the name they have given to the Earth and land in general is *mussava***,** which means sands (Junod, 1913b). This characteristic of the natural environment has significant implications for the rates of environmental change, including deforestation and soil erosion. This is because the many aspects of traditional material and spiritual culture had to rely on vegetation cover (e.g. building houses, domestic utensils, grinding cereals, fishing, sacred forests) (Junod, 1913b; Cunningham and Gwala, 1986; Cunningham, 1993).

Until recently, the area was considered poor in mineral resources. The only resources, which have been extracted from the region, have been the basic materials for the building of houses and road construction. Clay is collected from the termite mounds for pottery. There is no tradition of making bricks but traditional houses walls and floors can be plastered by clay mixed with dung. The ancient dune sands have

a potential for bearing heavy minerals, which can create minerable deposits. Recently huge deposits of minerable heavy sands have been discovered in South Central Chibuto and they are considered the biggest concentration in Southern Africa (Sansão Sigauke, pers. comm, 1999). The exploitation of these sands will be discussed in Chapter 6.

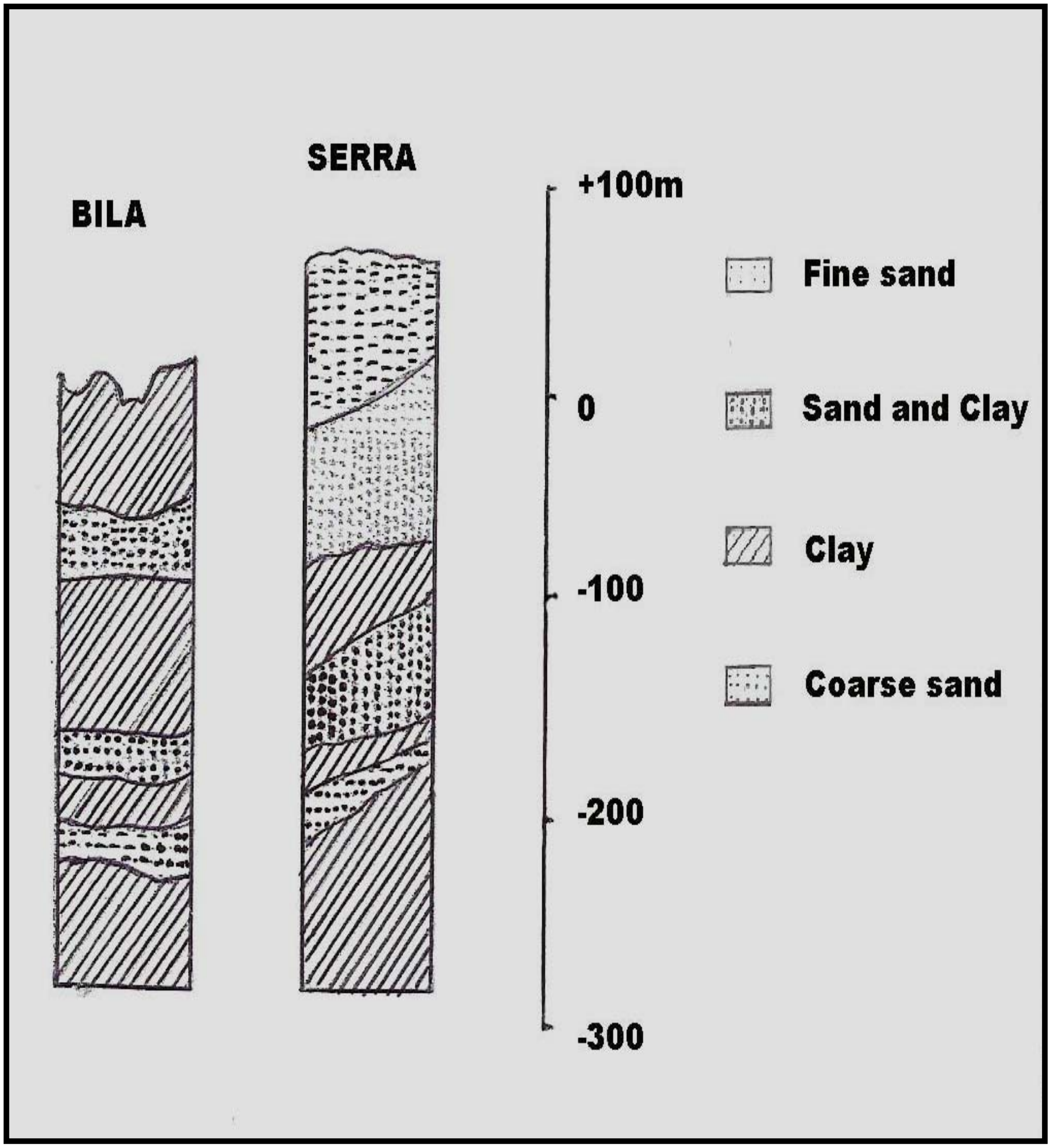

Fig.2.4: South Central Chibuto – Stratigraphy.
Source: Bouman (1983, 5).

2.2.1.1 Geomorphologic processes

The main geomorphic processes in the area are related to the fluvial dynamics of the Changane and Limpopo Rivers, mainly erosion and accumulation. Due to the weak flow of the Changane River in this basin, the accumulation of sediments tends to be more predominant than erosion (Barradas, 1962; Mate, 1993). Erosion processes, however, are very active in the ancient dune environment where the population densities are very high and agricultural activities and other anthropogenic factors are causing the formation of gullies in the edge of the dune escarpment where they contact abruptly with the floodplain. In the boundary surface between the *Serra* and *vale* or *bila* there is an intensive accumulation process (Ombe, 1991, 1998). Despite human factors (e.g. modifying the earth surface through land-use), the erosion intensity depends on the fluctuation of precipitation in Southern Mozambique.

2.2.2 Hydrography

South Central Chibuto belongs to the Limpopo River Basin of Southern Mozambique and is located near the confluence of the Limpopo with its principal left bank tributary, the Changane River. The Limpopo River source is on the Witwatersrand Plateau in South Africa and flows eastward into the Indian Ocean for 1170 km, 501 km of which is located within Mozambique. Nearly half of the river basin, approximately 47% belongs to South Africa, 34% belongs to Zimbabwe and Botswana and the remaining 19% to Mozambique (Portugal, 1974; Mate, 1993; Mozambique, 1993; INGC, 2003).

