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AGROCLIMATIC CONDITIONS AND ASSESSMENT METHODS FOR DROUGHT/FOOD SHORTAGES IN SUBEQUATORIAL AFRICA

EARLY WARNING PROGRAM

DECEMBER 1983

AGROCLIMATIC CONDITIONS AND ASSESSMENT METHODS FOR DROUGHT/FOOD SHORTAGES IN SUBEQUATORIAL AFRICA[1]

to

International Development Cooperation Agency
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Office of U.S. Foreign Disaster Assistance
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by

National Oceanic and Atmospheric Administration
National Environmental, Satellite, Data and Information Service
Assessment and Information Services Center
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EXECUTIVE SUMMARY

PROPOSED AGROCLIMATIC ASSESSMENT METHODS FOR EARLY WARNING OF DROUGHT/FOOD SHORTAGES IN SUBEQUATORIAL AFRICA

by Atanas V. Todorov and Louis T. Steyaert[1/]

The Agency for International Development (AID) needs reliable early warning of potential food shortages to make decisions affecting many of its programs for disaster preparedness, relief assistance and food security in Subequatorial Africa. Most of these agriculturally oriented economies are highly vulnerable to climate variability. Severe drought and flooding have historically led to crop failures, economic losses and famine. For these reasons, the AID/Office of U.S. Foreign Disaster Assistance sponspored this project, Agroclimatic Conditions and Assessment Methods for Drought/Food Shortages in Subequatorial Africa.

The objectives of the project were accomplished. An inexpensive Early Warning Program was developed to provide reliable, timely information on potential food shortages triggered by climatic events. Computerized data bases were assembled and used to determine historical relationships between climate anomalies, crop failures and the causes of abnormal food shortages. Qualitative impact assessments of unusual and severe weather events were provided to AID/OFDA on a biweekly and monthly basis during the project.

The Early Warning Program is based on 1) weather assessments and 2) monthly assessments of crop conditions. Weather assessments begin with an analysis of precipitation amount, the most important meteorological element influencing crop productivity in the sub-tropics. Regional rainfall estimates are determined from ground station reports received through an international communications network. Satellite cloud data are used to improve the accuracy of precipitation estimates, particularly in those region where weather data are sparse and unreliable. Weather data are then interpreted by applying agroclimatic indices which indicate potential crop production in relative terms. Finally, the potential for abnormal food shortages is identified from these indices.

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Regional agroclimatic indices are the core of the program. Various historical data bases were developed to determine the appropriate index for each region. Local agricultural practices, episodic event reports and results of experimental studies were incorporated in the choice of each index. Episodic event reports on documented occurrences of famine, drought, crop failure and other events are used to establish critical thresholds for potential food shortages and interpret indices.

Agroclimatic indices and associated crop calendars for major food crops were defined for 65 agroclimatically homogeneous regions throughout Subequatorial Africa. Historical meteorological data (1950-1980) from more than 440 stations were used to compute the indices.

Before the Early Warning Program in Subequatorial Africa becomes operational, the indices should be tested. The proposed evaluation should include: 1) statistical testing, 2) refinement and calibration, 3) routine test assessments, 4) user feedback and 5) continued development. This would provide experience in preparation of climatic impact assessment reports.

This program can potentially benefit AID by:

1) increasing the lead time for planning food assistance strategies,
2) enhancing the U.S. capacity to identify disaster conditions, thus improving recommended measures for disaster avoidance and mitigation, and
3) transferring agroclimate technology to developing countries.

The methods proposed in this report are based on sound agroclimatic principles, which have been adapted to existing local agricultural practices. This Early Warning Program can provide timely, reliable yet inexpensive information 30-60 days before harvest of the crop. This could potentially represent a 3-6 month warning prior to drought-related food shortages.

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Chapter I

INTRODUCTION

The Agency for International Development (AID) needs reliable early warning of potential food shortages to make decisions affecting many of its programs for disaster relief, preparedness, and food security in Subequatorial Africa. Many of these agriculturally oriented economies are highly vulnerable to climate variability. Severe drought and flooding have historically led to crop failures, economic losses, and famine. For these reasons, the AID/Office of U.S. Foreign Disaster Assistance sponsored this project: "Agroclimatic Conditions and Assessment Methods for Drought/Food Shortages in Subequatorial Africa."

The project covers eighteen developing countries in this part of the continent: Gabon, Congo, Zaire, Angola, Namibia, Lesotho, Swaziland, Botswana, Zimbabwe, Mozambique, Malawi, Zambia, Tanzania, Kenya, Uganda, Rwanda, Burundi and Madagascar (Figure 1.1). Each country was divided into several agroclimatologically homogeneous regions; the total number is sixty-five (Figure 1.2).

The objectives of the project were:

1. To study the existing agroclimatological conditions, agricultural practices and food security in each country and region.
2. To collect and compile a meteorological data base to adequately cover the whole territory of each country.
3. To collect and compile a crop data base for each country.
4. To study the relationships between weather and climate and the performance of the agricultural crops.
5. To develop a timely, reliable, yet inexpensive Early Warning Program for operational assessments of the current agro-meteorological conditions, the state of the crops and the potential for food shortages triggered by weather events.
6. To test and evaluate the Early Warning Program.

~~The preparation of the final report of the project is planned to be accomplished in two stages: Part One (this report) covers the first five objectives of the project, while Part Two will cover the sixth.~~

It is expected that the findings of this project, after being disseminated to Africa, will aid agrometeorologists and agronomists as well as policy and decision makers in each country. A better understanding of the relationship between weather and agriculture will help them to achieve their short and long term goals for increasing the food security in their countries.

SUBEQUATORIAL AFRICA

PROJECT COUNTRIES

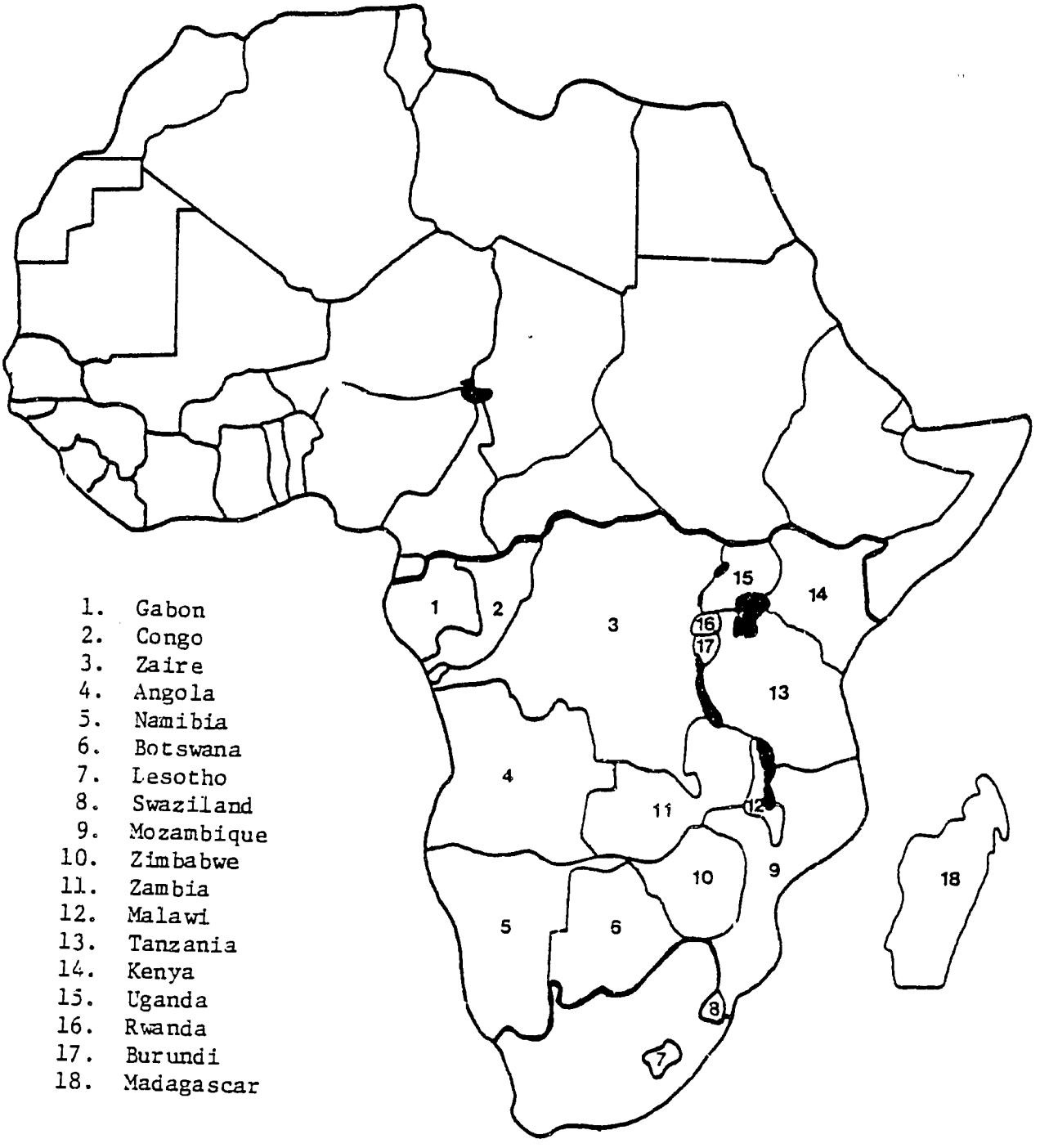

Figure 1.1.

SUBEQUATORIAL AFRICA

AGROCLIMATIC REGIONS

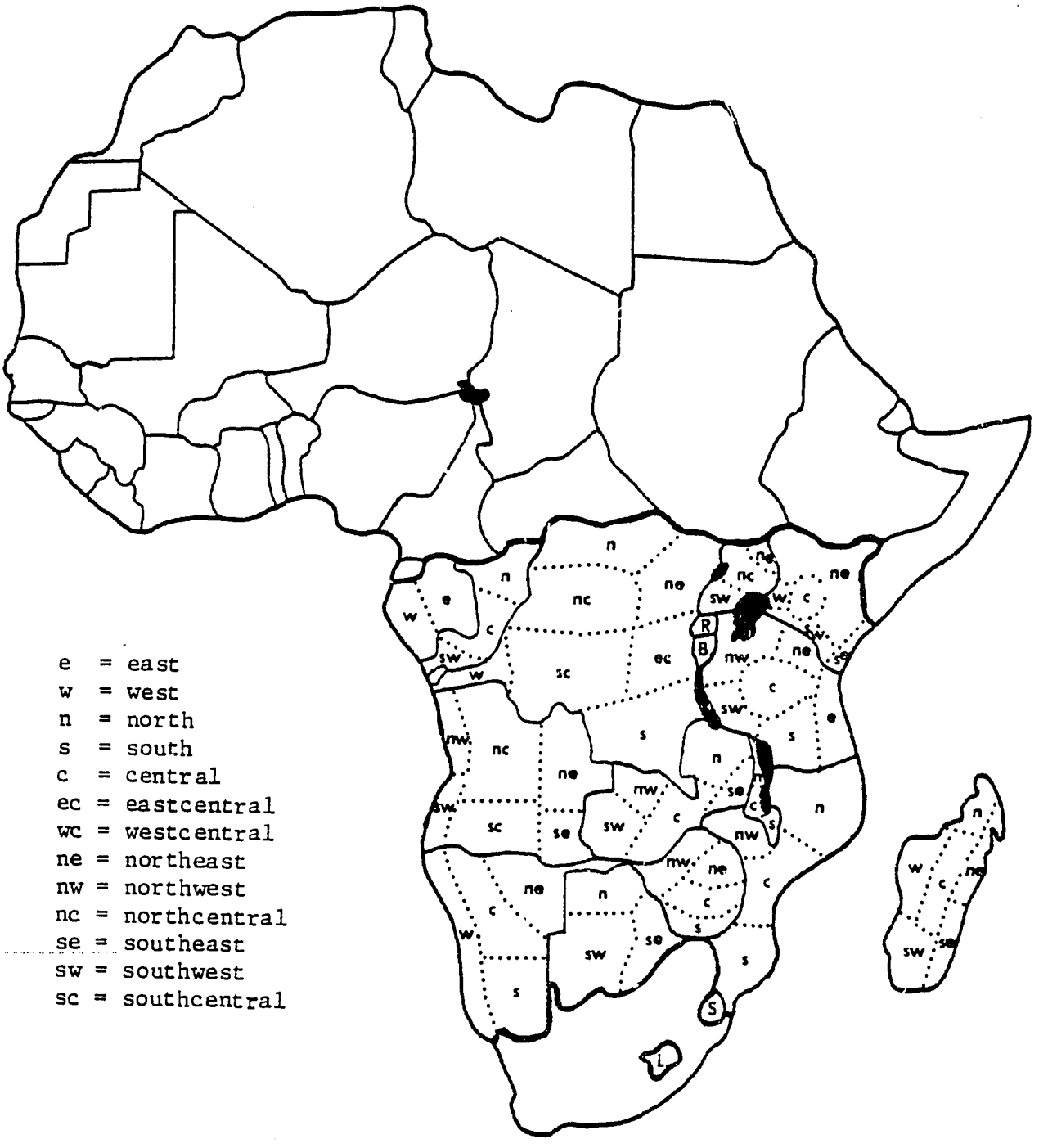

Figure 1.2.

Chapter II

PHYSICAL ENVIRONMENT

This chapter contains a brief overview of the physical environment for the whole region of Subequatorial Africa. The area and topography of each country is described in more detail in Chapter VI.

A. AREA

The 18 countries in this project cover an area of about 10 million square kilometers. From east to west the region stretches about 3,500 km around the equator and about 1,900 km in the South. From north to south, the region stretches about 3,000-3,300 km. The region is remarkably compact. The coastline is smooth and extends for only about 6,500 km, plus 3,700 km for Madagascar.

The greatest part of the region is located south of the equator; therefore "subequatorial" is used for identification. It should be kept in mind, however, that some parts of Gabon, Congo, Zaire, Uganda and Kenya, are located north of the equator.

B. TOPOGRAPHY

The territory of Subequatorial Africa includes all major geographical features. An area 100 to 400 km wide along the coast has an altitude of 0 to 500 m (Figure 2.1). Large parts of Northwestern Zaire and North Congo have the same altitude. Areas above 1,000 m cover the whole of Uganda, Rwanda and Lesotho, plus parts of all other countries except Congo (see individual topography maps for each country in Chapter VI).

The highest mountains in Subequatorial Africa are located in Tanzania (Mt. Kilimanjaro; 5895 m), Kenya (Mt. Kenya; 5,199 m) and Uganda (Mt. Ruwenzori; 5,120 m). The largest lakes are Victoria (with an area of 10,000 km^2), Tanganyika, and Malawi. The largest rivers are the Congo (or Zaire), Limpopo and Zambezi.

C. NATURAL VEGETATION

Natural vegetation depends on climate and therefore is a good indicator of the existing climatic conditions of an area. It is possible to divide Subequatorial Africa into ten vegetation types, as shown in Figure 2.2. Tropical rain forest occupies the most humid areas of the region - in Zaire, Congo, Gabon, a small part of Angola, and Madagascar. The forest - woodland savannah, which requires moderately wet conditions, has the

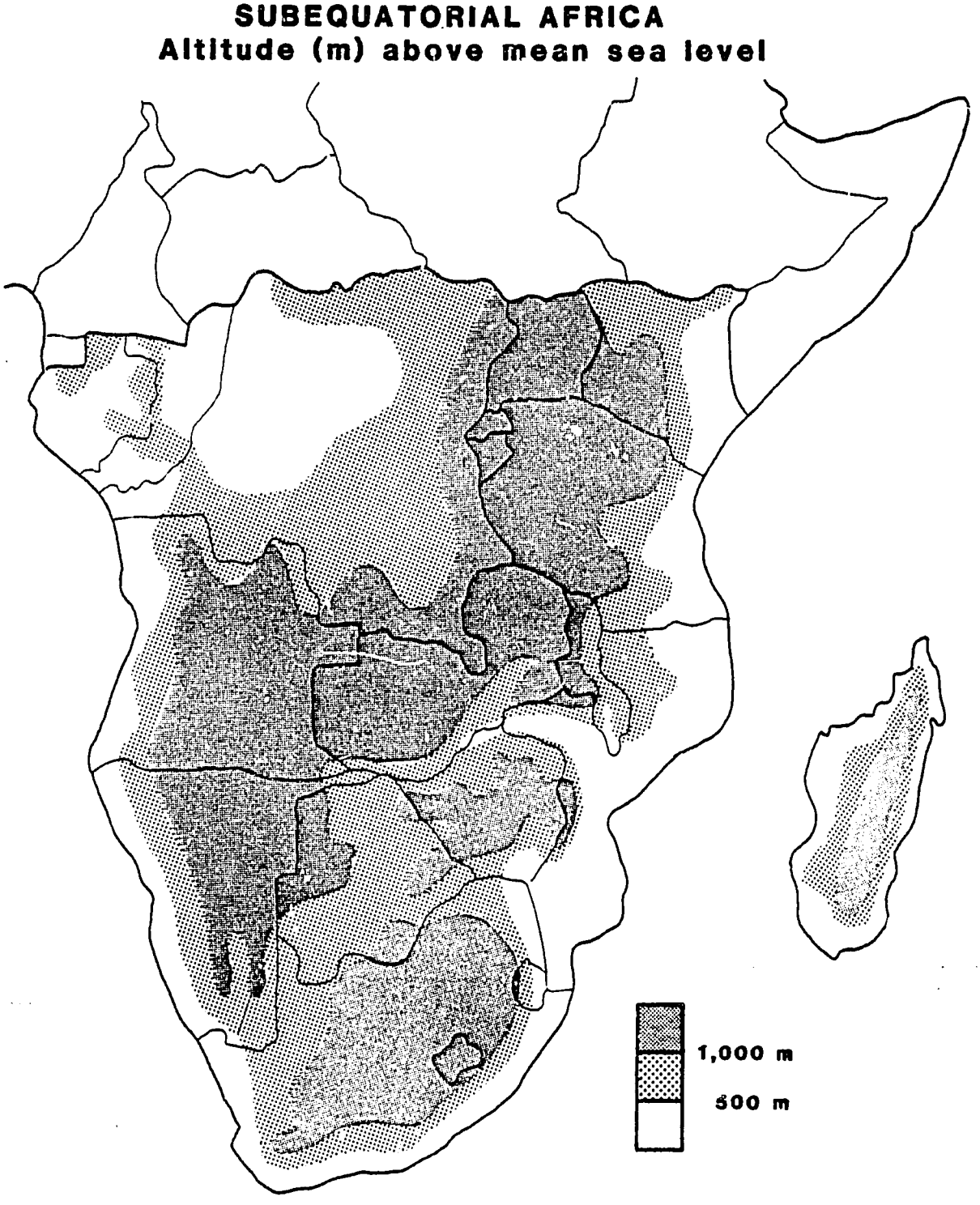
SUBEQUATORIAL AFRICA
Altitude (m) above mean sea level
1,000 m
500 m

Figure 2.1.

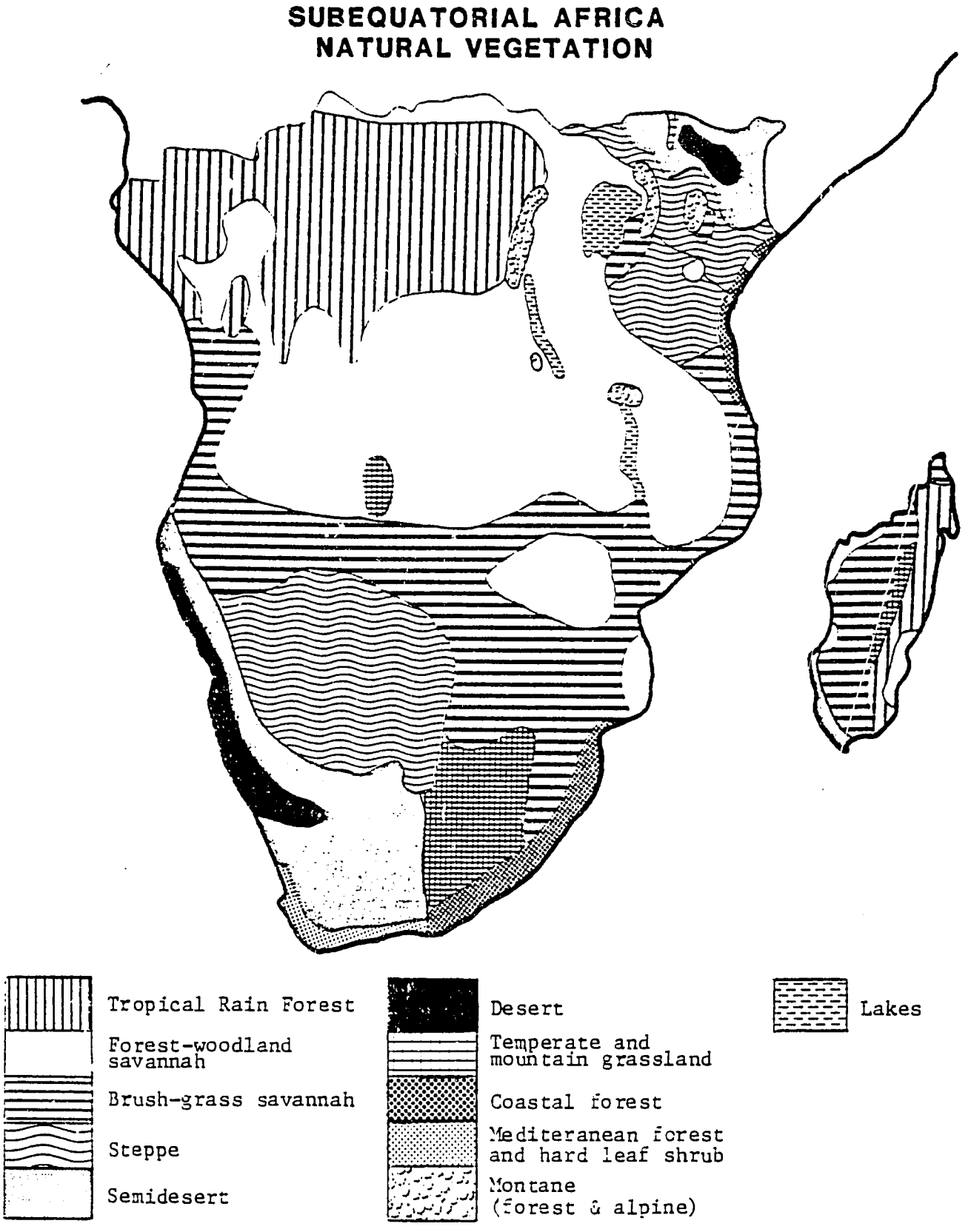
SUBEQUATORIAL AFRICA
NATURAL VEGETATION
Tropical Rain Forest
Forest-woodland savannah
Brush-grass savannah
Steppe
Semidesert
Desert
Temperate and mountain grassland
Coastal forest
Mediteranean forest and hard leaf shrub
Montane (forest & alpine)
Lakes

Figure 2.2.

largest area among the vegetation types. The brush-grass savannah thrives in dryer climates, while still dryer areas have steppe vegetation - bunch grass and scattered shrubs. On the extreme dry end are the semi-desert and desert. The high mountains of Eastern Africa, including Eastern Zaire, have montane vegetation - forest and alpine.

D. SOILS

There are a wide variety of soils in Subequatorial Africa. The FAO and UNESCO Soil Map of the World attributes over twenty soil types (units) to Subequatorial Africa; each can be further subdivided into several smaller units. The soil classification used is based on the origin (genesis) of the soils. For agrometeorological purposes, the water and physical properties of the soils, such as field capacity, wilting point, bulk density, etc. are more important and useful. Unfortunately, very little data and information of this kind are available for Subequatorial Africa.

Fertile soils are scarce, scattered in different locations in the 18 countries of this project. The greatest percentage of the soils in the study region are of low to medium grade.

Chapter III

CLIMATE

The climate of Subequatorial Africa can be briefly described as warm, with quite uniform temperatures and highly variable rainfall - both spatially and temporally. Due mainly to the differences in the rainfall regime, it will be more appropriate to speak of the "climates" rather than the "climate" of Subequatorial Africa. The various climatological classifications distinguish quite a large number of climates in the region covered by this project. According to Koeppen's classification, there are not less than ten different climates. A similar number are determined by Thornthwaite's, Trewartha's and other classifications.

It is common knowledge among agroclimatologists that general climatological classifications are of little use for agroclimatological purposes; therefore they will not be discussed here. Likewise, it is not the intent of this project to study the synoptic conditions that lead to weather changes over Africa. It should be mentioned, however, that the main meteorological phenomenon influencing the seasonal weather changes (mainly rainfall) over Subequatorial Africa is the Inter-Tropical Convergence Zone (ITCZ). This zone separates two different types of air masses: one dry and warm, the other humid and cool. The ITCZ has a seasonal migration over Africa, caused by the movement and position of the sun; the arrival of the ITCZ over an area generally begins the rainy season.

The regime of several meteorological elements - solar radiation, sunshine duration, air temperature, air humidity and pan evaporation - will be discussed in this chapter. The rainfall regime will also be discussed in Chapters VI and VII.

A. RADIATION

The number of stations with data for solar radiation is small. The data are for a few years only and are often incomplete. In spite of these limitations, several conclusions can be made:

- The smallest mean radiation is observed in the humid tropical areas of Gabon, Congo and Northwest Zaire, with an annual total of 380-400 cal/cm^2/day. Within the year, variations are small, between 340 and

450 cal/cm^2/day. It should be noted, however, that the smallest mean annual radiation in Subequatorial Africa is about twice that at 55° North, which is only about 200 cal/cm^2/day.

- The highest mean radiation is observed in the southern dry areas of Namibia, Botswana and Southern Zimbabwe, with an annual total of 500-550 cal/cm^2/day. The seasonal variations here are more pronounced. In October-November the radiation reaches about 600-650 cal/cm^2/day, while in June it drops to about 400-420 cal/cm^2/day. High radiation is observed also in the Northeastern region of Kenya.
- The other areas of Subequatorial Africa have intermediate values. Closer to the equator the radiation is smaller and less variable; further from the equator the radiation and its seasonal variations increase.

B. SUNSHINE

Data for the duration of sunshine are available both for a larger number of stations and a larger number of years (Table 3.1). The regime of the sunshine hours is similar to that of radiation. The smallest number of sunshine hours is observed in Gabon, Congo and Northwest Zaire, 3-4 hours per day during July, August and September rising to 5-6 hours per day in January, February and March. The mean annual number of sunshine hours is between 4.5 and 5.5 per day.

In contrast, in the drier areas of Namibia and Botswana the number of sunshine hours is doubled with an average of about 9.5-10.0 hours per day. Similar large durations of sunshine hours exist in the semi-desert areas of Kenya and on the southwest coast of Madagascar.

The rest of Subequatorial Africa has an annual average of about 6-8 sunshine hours per day. The seasonal variations depend mainly on the rainfall regime, with the largest number of sunshine hours occurring near the end of the dry season and the smallest during the peak of the rainy season.

C. AIR TEMPERATURE

1. Mean values

Africa is known as the "hot" continent, and there is a good justification for this. The mean air temperatures in Africa are higher than in

Table 3.1. Mean daily sunshine hours at selected stations in Subequatorial Africa

COUNTRY	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Gabon	Libreville	15	5.3	6.2	5.4	5.7	4.8	4.2	4.1	3.8	3.0	3.4	4.4	5.4	4.6
Congo	Brazzaville	316	4.5	4.8	5.0	5.5	4.4	4.3	4.0	4.7	4.1	4.2	4.8	4.5	4.6
	Impfondo	326	6.2	6.0	5.4	5.2	5.6	4.8	4.7	4.6	4.4	4.9	5.3	5.9	5.3
Zaire	Kisangani	396	6.1	6.3	5.7	5.9	5.9	5.0	4.5	4.1	5.2	5.4	5.4	5.4	5.4
	Kindu	497	5.0	5.4	5.6	5.7	6.0	5.9	4.9	5.0	5.4	5.4	5.2	4.7	5.4
	Kananga	657	4.8	4.7	4.9	5.4	7.0	8.6	7.3	6.2	6.1	6.2	5.3	4.5	5.9
	Kamina	1106	3.9	3.9	4.8	6.9	9.4	9.8	10.3	9.5	7.4	6.3	5.2	4.1	6.8
Angola	Luanda	69	6.9	7.4	6.8	6.5	7.3	7.2	5.4	4.7	4.9	5.4	6.4	6.7	6.3
	Huambo	1700	4.5	5.5	4.6	5.5	8.0	8.0	8.7	8.5	7.1	5.5	4.6	4.5	6.3
	Saurimo	1081	5.2	5.6	4.9	6.5	9.3	9.9	10.0	8.8	7.3	6.8	5.6	5.1	7.1
Namibia	Windhoek	1725	8.9	8.5	8.4	9.2	10.0	10.0	10.4	10.6	10.4	10.2	9.8	9.7	9.7
Botswana	Tsabong	960	10.7	10.2	10.1	9.6	9.5	9.7	9.7	10.7	10.7	11.1	11.1	10.7	10.3
	Maun	945	7.9	7.4	8.3	9.4	10.0	10.0	10.1	10.7	10.5	9.4	8.8	6.9	9.1
Mozambique	Beira	16	7.9	7.9	7.8	8.2	8.1	7.4	7.5	8.2	8.1	8.3	7.6	7.6	7.9
	Lichinga	1356	4.0	4.0	5.1	5.2	7.4	6.8	7.5	7.3	7.3	8.7	7.6	4.5	6.3
Zimbabwe	Harare	1471	6.3	6.3	6.9	8.2	8.6	8.4	8.8	9.3	9.5	9.1	6.9	6.1	7.9
	Bulawayo	1345	7.0	7.4	7.7	8.5	9.0	8.9	9.2	9.7	9.1	8.6	7.7	7.0	8.3
	Chipinge	1132	6.8	7.9	7.3	8.0	8.4	7.7	8.2	8.4	8.3	8.4	7.7	6.9	7.8
Malawi	Chileka	766	5.7	6.1	6.4	7.6	7.9	7.2	7.1	7.8	8.1	8.6	7.0	5.9	7.1
Zambia	Mongu	1053	4.9	5.2	6.5	8.5	9.2	9.2	9.8	10.1	9.4	8.4	6.8	5.5	7.8
	Kasama	1382	3.6	3.9	5.4	7.9	9.0	9.1	10.2	9.9	9.5	8.7	7.1	5.2	7.5
Tanzania	Tabora	1190	7.1	6.9	7.0	8.0	8.8	10.2	10.4	10.2	9.3	8.6	7.1	6.3	8.3
	Dar es Salaam	58	7.8	8.1	7.1	5.3	7.2	7.6	7.5	8.6	8.5	8.9	8.4	8.2	7.8
Kenya	Nairobi	1624	9.1	9.5	8.7	7.0	6.0	5.7	4.3	4.4	6.0	7.1	7.1	8.3	6.9
	Nanyuki	1946	7.5	7.4	6.3	5.1	5.9	6.6	5.7	6.0	6.3	5.3	4.4	5.6	6.0
	Lodwar	515	10.4	10.2	9.2	8.9	10.1	10.0	9.2	10.0	10.5	10.1	9.6	9.9	9.8
Uganda	Gulu	1105	9.2	8.7	7.9	7.1	8.1	7.8	6.3	6.9	8.0	8.1	8.2	8.9	7.9
	Entebbe	1155	7.5	7.2	6.6	6.0	6.2	6.2	6.4	6.3	6.5	6.6	6.7	6.9	6.6
Burundi	Bujumbura	782	5.1	5.0	5.5	5.1	6.3	8.1	8.7	8.0	6.7	5.6	4.7	4.8	6.1
Madagascar	Toliary	8	9.7	10.4	9.2	10.2	9.7	9.1	9.7	10.0	10.5	10.8	10.5	10.2	10.0
	Mananjary	6	7.0	6.9	5.6	7.1	6.8	6.0	6.3	7.6	8.2	7.9	7.8	7.4	7.1
	Antananarivo	1276	6.3	6.9	6.1	7.8	7.4	6.9	7.1	7.7	8.2	8.7	7.5	7.1	7.3

Table 3.2. Mean monthly and annual air temperature (°C) at selected stations in Subequatorial Africa

COUNTRY	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Gabon	Libreville	15	27	27	27	27	27	25	24	25	25	26	26	26	26
	Makokou	515	24	25	25	25	25	23	22	22	24	24	24	24	24
Congo	Brazzaville	316	26	26	26	26	26	23	22	23	25	26	26	25	25
	Impfondo	326	26	26	26	26	26	25	25	25	25	25	25	25	25
Zaire	Kisangani	396	25	25	25	25	25	24	24	24	24	24	24	24	24
	Kananga	657	23	24	24	24	25	24	24	24	24	24	23	23	24
	Kamina	1106	22	22	23	23	23	21	22	23	24	23	23	22	23
Angola	Luanda	69	26	26	27	26	25	22	20	20	22	24	25	25	24
	Huambo	1700	19	19	19	19	18	16	16	19	21	20	19	19	19
	Saurimo	1081	22	23	23	23	22	21	21	23	24	23	22	22	22
Namibia	Windhoek	1725	23	22	21	19	16	13	13	16	19	22	22	23	19
	Tsumeb	1311	25	24	23	22	19	17	17	19	23	26	26	25	22
Botswana	Tsabong	960	27	26	24	20	15	12	12	14	19	22	25	26	20
	Mahalapye	1006	25	25	23	20	16	13	13	16	20	24	25	25	21
Lesotho	Maseru	1554	21	20	19	15	11	7	7	10	14	17	19	20	15
Swaziland	Mbabane	1145	20	20	19	17	15	12	12	14	16	18	19	20	17
Mozambique	Beira	16	27	27	27	25	23	21	20	21	23	25	26	27	24
	Lichinga	1356	19	20	19	18	17	15	14	16	18	21	21	20	18
Zimbabwe	Harare	1471	21	20	20	19	16	14	13	16	19	21	21	21	18
	Bulawayo	1345	22	21	20	19	16	14	14	16	20	22	22	22	19
	Chipinge	1132	21	21	20	19	17	15	14	16	18	20	21	21	18
Malawi	Chileka	766	24	24	23	22	20	18	18	20	23	25	25	24	22
Zambia	Mongu	1053	23	23	23	22	20	17	18	20	24	26	24	23	22
	Kasama	1382	20	20	21	21	19	17	17	19	22	23	22	21	20
	Kabwe	1206	21	21	21	20	18	16	16	18	22	24	23	21	20
Tanzania	Tabora	1190	22	23	23	22	22	22	21	23	25	25	24	23	23
	Dar es Salaam	58	28	28	27	27	26	24	24	24	24	25	26	27	26
	Songea	1067	23	23	22	22	20	18	17	19	21	23	24	23	21
Kenya	Nairobi	1624	18	19	19	19	18	16	15	16	17	19	18	18	18
	Nanyuki	1946	16	17	17	17	17	16	15	15	16	16	16	16	16
	Lodwar	515	29	30	30	30	30	29	28	28	29	30	29	29	29
Uganda	Gulu	1105	24	25	25	24	23	22	22	22	22	23	23	23	23
	Entebbe	1155	22	22	22	22	22	21	21	21	21	22	22	22	22
Burundi	Bujumbura	782	23	23	23	23	23	23	22	23	24	24	23	23	23
Madagascar	Toliary	8	27	27	27	25	23	21	20	21	22	24	25	27	24
	Mananjary	6	26	26	25	24	22	20	20	20	21	23	24	25	23
	Antananarivo	1276	21	21	21	20	17	15	15	15	17	20	21	21	19

most other populated areas of the world; as elsewhere they vary considerably depending on the three factors of altitude, latitude and proximity to large water bodies.

The mean annual temperature in most populated areas of Subequatorial Africa varies between 24-26°C in the lowlands and about 15-17°C in the highlands (Table 3.2). The mean monthly temperatures have a wider range than the mean annual values. The highest mean monthly temperatures, around 30°C, occur in the semi-desert inland areas around the equator. The lowest mean monthly temperatures, 6-7°C, are observed in the highlands away from the equator.

2. Seasonal variations

Seasonal variations of the mean monthly air temperatures in Subequatorial Africa are very small; there are some areas where seasonal variations are almost nonexistent.

The area closest to the equator has its warmest month around March (either February, March or April), with a small secondary peak around October-November. Coolest are July and August. The difference between the warmest and the coolest months of the year is small - between 1 and 4°C.

The seasonal variations increase with the increase of latitude. At about 20° latitude (Namibia, Botswana, Zimbabwe, Mozambique), the difference between the warmest and the coolest months of the year is about 8 to 15°C in the inland areas and about 7-8°C along the coast. The warmest time of the year here is between December and February, while the coolest is again July.

3. Extreme temperatures

Maximum temperatures in Subequatorial Africa, contrary to expected, are lower than in many areas of Europe, America or Asia where temperatures can reach 40°C quite often during the summer time. In nearly all of Subequatorial Africa, the mean monthly maximum temperatures during the warmest month of the year do not exceed 37°C. The absolute maximum temperatures are no more than 1-2°C higher, remaining below 40°C.

Minimum temperatures, both mean and absolute, are about 13-18°C in the lowlands close to the equator. At higher latitudes and especially at high altitudes, they are lower. Minimum temperatures below 0°C occur only in the highlands of Botswana, Lesotho and Swaziland and in the high mountains of many other countries.

The mean monthly temperature range (the difference between the mean monthly maximum and mean monthly minimum temperatures) is smaller along the coast, mostly 10-12°C, and higher in the inland areas. Close to the equator, the range is mostly 12-18°C, while further south it increases to 18-22°C. The highest range, 25-30°C, is observed in Botswana.

4. Temperature sums (degree-days) and duration of the growing season

One important agroclimatic parameter to describe the existing temperature conditions and resources is the sum of temperatures (called also "degree days") that accumulate in an area. Another is the duration of the periods above a certain mean air temperature.

The approximate temperature sums required from sowing till maturity by some subsistence agricultural crops are as follows: wheat - about 1,600°C, millet - 1,600 to 1,900°C, sorghum - 1,700 to 2,000°C; beans - 1,800 to 1,900°C; maize - 2,400 to 2,800°C. The temperature data for Subequatorial Africa indicate enormous temperature resources: the sums of temperatures are mostly between 6,000 and 7,000° in the highlands and between 7,000 and 9,500° in the lowlands. This means that the temperature resources alone (providing water is not a limiting factor) allow growing 2, 3 or even 4 crops per year.

The duration of the growing period for most crops in the greater part of Subequatorial Africa is equal to the maximum possible - 365 days. The growing period of wheat takes place when the mean air temperature is above 5°C, for millet, sorghum and maize - above 8°C, for beans - above 10°C. From the stations selected for Table 3.2, only Maseru in Lesotho has two months (June and July) with a mean air temperature of 7°C. Thus, the duration of the period suitable for growing the above crops in Maseru is 10 months. All other stations listed in the table have a growing season of 365 days.

5. Conclusions

The temperature regime in Subequatorial Africa is extremely favorable for growing agricultural crops:

- There is no winter season, and the duration of the crop growing period over most of Subequatorial Africa is 365 days compared to 120-180 days in most of North America and Europe.

- The temperature sums (degree-days) accumulated during the growing season permit growing 2, 3 or 4 agricultural crops per year, as opposed to only one crop in most of North America and Europe.
- The maximum air temperatures in Subequatorial Africa are lower than those in many other areas of the world, and over most of the region they are not a limiting factor for growing most crops.
- The only negative feature of the temperature regime of Subequatorial Africa is the lower diurnal temperature range, but this happens mostly in the areas close to the equator or along the sea coast (this disadvantage is discussed in more detail in Chapter IV).

D. RAINFALL

The regime of rainfall, which for the purpose of this study is the most important meteorological element, will be discussed in more detail separately for each country in Chapter VI, as well as in Chapter VII. Here only a brief general overview for the whole of Subequatorial Africa will be made.

1. Wettest areas

The mean annual amount of rainfall has a very uneven distribution over Subequatorial Africa (Figure 3.1 and Tables 3.3 and 3.4). Wettest areas are Gabon, Congo, most of Zaire, and the east coast of Madagascar. The mean annual amounts over these areas exceed 1,400 mm, with many smaller areas receiving much higher amounts. Among the stations for which historical meteorological data are available, highest mean annual rainfall is recorded at the following: in Gabon - Cocobeach (3395 mm) and Libreville (2840 mm); in Congo - Djambala (2054 mm); in Zaire - Congomeka (2225 mm) and Befori (2176 mm); in Madagascar - Toamasina (3356 mm) and Mananjary (2729 mm).

Besides large annual rainfall, these areas also receive larger mean monthly amounts - over 200 or even 300 mm. The duration of the rainy season is 2-3 times longer than the dry season, or there is no dry season at all.

2. Dryest areas

The dryest area in Subequatorial Africa is the desert that covers the southern one-third of the Angolan coast, the entire Namibian coast and most of the southern part of Namibia. The mean annual rainfall here is between

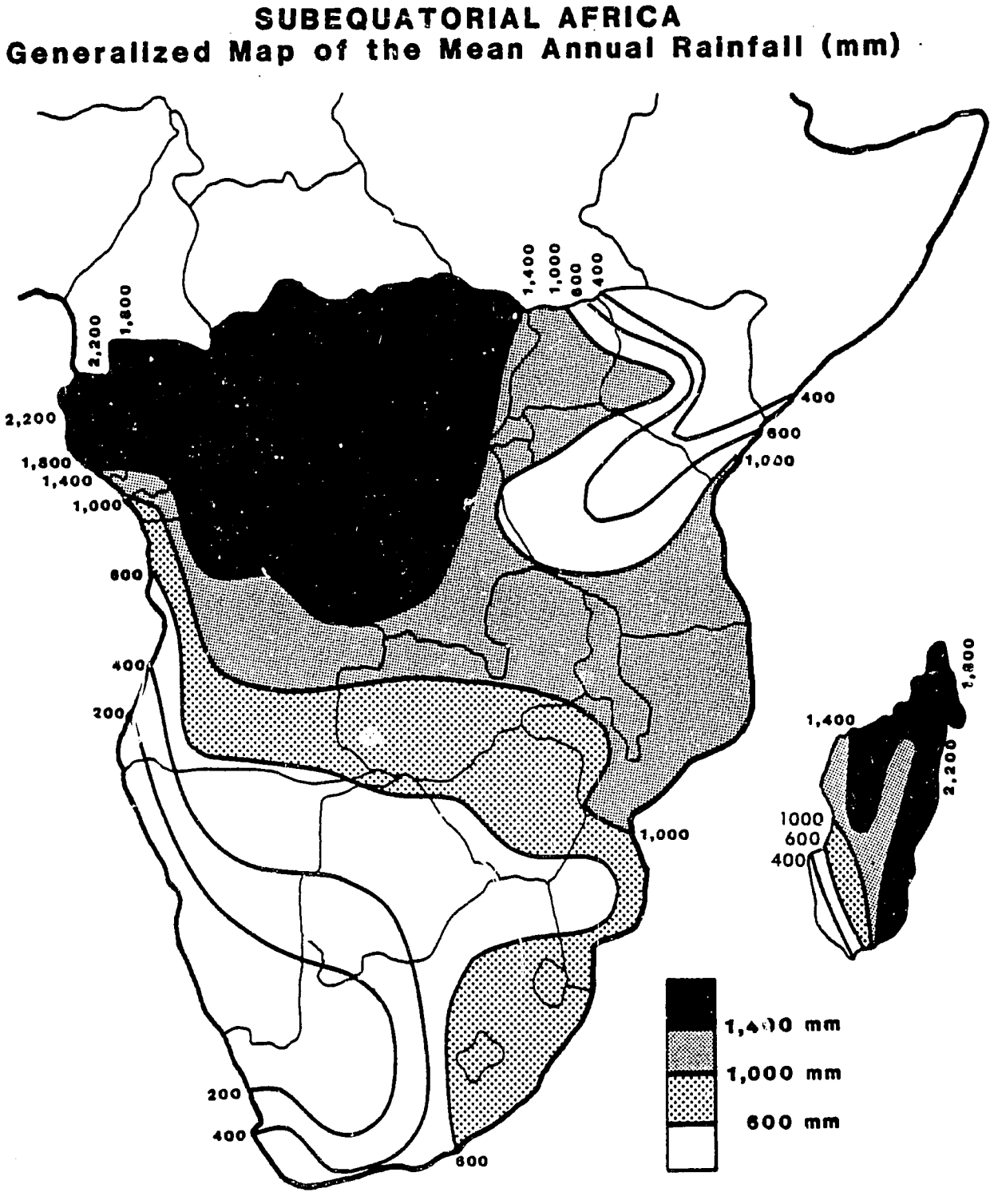
SUBEQUATORIAL AFRICA
Generalized Map of the Mean Annual Rainfall (mm)
2,200
1,800
2,200
1,800
1,400
1,000
600
400
1,400
1,000
600
400
400
600
1,000
1,000
600
400
200
1,000
200
400
600
1,800
1,400
2,200
1000
600
400
1,400 mm
1,000 mm
600 mm

Figure 3.1.

Table 3.3. Mean monthly and annual rainfall (mm) at selected stations in Subequatorial Africa

COUNTRY	STATION	ELEV. (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Gabon	Libreville	15	252	274	355	362	257	37	2	9	109	395	486	301	2840
	Makokou	515	93	122	227	225	208	60	8	27	149	318	240	124	1815
Congo	Brazzaville	316	138	125	187	212	121	6	1	3	39	143	241	165	1385
	Impfondo	326	69	83	153	156	168	149	146	170	190	207	170	85	1749
Zaire	Kisangani	396	95	115	152	181	167	115	100	186	174	208	187	114	1794
	Kananga	657	135	131	205	185	81	22	18	48	120	165	238	234	1584
	Kamina	1106	229	212	210	131	10	1	0	10	47	113	186	269	1416
Angola	Luanda	69	29	37	88	124	12	0	0	1	2	6	31	27	356
	Huambo	1700	215	170	233	147	14	0	0	1	18	122	216	241	1378
	Saurimo	1081	196	157	223	141	17	0	0	12	53	117	222	203	1338
Namibia	Windhoek	1725	78	80	83	40	7	1	1	1	3	12	27	43	376
	Tsumeb	1311	123	122	86	39	6	0	0	0	2	19	59	79	536
Botswana	Tsabong	960	51	53	56	33	13	7	2	2	5	14	25	34	294
	Mahalapye	1006	91	83	67	26	11	2	2	3	9	31	67	85	476
Lesotho	Maseru	1554	119	102	92	60	27	12	11	13	25	62	79	91	691
Swaziland	Mbabane	1145	247	211	173	79	24	19	22	29	62	128	178	214	1396
Mozambique	Beira	16	277	257	266	114	62	41	32	32	22	31	128	246	1510
	Lichinga	1356	231	238	214	79	24	4	3	1	3	15	79	232	1120
Zimbabwe	Harare	1471	192	168	103	34	11	2	1	2	7	31	101	167	822
	Bulawayo	1345	140	108	72	23	9	2	1	1	6	25	87	131	604
	Chipinge	1132	233	207	163	57	25	22	18	20	20	45	116	208	1140
Malawi	Chileka	766	203	171	135	41	10	3	3	1	4	22	85	177	859
Zambia	Mongu	1053	221	209	151	38	5	1	0	0	3	34	99	201	963
	Kasama	1382	277	250	256	73	11	0	0	1	2	18	147	258	1287
	Kabwe	1206	247	203	117	25	5	0	0	2	2	21	94	253	966
Tanzania	Tabora	1190	133	131	167	134	28	2	1	1	6	18	105	185	910
	Dar es Salaam	58	59	67	126	256	196	38	26	26	30	51	81	81	1035
	Songea	1067	274	226	246	109	14	1	2	1	2	7	55	197	1135
Kenya	Nairobi	1624	64	55	90	222	184	39	19	25	33	55	144	93	1023
	Nanyuki	1946	19	22	53	119	83	44	65	70	49	78	92	43	737
	Lodwar	515	9	8	22	49	26	8	18	9	3	8	18	9	188
Uganda	Gulu	1105	13	42	89	173	193	150	165	228	193	173	98	50	1561
	Entebbe	1155	75	92	166	260	254	119	78	78	77	103	143	114	1559
Burundi	Bujumbura	782	70	106	136	134	59	11	0	11	32	74	92	109	832
Madagascar	Toliary	8	94	83	41	13	22	13	6	5	9	10	24	101	421
	Mananjary	6	344	342	424	233	200	216	179	166	93	98	223	210	2729
	Antananarivo	1276	283	259	189	51	17	8	9	11	16	55	148	294	1338

Table 3.4. Mean monthly and annual number of days with rainfall ≥ 1.0 mm at selected stations in Subequatorial Africa

COUNTRY	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Gabon	Libreville	15	15	16	18	19	14	3	1	4	13	23	22	17	165
Congo	Brazzaville	316	9	8	10	13	8	1	0	0	3	9	13	12	87
	Impfondo	326	5	5	9	10	12	10	8	11	12	14	12	6	114
Zaire	Kisangani	396	7	9	14	13	14	11	11	14	15	17	15	12	152
	Kananga	657	12	12	14	15	8	2	2	5	10	13	15	15	122
	Kamina	1106	21	20	19	13	2	0	0	1	6	12	18	22	134
Angola	Luanda	69	2	3	6	9	2	0	0	0	1	2	4	3	32
	Huambo	1700	15	12	18	13	2	0	0	0	3	12	18	16	109
	Saurimo	1081	15	13	16	14	1	0	0	2	7	10	17	15	110
Namibia	Windhoek	1725	10	10	10	5	2	1	1	1	1	3	5	8	55
	Tsumeb	1311	12	11	9	4	1	0	0	0	0	3	7	10	57
Botswana	Tsabong	960	5	5	6	4	2	1	1	1	1	2	3	5	36
	Mahalapye	1006	10	9	7	4	2	1	1	0	2	4	7	9	56
Lesotho	Maseru	1554	10	10	10	7	5	2	2	2	3	7	8	9	75
Swaziland	Mbabane	1145	17	15	15	10	6	3	3	5	9	14	17	18	132
Mozambique	Beira	16	12	11	12	7	6	5	4	3	3	3	7	10	83
	Lichinga	1356	21	19	14	10	2	2	0	0	1	2	5	19	97
Zimbabwe	Harare	1471	15	13	9	4	1	1	0	0	1	3	10	13	71
	Bulawayo	1345	10	8	5	3	1	0	0	0	1	3	8	10	50
	Chipinge	1132	13	13	11	6	3	4	3	3	3	5	9	12	87
Malawi	Chileka	766	15	13	11	5	1	1	1	0	0	3	8	12	70
Zambia	Mongu	1053	21	18	15	4	0	0	0	0	1	8	13	19	99
	Kasama	1382	24	19	21	7	1	0	0	0	0	3	16	22	113
	Kabwe	1206	22	18	14	3	0	0	0	0	0	3	12	19	92
Tanzania	Tabora	1190	12	11	13	10	3	0	0	0	1	2	9	15	76
	Dar es Salaam	58	6	6	11	18	13	5	4	4	5	5	7	8	92
	Songea	1067	18	17	18	12	3	0	0	0	1	1	4	12	86
Kenya	Nairobi	1624	4	4	9	15	14	6	3	4	4	6	12	8	89
	Nanyuki	1946	4	4	9	17	14	8	8	10	10	14	13	9	120
	Lodwar	515	1	1	2	4	3	1	2	1	1	1	1	1	19
Uganda	Gulu	1105	3	4	9	14	16	13	14	17	14	14	9	5	132
	Entebbe	1155	7	8	13	18	17	10	7	8	7	9	12	11	127
Burundi	Bujumbura	782	17	16	18	21	13	3	1	2	8	13	20	20	152
Madagascar	Toliary	8	5	5	3	1	2	2	1	1	1	1	2	4	28
	Mananjary	6	17	17	19	15	15	15	14	13	10	8	11	13	167
	Antananarivo	1276	18	15	14	5	3	2	2	2	2	4	10	17	94

20 and 200 mm. The second dryest areas in Subequatorial Africa are those with a mean annual rainfall between 200 and 400 mm. They are found at three geographical locations: a.) parts of Angola, Namibia, Botswana, Zimbabwe and Mozambique, b.) northeastern Kenya, and c.) southwestern Madagascar (Figure 3.1, plus the more detailed country rainfall maps in Chapter VI).

3. Seasonal variations

The seasonal rainfall variations differ from area to area. One common feature for the greater part of Subequatorial Africa is that the rainy season starts around the end of the year (October, November) and lasts until March or April. The only exception to this pattern is in the area comprising Kenya and some parts of Tanzania, Uganda and Zaire where there are either two rainy seasons or no pronounced rainy season at all.

E. AIR HUMIDITY

Among the various expressions for air humidity, relative humidity is the most widely used and data for it are available for the largest number of stations.

1. Mean annual relative humidity

The areas with the highest annual relative humidity are those that receive the highest amount of annual rainfall (discussed earlier in this chapter). The relative humidity in these areas is between 80 and 85%. Conversely, the lowest annual relative humidity is observed in the areas with the smallest amount of rainfall. The relative humidity in these areas is between 30 and 50%. The rest of Subequatorial Africa has a mean annual relative humidity of between 50 and 80%.

2. Seasonal variations

The seasonal variations in relative humidity are affected not only by the rainfall regime but also by proximity to the sea and to some extent the air temperature.

The proximity of large water bodies leads to a very uniform relative humidity throughout the year (Table 3.5). At stations along the coast, the difference between the relative humidity of the most and least humid months of the year is only 3 to 10% (Luanda, Beira, Dar es Salaam, Entebbe, Toliary, Mananjary). On the other hand, stations located inland with a

Table 3.5. Mean monthly and annual relative humidity (percent) at selected stations in Subequatorial Africa

COUNTRY	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Gabon	Libreville	15	86	85	85	86	84	81	79	80	83	87	88	86	84
	Makokou	515	84	83	83	83	84	87	87	85	83	85	85	85	84
Congo	Brazzaville	316	81	80	79	80	82	80	78	73	73	77	80	82	79
	Impfondo	326	84	81	81	83	84	86	86	86	85	86	86	85	84
Zaire	Kananga	657	84	82	84	84	78	66	77	79	82	81	84	85	80
	Kamina	1106	85	85	84	81	68	50	43	47	63	73	81	85	70
Angola	Luanda	69	80	79	80	84	83	82	83	85	84	82	81	81	82
	Huambo	1700	74	68	76	70	53	41	37	30	41	61	74	74	58
	Saurimo	1081	79	77	79	74	50	38	33	36	56	67	76	78	62
Namibia	Windhoek	1725	41	56	53	44	35	33	26	20	18	22	30	35	34
	Tsumeb	1311	56	57	65	57	45	37	35	27	22	27	38	48	43
Botswana	Tsabong	960	44	50	55	56	56	55	49	45	38	36	38	39	47
	Maun	945	71	73	67	57	50	46	40	33	30	36	54	66	52
Mozambique	Beira	16	76	77	78	78	75	79	80	79	78	75	75	76	77
	Lichinga	1356	87	88	85	86	79	77	70	68	64	57	62	82	75
Zimbabwe	Harare	1471	75	75	72	64	58	54	50	45	42	44	57	68	58
	Bulawayo	1345	74	76	71	63	56	58	50	43	42	44	60	69	59
Malawi	Chileka	766	79	80	80	75	70	69	63	57	52	50	60	74	67
Zambia	Mongu	1053	77	80	75	65	55	49	43	34	31	41	65	75	57
	Kasama	1382	80	83	80	76	64	60	55	48	43	41	61	78	64
	Kabwe	1206	81	80	77	71	63	61	54	48	41	41	61	79	63
Tanzania	Tabora	1190	71	72	73	70	61	54	48	45	42	43	52	66	58
	Dar es Salaam	58	72	78	81	82	81	78	78	75	76	76	79	79	78
	Songea	1067	77	78	80	79	79	71	67	63	59	56	56	70	69
Kenya	Nairobi	1624	72	68	69	76	77	77	79	75	70	64	72	74	72
	Lodwar	515	43	41	45	54	51	51	51	49	45	44	46	47	47
Uganda	Gulu	1105	51	53	60	71	77	77	79	79	76	72	66	59	68
	Entebbe	1155	78	78	80	83	83	82	81	81	80	79	79	79	80
Burundi	Bujumbura	782	79	77	80	82	72	67	65	63	66	68	75	75	72
Madagascar	Toliary	8	76	76	76	76	74	75	73	73	73	74	74	76	75
	Mananjary	6	84	84	85	85	86	86	86	84	83	82	82	84	84
	Antananarivo	1276	84	84	85	82	80	80	80	77	74	71	76	82	80

more continental climate have a much larger range between the dryest and the most humid months - over 40% (Kamina, Huambo, Tsumeb, Maun, Mongu, etc.).

For the prevailing number of stations in Subequatorial Africa, the most humid months are those during the rainy season, while the least humid months are those at the end of the dry season. There are some exceptions, due mainly to the temperature effect; at Makokou, Beira, Nairobi and Gulu the most humid month is the coolest one.

F. PAN EVAPORATION

Data for Class A pan evaporation are scarce, and therefore no reliable conclusions can be derived. The rainfall and air humidity data have already indicated the wet and humid, as well as the dry, areas in Subequatorial Africa. The data on Table 3.6 show examples of pan evaporation data at some locations in Subequatorial Africa.

In the humid areas, the monthly and annual pan evaporation is small - mostly about 1.5 to 3.0 mm/day. The seasonal variations are also small. In the very dry areas, like Windhoek or Maun, the seasonal values vary from about 6 to 13 mm/day, while the annual values are around 9 mm/day. For the rest of Subequatorial Africa, the mean monthly pan evaporation is mostly between 3 and 8 mm/day.

