CHIMANIMANI MANAGEMENT PLAN

APPENDIX 2

AGRO ECOLOGICAL REGIONS AND CLIMATE OF CHIMANIMANI

1 Agro Ecological Regions

1.1 Basis for assessing agricultural potential

The agro-ecological zoning is based on the COBA of the Búzi River Basin study carried out between 1970 and 1981[1]. We have had access to the GTZ MAARP documents produced in the early 1990s. The introduction below is based on the GTZ MARRP Baseline study for the Sussundenga District.[2]

The description of the agro-ecological zones has been modified to fit the area of the ChNR and amended where there were areas that were not visited in the initial studies.

> "Realisation of the [ecological and] agricultural potential ChNR depends upon the interaction of the natural resources, infrastructural development, markets and social infrastructure and services. Negative aspects to each or any of these factors may seriously diminish the agricultural and development potential of an area.
>
> Agro-ecological zoning is one method of determining and describing the agricultural potential of an area but it is primarily based on natural edaphic characteristics. It does not necessarily take into account features such as land capability or socio-economic considerations. While a particular area may, for example, be suitable for specific agricultural practises from a climatic point of view it may be equally unsuitable because of limitations imposed by the soil and accessibility. To a large extent these factors are not mutually exclusive and farming systems have developed which are based on a wide variety of local circumstances: For instance, where the available resources in an area would be limiting to the production of a particular crop on a large-scale commercial basis, they may not be so limiting for production of the same crop on a small-scale family farm basis. An example might be the production of coffee bananas or tea in small isolated pockets within mountainous areas.
>
> The agro-ecological zoning discussed below and presented in Figure AC 1 has been modified from a number of previous

[1] COBA-PROFABRIL (1970) of the Zona "K" area of the province, which included that part of the district above the escarpment, and a bio-climatic classification of the district completed by COBA (1981)

[2] GTZ, MAARP, Baselinre Study for the Sussundenga District – Manica Province , January 1994.

classifications. These include comprehensive natural resource surveys undertaken by COBA-PROFABRIL (1970) of the Zona "K" area of the province, which included that part of the district above the escarpment, and a bio-climatic classification of the district completed by COBA (1981) as part of a study of the Buzi river catchment area. These studies, and others, have been used as the basis for undertaking an agro-ecological classification of the whole of Manica province for the current IRDSP studies (MARRP, 1994 - in preparation).

The Zona "K" study also delineated areas according to land use potential and this information is available for that part of Sussundenga district which lies above the main escarpment dividing the north from the south. The delineation is based on the arable potential of the land which has been classified into arable, marginally arable and non-arable land. Suggested land uses are provided. Knowledge of the arable nature of the land is important because, while the bio-climatic or agro-ecological conditions of a certain area might be favourable for the production of particular crops, based on the general natural features of the area, local soil, topographic and drainage conditions may render specific areas non-arable. Figure 3.8 shows those areas included in the Zona "K" study which were found to be arable or marginally arable and where crop production could be recommended."

1.2 Description of agro-ecological zones

The district has been classified into four major agro-ecological zones. These are:

Zone I	High rainfall mountainous area
Zone II	High rainfall plains
Zone III	Escarpment and steep Mussapa valley
Zone IV	Moderate to low rainfall areas

Each of the major zones, except the escarpment zone (Zone III) has been further subdivided into sub-zones. These share the same basic characteristics as the major zone which they comprise but are differentiated according to significant local characteristics, such as soil or catenal position, factors which have a large influence on land use and farming systems. The agro-ecological classification is shown in the Map that follows.