The Limpopo River flows in a semi-arid region and as such it displays a high seasonal flow characterized by variability and climatic cyclicity. The maximum river flows are usually registered during the rain season from November to March. Floods vary from 11 to 136 days and usually average 98 days (Mozambique, 1993). The water of the Limpopo River is potable in most parts of the river. Its mineral content is between of 180 and 200 mg/l and during the dry season the mineralization rises in the confluence of the Changane. Because of the high salinity of the Changane River, the salinity of Limpopo reaches 2400 mg/l (Mozambique, 1993) at the confluence.

2.2.3.1 The Changane River

Almost 90% of the Chibuto District forms part the Changane River basin. The Changane River now in places has a discontinuous course connected by pools and marshes and is considered a fossil river (INGC, 2003). It is probably a former lower course of the Sabi River, which during high floods found a shorter outlet to the sea (Wellington, 1955). Another aspect of the uniqueness of Changane is its location along an old beach line; its soils are very salty and vegetation is composed of typical halophytes. It is one of the principal occurrences of such vegetation, in Southern tropical Africa, the other being the Etosha depression in Namibia and the Makarikari basin in Botswana. Halophytic communities (plants growing on saline soils), in the valley of Changane, include wooded grassland with *Acacia nilotica*) and bushland (Romano, 1963; Mozambique, 1993). The degree of salinity of the Changane River is illustrated in the following quotation:

> “When the salinity increases the grasses form discontinuous patches with extensive bare areas between. Near the river itself, the salinity is high and some of the coastal species such as those growing on the sea beach occur (*Salicornia, Atriplex*)” (Mozambique, 1993, 93).

Having outlined the characteristics of surface water, attention shifts to the description of ground water in the area.

South Central Chibuto is part of the Mozambique Sedimentary Basin Hydro-geological Province. In this province, hydro-geological characteristics are not very favorable for ground water development, except in some alluvial valleys, in the dune area and in deeper aquifers. More than half the area has serious problems with saline ground water. The high salt concentrations originate from saline formation water, semi-arid conditions and marine inundation during Pleistocene transgressions (Romano, 1963; Barradas, 1966; Mozambique, 1993).

In South Central Chibuto, two hydro-geological regimes may be found, the *Serra* and *vale* hydrogeologies. The *Serra* consists mainly of permeable material (sand). A rain-fed aquifer, for example, is found at approximately 10 to 30 m depth, well above the bottom of the valley (Mate, 1993). At the foot of the dunes, the ground water infiltrates into the permeable organic soil and forms a swampy zone along the dunes. The swampy areas where the dunes meet the valley are particularly productive, as water from the base of the dunes is used for small-scale irrigation (INGC, 2003). Due to their porous sandy soils, the aquifers contain high quality, fresh water that is rapidly replenished (INGC, 2003).

The dunes of the *Serra* are about 100 m above the flood plain of the Limpopo and Changane valleys (Bouman, 1983; Mozambique, 1993).
The bottom of the valley consists of a practically impermeable layer of clay of some 10 to 20 m thickness on top of a sandy layer. In the clay a water level is found at a few meters depth (INGC, 2003). The depth of the water-table in the alluvial flood plain is only a few meters while on the *serra* (100 m above flood plain) the water table is 15 to 75 m deep (Bouman, 1983).

Lakes and marshes are mainly the old meanders and ox-bows of the Limpopo and Changane Rivers some of these are also used as sacred places (**Fig. 2. 5**). Having described the hydrology attention now shifts to the soils of the area.

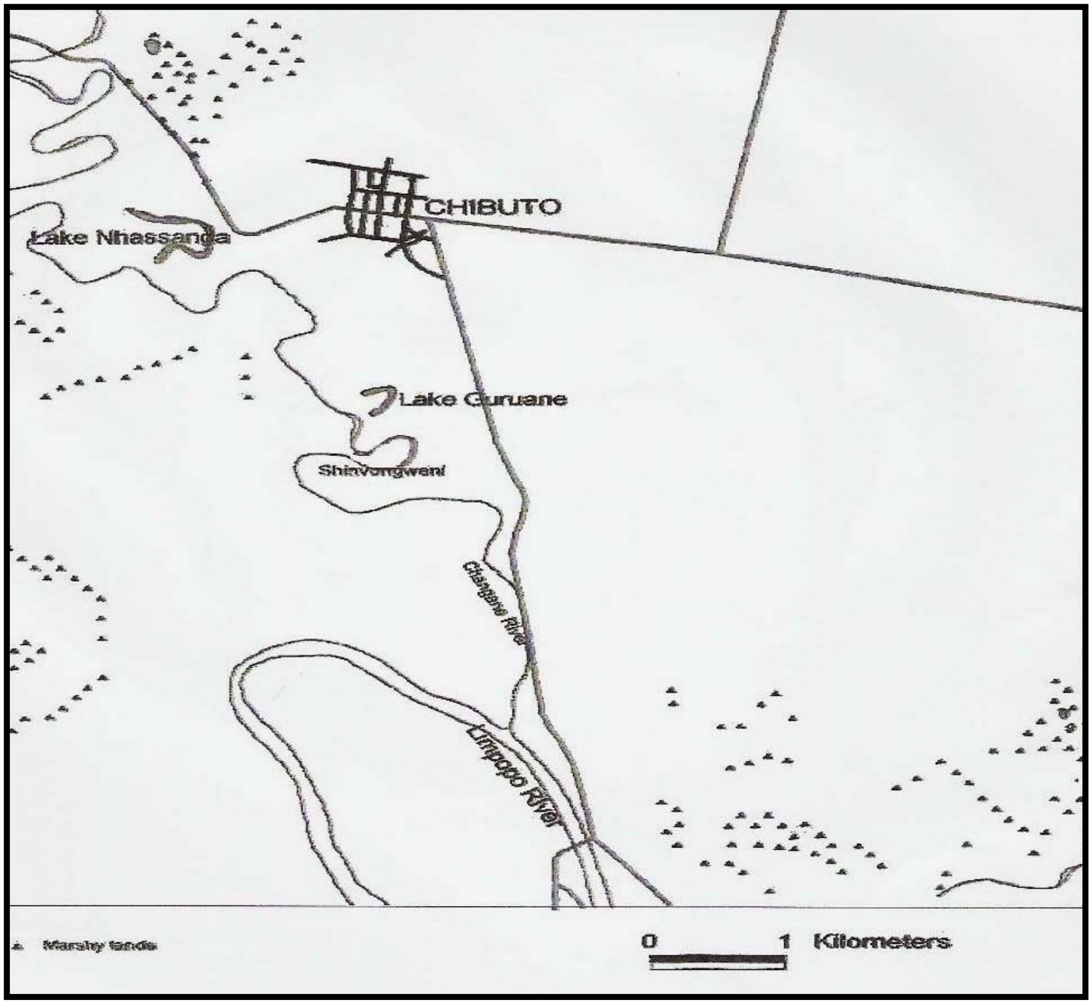

Fig. 2. 5: South Central Chibuto-Hydrography.