Table 3.6. Mean monthly and annual pan evaporation (mm/day) at selected stations in Subequatorial Africa

COUNTRY	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Gabon	Libreville	15	2.3	2.4	2.3	2.3	2.5	3.0	3.2	3.1	2.8	2.4	2.0	2.2	2.5
Zaire	Kananga	657	3.9	4.4	4.5	4.3	4.6	4.0	4.0	3.7	4.7	4.7	4.6	4.3	4.3
Angola	Luanda	69	2.6	3.0	2.6	2.0	2.0	2.0	1.7	1.6	1.8	2.4	2.6	2.5	2.2
	Huambo	1700	3.0	3.3	2.7	3.2	5.0	5.8	6.7	8.3	7.6	5.1	3.3	3.2	4.8
Namibia	Windhoek	1725	11.4	9.3	8.0	8.2	7.4	6.4	6.6	8.8	11.1	12.5	11.9	12.2	9.5
Botswana	Maun	945	8.5	7.4	6.9	7.0	6.1	5.9	7.1	8.9	11.0	13.0	10.4	8.3	8.4
Mozambique	Beira	16	5.5	5.5	5.0	4.5	3.9	3.4	3.3	3.8	4.6	5.5	5.7	5.4	4.7
Zimbabwe	Harare	1471	5.6	6.2	5.6	5.2	4.5	3.8	4.3	5.4	7.3	8.4	6.5	5.5	5.6
	Bulawayo	1345	6.0	5.2	5.5	4.8	4.1	3.6	3.9	5.2	7.0	7.9	6.3	5.9	5.4
Zambia	Mongu	1053	5.4	5.0	5.4	5.9	5.6	5.3	6.0	7.5	9.6	9.3	6.1	5.1	6.3
	Kasama	1382	4.6	4.3	4.5	5.0	5.1	5.1	5.4	6.7	8.0	8.4	5.8	4.5	5.6
Tanzania	Dar es Salaam	58	6.7	7.2	6.1	5.0	5.5	5.2	5.2	5.8	6.5	6.7	6.9	6.8	6.1
Kenya	Nairobi	1624	5.0	5.8	5.4	4.2	3.1	3.0	2.6	2.8	4.0	5.0	4.2	4.3	4.2
Uganda	Gulu	1105	7.0	7.6	7.0	6.2	5.3	5.5	4.5	5.0	5.5	5.9	5.5	6.2	5.9
	Entebbe	1155	4.7	5.5	5.6	5.7	4.8	4.2	4.2	4.3	4.8	5.3	4.8	4.6	4.9
Burundi	Bujumbura	782	4.2	4.1	4.2	4.2	4.5	4.8	4.5	4.8	5.4	4.6	4.3	4.1	4.5
Madagascar	Toliary	8	5.2	5.0	5.2	4.8	4.8	4.5	5.0	4.9	5.3	5.1	5.4	4.7	5.0
	Antananarivo	1276	3.0	2.9	2.6	2.9	2.9	2.7	2.6	3.2	3.9	4.6	4.2	3.0	3.3

Chapter IV

AGRICULTURE

Agriculture is the dominant sector of the economy for the developing countries in Subequatorial Africa. About 81 percent of the economically active population is engaged in agricultural production. Agriculture is also a major contributor to the Gross Domestic Product (the total value of goods and services produced within a country during a fixed period). Agricultural exports, mainly commercial crops, are a major source of hard currency. Most important, however, is the fact that agriculture provides food for the rapidly growing population. The most widely used subsistence crops are maize, millet and sorghum among the cereals, cassava and sweet potatoes among the roots and tubers, beans among the pulses, and groundnuts.

This chapter deals with agricultural problems common to all countries: types of agricultural practices, land use, descriptions of the agricultural crops. Further analysis of the agriculture in each country is made in Chapter VI.

A. AGRICULTURAL PRACTICES

Agricultural practice in subequatorial Africa has different forms and types, varying not only from country to country but also within a country. As a matter of fact, in many areas of Subequatorial Africa the different agricultural practices exist side by side. There are two basic types of farming practice: indigenous (or traditional) farming and modern agricultural practice. Between them, various transitional types of farming also exist.

1. Traditional Farming

The indigenous (or traditional) type of farming is most widespread. It is practiced on the greater part of the agricultural land and involves the majority of the population. Its main features are:

- Small scale. The size of the fields is small. In most cases only enough land is developed to satisfy family needs. The agricultural fields usually surround the dwelling where the farmer lives.

- Labor intensive. There are areas in Subequatorial Africa where all field work is carried out by manual labor. In other areas domestic animals are used for some of the work.
- Low level technology. There is very little use of fertilizers, pest and disease control, irrigation and drainage, high yielding varieties, soil conservation, etc. The agricultural tools are primitive: no machines are used. Many farmers still use the system of "shifting cultivation" where a piece of land is cleared of trees and bushes, used several years for growing agricultural crops, and then abandoned while a new lot is cleared nearby.
- Little or no crop specialization. Farmers at a given place usually grow most of the crops they need, regardless of the fact that the climate and/or the soils in their location might not be very suitable for some of the crops.
- Low yields. Due mainly to the low level of technology, as well as the lack of specialization and some natural factors (Chapter V), yield of food crops in Southern Africa is one of the lowest in the world.
- Little or no marketing. Most of the agricultural production is for local consumption. Very little is marketed within the boundaries of the country, and even less (if any) goes for export abroad.

2. Modern Farming

Modern agricultural practices can be found in varying degrees of development in all Subequatorial African countries. Although applied mainly to growing commercial crops, many farms grow food crops as well - mostly maize and wheat. The modern type of farming food crops is carried out on a small part of the agricultural land (except perhaps in Zimbabwe), and involves a smaller part of the population. Its main features are larger size farms (and fields), mechanization, use of modern technology (fertilizers, pest and disease control, high yielding varieties, etc.) crop specialization, higher yields, and production primarily for the market-domestic and foreign.

3. Transitional Farming

The transitional types of farming are improved indigenous farming techniques. By applying some modern technology, many farmers are narrowing the gap between indigenous farming and modern agricultural practices. In some cases the transitional farming is closer to the indigenous, in others to the modern agriculture. Often it is somewhere in the middle between them. Apparently narrowing the gap is a gradual and slow process, depending on a variety of socio-economic and political factors.

B. LAND USE*

The countries in Subequatorial Africa vary considerably in size. The largest is Zaire with 234 million hectares (Table 4.1), followed by Angola and Tanzania. The smallest are Swaziland, Lesotho, Rwanda and Burundi - each has only about 2-3 thousand hectares. The total area of all 18 countries is about one billion hectares, but only a small fraction of it is used for agricultural purposes. The area planted to annual crops is about 39 million hectares, or only about 4 percent of the total area. The area planted to perennial crops is even smaller - 5 million hectares, or 0.5 percent of the total land area. A comparison with the land use in the US and France** shows that agricultural crops (both annual and perennial) occupy a much larger portion of their total land area - about 20 and 35 percent respectively.

The size of the area under irrigation in Subequatorial Africa is very small, despite the dry climate prevailing over a great part of the region. In 1979, there were only 768,000 hectares under irrigation, or 1.7 percent of the area planted to agricultural crops (both annual and perennial). By comparison, 8.9 percent of the crop area in the US and 4.5 percent of that in France, were under irrigation.

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* All data are from the FAO Production Yearbooks

** Here as well as on several other occassions, the agriculture in Subequatorial Africa is compared with that of the US and France. As their climate and their economic potential are different from Africa, the comparison is made only with the purpose of getting a better understanding of the structure of the African agriculture and the magnitude of the problems encountered by the developing countries.

Table 4.1. Land Use in Subequatorial Africa (in 1,000 hectares)

Country	Total Area	Annual Crops		Perennial Crops		Pastures		Irrigated Area	
		1969-1971	1979	1969-1971	1979	1969-1971	1979	1969-1971	1979
1 Gabon	26,767	180	288	102	162	4,917	4,700	-	-
2 Congo	34,200	617	655	12	12	10,000	10,000	-	-
3 Zaire	234,541	5,419	5,707	480	550	9,221	9,221	-	5
4 Angola	124,670	2,917	2,950	550	550	29,000	29,000	-	-
5 Namibia	82,429	650	655	1	1	52,906	52,906	6	8
6 Botswana	60,037	1,169	1,360	1	-	42,800	44,000	2	2
7 Lesotho	3,035	364	320	-	-	2,055	2,000	-	-
8 Swaziland	1,736	149	150	3	4	1,342	1,250	24	30
9 Zimbabwe	39,058	2,335	2,465	15	15	4,856	4,856	47	60
10 Mozambique	80,159	2,757	2,850	224	230	44,000	44,000	61	68
11 Malawi	11,848	2,090	2,280	18	18	1,840	1,840	4	10
12 Zambia	75,261	4,950	5,050	6	8	35,000	35,000	3	5
13 Tanzania	94,509	3,867	4,110	941	1,030	35,000	35,000	46	62
14 Burundi	2,783	1,048	1,100	164	187	435	435	5	5
15 Rwanda	2,634	537	715	180	252	818	480	1	2
16 Uganda	23,604	3,787	4,080	1,200	1,530	5,000	5,000	4	5
17 Kenya	58,265	1,625	1,790	445	480	3,837	3,770	29	46
18 Madagascar	58,704	2,060	2,510	310	490	34,000	34,000	337	460
All 18 African countries	1,014,240	36,521	39,035	4,652	5,519	317,027	317,458	569	768
USA	936,312	188,706	186,552	1,765	1,741	243,911	242,038	16,002	16,697
France	54,703	17,346	17,413	1,673	1,537	13,745	12,903	750	860

The size of the area planted to different food crops (the FAO data report harvested instead of planted area) indicates that the cereal group of crops occupy the largest portion of the food crops area - about 14-15 million hectares (Table 4.2). Next come the roots and tubers with about 5-6 million hectares, pulses with about 3 million hectares, and groundnuts with 1.7 million hectares. The same order exists in the US and France, although the size of the area planted to roots and tubers is much smaller.

Maize is the most widespread crop produced in Subequatorial Africa, followed by cassava, sorghum, rice, groundnuts, millet and beans.

C. FOOD CROPS

This section contains description of plant characteristics, ecology and agrometeorological requirements, field operations, geography and utilization of the most important crops grown in Subequatorial Africa. Their economic importance for each country, distribution within a country and crop calendars are discussed in Chapter VI.

1. Cereals

Excluding Madagascar, the countries in Subequatorial Africa grow cereals on over 13 million hectares. Maize is the most widely grown (66%), followed by millet* (13%), sorghum* (11%), rice (5%), and wheat (2%). Some smaller areas are planted with barley (used for brewing), oats and other cereals of minor importance.

In Madagascar the ratio between the cereal crops is quite different. Rice is the predominant crop, planted on about 84% of the cereal area.

Nearly all cereals belong to the "Gramineae" family. Their fruit is commonly known as "grain" and therefore cereals are also called grain crops. The grains are very nutritious, consisting mainly of starch, plus some protein and traces of minerals and vitamins.

Despite many common botanical and genetic features, the cereal crops have quite different agrometeorological requirements. They will be discussed separately for each crop.

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* Four of the countries in this project report millet and sorghum together. Angola reports them as millet. Malawi, Lesotho and Swaziland report them as sorghum.

Table 4.2. Harvested area (in 1,000 hectares), yield (in kg/hectare) and production (in 1,000 metric tons) of selected crops

Crop	Country*	Harvested area		Yield		Production	
		1968-1970	1978-1980	1968-1970	1978-1980	1968-1970	1978-1980
Cereals, total	Africa	10,799	14,577	1,123	1,032	12,123	15,042
	USA	60,461	69,054	3,278	4,101	198,235	283,250
	France	9,360	9,828	3,494	4,642	32,707	45,622
Wheat	Africa	312	292	1,292	1,836	403	536
	USA	19,623	25,604	2,011	2,225	39,471	56,965
	France	3,957	4,270	3,569	4,999	14,122	21,344
Maize	Africa	5,963	8,848	1,104	981	6,584	8,681
	USA	22,650	29,325	4,967	6,310	112,514	185,041
	France	1,232	1,853	5,062	5,212	6,236	9,657
Rice (paddy)	Africa	1,344	1,802	1,750	1,567	2,352	2,824
	USA	849	1,232	4,984	5,043	4,231	6,202
	France	23	8	3,913	3,375	90	27
Millet	Africa	1,745	1,631	889	738	1,552	1,204
	USA	-	-	-	-	-	-
	France	-	1	-	3,000	1	3
Sorghum	Africa	1,400	1,916	854	883	1,196	1,691
	USA	5,517	5,265	3,292	3,422	18,160	18,019
	France	54	83	3,537	4,181	191	347
Roots & tubers, total	Africa	4,186	5,419	6,470	5,982	27,085	32,415
	USA	624	557	23,631	28,434	14,746	15,838
	France	435	268	21,455	27,862	9,333	7,467
Potatoes	Africa	135	245	5,059	6,098	683	1,494
	USA	569	513	24,815	29,762	14,120	15,268
	France	435	268	21,455	27,862	9,333	7,467
Sweet potatoes	Africa	906	596	4,042	6,715	3,662	4,002
	USA	54	44	11,537	12,886	623	567
	France	-	-	-	-	-	-
Cassava	Africa	3,105	4,471	7,244	6,023	22,492	26,930
	USA	-	-	-	-	-	-
	France	-	-	-	-	-	-
Pulses, total	Africa	2,888	3,187	550	559	1,587	1,780
	USA	752	768	1,410	1,609	1,060	1,236
	France	77	65	1,623	2,754	125	179
Beans (dry)	Africa	1,157	1,614	609	594	705	958
	USA	580	631	1,402	1,571	813	991
	France	41	17	1,244	1,706	51	29
Soybeans	Africa	8	58	375	1,466	3	85
	USA	16,858	2,760	1,812	19,570	30,547	54,012
	France	-	8	-	1,875	-	15
Ground-nuts in shell	Africa	1,523	1,741	647	684	985	1,191
	USA	588	598	2,073	2,584	1,219	1,545
	France	-	-	-	-	-	-

*"Africa" in this table means all 18 African countries investigated in this report.

MAIZE (Zea mais)

Maize is also called Indian corn; in the USA it is identified as corn. Unlike Europe and North America where it is used mainly as livestock fodder, maize is consumed mainly by the population in Subequatorial Africa. Maize is most commonly used by drying the grains and grinding them for the preparation of various porridge-like meals, named differently in each country. Whole maize grains are also cooked, alone or with beans. Sometimes maize is roasted while the grains are still soft and eaten on the cob. Maize flour is used in some parts of Africa to prepare bread.

Several features of the maize plant explain the high popularity it has in Subequatorial Africa, as compared with the other cereals: much higher yield potential, less frequent essential damages caused by pests and diseases, no attack by birds, less cumbersome methods of land preparation and growing (no threshing necessary).

The plant characteristics of maize grown in Subequatorial Africa are the same as in other parts of the world. There are several types of maize: dent (with a depression in the grain; it is high yielding and is the most widely grown type in Subequatorial Africa), flint (with hard grains), flour type (soft grains), sweet type. Each type has many varieties, which differ essentially in:

- Height of the plants. Some varieties are only 120-130 cm high, others reach 4 m or more. Most varieties however, are about 2 m high.
- Rooting depth. It varies, depending not only on the variety, but also on the types of soils and climate. In areas with evenly distributed and sufficient rainfall for optimal growth, the roots are located mostly in the top one meter of the soil. In deep, well drained fertile soils, maize roots are known to penetrate up to 3.0 - 3.5 meters. In most cases, however, roots do not go beyond 2 m of in depth.
- Duration of the growing season. There are early, medium and long maturing varieties. The most common duration of the growing season is between 3 and 5 months, with sowing done at the beginning of the rainy season. Naturally, the duration of the growing season depends also on the temperature conditions of the area. Thus, in the cool highlands of Kenya, at an altitude of 2,300 - 2,500 m, the long maturing varieties have a growing period of about one year. Acland (1971) has found that in Kenya, for a

given variety, each additional 100 m of altitude adds about 10 days to the growing season. Throughout Subequatorial Africa, farmers usually leave maize plants to dry in the field for several weeks before harvesting them.

- Agrometeorological requirements. If maize varieties differ essentially in the duration of their growing season, as well as in the height of the plants, the rooting depth, the number of leaves, etc., it is logical to expect that their agrometeorological requirements will also be quite different. Indeed, maize in Subequatorial Africa is grown in areas with as little as 300 mm of rainfall during the growing season of the crop (although such amount is much less than the crop requires for optimal growth), and in areas where the rainfall during the growing season exceeds 2,000 mm (such amount might be more than the crop requires). Agricultural practice in Subequatorial Africa indicates that best maize yields are achieved if the annual amount of rainfall is between 750 and 1,500 mm. The most critical time for water supply is around the middle of the growing season of the crop - when flowering and silking occur. Below optimal moisture conditions at this time have an adverse effect on the pollination, which leads to yield reduction. It should be noted that maize is also quite sensitive to excessive moisture. The plants require a well aerated soil, especially during the first 4-5 weeks of the growing season. Too much rainfall during this period reduces the yield. Throughout the whole growing period, maize does not tolerate waterlogging - the plants might even die if the soil is completely saturated with water for more than one day.

As for the temperature requirements of the crop, there are varieties suitable for quite different temperature conditions. Maize is grown in the warm coastal lowlands, where the high temperatures at night cause higher respiration which in turn leads to lower yield. Maize is grown also in the cool climate of the highlands, up to about 2,800 - 2,900 m altitude. In Eastern Africa, the highest yields are obtained at altitudes around 2,000 m where the day time temperatures are between 19 and 24°C and the night time about 10-14°C. Maize is killed by frost.

- Yield. As known, yields depend on weather, soils, technological standard and variety. As far as the latter is concerned, varieties with shorter growing season (3-4 months), normally give lower yields than varieties with a growing season of 5 or 6 months.

The Subequatorial African countries with the largest area planted to maize are Kenya, Tanzania, Zimbabwe, Malawi and Zambia (in that order) - each one with over 1 million hectares. Several countries (Zaire, Angola, Mozambique and Uganda) grow about 0.6 - 0.7 million hectares. The smallest areas with maize are in the warm and humid climates of Gabon, Congo and northern Zaire. The area with maize in Rwanda, Burundi, Swaziland and Lesotho is not very large, but this is due to the smaller total area of these countries - otherwise maize is quite popular there.

Throughout Subequatorial Africa maize is grown in smallholdings as a subsistence crop. Often farmers interplant it with beans or other crops. Big modern farms that produce maize for marketing (including export) exist mainly in Kenya, Zambia, Zimbabwe and Malawi.

MILLET

The name "millet" is applied to many annual grasses grown mainly for their grain. Their leaves are also used as fodder. Although not closely related botanically, nearly all of these species have small and round seeds covered with a hard coat. The seeds are nutritious - besides starch, they contain some protein and useful mineral salts. Millet seeds are usually ground into flour, used for the preparation of various meals. Sometimes they are used also for brewing.

The most widely grown millets in Subequatorial Africa are:

- Bulrush millet (Pennisetum typhoideum). Also known as pearl millet, it grows as high as 2 - 3 m and most varieties produce tillers. On top of the solid and errect stem it has a long (15 - 25 cm), compact ear with numerous seeds. It is the most drought resistant among the millets.
- Finger millet (Eleusine coracana). It is shorter - the stem normally reaches 1 - 1½ m height. The ear consists of about 6 spikes resembling fingers. Each spike is about 10 cm long.
- Proso millet (Panicum miliacem). It is also known as broom corn, or common, millet. It has a thin stem of about 1 m height which sometimes has branches.
- Foxtail millet (Seteria italica). It is also known as Italian millet. It is about 1½ m high.

problem in the relatively humid climate of Uganda and therefore farmers prefer millet with its excellent storage capabilities. Other countries with larger areas planted to millets are Zimbabwe, Tanzania and Zambia. No millet is grown in Gabon, Congo and Madagascar. Nearly all millet grown in Subequatorial Africa is for local consumption.

SORGHUM

The name "sorghum" is applied to different annual and perennial grasses. Most of them are grown for their grain for human consumption mostly as porridge, some bread, but some species are grown for fodder, brewing, sweet juice, or making brooms. The grain group of sorghums has several main representatives: Sorghum (Sorghum vulgare), Kaffir corn (Sorghum caffrorum), Dura (Sorghum dura), and Guinea corn (Sorghum guineense). Each has different varieties. As a result of this diversity, the sorghum plants grown in Southern Africa differ in many ways:

- Stems. Their height varies from 1 to 4½ m.
- Tassels (heads). They can be compact or open, errect or bent, small or large.
- Seeds. They can be white, yellow, brown or red. The white are the most palatable, the dark mostly for brewing. Some seeds have a persistent coat, on others it is easily removable. Some seeds are hard, others soft.
- Tillers. Most grain varieties produce several tillers per plant. Other kinds of sorghum have only one tillr or no tillers at all.
- Duration of the growing season. it varies widely - from 3 to 8 months - due only to varietal differences. In addition, the temperature conditions obviously have an influence on the duration of the growing period.

The qualities that make sorghum a desirable crop are: it is drought resistant (discussed in more details below), it has nutritious seeds (more or less the same as maize), it is resistant to waterlogging, it yields reasonably (more than millet but less than maize; except in drier areas where it yields better than maize), it yields reasonably well on less fertile soils, it can be ratooned - after harvesting a crop, the plants remain alive and soon produce a second, later even a third crop. The second and especially the third, ratoon crops do not produce yields as good as the first crop, and therefore the practice is not very popular in Subequatorial Africa.

The disadvantages of sorghum are: in areas with good or moderate amounts of rainfall and good or moderat soils it yields less than maize, it is often heavily attacked by birds, it requires more labor (land preparation, threshing, etc.).

The water requirements of sorghum are slightly higher than those of millet, but lower than those of maize. Unlike maize, sorghum gives a reasonable yield not only when the rainfall amount during the growing season is below the optimal but also when the distribution of rainfall is very uneven (long dry spells). The reasons for this are some specific biological features of the sorghums. First, the plants can become almost dormant during long dry spells, and then resume their growth when the rains come again. Second, the leaves of sorghum are narrower than those of maize (less evaporative surface); they curl during drought, further reducing the evaporative surface. Third, sorghum has one of the largest and deepest root systems among the agricultural crops. This enables the plants to absorb more water from the soil - stored there either before the growing season or by excessive rains during the growing season.

The optimal water requirements of sorghum, like those of any other agricultural crop, vary depending on the botanical features of the varieties (height of the plants, number of leaves, etc.), on the duration of their growing season, on the fertility of the soils (fertile soils produce bigger and healthier plants which require more water), on the climate of the area (higher air humidity decreases the water consumption), etc. There are, therefore, no common figures for the optimal water requirements of sorghum. The agricultural practice in Subequatorial Africa shows that for most of the grain sorghum varieties, a rainfall of about 250-350 mm during the growing season (or 500-900 mm for the whole year) will lead to a good yield. Sorghum yields better in wetter areas, but it needs some dry weather at the end of the growing season or the grain can be attacked by molds and other diseases.

Sorghum requires warm climate. It can tolerate very hot weather but is killed by frost. Like millet, most of the sorghum in Subequatorial Africa is grown in areas with altitude between 500 and 1,500 m, but sometimes farmers grow it in areas up to 2,500 m.

Sorghum is grown in pure stands or mixed with other crops such millet or pulses. Sometimes early and late maturing varieties of sorghum are grown together. The plants mature at different times-often over a period of up to two months, which not only decreases the workload (harvesting is done by hand) but also eliminates the need to store a great part of the grain.

Broadcasting of the seeds by hand is the common practice for sowing, especially among smallholders, but sowing in rows also takes place. Sowing normally is carried out at the beginning of the rainy season, in well prepared fields. During the first month after emergence, the plants grow slowly and weed control is essential. In areas with two rainy seasons, sorghum (like millet) most often is grown during the shorter one when the rainfall is less reliable. Sometimes, although rarely, a main crop of sorghum is grown during the main rainy season and a ratoon crop during the following shorter rainy season.

The countries with the largest area planted to sorghum are in the eastern part of Subequatorial Africa: Tanzania, Uganda, Mozambique and Kenya, followed by Botswana, Zimbabwe, Rwanda and Burundi (in that order). Very little, or none at all, is grown in the western part of Subequatorial Africa: Gabon, Congo, Zaire, Angola, Namibia, or Madagascar.

RICE (Oriza sativa)

The plant characteristics (height of the plants, number of tillers, yielding potential, etc.) of the rice grown in Subequatorial Africa are the same as elsewhere. They depend largely on the variety. The duration of the growing season also depends mainly on the variety - in most cases it is between 3 and 5 months.

Two types of rice are grown in Subequatorial Africa: irrigated rice (called also wet or swamp rice) and rainfed rice (also called dry, upland or hill rice). Unfortunately, there are no statistical data for the exact area planted to each of these types. It is known however, that irrigated rice occupies a much larger area than rainfed.

Irrigated rice is grown both in the lowlands - Madagascar, Zaire, Tanzania and Mozambique - and in the highlands - Madagascar, Tanzania. The main factor is the availability of water. Sources for water are rainfall, rivers, streams and groundwater storages. The rice fields are leveled and then divided into small plots, separated by mud walls called bunds. They

hold the water in the field. The seeds can be sown directly into the permanent fields, but more often are sown in nurseries and transplanted into the permanent fields when the plants reach a height of about 15 cm (or are about 3-5 weeks old). The latter are kept under water for most of the growing season, suppressing the weeds and at the same time providing water for the rice plants.

In areas with an abundant and uninterrupted supply of water - either by rainfall or from rivers - rice is grown continuously throughout the year. An average of 2 - 2½ harvests can be obtained per year. In areas where the main source of water is the unevenly distributed rainfall, sowing of the nurseries starts 2-3 weeks before the beginning of the rainy season, while transplanting is carried out after the arrival of the reliable rains; usually one crop is harvested per year.

Rainfed rice is grown either in areas that are not suitable for irrigation (e.g., hills), or in areas with an inadequate supply of water for irrigation. Sometimes rainfed rice is grown in flat lowland areas - either inundated or impounded by field dykes to retain the rain water for several days. In some countries, rice is grown in mangrove swamps. The seeds of the rainfed rice are sown directly into the permanent fields, mostly by hand broadcast, at the beginning of the rainy season. The preparation of the fields and the methods for growing the crop are the same as for the other cereals. Yields from rainfed rice are low - not only because of the below optimal water regime (in most cases) but also the poorer soils on which upland rice is grown.

The water requirements of rice depend on local climate, variety, cultural practice, and other factors. The International Rice Research Institute (IRRI, 1974) has estimated that in the tropical and subtropical conditions of Southern Asia (with climate similar to that in many areas of Subequatorial Africa), the water needed for growing irrigated rice is about 200 mm per month during the growing season of the crop. This amount includes water needed for evapotranspiration and water lost as percolation or seepage in the soil. The optimal temperature conditions for rice are between 18 and 33°C; about 25-28°C is the best.

As indicated earlier, Madagascar is the biggest producer of rice in Subequatorial Africa and one of the biggest in the world. Among the other

Subequatorial Africa countries, relatively large areas with rice are found in Zaire, Tanzania and Mozambique. No rice, or very little rice, is grown in Gabon, Namibia, Botswana, Lesotho, Swaziland, Zimbabwe, Zambia, Rwanda or Burundi.

WHEAT (Triticum spp.)

Despite the fact that wheat has the most nutritious grain among the cereals (most protein), it is grown very little in Subequatorial Africa. The main reason for this is the discrepancy between the agrometeorological requirements of the crop and the existing climatic conditions. Wheat requires cooler and less humid air, especially during the early stages of development, coupled with a good, steady water supply. Such conditions exist mainly in some of the highlands in the eastern half of Subequatorial Africa - Kenya, Tanzania, Zimbabwe, and Lesotho. In Kenya, where about half of the wheat in Subequatorial Africa is produced, the crop is grown between 1,800 and 2,900 m. In Tanzania wheat grows in areas between 1,200 and 2,600 m. The altitudes at which the crop is grown in the other countries are similar.

Wheat is moderately drought resistant. The highest water demand is between earing (heading) and 1-2 weeks after flowering. In Kenya, wheat is grown in areas with a mean annual rainfall of about 750 mm or more. Only a small part of this amount, however, might fall during the growing season of the crop. There are cases in Kenya (Acland, 1971) when good yield has been obtained with as little as 100-150 mm of rain during the growing period, providing there was a good storage of soil moisture at sowing time. In some of the wheat growing areas of Tanzania (the western slopes of Mt. Kilimanjaro, for example), the mean annual amount of rainfall is only 550-600 mm. Wheat requires dry weather at the end of its growing season. Heavy rains and strong winds at that time may cause lodging, (i.e.,the crop falls to the ground).

As known, two types of wheat are grown in the temperate regions of the world: winter and spring. The wheat grown in Subequatorial Africa is only the "spring" type. It is ground into flour for making bread, although its baking qualities are not as good as in the temperature regions.

The duration of the growing season of wheat in Subequatorial Africa varies, depending on variety and altitude. It is mostly between 4 and 5

months, although it can be as short as 3 and as long as 7 months. Normally a change of 100 m in altitude leads to about 5 days change in the duration of the growing season. The time for sowing and harvesting varies not only from country to country, but also within a country. Normally, the crop is sown at the beginning of the rainy season (the longer one, if there are two) in order to ensure a good water supply. Another, equally important consideration is to secure relatively dry weather for harvesting; sowing is therefore sometimes delayed until the middle of the rainy season. In Kenya for example, most wheat is sown at the beginning of the rainy season (March, April), but in some areas (Molo) sowing is carried out in June and July.

Wheat is grown not only by smallholders, but to a large extent also by large farms where both sowing and harvesting are mechanized.

2. Roots and Tubers

Several crops in Subequatorial Africa are grown for their roots or tubers. Most important among them is cassava (about 83% of the area with roots and tubers), followed by sweet potatoes (11%), ordinary potatoes (5%), and yams. These crops are grown mainly in the more humid tropics, where cereal crops do not flourish. The roots and tubers crops are produced more cheaply and with less labor and attention than the cereals. They also can better adapt to diverse climatic conditions and suffer from few diseases and pests.

The roots and tubers are rich in starch (which provides calories), but very low in protein. Besides human consumption, small amounts are used as livestock feed and for industrial products such as starch and alcohol. Very few are exported outside Subequatorial Africa - mainly dried cassava chips to Europe.

CASSAVA

Cassava is also known as tapioca, manioc and yuca. Botanically it belongs mostly to Manihot esculenta. It is grown for its swollen roots which are used in several ways - boiled, ground into flour, eaten raw, or roasted. Young cassava leaves are also eaten in some countries.

Cassava is a shrub that normally grows to about 1.5 - 2.5 m in height. It is propagated by means of stem cuttings planted in rows (about 1.5 by

1.0 m). Planting is done at any time when the soil is wet - normally most plantings take place at the beginning of the rainy season. The growing period varies widely. Some varieties, mainly sweet ones, are ready for harvesting (swelling of the roots) about 8-10 months after planting. Other varieties, especially bitter ones, require up to two years to reach this stage. An important factor of the cassava plant is that after reaching maturity the swollen roots can remain in the soil for another 2-3 years without deterioration. The crop is therefore valued as a famine reserve. Furthermore, this quality of the cassava roots enables farmers to harvest it piecemeal (one or two at a time) over a long period, eliminating the need for storage.

Cassava is grown in pure stands or mixed with other annual crops - sweet potatoes, maize, and beans. Within several months, the annual crops are harvested and the cassava plants normally left alone until their own harvest. In some more humid areas, cassava is interplanted with some perennial plants - bananas, yams, and sugar cane. Where farmers practice shifting cultivation (the slash and burn method), cassava, due to its undemanding nature, is planted as the last crop in the arable break before the land reverts to a bush fallow.

Cassava is the most drought resistant crop among the roots and tubers. During dry spells the plants shed part of their leaves, reducing transpiration. Nevertheless, good yields are received only in areas with large amounts of evenly distributed rainfall. The exact water requirements of the crop are not known. Cassava needs a warm climate, and therefore is grown mainly in areas with altitude below 1,500 m. The nutrient requirements are small - good yields can be obtained even in relatively poor soils (the bulk of the crop consists of carbohydrates).

Most of the cassava in Subequatorial Africa is grown north of the 10th parallel, plus some coastal areas of Mozambique and Madagascar. Little cassava is grown in Zambia and Zimbabwe, and practically none in Namibia, Botswana, Lesotho and Swaziland.

SWEET POTATOES (Ipomea batatus)

Sweet potato is a perennial vine plant. Sometimes, however, farmers keep it in the field for one season only. The plant lies low on the ground

(up to about 40-50 cm high) and consists of many trailing stems. When stem nodes touch the soil, they produce new root tubers. The shape and color of the leaves and tubers differ essentially from one variety to another.

The plant is propagated by stem cuttings buried in the soil. Cuttings are planted at any time when the soil is wet, but normally this occurs at the beginning of the rainy season. Harvesting begins 3 to 5 months after planting, and the duration of this period depends both on variety and climate. The tubers are harvested piecemeal because storing them fresh is not possible for more than 3-4 days. They are mostly consumed boiled, but also are eaten roasted or fried. In some countries the tubers are ground into flour and mixed with sorghum or maize for making a porridge. Stems and leaves are used also as fodder for livestock.

As sweet potatoes grow actively and suppress other plants, they normally are not interplanted with other annual crops. Pure stands of sweet potatoes cover all of the ground. Nearly all sweet potatoes are grown in smallholdings.

Sweet potatoes are tolerant to drought - the vines do not wither during drought conditions, but tuber growth nearly stops. The plants grow well in areas with annual rainfall amounts between 750 and 1,300 mm. If the rainfall is evenly distributed, the sweet potatoes may be grown as a perennial; if there is a long dry season, the crop is grown as an annual. Sweet potatoes are more tolerant to cool weather than cassava; they grow well up to about 2,100 - 2,200 m altitude.

Most sweet potatoes in Subequatorial Africa are grown in Uganda, Rwanda and Burundi. They are quite popular also in many areas of Zaire, Tanzania, Kenya and Madagascar. Small acreages of sweet potatoes are planted in Gabon, Congo, Zimbabwe, Mozambique, Malawi, Zambia and Swaziland. Sweet potatoes are not grown in Namibia, Botswana or Lesotho.

POTATOES (Solanum tuberosum)

To distinguish them from the sweet potato the people in Africa refer to potatoes as Irish or European potatoes. They prepare potatoes the same ways as they are prepared in the rest of the world.

The potato plant grows up to about 50 cm high, mostly planted in rows (about 70 cm apart) but often irregularly spaced in the field. Potato

tubers are swollen underground stems. Small size tubers (called seed potatoes) are used for propagating the crop. Planting starts at the beginning of the rainy season. Potatoes have the shortest growing season among the roots and tubers crops - it takes about 3-4 months for the new tubers to be ready for harvesting.

As known, potatoes do not grow well in warm climate. In Subequatorial Africa, they are best suited to the cooler conditions from 1,600 - 1,700 m up to about 2,900 - 3,000 m altitude. Most of the potatoes are grown in the highlands of Eastern Africa - Kenya, Uganda, Rwanda, Tanzania, Malawi and in the highlands of Madagascar. The exact water requirements of the potatoes in Subequatorial Africa are not known. However, experience indicates that optimum growth can be achieved if the rains are steady (about 20-30 mm per week) and continue for about 3-3½ months.

YAMS (Dioscorea spp.)

The area planted to yams in Subequatorial Africa is very small - about one percent of the area planted with roots and tubers. Yams are climbing plants and need stakes or other plants for support. Their swollen roots (tubers) can be boiled, roasted or ground into flour.

The growing period of yams is about 8 months. Little is known of their agrometeorological requirements in Subequatorial Africa, except that they prefer a wet, warm climate.

3. Bananas and Plantains

Bananas and Plantains belong to the genus "Musa" and have many varieties, each with a different size, shape, color and flavor. The species which contain more sugar are eaten raw and are called bananas. The species containing more starch are cooked and are called plantains, or cooking bananas. Some species are fermented into beer.

Bananas are shallow rooting plants - most of the roots are found in the top 20 cm of the soil. The plants have a large structure of underground stems called rhizomes. The latter produce suckers which later develop into new plants. Sometimes farmers cut the suckers, or even pieces of the rhizome, and transplant them. Each stem bears one inflorescence containing the flowers which develop into fruits. Cultivated banana varieties do not pollinate.

Most banana varieties begin to bear fruit 11 to 15 months after the appearance of the sucker above the ground. In areas without a pronounced dry season, suckers appear continuously throughout the year. In areas with dry and wet seasons, most of the suckers appear at the beginning of the rainy season. Transplanting by farmers is also done at this time.

Bananas in Subequatorial Africa are grown in different ways: as single plants or in plantations, in pure stands or mixed with other crops. Single plants are to be found around or close to farmers' huts. Plantations (plants are grown in rows) exist mainly for supplying large urban centers or when interplanted with coffee. Bananas can also be interplanted with food crops such as maize, beans, potatoes, and yams. Large scale annual yield data for bananas are unavailable for most African countries. It is known, however, that average yields, depending mostly on the variety, are about 10 - 18 kg per plant or 15-20 tons per hectare per annum.

Bananas grow in most types of soil, the best being deep, well drained sandy loam rich in organic matter. For optimum yield, bananas require an uninterrupted supply of water - the best moisture conditions exist in areas with evenly distributed annual rainfall of about 1,800 mm. In areas of poor rainfall, or with a pronounced dry season, bananas are often grown in low lying places along riverbanks, seepage lines, or drains, which maintain a constant supply of ground water. Bananas require warm conditions - optimal temperatures about 23 - 26°C found at altitudes between sea level and 1,800 m. Strong winds often blow the banana plants down, especially when they are heavy with fruits.

Most of the bananas in Subequatorial Africa are grown north of the 15th parallel. Sweet bananas are an important food in Gabon, Zaire, Northwestern Angola, Kenya, Tanzania and Malawi. They are grown also in some small coastal areas of Mozambique and Madagascar. Cooking bananas (plantains) are the staple food in Uganda and are also important Congo, Rwanda, Burundi and parts of Zaire.

4. Grain Legumes

This is a group of plants belonging to the Leguminosae family grown for their grains. They are grown mainly in the eastern part of Subequatorial Africa, with the largest areas in Uganda, Kenya and Tanzania followed by Burundi, Rwanda and Malawi. Most important are the following crops:

COWPEAS (Vigna sinensis)

Cowpeas are the most widely grown grain legume in the area south of the Sahara, the source of 90% of the world's production. The tender green leaves are cooked as a vegetable (the leaves are normally picked beginning around the middle of the growing season), the seeds are consumed either green or dried; the green pods and sprouted seedlings are also edible. Whatever remains from the plant is used as stock feed. Some varieties are spreading, others grow upright or semi-upright. The size and color of the seeds differ considerably from one variety to another. The duration of the growing period also differs, although for most varieties it is about 3 months.

Cowpeas grow better in warmer climate, and therefore are rarely found above 1,500 m altitude. The plants are drought resistant (more than beans) but cannot tolerate waterlogging. Most cowpeas are interplanted with other food crops, like sorghum or maize. Normal yield is about 350-450 kg/hectare. It can be much higher if the crop is protected from the numerous pests and diseases to which it is vulnerable.

PIGEON PEAS (Cajanus cajan)

Pigeon peas are grown as an annual or biannual crop. The plants are taller than those of the other grain legumes and the roots penetrate into the deeper soil layers. This makes pigeon peas more drought tolerant than the other grain legumes. Another difference is the duration of the growing period - most pigeon peas need 4 to 6 months to mature while some varieties require up to 9 or 10 months. Pigeon peas very seldom are sown in pure stands - in most cases they are intersown as a minor crop with millet, sorghum or maize. Often the main crop is harvested and pigeon peas are left in the field to grow and mature. Yields are usually about 400 kg/hectare, despite the fact that their potential under good management is much higher. Pigeon peas are a low and medium altitude crop - from sea level to about 1500 m.

BEANS (Phaseolus species)

Numerous types of beans are grown in Subequatorial Africa: common, snap, kidney, dwarf, string, bush, French, garden, pole, field and others. Usually they are referred to simply as beans. The plant characteristics of

beans are variable: they have different height, nodulation and stem structure, color of the flowers, size and color of the seeds, etc.

Beans grow well at different altitudes, the optimal range is between 800 and 2,000 meters. The duration of the growing period for most varieties grown up to 1,000 - 1,200 m is about 3 months. At about 1800 m altitude the growing period extends up to 4 months, and at 2,400 m it lasts about 5 months. Beans are less drought resistant than cowpeas or pigeon peas, one reason being their shallow root system. Excess rainfall also has an adverse effect especially if it occurs at flowering time or at maturity. Very hot weather at flowering is also harmful.

Beans are sown in pure stands, but more often they are intersown with various cereals, cassava or even bananas. Several countries - Tanzania, Kenya and Malawi among them - grow seed beans for export to Europe. Although slightly inferior nutritionally to cowpeas and pigeon peas, beans are a principal protein source in many areas: Eastern Zaire, Uganda, Rwanda and Burundi. The seeds are cooked alone or mixed with maize, bananas or vegetables. Bean yields in Subequatorial Africa are low - mostly between 250 and 650 kg of dried seeds per hectare. With good pest and disease control, however, (beans are plaqued by many pests and diseases), and better husbandry, yields could be several times higher.

5. Oilseed Crops

Crops in this group are not related botanically. Their common feature is that oil is extracted from their seeds and used for cooking as margarine or salad oil.

GROUNDNUTS (Arachis hypogaea)

Groundnuts are an annual legume crop, whose seeds contain about 40 percent oil and about 25 percent protein of relatively low quality. The plants are short in size and have a growing period of about 3 to 4, sometimes even 5 months, depending on variety and altitude. Groundnuts grow better in warmer conditions, and are therefore very seldom found above 1,500 altitude. For most of the growing period the plants require well moistened soil; however, very wet conditions are unsuitable because the fruits are attacked by fungus. The crop is usually timed to ripen at the end of the rainy season. Yields are low - mostly around 500-600 kg/hectare

for shelled nuts due mainly to the lack of pest and disease control among the majority of the smallholding farmers. The largest area planted to groundnuts is in Zaire, followed by Malawi, Uganda and Mozambique. Considerable amounts are grown also in Zambia, Zimbabwe and Tanzania.

SESAME (Sesamum indicum)

Sesame, also known as simsim, is an erect annual plant 1-2 meters tall with branched or unbranched stem and a tap root. The seeds are very small - about 300 seeds to the gram - either white or black in color with an oil content of about 50 percent. The crop is moderately drought resistant. Heavy rainfall can be harmful soon after sowing because it washes away the tiny seeds. It is a low and medium altitude crop - from sea level up to about 1,500 m altitude.

Sesame is sown in pure stands or together with pigeon peas, sorghum or maize. Harvesting is carried out by uprooting the whole plants when the lowest seed capsules mature. The plants are then tied to a fence for several weeks until all capsules ripen. Yields are usually 250-300 kg of seed per hectare.

SOYBEAN (Glycine soja)

Soybean, called also soya bean, can give a good yield of oil and protein but is not well established in Africa; yields at present are lower than those of groundnuts. The crop is grown mostly in Zimbabwe, Zaire, Rwanda and Tanzania. For the varieties grown in Africa, the height of the plants is usually about 1 meter. The duration of the growing season depends on variety and altitude; it is mostly between 4 and 5 months.

Chapter V

POPULATION, ECONOMY AND FOOD SECURITY

The food security in Subequatorial Africa is bad, and what causes serious concern is that there is no expectation that the situation will improve in the immediate future. A brief analysis of the factors and reasons related to food security follows.

A. POPULATION

The food security of a country depends not only on the natural resources that determine food output, but also on the demand for food which in turn depends on the size of the population. In 1980 the total population of the 18 project countries was about 136 million people. The most populous country is Zaire with 28 million, followed by Tanzania - 18 million, Kenya - 16 million and Uganda - 13 million (Table 5.1). The smallest number of people live in Gabon and Swaziland - each with only about one-half million people - followed by Botswana and Namibia with about one million each.

The population of Subequatorial Africa is distributed very unevenly. In general, far more people live in the eastern half of the region - about 110 million versus 26 million in the western half. This is due mainly to the unfavorable rainfall regime in the western half - there are too many areas with either excessive (tropical jungle) or inadequate (deserts and semi-desserts) rainfall. In the eastern half of Subequatorial Africa moderate rainfall amounts prevail, and therefore most of the population has settled there (Figure 5.1).

Namibia, Botswana and Gabon have the smallest population density - only about 1-2 persons/km^2 while Rwanda and Burundi have the highest density - 182 and 162 persons/km^2 respectively (Table 5.1). As a matter of fact, Rwanda and Burundi are two of the most densely populated countries in the world. The average population density in Subequatorial Africa is relatively small - only 13.5 persons/km^2, or about two times smaller than that of the US (Alaska included) and seven times smaller than that of France. It is also smaller than that in many countries in Asia and South America.

The structure of the population is another factor related to food security. A very large part of the population in Subequatorial Africa -

Table 5.1. Population

Country	Year	Population		Economically active population			Population density (persons per 1 km^2)
		Total	Agricultural	Total	Agricultural	Percent in agric.	
		(in thousands)		(in thousands)			
1 Gabon	1970	500	407	250	203	81.4	1.9
	1980	551	421	262	200	76.3	2.1
2 Congo	1970	1,198	501	430	180	41.8	3.5
	1980	1,537	526	526	180	34.2	4.5
3 Zaire	1970	21,638	17,159	9,720	7,708	79.3	9.2
	1980	28,291	21,008	11,925	8,855	74.3	12.1
4 Angola	1970	5,588	3,562	1,539	981	63.7	4.5
	1980	7,078	4,086	1,865	1,007	57.7	5.7
5 Namibia	1970	764	424	262	146	55.6	0.9
	1980	1,009	490	323	157	48.5	1.2
6 Botswana	1970	634	550	305	265	86.7	1.1
	1980	821	658	382	306	80.2	1.4
7 Lesotho	1970	1,061	952	592	530	89.7	40.0
	1980	1,341	1,123	703	588	83.7	44.2
8 Swaziland	1970	430	349	208	169	81.1	24.8
	1980	556	403	253	184	72.6	32.0
9 Zimbabwe	1970	5,308	3,391	1,875	1,198	63.9	13.6
	1980	7,396	4,338	2,427	1,424	58.7	18.9
10 Mozambique	1970	8,140	5,981	3,342	2,456	73.5	10.2
	1980	10,473	6,746	3,953	2,546	64.4	13.1
11 Malawi	1970	4,511	4,019	2,117	1,886	89.1	38.1
	1980	6,162	5,159	2,746	2,299	83.7	52.0
12 Zambia	1970	4,152	3,023	1,613	1,175	72.8	5.5
	1980	5,645	3,761	2,049	1,365	66.6	7.5
13 Tanzania	1970	13,300	11,434	5,780	4,969	86.0	14.1
	1980	17,934	14,532	7,315	5,928	81.0	19.0
14 Burundi	1970	3,621	3,156	1,853	1,615	87.2	130.1
	1980	4,512	3,745	2,154	1,788	83.0	162.1
15 Rwanda	1970	3,573	3,329	1,931	1,799	93.2	135.6
	1980	4,797	4,295	2,503	2,241	89.5	182.1
16 Uganda	1970	9,806	8,427	4,262	3,662	85.9	41.5
	1980	13,201	10,678	5,415	4,380	80.9	55.9
17 Kenya	1970	11,265	9,252	4,577	3,759	82.1	19.3
	1980	16,402	12,723	6,202	4,811	77.6	28.2
18 Madagascar	1970	6,800	6,076	3,553	3,175	89.4	11.6
	1980	8,742	7,280	4,263	3,551	83.3	14.9
All 18 African countries	1970	102,289	81,992	44,209	35,876	81.1	10.1
	1980	136,448	101,972	55,266	41,810	75.6	13.5
USA	1970	204,879	7,519	87,115	3,197	3.7	21.9
	1980	222,159	4,776	101,148	2,175	2.2	23.7
France	1970	50,770	6,961	20,978	2,876	13.7	92.8
	1980	53,712	4,641	22,951	1,983	8.6	98.2

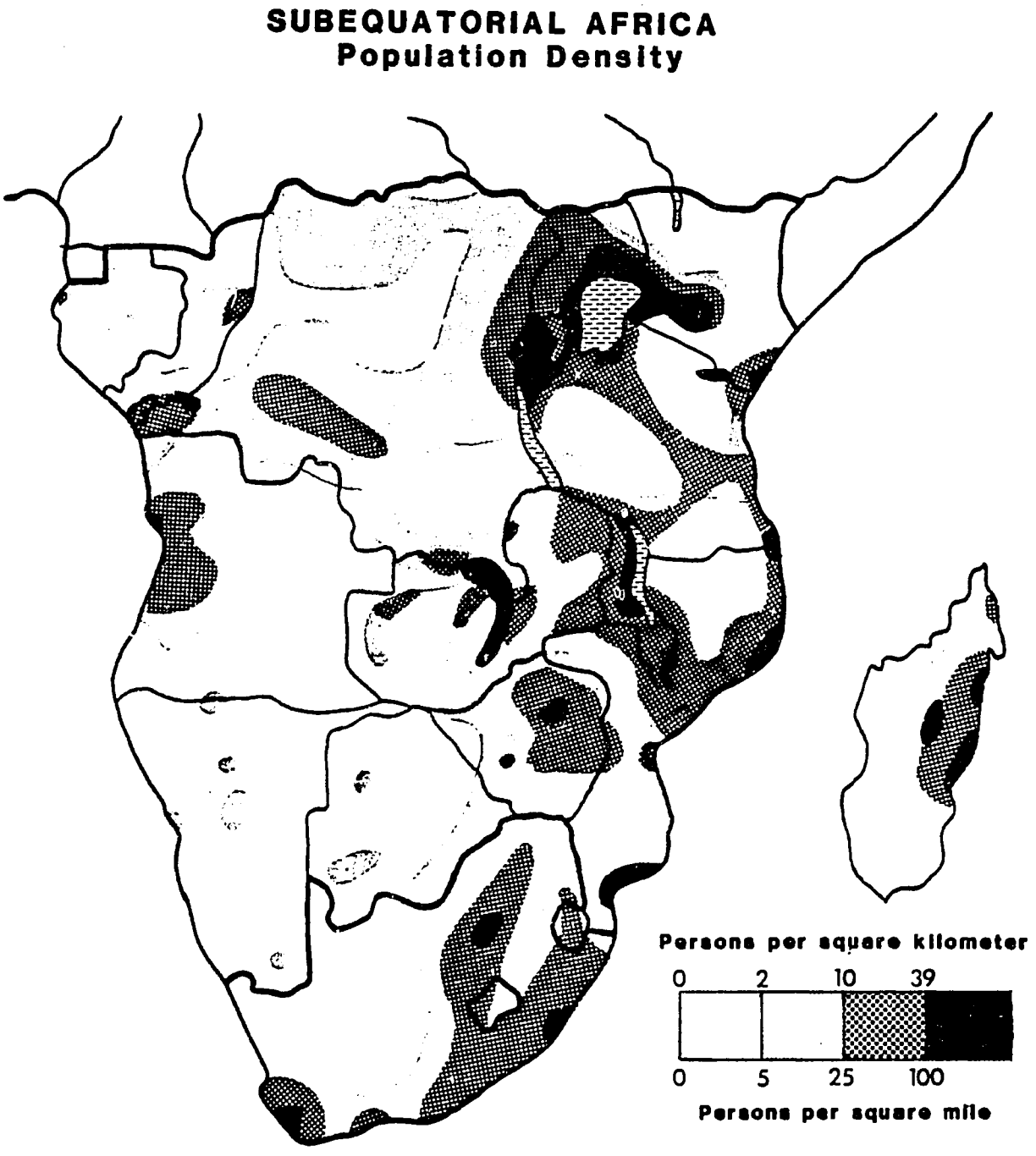

SUBEQUATORIAL AFRICA
Population Density
Persons per square kilometer
0
2
10
39
0
5
25
100
Persons per square mile

Figure 5.1.

about 102 million or 75 percent of the total population is engaged in agricultural production. By comparison, far fewer people are engaged in agriculture in the US and France - only about 2 and 8 percent respectively.

B. SUPPLY AND DEMAND OF FOOD

Despite the large number of people engaged in agriculture, food production in Subequatorial Africa has fallen sharply behind demand. The per capita production of basic foods in 1980 (Table 5.2) indicates a production of only 190 kg of the most important basic food (cereals), while the US and France produce eleven and eight times larger amounts. Subequatorial Africa produces more roots and tubers, but they have far smaller nutritional value (a great portion of their mass is water). The data also indicate the distribution of the basic foods production in Subequatorial Africa. Countries with a more humid climate, such as Gabon, Congo, Zaire, Rwanda and Burundi, produce larger amounts of roots and tubers and little cereal while countries with drier climates produce smaller amount of roots and tubers but more cereals.

The well developed agricultural economics of the US and France are not the only ones that are ahead of Africa. Asia and Latin America also produce more food than Africa. The index of per capita food production during the period between 1964 and 1978 (Figure 5.2) has an upward trend in Asia and Latin America, with the production in 1978 being about 13-15 percent higher than that in 1964. In Sub-Saharan Africa, which includes all 18 countries in this project plus several others, the per capita food production has a downward trend with production in 1978 being about 22 percent lower than in 1964.

Numerous estimates have been made of the future food demand in Africa. Although the figures in these estimates differ to some extent, all of them agree that the demand for food will continue to increase at a high rate. As there is no estimate specifically for the 18 countries included in this project, a review for the whole of Africa made at the World Food Conference in 1976 serves as a reference for the rate of increase. As shown on Table 5.3, the demand for food will approximately double for every 20 year period: between 1970 and 1990, and between 1980 and 2000.

The increasing discrepancy between the supply and demand of food leads to

Table 5.2. Per Capita Production of Basic Foods in 1980 (in kilograms)

Country	Cereals, total	Roots & Tubers, total	Pulses, total	Groundnuts in shell
Gabon	16	499	-	13
Congo	12	386	5	12
Zaire	32	463	5	11
Angola	57	292	6	3
Namibia	63	151	4	-
Botswana	54	9	22	9
Lesotho	157	5	16	-
Swaziland	185	29	4	-
Zimbabwe	276	11	3	11
Mozambique	46	278	6	9
Malawi	206	33	33	30
Zambia	160	35	2	14
Tanzania	80	280	8	1
Burundi	76	487	47	2
Rwanda	53	340	46	3
Uganda	108	174	21	15
Kenya	158	81	15	1
Madagascar	281	239	7	3
All 18 African countries	109	251	13	9
USA	1,215	64	6	5
France	890	139	3	-

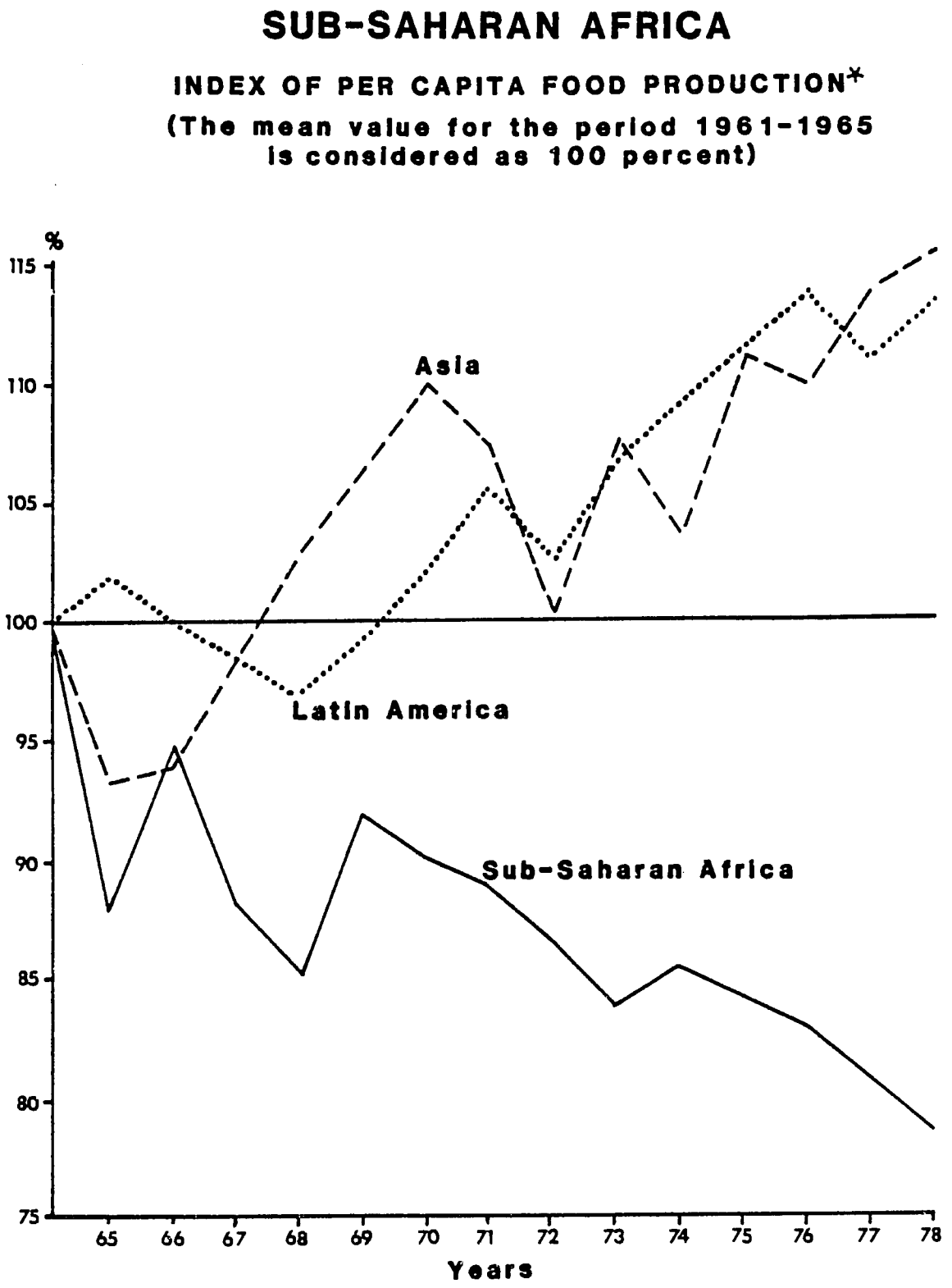
Table 5.3. Demand for Cereals in Africa (in million tons)

Year	Wheat	Coarse Grains	Rice
1970	7.2	33.0	5.7
1980	10.5	45.9	8.2
1990	14.6	65.0	12.9
2000	24.2	91.7	19.8

Table 5.4. Imports (in thousand metric tons) of Wheat and Maize in the Major Food Importing Countries of Subequatorial Africa

Country	WHEAT			MAIZE		
	1960	1970	1980	1960	1970	1980
Congo	12	23	75	X	X	X
Zaire	31	103	170	10	60	202
Angola	29	84	150	0	13	150
Botswana	X	X	X	16	10	77
Lesotho	5	35	83	0	0	90
Swaziland	X	X	X	0	0	35
Mozambique	20	86	200	0	2	175
Zambia	5	85	100	0	80	270
Malawi	X	19	22	0	92	85
Tanzania	12	18	44	10	45	250
Uganda	X	X	X	0	3	100
Kenya	1	3	45	0	0	360
Madagascar	21	38	76	0	0	0
TOTAL	136	494	965	36	305	1,794

X=No data available. There are no data also for some other food importing countries, like Namibia, Rwanda, Burundi and Gabon.



