PART II

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CHAPTER 4 - CLIMATE

INTRODUCTION

Central Mocambique is situated 19° south of the equator on the east coast of Africa at about 34° east longitude, and lies due west of Madagascar Island, from which it is separated by a 400 to 850 km wide strait, the Mocambique Channel. Madagascar Island is about 1600 km in length and with a high mountain spine along its east coast it effectively blocks off the direct influences of the Indian Ocean. Almost the full length of Mocambique thus lies in the lee or shadow of Madagascar which causes far-reaching climatic implications.

Apart from the local and regional climatic data personally collected, or recorded by stations, these notes on climatic processes are obtained mostly from Thompson (1965), Tyson (1969) and Griffiths (1972). Due to its geographical position, Central Mocambique, though lying directly in the path of the southeast trade wind belt, is close to the southern limits reached by the northeast monsoon in summer. The major determinants of climate in this region are therefore the zonal wind systems of both the Southern and Northern Hemispheres. The southeast trades are air masses blowing from the semi-permanent tropical high pressure centres of the South Indian Ocean. The monsoon system is an alternating macroscale air stream flow blowing in opposite directions in summer and winter. During the boreal winter, some of the air streams emanating from the Asian Continent traverse the northwestern Indian Ocean to the East Coast of Africa and pass south of the equator to Mocambique and Madagascar, where they contribute to precipitation processes or drying, depending on their trajectory. During the boreal summer the air streams are reversed. The southwest monsoon, of recurved Southern Hemisphere southeast trades, blows towards the Asian landmass from the equator and forms the major air mass contribution to Arabia, India and Burma at this time (see Fig 4.5).

In midsummer, tropical cyclones (hurricanes) move from east to west and are mostly intercepted by Madagascar. As the hurricane tracks recurve southwards, chiefly along the west coast of Madagascar or in mid-channel, drought conditions occur in Mocambique over the months of their greatest frequency (Fig 4.6 and pers. data). Conversely a hurricane track which approaches or crosses the Mocambique Coast causes floods.

Interrupting the interplay between two major zonal air flows, are invasions of temperate depressions moving from west to east and up the southern coast. In addition
FIG 4.1 OROGRAPHIC & MARITIME CONTROL OF RAINFALL REGIMES IN THE GORONGOSA - CHERINGOMA REGION.
to these polar low pressure centres are equatorial low pressure troughs formed by recurved South Atlantic Anticyclone air, known as Congo air. This low pressure trough system penetrates southwards during the austral summer over the interior plateau of the subcontinent.

The tropical anticyclone centres do not occur vertically from ground level upward but are inclined westward with increasing height. Thus, at a height of 6 km the east coast cell is centred over South West Africa, this displacement causing an opposing flow of easterlies at the surface and of westerlies at 6 km. The persistence of the upper westerly geostrophic air stream is made conspicuous by the northeasterly anvil spread of cumulonimbus which develop on Gorongosa Mountain (Fig. 4.9). Beneath these major wind systems are tertiary surface, diurnal air reversals of sea and land breeze circulations between the Eastern Great Escarpment and the Mocambique Channel, which are probably linked with similar centripetal flow from the western slopes of Madagascar. The nocturnal katabatic land breeze component is strongly developed throughout the year whenever clear skies occur. The sea breeze, or anabatic component, is due to deepening of the trade wind groundwards from above the cold air drainage flow in the mornings as the surface of the land heats up.

The interaction of the above air masses and their streamlines, produce a moving pattern of interacting anticyclone and cyclone centres which are responsible for either precipitation or alternatively, drought.

SEASONAL CLIMATIC CONTROLS

Summer

In the southern summer the major determinants of climate in Central Mozambique are two anticyclone systems and two low pressure areas. The high pressure cells are those over the Asian landmass, and the other is situated midway between Africa and Australia and is known as the South Indian Ocean high. A low pressure cell (heat low) occurs over the interior of the sub-continent, or is associated with the Zambeze Valley. A persistent low pressure cell occurs over the Zambeze Delta, or seaward of it, extending at times from Beira to Pebane (as plotted on synoptic charts).