Source: Topographical Map of Chibuto.

2.2.3 The soils

The distribution of the soils of South Central Chibuto exhibits an intrinsic connection to the geology and geomorphology of the region. Soils develop in two main types of sediments: The alluvial sediments of the Limpopo and Changane rivers and the eolic deposits of the sandy dunes escarpment. Within each of the soil formation environments differences in soil properties can be found (Marques, 1960; Ombe, 1991).

Ancient dunes dominate the eastern and northeastern part of the region. In the ancient dunes' environment the soils are mainly sandy with low water holding capacity, low cation exchange capacity and very high permeability. Differentiation in soil properties within the sandy dune environment is due to the position of a site in the different forms of the relief (e.g. plateau, moderate, moderate slopes, abrupt slopes or interdunal depressions) forming the soil catenas (Barradas, 1962).

The origin of the sandy dunes and the mechanism of their formation are linked to climatic change and sea eustatic movements (Barradas, 1955). During the dry spells of the Quaternary period, which coincided with glacier periods in the Northern Hemisphere, there was an accumulation of sands by high-speed winds. While the interglacial periods coincided with the sea level rise, the formation of humid conditions in the Tropics led to intense erosional process. The red colour of some parts of the dunes in the area is related to the accumulation of clays after the formation of the dunes (Barradas, 1945, 1947).

The western part of the study area is dominated by the Limpopo and Changane flood plains with the accumulation of alluvium. The soils of this region are of clay texture, high water-holding capacity, high cation exchange capacity and low permeability (INIA, 1995). Due to the poor drainage of some part of the study area swampy soils are found mainly on the edge of ancient dunes where water infiltrated from the sandy dune escarpment *serra* is accumulated (Marques, 1960, Muchangos, 1999). The common characteristic of the sandy soils is that organic matter is transferred to the sands from the sometimes dense and vegetation cover (Marques, 1960; Ombe, 1991). This imprints in the soil a certain character which allows a clear distinction into three layers**:** A surface layer, rich in organic debris in the process of decomposition; a transitional layer, which contain less organic matter than the previous one; and a third, usually with very little organic matter (Marques, 1960; Ombe, 1991). This layer, with increased depth, becomes more compact and with clearer colouring (Marques, 1960; Ombe, 1991).

2.2.3.1 Soil types according to FAO/ UNESCO classification

In the vale environment, the main soil type is *Fluviosols*. In the poorly drained sites, which accumulation of organic matter, *Umbric fluviossols* or *Fluventic humitropepts* (USDA classification) are found (INIA, 1995). In well-drained sites, the main soils are *Mollic fluviosols,* which are formed both in clay alluvium and in soils of coarse to medium texture. *Fluviossols* are characterized by clay texture, low permeability and high water-holding capacity as well as high cation exchange capacity. Because of these properties, these soils are suitable for irrigated agriculture and the use of fertilizers. In the *serra* the main soils are *Arenossols.* Because of the sandy texture and the high concentration of iron they are called *Ferralic arenosols* or *Ustic ferripsament* (USDA) (INIA, 1995). Sandy soils have relatively poor organic matter and poor water-holding capacity if compared with the alluvial soils (Barradas, 1962; Ombe, 1991; Mate, 1993). Due to their low cation exchange capacity and low water-holding capacity they are not suitable for irrigated agriculture or the use of fertilizer (Marques, 1960).

2.2.4 Climate

The main climatic factors influencing the study region include the high pressure of the anticyclones of the Southern Indian and Atlantic oceans (Ferreira, 1965, Muchangos, 1992,1999), the low pressure which is formed over the highlands of the African continent in summer, the high pressure which is originated over the African continent in winter, the warm Mozambican current, cold polar fronts and sporadic tropical cyclones which usually cause intensive rains and flooding (as it will be described in next sections) (Alexander, 2000).

During the summer period, when a low pressure dominates the region, the, the region is affected by unstable marine air, which causes the formation of clouds and rains (Faria, 1964; Tyson and Preston-Whyte, 1988). In the winter season, the region is mainly influenced by continental air where the wind is generally weak from the north or south, depending on the predominance of either the Indian Ocean or the African continent. In this period, cold fronts are very frequent and may cause weak and dispersed precipitation (Muchangos, 1999; Faria, 1964; Ferreira, 1965) (**Fig.2.6**).

2.2.4.1 Rainfall variability

South Central Chibuto is situated in the transition zone between the tropical humid climate of the coastal belt and the tropical steppe climate of the interior regions of Southern Mozambique east of Lebombo (Marques, 1960). Its rainfall regime, which totals about 730 mm per annum, is rather irregular, with great variability both inter-annually and from year to year. During the year the precipitation is distributed in the following way (Marques, 1960).

On shorter time scales, roughly 70% of the rainfall occurs during the November-March wet period, 15% during April to August dry period and the remaining 15% in the September-October transition period (Marques, 1960). Climate variations, often accompanied by periods of extremes, such as droughts and floods occur regularly (INGC, 2003). These extreme rainfall events usually leave behind distinct land-use changes observable in the environment. Rainfall variations may for example, provoke cyclical processes of cutting and incision of newer beds during wetter spells and in-filling of gullies during drier spells. It appears that the wet spell, which began in South Central Chibuto during the 1992s, for example, was characterized by accelerated erosion incision causing gully formation (Bull and Kirby, 1996).