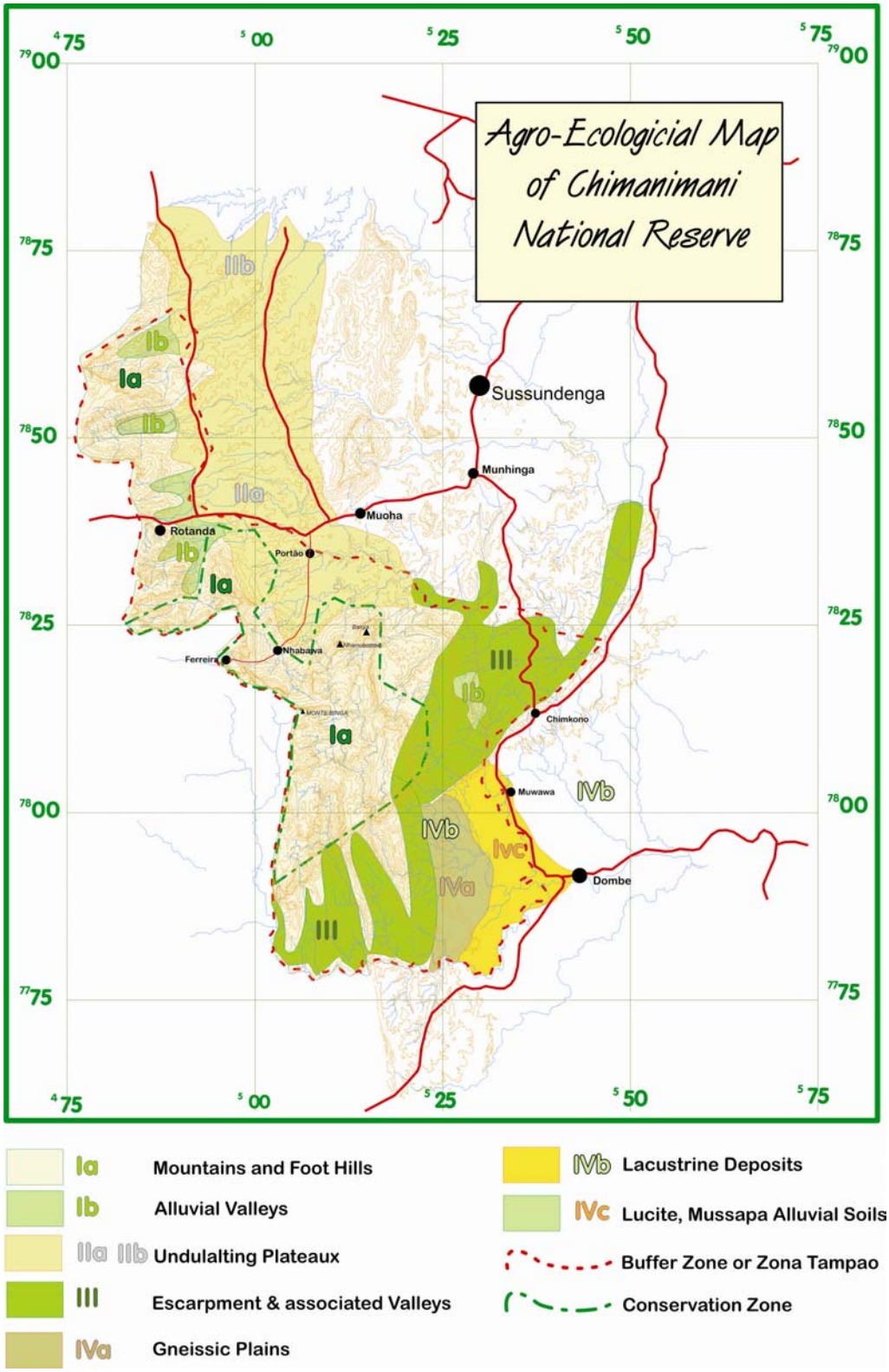

Agro-Ecologicial Map of Chimanimani National Reserve
Sussundenga
Munhinga
Muoha
Rotanda
Portão
Nhabaluva
Ferreira
Chimkono
Muwawa
Dombe
IIb
Ib
Ia
IIa
III
IVb
IVc
IVa
Ia Mountains and Foot Hills
Ib Alluvial Valleys
IIa IIb Undulalting Plateaux
III Escarpment & associated Valleys
IVa Gneissic Plains
IVb Lacustrine Deposits
IVc Lucite, Mussapa Alluvial Soils
Buffer Zone or Zona Tampao
Conservation Zone

Table 1. Agricultural Potential and Agro-Ecological Zones in Chimanimani

Zone	Agricultural potential	Locations
Ia	Low	Mountains / Conservation Zone
IIb	High	Rotanda, Messambudzi Bonde, Mahate
IIa	Very high	Muoha Area
IIb	Low	Mupandeia, Chicamba
III	Medium	Zomba, Mahate, Mpunga
IVa	Medium	Zomba, Muoco
IVb	Very low	Zomba , Muoco, Darue
IVc	High	Lucite, Muvumodzi, Muoco, Dombe
IVd	Medium	Southern Valleys

1.3 Zone I - High rainfall mountainous areas

This zone includes the high mountain ranges along the western border with Zimbabwe, the secondary mountain ranges in the north and south west of the district and associated alluvial valleys found along the larger rivers at the foothills of the mountains. The mountains arise from the adjoining plateaux at about 700 m altitude and rise to peaks of up to 2 400 m.

Rainfall increases rapidly with the rise in altitude from about 1 200 mm per annum along the south east facing foot hills to well over 2 000 mm at higher altitudes. Temperatures are generally mild to very cold with heavy frosts in the winter month.

Soils developed from basic rocks on moderate slopes tend to be stable, deep, highly weathered, permeable, red sandy clays to clays. They are moderately fertile. Where the soils have developed from acid rocks (as is most common in these mountain ranges) they tend to be sandy loams with a low to very low fertility status. Though many of the soils in the Chimanimani Mountains are derived from schizts and shales

On steep and rocky slopes the soils tend to be shallow to skeletal, normally overlying shallow gravel and rubble layers. Soil textures vary with parent material from sandy loams to loamy sands. Fertility is usually low to very low.

The lower mountain slopes support *miombo* woodland. The climatic conditions would support sub-tropical forest communities but due to past disturbance these are now confined to relic forest communities on very steep slopes and steep, deeply incised drainage lines - the so called gallery forests.

The more even mountain slopes have been subject to extensive past cultivation cycles and now support secondary open woodland and shrub and scattered tree communities, characterised by dwarf or stunted *Parinari curatellifolia — muchacata*. There are also extensive areas of montane grasslands on the high even sloping mountain crests and plateaus. These grasslands are fire maintained.

Numerous rivers and mountain streams are a major feature of this zone and generally ensure plentiful supplies of water for domestic and agricultural purposes.

Two sub-zones of Zone I have been identified differentiated primarily on the basis of physical position and the subsequent land use opportunities.

1.4 Sub-zone Ia - Mountains and foothills

This sub-zone includes the high mountains of the western border. The mountains are characterised by very steep slopes and deeply incised drainage lines. Rainfall is high and temperatures cool to warm. The higher the rainfall and the cooler the temperatures the less suitable the area becomes, from a climatic point of view, for traditional crops such as maize, although many perennial crops, temperate fruit trees and exotic tree species do well in this climate. The skeletal nature and low to moderate fertility status of most of the mountain ranges, together with climatic constraints, give them a generally low agricultural potential. Exceptions occur on small mountain plateaus near the upper reaches of the Bonde River and south of Rotanda where potatoes were once grown on a commercial basis.

Commercial plantations have already been established along the mountain ranges north and south of Rotanda.

Prospects also exist for the establishment of tea, coffee and fruit trees where slope, aspect and altitude are favourable. The more even slopes of the secondary mountain ranges may well prove to be ideal for these crops.