*Source: Economic, Statistics, and Cooperatives Service, U.S. Department of Agriculture, Indices of Agricultural Production.

Figure 5.2.

larger food imports. During the last 20 years, the import of wheat in thirteen of the Subequatorial countries (Table 5.4) increased seven times - from 136,000 tons in 1960 to 965,000 tons in 1980. This is an average annual increase of an alarming 38 percent. More pronounced and far more alarming were the imports of maize - from 36,000 to 1,794,000 tons, or a 50-fold increase! The average annual increase for maize is an unprecedented 249 percent.

C. REASONS FOR THE WORSENING FOOD SECURITY

The reasons for the worsening and unstable food security are numerous and complex. They can be divided into two main groups: natural and social.

1. Natural factors

The natural factors explain some of the reasons for the low agricultural output. Most important among the natural factors is the unfavorable rainfall amount. There is hardly an area in Subequatorial Africa not affected in one way or another by the rainfall regime. Most often unfavorable rainfall regime means drought of differing duration and intensity. In other instances, excess rainfall causes the damage.

Another natural factor is the unfavorable temperature regime. It is known that a high diurnal temperature range is optimal for plants. High day-time temperatures (to a limit) stimulate assimilation, while cooler nights reduce respiration. In many areas of Subequatorial Africa, especially along the coasts, the diurnal temperature range is small because of the warmer nights. This leads to greater respirational losses at night.

2. Social Factors

Social factors explain the remainder of the reasons for low agricultural output, plus all of the reasons for higher demand for food. The social factors have been studied extensively by local experts from most countries in Subequatorial Africa, as well as by experts from other countries or international agencies. The factors can be summarized as follows:

a. Population Increase

Africa has the largest population growth in the world. During the last decade the population of the 18 countries in the project has increased from 102 million in 1970 to 136 million in 1980 (Table 5.1). This is an

increase of 33.4 percent for the decade, or an average of 3.34 percent per year. During the same period the population of the US has increased by 8.4 percent, or an average of 0.84 percent per year. The population of France has increased by 5.8 percent, or an average of 0.58 percent per year. It appears that the annual rate of population growth in Subequatorial Africa is 4 times higher than that of the US and about 6 times higher than that of France. Bearing in mind that the large majority of the African population at present is at child bearing age, an even higher rate of population growth could be expected during the next decade.

It is important to note that the decadal increase of the agricultural production has proceeded at a much slower rate than population (Table 4.2). The average annual increase in the production of cereals was 2.4 percent, for roots and tubers 2.0 percent, and for pulses only 1.2 percent. These data further explain the gap between supply and demand for food discussed earlier.

b. Inadequate Agricultural Technology

Besides the natural factors influencing yield, there are many social factors that keep the crop yields in Subequatorial Africa at a very low level. Among them, the most important are: little or no use of fertilizers, little or no pest and disease control, little or no use of tractors and other machines, little or no irrigation, and little or no measures to prevent erosion or desertification. For example, the amount of fertilizers used per hectare in Africa is 4.4 kg versus 45.4 kg in Asia and 38.8 kg in South America. The percentage of irrigated land in Africa is 3½ times smaller than that in South America, and 15½ times smaller than in Asia. A comparison with the US and France shows far larger differences.

As a result of the inadequate technology, the average yield of the crops in Subequatorial Africa is 3 to 15 times lower than in the developed countries (Table 4.2). The importance of good technology is illustrated by the fact that with proper husbandry in the Agricultural Experimental Stations all over Subequatorial Africa the crop yields are at par with or even higher than those in the rest of the world.

c. Inadequate Agricultural Policy

During the first 15-20 years after independence, in nearly all countries in Subequatorial Africa, most of the available funds were

invested either for industrialization, development of estates with commercial crops, or other urban projects. Very little investments were made in, or attention paid to increasing the output of subsistence crops. The extension services, the research activities, the education and training, the infrastructure, the marketing and price policies - all these are considered as inadequate and needing essential improvements in order to increase the output of subsistence crops. The extension services, the research activities, the education and training, the infrastructure, the marketing and price policies - all these are considered as inadequate and needing essential improvements in order to increase the output of subsistence agricultural crops.

d. Changing Habits

The development of a new class of mostly urban people, with better education and higher economic potential, has led to increased demand for more and better quality food. Wheat and especially rice are now the cereals of first preference. Demand for various meats has also increased.

e. Social Disorders

Social disorders in a country have an adverse effect on agricultural production. Several countries in Subequatorial Africa have had wars or other social disorders for periods ranging from several months to several years. Mozambique, Zimbabwe and Angola had disorders before gaining their independence. Other countries, like Zaire and Uganda, had disorders after independence. There are three or four countries where some kind of social disorder exists at present.

Chapter VI

AGROCLIMATIC CONDITIONS IN THE COUNTRIES

(each country has three sections: 1. Agroclimatic Conditions and Regions, 2. Agriculture, and 3. Factors Affecting Yield and Their Assessment.)

A. ANGOLA

1. Agroclimatic Conditions and Regions

The greater part of Angola consists of highlands with altitudes between 1,000 and 1,500 m (Figure 6.1). Individual peaks reach 2,500 m. In the western half of the highlands there are several plateaus with fertile soils: the Malange plateau to the north, the Benguela-Bie plateau in the center and the Humpata highland in the south. The highlands gradually slope downward towards the northern, eastern and southern borders of the country. Westwards there is a steeper slope towards the coastal plain. The latter is 30 to 100 km wide in the south and 100 to 150 km in the north.

The country has been divided into six agroclimatic assessment regions (Figure 6.3). Wettest are the Northeast and Northcentral regions with about 1,300 mm mean regional annual rainfall. Some locations, however, receive up to 1,600 mm (Table 6.1). The Southcentral and Southeast regions receive less than 800 mm annually, with higher amounts in the northern parts of the regions and smaller amounts southwards. The coastal regions have their lowest amounts on the coastline, rapidly increasing eastwards with the increase of altitude.

The rainy season normally begins in October and lasts until April. The period with mean monthly rainfall of 100 mm or more lasts seven months in parts of the Northcentral and Northeast regions, with a gradual decrease of the duration southwards and a rapid decrease westwards (Figure 6.2; see also Chapter VII, E).

2. Agriculture

The most important food crops in Angola are maize, cassava, beans, millet and sorghum. Of lesser importance are groundnuts, sweet potatoes, wheat, rice and potatoes (Table 6.2). The most important commercial crops are coffee, sisal, cotton, oil palm and sugar cane (Figure 6.5). Intensive farming takes place mostly in the highlands and in the river valleys of the coastal plain (Figure 6.6). The largest areas planted to various agricultural crops are in the Northcentral agroclimatic assessment region,

followed by Northwest and Southcentral (Table 6.3). Rainfed annual crops are sown soon after the beginning of the rainy season. Harvesting begins in March and usually lasts until May, sometimes extending until June (Table 6.4).

About 85 percent of the population lives in rural areas. The vast majority continue to cultivate their own holdings. About 200,000 persons, however, work on the state or cooperative farms created after Angola became independent in 1975. A large part of the commercial farms were abandoned by their Portuguese owners and taken over by the new government. The larger units became ate, the smaller cooperative, farms. The traditional sector still mostly actices shifting cultivation. Some modern technology - fertilizers, pest and disease control, mechanization, etc.- is used in commercial farming.

3. Factors Affecting Yield and Their Assessment

Drought is the most important meteorological factor affecting crop yields. The episodic event data for the last five years indicate that drought has occurred every year in one part of the country or another (Table 6.5). During some years drought conditions occurred two or even three times during the growing season. It is important to note that the term drought condition includes irregular rainfall as well as lack of rain. The years with drought as well as those with good rainfall are shown on Figure 6.7.

The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Angola and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.8. In addition to the stations with common period of records (used for the assessments), Angola has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative provinces of the country, their boundaries, together with those of the agroclimatic regions, are shown in Figure 6.4.

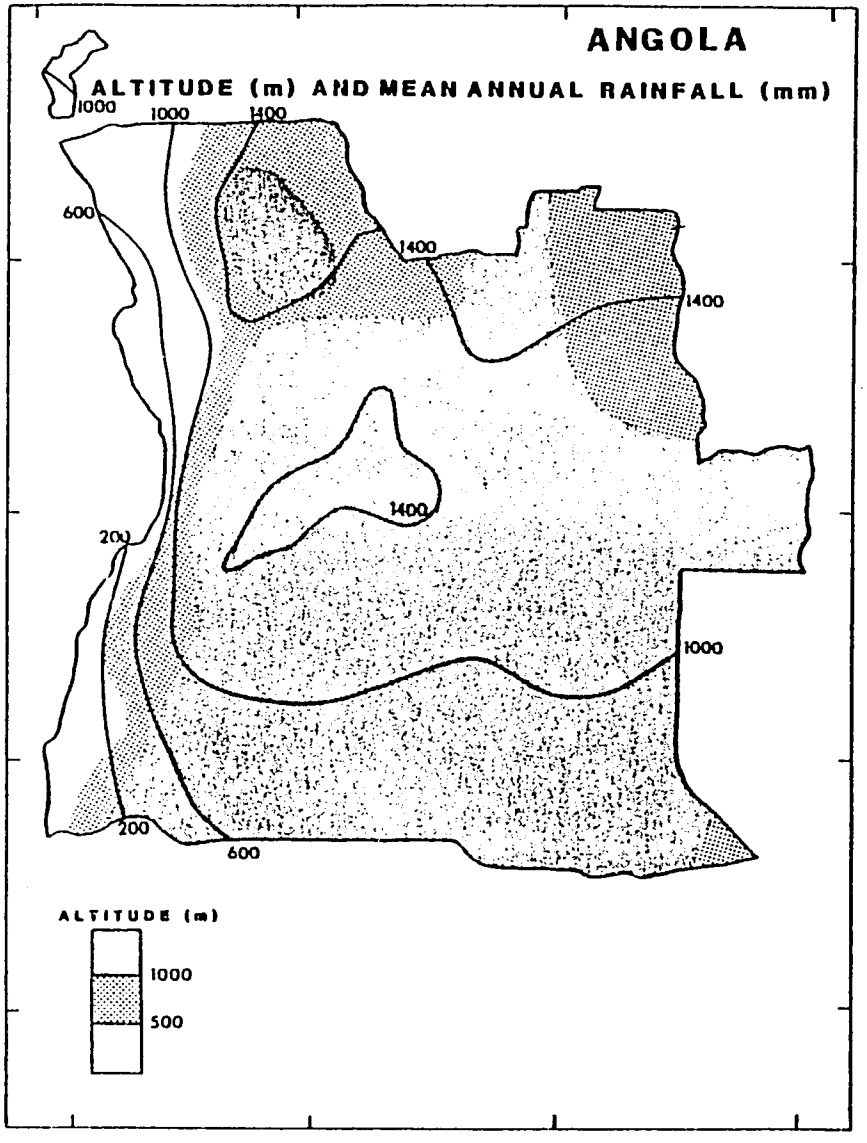


Figure 6.1.

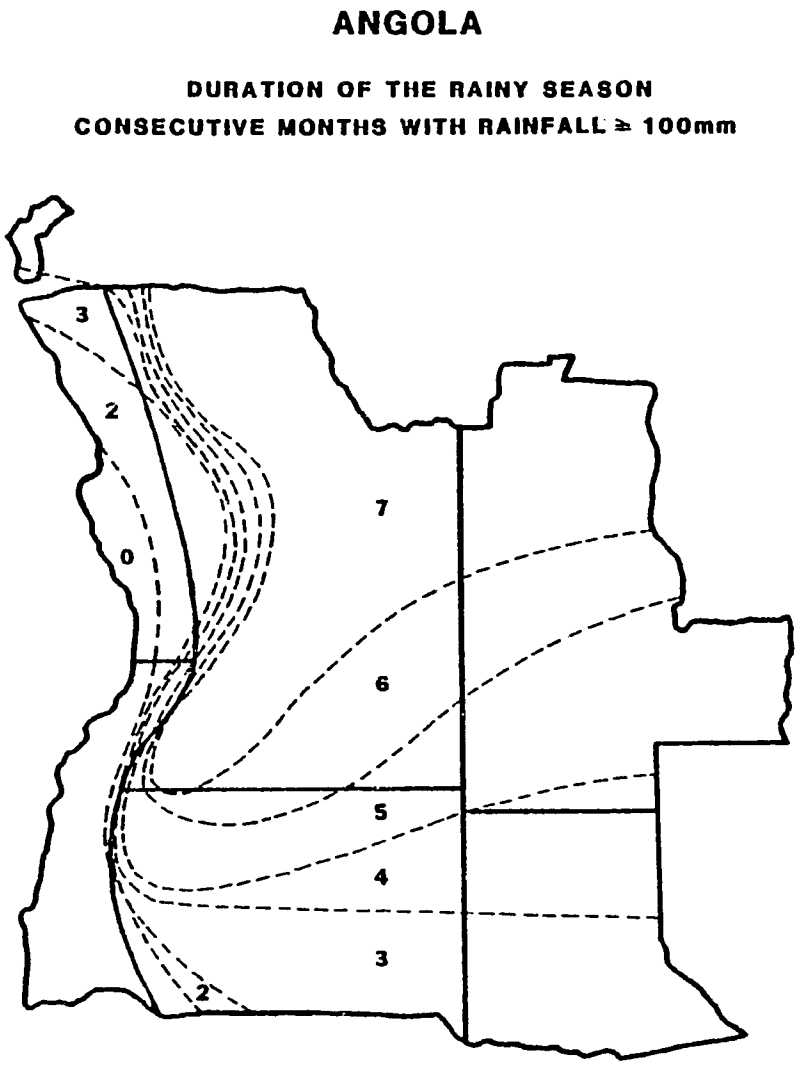
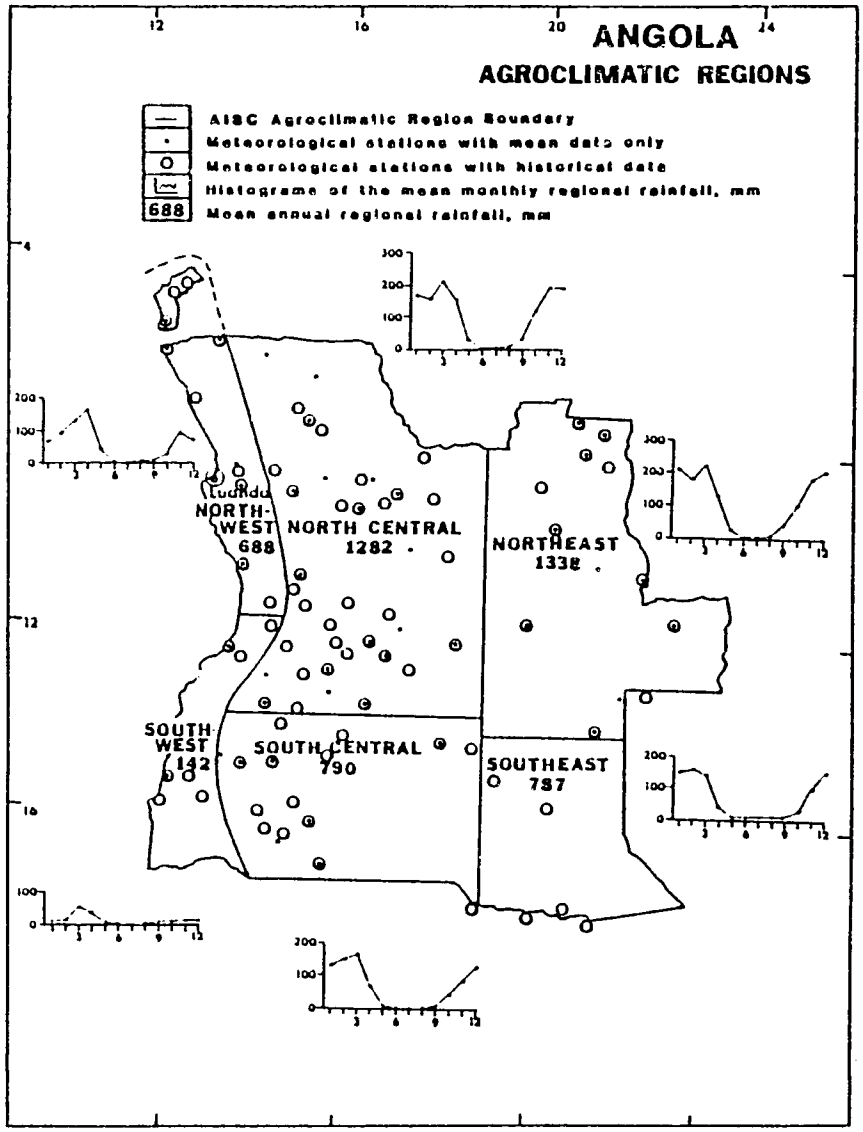


Figure 6.2.



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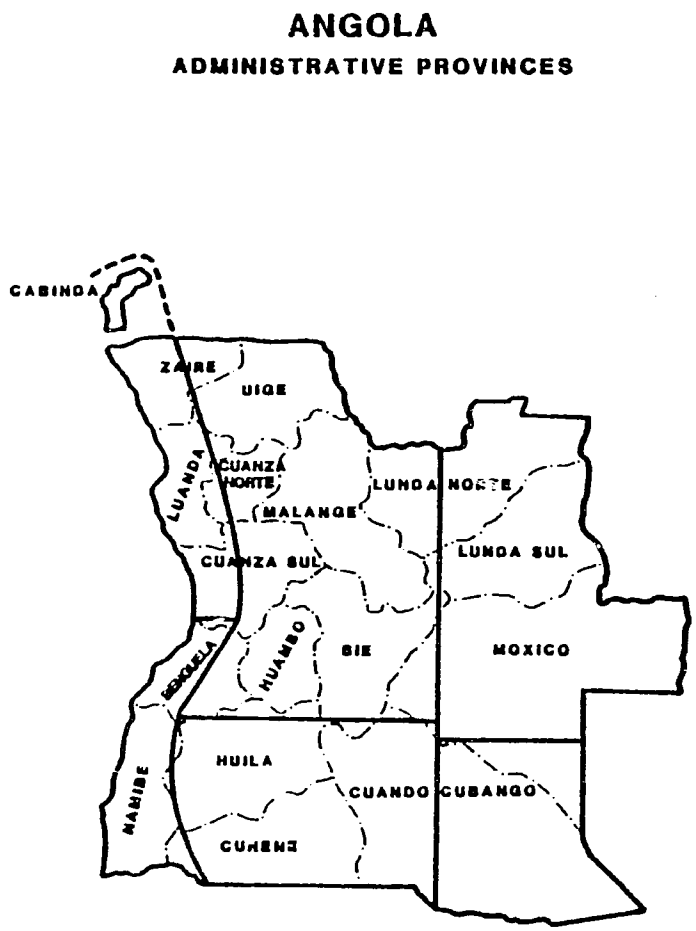


Figure 6.4.

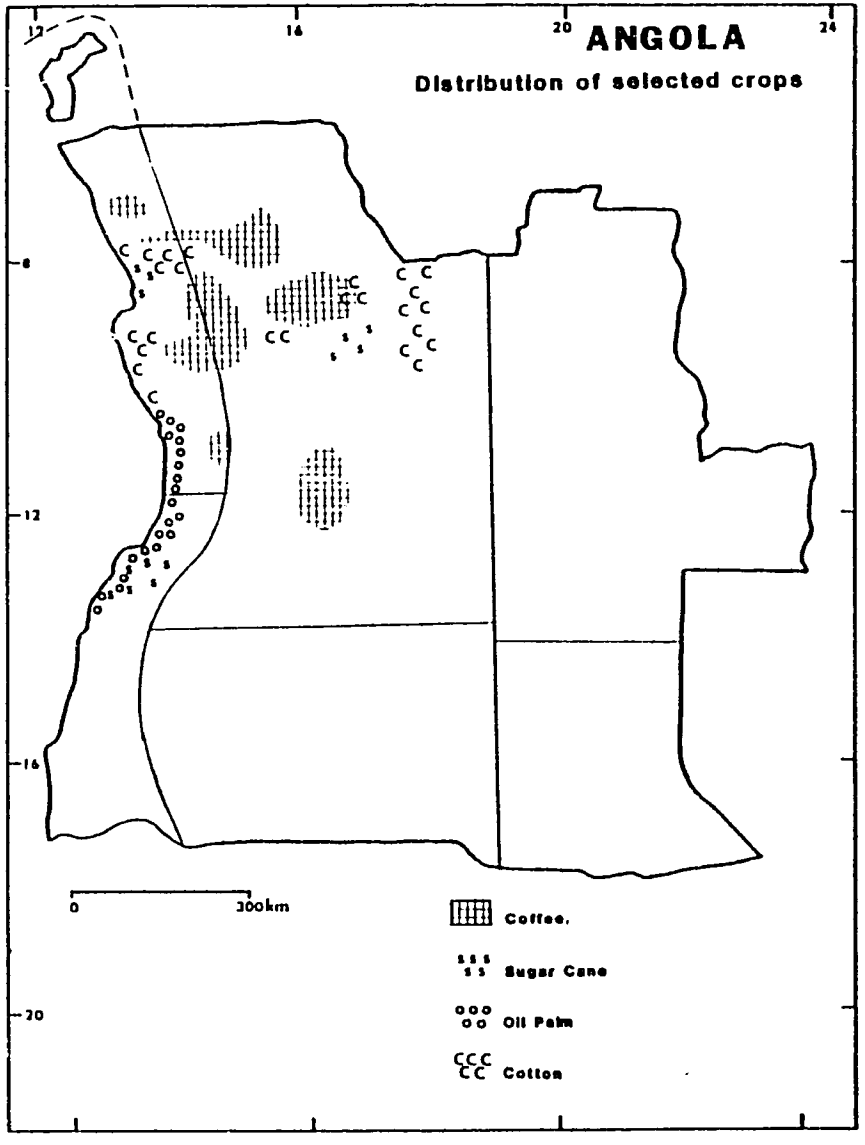


Figure 6.5.

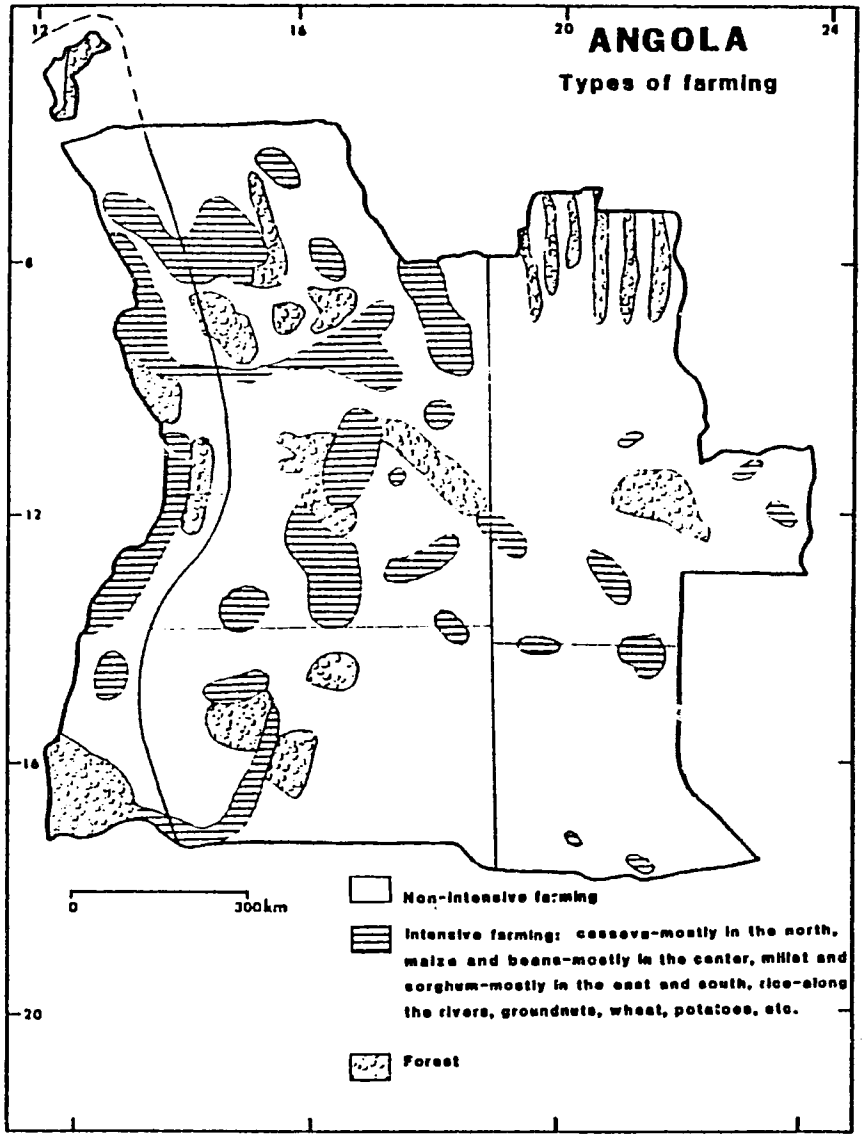


Figure 6.6.

ANGOLA: NORTHCENTRAL AGROCLIMATIC REGION
CROP CONDITION/FOOD SHORTAGE INDEX FOR MAIZE
ASSESSMENT PERIOD: OCTOBER-MARCH

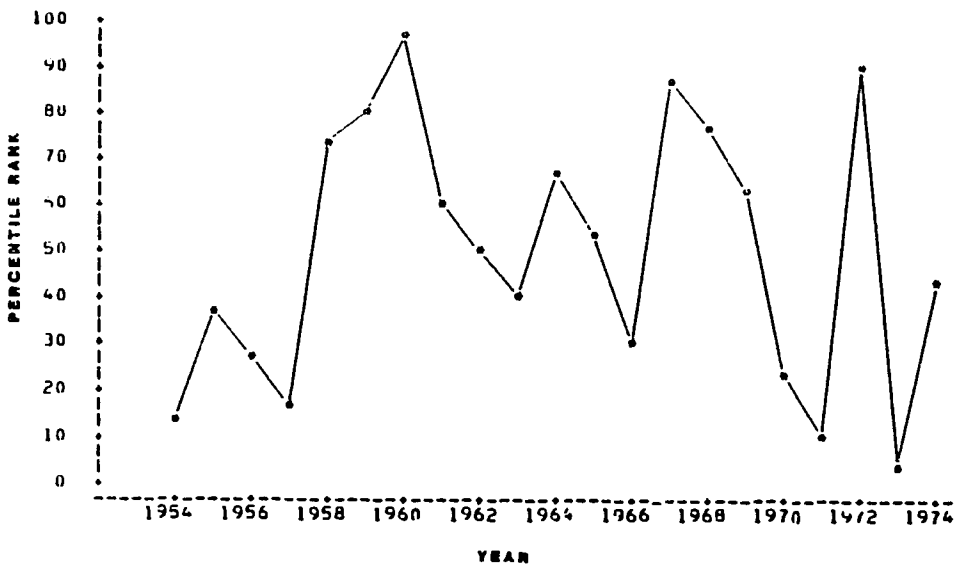


Figure 6.7.

ANGOLA
STATIONS USED FOR AGROCLIMATIC INDICES

Figure 6.8.

Table 6.1. Mean monthly and annual rainfall (mm) at selected stations in Angola

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Northwest	Buco Zau	350	139	181	186	206	66	0	0	1	8	67	220	167	1252
	Cabinda	20	118	130	176	150	45	0	0	1	6	41	141	80	894
	Noqui	50	129	114	144	204	61	0	0	1	3	36	178	109	974
	Soyo	1	79	124	166	178	56	0	0	0	2	18	117	99	851
	Nzeto	17	86	83	132	133	25	0	0	1	4	22	66	32	592
	Tentativa	20	28	34	122	164	23	0	0	0	2	10	62	40	491
	Luanda	69	25	37	114	138	11	0	0	1	2	5	42	31	404
	Onga-Zanga	40	40	64	157	194	26	0	0	0	2	15	90	61	658
	Porto Amboim	5	25	35	138	118	6	0	0	1	4	14	42	30	423
	Nova do Seles	1050	55	63	197	164	20	0	0	0	10	62	132	78	789
Northcentral	Pango Aluquem	560	89	76	225	316	44	4	5	7	12	81	217	106	1202
	Ndalatando	800	110	91	237	257	40	1	1	3	13	73	213	120	1157
	Malange	1139	127	108	209	165	34	1	0	4	39	134	227	119	1161
	Damba	1240	137	118	199	169	22	1	1	4	48	147	208	123	1170
	Quela	1210	204	170	231	182	17	0	1	5	73	170	258	215	1521
	Quibala	1290	103	76	155	161	37	0	0	7	65	194	225	152	1182
	Ebo	1370	99	68	197	197	35	0	0	3	36	185	264	153	1236
	Waku Kungu	1304	116	101	206	150	26	0	0	6	56	199	221	174	1255
	Chiengue	1710	168	151	220	131	18	0	0	7	43	126	182	219	1271
	Bailundo	1560	167	123	188	161	21	0	0	5	30	123	203	213	1232
	Ceilunga	1670	222	176	208	114	12	1	0	4	19	91	179	276	1298
	Coemba	1300	237	210	232	99	14	1	0	5	16	108	220	213	1346
	Bie	1700	204	181	201	123	12	0	0	4	23	92	194	270	1291
	Huambo	1700	210	152	221	155	18	0	0	1	19	115	198	248	1335
	Chenga	1430	147	124	215	150	10	0	0	0	24	149	181	204	1208
	Cacondo	1660	176	150	275	146	14	0	0	1	13	99	182	205	1266
	Lucipa	1850	152	135	265	142	7	0	0	1	10	134	184	180	1216
	Chitembo	1620	184	138	241	110	12	0	0	1	18	76	150	220	1144
Northeast	Dundo	776	210	157	233	204	52	7	3	35	98	150	269	228	1638
	Luxilo	750	178	163	195	191	40	7	1	31	90	159	198	190	1431
	Maludi	840	170	173	223	177	40	3	4	30	100	153	215	204	1504
	Cachimo	900	172	177	209	185	37	4	5	22	80	133	206	203	1426
	Saurimo	1081	195	152	233	146	20	0	0	13	57	121	227	209	1369
	Luao	1100	234	223	229	115	10	2	0	4	40	106	202	270	1436
	Cavungo	1170	272	244	229	93	11	0	0	3	27	83	192	245	1409
	Luena	1357	205	175	204	105	9	0	0	2	22	100	175	233	1238
	Lumbala	1130	214	175	184	51	10	0	0	0	5	35	133	184	987

continue.....

Table 6.1. Mean monthly and annual rainfall (mm) at selected stations in Angola (continued)

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Southwest	Lobito	1	10	25	125	65	4	0	0	0	3	12	23	26	299
	Biopio	140	22	28	122	93	3	0	0	0	1	21	34	38	367
	Caracul	440	23	17	68	35	1	0	0	0	0	3	6	9	167
	Namibe	44	8	8	18	11	0	0	0	0	0	2	2	4	57
	Tombua	10	3	2	8	3	0	0	0	0	0	0	1	1	19
Southcentral	Cue	1420	152	154	270	127	9	0	0	0	4	94	150	160	1127
	Capelongo	1460	201	157	182	100	8	0	0	0	6	42	129	156	959
	Menongue	1348	204	162	197	72	6	0	0	0	5	42	123	175	982
	Gambos	1290	145	133	240	76	2	0	0	1	3	66	119	140	931
	Lubango	1763	141	136	199	90	8	0	0	1	2	70	126	135	915
	Chibemba	1300	115	135	177	75	2	0	0	0	1	35	80	85	708
	Cahama	1160	122	91	155	43	1	0	0	0	1	15	55	71	556
	Mulondo	1150	144	132	160	54	0	0	0	0	1	32	84	95	712
	Mupa	1270	135	137	165	58	2	0	0	0	3	18	63	98	682
	Chiulo	1100	136	122	149	40	1	0	0	0	1	15	82	75	623
	Ngiva	1110	122	131	102	45	1	0	0	1	1	20	69	81	573
	Kuring Kuru, Namibia*	1110	167	129	122	45	3	1	0	1	3	17	78	90	654
Southeast	Cuito Cuanavale	1240	216	158	163	50	2	0	0	1	7	36	91	148	854
	Mavinga	1118	192	170	144	37	5	0	0	1	4	25	88	133	790
	Dirico	1060	124	122	96	33	3	0	0	0	5	17	50	100	545
	Rundu, Namibia*	1102	151	134	102	35	3	0	0	0	3	18	60	71	578
	Andara, Namibia*	1100	149	134	94	29	1	0	0	0	3	13	65	87	574

*The station is located in a neighboring country, and may be used for Angola assessments.

Table 6.2. Harvested area, yield and production of selected crops in Angola

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	713	713	713	673	519	561	480	370	400
Wheat	13	13	13	769	769	769	10	10	10
Maize	600	600	600	667	500	533	400	300	320
Rice (paddy)	9	8	9	930	1,244	1,333	9	10	12
Millet and sorghum	80	80	80	625	500	625	50	40	50
Roots & tubers, total	144	155	155	13,275	13,074	13,398	1,905	2,020	2,070
Potatoes	6	6	6	6,364	7,273	7,273	35	40	40
Sweet potatoes	18	19	19	9,444	9,474	9,474	170	180	180
Cassava	120	130	130	14,167	13,846	14,231	1,700	1,800	1,850
Pulses, total	120	120	110	542	458	378	65	55	42
Beans (dry)	120	120	110	542	458	378	65	55	42
Groundnuts in shell	40	40	40	500	500	500	20	20	20

Table 6.3. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Angola (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Millet/Sorghum	Wheat	Rice	Cassava
Northwest	108,000	6,500	400	6,500	38,000
Southwest	12,000	4,000	-	1,500	-
North Central	360,000	34,000	10,000	10,000	63,000
South Central	72,000	20,000	2,000	1,000	4,000
Northeast	48,000	8,000	600	500	20,000
Southeast	-	8,000	-	300	2,500

Table 6.4. CROP CALENDAR FOR ANGOLA

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northcentral	Rainfall		168	159	216	157	29	1	1	3	33	120	199	195
	Maize				000	000000	000000	000				///	//////	///
	Sorghum				000000	000000	00					///	//////	
	Millet			000	000000	000000	00					///	//////	
Northeast	Rainfall		207	180	223	131	26	1	1	12	43	109	186	219
	Maize				000	000000	000000					///	//////	///
	Sorghum				000000	000000	00					///	//////	
	Millet				000000	000000	00					///	//////	
Southcentral	Rainfall		135	154	163	69	4	0	0	0	3	42	88	131
	Sorghum				000	000000	000					///	//////	///
	Millet				000000	000000	000					///	//////	///
Southeast	Rainfall		150	160	140	40	5	3	2	2	5	30	100	150
	Sorghum				000	000000	00						//////	///
	Millet				000000	000000	00						//////	///

TABLE 6.5.

ANGOLA

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1978, May	Coastal Areas are Suffering from a Severe and Prolonged Drought. In the Central Highlands, Crops Previously Affected by Drought have been Washed Away by Torrential Rain
1979, May-June	Irregular Rainfall Affecting Crops. A Locust Invasion is Devastating Some Provinces
1979, December	The Northeast and the Coastal Regions Received Little Rainfall in November, which is the First Month of the Rainy Season
1980, April	Maize Crop is Damaged by Irregular and Insufficient Rainfall in the Main Producing Areas - Bie and Huambo
1980, June	Drought Causes a 20% Decline in the Coffee Crop
1981, March	Drought Caused Failure of the 1981 Maize Crop
1981, July	Drought Reduced the 1981 Maize Crop to 40% of the Normal
1981 -	Coffee Production in the Important Kwanza-Norte Province Dropped Due to the Lack of Rain
1982, January	Food Shortages in Several Parts of the Country Due to the Drought in 1981
1982, January	Drought in the Benguela Province
1982, March	Torrential Rains in Malanje Province Destroy Crops, Livestock and Trees. A 15 Minutes Storm Caused Enormous Damage

B. BOTSWANA

1. Agroclimatic Conditions and Regions

The topography consists of a large plateau with an altitude mostly between 800 and 1,200 meters and surrounded by the higher land of Namibia, Zimbabwe and South Africa (Figure 6.9). The western part of the country is covered by the Kalahari Desert. A large part of the Northwest is covered by the Okavango Swamps, caused by the spreading of the Okavango River. In the Northeast are the Makarikari salt pans - vast salty swamps, caused by the poor drainage of the region. The eastern areas of the country have the best soils suitable for agriculture.

The country has been divided into three agroclimatic assessment regions (Figure 6.11). Wettest is the North with mean annual rainfall of 580 mm; some locations however receive up to 700 mm (Table 6.6). The agriculturally important Southeast region has a mean annual rainfall of 477 mm. Driest is the Southwest region, where mean annual amounts rapidly decrease from over 400 mm in the northern parts, to below 200 mm in the southwestern corner of the region.

The rainy season normally begins in late October or early November and lasts until late March or early April. The duration of the period with mean monthly rainfall of 100 mm or more is between 2 and 4 months in the northern region (Figure 6.10; see also Chapter VII E). In the two southern regions there are no stations with mean rainfall of 100 mm or more for two consecutive months. As a matter of fact, half of the stations in these regions do not have even one month with rainfall of 100 mm. This classifies the existing agroclimatic conditions in the two southern regions as marginal for growing agricultural crops.

2. Agriculture

The majority of the population lives in the traditional way by subsistence agriculture. The most important food crop in Botswana is sorghum, followed by pulses (mostly beans) and maize (Table 6.7). Citrus fruit trees are also grown. The only commercial crop grown in the country is cotton. Nearly all agricultural activities in Botswana are concentrated in the Southeast agroclimatic region (Figure 6.13 and Table 6.8), despite the fact that it receives about 100 mm less rainfall per year than the North region. It has however not only the best, but with few exceptions, the

only soils in the country that are suitable for growing agricultural crops.

Rainfed annual crops are sown soon after the first rains have moistened the arable soil layer and continues up to the second half of December (Table 6.9). Harvesting begins in March and lasts until the end of April, sometimes even the first 1-2 weeks of June.

3. Factors Affecting Yield and Their Assessment

Drought is the most important meteorological factor affecting crop yields. The episodic event data indicate that nearly every year agricultural production is affected by insufficient or irregular rainfall (Table 6.10). Only in years with above normal rainfall can all of the planted area be harvested. During years with normal rainfall an average of 20 percent of the area planted to subsistence crops fails to produce any harvest. Under such marginal agroclimatic conditions, small departures from the normal amounts of rainfall have far greater effect on the agricultural output than in the more humid areas. The years with drought as well as those with good rainfall are shown on Figure 6.15.

The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Botswana and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.14. Detailed information describing the stations can be found in the "Directory of Stations" - Appendix A.

Botswana is divided into 13 administrative districts (Figure 6.12).

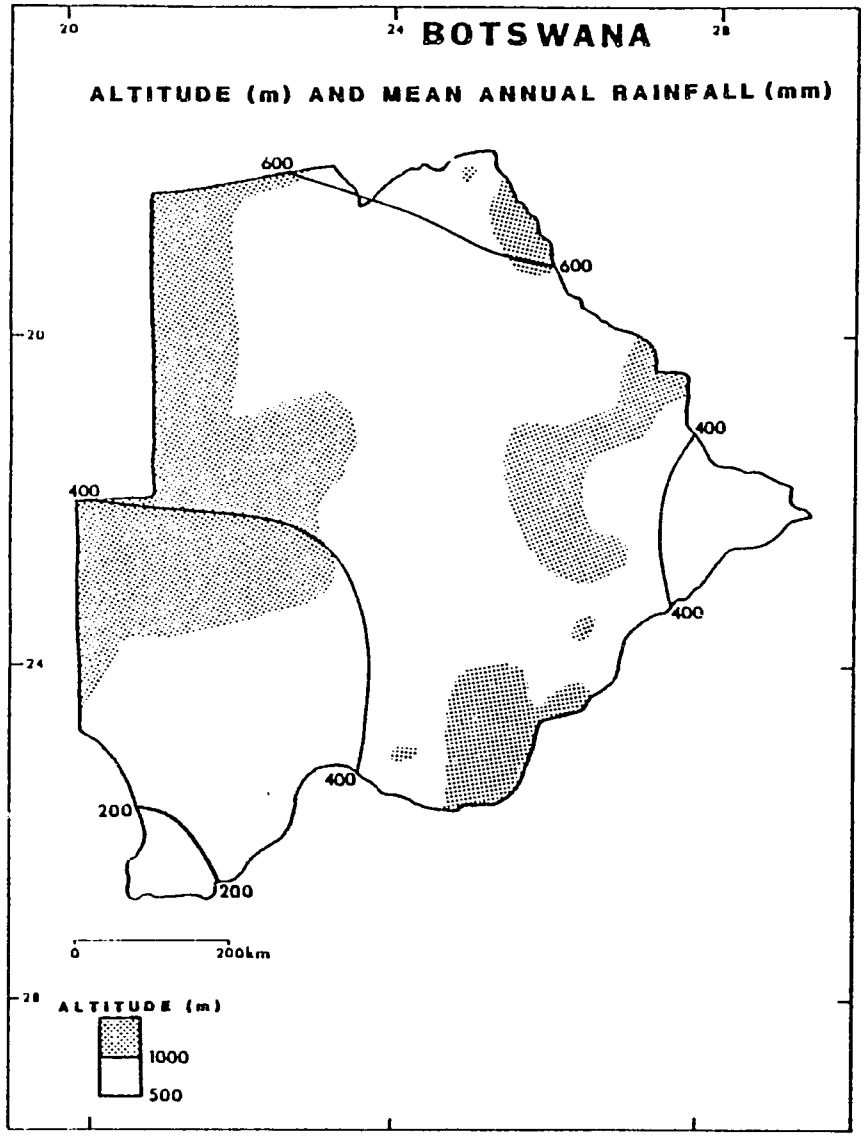


Figure 6.9.

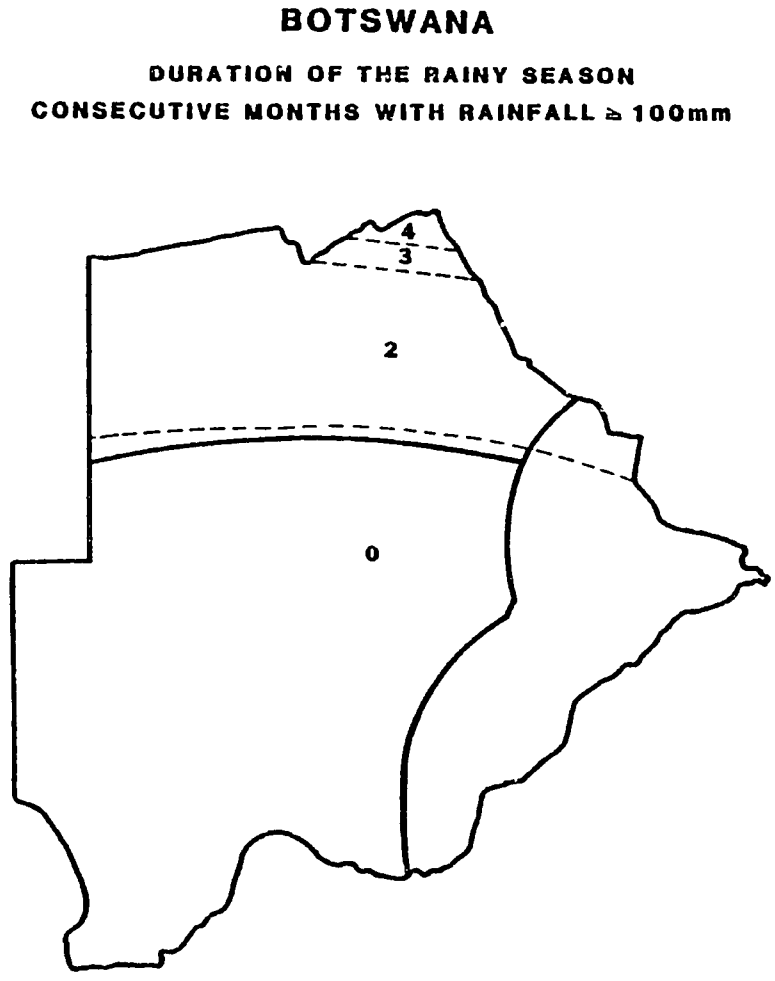


Figure 6.10.

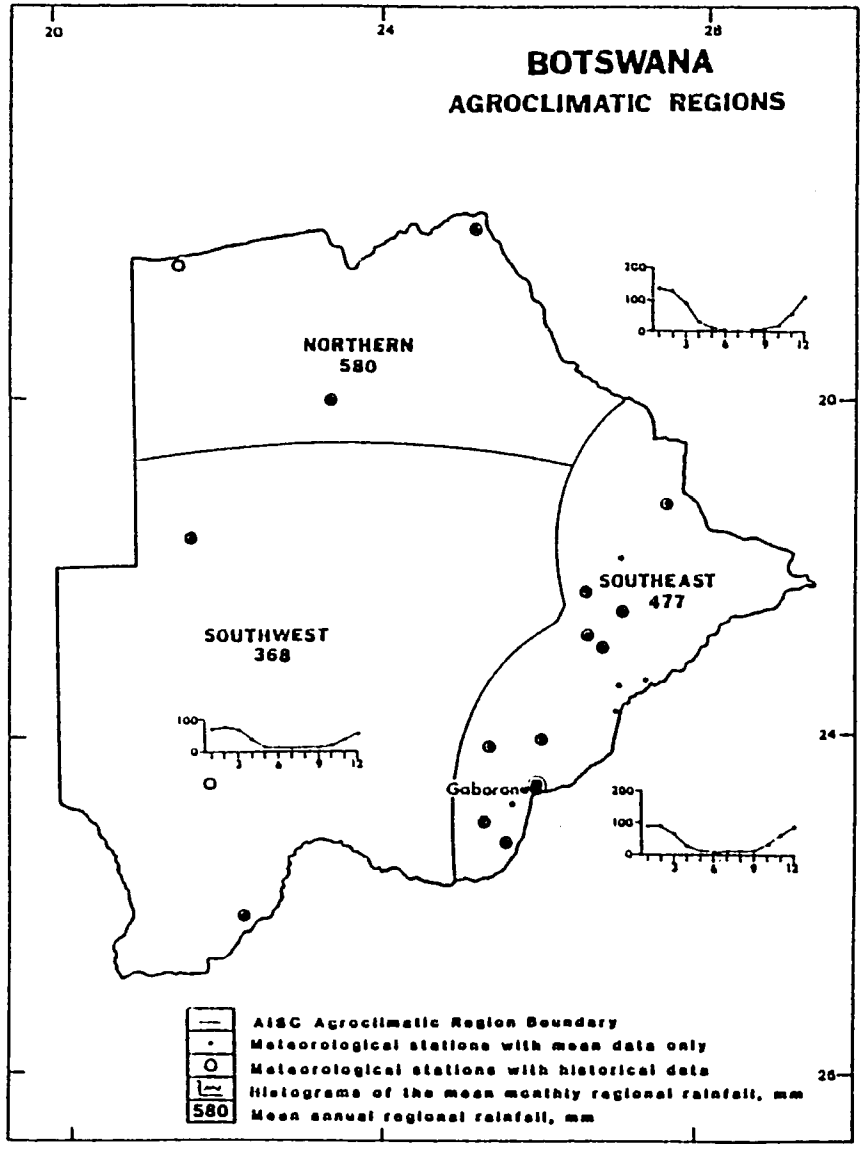


Figure 6.11.

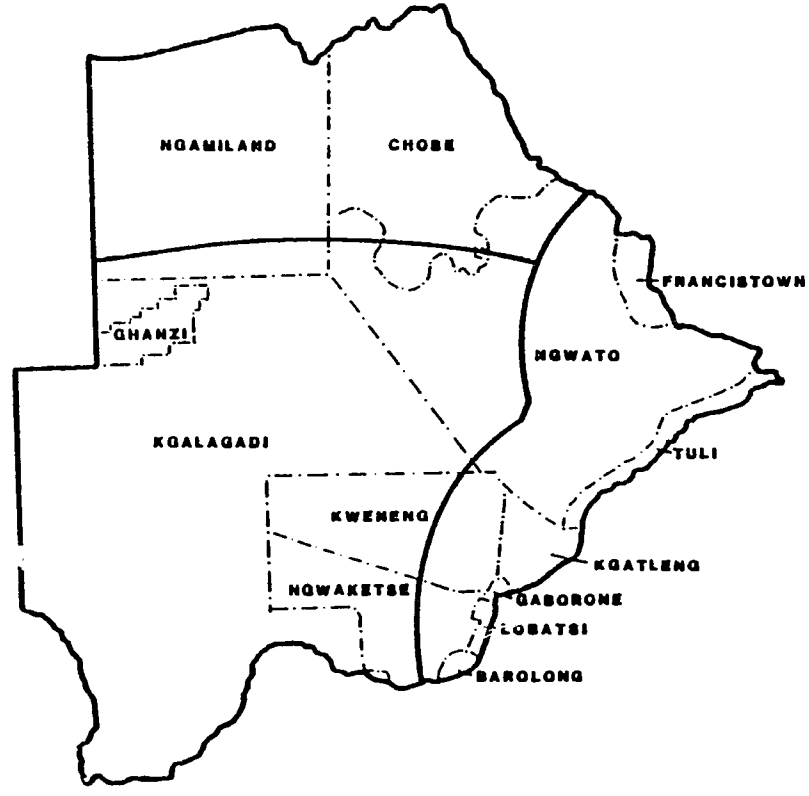


Figure 6.12.

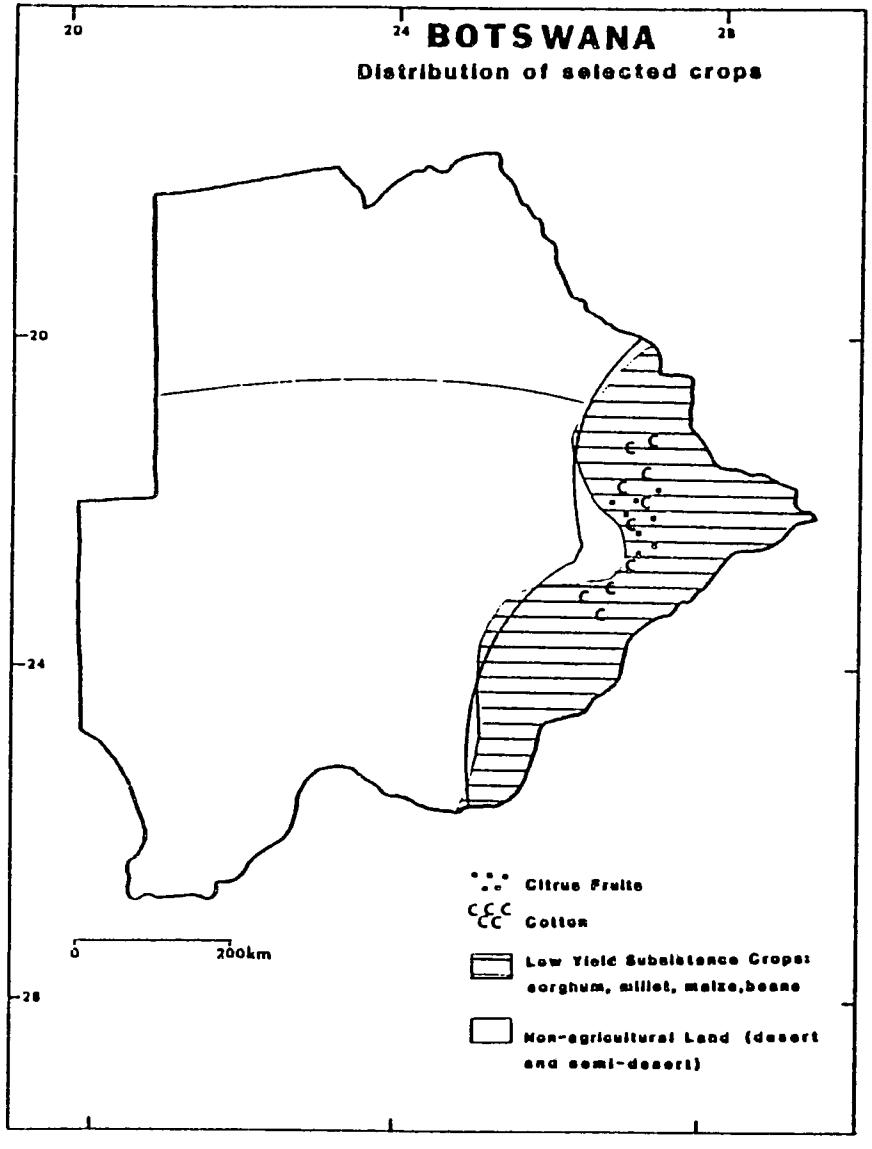


Figure 6.13.

Figure 6.14.

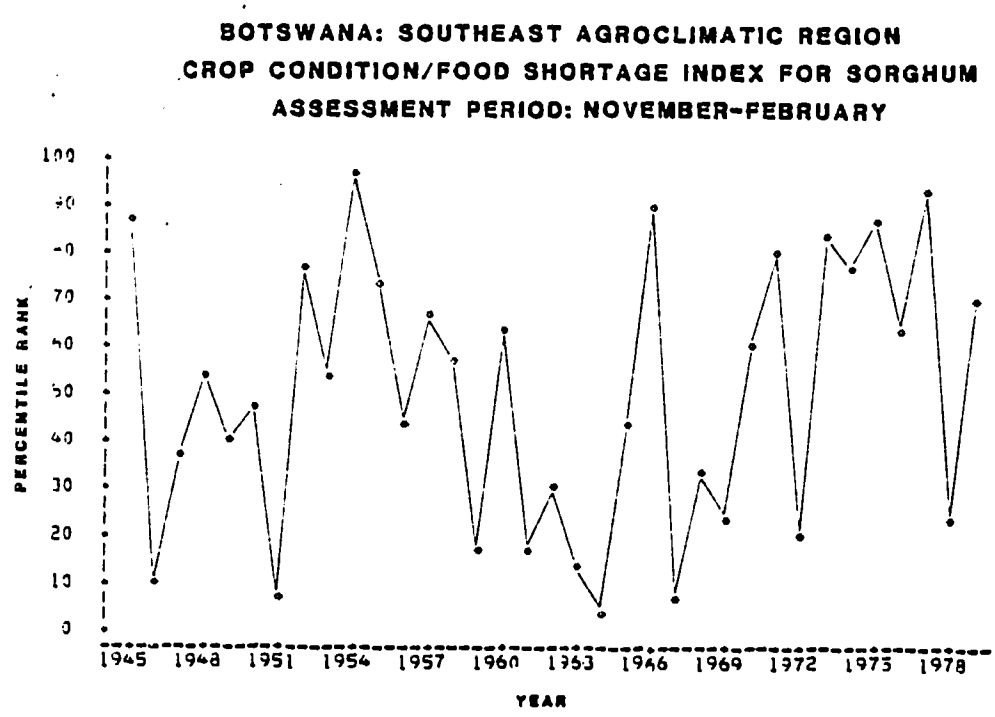

BOTSWANA: SOUTHEAST AGROCLIMATIC REGION
CROP CONDITION/FOOD SHORTAGE INDEX FOR SORGHUM
ASSESSMENT PERIOD: NOVEMBER-FEBRUARY
PERCENTILE RANK
100
90
80
70
60
50
40
30
20
10
0
1945
1948
1951
1954
1957
1960
1963
1966
1969
1972
1975
1978
YEAR

Figure 6.15.