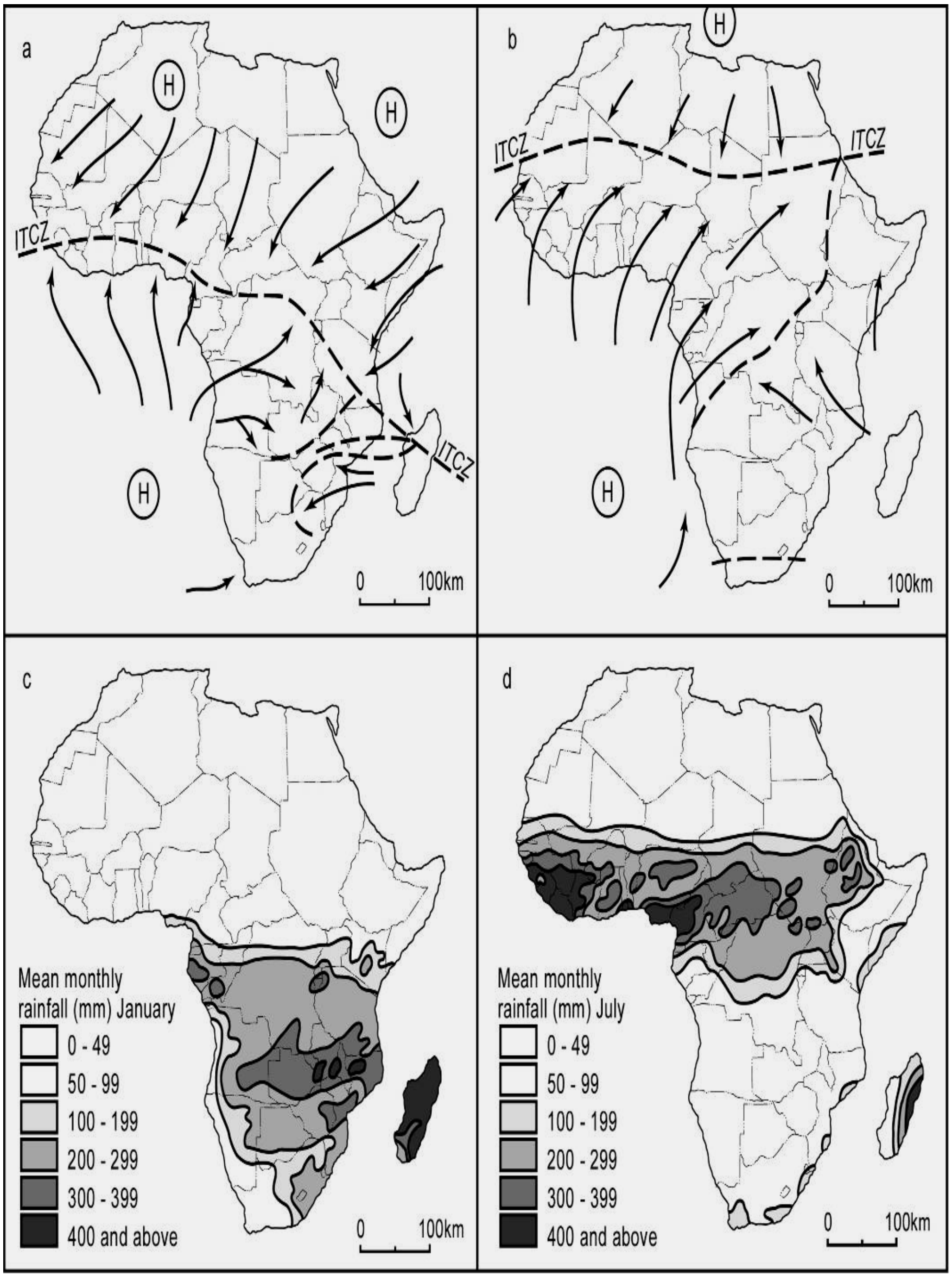

Fig.2.6: Atmospheric circulation over Mozambique showing the shift of the ITCZ that plays a role in determining rainfall over Mozambique.
Source: Ferreira (1965, 156).

Rainfall variability including extreme events has played a major role in “shaping” the environment. In Chibuto flooding, for example, has also been extensively documented in historic accounts since the middle of the 19th Century by missionaries and Portuguese administrators (e.g.Young, 1996) and is related to episodes of above-normal precipitation According for example with (INGC-2003, p11), the Limpopo basin has suffered a number of severe floods (1955, 1967,1972, 1975,1977, 1981 and 2000). Heavy rains are connected to non-ENSO (El Niño Southern Oscillation) events or La-Niña events (cold tropical Pacific Sea Surface Temperature) (Jury and Nkosi, 200*)*. The links between precipitation in Southern Africa and ENSO events are clear but not always strong or predicable (Manson, 1997). The 1997 El-Niño (warm tropical Pacific Sea Surface Temperature), for example, which produced extreme climatic anomalies all over the globe, had relatively little impact in the study region.

> “There was a strong El-Niño from mid-1997, to mid-1998, followed by an unusually sudden switch to a strong La Niña from mid-1998. This phenomenon fuelled predictions of droughts in Mozambique (which did not happen) and above average rainfall in 2000 (which clearly did happen)” (Christie and Hanlon, 2001, 108).

Factors other than the state of tropical Pacific Ocean Sea Surface Temperature (SST) known as ENSO that cause El Niño and La Niña events influence regional climate variability (INGC, 2003). These include internal atmospheric dynamics, SST in other oceans basins, land surface conditions and the fact that the region can be divided into numerous homogeneous rainfall regions, each region having different connections with ENSO. Generally, ENSO explains only about 30% of rainfall patterns, so other factors must also be taken into account when predicting future rainfall (INGC, 2003).

Annual precipitation data in Chibuto, are available from 1944 to 1984) and from the closest station to the study area station named Chokwe (1970-98) (**Figs. 2. 7 and 2. 8**). It is clear that since the middle 1960s, the region under study was characterized by the predominance of overall decline in rainfall. This period was, however, characterised by years of above-and-below-normal rainfall with catastrophic floods. In 1977 catastrophic floods occurred. During the period 1977 until 1992, rainfall was predominantly below-normal with extreme droughts in 1982/83 and 1991/92. The period after 1992 was characterised by above-normal rains, which culminated with the catastrophic floods in 2000 (Christie and Hanlon 2001).

The 2000 floods were of unprecedented magnitude similar to those occurring in 1977 (**Table 2.1**). Due to its unprecedented character, the 2000 floods are described in detail in the following section.

Table 2.1: Historical Floods in Southern and Central Mozambique.

Flood	**Last historic maximum**				**Flood 2000**
Basin	**N**	**Period**	**Year**	**Flow (m3/s)**	**Flow (m3/s)**
Umbeluzi	**4**	**1966-84**	**1984**	**6.150**	**1 140**
Incomati	**12**	**1937-98**	**1976**	**6.250**	**11 000**
Limpopo	**13**	**1915-96**	**1977**	**8.740**	**10 581**
Buzi	**12**	**1957-95**	**1973**	**8.246**	**>10 000**
Save	**5**	**1960-81**	**1974**	**6.300**	**>10 000**

Source: Vaz (2000). N denotes the number of floods observable over the period 1966-2000. The year 2000 floods are shown in a separate column for comparison (see also **Figure 2.3**).