While the steep mountain slopes, particularly at high altitude, are not extensively settled numerous isolated settlements have been established at lower to medium altitudes in the many small valleys in the Chimanimani mountain range. This is probably due to the presence of very small pockets of fertile alluvial soils in these locations. The aerial survey undertaken as part of this study confirmed the presence of settlements in these areas.

1.5 Sub-zone Ib - Alluvial valleys

This only covers small areas in the valleys of the Bonde, Nhaminguene, Munhinga, Rotanda, Mussapa Pequena. A small zone was also identified in the upper valley of the Mutucutu in Mahate but this could be more in the nature of a wetland. It has been differentiated because of the existence of alluvial deposits which have developed along the even, sometimes broad, valley floors of the main perennial rivers and streams as they emerge from the mountains. They are usually intensively cultivated with cultivation extending to the adjacent pediment and mountain slopes. Numerous small gravity irrigation schemes have been developed by family sector farmers, especially around Rotanda. Water is led from the streams and distributed over irrigated lands by earth furrows. These schemes have been developed by local farmers from within their own resources and in the past they have been able to establish stable market outlets for the high valued horticultural crops produced.

The main farming sector using these valleys is the family sector although commercial farming activities have taken place in the past. Commercial exotic forests also extend into some of these areas from the higher mountain slopes.

The main crop grown is maize but significant areas are planted to wheat and some barley which is irrigated in winter. Production of garlic for sale has become an important feature of the farming system in this area. Vegetables and other crops, such as bananas and sugarcane, are extensively grown along the banks of the numerous streams or in the stream beds themselves (*baixas* or *dimba* gardens). These *baixas* are important for the local population, especially during the winter months.

Livestock, particularly cattle, are an important feature of the farming systems of this sub-zone, numbers are now increasing after the war and subsequent drought.

The major area where settlement has occurred include the valleys of the Bonde, Munhinga, Messambuzi, Rotanda and Mussapa Pequena rivers in the north and the middle valleys of the Mussapa Grande and Mucutuco rivers towards the south of the district.

Zone II - High rainfall plains

The western boundary of this zone is demarcated by the high mountain ranges along the Zimbabwe-Mozambique border and the southern and south eastern boundary by the deeply incised Mussapa river and the escarpment zone. Overall there is an even fall in altitude from 700 m along the western mountain ranges to 500 m along the top of the escarpment zone. The topography is gently undulating. . Isolated inselbergs occur and the peneplane zone is divided by the Chicamba range.

Average annual rainfall is 1 000 mm and is suitable for growing a wide range of annual and perennial crops. The combination of soils and vegetation indicates that this peneplane lies within an overall high rainfall zone.

Highly weathered soils occur with low cation exchange capacities and base status. Brachystegia spiciformis forms the dominant species within the semi-deciduous miombo woodland on the plateau with moist semi-deciduous forest species within the dense woodland on the areas of more defined topography along the margins of the escarpment zone.

Perennial surface water is confined to the larger rivers and there is limited groundwater occurrence, with exceptions in fault zones and alluvial valleys. Much of the area is, however, topographically suited to the construction of small farm dams.

Two sub-zones have been identified, based primarily on limitations for land use imposed by topography and drainage.

1.6 Sub-zone IIa — Undulating Plateaux Even

This zone covers much of the Sussundenga District but not so much of the ChNR. It is found below the foot hills of the mountain ranges mainly in the Rotanda and Muoha areas,

The Topography is gently undulating with broad ridges. The soils are mainly deep to moderately deep, well drained, red sandy clays to clays. The high proportion of arable land decreases towards the south and the west as topography becomes more broken.

Vegetation comprises well grown semi-deciduous miombo woodland with *Brachystegia spiciformis* and boehmii and *Julbernardia globiflora* being the dominant species. However, due to considerable past cultivation the vegetation is now predominantly secondary. Large parts of the plains were at one time developed for commercial agriculture. Though this was outside the ChNR in the north east around Sussundenga sede.

The sub-zone is today characterised by two main farming sectors. A limited amount of commercially oriented farming activity takes place around Muoha and Rotanda mainly ranching. While maize production is the major activity it includes irrigated farming and livestock production. Mechanised draught power is usually used.

The family farming sector predominates. The farming system is based on the production of maize, supported by small grains, for subsistence and while animal draught is becoming more widely used hand methods are still very common. Winter vegetables, green maize, bananas, sugarcane and,

sometimes, rice are produced extensively in *baixas*. Local population pressure has, however, meant that access to baixas is becoming more problematic for an increasing number of people.

Cattle have not been a major part of the family sector farming systems in this sub-zone but are becoming increasingly more important as the need for draught power increases.

1.7 Sub-zone II b - Hydromorphic, Sandy Plateau

Flat, hydromorphic plains occur to the south of Lake Chicamba. They are characterised by overall flattish to undulating topography, broad drainage lines with extensive poorly drained grey sandy soil margins.

A layer of laterite exists about a metre below the sandy soil surface, which has the effect of increasing the erosion hazard when these soils are cultivated.

Uplands have deep to moderately deep, coarse grained dark brown to grey sands to loamy sands. Fertility is low and drainage is often restricted at depth. There are, however, small isolated pockets of marginally arable land. Vegetation comprises slow growing early deciduous miombo woodland.

Poor agricultural potential has resulted in this area being lightly settled in the past except where localised settlement has occurred on better drained soils and along the major rivers.

Overall, sub-zone IIb is of low agricultural potential. However, with the use of fertiliser, similar sandy soils found north of Lake Chicamba in Manica district, have proved suitable for the commercial production of Virginia tobacco. Attempts at establishing Eucalyptus plantations on similar soils in Manica district have also proved successful.