Part of the Asian air masses flowing south, as the northeast monsoon, maintain an oceanic trajectory and are thus moist. Another branch curves over the East Africa interior via Somalia and the Rift Valley heat lows to Central Mozambique, where they are very dry winds.

The northeast monsoon reaches its southern geographical limit in midsummer at about 16 to 17°S, and the southeast trades are then confined mostly south of the 18° latitude. The interface between these two air masses along an eastwest trough is generally regarded as being the southern position of the Intertropical Convergence Zone (ITCZ).

Winter

In the winter dry season the ITCZ moves north, with a northward shift in the South Indian Ocean anticyclone, resulting in a deepening and freshening southeast trade wind as its air masses are recurved past the equator to form the southwest monsoon.

CLIMATIC CLASSIFICATION

The sector of Central Mozambique forming the study area all falls within Köppen's Tropical Savanna Climate (Aw), with the exception of a small island of Warm Temperate Rainy Climate (Cw) formed by Gorongosa Mountain (Faria & Goncalves 1968). Köppen's Steppe Climate (BS) is noted by these authors on either side of the study area in the Zambeze Valley and from the Save Valley southwards (Gazaland). However, analysis of Rift Valley data recorded at Chitengo since the publication of the above authors, shows that the Urema Trough experiences a BS climate in six years out of eight.

De Martonne's Index of Aridity (P/ (T+10)) separates the four main physiographic regions of the Gorongosa—Cheringoma transect into: (1) Mountain (90%), (2) Midlands (41%), Rift Valley (23%), Coast Plateau (30%), and land-sea junction (41%). The high Aridity Index for the Urema Trough is of the same order as those in the Zambeze Valley and Gazaland areas.

CLIMATIC PARAMETERS

As the various climatic components are summarized in diagrammatic form the relevant data and their seasonal relationships can be read from these. The long term climatic features of the physiographic units in the Gorongosa—Cheringoma transect are depicted by comparative (Gaussen 1955) climatograms in Fig.4.1.
RADIATION
1 potential values with constant clear sky
2 actual values

CLOUD COVER
mean of 09h + 15h % occurrence
- 80 > 5/10 cover

INSOLATION

SMOKE HAZE

DALENGTH (hours)

BEIRA

1 Ab. Max.
2 Mean Max.
3 Annual Mean
4 Mean Monthly
5 Mean Min.
6 Abs. Min.

INSOLATION

CLOUD COVER

BEIRA

SA LISBU RY

FIG 4.2
RADIATION & TEMPERATURE

Contrasting regimes of the East Coast (BEIRA) & the Interior Continental Plateau. Note bimodal peaks in radiation resulting from the interposition of heavy cloud cover during the mid-summer rains.
Radiation, Insolation and Daylength: see Fig 4.2

Temperature: see Figs 4.3 and 4.13

Humidity: see Table 4.1

Cloud Cover and Cloud Types: see Fig 4.4

Wind: see Fig 4.5 for regional airstreams, and Fig 4.7 for frequency of direction of winds in the Rift Valley. Hurricane tracks are plotted in Fig 4.6

Rainfall: The mean annual isohyets for the whole territory are depicted in Fig 4.8. The trigger effect of the Gorongosa orographic high on cumulonimbus thunderstorm development, or instability rains (guti drizzle), is shown by a series of sketches, drawn at intervals on one day, of the growth of a thunderstorm (Fig 4.9). The importance of this feature on all life surrounding the mountain is highlighted by a variety of examples throughout the thesis. Its key position in the water cycle of the Gorongosa ecosystem is emphasized by the contrasting precipitation regimes of the adjacent Urema Rift Valley 15 km distant (Fig 4.1, 4.10 and 4.11). Nevertheless, dry months in the orographic rain forest climate are experienced at intervals (Table 4.2).