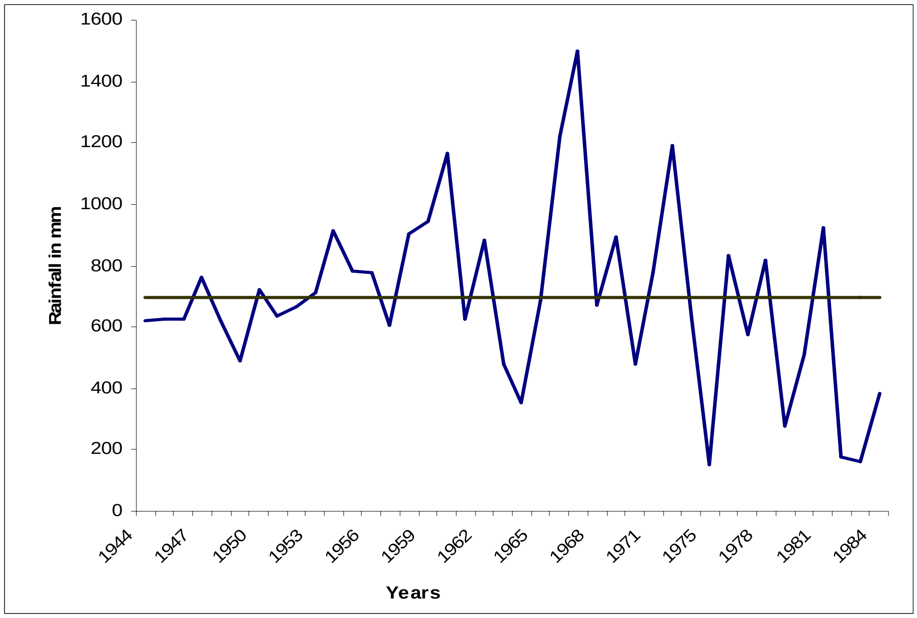

Fig.2.7: Yearly rainfall in Chibuto, 1944-1984.
Note the prevailing below-normal rainfall since late 1970s to middle 1980s.
Source: INAM (1999).

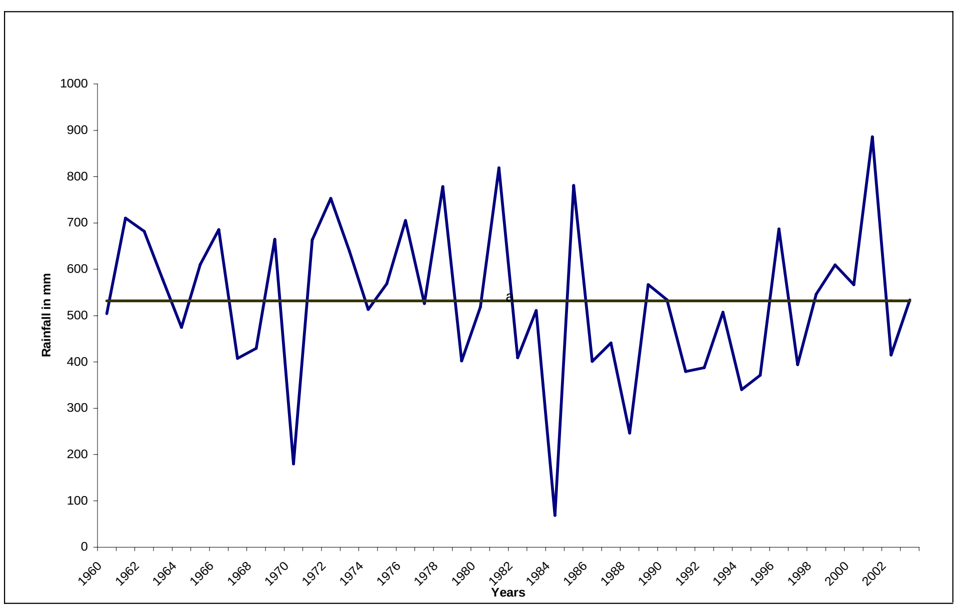

Fig.2. 8: Yearly rainfall in Chokwe 1960-2002. Note prevailing below-normal rainfall during the 1980s and an increase from middle 1990s.
Source: INAM, (1999).

2.2.5 The year 2000 catastrophic floods and their causes

Catastrophic floods are usually characterized by unprecedented magnitude and low frequency of occurrence; they may result from unusual or persistent climatic regimes and failure of natural and man-made dams (Alexander, 2000; Dyson, 2000; Huda, 2000).

The direct causes of catastrophic flooding are related to the following factors (Dyson, 2000):

- The distribution of rainfall over the catchment,
- The distribution of rainfall over the time,
- The size and characteristics of the catchment, and
- The position of human activities in the flood plain.

These factors combine to provoke unprecedented runoff in the river basins of Southern and Central Mozambique. These factors will be described in detail in this section.

2.2.5.1 The distribution of rainfall over the catchment.

During the floods, tropical cyclones moved almost perpendicularly from east to west and were responsible for heavy rains far west as Namibia. These weather conditions are highly unusual because tropical cyclones only occasionally manage to cross the Mozambican channel into the sub-continent (Dyson, 2000). Due to the location of Southern Mozambique down-stream from the major Southeast African river basins, the runoff produced by these rains inevitably flowed to the coast through the Lower Limpopo region, thus flooding the whole flood plain (Filipe Lucio, pers, com, 2000).

2.2.5.2 Distribution of rainfall over time

During the year 2000 flooding, the extent and irregularity of rainfall distribution over time was anomalously high (Jury and Lucio, 2004). In many cases, the meteorological stations recorded 200% rainfall above normal over 24 hours. In the Maputo gauging station, for example, the rainfall of the first decade of February was about 40% of the annual mean. This was the product of a two-day storm that was provoked by a cyclone. The contribution of the year 2000 January to March rainfall in many cases reached 300% above normal (**Table 2.2 and 2.3**). The combination of the aforementioned events produced extremely high flows in the Crocodile and Sabie Rivers in South Africa and the water crossed the border into Mozambique (INAM, 2000; Vaz, 2000).

The La-Niña event, a cold-water oscillation in the Equatorial Pacific, was another contributory factor causing the floods. It has been established that 8 out of 10 years, La-Niña usually brings above average rains to Southeast Africa (Jury, 2000). The La-Niña conditions of the time had been amplified by the tropical cyclone. La-Niña conditions favour the development of tropical cyclones. This is because the jet streams which usually divert tropical cyclones south, away from land are weak during La-Niña, and allow cyclones to penetrate deep inland (Jury and Nkosi, 2000; Jury and Lucio, 2004).