1.8 Zone III — Escarpment & Associated Valleys

This zone the escarpment from the high rainfall plains (Zone II) to the southern low altitude plain (Zone IV), a fall in altitude of 200 m to 300 m over a distance of 10 km to 15 km, with very steep secondary drainage lines and ridges. The deeply incised valley of the Mussapa River is included. Moist Lowland Evergreen Forest covers, or covered, much of this area including Mpunga, Zomba, Mahate and Maronga

However, small isolated areas of arable soils and baixas do occur and these have been intensively cultivated in the past due to the accumulation of deeper and more fertile soils. These have become an important means of support for

the local population. Current land pressure around Nhaurombe has caused more of the steeper slopes of the escarpment hills to be cultivated.

1.9 Zone IV – The Lowland Plains

Zone IV comprises a series of broad parallel, north east to south west oriented, generally featureless, level plains at altitudes of 100 - 300 m. It consists of the gneissic plain situated immediately below the escarpment zone and extending to the Sitautonga Mountains. The basalt plain lies to the south east of the gneissic plain and outside the ChNR..

Average rainfall in the zone ranges from 1 000 mm to 1 200 mm. The low altitude and consequent high temperatures reduce the effectiveness of the rainfall. Shorter growing season and more variable rainfall patterns can be expected compared to the higher, more assured, rainfall patterns of the escarpment and plateaux.

Apart from the major rivers (Revue, Buzi, Lucite and Mussapa) permanent surface water is scarce. This has led most of the population to be concentrated near these rivers.

Three zones exist in the ChNR, differentiated primarily on soil characteristics as determined by the underlying geology.

These characteristics are major factors influencing agricultural potential.

1.10 Sub-zone IVa - General gneissic plains

This zone is mainly encountered in Zomba and Muoco where it occurs as a gneissic plain astride the western bank of the Mussapa river, from Darue to the Sitautonga mountains.

The soils developed from the underlying gneissic parent material have not been differentiated but are expected to be dark brown sandy loams to sandy clay loams of variable depth and moderate to low fertility. Vegetation, in the main, consists of either deciduous *miombo* (savannah woodland), or more well-developed *Erythrophleum Burkea Brachystegia* woodland with the main species being *Brachystegia spiciformis*, *Erythrophleum suaveolens*, *Burkea africana*, ands *Millettia stulhmanii* woodland.

Underground water resources are reasonable with the occurrence of aquifers of limited productivity and which may be exploited locally by digging wells or, more generally, by sinking common boreholes.

The generally lower fertility of the soils of this sub-zone compared to those within the rest of the zone, coupled with the moderate rainfall, means that agricultural potential is low, except in the western segment of the sub-zone (around Muoco), where rainfall is higher. As a result, the area has been lightly settled in the past. This, however, may well have been due to the availability of more productive areas nearby rather than to total unsuitability of the sub-zone for agriculture.

An important feature of the land use of this sub-zone has been the commercial extraction of indigenous hardwoods.

1.11 Zone IVb - Lacustrine Deposits

This area mostly lies outside the ChNR to the east of the Mussapa River. Extensive lacustrine deposits onto the underlying gneissic geological formation extend beyond the alluvial deposits north and south of the Lucite River. The very flat topography with extensive seasonally waterlogged to swampy areas and poorly drained sandy soils on the intervening areas gives an area of overall low agricultural potential. These areas are used by local people for fishing, especially after heavy rains. They exist in the Muoco and Zomba areas but not in sufficient quantity to be mapped.

1.12 Sub-zone IVc - Lucite River Alluvial Deposits

Extensive alluvial deposits along the Lucite River and its main tributaries, the Mussapa and the Mevumodzi, extend north and south of the Lucite River, centred on Dombe. This sub-zone, which is the most heavily settled and utilised in the ChNR.

It contains some of the most fertile soils in the ChNR. The farming system is based on subsistence farming by the family sector with maize being the most important food crop, although more drought resistant small grains are an important component of the cropping programme. Vegetables, green maize, sesame, sweet bananas, plantain bananas a, sugarcane and rice are grown in drainage lines and on terraces close to the major rivers.

Past attempts at encouraging the production of cotton (by both commercial and family sector farmers) have made this crop a very important feature of recent farming systems. There was a major cotton ginnery at Mutaratara lower down the Lucite on the road to Goonda.

Livestock have traditionally been an important part of the farming system. However, the presence of tsetse fly has sometimes been a constraint to cattle

production and today, primarily due to the effects of war and drought, there are few cattle in the area. This is a major constraint to increasing production since all cultivation has to be done by hand.

The area offers tremendous scope for agriculture and development. A wide variety of crops can be grown and attempts at introducing many other crops, such as cashew, have proved reasonably successful. Irrigation potential is enormous with over 25000 ha of irrigable land, which could be commanded by future dams constructed on the major rivers, being identified on the river alluvium (COBA, 1981).

Development of the area is highly dependant on the development of suitable domestic water supplies, other than those currently supplied by the major rivers.

2 Climate and Rainfall[3]

There is a serious lack of climatic data covering Chimanimani area in sufficient detail to enable accurate ecological, agricultural and development planning at the local level. Although climatic data has been collected at certain locations in the Sussundenga District (for usually short and discontinuous periods) they have generally only been collated and analysed at the national or provincial levels. Even so, there appears to be considerable inconsistency among the various sources of information presently available.

The only attempts to analyse data covering the district at the local level include the Zona 'K' land use studies (COBA-PROFABRIL, 1970) and the hydrological study of the Búzi river basin (COBA, 1981).

Further recent information and analysis of the climate of Mozambique is provided by Reddy (1984 and 1986). These, however, are presented on a country-wide basis, at a large scale, and do not account for local variations that would be important for planning at the district level.

However, these sources have been assessed to provide a generalised description of the climate of Sussundenga District.

The climate Chimanimani is basically humid temperate with a drier winter. The western parts, especially in the high mountains, are generally semi-humid while the south and east has a wet humid to semi humid climate.