Table 6.6. Mean monthly and annual rainfall (mm) at selected stations in Botswana

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
North	Kasane	914	183	137	101	22	2	4	0	0	1	18	71	173	713
	Shakawe	1002	136	139	77	36	2	0	0	0	3	10	48	96	548
	Maun	945	128	115	67	34	5	1	0	1	5	15	50	83	505
Southwest	Ghanzi	1131	110	73	62	32	8	1	1	1	5	16	52	67	428
	Tsane	1118	82	75	64	34	7	3	1	1	4	15	32	34	353
	Tsabong	960	52	55	52	35	15	4	1	2	4	15	29	28	303
Southeast	Francistown	1001	110	84	50	23	8	2	0	1	6	27	60	93	463
	Serowe	1070	105	97	66	26	11	1	1	0	6	31	55	92	491
	Palapye Road	921	81	81	57	25	8	2	1	1	6	25	55	74	418
	Kalamari	1036	92	83	61	26	8	2	1	2	6	31	60	78	450
	Mahalapye	1006	85	89	58	30	11	2	2	2	9	31	67	90	475
	Molepolole	1052	96	82	67	46	13	5	3	2	17	36	62	88	517
	Mochudi	946	93	73	60	47	12	4	3	1	12	38	58	92	492
	Gaborone	983	102	82	64	47	14	5	4	3	15	43	67	89	534
	Kanye	1372	107	85	70	42	14	7	4	4	12	40	66	83	533
	Lobatsi	1192	108	89	85	55	15	8	5	3	18	46	73	88	593

Table 6.7. Harvested area, yield and production of selected crops in Botswana

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	125	67	191	280	121	228	35	8	44
Wheat	-	-	-	3,000	3,000	3,000	1	1	1
Maize	45	10	47	311	220	249	14	2	12
Millet	10	7	14	500	143	159	5	1	2
Sorghum	70	50	130	221	86	223	16	4	29
Roots & tubers, total	1	1	1	5,154	5,385	5,385	7	7	7
Pulses, total	30	30	30	600	600	600	18	18	18
Groundnuts in shell	8	8	8	933	933	933	7	7	7

Table 6.8. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Botswana (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
Southwest	1,000	4,000	1,000	-	-	-
Southeast	29,000	65,000	8,000	*	-	-
North	4,000	13,000	1,000	*	-	-

Table 6.9. CROP CALENDAR FOR BOTSWANA

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
North	Rainfall		137	129	92	26	6	1	0	0	2	17	58	113
	Maize				000	000000	000						///	////
	Sorghum				000	000000	000						///	////
	Millet				000000	000000							///	////
	Beans				000000	000000							///	//////
Southeast	Rainfall		88	84	70	27	11	5	3	2	9	32	60	85
	Maize				000	000000	000						///	////
	Sorghum				000	000000	000						///	////
	Millet				000000	000000							///	////
	Beans			000	000000	000000							///	//////
Southwest	Rainfall		69	72	62	35	10	5	1	1	5	17	35	54
	Sorghum				000	000000	000						///	//////
	Millet				000000	000000							///	//////
	Beans			000	000000	000000							////	//////

TABLE 6.10.

BOTSWANA

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1965 -	Drought Nationwide
1968 -	Drought Nationwide
1969 -	Drought Nationwide
1972, January	Flood
1976, May	Continued Rains Adversely Affect Crop Harvesting. Damage from Birds Reported in Northern Regions
1978, December	Dry Weather is Delaying Sowing of Maize in Southern Botswana
1979, May-June	A Severe Drought has Reduced the Coarse Grain Crops by About 90%
1980, January	The Drought in 1979 has Created Serious Food Shortages
1980, July	The 1980 Cereal Harvest was Only About 60% of Normal
1982, February	Late and Below Normal Rains are Hurting the Main Season Coarse Grain Crop. Acreage has been Reduced to 50% of 1981
1982 -	Drought Nationwide
1982, November	At Least 13,000 Cattle in the NE District have Died as a Result of Drought. Production of the 4 Main Food Crops - Sorghum, Maize, Millet and Beans During the 1982 Harvest Season is Only 30% of that in 1981 Season. Only About 35% of the Planted Area was Harvested, as Compared with 80% During Normal Years

C. BURUNDI

1. Agroclimatic Conditions and Regions

Due to its small size, Burundi constitutes one agroclimatic assessment region (Figure 6.18). Major geographic areas in the country are:

- Lowland plain. This is a narrow strip of land along the shores of Lake Tanganyika, with altitude between 800 and 1,000 m (Figure 6.16).
- Mountains. They run from north to south in the western half of the country. The highest peak is 2,601 m. The western slopes of the mountain range are steep; eastwards they are more gentle.
- Highland plateau. It occupies the eastern two thirds of the country, with altitude decreasing eastwards.

The mean annual amount of rainfall is slightly below 1,000 mm in the lowland plain, mostly 1,000-1,100 mm in the highland plateau, and 1,300-1,500 mm in the high mountains (Figure 6.16 and Table 6.11). The rainy season normally begins in late September or early October, peaks in April and ends in late May. The period with mean monthly rainfall of 100 mm or more is 7-8 months in the higher altitude areas of the country, decreasing to 2 months in the lowland plain and in the northeastern most corner of the country (Figure 6.17; see also Chapter VII, E).

2. Agriculture

The main food crops in Burundi are beans, maize, sorghum, sweet potatoes and cassava (Table 6.12). A large amount of plantains are also grown. Commercial crops (Figure 6.20) are mostly coffee (in the highlands) and cotton (in the lowland plain). Food crop farming methods are primitive and as a result yields are low.

Over most of the country, farmers grow one crop per season. Sowing starts with the beginning of the rainy season in October and lasts for 2-3 months (Table 6.14). The bulk of harvesting is done during April and May. In areas with a longer duration of the rainy season, farmers grow two crops per season. The first is sown in late September and October and harvested in January-February. Immediately after the first crop is harvested, the field is prepared and sown with the second crop, which matures normally in late May and early June.

3. Factors Affecting Yield and Their Assessment

Unlike most other Subequatorial African countries where the main

meteorological factor adversely affecting crops is lack of rainfall, excess rainfall damages the crops in Burundi, especially in the highlands. Drought occurs mostly in the lowland plain along Lake Tanganyika and in the northeastern most corner of the country. The episodic event information for the country is incomplete (Table 6.13). The years with insufficient and excess rainfall are shown on Figure 6.22.

The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years. There are only four stations in Burundi for which we have such data and unfortunately their periods of record are either not the same or very short. It was therefore necessary to use stations from neighboring countries. The best combination was to use only Bururi from Burundi, and Kibondo and Ngara from Tanzania, which have data for 20 years - 1940 to 1959 (Table 7.1 and Figure 6.21). In addition to the stations with common period of records (used for the assessments), Burundi has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative provinces of Burundi, their boundaries are shown on Figure 6.19.

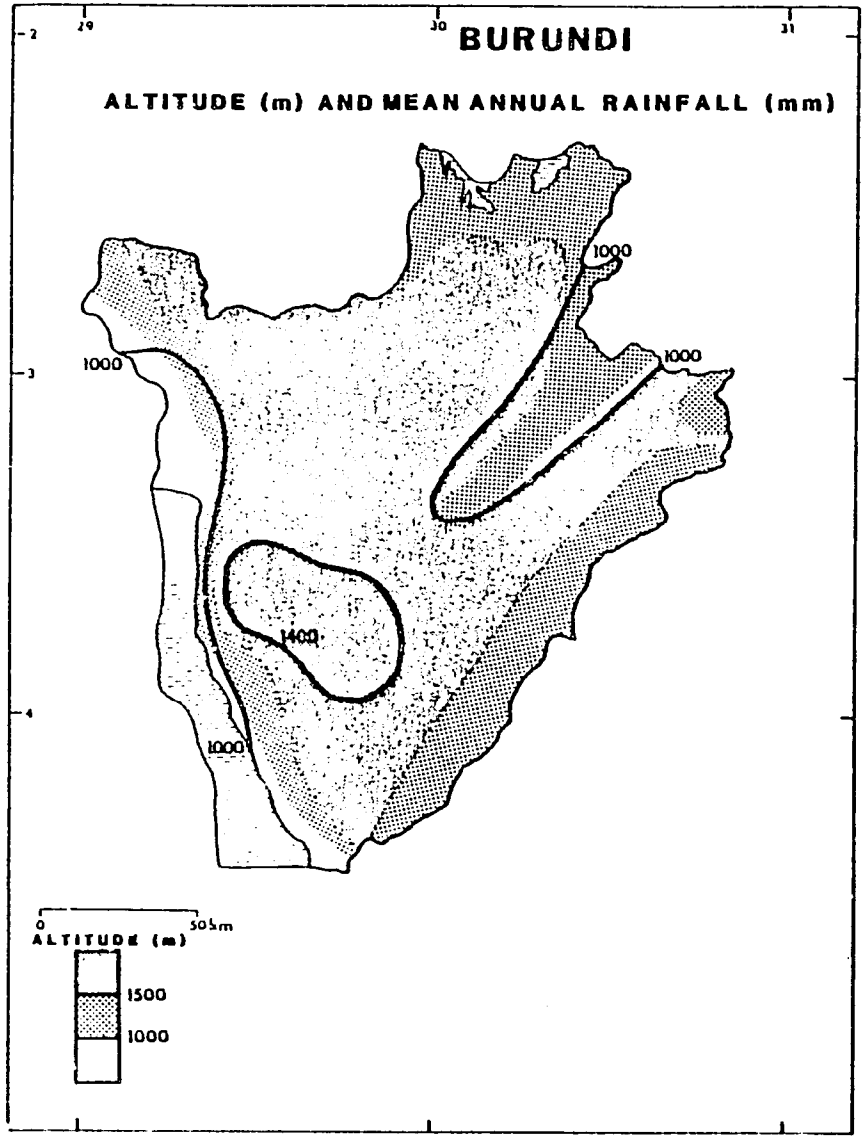


Figure 6.16.

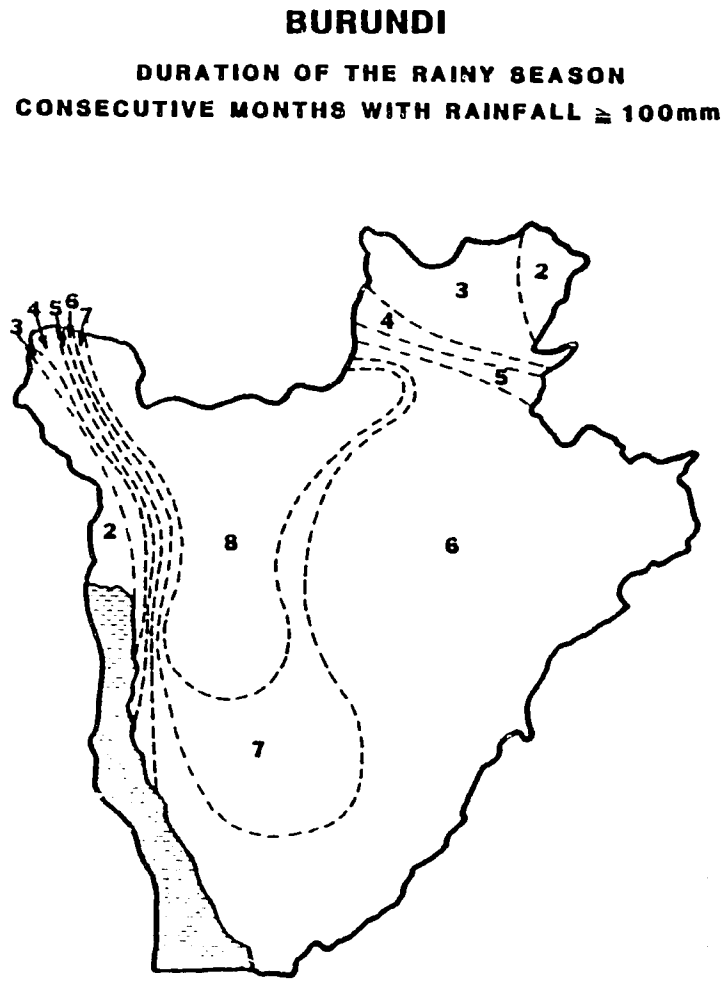


Figure 16.17.

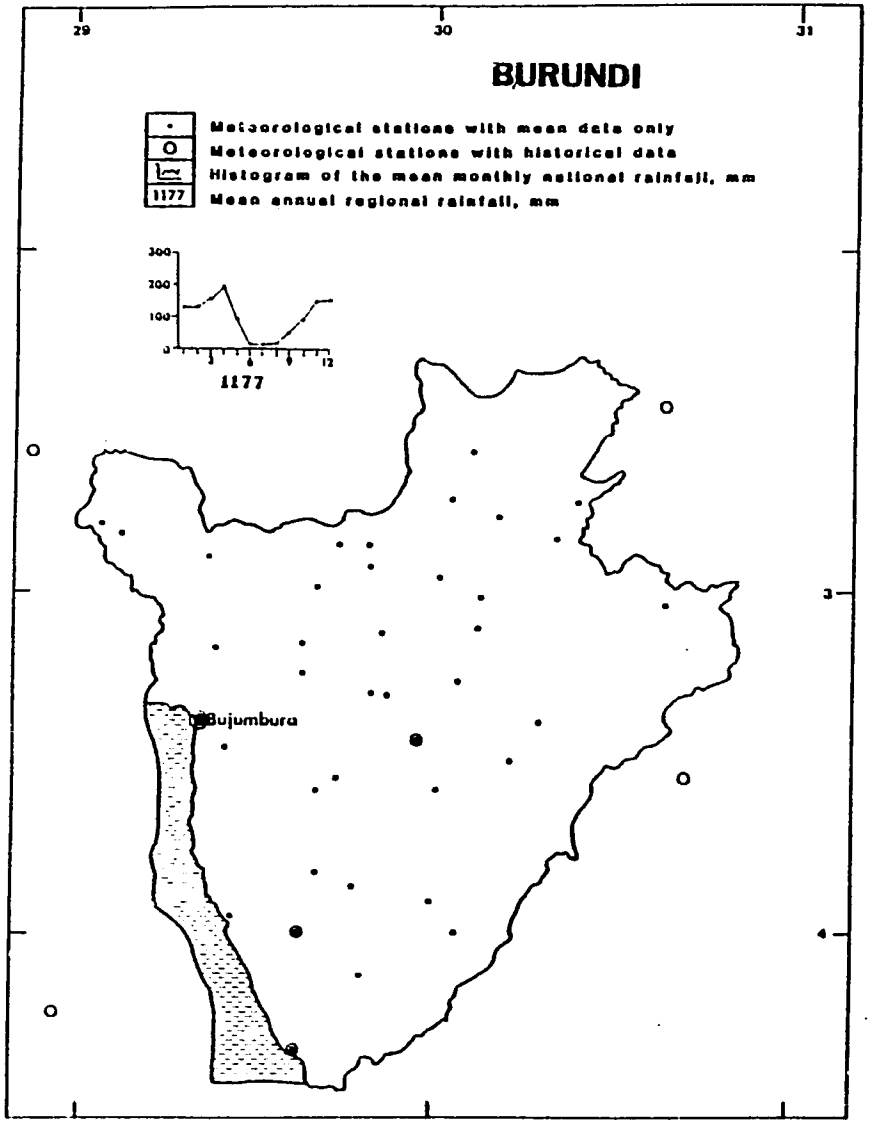


Figure 6.18.

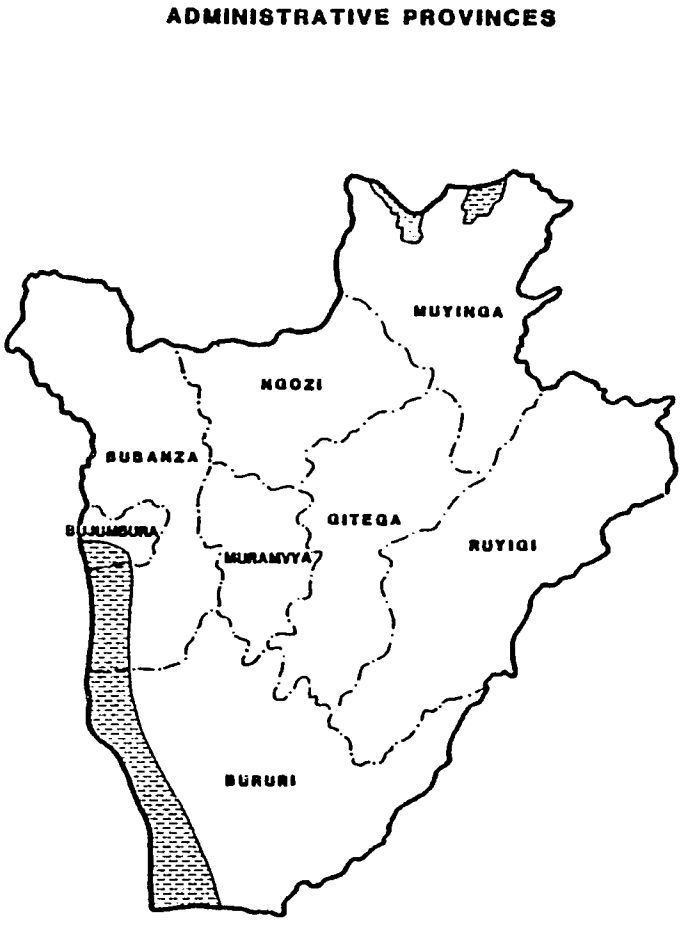


Figure 6.19.

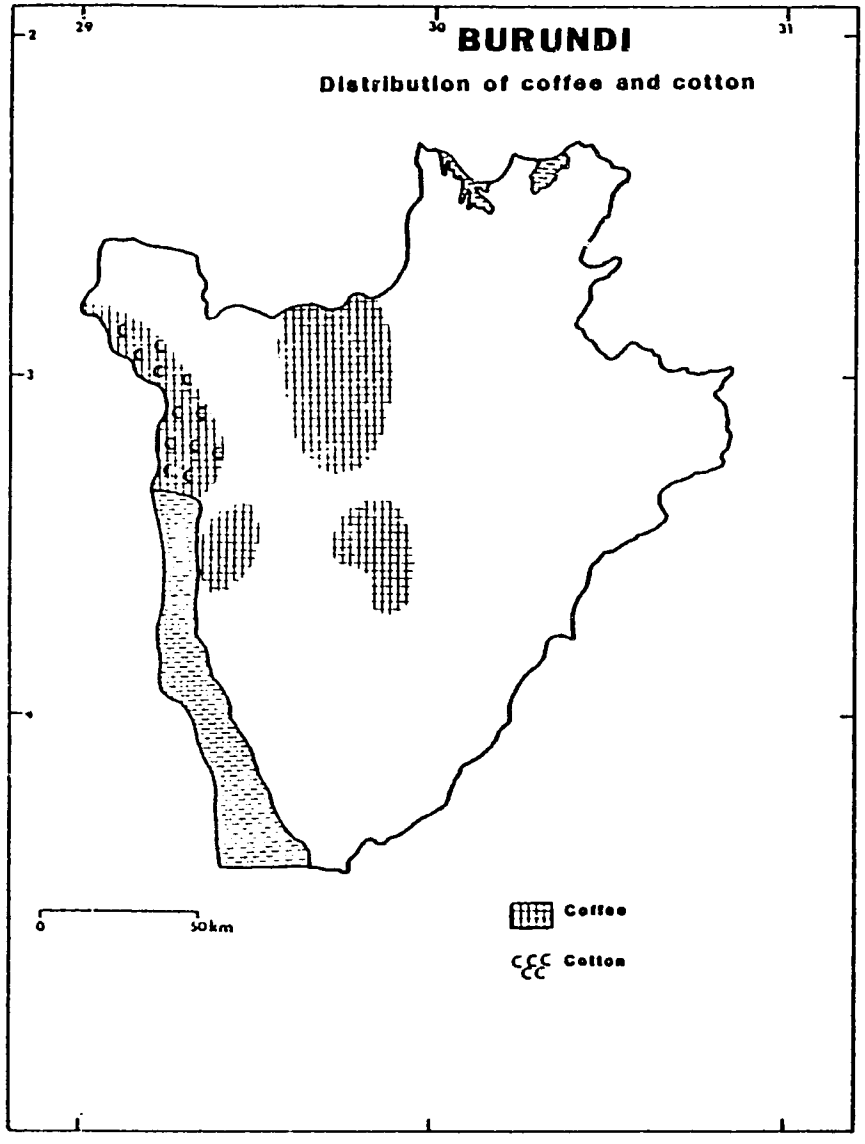
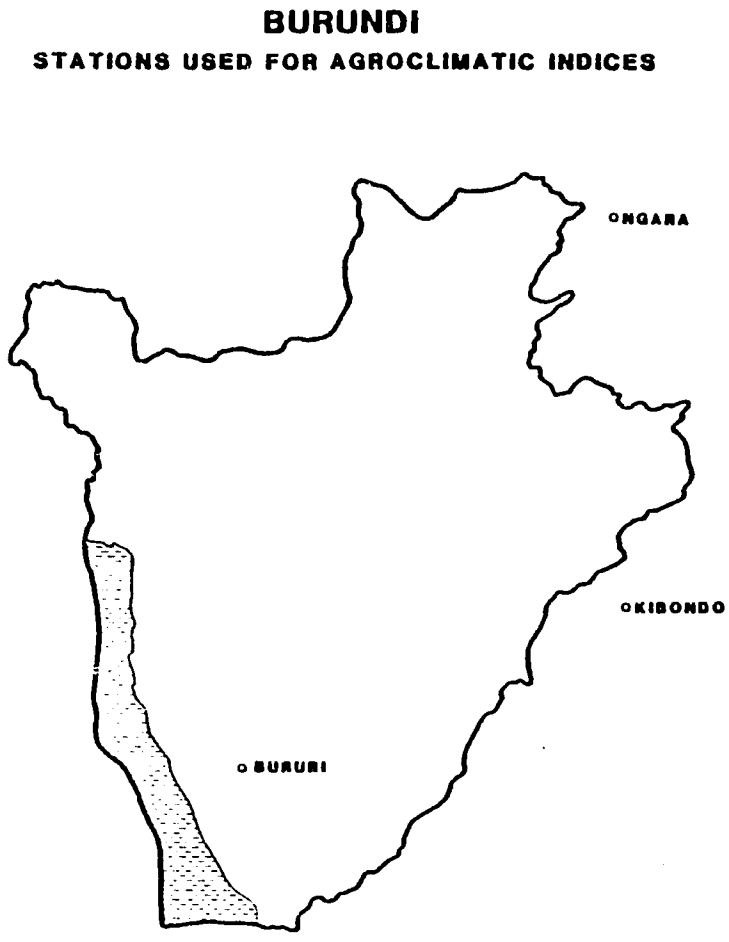


Figure 6.20.



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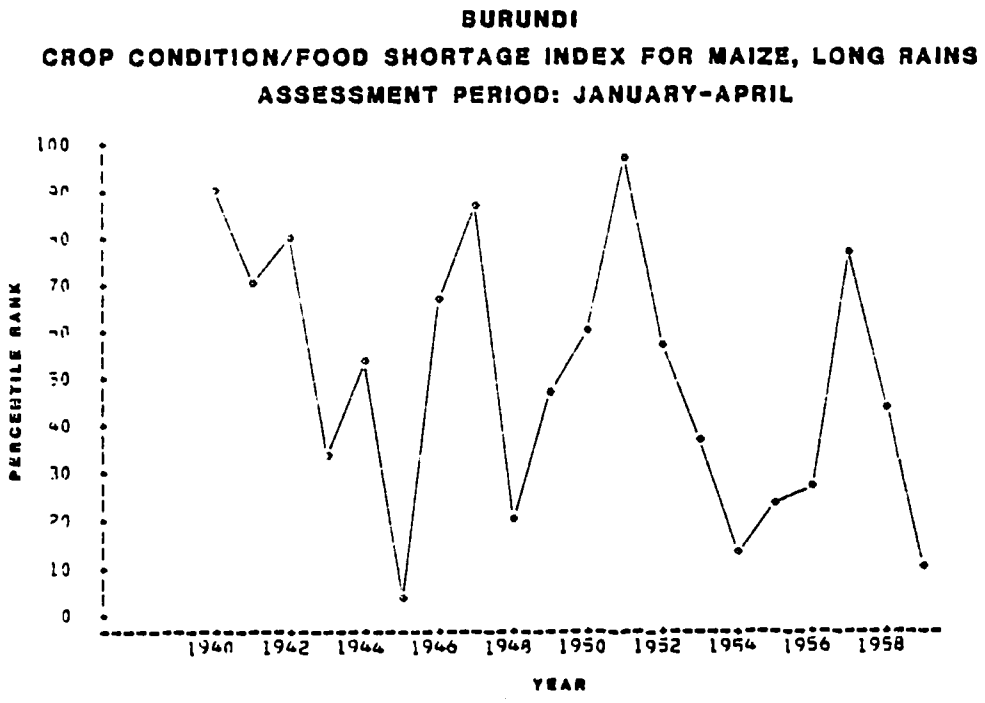

BURUNDI
CROP CONDITION/FOOD SHORTAGE INDEX FOR MAIZE, LONG RAINS
ASSESSMENT PERIOD: JANUARY-APRIL
PERCENTILE RANK
100
90
80
70
60
50
40
30
20
10
0
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
YEAR

Figure 6.22.

Table 6.11. Mean monthly and annual rainfall (mm) at selected stations in Burundi

STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Bukavu, Zaire*	1612	126	134	177	153	77	28	13	87	103	155	179	145	1317
Ngara, Tanzania*	1798	97	113	122	191	98	12	5	15	57	76	134	111	1032
Bujumbura	782	70	106	136	134	59	11	0	11	32	74	92	109	832
Gitega	1718	128	131	165	164	70	6	6	6	37	97	117	136	1063
Kibondo, Tanzania*	1518	158	152	186	221	79	7	3	6	28	68	177	179	1263
Bururi	1894	179	167	205	206	94	14	3	9	57	105	185	205	1430
Fizi, Zaire*	1249	125	135	154	212	112	16	12	17	36	80	140	163	1202
Nyanza-Lac	799	127	110	168	205	81	10	6	6	21	52	114	141	1041
Kigoma, Tanzania*	885	142	118	143	174	65	6	2	1	17	52	136	148	1005

*The station is located in a neighboring country, and may be used for Burundi assessments.

Table 6.12. Harvested area, yield and production of selected crops in Burundi

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	293	299	310	1,057	1,078	1,109	310	323	344
Wheat	4	5	6	741	510	650	3	3	4
Maize	125	125	125	1,120	1,200	1,200	140	150	150
Rice (paddy)	4	4	4	2,286	2,469	2,500	8	10	10
Millet	51	56	55	966	1,090	1,091	49	61	60
Sorghum	110	110	120	1,000	900	1,000	110	100	120
Roots & tubers, total	187	191	195	10,960	10,980	11,284	2,047	2,094	2,198
Potatoes	8	11	12	2,774	1,774	1,833	23	19	22
Sweet potatoes	92	92	93	10,000	9,457	9,892	920	870	920
Cassava	77	79	80	13,636	14,631	14,963	1,050	1,150	1,200
Pulses, total	306	306	309	650	676	680	199	207	210
Beans (dry)	255	255	258	635	667	671	162	170	173
Groundnuts in shell	8	8	8	933	933	933	7	7	7

TABLE 6.13.

BURUNDI

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1974, July	Heavy Rains Reduced the Pulse Crop by 50-70 Percent
1975, January	Due to Last Year's Bad Harvest (Heavy Rains), Food Supply is Critical and 100,000 Persons Suffer from Food Shortages
1976, December	Hailstorms Heavily Damaged Food Crops in Most Areas
1977, May	Heavy Rainfalls Caused Flooding in Some Areas
1977, December	Crop Production Drastically Reduced Due to the Delayed Start of the Rainy Season

Table 6.14. CROP CALENDAR FOR BURUNDI

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
This country constitutes one agroclimatic region	Rainfall		130	129	158	193	98	13	4	14	50	93	143	152
	Sorghum	Single			000	000000	000000				///	//////	//////	//////
		Long Rains	//	//////			000	000						
		Short Rains	000000	000000							///	//////		
	Maize	Single			000	000000	000000	000				//////	//////	//////
		Long Rains	//	//////			000	000						
		Short Rains	000	000000								//////		
	Millet	Single			000	000000	000000				///	//////	//////	
		Long Rains	///	//////		000	000000	000						
		Short Rains	000000	000							///	//////		000
	Beans	Long Rains		//////	///		000000	000						
		Short Rains	000000	000								//////		00

D. CONGO

1. Agroclimatic Conditions and Regions

There are four major geographic regions in Congo:

- Coastal Plain. This is an area of rolling hills stretching for about 150 km along the Atlantic coast.
- Niary Valley. This is an area of about 50,000 km^2 on both sides of the Niary River in Southcentral Congo (southeast and mostly southwest of station Mouyondzi on Figure 6.30). Congo's most fertile soils are in this area.
- Highlands. This is the area above 300–400 m altitude in the southern half of the country, along the western border (Figure 6.23). A large part of the highlands is covered with tropical forest.
- Congo River Basin. This is a flat swampy area in the northeastern one third of the country. Most of it is covered with dense tropical forest; flooding occurs every year during the rainy season.

The country has been divided into three agroclimatic assessment regions (Figure 6.25). The North and Central regions receive approximately the same amount of annual rainfall - an average of about 1,700 mm - while the Southwest region receives about 1,300 mm. With few exceptions, the rainfall amounts received within the boundaries of each region are quite uniform (Table 6.15).

Congo has two rainy and two dry seasons per year (Figure 6.25). The first rainy season has its peak in March, April and May, while the second peaks between September and November. The dry seasons in the North region are equally pronounced. In the Central, and especially in the Southwest regions, the second dry season (June–September) is far more pronounced than the dry season that occurs in January and February.

The duration of the period with mean monthly rainfall of 100 mm or more is about 5–6 months in the Southwest, 8–9 months in the Central, and 4–9 months in the North region (Figure 6.24; see also Chapter VII, E).

2. Agriculture

The principal subsistence crops in Congo are cassava and maize (Table 6.16). Farmers also grow beans, sweet potatoes, rice and bananas (Figure 6.27). The most important commercial crops are groundnuts, oil palm, cocoa, coffee and cotton (Figure 6.28). As the majority of the population

lives in the Southwest region, most of the food crops are grown there (Table 6.17). The crop calendar for some crops is shown in Table 6.18.

3. Factors Affecting Yield and Their Assessment

Despite the large amounts of rainfall, drought conditions do occur in Congo, especially in the Southwest region. Although the episodic event record for Congo is incomplete (Table 6.19) it indicates two drought occurrences within one calendar year. Another meteorological factor adversely affecting crops is heavy rains, and the subsequent flooding. This occurs most frequently in the Congo River basin. The years with insufficient, as well as with good, rainfall in the Southwest region are shown on Figure 6.29.

The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Congo and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.30. In addition to the stations with common period of records (used for the assessments), Congo has historical meteorological data for some other stations. They are not used for the assessment because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative regions of the country, their boundaries, together with those of the agroclimatic regions, are shown in Figure 6.26.

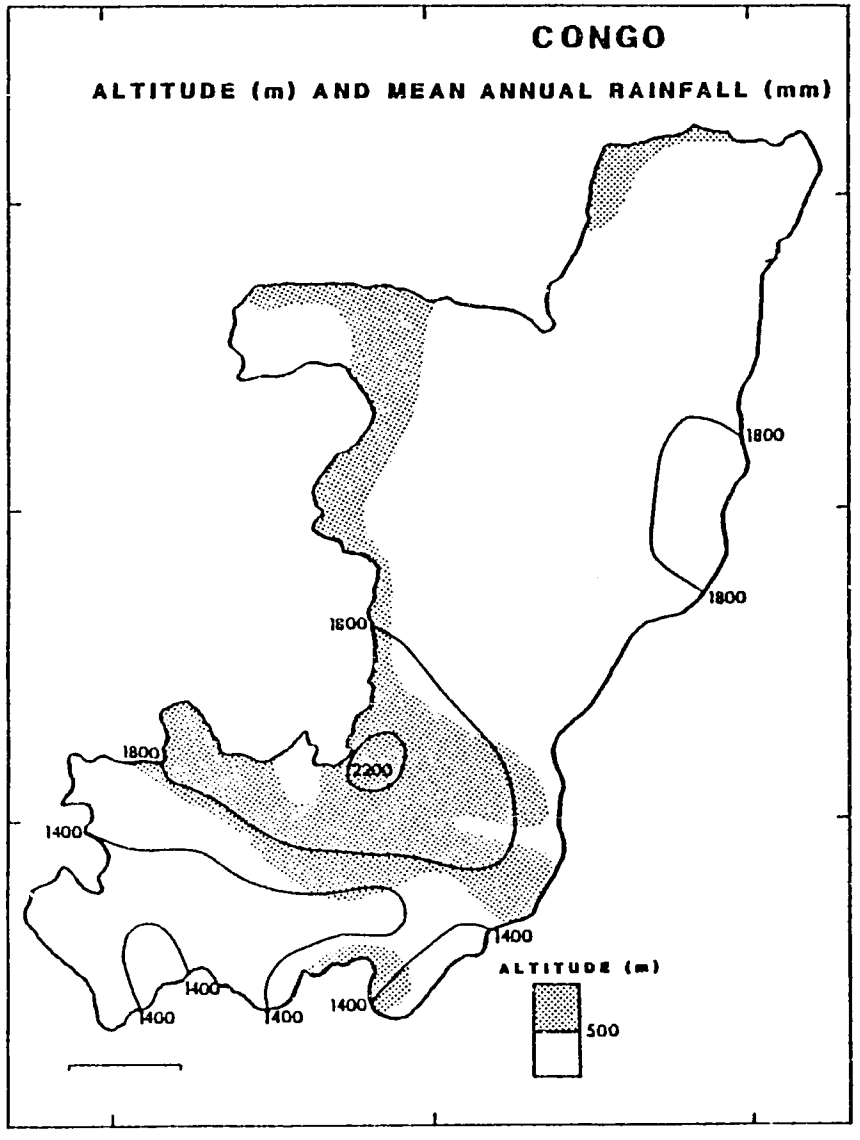


Figure 6.23.

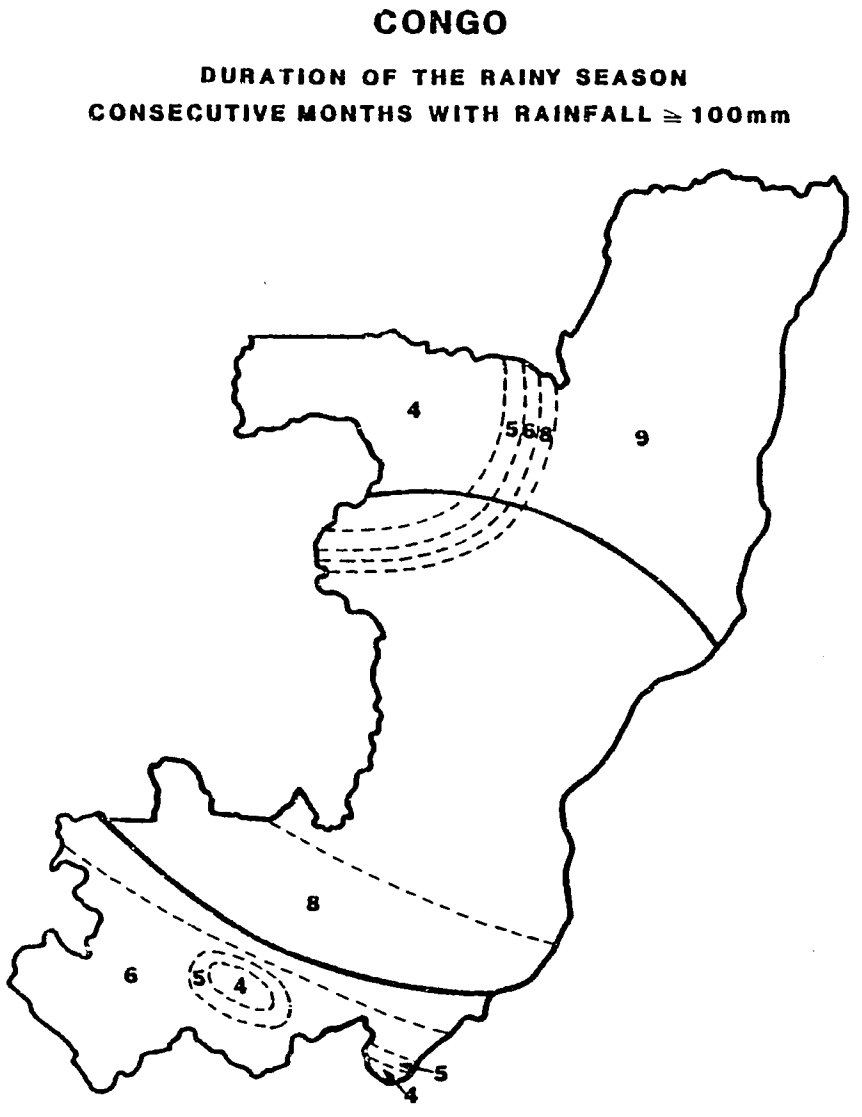


Figure 6.24.

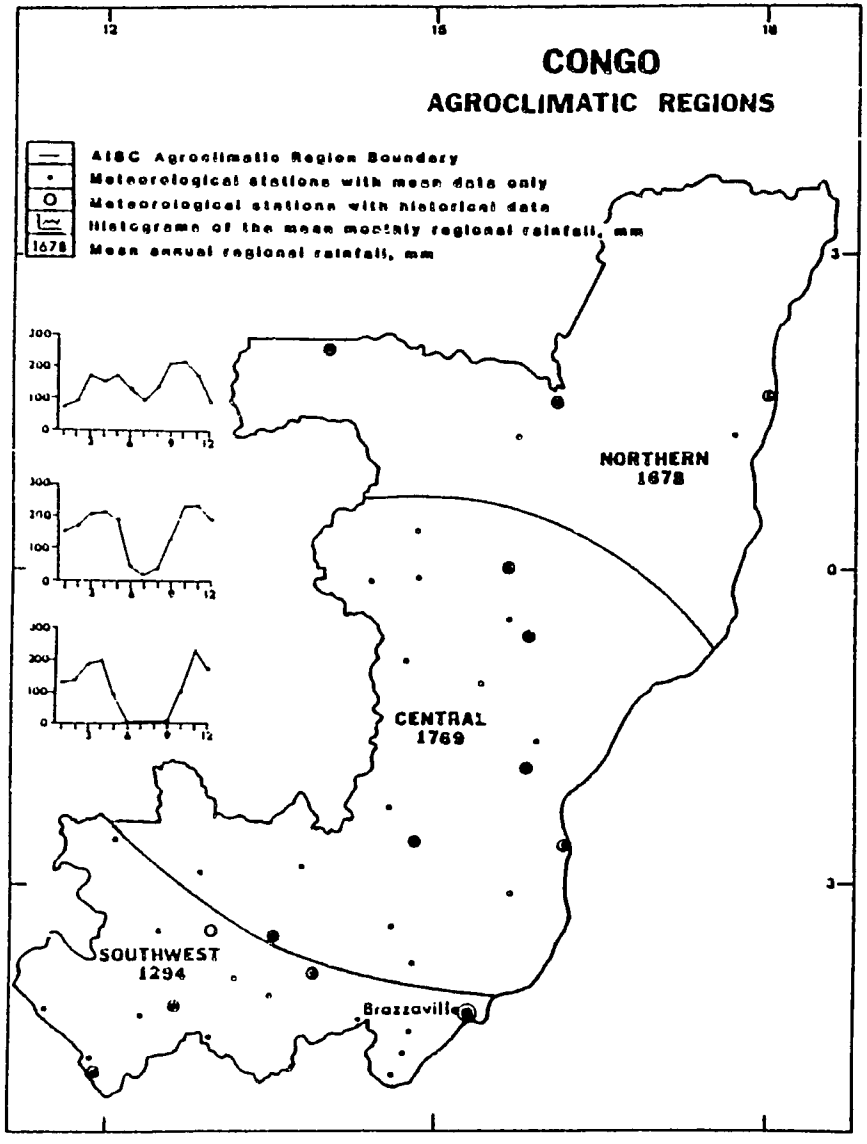


Figure 6.25.

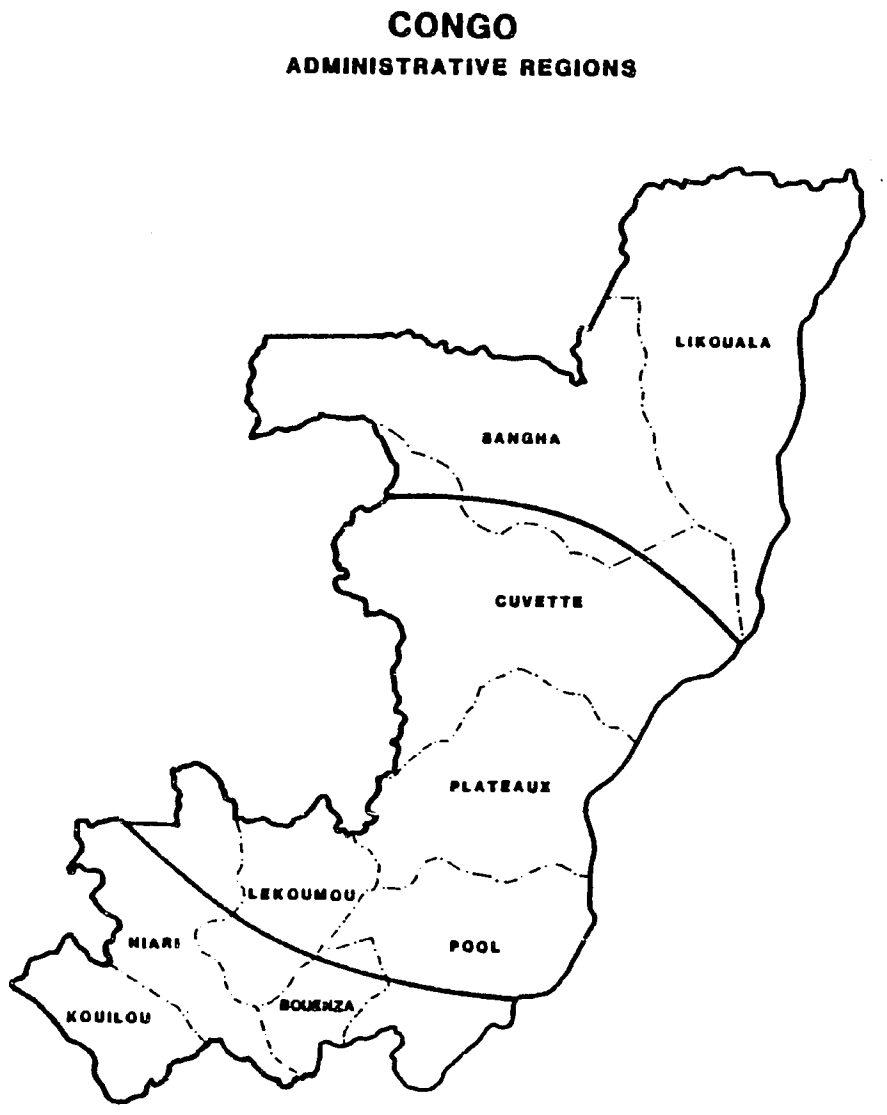


Figure 6.26.

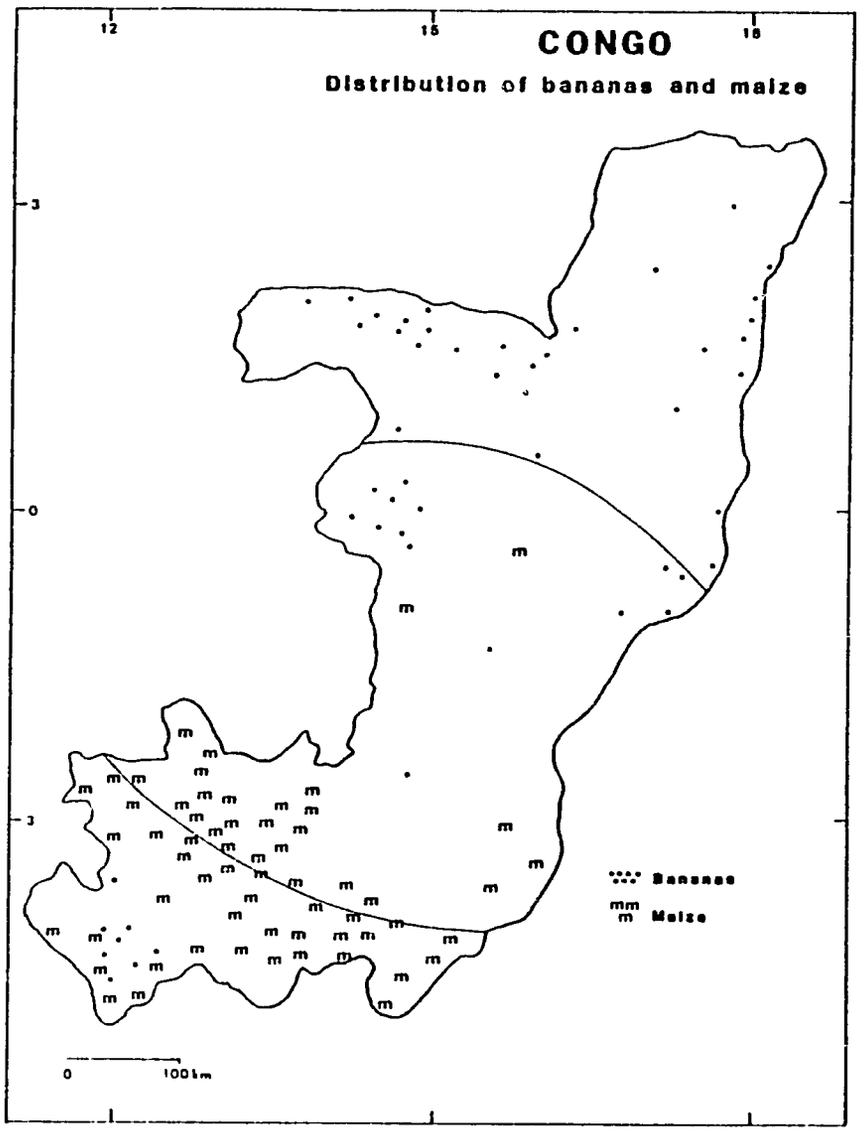
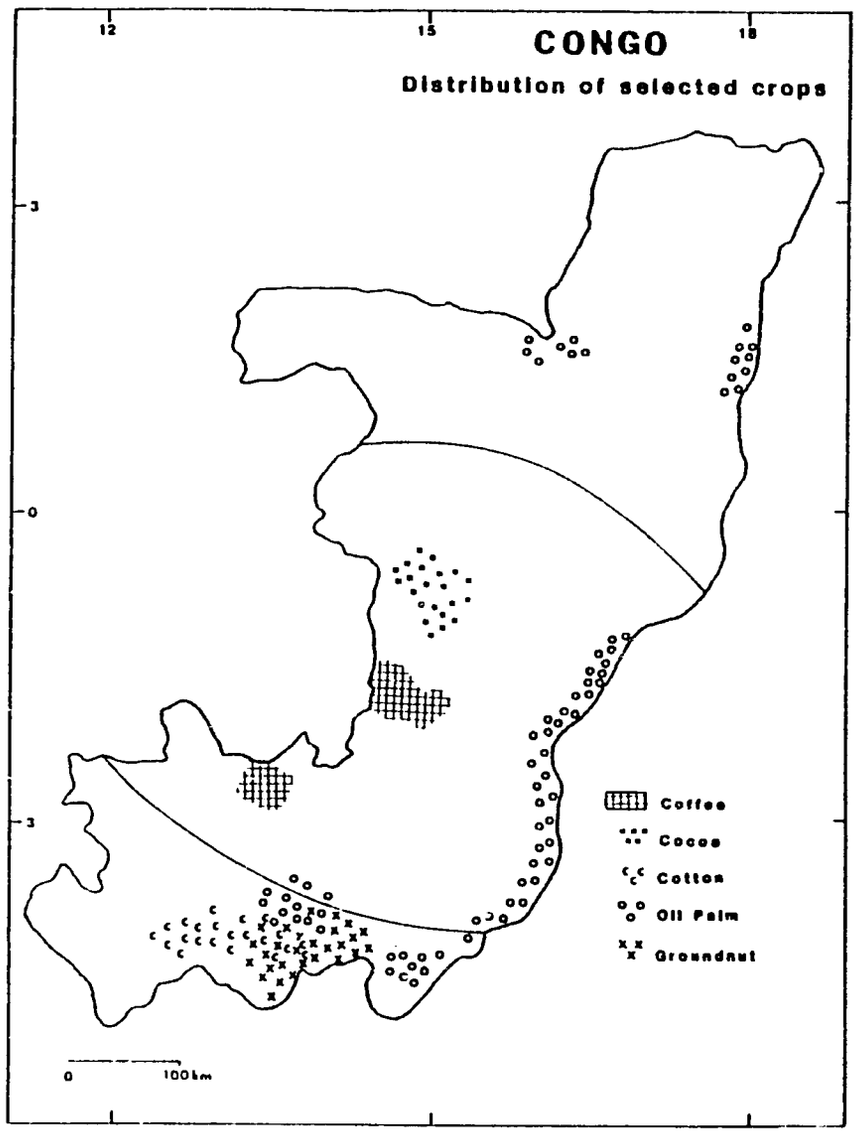


Figure 6.27.



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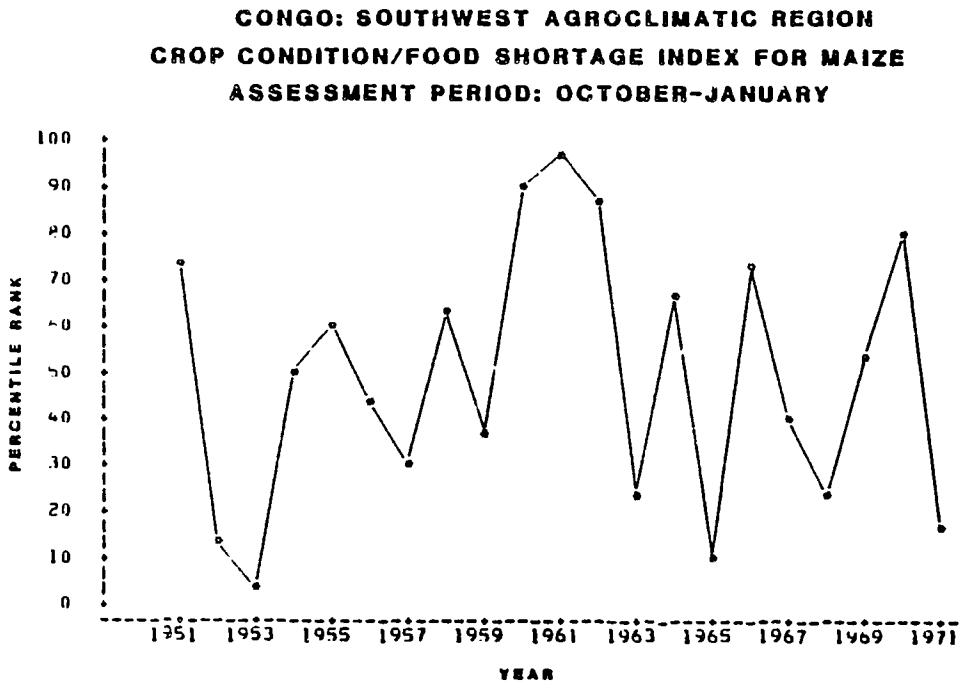


Figure 6.29.

Figure 6.30.

Table 6.15. Mean monthly and annual rainfall (mm) at selected stations in Congo

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
North	Souanke	550	55	81	181	168	216	114	75	92	227	252	166	56	1683
	Ouesso	352	53	93	149	136	182	138	100	141	219	243	174	74	1701
	Impfondo	326	69	94	167	168	166	156	163	178	180	208	186	76	1810
Central	Makoua	379	107	132	162	187	177	85	33	89	212	245	196	135	1761
	Fort Rousset	335	114	132	180	164	198	73	23	82	164	217	200	160	1706
	Gamboma	377	153	168	181	177	154	48	27	62	186	268	207	184	1814
	Djambala	790	194	188	252	255	199	28	12	37	160	275	269	245	2114
	M Pouya	312	151	151	187	190	151	20	7	34	102	203	222	149	1566
	Sibiti	531	153	158	222	238	145	4	2	2	20	128	308	216	1595
Southwest	Mouyondzi	512	153	116	174	182	111	2	0	1	17	117	266	178	1316
	Dolisie	330	118	159	215	200	84	1	0	0	5	70	223	159	1235
	Brazzaville	316	140	120	191	201	126	5	1	3	37	133	238	173	1368
	Pointe Noire	17	158	187	232	172	77	0	0	2	11	81	210	136	1265

Table 6.16. Harvested area, yield and production of selected crops in Congo

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	30	30	31	458	697	612	14	21	19
Maize	26	26	27	385	654	556	10	17	15
Rice (paddy)	4	4	4	1,000	1,000	1,000	4	4	4
Roots & tubers, total	89	89	90	6,603	6,602	6,602	578	585	593
Potatoes	-	-	-	4,680	4,800	4,800	1	1	1
Sweet potatoes	4	4	4	6,075	5,976	5,886	24	25	26
Cassava	80	81	82	6,650	6,653	6,657	532	538	543
Pulses, total	11	11	12	607	614	621	7	7	7
Beans (dry)	6	6	7	571	578	585	4	4	4
Groundnuts in shell	30	30	30	600	601	603	18	18	18

Table 6.17. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Congo (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
Southwest	20,000	-	-	-	2,600	53,000
Central	6,000	-	-	-	1,200	20,000
North	800	-	-	-	200	8,000

Table 6.18. CROP CALENDAR FOR CONGO

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Central	Rainfall		148	167	202	215	182	40	17	37	124	222	233	181
	Maize			000000	0000							//////		
	Rice	First	000000	000							//////	//////		000
	Rice	Second	//////	//////			000	000000	000					
Southwest	Rainfall		138	140	196	200	99	2	1	2	16	100	231	170
	Maize			000000	0000							//////		
	Rice					000000	000000					///	//////	//////
	Groundnut		//////				000	000000						

TABLE 6.19.

CONGO

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1975, January	Bugs and Scale Insects Severely Damaged Cassava Crop
1978, May	Severe Drought is Damaging All Crops
1978, December	Cassava Hurt by Drought, While Peanuts are Attacked by Insects

E. GABON

1. Agroclimatic Conditions and Regions

There are two major geographic regions in Gabon:

- Coastal Plain. It is between 50 and 150 km wide along the Atlantic coast. River estuaries are swampy. Tropical forest covers most of the plain.
- Inland Plateaus. The rest of the country consists of several large plateaus, mostly between 300 and 800 meters high, cut by deep river valleys (Figure 6.31). About 80 percent of the area is covered by tropical forest.

Gabon has been divided into two agroclimatic assessment regions (Figure 6.33). Both receive abundant rainfall - an average of 1,700 mm in the East and about 2,200 mm in the West. Rainfall in the eastern region is more uniform, while in the western region it ranges from less than 1,400 mm in the south to 3,400 mm in Cocobeach in the north (Figure 6.31 and Table 6.20.). Originally, the western region consisted of two separate regions - Northwest and Southwest - which later had to be united in order to coincide with those used by CAB.

The seasonal variations of rainfall in both agroclimatic regions are very similar. Both regions have two rainy and two dry seasons (Figure 6.33). The first rainy season peaks in March and April, the second in October and November. The main and real dry season is during June, July and August, when monthly amounts are negligible. The other "dry" season occurs in December, January and February, when monthly amounts decrease, but are still over 100 mm/month.

Gabon has one of the longest durations of the rainy season in Subequatorial Africa. The period with mean monthly rainfall of 100 mm or more is 8-9 months in the western, and in the southern half of the eastern region (Figure 6.32). The northern half of the eastern region has two such periods - each about 3-4 months.

2. Agriculture

Cereal crops do not grow well in Gabon. Farmers grow some maize and rice (Tables 6.21 and 6.22; FAO data do not indicate rice, although it is grown in the country). Major food crops in the country are bananas, cassava, sweet potatoes, yams and groundnuts. The main commercial crops

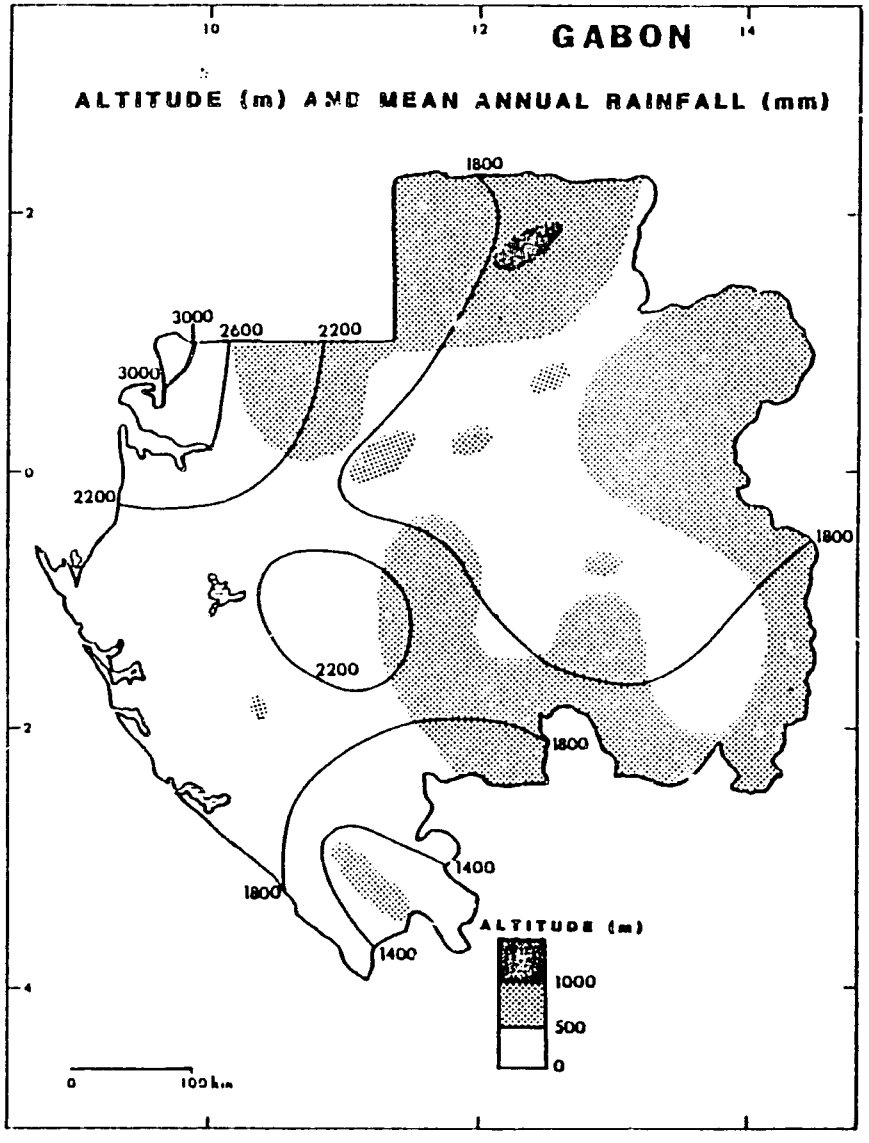
are cocoa, coffee, and oil palm (Figures 6.35 and 6.36). The crop calendars are shown on Table 6.23.