Another contributory factory for the catastrophic flooding is the existing moisture remnant from previous rains, the so-called antecedent moisture. During the fieldwork in January 2000, the Limpopo River was flooding with overflowing banks. When the heavy storms and floodwater came in February, the ground had been saturated (Field visit, January, 2000 in Maniquenique).

Table 2.2: The January to March 2000 rainfall compared with the normal.

Station	January-March precipitation		Deviation From normal (mm)
	Jan-March (mm)(2000)	Jan-March (mm)(Normal)	
Maputo	1101. 7	354. 3	747. 4
Mavalane (Maputo Airport)	1387.1	354. 3	1027. 8
Changalane (Maputo Prov.)	789. 0	354. 3	434. 7
Xai-Xai	958. 3	327. 6	631. 1
Inhambane	901. 1	360. 5	99. 6

Source: INAM (2000).

2.2.5.3 The size and characteristics of the catchment

The hydrological and topographical features of the Lower Limpopo are characterized by a flat plain with many depressions. Meanders as well as oxbow lakes characterise the river basin, and this usually contributes to an increase in the magnitude of the floods. More than 50 % of the Limpopo basin is situated in terrain below 200 m. In the Mozambican part of the basin, 80% of the basin lies below 100 m (Mozambique, 1996)**.** The average slope gradient of the basin in Mozambique is approximately 0.25m/km or 0.00035(Mozambique, 1993) and the final 175kms between Chokwe and the river mouth are at elevations of less than seven meters above sea level (INGC, 2003) (**Figs 5.2 and 7.2**)**.** The catchment's characteristics together with the impact of the intensive rains made the flow of water into the ocean deficient. The tidal regime of the Mozambican channel with successive rises in sea level also aggravated the flood impact.

2.2.5.4 Human activities in the catchment

The management of dams and its impact on the catastrophic flooding has been taken into consideration in recent times. Catastrophic flooding occurred due to the inadequate management of dams existing mostly in South Africa and Mozambique. During an international seminar on floods in October 2000 in Maputo, it was highlighted that the layout of the main roads crossed the Limpopo Valley perpendicularly to flood plain consequently acting as dams and so exacerbating the impact of the floods. The need for water sharing between South Africa and Mozambique and the management of the whole river basin in a sustainable way was also stressed.

Between Mozambique and South Africa, measures are being taken in order to draft an agreement on water sharing. For the purpose of integrated water management, the protocol on shared watercourse systems has been produced during the 1990s (SADC Protocol on Shared Watercourse Systems and Water Sector Co-ordination Unit (WSCU)(SADC, 2000; Taucale and Leestermaker, 2000; INGC, 2003).

The most important objectives of that protocol are to use the shared watercourse systems in an equitable manner and protect them adequately (SADC, 2000; Biljon and Houghton-Carr, 2000). Having characterised the climate and the 2000 catastrophic floods, attention now shifts to the outline of the vegetation cover of the area.

2.2.6 Vegetation cover

Mozambique is situated in the Zambezi endemic region; South Central Chibuto lies in the mosaic transition of the Zanzibar- Inhambane and Tongaland-Pondoland sub regions (Muchangos, 1999). Open forests or Miombo woodland and savannahs are the natural vegetation of South Central Chibuto including riverine forest (Bila, 1993). In the Miombo woodlands, the dominant species are *Brachystegia speciformis* as well as *Julbernardia globiflora* and *Sclerocarya birrea.* South Central Chibuto is located in the gradient zone, which separates Miombo region and other vegetation formations of southern Mozambique (Morais, 1988; Bila, 1993; Mate, 1993; Muchangos, 1999).

In the study area, savannas are formations dominated by grasses with a thin distribution of trees and bushes in a mosaic form. They are associated with extensive agriculture, livestock grazing and areas of degraded forests (Bila, 1993). A few relict patches of a dense, multi-storeyed riverine gallery-forest subsist only in some parts of the Limpopo on coarse-textured sandy soils associated with recent alluvial deposits. A wide variety of species is found, including *Ficus, Acacia, and, Phragmities* (Sousa, 1966; Bila, 1993; Mozambique, 1993). The natural vegetation cover of South Central Chibuto has, however, almost been cleared for agricultural fields and fuel wood, and has been gradually substituted by anthropogenic vegetation including a variety of fruit trees.

One of the main anthropogenic factors of vegetation change is the clearance of vegetation for various purposes including building materials, fuel and wood. The clearance of vegetation for building materials, however, depends on the settlement patterns, vegetation type and abundance and patchiness of favored building resources (Marques, 1960; Cunningham, 1993).

Demand for building timber depends not only on human population densities and regeneration of the species bearing building materials (e.g. poles), but also on the amount of wood needed for the construction of a particular architectural style of house and other structures (e.g. storehouses). For a long time, continued availability of building materials from natural vegetation, whether wetlands, woodlands or forests has been particularly important in vast areas of the Southern African subcontinent which are covered by coastal or continental sands, such as South Central Chibuto. There are two reasons for this (Cunningham, 1993). First, these areas are marginal for agricultural production, often occupied by poor rural communities unable to afford expensive building materials; second, with the absence of clay and stone, wild plants resources provide a major source of building material. Particularly important on these sites are the vast areas of *brachystegia-Jubelnardia* (miombo and

Colophosperum mopane woodlands) (Feliciano, 1998). Other uses of vegetation consist of the gathering fruits, nuts and medicine (Marques, 1960; Cunningham, 1993).