Fog: Two quite different kinds of fog occur in the ecosystem. An anabatic orographic fog, or drizzle, which is known locally as guti along the Great Escarpment, or chiperoni in Zambezia and Malawi, and a low level nocturnal cool air, land breeze from the uplands to the sea (Fig 4.12). The katabatic fog is carried by the land breeze far out to sea over the Mocambique Channel, and often clears at Beira only in midmorning during winter (Tinley 1971).

Guttation and Dew

A notable feature in all physiographic units is the occurrence of heavy dews. As can be ascertained by direct observation, however, most of this “dew” is in fact guttation.

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1 = Midlands
2 = Rift Valley Floor
3 = Cheringoma Plateau crest
4 = Land-Sea Junction (Cheringoma Coast)

### Table 4.2

Occurrence of dry months (< 50 mm) in an orographic rainforest climate. Recorded on the windward S slopes of Gorongosa mountain (1500 m a.s.l.).

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Evapotranspiration (mean value mm) from Goncalves & Soares (1972: 485)
FIG 4.3 TEMPERATURE REGIMES OF EACH PHYSIOGRAPHIC UNIT

MIDLANDS
Vila Paiva de Andrade

RIFT VALLEY
Vila Machado

COAST PLATEAU
Inhambinga

LAND-SEA JUNCTION
Beira
that moisture exuded by plants at specialized pores termed hydathodes. This occurs when soil moisture is near field capacity at night or in the early morning when no evapotranspiration is taking place. The conditions under which guttation takes place are generally favourable for dew formation, but guttation continues in conditions unfavourable to the formation of dew.

It is significant that the abrupt termination of valley fog occurrence in September (Fig 4.12) is associated with the termination of guttation (soil moisture depletion). The spring thermal changes and wind intensity patterns may also be contributory factors, but light valley fog occurs again in midsummer on cloudless nights, thus the pumping out of soil moisture by plants may be of more than local significance and may contribute directly to katabatic fog development.

**Frost:** No frost is recorded from the Rift Valley, and only rarely from the Midlands. There are no records of its incidence on the summit areas of Gorongosa Mountain. At Inyanga (Rhodes Estate), at a comparable altitude and latitude 120 km inland, frosts are recorded only in June and July.

**Evaporation:** Actual and potential evapotranspiration for the transect (excluding the mountain) are presented in Table 4.3.

**The Seasons:** Fig 4.13 summarizes the march of the seasons in each physiographic unit. Due to cold air drainage of the nocturnal land breeze component, the Rift Valley trough, which lies at right angles to the flow, is a cold air sink and thus experiences a mild midwinter period. The coast plateau and land-sea junction experience torrid or hot thermal conditions throughout the year.

**REFERENCES / CLIMATE**


MONTHLY PERCENT OF CLOUD TYPES RECORDED ABOVE THE UREMA RIFT VALLEY (over a 2 year period at 07h00, 14h00, 21h00)

PER.CENT OF CLOUD TYPES RECORDED ABOVE THE UREMA RIFT VALLEY (over a 2 year period at 07h00, 14h00, 21h00)

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AUG 70 SEP 70 OCT 70 Nov 70 DEC 70 JAN 71 FEB 71 MAR 71 APR 71 MAY 71 JUN 71

JUL 71 AUG 71 SEF 71 OCT 71 NOV 71 DEC 71 JAN 72 FEB 72 MAR 72 APR 72 MAY 72 JUN 72

FIG 4.4
CLOUD COVER SEQUENCES
OVER THE RIFT VALLEY.

% occurrence of x s/ho cloud cover (other than 1/ho)

21h00

14h00

07h00

mean total

Cloud cover variations over a 2 year period above the Mozambique sector of the Great Rift Valley. (p.e. data)

Percent cloud cover recorded above Rift Valley (mean of 2
year period).

Chicango, Urema Trough sector
of Great Rift Valley.