2.1 Rainfall

Rainfall in Sussundenga district is generally derived from low pressure areas moving north east up the Moçambique Channel and north westerly inland. The moisture laded winds associated with these low pressure areas cause orographic rainfall when they come into contact with the escarpments and mountains of the Chimanimani. Some of this rainfall occurs in the so-called dry season and can be quite heavy on occasions.

However, in the summer months much of the heavy rainfall is associated with the Inter Tropical Convergence Zone, which moves southwards across the equator as far as south central Moçambique. Much of this rainfall consists of heavy thunderstorms, and the movement of moist air in the lower levels of

[3] This section draws heavily on the MAARP/GTZ *Baseline Report for Sussundenga* January 1994 in which one of the authors (JHB) was involved.

the atmosphere into the areas, as described in the previous paragraph will intensify the convergence and rainfall.

Associated with the Inter Tropical Convergence Zone tropical cyclones often form in the Indian Ocean and move towards Africa and Madagascar.

2.2 Cyclones

These cyclones often cross the Mozambican cast and may move inland towards the Chimanimani Mountains, following the wetland along the Búzi and Revue River basins. They may be stationary at times and their effects may last up to five days and more. Inland, over Sussundenga district, the cyclone effect can be marked by severe rain storms with strong, gale-force winds, causing serious flooding, destruction and loss of life and property, especially in the low-lying alluvial area in Zomba and Muoco.

The total annual rainfall increases from the flat plain areas in the south east to the central peneplane. Amounts increase from about 1000 mm to well over 1400 mm in the low altitude plain to 1000 mm to 1500 mm in the central peneplane and lower escarpments. There is also a sharp increase in the amount of rainfall received along the mountain ranges from 1200 mm along the foothills to over 2000 mm with the rise in elevation up the mountain slopes. Over 2000 mm have been recorded at higher elevations in the western mountain ranges. The coefficient of variation is between 25% and 30%.

Table 2 shows rainfall data for selected stations, with available records, within the district and for three stations outside the district, but whose climatic characteristics are similar to those within the district. Figure 1 shows the distribution of mean annual rainfall over the district.

MEAN MONTHLY AND ANNUAL RAINFALL FOR LOCATIONS IN OR ADJACENT TO THE CHIMANIMANI NATIONAL RESERVE.

Month	Chimoio*[1]	Manica*[1]	Rotanda[2]	Mavita[3]	Gogoi[4]
January	226,9	229,6			
February	200,2	181,7			
March	157,9	135,5			
April	51,6	48,8			
May	25,8	18,9			
June	22,1	12,8			
July	13,9	8,9	7,8		
August	21,4	12,7			
September	15,3	15,5			
October	31,9	33,9			
November	113,8	103,2			
December	186,6	210,1	285,8		
Annual	1067,3	1011,7	1289,0	1041,5	1090,0

Table ex MAARP Baseline Report for Sussundenga January 1994

NOTE * Indicates Outside Sussundenga District
Source 1 = MARRP, (1992b)
2 = Reddy 1984
3 = Seabre, 1961
4 = MARRP, (1993b)

From Table 2 it can be seen that over 85% of the rain falls in summer during the period November to March. However, this rainy season tends to start somewhat later (December) further south. It should be noted that some precipitation does occur during the winter months as noted above

Rainy season length and length of growing season also increase from about 150 days in the south west to around 180 days in the centre of the district. The season length can theoretically exceed 240 days, at higher altitudes in the high mountains along the western border.

The annual frequency and duration of mid season dry spells also increases towards the south east and the effectiveness of rainfall at the lower altitudes is markedly reduced by higher ambient temperatures.

While the Chimanimani Mountain ranges have higher rainfall and longer growing seasons their potential for crop production is limited by steep slopes and altitude. The central area and most of the southern part of the district receive sufficient rainfall to allow a wide variety of crops to be grown.

2.3 Temperature

Moderately warm temperatures, averaging approximately 20°C during the growing season, occur throughout much of the Chimanimani area, save on the very high areas over 1800 m. In the central area of Sussundenga the highest mean monthly temperature occurs in October (30°C), while the coldest month is July with a mean temperature of 11.3°C.

Temperatures in the Chimanimani ranges are somewhat cooler with mean monthly minimum temperatures dropping to less than 8°C in July and mean annual temperatures of less than 18°C being experienced.

Mean monthly temperatures are more constant throughout the year in the lower to medium altitude areas than in the high Chimanimani Mountains where greater variations of mean monthly temperature are encountered.

Frost is commonly encountered on the nigh mountains and plateaux over 1880 m as well as in some low lying areas, especially those areas not open to the south east prevailing winds. Elsewhere frost is not a frequent occurrence.

Overall, the temperature regime, except at very high altitudes, is suitable for the production of most tropical crops and trees.

2.4 Sunshine

Mean daily sunshine duration is significantly higher in the lower to medium altitude areas and decreases significantly in the mountains.