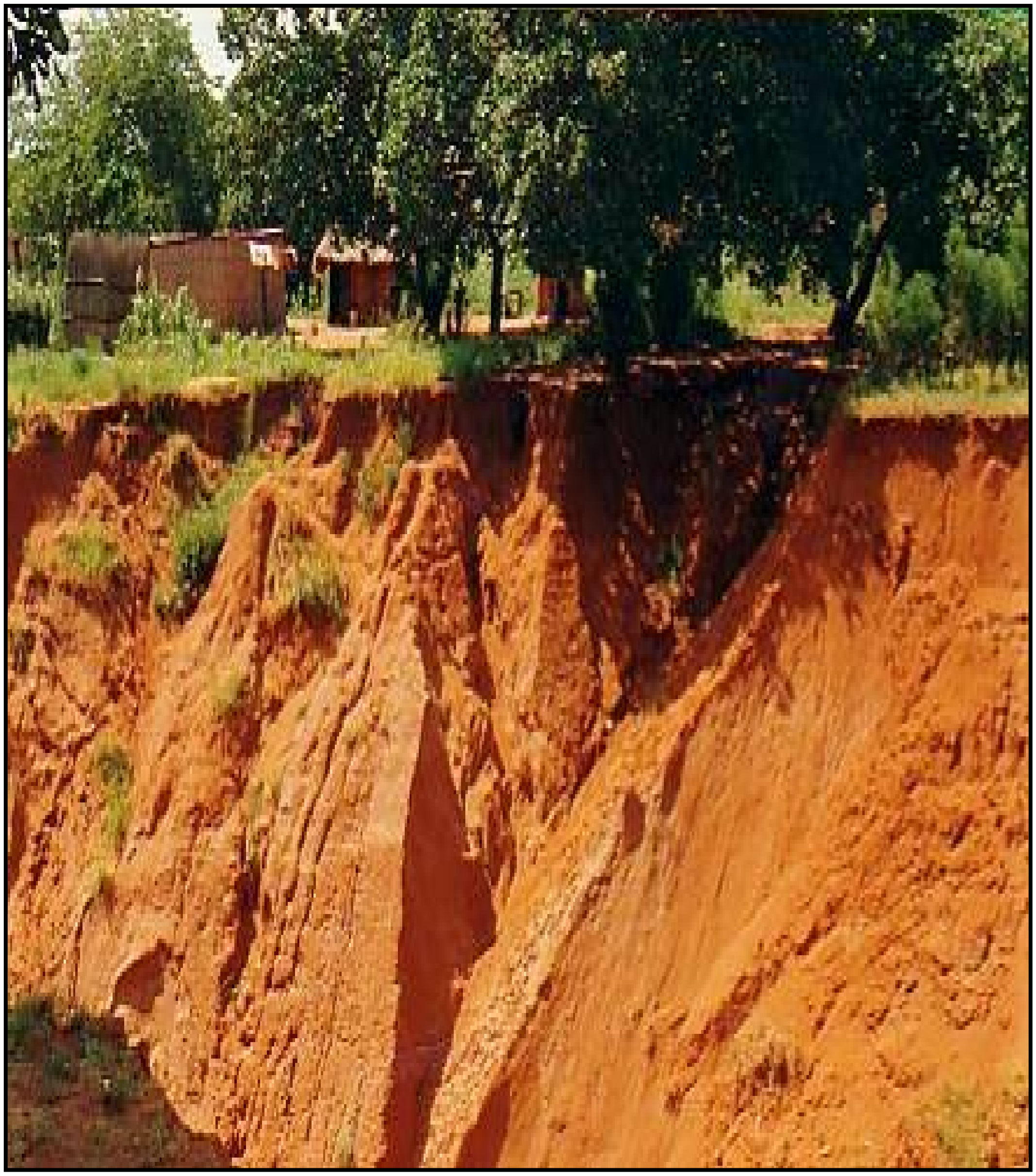

Fig.2.9: The cashew tree (*Anacardium ocidentalle*) is the predominant tree species in the *serra* landscape on deep sandy red soils (Chibuto, January, 1999). Note, however, the marked gullies in the foreground caused by accelerated soil erosion (Ombe, 1998; 2003; Feitio, 2004).

2.3 The Constraints and opportunities for food security in South Central Chibuto

Having outlined the physical characteristics of South Central Chibuto, the research now seeks to provide a background to the constraints and opportunities of food production in the region. These regions include people who share similar options for obtaining access to food and cash income and who are therefore subject to similar risks (Heltberg and Tarp, 2000; Boudreau and Coutts, 2002).

Mozambique, in terms of food systems, is divided into four regions (Inter-sectorial Vulnerability Assessment and Mapping Group, 1998; Boudreau, 2001): the lowlands plains and coastal food system, the major river basin food system, the dry land and semi-arid food system, and highland food systems. The geographical distribution of these regions coincides with the main agro-climatic zones of the country. Southern Mozambique is characterized by 3 food systems, which include:

2.3.1 *The lowlands plains and coastal food system*

This region occupies the Indian Ocean coast of Mozambique and the transitional zones between the plateau and coastal areas with altitude of less than two hundreds meters above sea level. The food system is characterized by the combination of fishing, crop production and livestock rearing in some areas and trading. Rainfall is regular in most years, but drought is reported in some years (Inter-Sectorial Vulnerability Assessment and Mapping Group, 1999; Boudreau, 2001).

2.3.2 Major river basin food system

This food system occupies the lower elevation of river valleys of major rivers including the Zambezi-Chire river basin, Lugenda river basin, Lurio river basin Buzi-Save river basins, and Limpopo-Incomati river basins. The food system is characterized by good soil fertility, good irrigation potential and suitability for horticultural and food crops. Fishing is also important. Periodic flooding with the possibility of crop and property damages (Inter-Sectorial Vulnerability Assessment and Mapping Group, 1999) also occurs.

2.3.3 The dry land and semi-arid food system

Finally, the dry land and semi-arid food system is mainly located in the southern part of the country with rainfall less than 600 mm per year. Rain-fed crop production is susceptible to climatic variability and prone to periods of moisture stress for vigorous plant growth and development; irrigation potential exists but is unlikely to be optimally utilized given the prevailing family sector investment levels and technical capacity. This food system, however, is suitable for large-scale livestock production. Despite its suitability for agricultural production, the food system has shown a production deficit in most years (Inter-Sectorial Vulnerability Assessment and Mapping Group, 1999; Boudreau, 2001).

Due to its location in southern Mozambique, Gaza Province in the Lower Limpopo, South Central Chibuto is located in the transitional zone because it belongs to both dry land semi-arid and the major river basin food systems and also shares some characteristics of the lowland plains because it is located only 60 kilometers away from the coast. In South Central Chibuto there are soils of high fertility, the alluvial soils of Limpopo and Changane river valleys in its Southern and South Western part (INIA, 1995; Barradas, 1966). The fertility is due to the accumulation of fine materials consisting mainly of montemorilonite clays and the fine texture of the material renders to soils a relatively high water-holding capacity and suitability for irrigation. In some parts, the soils are of very low permeability forming marshes; other parts have a high concentration of salts, which make them unsuitable for cropping but usable for pastures (Barradas, 1962; Muchangos, 1992).

In comparison to the southwestern half of the study area, the northern and northeastern half has a higher elevation; its soils are mainly sandy with low nutrients and low water-holding capacity. Because the soils are not suitable for irrigation by Limpopo River water, the agricultural production is rain-fed and mainly subsistence agriculture. Due to their low fertility the soils are extensively utilized and the most important suitable cash crop is groundnuts.