3. Factors Affecting Yield and Their Assessment

There are no episodic event records for Gabon. The regime of rainfall suggests that flooding and drought are the major meteorological factors adversely affecting crops in Gabon. Drought occurs more frequently in the drier areas in the southwest part of the country, while floods occur more frequently in the wetter areas. The years with insufficient as well as excess rainfall are shown on Figure 6.37.

The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Gabon and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.38. In addition to the stations with common period of records (used for the assessments), Gabon has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative divisions of the country, their boundaries, together with those of the agroclimatic regions, are shown on Figure 6.34.



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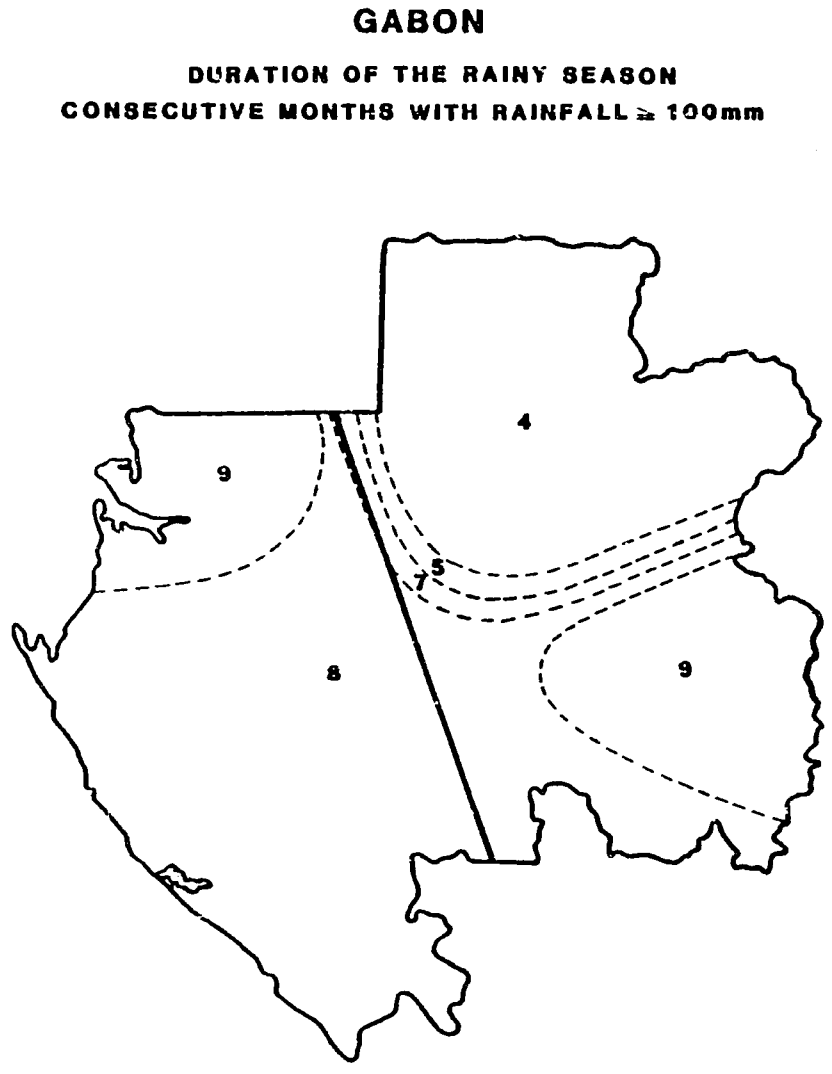

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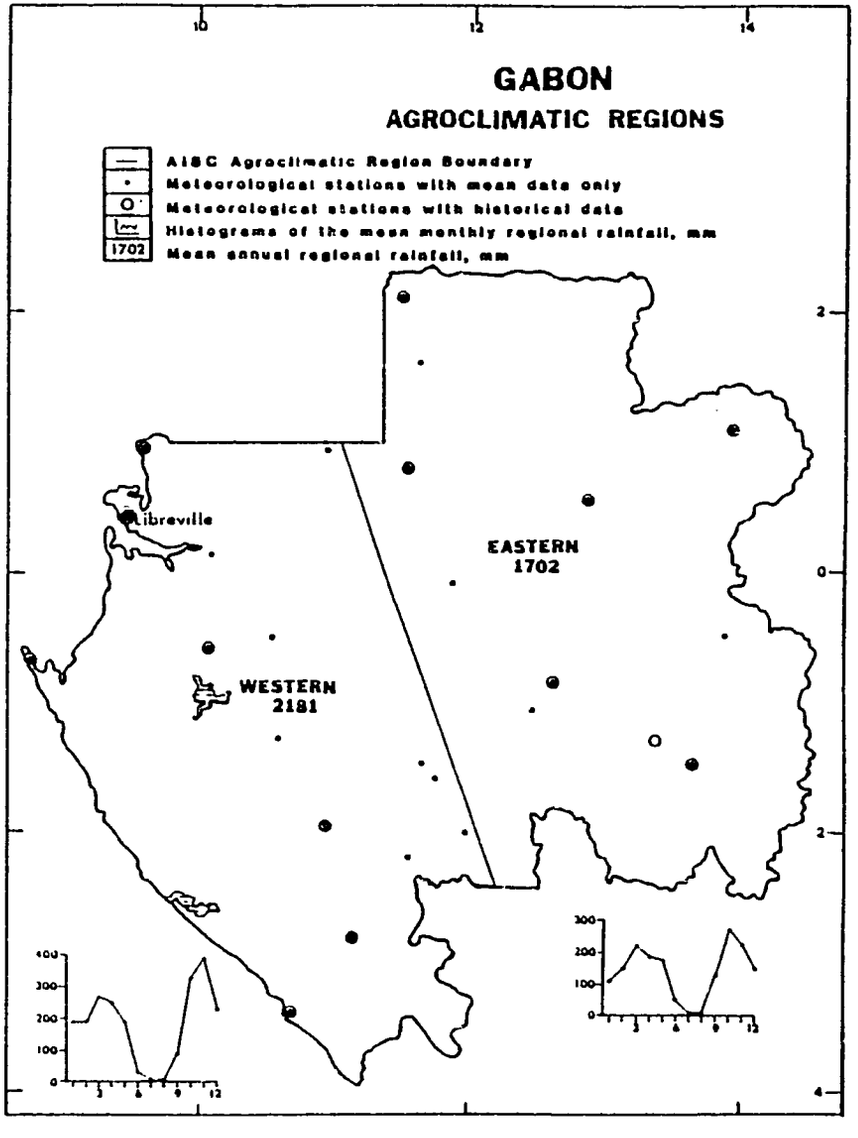

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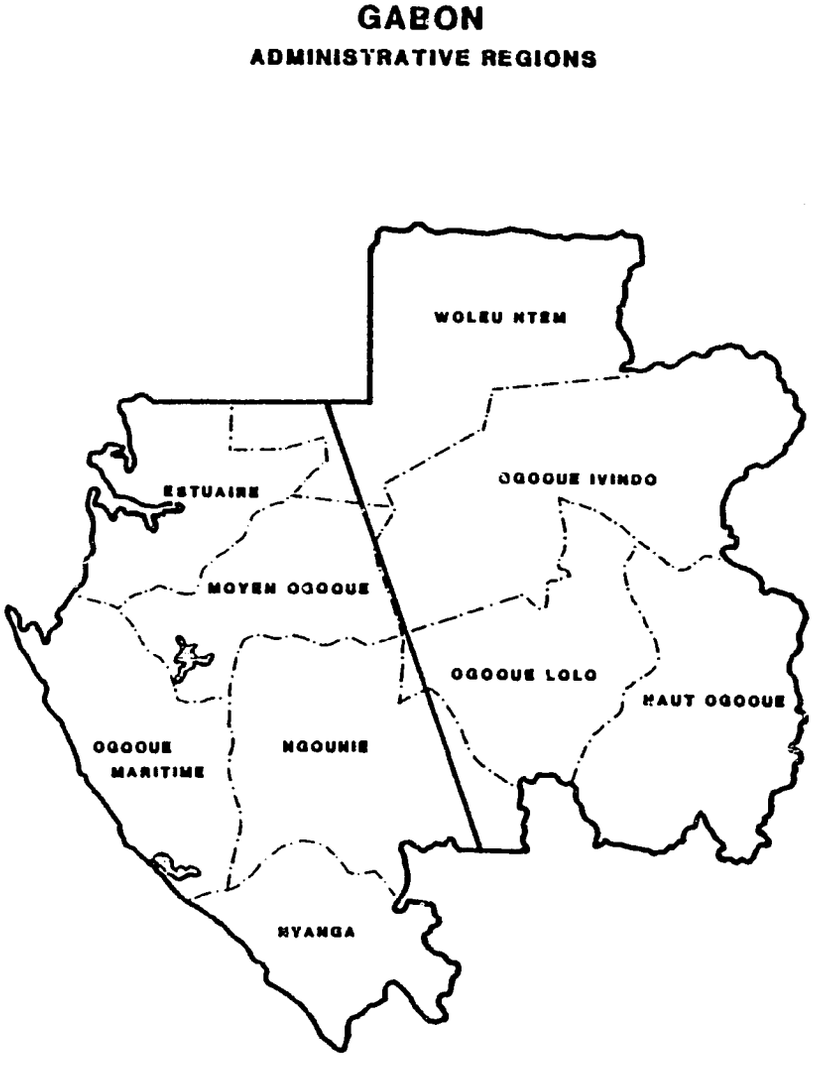

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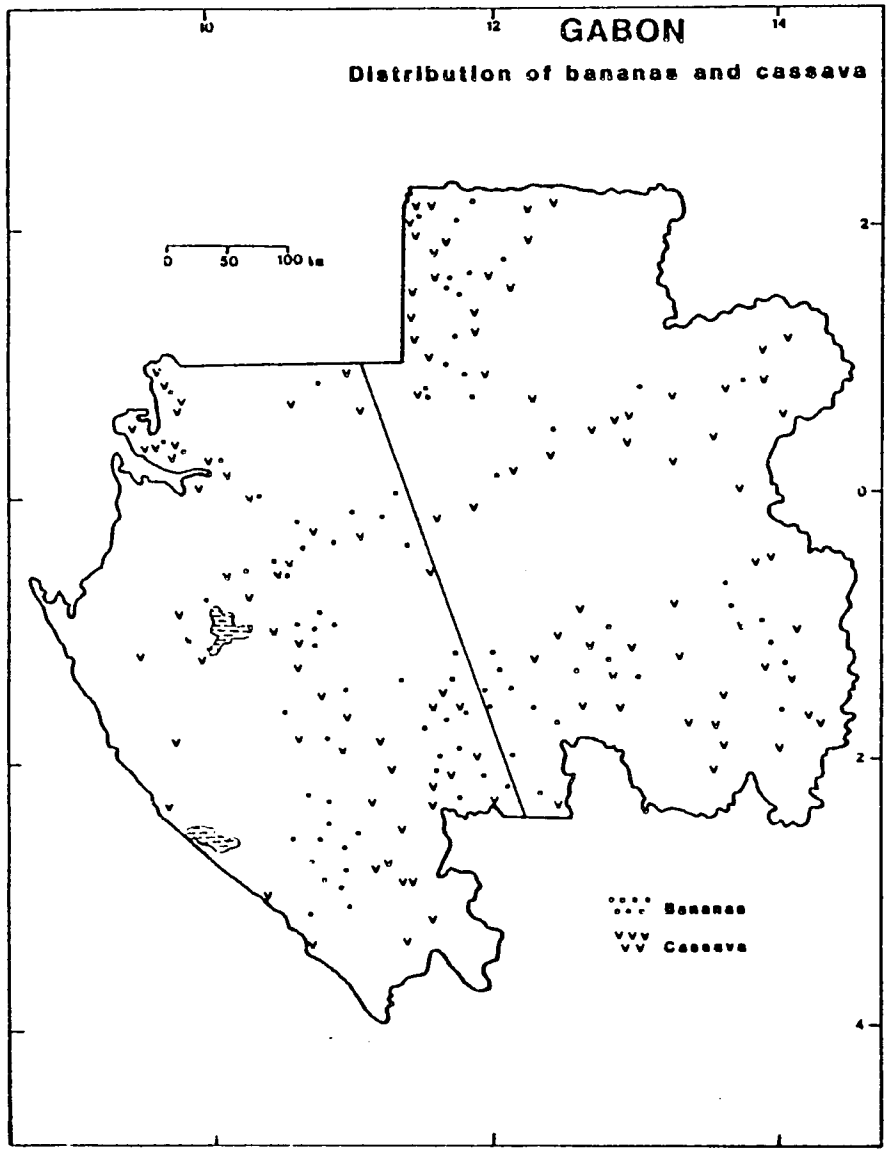

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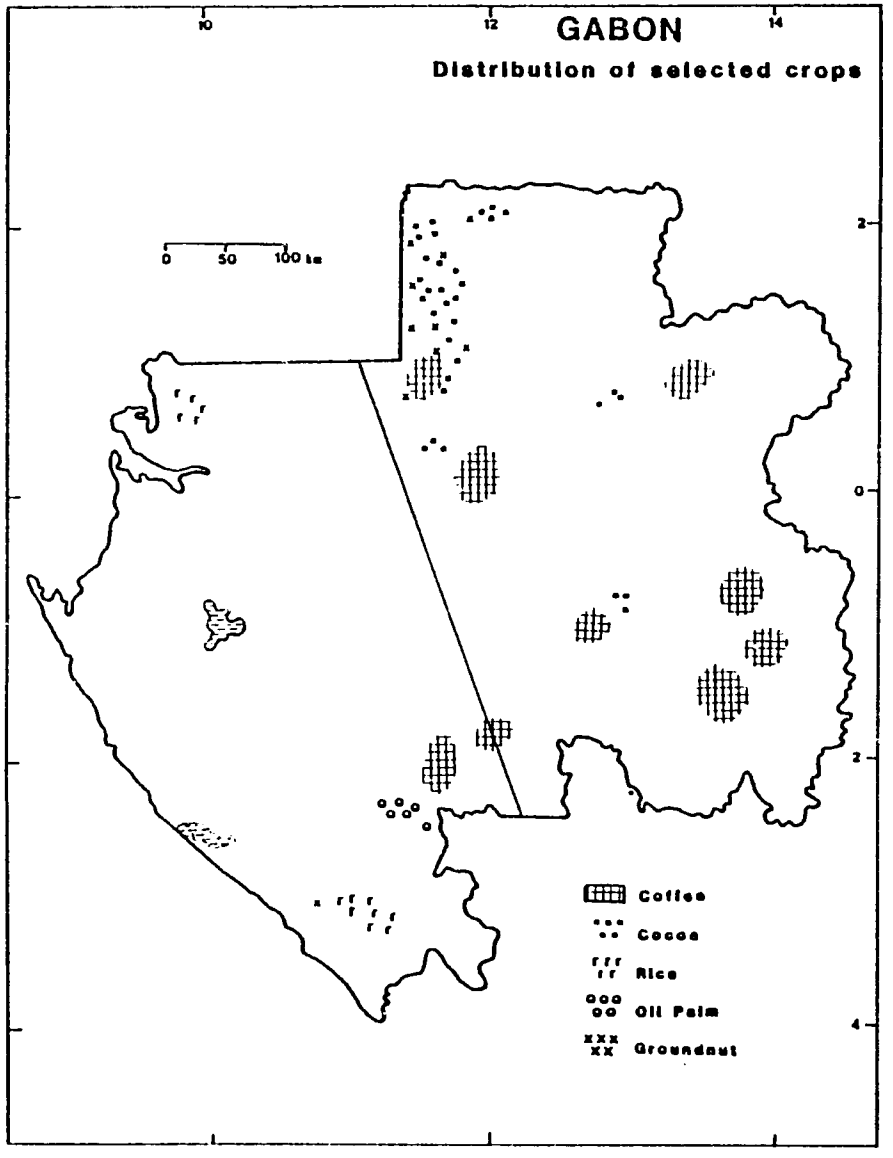


Figure 6.36

GABON: EAST AGROCLIMATIC REGION
CROP CONDITION/FOOD SHORTAGE INDEX FOR GROUNDNUT, FIRST ASSESSMENT PERIOD: DECEMBER-MARCH

Figure 6.37.

GABON
STATIONS USED FOR AGROCLIMATIC INDICES

Figure 6.38.

Table 6.20. Mean monthly and annual rainfall (mm) at selected stations in Gabon

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
West	Cocobeach	13	269	228	313	356	366	54	4	18	231	665	516	343	3398
	Libreville	15	276	258	414	351	269	19	1	6	98	398	528	328	2960
	Port Gentil	4	242	204	262	290	188	3	0	3	25	169	316	215	1922
	Lambarene	26	172	140	256	236	191	12	3	5	54	342	370	192	1986
	Mouila	89	236	213	251	237	182	11	4	5	49	365	395	259	2204
	Tchibanga	79	158	146	202	192	100	2	0	0	25	141	262	175	1410
	Mayumba	34	241	264	224	161	100	0	1	4	40	225	377	208	1843
East	Bitam	599	47	76	204	204	234	133	35	50	247	301	196	59	1783
	Mekambo	501	83	112	189	168	173	74	25	57	150	259	206	106	1601
	Mitzic	583	91	112	213	192	206	43	13	13	134	326	230	108	1674
	Makokou	515	94	122	226	232	205	60	9	28	145	320	245	121	1817
	Lastoursville	485	146	147	226	182	182	24	4	16	107	251	256	179	1734
	Franceville	426	161	185	231	208	207	24	7	16	100	256	262	194	1850

Table 6.21. Harvested area, yield and production of selected crops in Gabon

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	6	6	6	1,575	1,582	1,559	10	9	9
Maize	6	5	6	1,498	1,481	1,466	9	8	9
Rice (paddy)	-	-	-	7,500	7,000	7,000	1	1	1
Roots & tubers, total	59	60	60	4,315	4,520	4,552	254	271	275
Sweet potatoes	2	3	3	458	480	500	1	1	1
Cassava	40	40	40	2,675	2,750	2,811	107	110	113
Groundnuts in shell	6	7	7	1,000	1,000	1,000	6	7	7

Table 6.22. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Gabon (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
West	2,500	-	-	-	*	16,000
East	3,500	-	-	-	*	24,000

Table 6.23. CROP CALENDAR FOR GABON

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
East	Rainfall		116	147	220	188	178	48	9	17	132	279	222	146
	Maize		//////	///		000	000000	000						
	Groundnut	First	//////			000000	000000							//////
	Groundnut	Second	000000	000							//////	///		000
West	Rainfall		188	199	268	252	196	24	4	8	85	331	395	231
	Maize		//////	///		000	000000	000						

F. KENYA

1. Agroclimatic Conditions and Regions

There are several major geographic regions in Kenya:

- Highlands. Although there is no strict altitude separating highlands from the rest of the country, areas above 1200-1300 m are usually referred to as highlands. Kenya highlands occupy the west-central part of the country and stretch between 200 and 300 km in length and width (Figure 6.39). They are divided into eastern and western halves by the Rift Valley. Highest points of the highlands are the mountains (Kenya, Aberdare and Elgon) reaching 4000 to 5000 m altitude. Soils are generally good, rainfall is adequate and farming is extensive in the areas to 2,500 m altitude.
- Western Plateaus. This is an area about 100 km wide between the highlands and Lake Victoria. The terrain rises gradually from west to east. At the lakeshore the altitude is around 1150 m; the eastern end of the plateau is 1300-1350 m high. The Western Plateaus cover most of the territory of two administrative provinces: Nyanza and Western (Figure 6.42). The soils are fertile, rainfall is adequate and farming is extensive.
- Coastal Plain. This is a strip of land 60-70 km wide, along the Indian Ocean coast. The altitude is from sea level to about 200 meters. Soils are relatively good, and adequate rainfall permits growth of various agricultural crops.
- Northeastern Plains. They occupy the northern one third of the country plus the large area from the highlands to the Somalia border and the Coastal plain. The altitude in the northern part is mostly between 500 and 800 meters, while in the eastern section it between 200 and 500 m. Due to the semidesert climate, the population is scarce and mostly nomadic; farming is carried out in only a few isolated spots.
- Intermediate Areas. These are the areas that surround the highlands to the north, east and south. They are about 50-100 km wide with rainfall rapidly decreasing with the decrease of altitude. Conditions for growing crops are marginal.

The country has been divided into five agroclimatic assessment regions (Figure 6.41). Wettest is the West region with mean annual rainfall of 1,343 mm. Some stations, however, receive over 1,900 mm (Table 6.24).

Second wettest is the Southeast region (1,072 mm), followed by the Central (860 mm) and Southwest (590 mm). Driest is the Northeast, with some stations receiving slightly over 200 mm annually.

The seasonal distribution of rainfall varies essentially from region to region. The Western region has a rainy season of about seven months - from March until September, with reasonable amounts still received in October and November. The duration of the rainy season in the other regions is not more than 2-3 months (Figures 6.40 and 6.41 and Table 6.24; see also Chapter VII, E). Furthermore, the Central, Southwest and Northeast regions have two pronounced rainy seasons; one peaks in November called "short rains", the other in April called "long rains." The Southeast and West regions have only one rainfall season.

2. Agriculture

Kenya is one of those few Subequatorial African countries where modern farming is relatively well developed. There is no information on the exact areas under modern, traditional and transitional farming practices (see their description in Chapter IV). It is known, however, that nearly all of the modern and a great part of the transitional farming is carried out in the central and western agroclimatic regions.

The most important food crop in Kenya is maize. A very distant second are the pulses, followed by sorghum and wheat. Of some importance are millet, cassava and potatoes (Table 6.25 and Figure 6.43). Most important commercial crops are coffee and tea (Figure 6.44).

The largest areas planted to various food crops are in the Central and West agroclimatic regions (Table 6.26). Very little is grown in the Northeast region, mostly in the marginal areas adjacent to the highlands. Rice in the Northeast region is grown along the Tana River.

Three major factors determine the crop calendars: rainfall regime, altitude and variety (Table 6.27). In areas with a rainy season of 2-3 months, sowing of the crops starts soon after the beginning of the rainy season. In areas with a longer rainy season, sowing of the crops often is delayed in order for harvesting to coincide with the arrival of the dry season. The effect of altitude on the duration of the growing season is discussed in Chapter IV, C; maize in the lowlands can mature in 4 months,

while at 2500 m altitude it may need one year. The data in Table 6.27 indicate the most common crop calendars.

3. Factors Affecting Yield and Their Assessment

Drought is the most important meteorological factor affecting crop yields. The episodic event data indicate that drought has occurred three times during the last five years (Table 6.28). The years with drought, as well as with good rainfall, are shown on Figure 6.45. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Kenya and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.46. In addition to the stations with common period of records (used for the assessments), Kenya has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative provinces of the country, their boundaries, together with those of the agroclimatic regions, are shown on Figure 6.42.

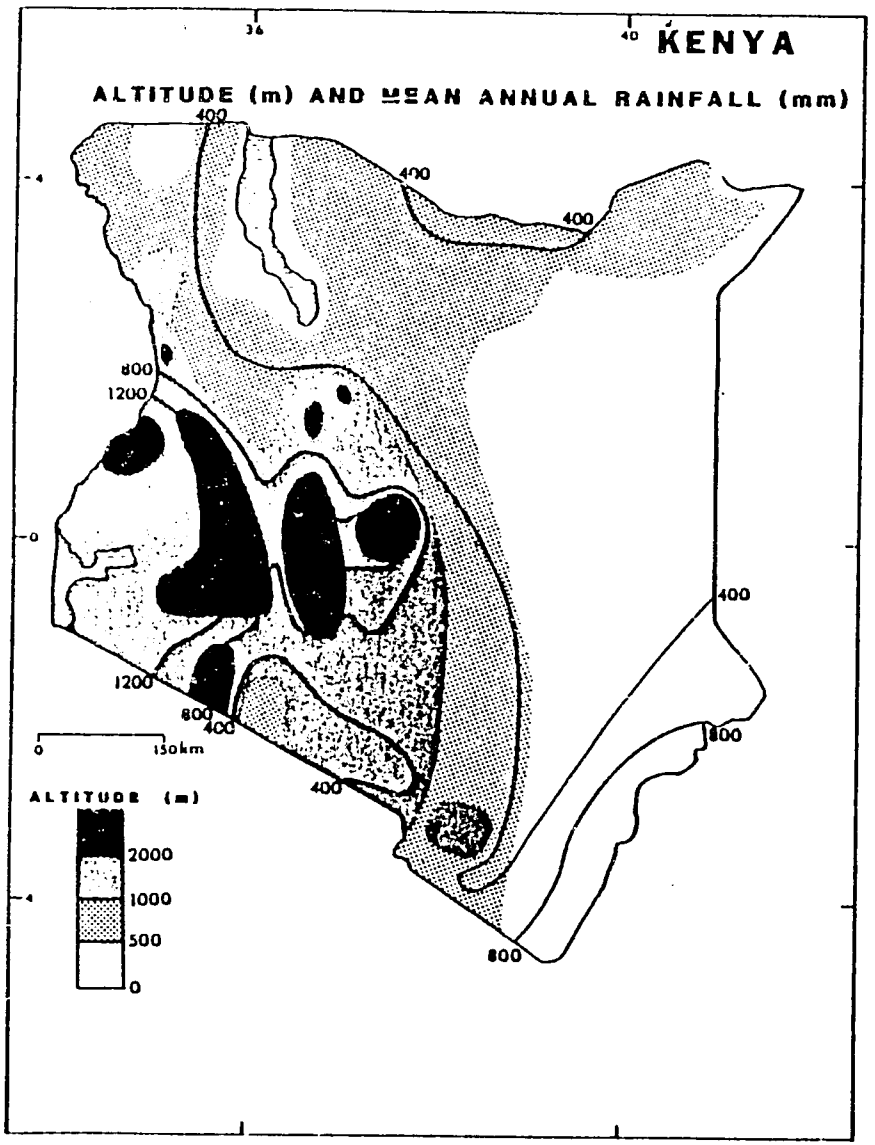


Figure 6.39.

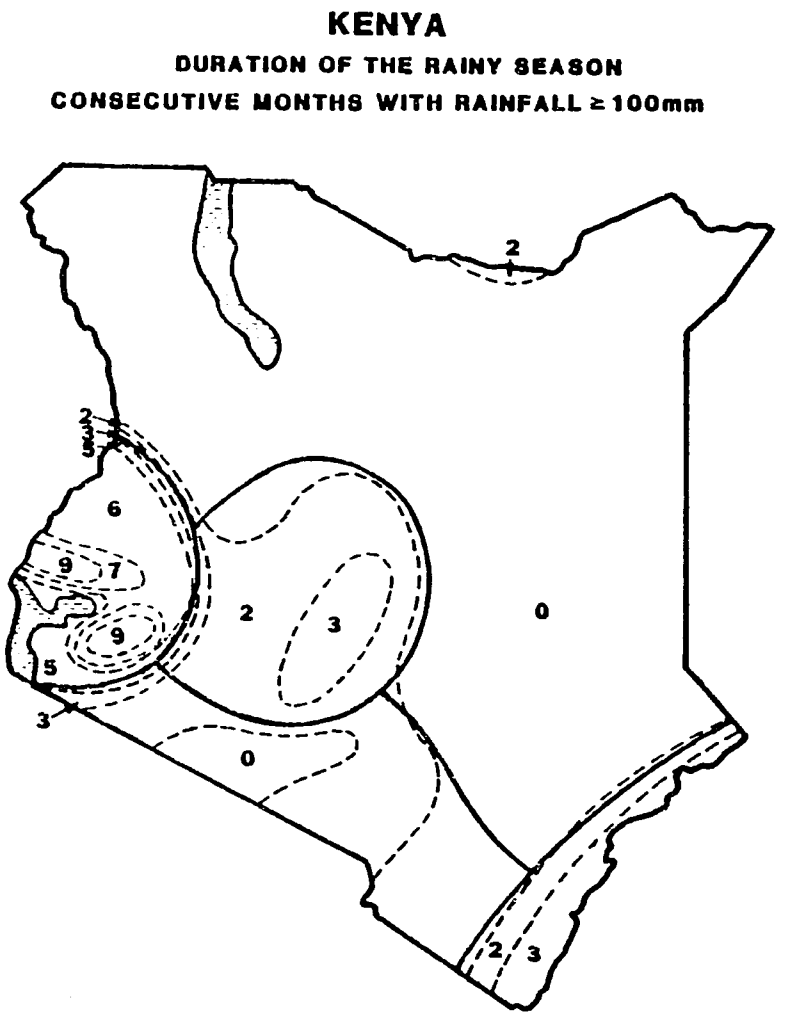


Figure 6.40.

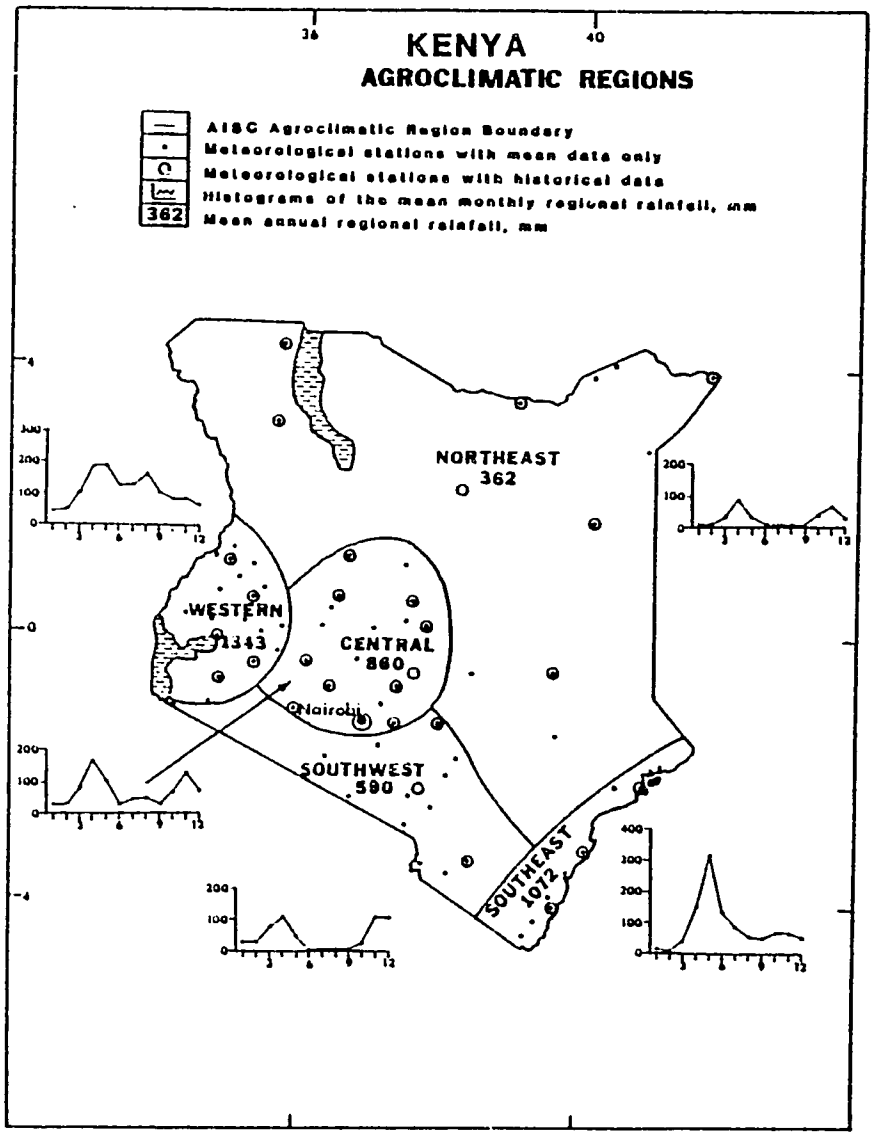


Figure 6.41.

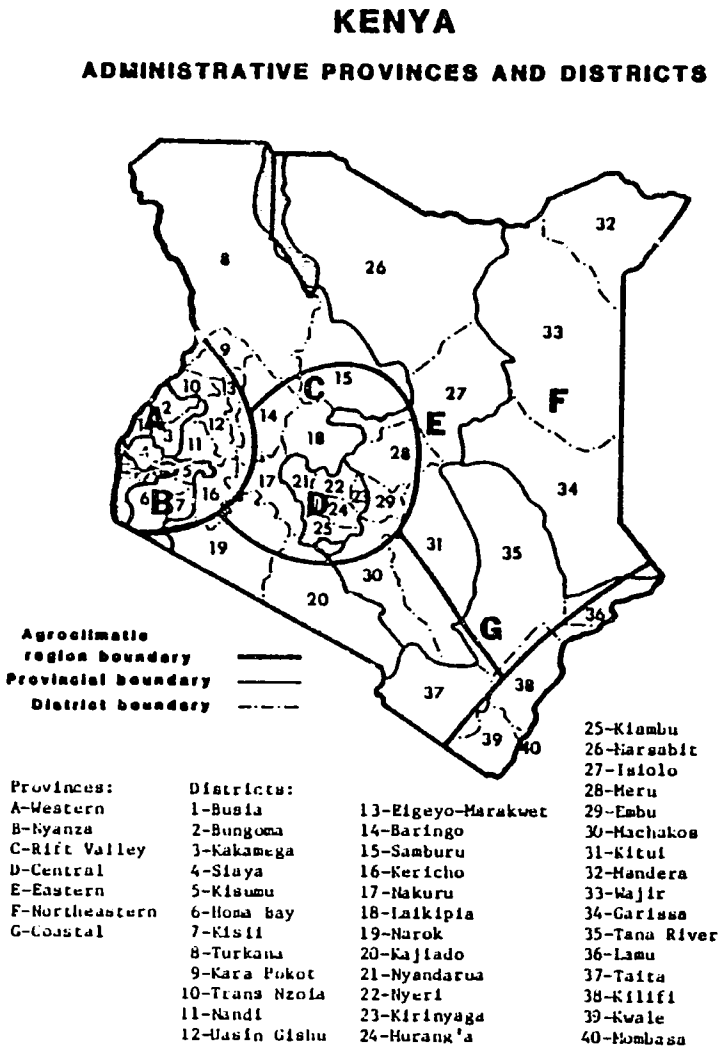


Figure 6.42.

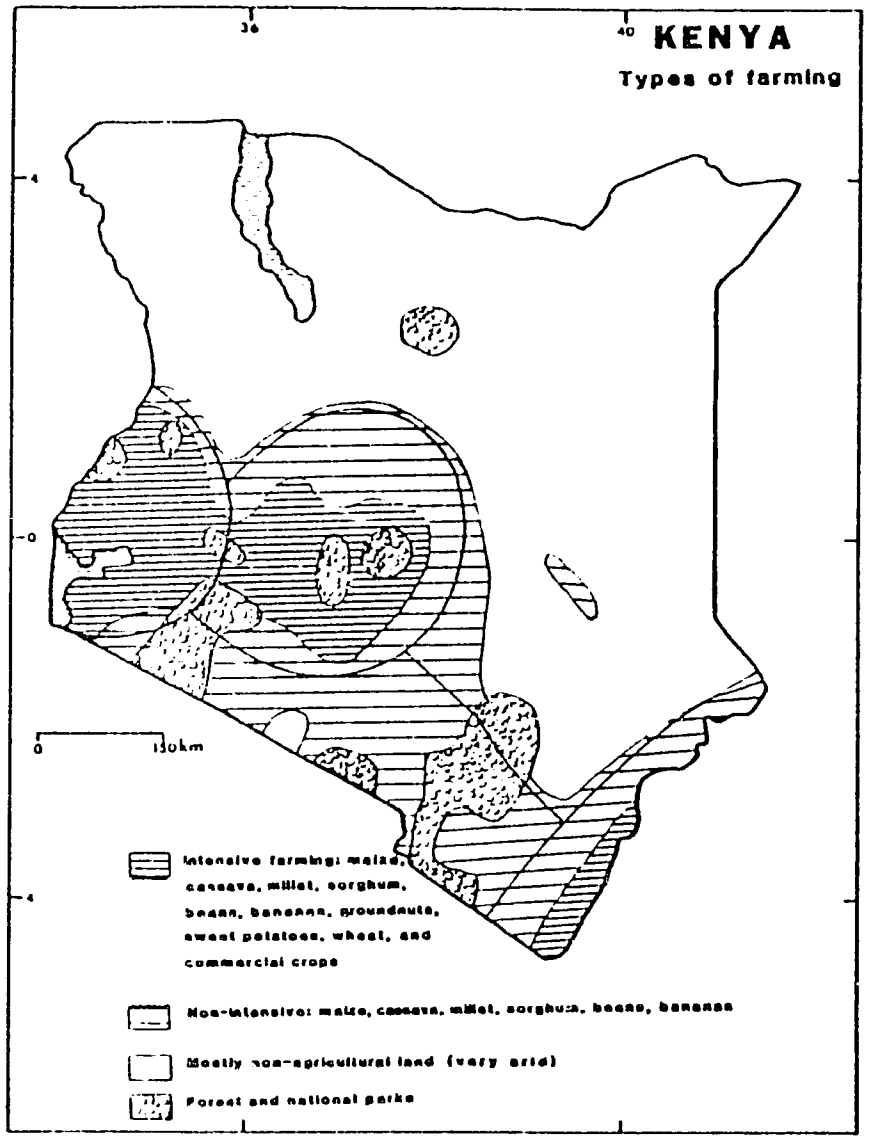


Figure 6.43.

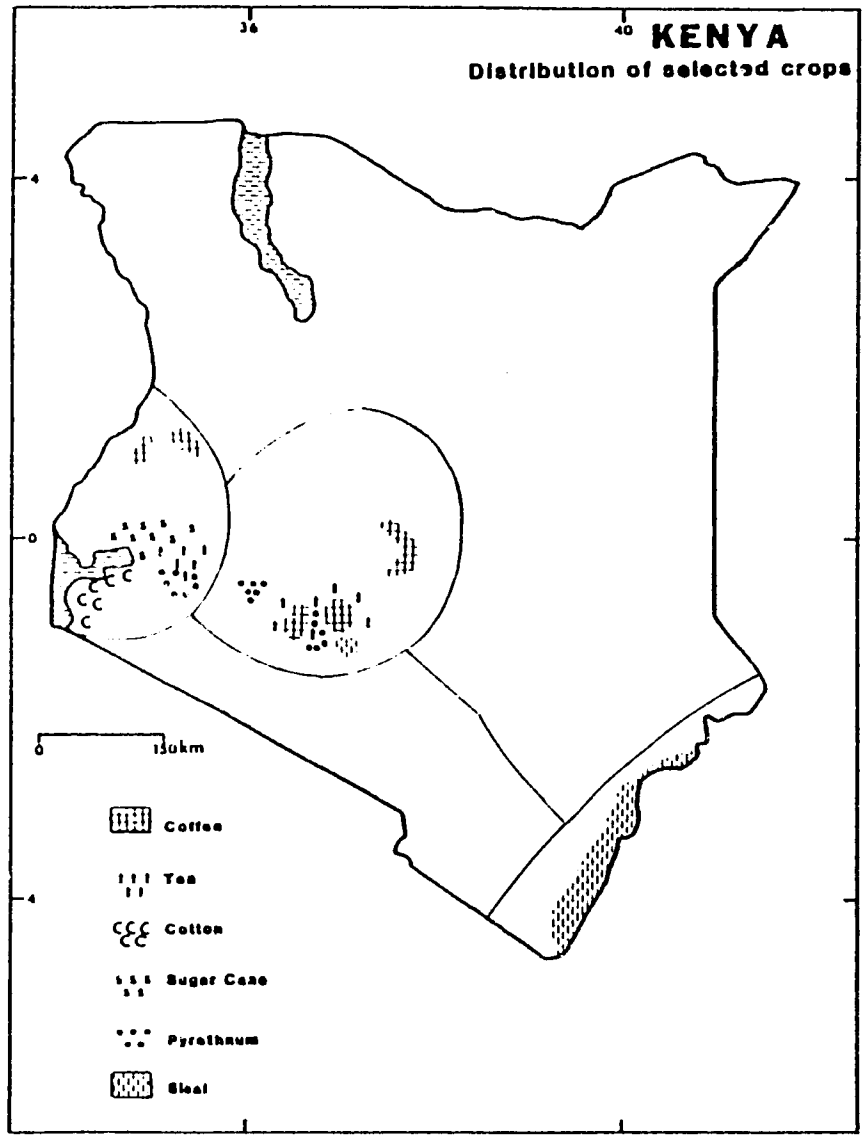


Figure 6.44.

KENYA: CENTRAL AGROCLIMATIC REGION
CROP CONDITION/FOOD SHORTAGE INDEX FOR MAIZE, LONG RAINS
ASSESSMENT PERIOD: MARCH-JULY

Figure 6.45.

KENYA
STATIONS USED FOR AGROCLIMATIC INDICES

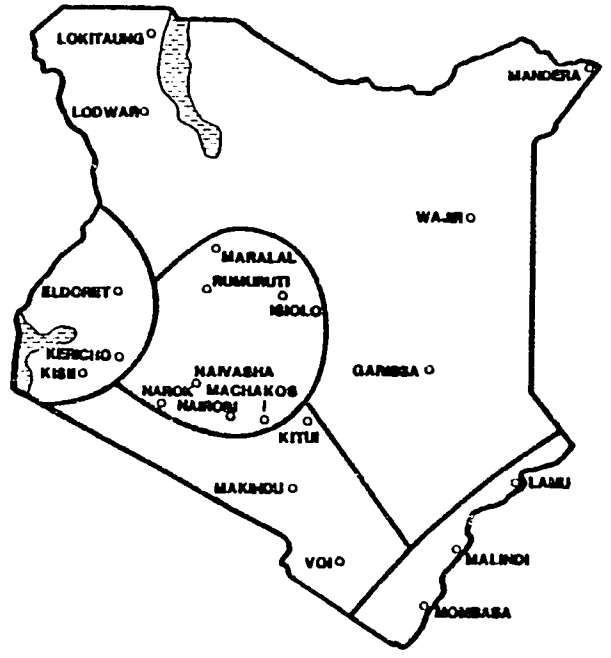


Figure 6.46.

Table 6.24. Mean monthly and annual rainfall (mm) at selected stations in Kenya

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Northeast	Lokitaung	732	12	23	41	109	48	16	21	12	6	16	46	24	375
	Mandera	231	2	8	22	89	28	1	2	0	1	32	51	9	246
	Lodwar	515	15	9	27	57	23	6	23	11	3	8	24	11	218
	Wajir	244	8	4	33	98	49	3	2	2	3	31	81	21	335
	Carissa	147	9	7	45	66	19	5	3	4	8	24	100	53	342
West	Kitale	1875	22	47	80	143	155	114	154	169	105	86	57	34	1166
	Eldoret	2133	37	57	74	157	152	122	174	195	108	70	64	46	1256
	Kisumu	1146	48	78	136	188	144	80	56	73	63	55	87	90	1099
	Kericho	2184	86	97	156	264	232	143	122	150	135	129	131	108	1752
	Kisii	1768	80	118	190	275	224	156	103	160	173	150	167	129	1924
Central	Maralal	1951	17	22	37	90	62	55	80	92	34	43	51	22	605
	Rumuruti	1856	33	27	57	105	68	50	75	75	38	37	81	39	684
	Isiolo	1104	47	43	84	131	38	5	6	3	8	70	159	80	674
	Naivasha	1899	37	43	51	111	90	43	43	57	36	41	57	47	655
	Narok	1890	91	88	103	163	99	31	20	26	27	28	70	85	831
	Nairobi	1624	64	55	90	222	184	39	19	25	33	55	144	93	1023
	Machakos	1646	58	52	109	188	83	11	7	4	9	46	184	101	851
Southwest	Kitui	1177	37	18	107	201	49	5	3	4	7	73	326	133	963
	Makindu	1000	38	33	74	103	31	2	1	2	4	31	187	105	609
	Voi	579	33	30	95	87	22	5	3	7	15	38	112	106	552
Southeast	Lamu	30	5	4	28	142	313	133	78	39	52	43	38	27	902
	Malindi	23	6	6	36	172	345	157	85	60	66	64	49	36	1081
	Mombasa	55	24	15	56	212	291	103	75	76	72	88	97	47	1155

Table 6.25. Harvested area, yield and production of selected crops in Kenya

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	1,971	1,902	2,012	1,410	1,277	1,287	2,778	2,428	2,589
Wheat	119	117	122	1,472	1,772	1,721	175	207	210
Maize	1,490	1,400	1,500	1,456	1,286	1,267	2,169	1,800	1,900
Rice (paddy)	7	7	7	6,000	6,143	5,714	42	43	40
Millet	81	81	81	1,605	1,358	1,605	130	110	130
Sorghum	210	210	210	1,052	886	1,048	221	186	220
Roots & tubers, total	165	166	167	7,937	8,012	8,018	1,310	1,330	1,335
Potatoes	48	48	48	7,516	7,500	7,500	361	360	360
Sweet potatoes	37	38	38	8,884	8,947	8,947	330	340	340
Cassava	80	80	81	7,750	7,875	7,888	620	630	635
Pulses, total	600	550	550	457	425	436	274	234	240
Groundnuts in shell	13	14	14	600	589	578	8	8	8

Table 6.26. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Kenya (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
West	750,000	84,000	24,000	24,000	1,500	20,000
Central	635,000	42,000	24,000	83,000	1,500	12,000
Southwest	20,000	42,000	16,000	12,000	-	28,000
Southeast	50,000	10,000	4,000	-	300	20,000
Northeast	-	32,000	12,000	-	4,000	-

Table 6.27. CROP CALENDAR FOR KENYA

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
West	Rainfall		41	55	103	185	184	128	139	164	113	83	83	65
	Maize	Long Rains			///	//////	//////			000000	000000	000000	000000	000000
	Sorghum	Long Rains			//////			000000	000000					
	Sorghum	Short Rains							//////	///		000000	000000	
	Millet	Long Rains		//	//////		00	000000	000					
	Millet	Short Rains						//	//////		00	000000	00	
	Wheat				//////	//////	///	000	000000	000000	000000	000		
Central	Rainfall		35	36	81	165	105	38	49	51	32	73	125	71
	Maize	Long Rains			//////	//////			000000	000000	000000	000000		
	Sorghum	Long Rains			//////			000000	000					
	Sorghum	Short Rains	000000	000000								//////		
	Millet	Long Rains			//////		00	000000	000					
	Millet	Short Rains	000000	000								//////		00
	Wheat				//////	//		000	000000	000000	000			
Southeast	Rainfall		20	11	43	152	319	128	84	60	58	71	67	57
	Maize	Long Rains			///	//////			000000	000000				
Southwest	Rainfall		36	33	78	118	47	7	3	5	7	29	120	105
	Sorghum	Long Rains		///	///			000000						
	Sorghum	Short Rains		000	000							//	///	
	Millet	Long Rains		///	//////			000000						
	Millet	Short Rains		000000	000							//	///	
Northeast	Rainfall		7	6	38	96	39	7	11	6	9	40	67	37
	Sorghum	Long Rains			//////			000000						
	Millet	Long Rains			//////			000000						

TABLE 6.28.

KENYA

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1964, May	Floods in Nyanza and Western Regions
1965, August	Drought in the Dry Belt
1968, May	Floods in Nyanza and Western Provinces
1971 -	Drought Countrywide
1975 -	Flood
1976, January	Late Start of the Rainy Season in Kitui Province Caused Failure of Crops Planted in October
1976, March	Drought Conditions in Parts of the Eastern Province
1976, April	A Severe Drought Persists in the Coastal Province
1976, July	Severe Drought in the Eastern Province Caused Complete Crop Failure
1977, May	Crops Affected by Strong Winds, Heavy Rains and Floods
1978, December	Birds Damage Wheat in Nakuru and Laikipia Areas
1980, January	Reduced Acreage, Early Heavy Rains and Drought Late in the Growing Season, Decreased Maize Production
1980, June	The Main Season Maize Crop has been Damaged by Erratic and Insufficient Rainfall
1980, May	Drought
1981, February	Both 1980 Seasons Crops were Affected by Drought

G. LESOTHO

1. Agroclimatic Conditions and Regions

Due to its small size, Lesotho constitutes one agroclimatic assessment region (Figure 6.49). There are two major geographic areas in the country:

- Mountainous areas. These are the areas above 2000-2200 meters altitude Figure 6.47). Many mountain peaks rise above 3,000 m. The mountains are deeply cut by river valleys.
- Highland plateaus. These are the areas from 1,500 m altitude (the lowest point in Lesotho) to the mountain foothills at 2,000-2,200 m. The plateaus, as well as some river valleys with the same altitude, are located mostly in the western half of the country.

The mean annual amount of rainfall for the country is about 700 mm (Figure 6.49). The plateaus and river valleys are drier - from 450 mm (in Mashai, Figure 6.52) to about 800 mm annually (Figure 6.47 and Table 6.29). The mountainous areas receive mostly between 800 and 1,200 mm. The rainy season normally begins in October and lasts until April. There is no pronounced peak of the rainy season. The period with mean monthly rainfall of 100 mm or more is mostly between 2 and 4 months, although in some valleys it is nil. Some mountainous areas have six consecutive months with such rainfall (Figure 6.48; see also Chapter VII, E).

2. Agriculture

The most important food crop in Lesotho is maize (Table 6.30). Farmers also grow a large amount of wheat, sorghum, millet and beans. Subsistence farming is carried out mainly in the highland plateaus and along the river valleys (Figure 6.51). Sowing of the crops starts after the beginning of the rainy season in October, and continues throughout November and even into the first half of December (Table 6.31). Harvesting for summer wheat begins as early as late January, for sorghum in late February, and for maize in April. Winter wheat is grown in the cool and humid mountainous areas during the dry season. Sowing begins at the end of the rainy season (April), when soils are saturated with water, and harvesting takes place in October and November.

3. Factors Affecting Yield and Their Assessment

Drought is the most important meteorological factor adversely affecting crops. The episodic event records indicate that drought damages occur

nearly every year (Table 6.32). Apparently, crops in the drier and warmer plateaus and river valleys are more vulnerable to drought than crops grown in the wetter and cooler mountainous areas. The years with drought, as well as with good rainfall, are shown on Figure 6.53.

The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years. There are only five stations in Lesotho for which we have such data, and unfortunately not all of them have the same period of records. It was therefore necessary to select stations from the Republic of South Africa located on the border with Lesotho (Figure 6.52). This allows the use of a total of 16 stations with data for 27 years (Table 7.1). In addition to the stations with common period of records (used for the assessments) Lesotho has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative districts of Lesotho, their boundaries are shown on Figure 6.50.

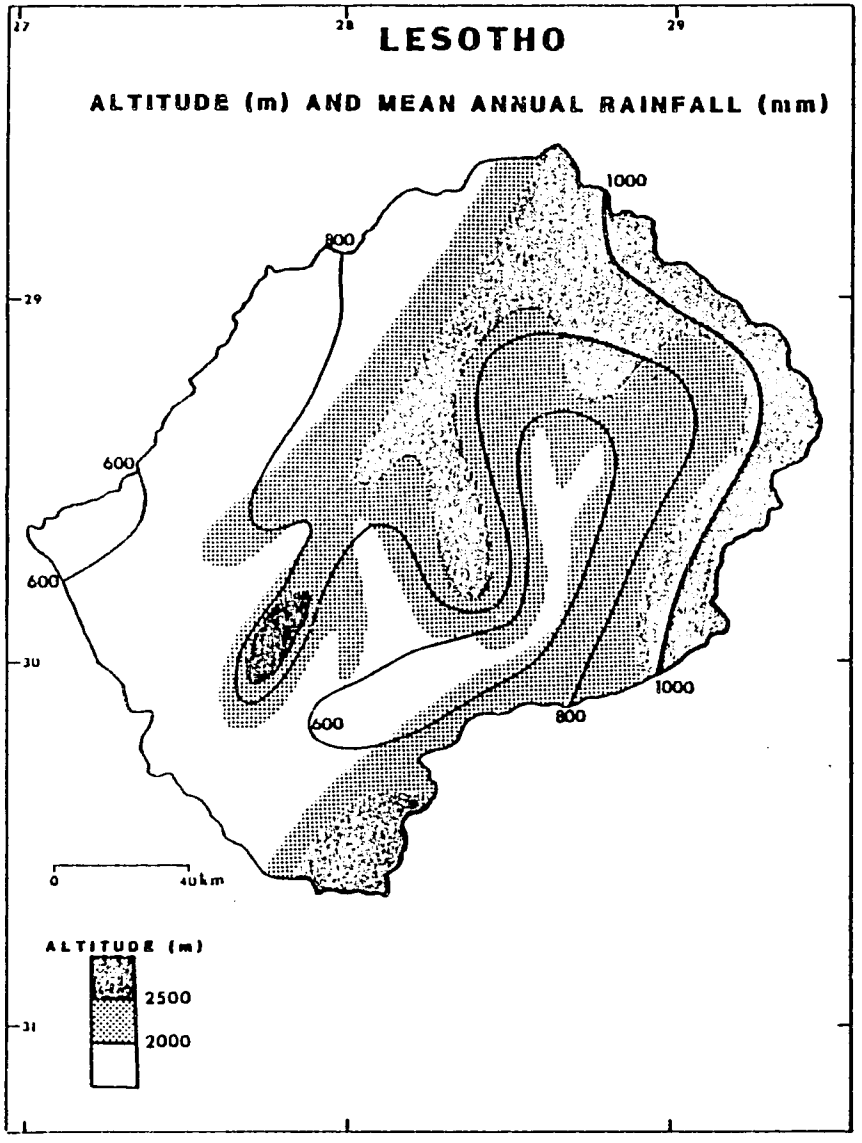


Figure 6.47.

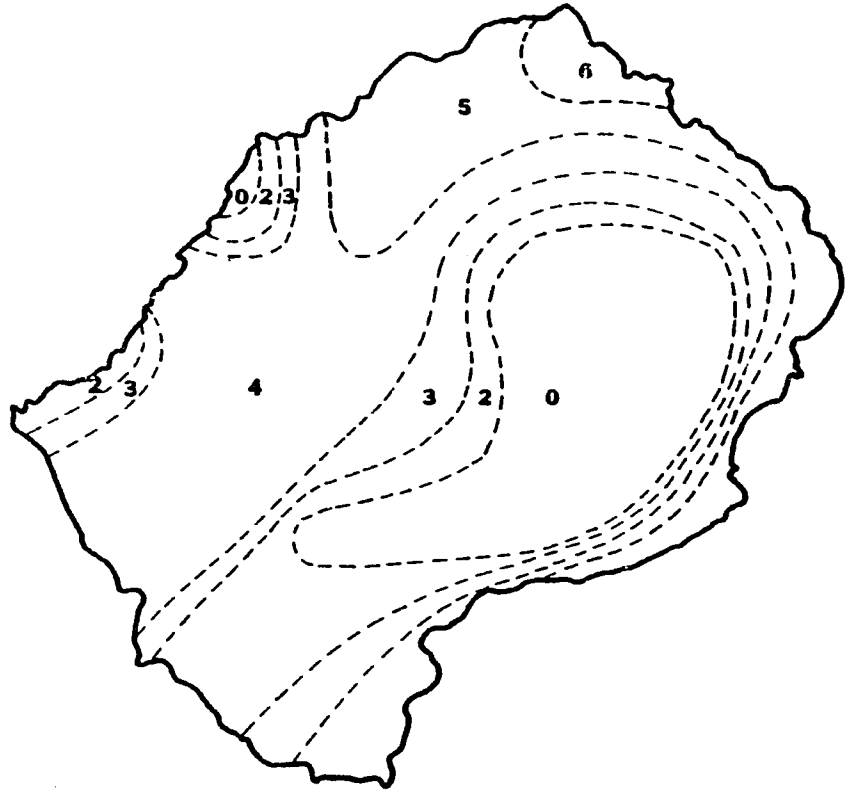


Figure 6.48.