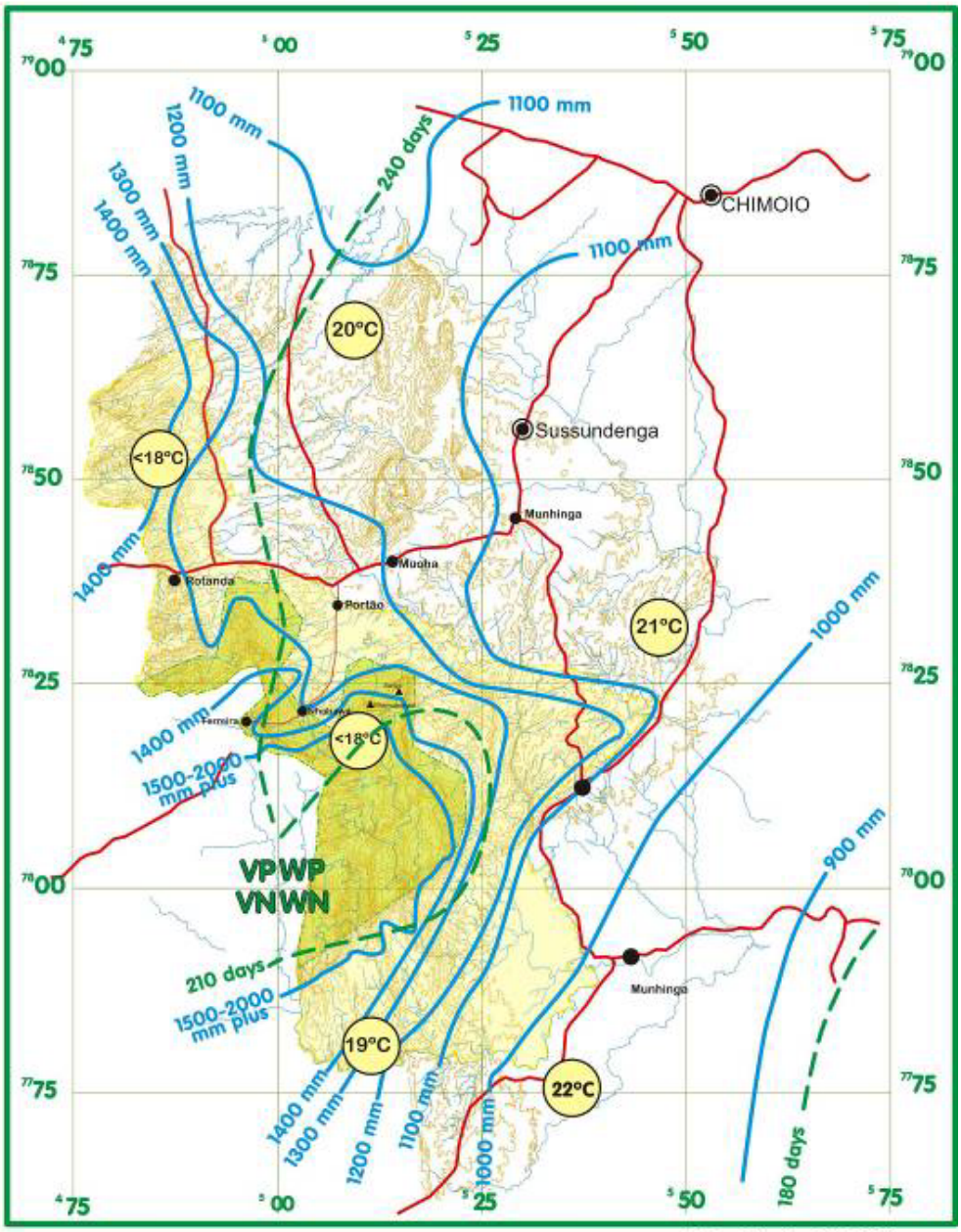
2.5 Relative humidity

Relative humidity averages about 70% and the district may be described as humid to sub-humid. Humidity ranges from a low of approximately 63% in October to 77% in March.

2.6 Evaporation and Evapotranspiration

Crop evapotranspiration is reduced with rising altitude and cooler ambient temperatures. Evaporation generally exceeds rainfall from April to November. Annual evapotranspiration totals range from 1500 mm in the low altitude plain to 1300 mm in the central peneplane to 1 000 to 1200 mm in the mountains.

Mean Average Rainfall and Temperature Chimanimani



22°C Mean annual temperature

Isohytes of mean annual growing period (days)