ASONDJFMAMJJASONJJFMA MJ
1970
1971
Fig 4.5
Examples of surface streamlines over Mozambique & Madagascar.
These show the close interplay of the macro-scale air masses across the equator in the development & movement of anticyclonic & cyclonic processes.
FIG 4.6


Hurricanes or near-hurricane strength
Tropical storms of medium to low intensity

From J. Maria da Rosa 1969
FIG 4.7

WIND DIRECTION FREQUENCIES
FOR THE RIFT VALLEY (UREMA TROUGH)
(recorded over a 2 year period: pers. data)

JAN 71    FEB 71    MAR 71    APR 71    MAY 71    JUN 71
07h00

14h00

21h00

JAN 72    FEB 72    MAR 72    APR 72    MAY 72    JUN 72
07h00

14h00

21h00

FIG 4.7
RAINFALL
mean annual isohyets (mm.)

FIG 4.8

OMIBRO-PHTO-
EDAPHIC ZONES

> 2000 mm
Rain Forest

> 1800 mm
M把持 Savanna/
Moc Forest

600 to 1000 mm
Moc Savanna,
Dry Forest
(Transitional Biome)

< 600 mm
Arid Savanna
Dry Forest &/or
Thicker

FIG 4.8
FIG 4.9

A typical example of orographic cumulonimbus rain development over the isolated massif of Gorongosa Mt. (1568 m a.s.l.) on the western edge of the Rift Valley in Mozambique.

The ground-level wind was from the SE Trades off the sea (from the observer toward the mountain) with a condensation level at c.1600 m. Above this at about 6000-7000 m was the opposing SW geostrophic flow from the upper level of the same anticyclone system centred over the Kunene at the 6 km level.
FIG 4.10
DAILY SUMMER RAINFALL COMPARISONS BETWEEN GORONGOSA MOUNTAIN & THE ADJACENT UREMA RIFT VALLEY.
FIG 4.11
RAINFALL DEPARTURES FROM THE MEAN IN THE UREMA RIFT VALLEY
(as recorded at Chitengo Camp)
Fig 4.12

**Occurrence of Orographic & Katabatic Fog in Central Mozambique.**

1. Data from Rhodesian Meteorological Dept. (Salisbury).
2. Data from Correia (1948)

Valley Mist Occurrence on Rift Floor (Chitengo - pers. data)
GORONGOSA MOUNTAIN
SUMMIT 1863m
(USING INYANGA RHODES
ESTATE DATA 1878m)

GORONGOSA
MOUNTAIN
SW SLOPES
(RANCH 950 m)

MIDLANDS
(VILA DA GORONGOSA
300 m) alias Vila Rei

RIFT VALLEY
(CHITENGO 34 m)

COAST PLATEAU
(INHAMINGA 318 m)

LAND-SEA
JUNCTION
(BEIRA 7 m)

FIG 4.13 THE SEASONS

TORRID 25 - 30°C
HOT 20 - 25°C
MILD 15 - 20°C
COOL 10 - 15°C

A 10°C/100mm
B 20°C/200mm
C 30°C/300mm
FIG 4.13 THE SEASONS

<table>
<thead>
<tr>
<th>Land-Sea Junction</th>
<th>Coasts Plateau</th>
<th>Rift Valley</th>
<th>Midlands</th>
<th>Gorongosa Mountain SW Slopes</th>
<th>Gorongosa Mountain Summit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beira 7m</td>
<td>Inhaminha 316m</td>
<td>Chitemo 24m</td>
<td>Vila da Gorongosa (950m)</td>
<td>Gorongosa Summit (7863m)</td>
<td>Gorongosa Mountain Summit (1863m)</td>
</tr>
</tbody>
</table>

**TORRID**: 25 - 30°C
**HOT**: 20 - 25°C
**MILD**: 15 - 20°C
**COOL**: 10 - 15°C

**T° INTERVALS**

- A: 10°C / 100mm
- B: 20°C / 200mm
- C: 30°C / 300mm