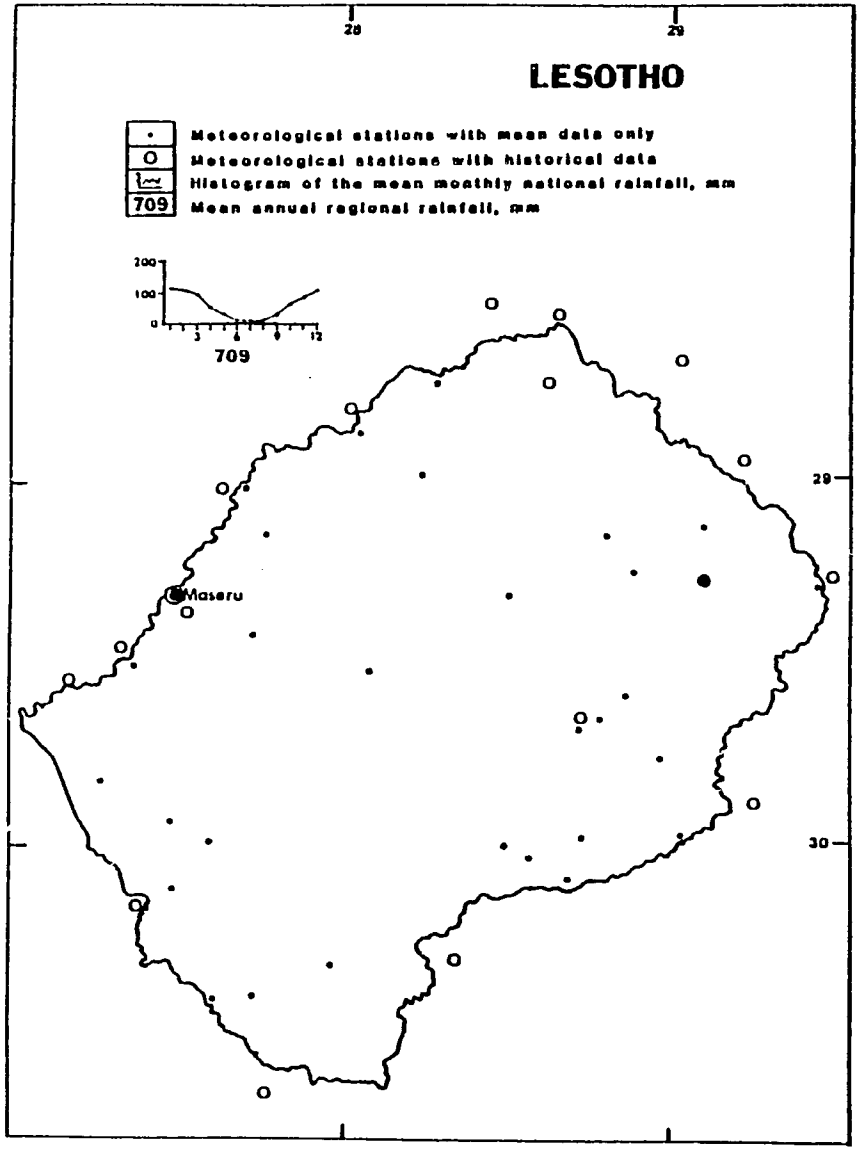


Figure 6.49.

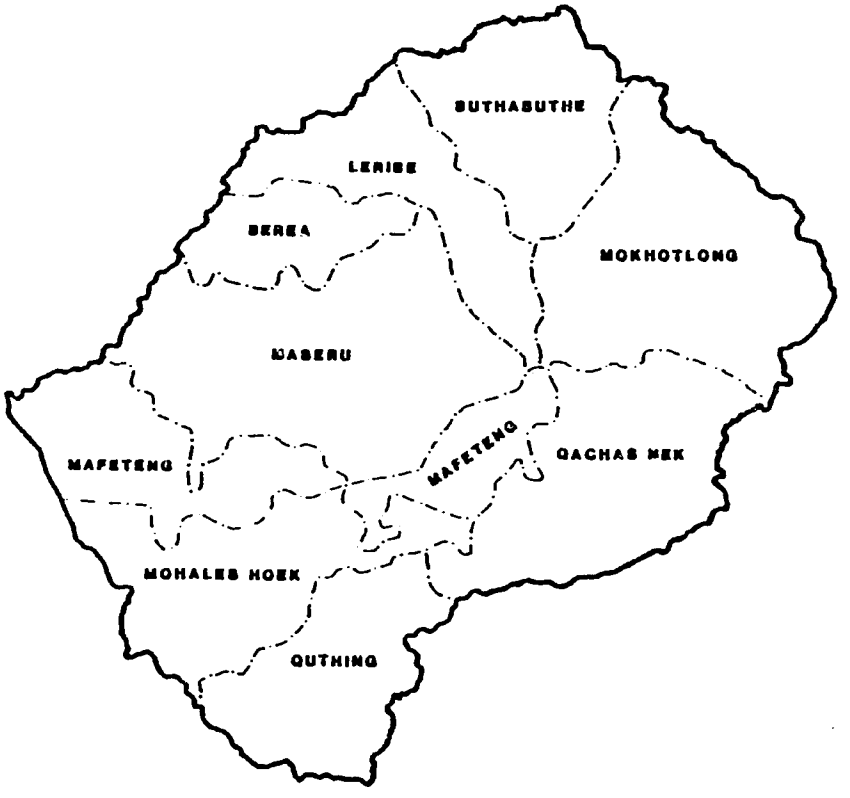


Figure 6.50.

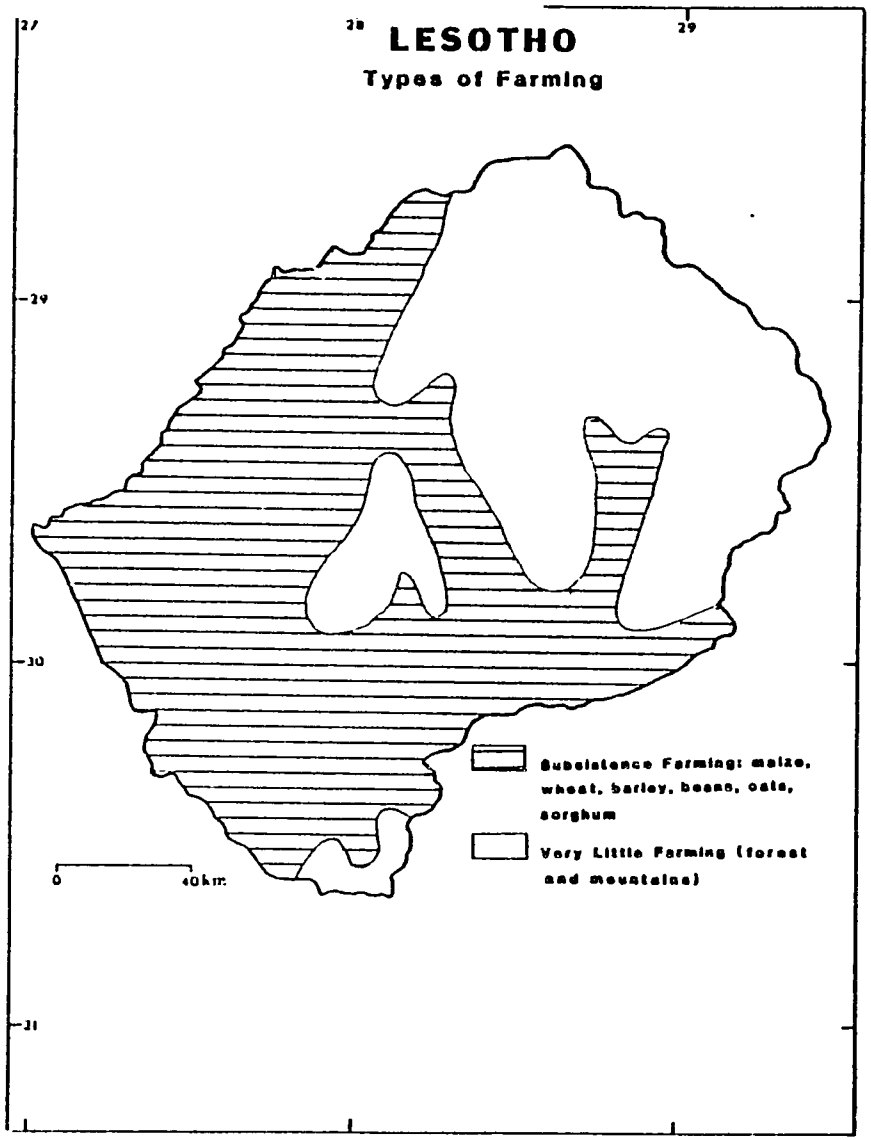


Figure 6.51.

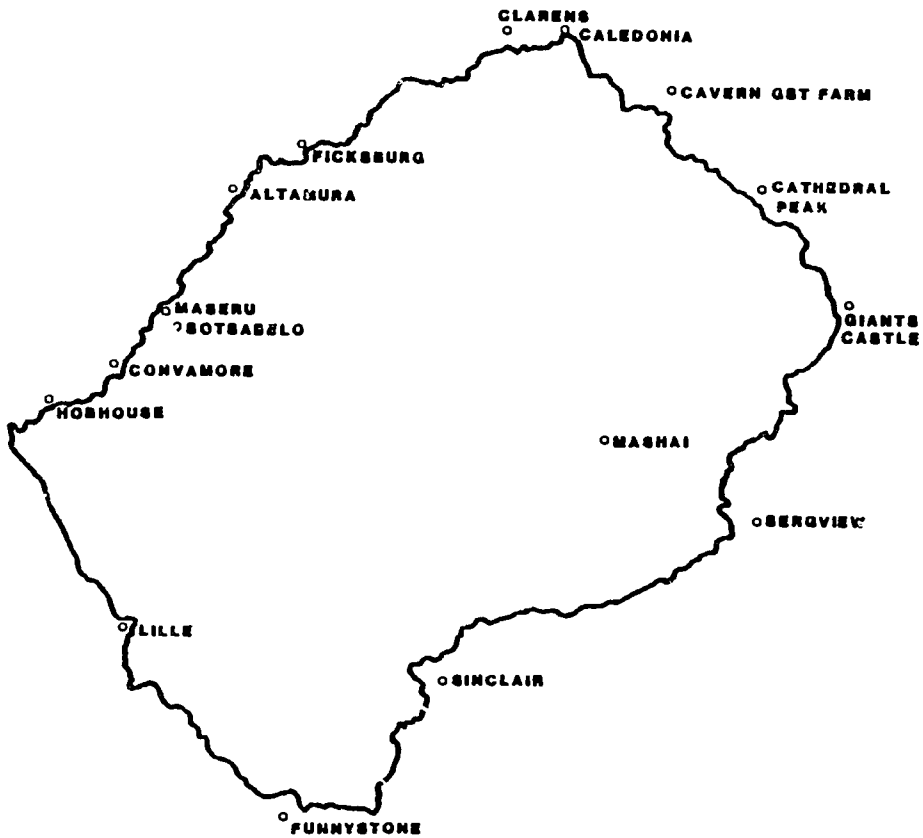


Figure 6.52.

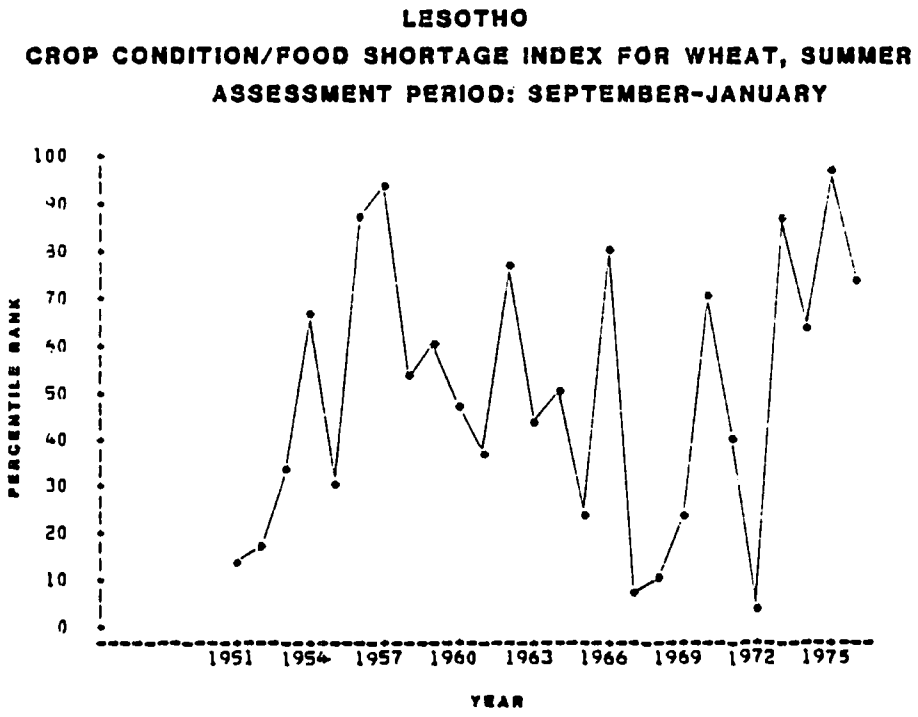

LESOTHO
CROP CONDITION/FOOD SHORTAGE INDEX FOR WHEAT, SUMMER
ASSESSMENT PERIOD: SEPTEMBER-JANUARY
PERCENTILE RANK
100
90
80
70
60
50
40
30
20
10
0
1951
1954
1957
1960
1963
1966
1969
1972
1975
YEAR

Figure 6.53.

Table 6.29. Mean monthly and annual rainfall (mm) at selected stations in Lesotho

STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Clarens, R. S. A.*	1676	115	89	85	57	26	11	12	14	32	83	99	97	720
Caledonia, R. S. A.*	1951	154	119	104	70	47	17	13	20	45	105	134	128	955
Ox-Bow	2591	187	145	176	82	61	17	13	34	59	129	165	180	1255
Cavern Gst Farm, R. S. A.*	1980	242	210	160	77	38	20	13	31	60	118	166	215	1350
Ficksburg, R. S. A.*	1585	117	112	94	60	30	10	9	13	29	74	84	105	736
Altamura, R. S. A.*	1652	117	95	86	50	28	11	7	12	24	62	77	93	661
Cathedral Peak, R. S. A.*	1448	236	226	196	80	30	14	12	30	58	92	159	190	1323
Mokhotlong	2375	117	85	79	37	19	8	9	11	25	50	84	96	627
Giants Castle, R. S. A.*	1981	195	169	135	65	21	11	7	32	48	81	125	153	1044
Maseru	1554	122	101	92	60	28	12	10	12	27	62	80	89	696
Botsabelo	1646	122	116	101	64	31	12	13	14	28	65	89	99	753
Convamore, R. S. A.*	1539	115	102	91	62	24	12	11	13	24	62	78	90	685
Hobhouse, R. S. A.*	1448	95	95	93	57	24	11	10	11	20	63	63	79	621
Mashai	1829	86	61	58	24	19	4	5	11	23	40	54	68	453
Bergview, R. S. A.*	1676	228	199	161	72	30	12	8	23	40	92	143	176	1184
Lille, R. S. A.*	1463	107	103	92	64	27	15	12	15	30	61	75	90	692
Sinclair, R. S. A.*	1830	153	146	119	65	30	20	14	26	46	80	99	123	921
Funnystone, R. S. A.*	2286	124	105	109	77	46	28	18	23	40	71	86	91	818

*The station is located in a neighboring country, and may be used for Lesotho assessments.

Table 6.30. Harvested area, yield and production of selected crops in Lesotho

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	203	219	208	1,419	1,022	1,009	288	223	210
Wheat	43	38	30	1,359	905	1,050	58	34	32
Maize	102	120	112	1,408	994	1,000	143	119	112
Sorghum and millet	57	59	64	1,510	1,163	1,015	86	69	65
Roots & tubers, total	–	–	–	13,158	15,789	15,789	5	6	6
Pulses, total	26	26	26	769	846	846	20	22	22
Beans (dry)	13	13	13	1,154	1,154	1,154	15	15	15

Table 6.31. CROP CALENDAR FOR LESOTHO

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	Rainfall		113	105	91	50	31	10	12	17	29	65	83	102
This country constitutes one agroclimatic region	Maize					000000	000000	000				///	//////	///
	Sorghum			000	000000	000000	000					///	//////	///
	Wheat	Winter				///	//////					000	000000	
	Wheat	Summer	00	000000	000						//	//////	//////	

TABLE 6.32.

LESOTHO

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security

DATE	EPISODIC EVENT
1968 -	Drought Nationwide
1975, March	Wet Weather Spoiled Much of the Bean Crop
1977, March	Food Crops Affected by Drought
1979, February	Maize, Beans and Sorghum Affected by Dry Weather
1979, May	Drought Reduced Maize Production by About 60%, and Wheat Production by About 20% (Compared with 1978)
1979, December	Drought in Early 1979 Adversely Affected Wheat and Sorghum Crops
1980, June	For the Second Year in a Row, the Wheat, Maize and Sorghum Harvests have been Substantially Below Normal
1981, January	The Drought still Continues, and Affects the Wheat Crop. Famine Experienced in Several Districts
1982, May	Drought in October and November 1981, a Dry Spell in January and Early Frost in April, Caused Damage to the 1982 Coarse Grain Crop
1983, January	Lesotho's Worst Drought in 10 Years has Put Crop and Livestock in Danger

H. MADAGASCAR

1. Agroclimatic Conditions and Regions

Madagascar is the fourth largest island in the world. It has a smooth coastline. The few natural harbors are mostly found on the northwestern coast. Coastal plains - areas with an altitude up to several hundred meters - are narrow on the eastern coast and rise abruptly to the central highlands. On the western side of the island, the coastal plains are wider and rise gradually to the highlands (Figure 6.54). The highlands are comprised of rolling hills, plateaus and valleys of different altitudes, the majority between 1,000 and 1,500 meters. Over most of the country, soils are shallow and relatively poor in nutrients.

The country has been divided into six agroclimatic assessment regions (Figure 6.56). Wettest are the two eastern regions with mean regional annual amounts of 2,400 and 2,800 mm; some locations receive up to 3,400 mm annually (Table 6.33). The northern, central and western regions receive between 1,400 and 1,600 mm annually. Driest is the southwest region with about 600 mm (the coastal area, about 50 km wide, receives less than 400 mm).

The seasonal distribution of rainfall on the east coast shows a peak in March and a low in October (Figure 6.56). There is virtually no dry season here. The duration of the period with mean monthly rainfall of 100 mm or more is about 10-11 months (Figure 6.55; see also Chapter VII, E). The rest of Madagascar has very well pronounced wet and dry seasons. The rainy season normally begins in November, reaches its peak in January and ends in March. The duration of the period with mean monthly rainfall of 100 mm or more is about 5 months in the northern, central and western regions, and 0 to 4 months in the southwest.

2. Agriculture

The most important food crop in Madagascar is rice (Table 6.34), which is grown both irrigated and in flood cultivation. Widely used food crops are cassava, maize, beans, groundnuts, sweet potatoes and potatoes. Rice is grown mostly in the regions with good rainfall: Central, North, Northeast and Southeast. Maize is grown mostly in the West and Southwest (Table 6.35). The types of land use are shown on Figure 6.58. The distri-

bution of some commercial crops appears on Figure 6.59. Two, even three, crops per year are grown in the wet regions, while in the drier regions only one is grown (Table 6.36).

3. Factors Affecting Yield and Their Assessment

There are two major meteorological phenomena adversely affecting crops in Madagascar: lack of rainfall and excess rainfall. Drought occurs mostly in the drier western and southwestern areas of the country, while flooding is observed more often in the eastern half of the island (Table 6.37). The years with drought, as well as those with excess rainfall, are shown in Figure 6.60. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Madagascar and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.61. In addition to the stations with common period of records (used for the assessments), Madagascar has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A. Since agrometeorological events and crop information are often reported for the administrative provinces of the country, their boundaries, together with those of the agroclimatic regions, are shown in Figure 6.57.

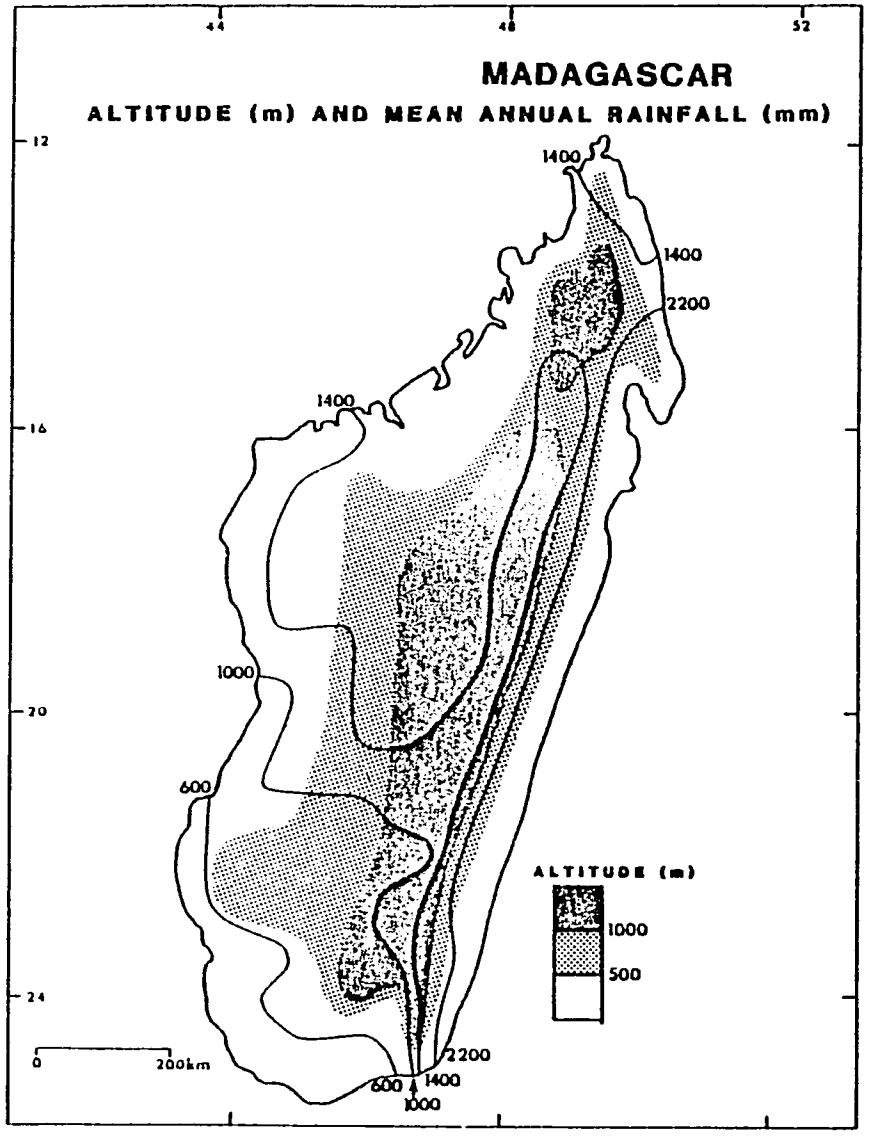
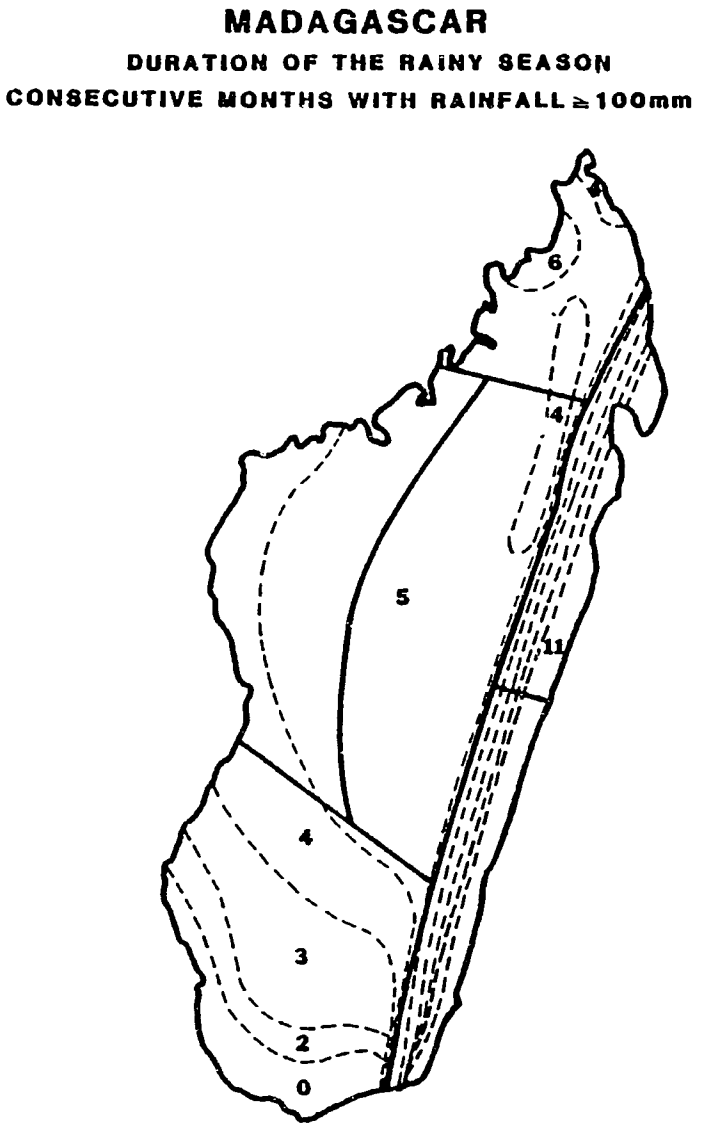


Figure 6.54.



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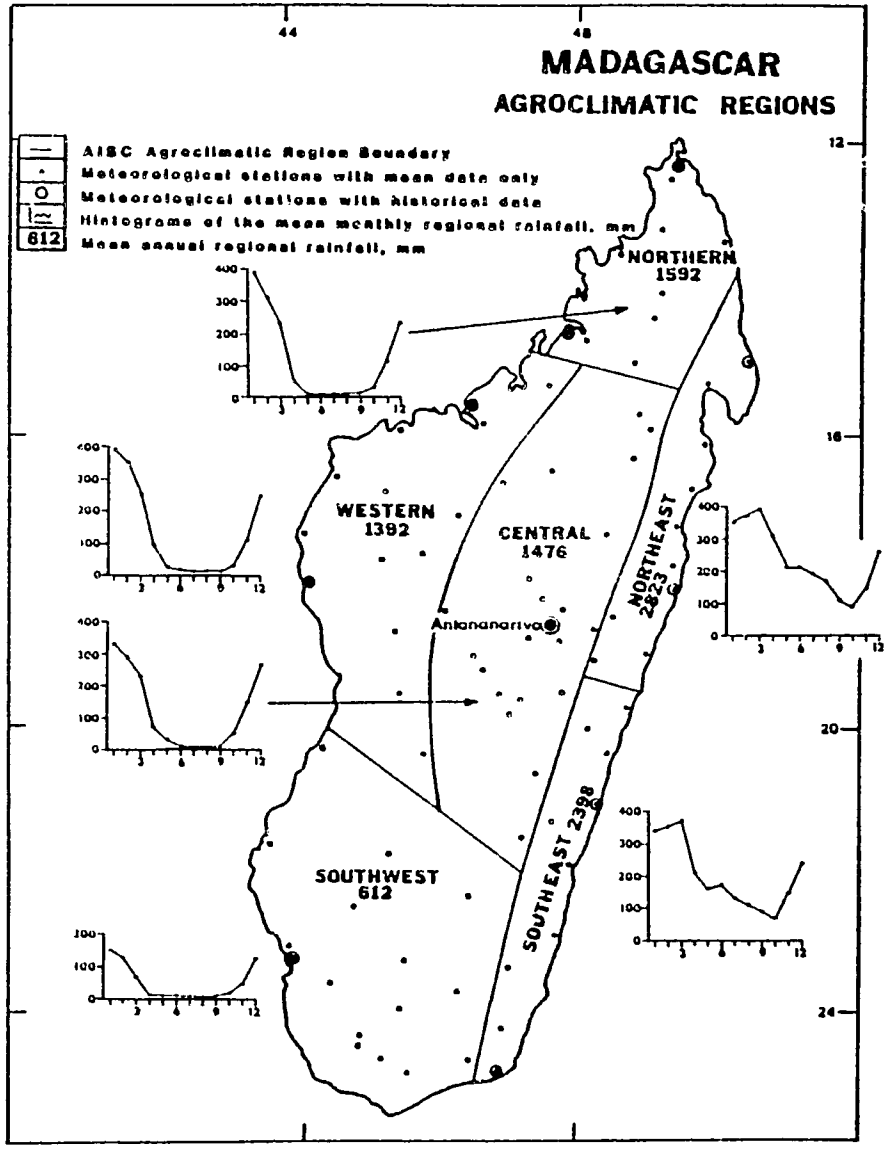


Figure 6.56.

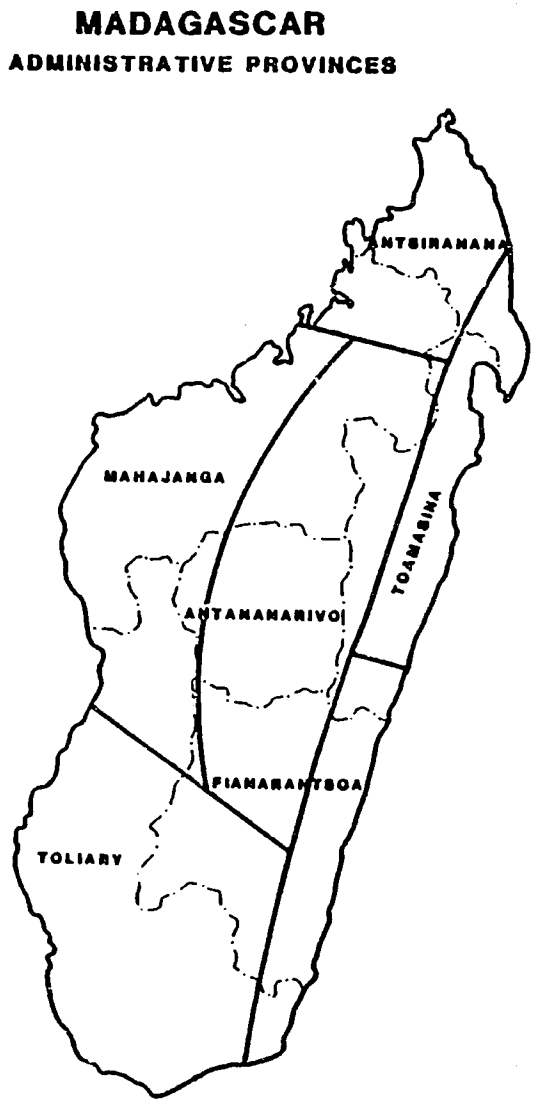
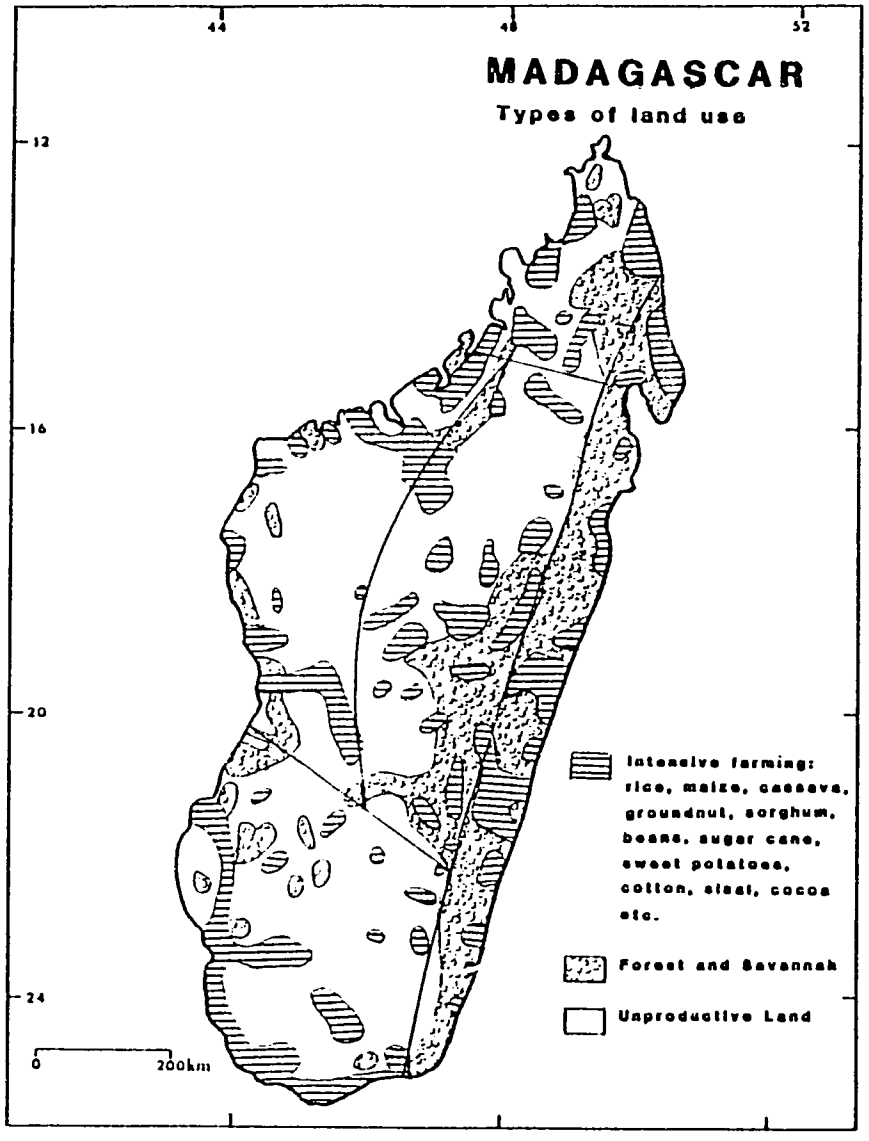


Figure 6.57.



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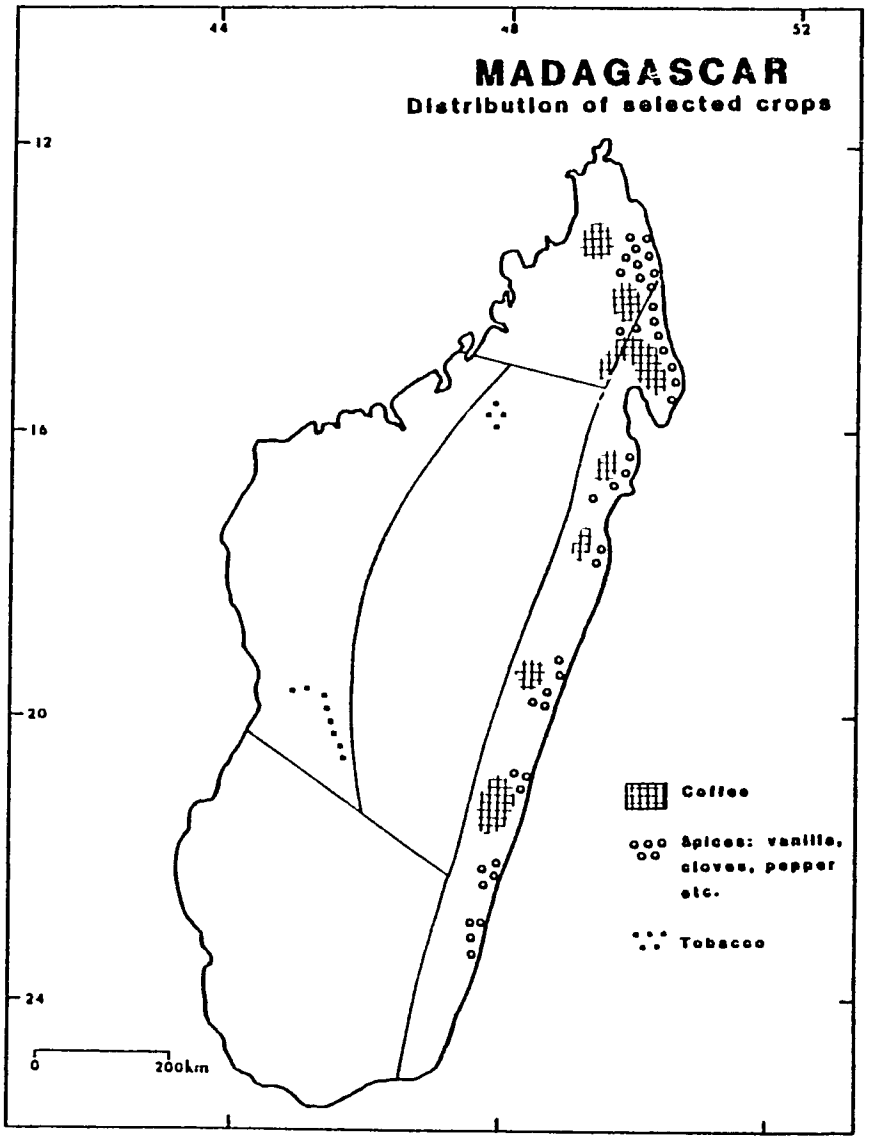

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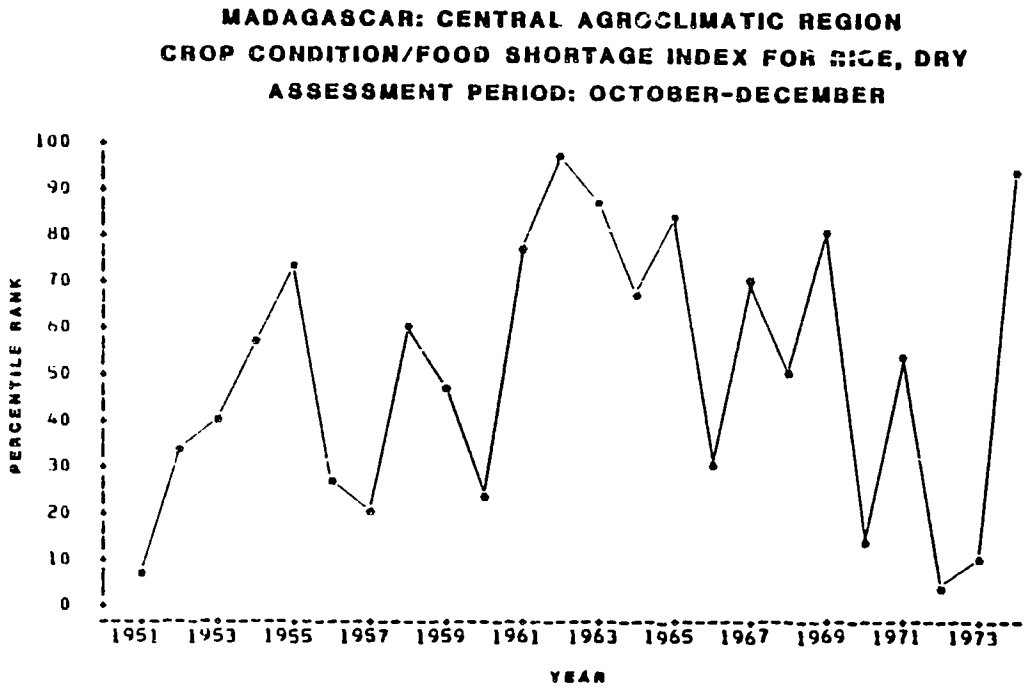


Figure 6.60.

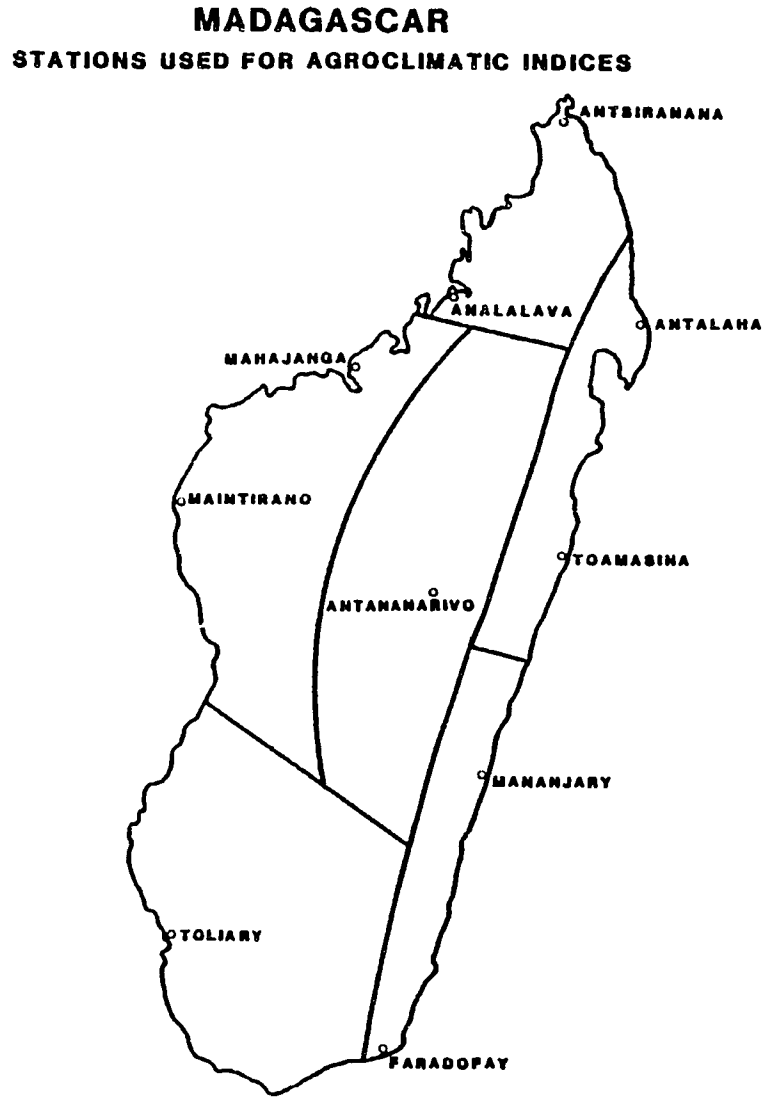


Figure 6.61.

Table 6.33. Mean monthly and annual rainfall (mm) at selected stations in Madagascar

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
North	Antsiranana	105	277	291	178	50	11	19	16	19	9	16	45	150	1081
	Analalava	57	450	382	263	63	14	4	3	5	12	47	186	314	1745
West	Mahajanga	18	419	373	254	67	7	1	1	5	2	18	113	264	1522
	Maintirano	23	361	266	168	29	11	3	3	5	5	16	47	211	1124
Central	Antananarivo	1276	271	206	214	41	16	10	12	14	18	44	171	335	1351
Northeast	Antalaha	88	336	246	269	218	167	190	170	194	98	81	111	190	2270
	Toamasina	6	456	438	488	290	248	276	276	214	111	91	182	317	3386
Southwest	Toliary	8	95	87	45	12	23	13	5	4	11	8	27	98	428
Southeast	Mananjary	6	344	342	424	233	200	216	179	166	93	98	223	210	2729
	Faradofay	9	208	161	236	144	142	127	153	122	70	106	148	145	1759

Table 6.34. Harvested area, yield and production of selected crops in Madagascar

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	1,159	1,304	1,344	1,750	1,826	1,827	2,029	2,382	2,455
Wheat	-	-	-	1,615	1,667	2,000	-	1	1
Maize	122	131	128	943	999	999	115	131	128
Rice (paddy)	1,037	1,173	1,126	1,845	1,918	1,914	1,914	2,250	2,327
Roots & tubers, total	303	325	334	6,314	6,286	6,239	1,915	2,041	2,086
Potatoes	29	36	40	6,226	6,046	6,045	180	215	242
Sweet potatoes	63	60	59	5,284	5,333	5,254	333	320	310
Cassava	198	215	220	6,695	6,628	6,591	1,322	1,425	1,450
Pulses, total	60	70	65	893	924	1,004	53	65	65
Beans (dry)	50	59	53	902	937	1,037	45	56	55
Groundnuts in shell	38	46	31	888	944	882	34	43	28

Table 6.35. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Madagascar (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
Northeast	2,500	-	-	-	230,000	20,000
Southeast	13,000	-	-	-	230,000	20,000
North	10,000	-	-	-	230,000	40,000
Central	13,000	-	-	-	340,000	42,000
West	38,000	*	-	-	55,000	65,000
Southwest	50,000	*	-	-	55,000	20,000

Table 6.36. CROP CALENDAR FOR MADAGASCAR

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Central	Rainfall		337	291	230	66	23	15	14	16	16	52	147	270
	Maize				000	000000							///	//////
	Rice	Dry Season	000000	000000						//////	//////	//////		
	Rice	Wet Season	//////	///		000	000000	000						//////
West	Rainfall		393	313	230	57	8	3	3	5	10	36	110	224
	Maize				000	000000							///	//////
	Rice	Dry Season				///	//////	///			000000	000000		
	Rice	Wet Season	///			000000	000000						///	//////
North	Rainfall		397	350	252	97	23	20	18	19	17	36	108	253
	Maize				000	000000							///	//////
	Rice	Dry Season				///	//////	///			000000	000000		
	Rice	Wet Season	///			000000	000000						///	//////
Northeast	Rainfall		356	375	387	307	210	218	198	168	115	83	145	260
	Rice	First						///	//////	///			000000	000000
	Rice	Second			000000	000000						///	//////	///
Southeast	Rainfall		340	355	378	203	160	176	134	114	86	72	142	240
	Rice	First						///	//////	///			000000	000000
	Rice	Second			000000	000000						///	//////	///
Southwest	Rainfall		144	124	74	18	16	17	8	6	10	20	52	123
	Rice				000000	000000							//////	///
	Maize				000000	000000							///	//////
	Sorghum				000000	000000							///	//////

TABLE 6.37.

MADAGASCAR

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1968, January	Cyclone Georgette Damages Andapa in the NE and Tulear in the SW
1969, February	Cyclone Dany Damages East and West Coasts
1970, February	Cyclone Jane Damages Central and Southern Madagascar
1972, February	Cyclone Eugenie Damages Central Region
1975, January	Cyclone Deborah Damages Southern Madagascar
1975, March	Cyclone Ines Damages Tamatave Vicinity
1976, January	Three Cyclones Damage Northern Areas
1976, March	Poor Rainfall Resulted in Some Crop Failures
1976, May	Drought Damaged About 50% of the Rice Crop in Fianarantsoa Province
1976, September	Due to Drought in Early 1976, Total Rice Production Estimated at 8% Below 1975
1977, February	Cyclone Emilie Damages 5 Provinces
1977, February	Floods Caused Loss of 68,000 Tons of Rice (Paddy)
1978, April-May	A Prolonged Drought Affected the Main Season Rice Crop, as well as Maize, Cassava, Sweet Potatoes and Pulses
1978, December	Cyclone Angele Hits Tulear Province, Damaging Newly Planted Crops
1979, April	The First Season 1979 Rice Crop Slightly Reduced by Drought
1980, June	Severe Drought in the Southwest Province of Morondava and the Northern Province of Maintarano Affected Crops
1981, January	Delayed and Erratic Rainfall in the Northeast Affected the Rice Crop, which is in Poor State
1981, March	About 300,000 Hectares in the South were Recently Damaged by Locust
1981, April	Floods Caused by Tropical Cyclone Klara Damaged Rice Crop Along the Eastern Coast. The Main Rice Crop has been Damaged Also by the Drought Preceding the Floods

continue.....

TABLE 6.37

MADAGASCAR CONTINUED:

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1982, January	Floods and Cyclones Left 22,000 Persons Homeless and Damaged Crops Around Antananarivo, Devastated Agricultural Areas on the East Coast. More than Half of the Year's First Rice Crop has been Damaged
1982, January	Drought Caused Excessive Crop Damage
1982, March	Cyclones in Late January and Early February Damaged Crops. Floods have Nearly Destroyed the Rice Crop in Antananarivo Plain. Damage Also Reported in Fianarantsoa and Tulear Prefectures

I. MALAWI

1. Agroclimatic Conditions and Regions

There are several major geographic regions in Malawi:

- Shire Valley. Lake Malawi drains southward into the Shire River. Its valley is about 270 km long, descending from 465 m altitude at Lake Malawi to 40 m at the southern-most point of the country. The valley is heavily cultivated.
- Lake Malawi Coastline. It has an altitude of 465 m at the lake to about 1000 m (Figure 6.62). The topography consists of rolling hills and open, shallow valleys.
- Plateaus. Highland plateaus form the western half of the country. Several plateaus are also found in the South. These are extensive flat or rolling surfaces, with altitudes mostly between 1,000 and 1,500 meters.
- Mountains. Several mountains rise above the plateaus: Nyika in the north (2,600 m), Dedza in the central region (2,220 m), and Zomba and Mlanje in the south (2,000 and 3,000 m respectively).

The country has been divided into three agroclimatic assessment regions (Figure 6.64). The mean regional rainfall is the same for all three regions - slightly over 1,000 mm annually. Within the regions however, eastern areas are usually wetter than the western (Figure 6.62). Individual stations indicate even greater differences, from 717 mm in Mponela to 1930 mm in Chinteche (Table 6.38).

The seasonal variations of rainfall are similar all over the country. There are well pronounced dry and wet seasons. The rainy season normally begins in November and ends in April (Figure 6.64). The period with mean monthly rainfall of 100 mm or more lasts 4 months over the greater, mostly western part of the country (Figure 6.63; see also Chapter VII, E). Durations of 5 or even 6 months occur in some eastern locations.

2. Agriculture

The most important food crop in Malawi is maize; the area planted to maize is larger than the combined area of all the other food crops (Table 6.39). Farmers also grow pulses, groundnuts, sorghum, millet, potatoes, rice and cassava. The most important commercial crop is tobacco, followed by cotton and tea.

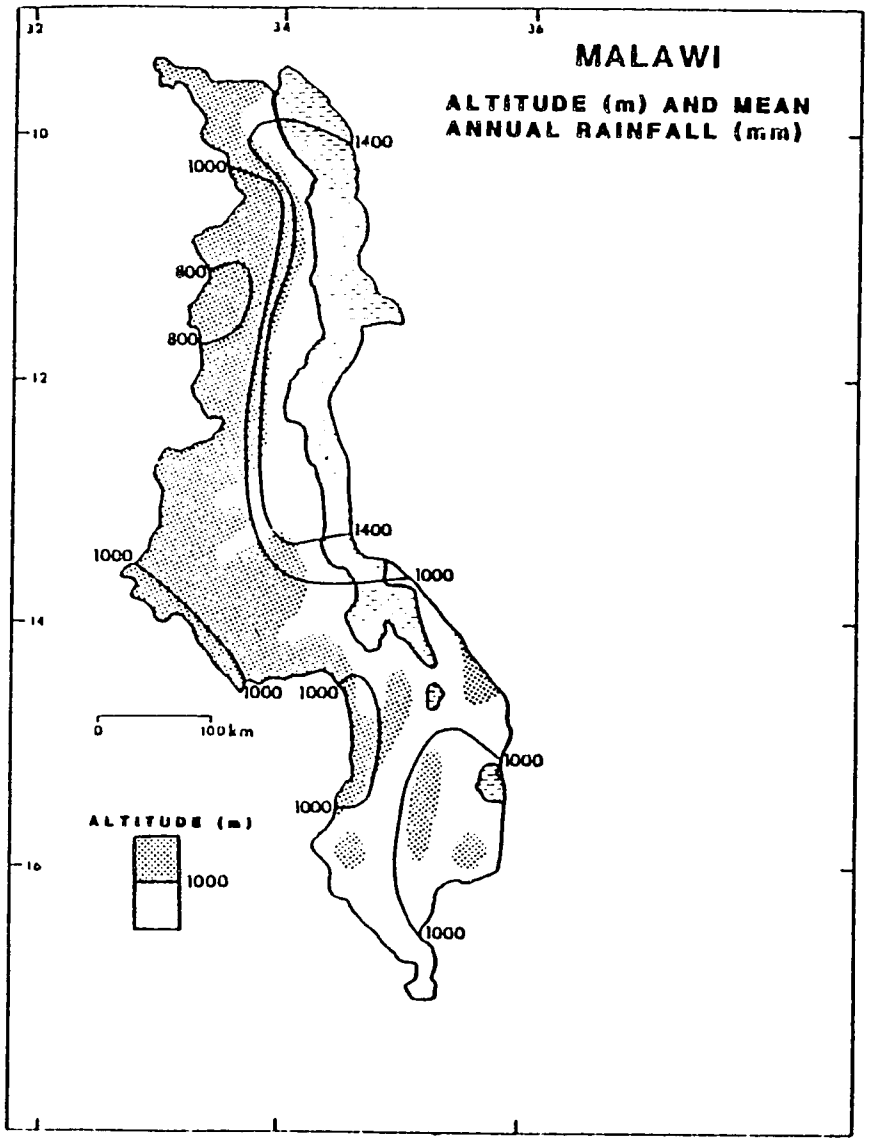
Most agricultural activities take place in the southern agroclimatic region (Figures 6.66 and 6.67, and Table 6.40.) The northern region is the least agriculturally developed.

The crop calendar depends on the rainfall regime, altitude and variety. Sowing normally starts soon after the beginning of the rainy season, while harvesting takes place at the end (Table 6.41).

3. Factors Affecting Yield and Their Assessment

Drought and floods are the meteorological factors that affect crops nearly every year (Table 6.42). The years with drought, as well as those with good rainfall, are shown on Figure 6.68. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Malawi and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.69. In addition to the stations with common period of records (used for the assessments), Malawi has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative regions and districts of the country, their boundaries, together with those of the agroclimatic regions, are shown in Figure 6.65.



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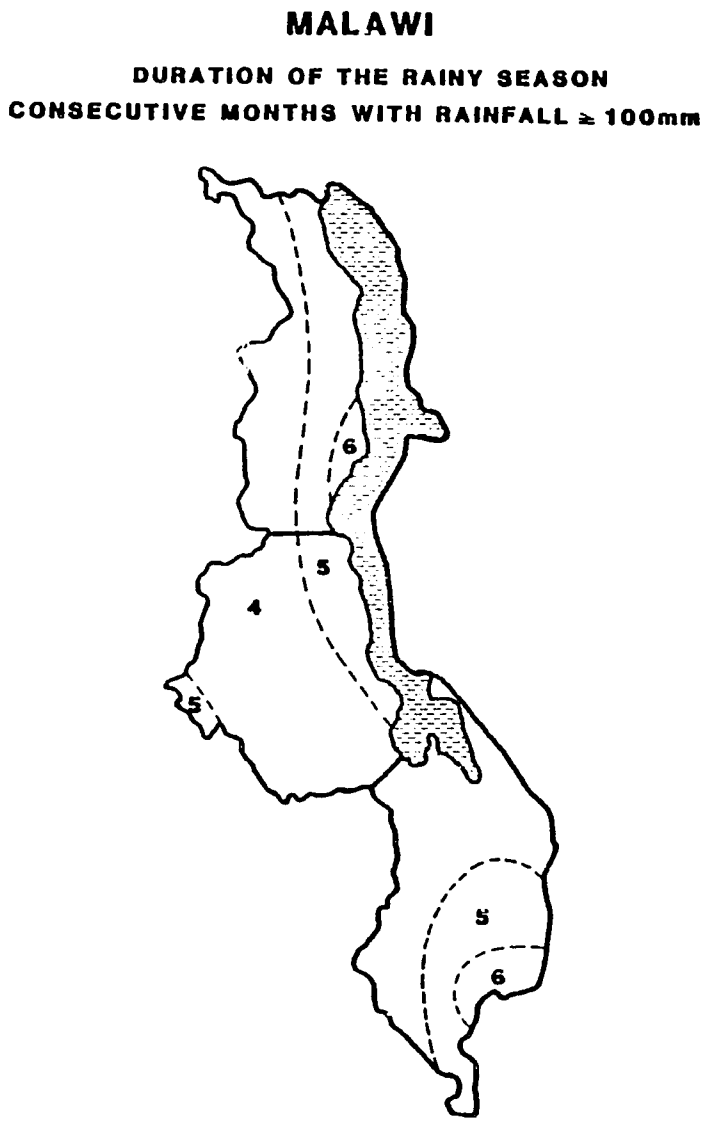
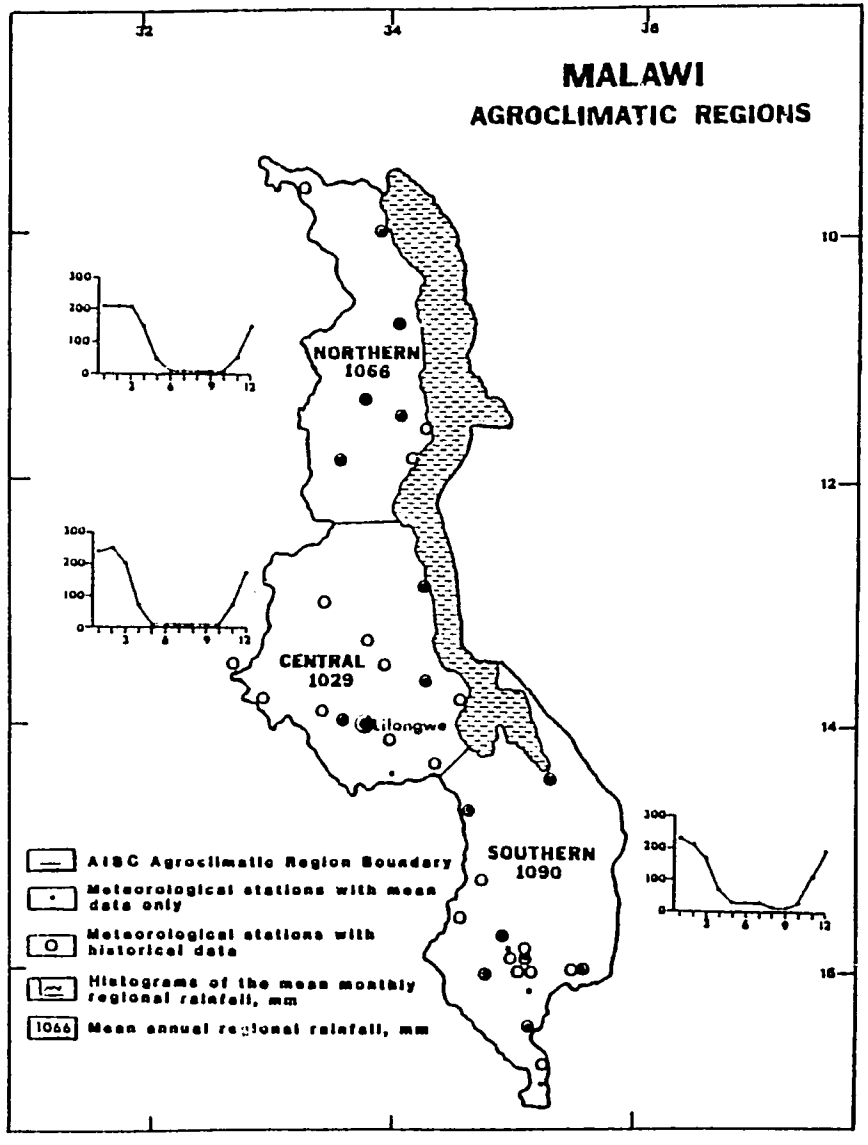


Figure 6.63.