Isohytes of mean annual rainfall

Core Zome - Zona de Consevaçaõ

Buffer Zone - Zona Tampão

Figure 1. Average rainfall and mean temperatures in Chimanimani

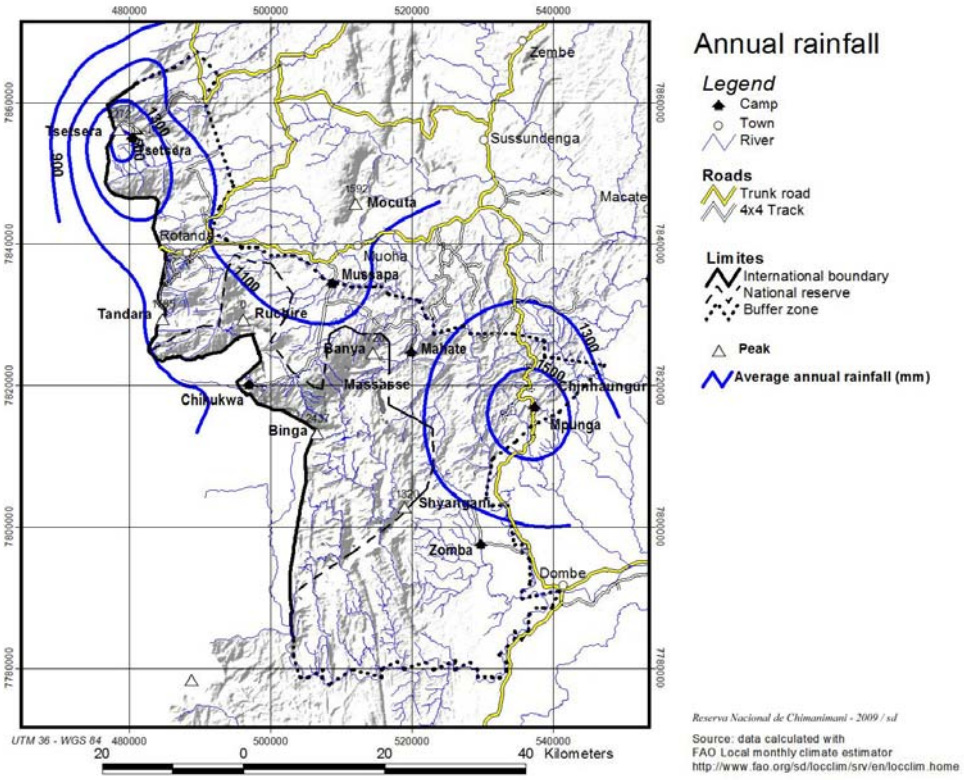


Figure 2. Annual rainfall distribution

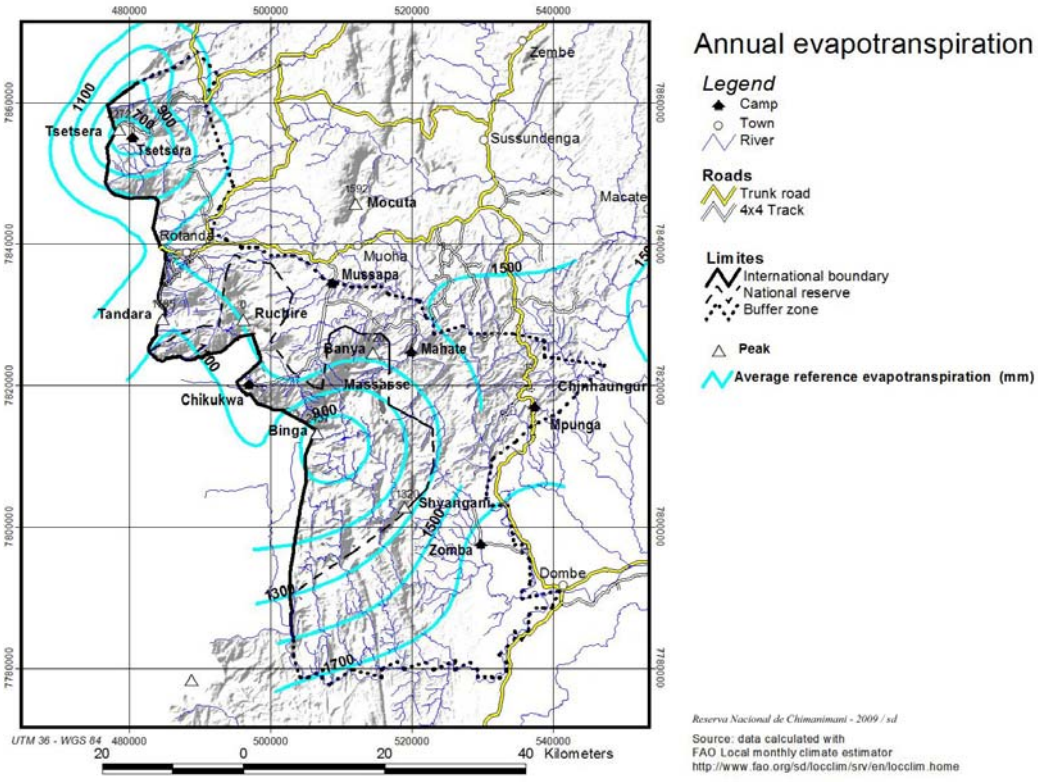