Despite these apparent biophysical advantages in the area, some constraints for food production also occur. There is Limitation for agricultural development of the region due to the water shortages caused by the recurrent droughts and the international character of the Limpopo River. The water of this drainage basin is also intensively used in South Africa and during years of below-normal rainfall, too little water is released downstream to Mozambique. As mentioned before, the Changane River water is also highly saline and is unsuitable for irrigation, unless technical measures are first taken to make the water less saline (Barradas, 1966; Portugal, 1974).

The two environments, the *serra* and the *bila* exhibit complementary characteristics and land-use suitability where strengths and weaknesses of both ecosystems are shared. During catastrophic floods, for example, people from the vale escape death by moving to safer places in the *serra***.** When the floods cease, the *bila* is fertilised and provides a good harvest, which is shared with the *serra* dwellers. Peasants of both environments usually cultivate both *serra* and *bila* lands (Christian Council of Mozambique, 1988). The complementarities between *serra* and *bila* is also observable in the field of building materials: good thatching grass, reeds and mud for walls and floor are plentiful in the *bila* while wooden parts such as poles and lathes are available in the *serra.* The soils of the *serra*, although poor in nutrients, are suitable for the growing of drought resistant crops such as cassava, beans and ground nuts. Indigenous dry resistant fruit trees are also abundant in the *serra* and are used for drought relief for people from the both environments. During severe drought, cattle from the *bila* landscape prone to floods can be driven to highland *serra* (Lifestores, 2002, 2003, 2004) (**Table. 2.3**).

The steep slopes of the ancient dunes give the *serra* a high potential for soil erosion. Because these soils have a weak structure and small nutrient reserves, when they are cultivated without the use of fertilisers, or other ways of returning nutrients removed with the plants at harvest time, the process of their exhaustion becomes rapid (Ombe, 1991).

2.3.4 The traditional strategies to cope with the constraints of the natural environment in South Central Chibuto

Having characterised the land-use suitability according to conventional western resource use, the analysis of the traditional methods of resource use in the region follows below. Since pre-colonial times, Tsonga farmers of South Central Chibuto have adopted strategies to cope with existing uncertainties related to dry land zones (Feliciano, 1998). These strategies persist in modified forms due to the need to adapt to changing circumstances, as will be shown in chapters 3 and 6 (Young, 1977; Feliciano, 1998). Some of these strategies could be observed during the PRA, in transect walks, informal interviews in the fields.

Table 2. 3: Land-use suitability of South Central Chibuto.

Serra	*Bila*
• Loose sandy soils • High infiltration rate • Not suitable for irrigation • Low fertility • Poor pastures • Relatively high biodiversity • Cassava, cowpeas and cashew trees the main crops • Prone to droughts and soil erosion	• Heavy clay soils • Low infiltration rate • Suitable for irrigation • High fertility • Good palatable pastures • Relatively low biodiversity • Maize and pumpkins are the main crops • Prone to droughts and floods

Some of the coping strategies are similar to those used elsewhere in Sub-Saharan Africa in savannah and forest environments (e.g., Scoones *et al*., 1996, Richards, 1983; Mortimore and Adams, 1999). The most important of these coping mechanisms include:

- Spreading the risk of crop failure by seeding several small plots located at different microclimates. In South Central Chibuto because of the difference in soil properties between the Limpopo floodplain and sandy ancient dunes *serra*, peasants cultivate both soils sowing different crops (Christian Council of Mozambique, 1988, PRA, 1999) (**Table 2. 3**).

- Anticipated seeding (*kussessa*), which means, seeding before the rain in order to maximize the use of moisture when the rain eventually comes (Feliciano, 1998).
- The preservation of trees in the farms is also a strategy, which peasants use to cope with the environmental constraints. The main function of the trees left has been discussed (Wilson, 1989; Scoones *et al.,* 1996). They mention the supply of fruits particularly by the *kanyu* trees, which are used for general consumption and the brewing of beer; and the provision of shadow where people can rest on hot days, especially during the harvest of groundnuts. The litter from the trees fertilizes the fields; they may minimize soil erosion and contribute to enhancing biodiversity by giving shelter for birds (Wilson, 1989). Trees can also be used to collect edible insects (Junod, 1913b; Feliciano, 1998).
- Cattle are also used as a coping resource during severe droughts, in exchange for cash to buy foodstuffs and are used for draught power as well as for producing manure to fertilize the fields (PRA, 1999).
- The farming of microhabitats such as planting under big trees (*Sclerocarnya birrea* and *Trichilia emetica*) of crops with high demand in nutrients and water (e.g. sweet potatoes, cabbage and, onions, mostly for sauces). These plants benefit from the nutrients released by the litter and the moderate temperatures and evaporation resulting from the shadows and tree canopies (My own observations during the field work, 1999, 2000).
- Creating social and spatial networks in different parts of a region with slightly different land-use capabilities where people could travel during periods of stress (Manghezi, 1983; Covane, 1996). This is a strategy for using the opportunities created by the spatial heterogeneity in the distribution of the rainfall and water holding capacity of the soils within a season, where there is a mosaic of wet and dry sites. People go to the wetter sites to ask for food and seeds (Manghezi, 1983; Covane, 1996, Rafael Cossa, pers. comm., 1999).

Summary

It is evident that South Central Chibuto provides a rich, natural resource base for the inhabitants of the area. The region exhibits almost all the features of African savannah environments; the combination of highlands (serra) and low-lying lands (bila) with complementary resources. This region allows for both dry-land agriculture and irrigation. Differences in geology between serra and bila provide differences in land use suitability of both environments. This is due to differences in soil texture, water-holding capacity of the soils and vegetation diversity.

The combination of relief and climate, however, make the region prone to floods and droughts as well as soil erosion and sedimentation. These natural phenomena are important drivers of land-use change in the area. These phenomena also make the environment uncertain for many who derive a livelihood from the area. To cope with the environmental constraints such as droughts and floods, local communities have therefore adopted a series of strategies in their lifestyles and in the cultivation practices as well as settlement patterns. Some of these strategies will be shown in more detail in chapters that follow.

Environmental change and land-use change are not only the result of natural phenomena and the constraints these may place on resource use. Various socio-economic factors also shape and influence land-use. In the next chapter a description of the most important aspects of the colonial economy and land-use will be undertaken and the ways of assessing and using the existing natural base will be shown.