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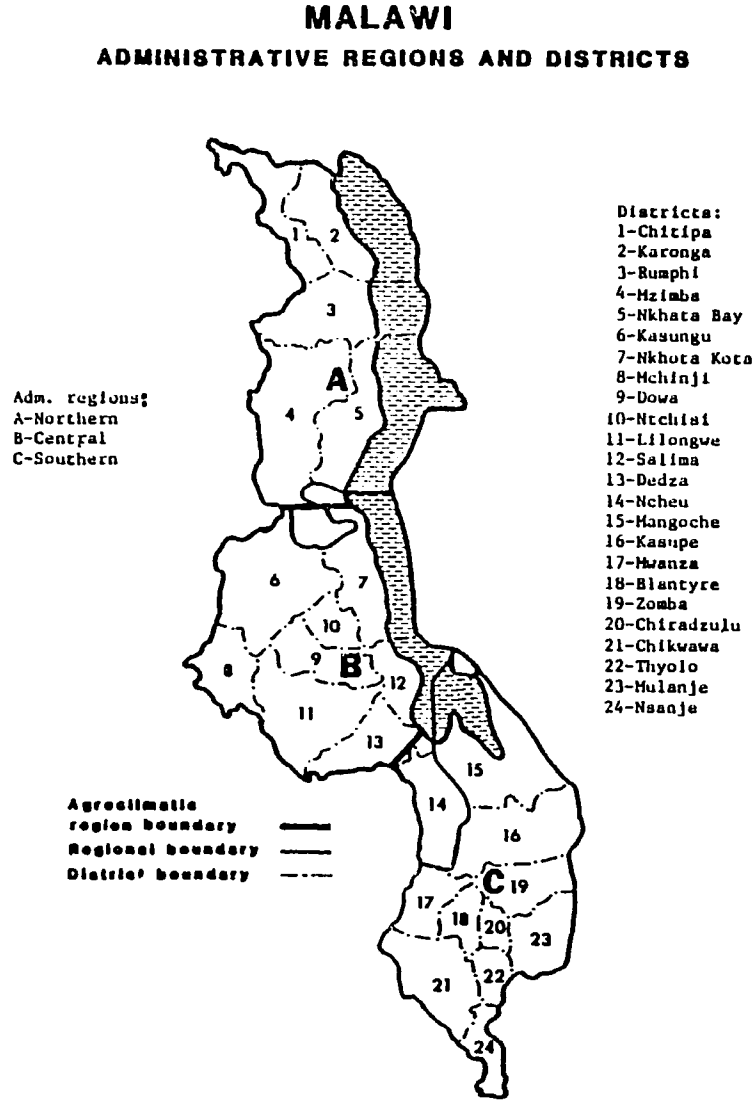

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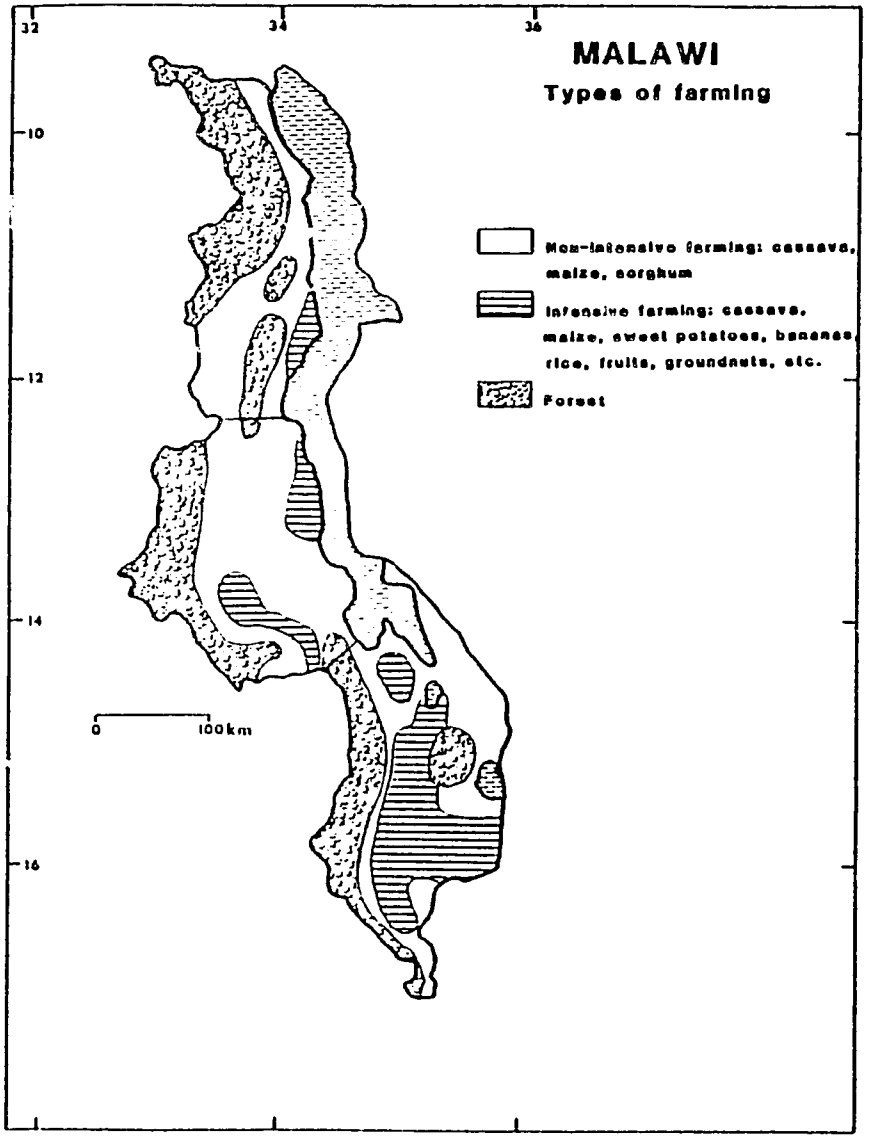

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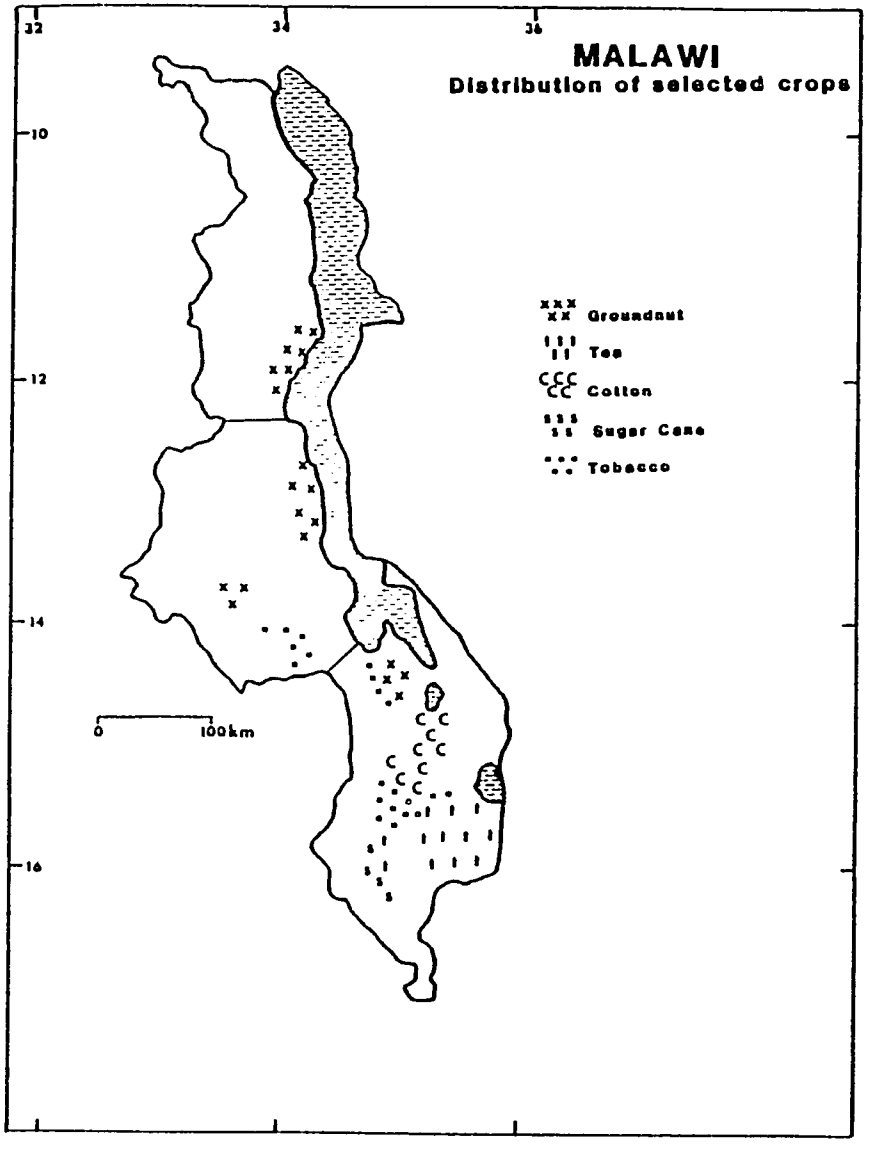

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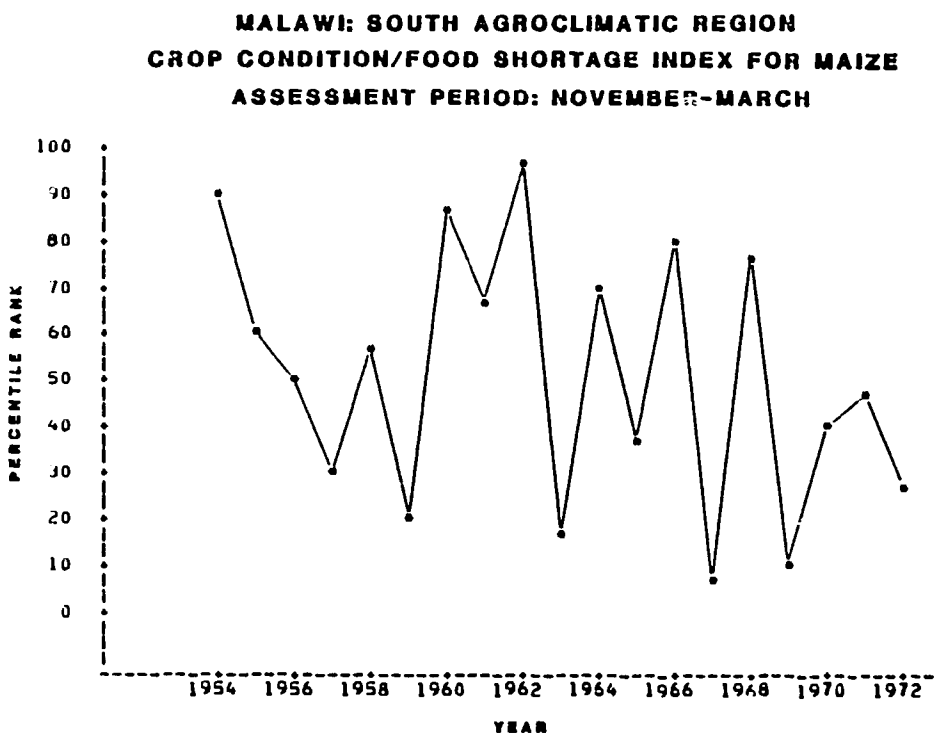

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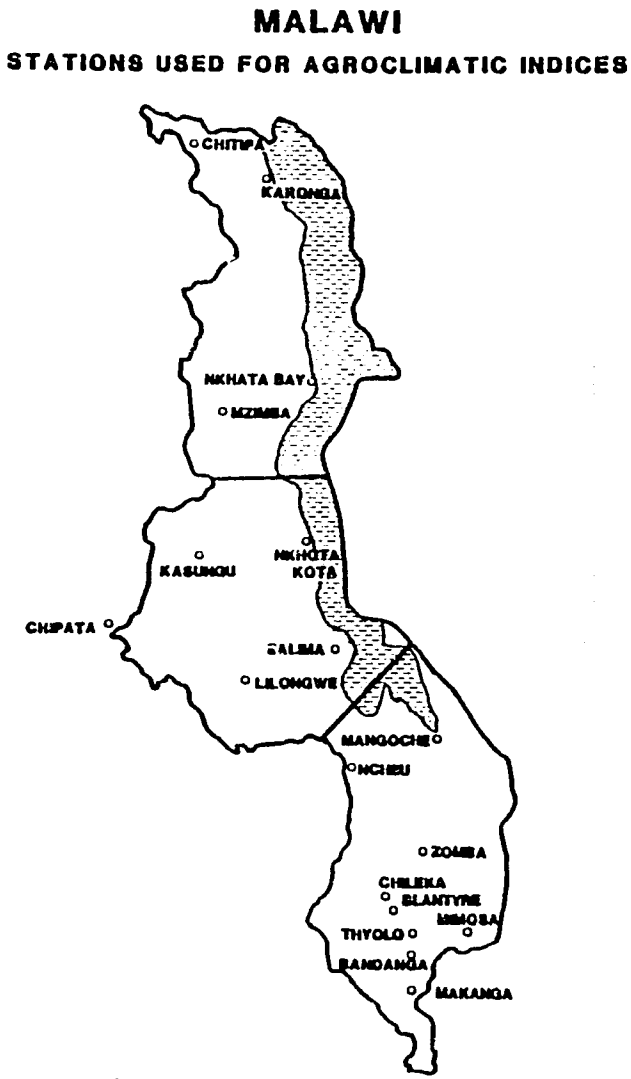


Figure 6.69.

Table 6.38. Mean monthly and annual rainfall (mm) at selected stations in Malawi

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
North	Chitipa	1276	206	211	189	63	7	1	1	0	1	5	58	199	947
	Karonga	529	189	161	348	254	35	8	2	1	1	2	54	190	1246
	Nchenachena	1289	238	214	256	174	39	12	11	5	6	7	81	202	1227
	Mzuzu	1251	210	175	227	223	52	33	23	11	11	21	68	188	1235
	Nkhata Bay	500	262	186	361	281	117	56	33	6	5	9	96	222	1633
	Mzimba	1349	229	191	152	39	11	4	5	1	1	3	53	179	869
	Chinteche	488	265	254	437	387	131	58	32	10	5	11	110	230	1930
Central	Nkhota Kota	500	341	331	331	217	36	11	8	2	1	8	70	269	1625
	Kasungu	1100	198	206	117	30	5	1	0	0	1	3	45	172	776
	Mponela	1400	202	181	100	30	6	3	2	0	0	4	38	149	717
	Chipata, Zambia*	1032	261	229	138	62	3	1	0	0	1	7	98	217	1018
	Mchinji	1500	251	219	181	89	9	7	1	1	3	14	107	241	1072
	Dowa	1500	212	237	155	28	6	6	1	0	1	5	55	200	912
	Salima	513	325	283	226	93	12	3	0	1	2	7	41	214	1214
	Chitedzi	1149	242	194	133	50	11	3	1	0	2	5	75	209	913
	Lilongwe	1135	207	191	110	38	10	1	0	1	2	6	64	188	819
	Dedza	1630	256	200	125	56	12	5	4	2	3	17	53	200	933
South	Mangoche	485	214	178	112	36	5	6	2	3	9	11	63	161	800
	Ncheu	1277	260	214	123	49	8	1	2	1	3	15	77	186	940
	Neno	1300	244	253	176	53	23	19	19	13	11	26	113	278	1218
	Zomba	957	300	249	193	89	25	16	8	5	12	22	141	293	1352
	Mwanza	1000	244	209	136	44	14	14	16	8	5	19	59	232	993
	Chileka	766	199	147	103	43	11	4	3	1	5	19	80	194	806
	Blantyre	1039	251	191	153	65	11	9	9	3	3	19	107	203	1025
	Thyolo	819	239	199	195	122	31	30	28	20	10	26	101	252	1244
	Mimosa	653	288	254	254	156	56	57	41	27	25	38	157	278	1621
	Bandanga	820	267	198	204	123	36	41	33	23	9	25	109	255	1321
	Makanga	80	186	112	110	38	13	15	14	9	3	16	74	171	760

*This station is located in a neighboring country, and may be used for Malawi assessments.

Table 6.39. Harvested area, yield and production of selected crops in Malawi

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	1,267	1,167	1,277	1,255	1,166	995	1,590	1,361	1,271
Wheat	-	-	-	2,500	2,500	2,500	1	1	1
Maize	1,100	1,000	1,100	1,273	1,200	1,000	1,400	1,200	1,100
Rice (paddy)	47	47	47	1,060	1,064	1,064	50	50	50
Sorghum and millet	120	120	130	1,167	917	923	140	110	120
Roots & tubers, total	44	44	45	3,977	4,222	4,556	175	190	205
Potatoes	29	30	30	3,621	3,667	3,833	105	110	115
Cassava	15	15	15	4,667	5,333	6,000	70	80	90
Pulses, total	293	296	300	693	672	683	203	199	205
Beans (dry)	95	96	95	653	625	653	62	60	62
Groundnuts in shell	200	200	219	732	893	832	146	179	183

Table 6.40. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Malawi (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum/Millet	Wheat	Rice	Cassava
North	215,000	25,000	-	5,000	3,000
Central	375,000	43,000	-	16,000	5,000
South	480,000	55,000	-	26,000	7,000

Table 6.41. CROP CALENDAR FOR MALAWI

Six symbols (//////) indicate a month; three symbols (///) indicate half month, two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
North	Rainfall		206	208	214	145	44	11	8	6	5	14	57	149
	Maize		//////			00	000000	000000						//////
	Sorghum		///			000	000000	000						//////
	Millet		///			000	000000	000						//////
Central	Rainfall		240	258	200	65	14	2	1	2	3	4	65	175
	Maize		//////			00	000000	000000						//////
	Sorghum		///			000000	000000	000					///	//////
	Millet		///			000000	000000	000					///	//////
South	Rainfall		232	218	163	73	24	21	14	13	9	25	103	196
	Maize		///			000	000000	000					///	//////
	Sorghum		///			000000	000000	000					///	//////
	Millet		///			000000	000000	000					///	//////

TABLE 6.42.

MALAWI

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1967, March	Floods in the South
1969, January	Floods Along the Shive River Valley
1979, January	Drought Reported in Some Areas
1979, May	Floods Along Lake Malawi Shores
1979, June	The Flooding of Lake Malawi Caused Extensive Damage to Sugar Cane in Lakeshore Districts
1980, February	Crops, Especially in the Southern Region have been Severely Affected by Two Extended Dry Periods in January and February
1981 -	The 1980/81 Season Maize Crop was Seriously Affected by Drought
1982, August	Inconsistent Rainfall During the 1981/82 Crop Season Affects Maize

J. MOZAMBIQUE

1. Agroclimatic Conditions and Regions

The topography of the country consists of a wide coastal plain, gradually rising westwards into highlands (Figure 6.70). Only about 15 percent of the land is over 1,000 meters; several mountain peaks reach 2,000 m. Most of the highlands are in the north and west. Many river valleys, especially in the south, have large marshes.

The country has been divided into four agroclimatic assessment regions (Figure 6.72). The Central is the wettest with about 1,300 mm mean annual rainfall; the South is the driest with only 743 mm mean regional rainfall per year. Within the regions rainfall amounts vary depending on topography and location (Figure 6.70 and Table 6.43).

The seasonal variations of rainfall are similar throughout the country. There are distinct wet and dry seasons. The rainy season normally begins in November, reaches its peak in January and ends in April (Figure 6.72). The duration of the period with mean monthly rainfall of 100 mm or more is 4-5 months in the Central and North regions, 3-5 months in the Northwest and 0-4 months in the South (Figures 6.71; see also Chapter VII, E).

2. Agriculture

The most important agricultural crops are maize and cassava (Table 6.44). Farmers also grow considerable amounts of sorghum, groundnuts and pulses. The most important commercial crops are cotton, sugar cane, cashew nuts, tea and sisal. The areas with intensive farming are along either the coast or the river valleys (Figures 6.74 and 6.75). The largest areas with food crops are planted in the North and Central agroclimatic regions (Table 6.45).

Sowing of the crops normally begins soon after the beginning of the rainy season, while harvesting takes place at the end (Table 6.46).

3. Factors Affecting Yield and Their Assessment

As the episodic data indicate, drought and floods are the major meteorological factors causing damage to crops (Table 6.47) The years with drought, as well as those with good rainfall, are shown on Figure 6.76. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number

of these stations in Mozambique and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.77. In addition to the stations with common period of records (used for the assessments), Mozambique has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative districts of the country, their boundaries, together with those of the agroclimatic regions, are shown in Figure 6.73.

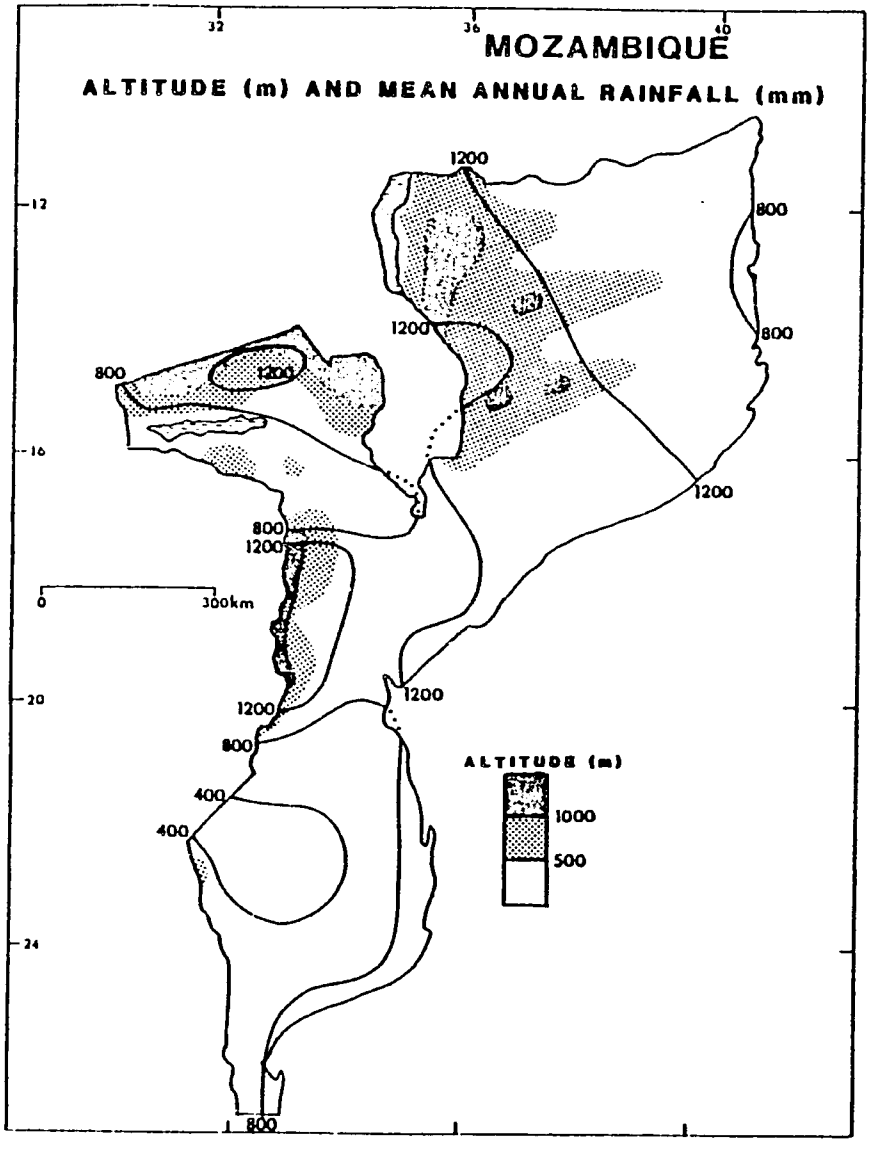


Figure 6.70.

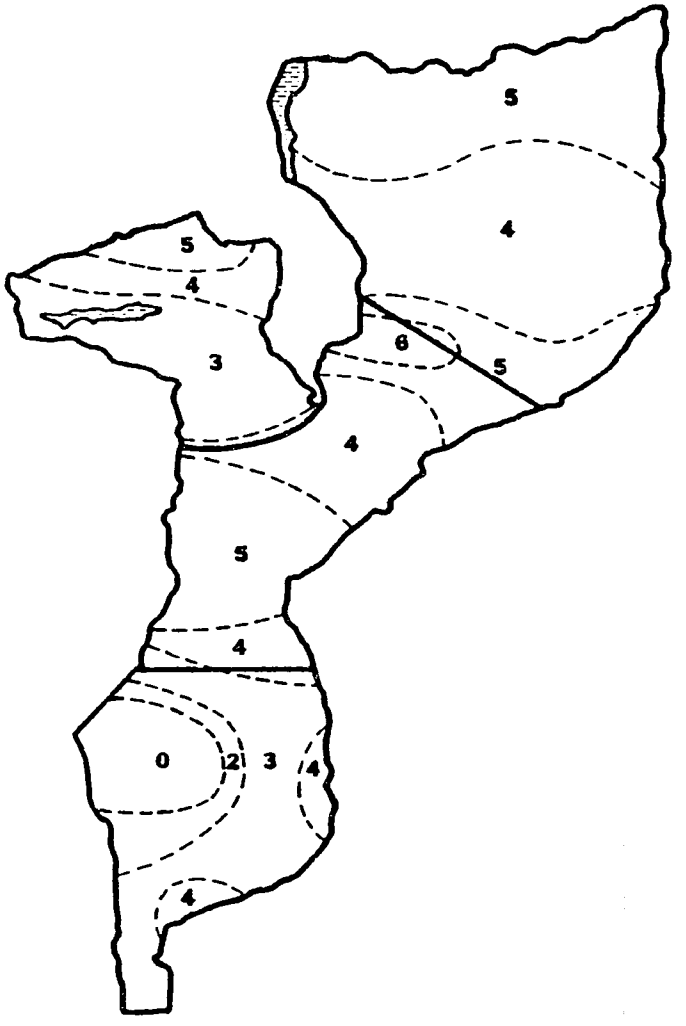


Figure 6.71.

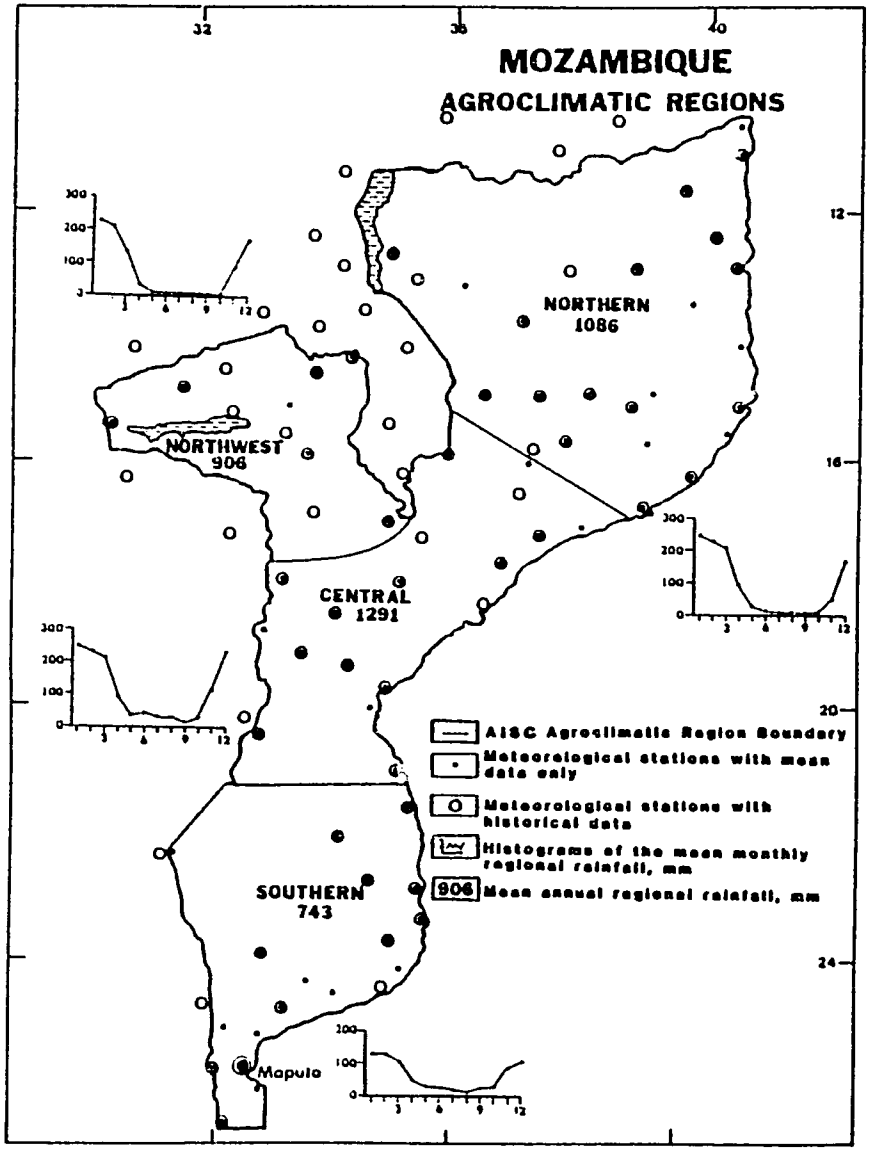


Figure 6.72.

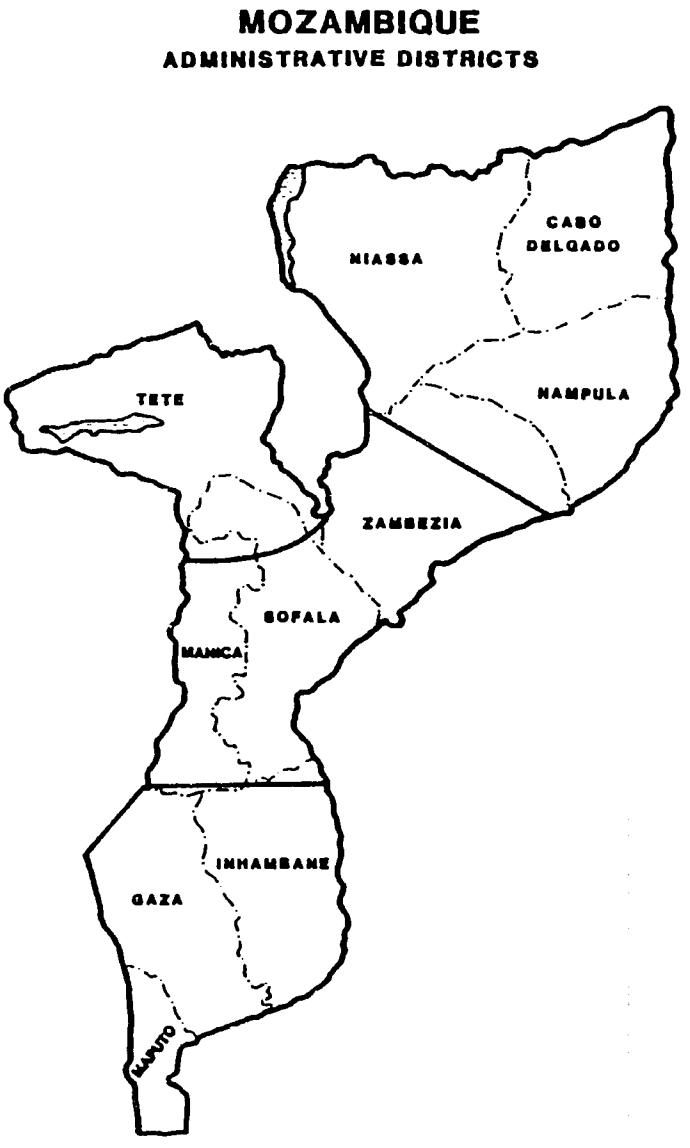
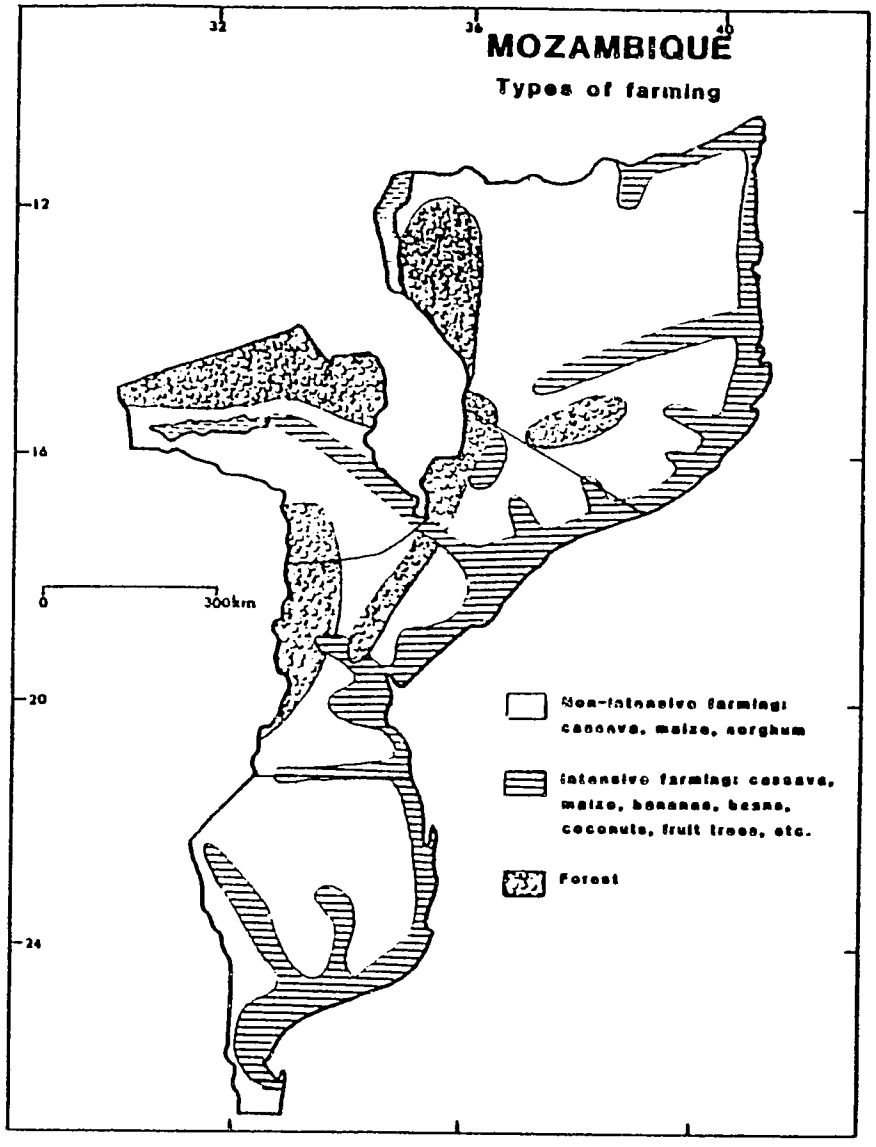


Figure 6.73.



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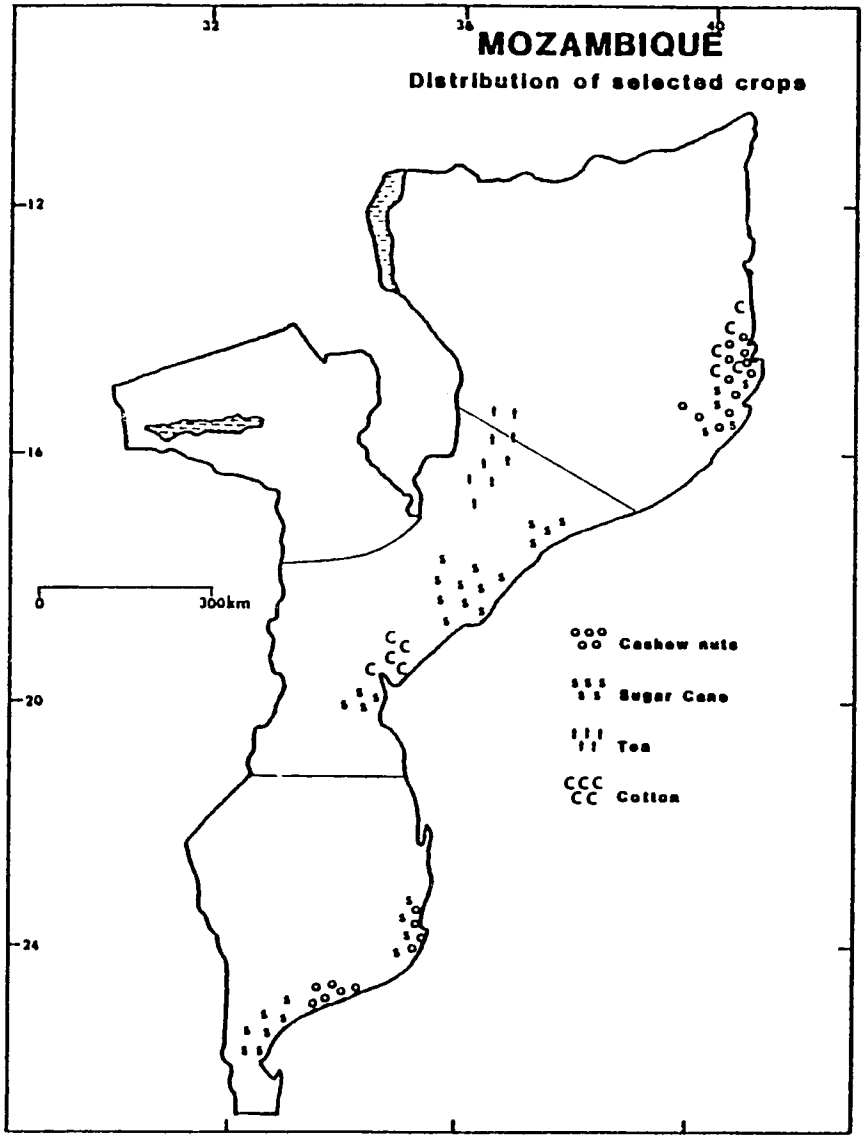

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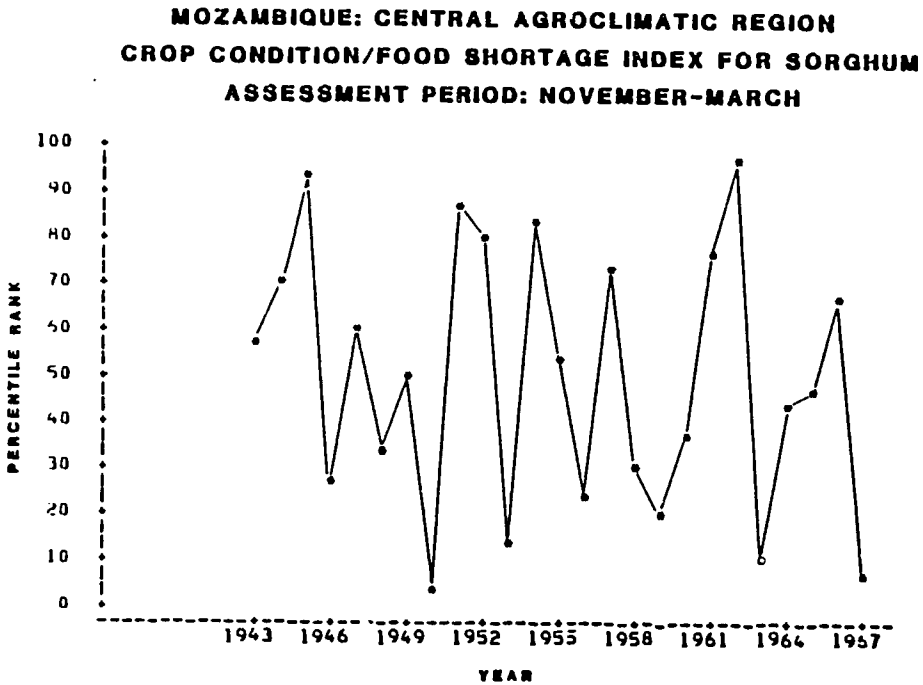


Figure 6.76.

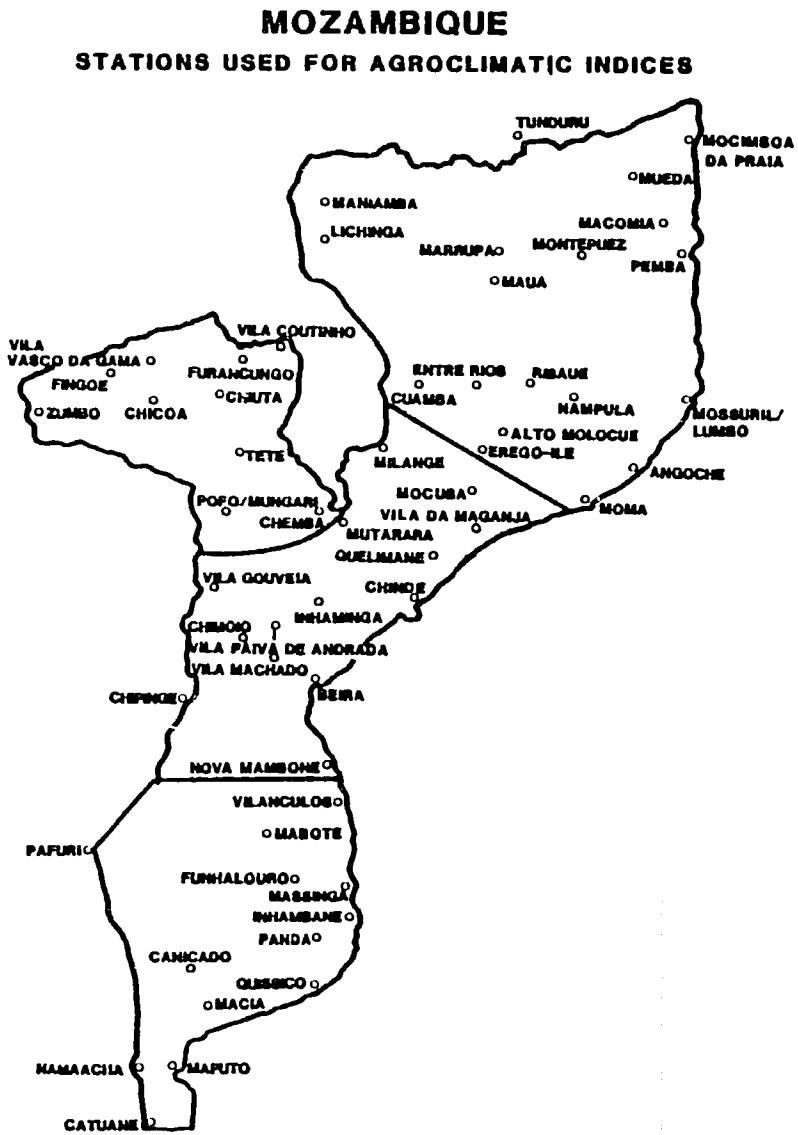


Figure 6.77.

Table 6.43. Mean monthly and annual rainfall (mm) at selected stations in Mozambique

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
North	Tunduru, Tanzania*	701	256	258	225	81	11	2	2	1	3	6	45	184	1075
	Mocimboa da Praia	27	163	186	187	188	42	16	10	6	9	13	51	101	971
	Mueda	847	253	210	254	117	23	4	2	3	2	4	47	214	1132
	Maniamba	1093	287	280	302	171	32	8	2	2	1	15	89	250	1439
	Macomia	343	299	222	252	121	17	4	9	4	7	8	49	205	1197
	Lichinga	1356	239	239	232	74	18	4	2	2	3	14	78	223	1129
	Marrupa	760	288	242	228	60	7	1	1	1	3	4	73	192	1097
	Montepuez	534	235	212	193	53	8	2	2	1	1	9	54	168	938
	Pemba	49	171	153	180	120	26	17	18	4	6	10	34	129	868
	Maua	594	300	245	255	59	12	4	2	2	6	11	82	219	1195
	Cuamba	606	241	221	167	37	7	3	1	2	6	12	64	202	962
	Entre Rios	625	253	233	205	39	4	3	1	1	4	4	53	178	977
	Ribaue	535	264	230	215	67	19	9	10	9	6	17	97	201	1143
	Nampula	441	249	216	203	77	25	17	19	8	6	14	77	186	1098
	Mossuril/Lumbo	15	211	183	172	103	21	39	22	13	7	6	37	130	945
	Alto Molocue	563	298	309	281	86	36	23	26	16	15	14	109	228	1441
	Erego-Ile	533	296	304	304	135	47	51	36	30	21	24	129	212	1588
	Angoche	61	238	176	213	122	55	52	45	16	7	8	62	154	1145
	Moma	4	243	222	243	89	72	39	39	15	10	10	53	154	1186
Northwest	Vila Coutinho	1300	234	206	140	48	12	4	3	4	6	13	69	194	933
	Vila Vasco da Gama	1170	319	315	231	89	21	17	14	7	6	10	111	314	1456
	Furancungo	1258	246	237	150	64	9	6	5	4	3	21	105	244	1093
	Fingoe	857	262	249	160	41	7	6	5	4	1	5	90	237	1066
	Zumbo	339	173	170	91	10	3	2	0	2	0	6	66	178	700
	Chicoa	274	167	153	63	12	2	3	1	0	0	3	49	151	604
	Chiuta	1333	248	205	143	45	11	13	10	5	3	13	82	194	973
	Tete	149	154	176	89	15	3	4	2	2	2	3	54	136	640
	Pofo/Mungari	500	171	153	79	21	7	5	1	2	1	7	57	122	626
	Chemba	100	148	143	73	38	20	9	8	7	9	12	79	132	677

continue.....

*The station is located in a neighboring country, and may be used for Mozambique assessments.

Table 6.43. Mean monthly and annual rainfall (mm) at selected stations in Mozambique (continued)

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Central	Milange	745	312	326	302	161	63	75	50	36	24	40	134	269	1794
	Mocuba	134	233	220	211	97	33	31	25	22	12	30	98	190	1200
	Mutarara	88	163	158	123	38	25	13	11	10	10	10	82	118	758
	Vila da Maganja	70	253	265	252	127	68	60	46	37	15	22	80	186	1411
	Quelimane	16	281	278	273	111	87	69	52	28	16	12	82	174	1462
	Vila Gouveia	611	385	331	206	99	32	21	11	20	15	29	141	294	1585
	Inhaminga	315	243	208	177	59	35	28	18	20	17	23	95	170	1092
	Chinde	4	229	192	199	93	82	73	51	37	20	9	58	147	1191
	Chimoio	731	236	214	157	53	23	20	13	23	16	29	114	174	1072
	Vila Paiva de Andrada	300	235	277	180	77	27	27	24	28	25	30	128	215	1273
	Vila Machado	57	184	174	118	51	16	15	9	19	5	22	92	168	871
	Beira	16	275	287	267	127	65	39	38	37	25	19	128	215	1522
	Chipinge, Zimbabwe*	1137	212	224	138	55	19	30	15	28	21	45	131	190	1107
	Nova Mambone	4	180	182	141	48	29	27	20	22	15	28	66	165	922
South	Vilanculos	20	144	189	115	42	29	27	15	21	18	30	73	138	840
	Mabote	143	94	140	86	26	15	9	3	6	11	17	61	126	592
	Pafuri, R. S. A.*	305	84	72	42	27	7	5	2	4	5	15	48	81	393
	Funhalouro	116	103	138	67	24	13	9	7	8	13	27	66	119	594
	Massinga	109	181	230	131	77	70	57	41	37	29	42	91	141	1127
	Inhambane	14	150	145	110	67	52	59	34	26	29	33	79	160	945
	Panda	150	125	164	84	38	25	19	18	17	21	34	62	118	725
	Canicado	40	116	152	65	43	20	18	12	11	18	30	65	87	636
	Quissico	147	151	164	91	75	70	60	50	31	41	42	93	117	985
	Macia	56	129	208	129	83	43	44	24	26	30	52	74	116	956
	Namaacha	523	152	160	117	76	28	23	24	24	43	78	112	104	941
	Maputo	44	159	136	80	68	24	17	19	17	34	53	68	92	766
	Catuane	37	93	90	62	40	26	11	14	17	31	57	72	68	580

*The station is located in a neighboring country, and may be used for Mozambique assessments.

Table 6.44. Harvested area, yield and production of selected crops in Mozambique

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	945	984	958	648	567	499	612	558	478
Wheat	5	4	3	600	631	1,000	3	3	3
Maize	600	620	600	583	483	417	350	300	250
Rice (paddy)	70	70	75	743	933	933	52	70	70
Millet	20	20	20	350	250	250	7	5	5
Sorghum	250	264	260	800	682	577	200	180	150
Roots & tubers, total	616	617	615	4,377	4,551	4,732	2,694	2,807	2,910
Potatoes	6	5	6	8,333	10,853	10,909	50	57	60
Sweet potatoes	9	9	9	4,706	5,294	5,294	40	45	45
Cassava	600	602	600	4,333	4,485	4,667	2,600	2,700	2,800
Pulses, total	120	122	125	542	417	480	65	51	60
Groundnuts in shell	180	170	180	444	471	500	80	80	90

Table 6.45. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Mozambique (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
North	152,000	130,000	8,000	2,400	3,600	450,000
Northwest	120,000	33,000	2,000	800	3,600	12,000
Central	183,000	90,000	7,000	800	36,000	108,000
South	152,000	3,000	3,000	-	14,000	30,000

Table 6.46. CROP CALENDAR FOR MOZAMBIQUE

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
North	Rainfall Maize Sorghum Millet		249 ////// /// //	226	207	94 000000 000000 000000	30 000000 000000 000000	18 000000 00	11	10	7	12	55	167 ////// //// ///
Northwest	Rainfall Maize Sorghum Millet		223 /// /// ///	204	139	35 000000 000000 000000	7 000000 000000 000000	7	6	4	3	12	89	178 ////// ////// //////
Central	Rainfall Maize Sorghum Millet		252 /// /// ///	225	211	85 000000 000000 000000	39 000000 000000 000000	40 000	29	25	18	29	114 /// /// ///	226 ////// ////// //////
South	Rainfall Maize Sorghum Millet		126 /// /// ///	124	104	48 000000 000000 000000	34 000000 000000 000000	28 00	20	16	25	34	83	102 ////// ////// //////

TABLE 6.47.

MOZAMBIQUE

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1966, January	Floods Along Umbeluzi River
1967, February	Floods Around Maputo and Gaza
1971, January	Floods in Zambezia
1975, February	Floods in the Limpopo River Valley
1976, February	Flooding Along the Incomati River Damaged Maize, Wheat, Rice and Beans
1976, April	Heavy Floods in Zambezia Province Affect Crops and People
1977, February	Floods in the Limpopo River Valley Damage Crops
1977, March	Severe Floods from a Recent Cyclone in Southern Mozambique, Damaged Rice Crop
1977, October	Hailstorm in Maputo
1978, March	Torrential Rains Caused Flooding and Damaged Crops in Zambezia, Tete and Sofala Provinces
1978, December	Cyclone Angele Hit Nampula Province, Damaged Crops
1979, February	Maize and Sorghum Affected by Drought
1979, April	Drought in All Major Production Areas has Severely Affected the Main Season 1979 Crops
1979, July	Government Estimates that 100,000 Tons of the Maize Crop has been Lost to Drought and Cyclone "Angele"
1980, January	Rainfall in December 1979 and Current January have been Seriously Insufficient in Several Maize Producing Regions
1980, May	This Year Food Crop are Being Affected by Drought
1980, September	A Severe Two Year Drought has Drastically Reduced Food Crops Production
1980, October	Drought Ruined Crops and Caused Human Deaths
1980 -	Drought in 6 Provinces

continue.....

TABLE 6.47.

MOZAMBIQUE CONTINUED:

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1981, February	Crops were Damaged by a Dry Spell in January
1981, August	Drought, Floods Along the Zambezi River in February, and Seed Shortages, Held the Maize Crop to a Below Average Level, Although it was Higher than Last Year
1981, December	Coastal Areas in Nampula and Cabo Delgado Provinces in the North, and the Inhambane Province in the South, have Food Shortages Caused by Drought
1981 -	Drought in NE Provinces
1982, January	Drought Devastated Mozambique's Northern Coast
1982, February	Floods Damaged Crops in Central Mozambique
1982, March	In Addition to the Northern Coast, Severe Drought Affected Also the Inhambane Coastal Area in the South
1982, July	Nampula Province Hard Hit by 2 Years of Drought
1983, January	The Government Asked Foreign Donors for Emergency Food Aid Following the Worst Drought (1982/83) in 50 Years - Particularly in the Central and Southern Provinces. Cattle are Dying at a Rate of 50 a Day. Some Districts have had No Rain in Four Months. Above Normal Temperatures Make the Situation Worse.

K. NAMIBIA

1. Agroclimatic Conditions and Regions

The greater part of the country consists of a highland plateau with an altitude ranging mostly from 1,100 to 1,500 meters (Figure 6.78). The altitude slowly decreases from west to east and from north to south. The coastal area, about 100 km wide, is desert. Desert conditions also exist along the Orange River which forms the southern border of Namibia.

The country has been divided into four agroclimatic assessment regions (Figure 6.80). Wettest is the Northeast with mean regional rainfall of 530 mm per year, followed by the Central (353 mm), South (161 mm) and the West (58 mm). Within the regions rainfall is more or less homogeneous, with a tendency to decrease from northeast to southwest (Table 6.48 and Figure 6.78).

The rainy season in the Northeast and Central regions begins normally in November and lasts until the end of March. Along the northern border of the country there are three consecutive months with mean monthly rainfall of 100 mm or more; most of the Northeast region has two such months (Figure 6.79). The remainder of the country does not have even one month with such rainfall (see also Chapter VII, E).

2. Agriculture

All rainfed crops in Namibia are grown in the Central and Northeast regions (Figure 6.82 and Table 6.50). Most important food crops are maize and millet Table 6.49). Rainfed as well as most of the irrigated crops are grown during the short rainy season (Table 6.51).

3. Factors Affecting Yield and Their Assessment

Drought is the main meteorological factor causing damage to crops (Table 6.52). The years with drought, as well as those with better rainfall, are shown on Figure 6.84. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Namibia and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.83. In addition to the stations with common period of records (used for the assessments), Namibia has historical meteorological data for some other stations. They are not used for the assessments

because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative districts of the country, their boundaries, together with those of the agroclimatic regions, are shown on Figure 6.81.

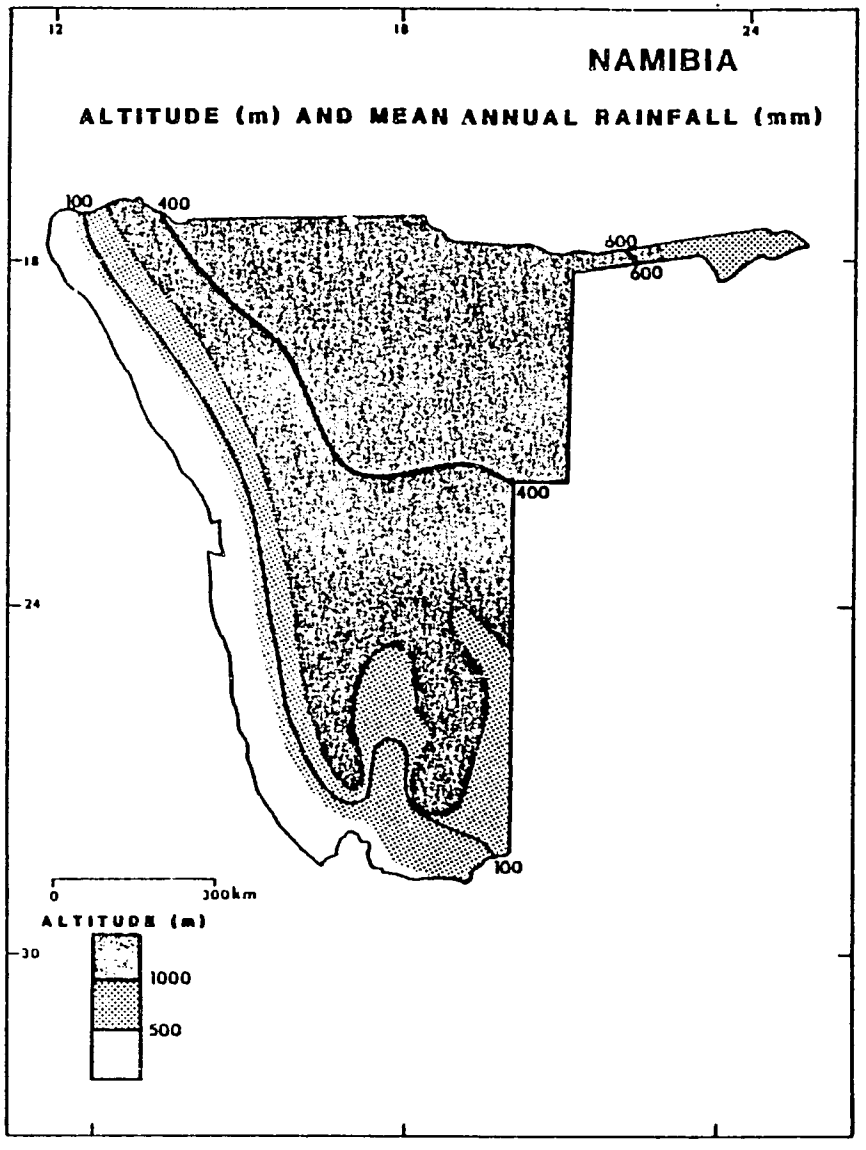


Figure 6.78.