Figure 3. Annual evapotranspiration

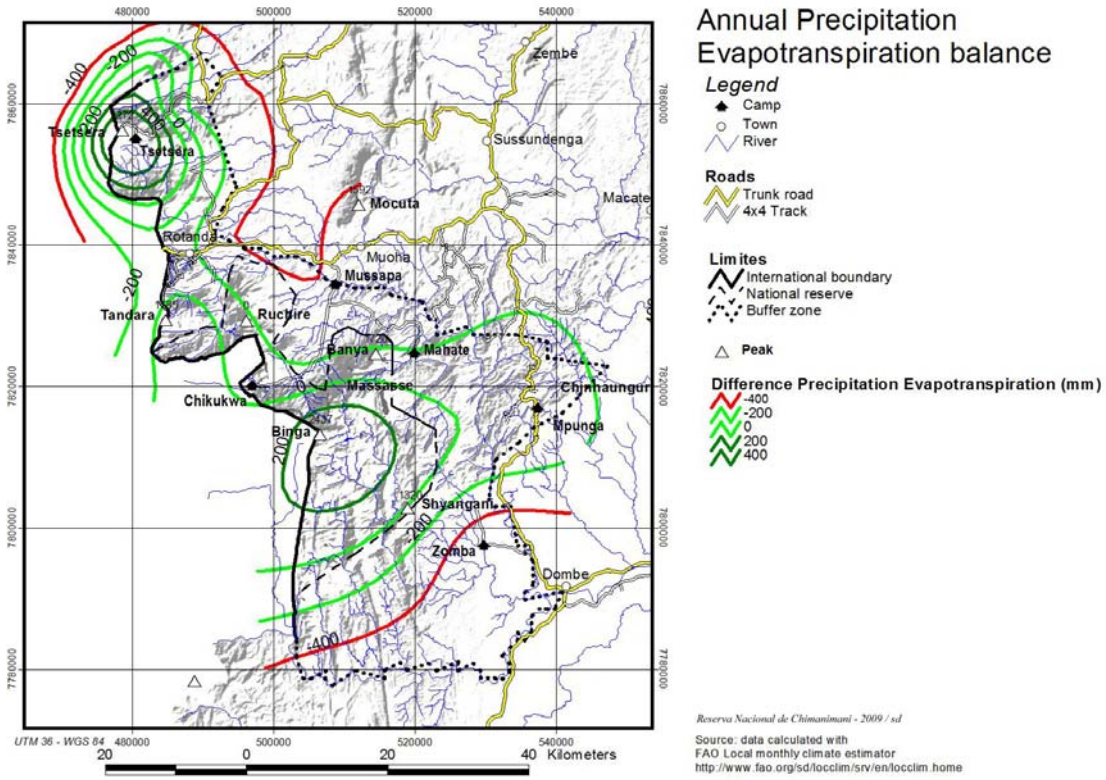


Figure 4. Annual precipitation/evapotranspiration balance

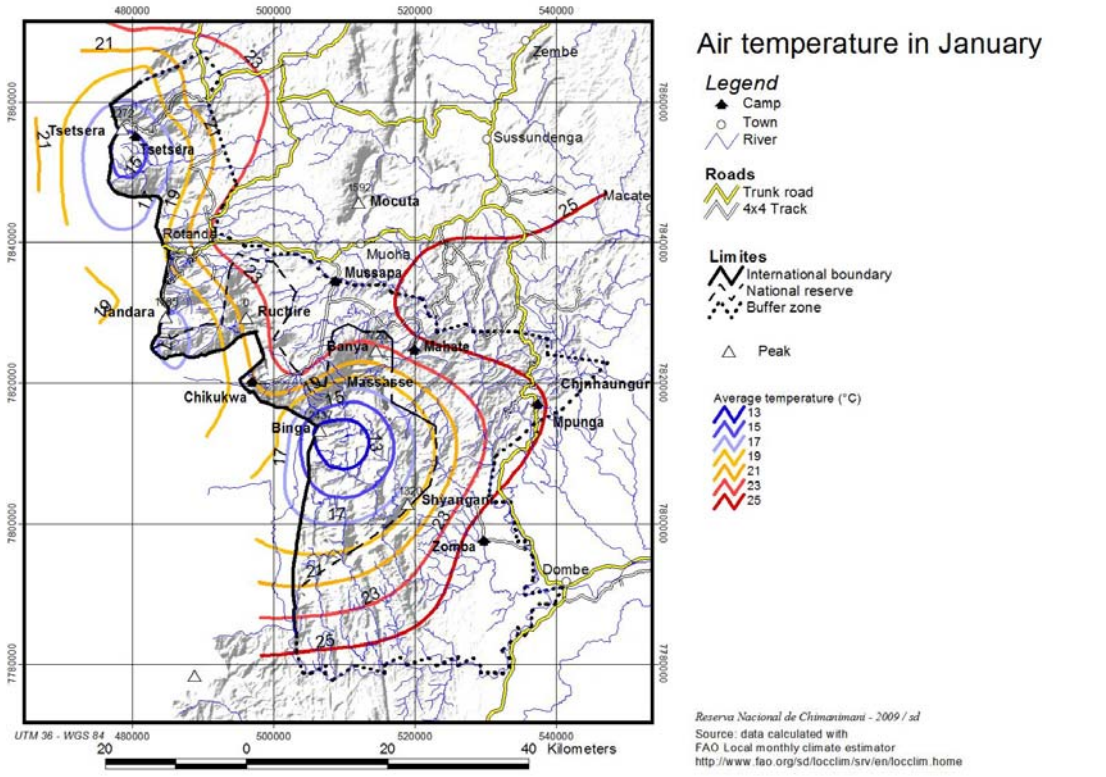


Figure 5. Air temperature in January

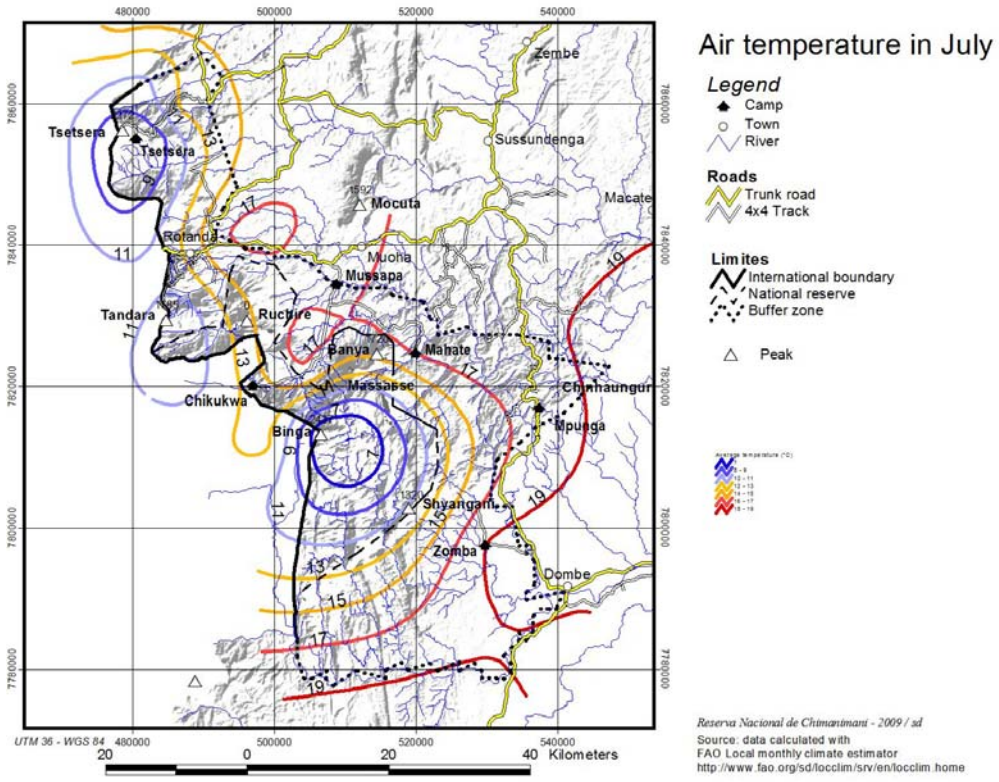


Figure 6. Air temperature in July