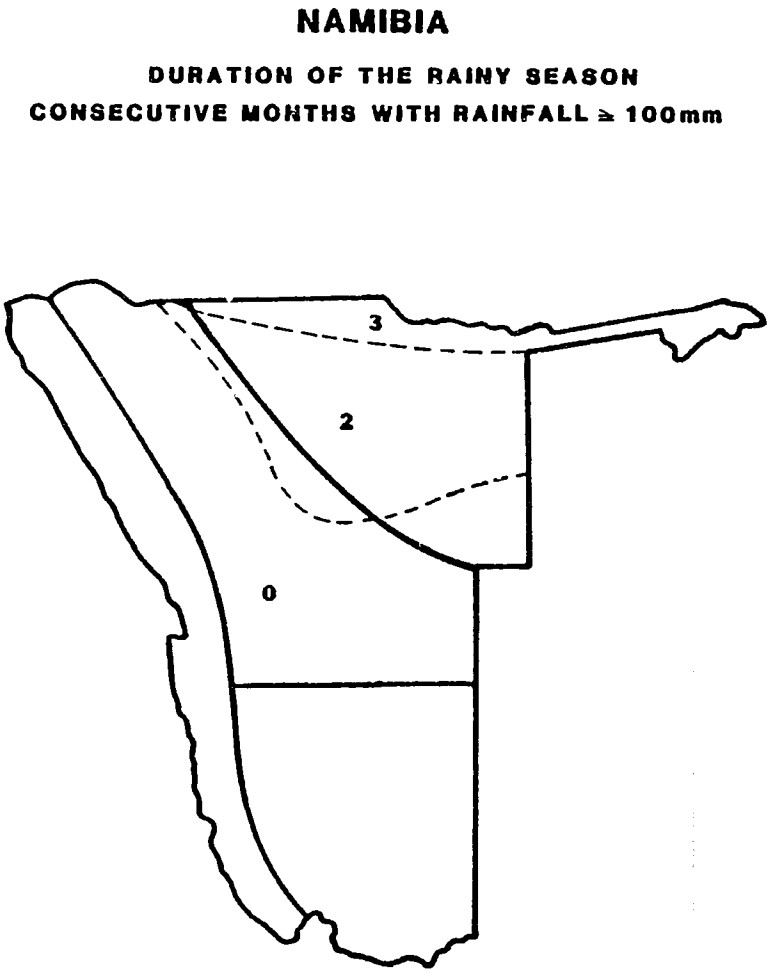


Figure 6.79.

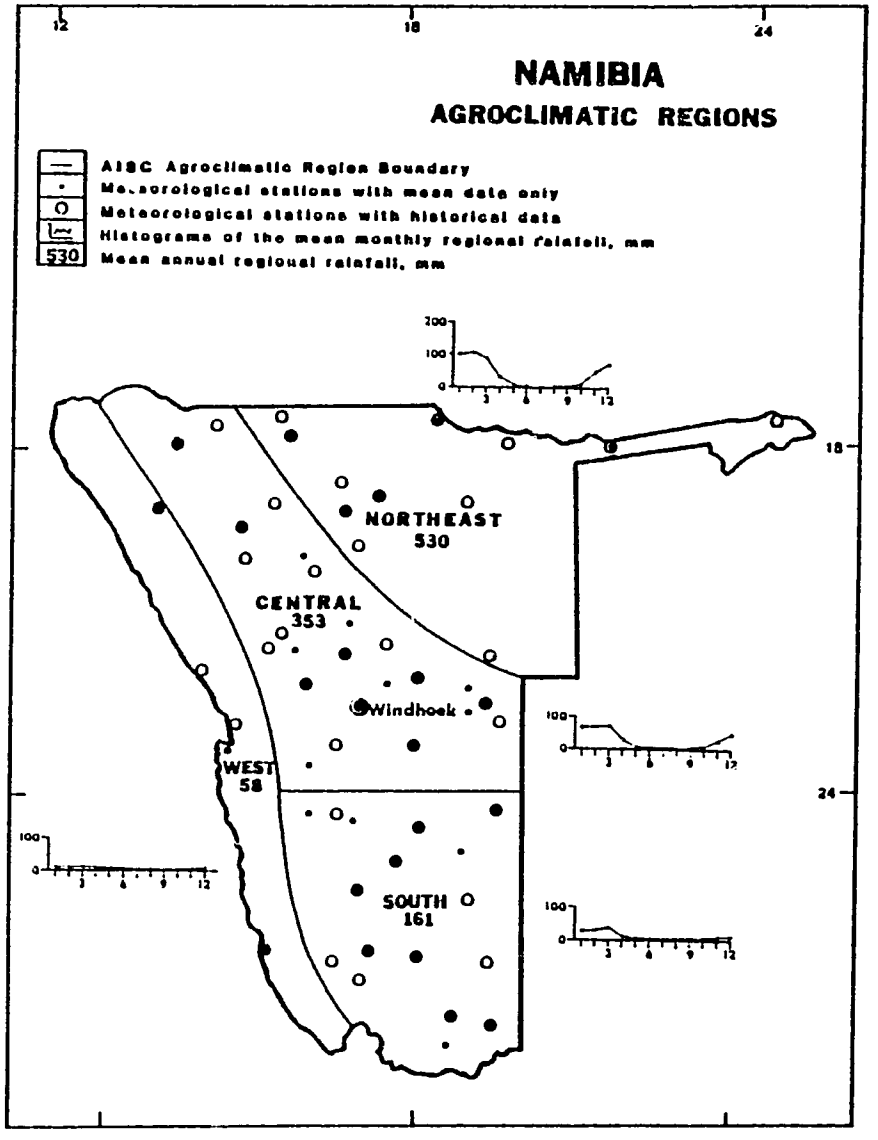


Figure 6.80.

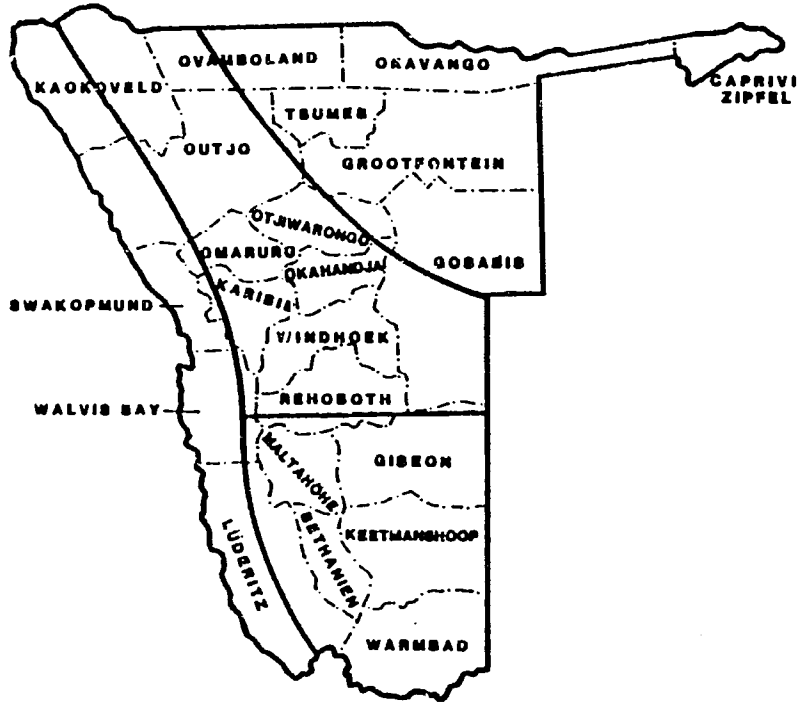


Figure 6.81.

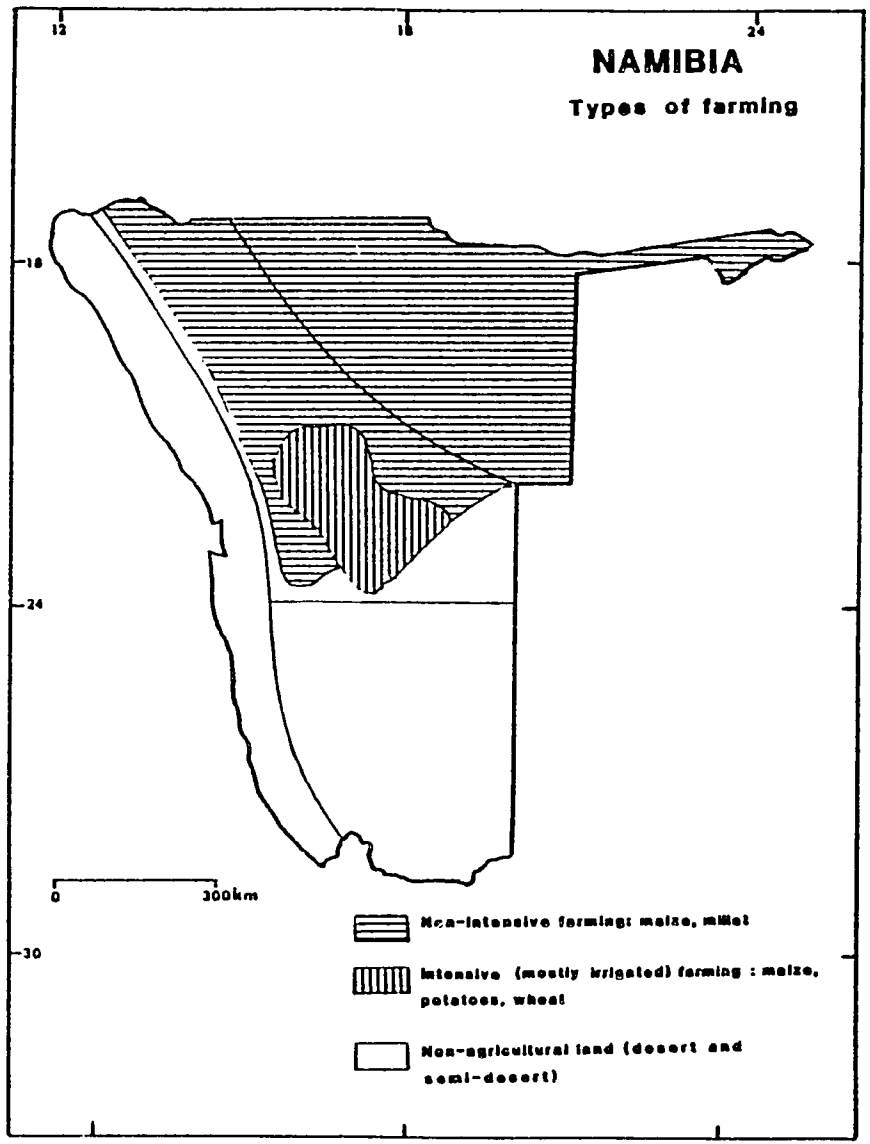


Figure 6.82.

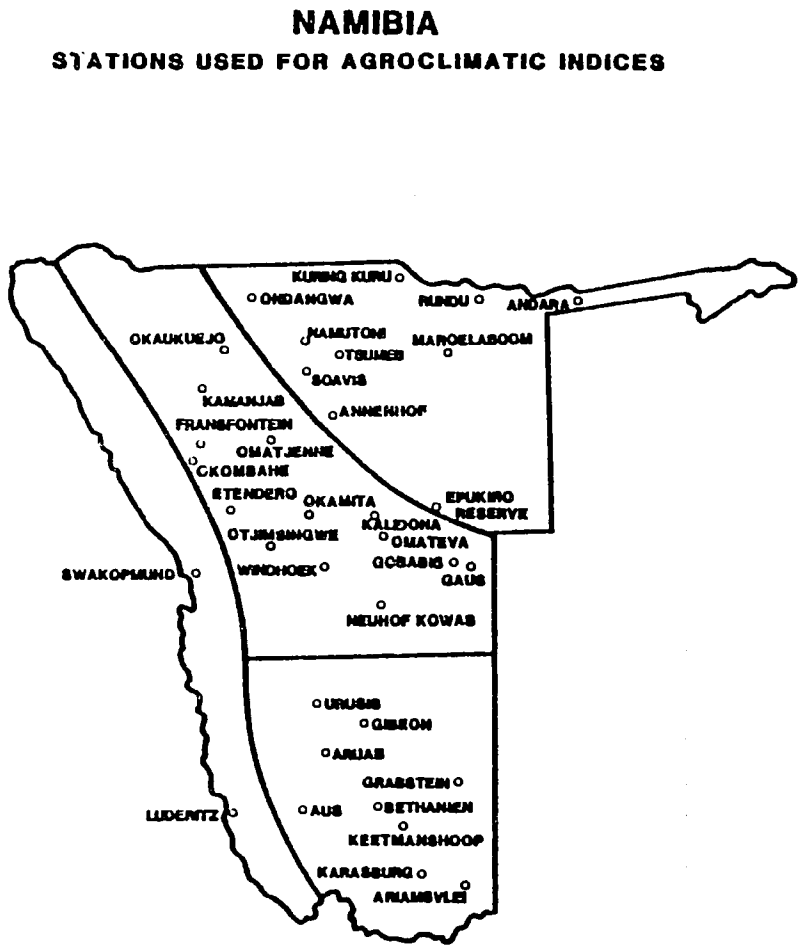


Figure 6.83.

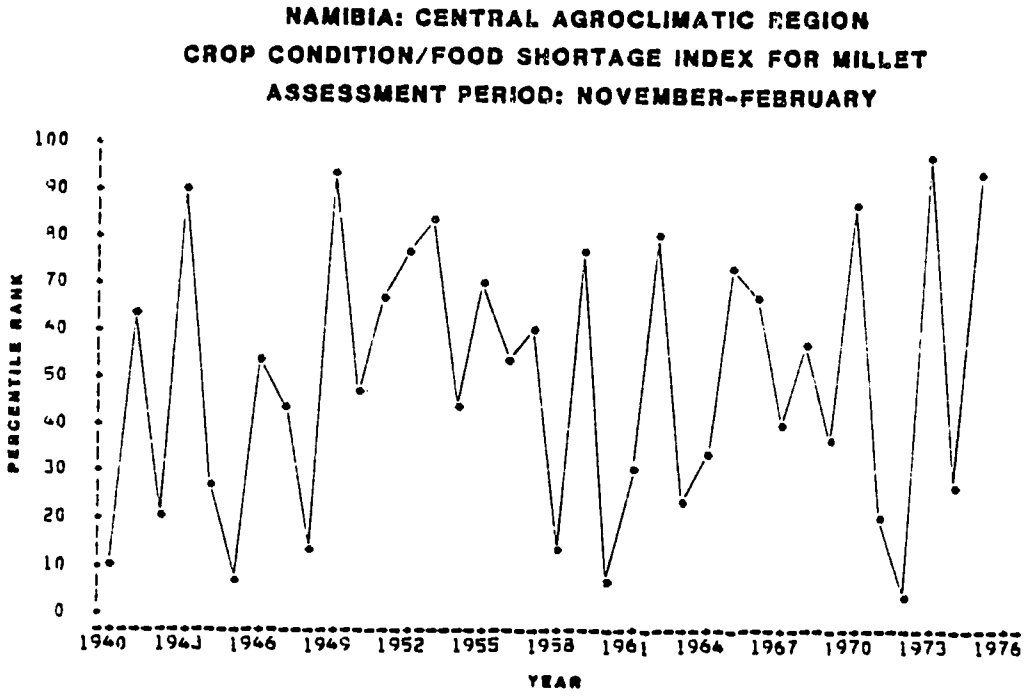

NAMIBIA: CENTRAL AGROCLIMATIC REGION
CROP CONDITION/FOOD SHORTAGE INDEX FOR MILLET
ASSESSMENT PERIOD: NOVEMBER-FEBRUARY
PERCENTILE RANK
100
90
80
70
60
50
40
30
20
10
0
1940
1943
1946
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
YEAR

Figure 6.84.

Table 6.48. Mean monthly and annual rainfall (mm) at selected stations in Namibia

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Central	Okaukuejo	1102	87	105	75	27	2	0	0	0	1	9	34	62	403
	Kamanjab	1200	68	89	78	29	2	0	0	0	1	12	21	39	339
	Fransfontein	1150	53	71	73	32	4	0	0	1	1	7	15	26	283
	Omatjenne	1380	102	102	74	33	4	0	0	1	2	11	40	49	418
	Okombahe	945	39	49	60	21	1	0	0	0	1	4	13	13	201
	Etendero	1300	62	86	101	29	3	1	0	0	1	6	23	36	347
	Okamita	1430	84	98	82	33	6	1	0	1	3	10	33	37	388
	Kalidona	1450	98	92	84	38	6	1	0	0	3	11	41	60	435
	Otjimbingwe	860	38	48	44	19	2	0	0	0	0	3	11	14	179
	Omateva	1550	84	90	68	40	7	3	0	0	3	11	31	48	385
	Windhoek	1725	75	77	89	43	6	2	1	1	4	15	31	37	379
	Gobabis	1445	74	73	65	38	7	3	0	0	6	15	35	34	350
	Gaus	1450	77	65	73	39	8	3	0	1	5	20	35	40	365
	Neuhof Kowas	1350	61	63	57	28	6	2	0	1	2	11	19	30	280
Northeast	Kuring Kuru	1110	155	132	105	39	3	0	0	1	2	19	68	98	623
	Ondangwa	1096	106	112	93	35	3	0	0	0	1	13	44	70	477
	Rundu	1102	148	147	100	36	2	0	0	0	2	18	57	88	600
	Andara	1100	151	135	86	28	3	0	0	0	3	15	60	98	579
	Namutoni	1100	112	107	82	29	2	0	0	0	2	10	48	66	458
	Maroelaboom	1200	100	109	70	35	5	0	0	0	4	15	41	54	433
	Tsumeb	1311	129	128	89	38	5	0	0	0	2	19	60	73	545
	Soavis	1200	119	127	84	36	4	0	0	0	1	18	57	74	521
	Annenhof	1400	100	118	74	30	4	1	0	0	2	13	40	60	441
	Epukiro Reserve	1400	76	81	62	36	7	0	0	0	3	13	37	46	361
South	Urusis	1400	38	52	51	13	2	0	0	0	2	2	9	10	180
	Gibeon	1059	36	48	45	15	2	2	0	0	1	6	10	17	182
	Aruab	1700	34	49	49	15	4	3	1	2	2	4	9	12	183
	Grabstein	900	28	47	37	19	6	2	0	1	1	5	13	16	176
	Aus	1421	10	12	20	11	9	6	6	5	3	3	2	4	90
	Bethanien	1150	21	27	35	14	3	2	1	0	2	5	9	8	128
	Keetmanshoop	1004	27	38	37	18	6	2	0	0	3	6	10	13	159
	Karasburg	1013	18	34	29	13	4	3	2	1	2	6	8	12	132
	Ariamsvlei	774	19	24	31	12	6	2	1	1	2	7	10	10	126
West	Swakopmund	12	2	2	5	1	0	0	0	0	0	0	1	0	13
	Luderitz	16	1	2	4	2	3	2	1	2	1	1	0	1	19

Table 6.49. Harvested area, yield and production of selected crops in Namibia

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	173	173	173	368	339	368	64	59	64
Wheat	1	1	1	1,000	1,000	1,000	1	1	1
Maize	110	110	110	364	318	364	40	35	40
Millet	55	55	55	364	364	364	20	20	20
Sorghum	8	8	8	400	400	400	3	3	3
Roots & tubers, total	16	16	16	9,063	9,375	9,395	145	150	152
Pulses, total	4	4	4	1,071	1,093	1,143	4	4	4

Table 6.50. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Namibia (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
West	-	-	-	-	-	-
Central	66,000	5,000	33,000	800	-	-
South	11,000	1,000	8,000	150	-	-
Northeast	33,000	2,000	14,000	50	-	-

Table 6.51. CROP CALENDAR FOR NAMIBIA

Six symbols (//////) indicate a month; three symbols (///) indicate half month, two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Central	Rainfall		73	74	74	35	12	1	1	0	1	10	25	46
	Maize				000	000000								//////
	Sorghum				000000	000000								//////
	Millet				000000	000000								//////
Northeast	Rainfall		113	118	94	37	4	0	0	0	1	18	52	92
	Maize				000	000000							//	//////
	Sorghum				000000	000000							//	//////
	Millet				000000	000000							//	//////

TABLE 6.52. NAMIBIA

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1982, January	Kaokoland Area (NW Namibia) Suffers from Drought and War. Thousands of Cattle are Starving to Death
1982, March	The Current Drought is Considered to be the Worst in More than a Generation
1982, April	Continuing Drought in Southern Namibia Reached Disastrous Proportions

L. RWANDA

1. Agroclimatic Conditions and Regions

Due to its small size, Rwanda constitutes one agroclimatic assessment region (Figure 6.87). Major geographic areas in the country are:

- Mountains. There is a mountain range in the western half of the country running from north to south. Another mountainous area is located in the northcentral part of Rwanda (Figure 6.85). Several peaks are higher than 4,000 meters.
- Highland plateau. The rest of the country is a highland plateau; the altitude decreases gently eastwards and more rapidly westwards from the mountains. The lowest areas in Rwanda have an altitude of about 1,200 meters.

The mean annual amount of rainfall increases from east to west (Figure 6.85). At the eastern border with Tanzania the amount is about 800 mm, while the western areas along Lake Kivu receive mostly between 1,300 and 1,400 mm annually. The rainy season normally begins in September and lasts until the end of May. There is a slight decline in the monthly amounts during January and February; some therefore consider there to be two successive rainy seasons (Figure 6.87 and Table 6.53). The period with mean monthly rainfall of 100 mm or more increases from 2 months along the Tanzanian border to 9 months in the Lake Kivu areas (Figure 6.86; see also Chapter VII, E).

2. Agriculture

The main food crops in Rwanda are beans, sorghum and sweet potatoes (Table 6.54). Other important crops are maize, cassava, potatoes, groundnuts and plantains. The main commercial crops are coffee and tea. Agricultural activities are spread over most of the country (Figure 6.89).

In the eastern drier areas of the country, farmers usually grow one crop per season. In the central and western areas where the duration of the rainy season is much longer, farmers usually grow two crops per season. The most common crop calendars are shown on Table 6.55.

3. Factors Affecting Yield and Their Assessment

Drought is the most important meteorological factor adversely affecting crops. Often, however, especially in the western half of the country,

damage is also caused by heavy rains and floods (Table 6.56). The years with insufficient and with excess rainfall in Rwanda are shown in Figure 6.91.

The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years. There are only two stations in Rwanda for which we have such data, and unfortunately their periods of record are not the same. It was therefore necessary to use stations from neighboring countries: Bukavu in Zaire, Ngara in Tanzania and Kabwe in Uganda (Figure 6.90). These stations have the shortest common period of records in Subequatorial Africa - only 10 years (Table 7.1). In addition to the stations with common period of records (used for the assessments), Rwanda has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative units of Rwanda, their boundaries are shown on Figure 6.88.

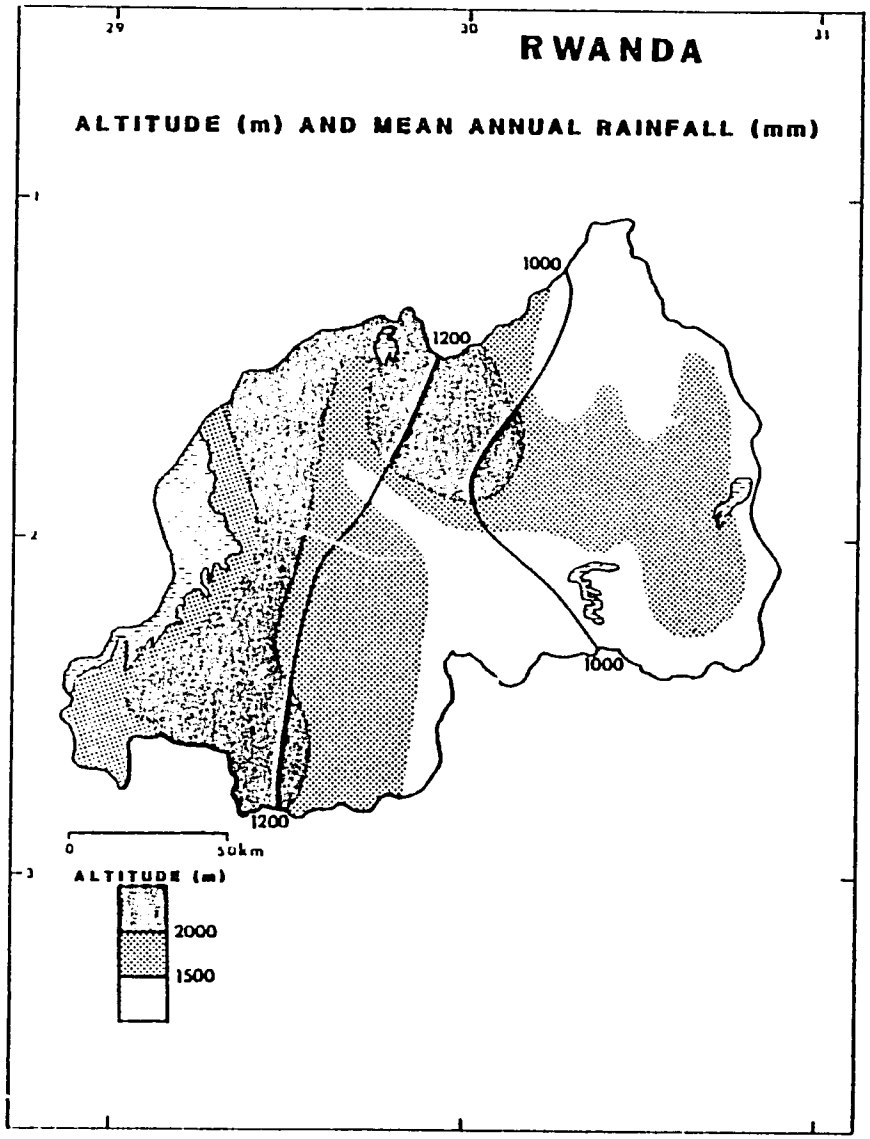


Figure 6.85.

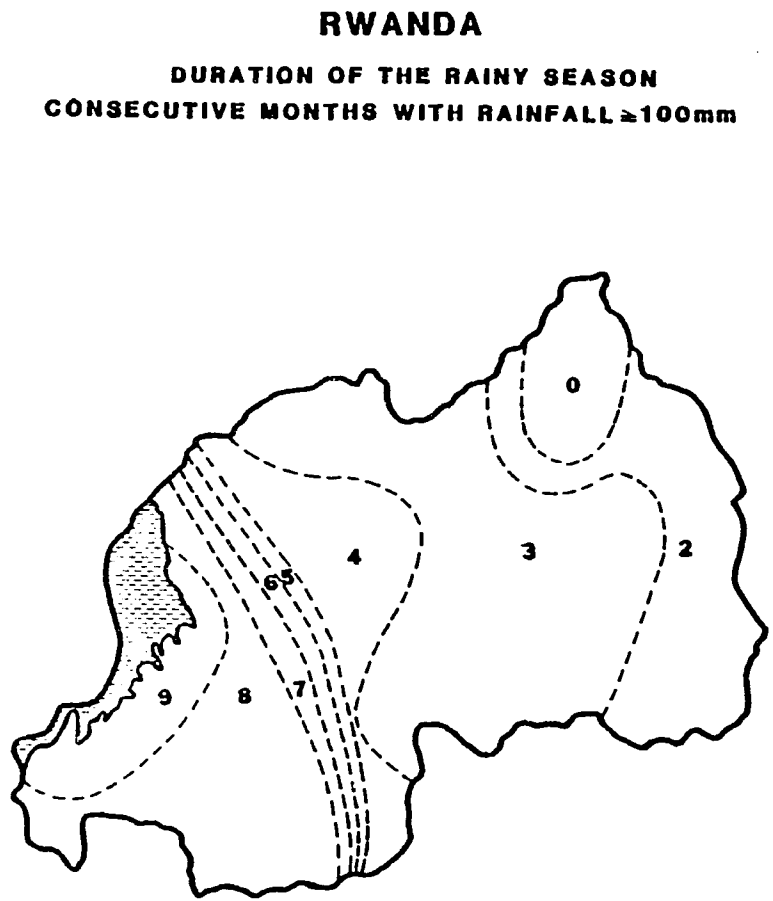


Figure 6.86.

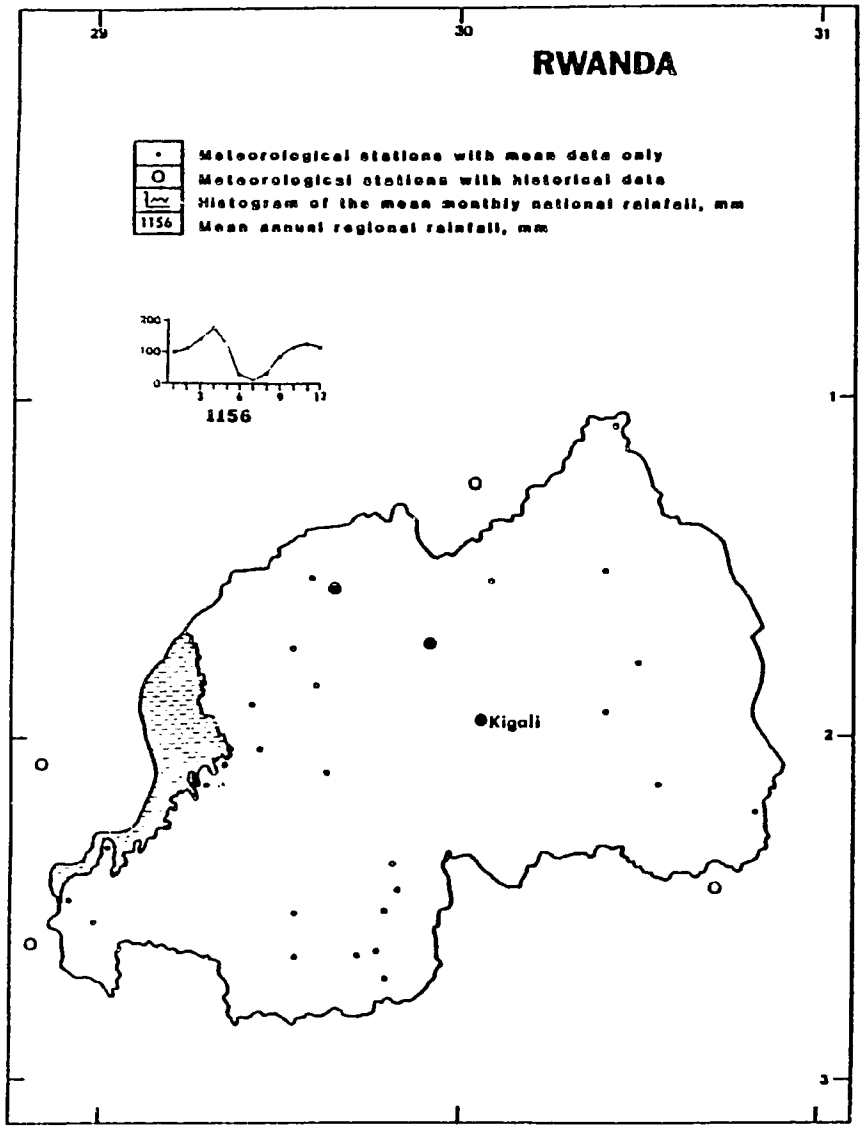


Figure 6.87.

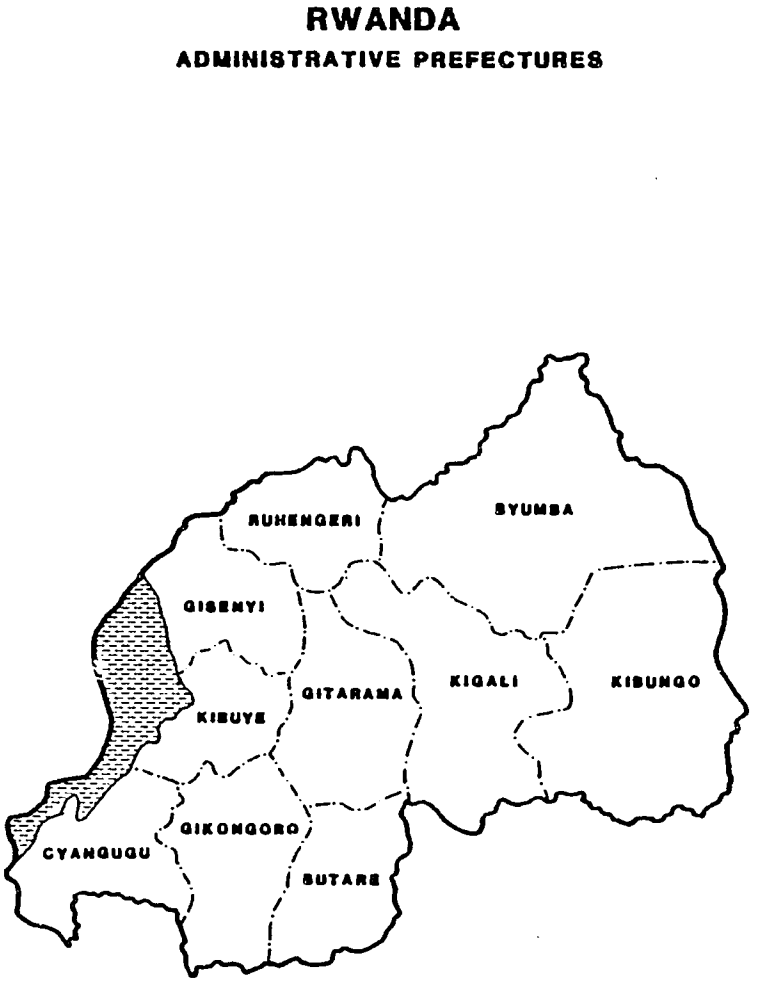


Figure 6.88.

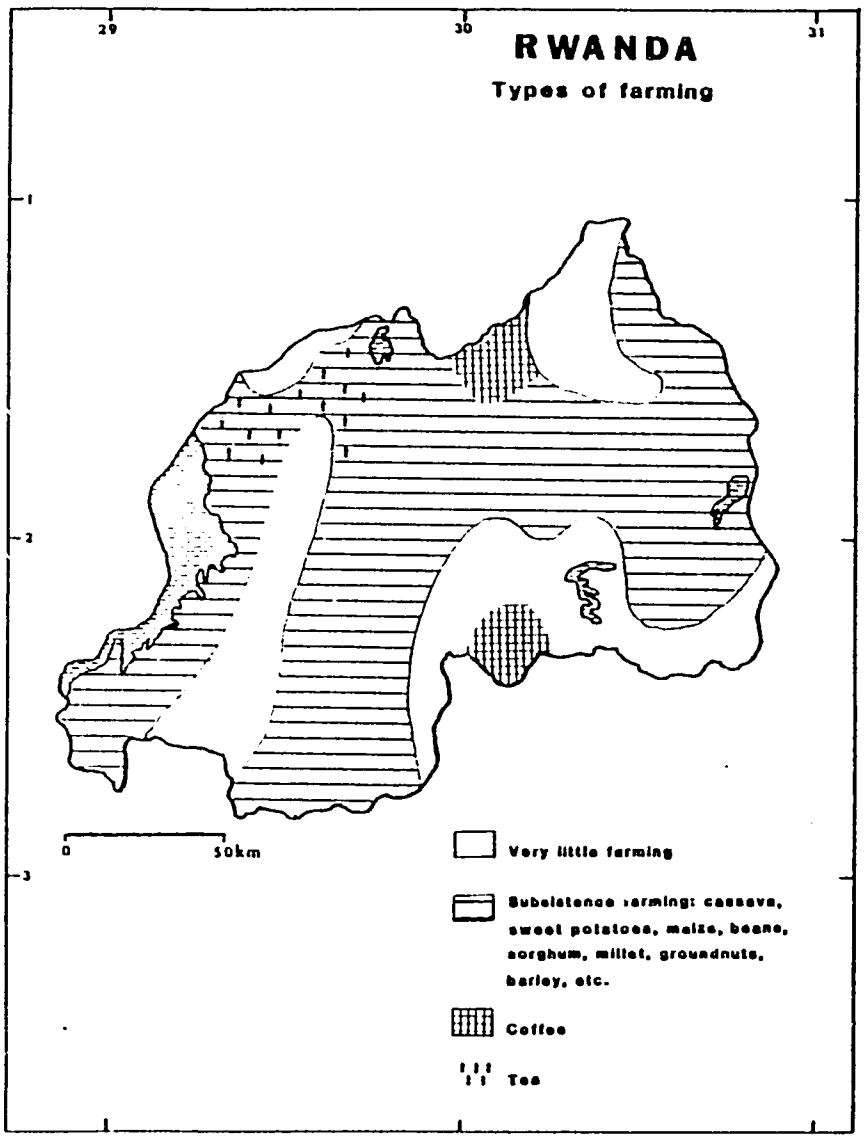


Figure 6.89.

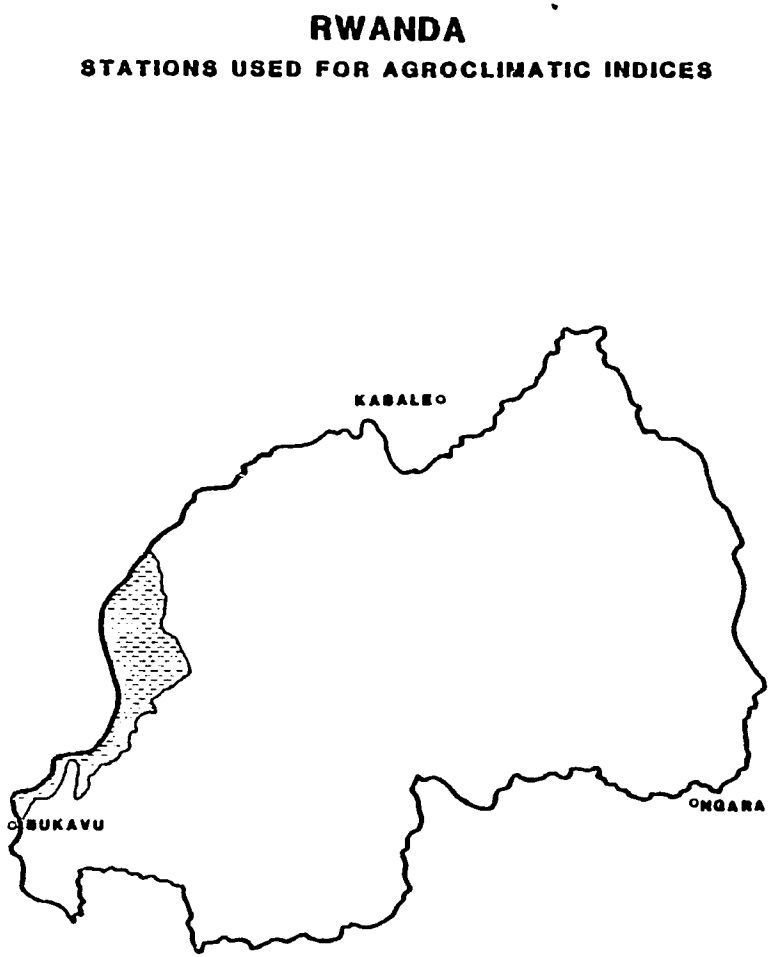


Figure 6.90.

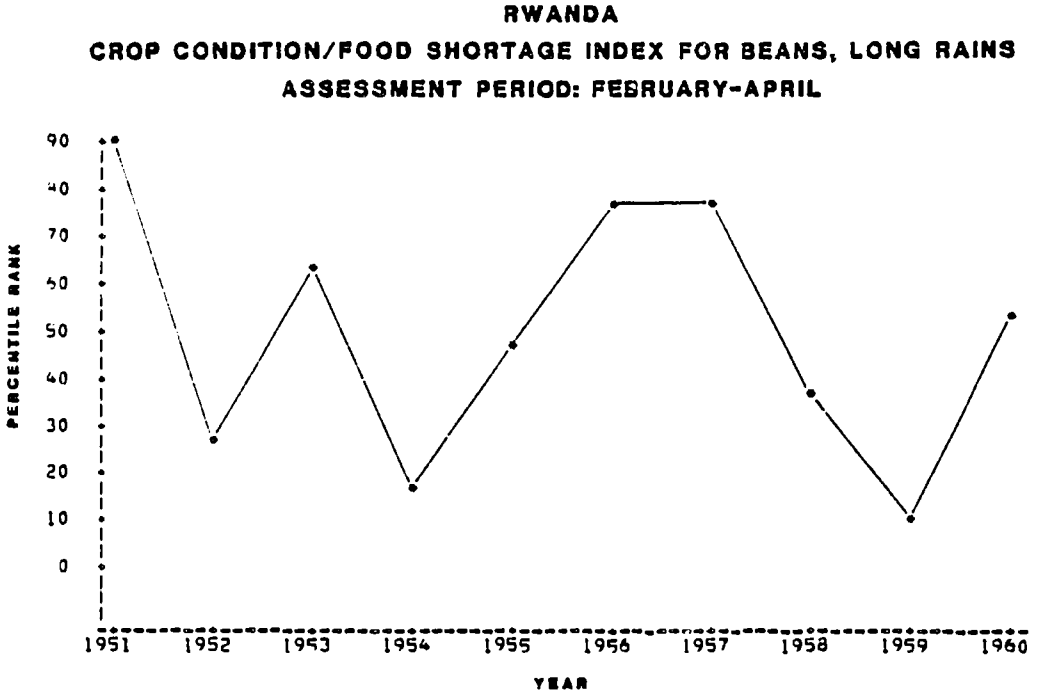

RWANDA
CROP CONDITION/FOOD SHORTAGE INDEX FOR BEANS, LONG RAINS
ASSESSMENT PERIOD: FEBRUARY-APRIL
PERCENTILE RANK
90
80
70
60
50
40
30
20
10
0
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
YEAR

Figure 6.91.

Table 6.53. Mean monthly and annual rainfall (mm) at selected stations in Rwanda

STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Mbarara, Uganda*	1413	48	65	96	125	79	25	21	59	97	106	116	73	910
Kabale, Uganda*	1869	61	91	116	138	93	27	20	52	95	97	110	89	988
Rwaza	1799	72	96	133	202	154	38	20	62	89	159	158	100	1282
Rulindo	1799	96	109	143	199	145	32	16	37	80	119	119	96	1189
Bukavu, Zaire*	1612	126	134	177	153	77	28	13	87	103	155	179	145	1317
Ngara, Tanzania*	1798	97	113	122	191	98	12	5	15	57	76	134	111	1032

*The station is located in a neighboring country, and may be used for Rwanda assessments.

Table 6.54. Harvested area, yield and production of selected crops in Rwanda

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	227	218	202	1,121	1,117	1,250	254	243	256
Wheat	5	4	4	917	833	833	4	3	3
Maize	63	67	71	1,114	1,075	1,056	70	72	75
Rice (paddy)	1	2	2	3,666	2,667	2,667	3	4	4
Millet	5	6	6	895	727	727	5	4	4
Sorghum	153	140	120	1,123	1,143	1,417	172	160	170
Roots & tubers, total	186	193	201	8,248	8,156	8,114	1,531	1,577	1,632
Potatoes	30	32	34	6,825	6,840	6,854	206	218	230
Sweet potatoes	106	111	116	7,909	7,793	7,689	842	865	888
Cassava	42	43	45	10,472	10,369	10,443	439	450	469
Pulses, total	274	275	276	804	806	807	220	222	223
Beans (dry)	215	216	216	811	813	815	174	175	176
Soybeans	6	6	6	823	825	828	5	5	5
Groundnuts in shell	18	18	18	918	915	915	16	16	16

Table 6.55. CROP CALENDAR FOR RWANDA

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	Rainfall		97	109	134	176	132	29	13	34	84	114	122	112
	Maize	Single				000	000000	000				//////	//////	
	Maize	Long Rains	///	//////			000000	000000						
This country constitutes one agroclimatic region	Maize	Short Rains	000000								//////			000
	Sorghum	Single				000000	000000					//////	//////	///
	Sorghum	Long Rains		//////	///		000	000000	00					
	Sorghum	Short Rains	000000								//////			000
	Beans	Long Rains		//////	///		000000	000000						
	Beans	Short Rains	000000								//////	//////		000000

TABLE 6.56.

RWANDA

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1974, June-July	Heavy Rains and Flooding Damage Crops in Highlands
1975, January	Two Million People are Suffering from Abnormal Food Shortages Due to Crop Failures from July 1974 Floods and a Subsequent Drought
1975, April	Storms Caused About 50% Loss to the Grain Crop
1976, February	54,000 People in Kibuye District (Western Rwanda) Suffering from Famine Brought by Heavy Rains and Hailstorms Last December
1976, November	Heavy Flooding in North Ruhengeri Prefecture
1976, September-October	Severe Drought Damaged Food Crops in Most Areas. Flooding Also Affected Some Areas
1977, April	Poor Rainfall During the Growing Season Resulted in Substantial Loss in Production of Beans, Cassava, Sweet Potatoes and Millet
1977 -	Drought Nationwide
1979, July	Heavy Rains in May Damaged Potato and Pulse Crops, Especially in the High Altitude Areas of Ruhengeri and Byumba
1980, February	Main Season Maize and Beans Crops Harvested in January have Suffered from Irregular and Deficient Rainfall

M. SWAZILAND

1. Agroclimatic Conditions and Regions

The eastern half of the country is a plateau with an average altitude of 250 meters. Westwards it rises gradually into a hilly and then a mountainous area (Figure 6.92). Due to its small size, Swaziland constitutes one agroclimatic assessment region (Figure 6.94).

The mean annual amount of rainfall for the country is 946 mm. The plateau occupying the eastern half of the country is drier, receiving mostly between 600 and 700 mm annually. Westwards the rainfall increases to 1000 - 1200 mm (Figure 6.92 and Table 6.57). There are distinct wet and dry seasons in Swaziland. The rainy season normally begins in late September or early October, peaks in January and ends in early April. The period with mean monthly rainfall of 100 mm or more ranges from 0 to 5 months in the eastern half of the country and 4 to 6 months in the hilly western areas (Figure 6.93; see also Chapter VII, E).

2. Agriculture

With the exception of the forested area along the western border and some steeper mountains, all available land is used for farming (Figure 6.96). The most important food crop is maize (Table 6.58). Farmers also grow some millet, sorghum, potatoes, sweet potatoes and beans. The main commercial crop is sugar cane, followed by cotton and tobacco. The growing seasons of the crops coincide with the rainy season (Table 6.59).

3. Factors Affecting Yield and Their Assessment

As the episodic event data show, drought is the main meteorological factor adversely affecting crops (Table 6.60). Apparently, crops in the drier, warmer eastern areas are more vulnerable to drought than crops grown in the wetter, cooler western regions. The years with drought, as well as those with good good rainfall, are shown on Figure 6.98. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Swaziland and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.97. In addition to the stations with common period of records (used for the assessments), Swaziland

has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative districts of the country, their boundaries, together with those of the agroclimatic regions, are shown on Figure 6.95.

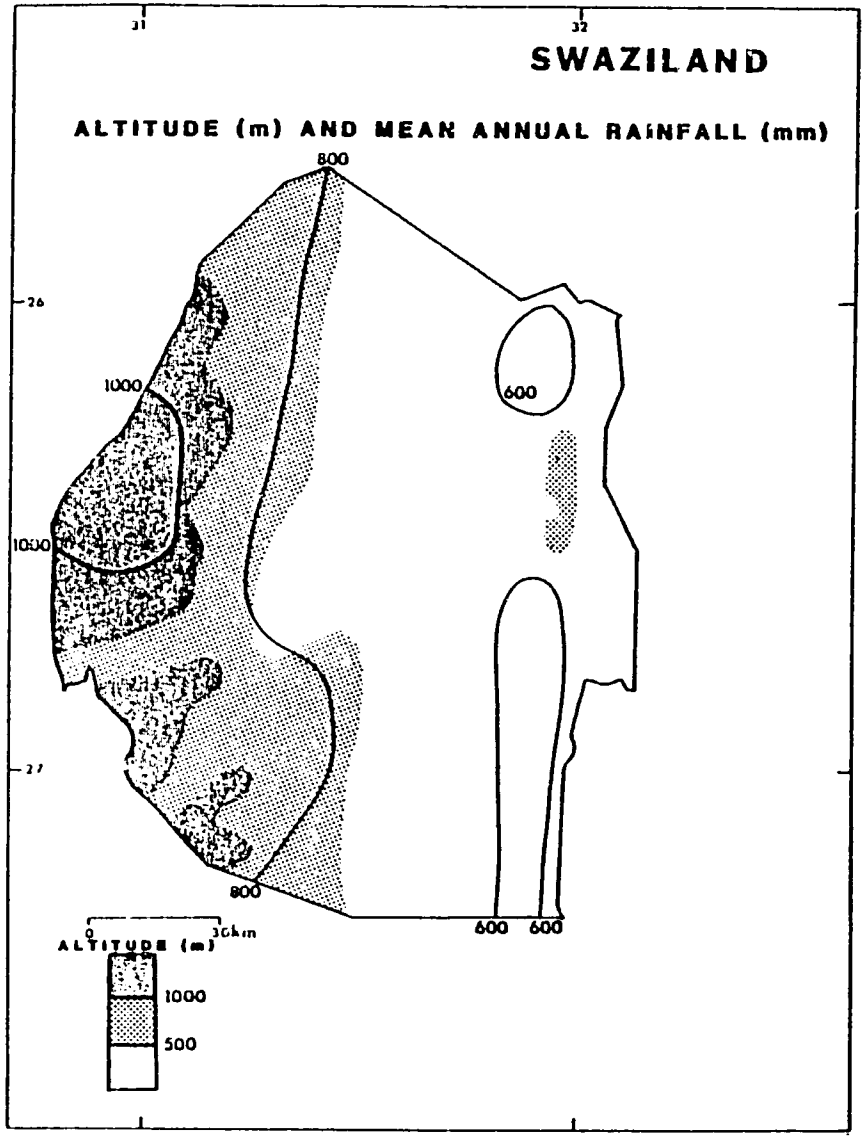


Figure 6.92.

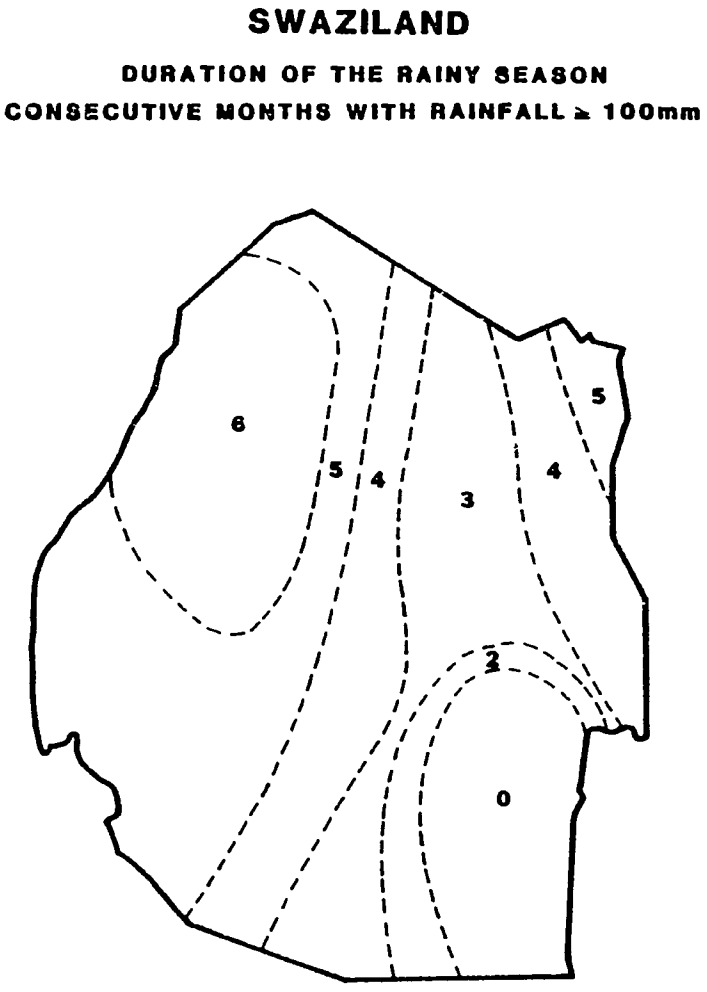


Figure 6.93.

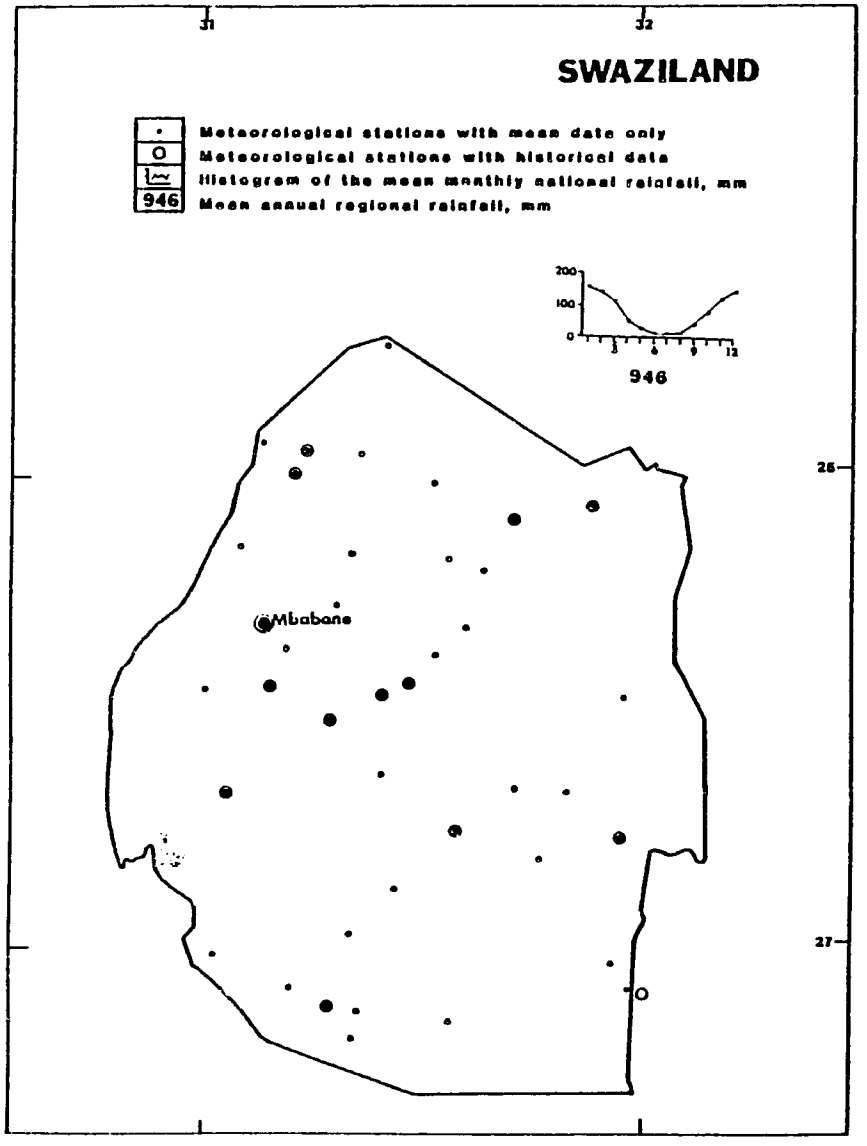


Figure 6.94.

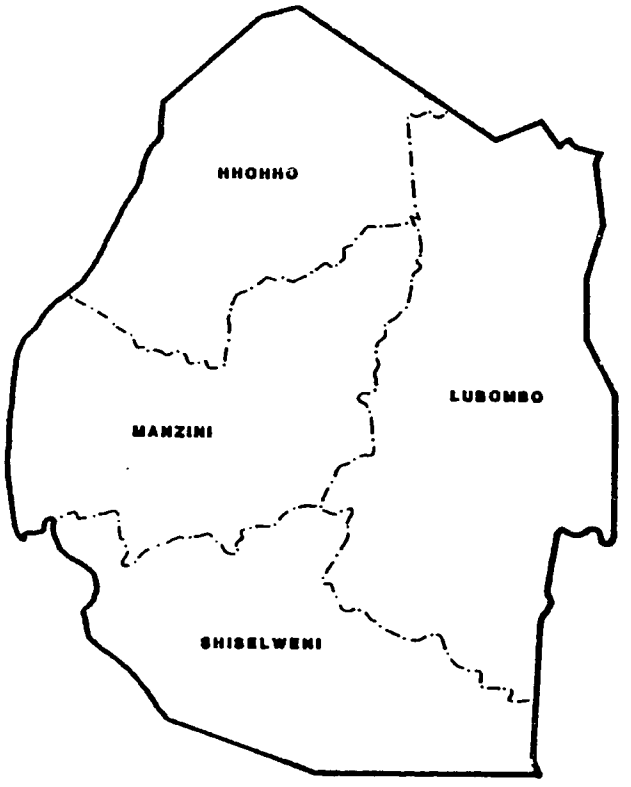


Figure 6.95.

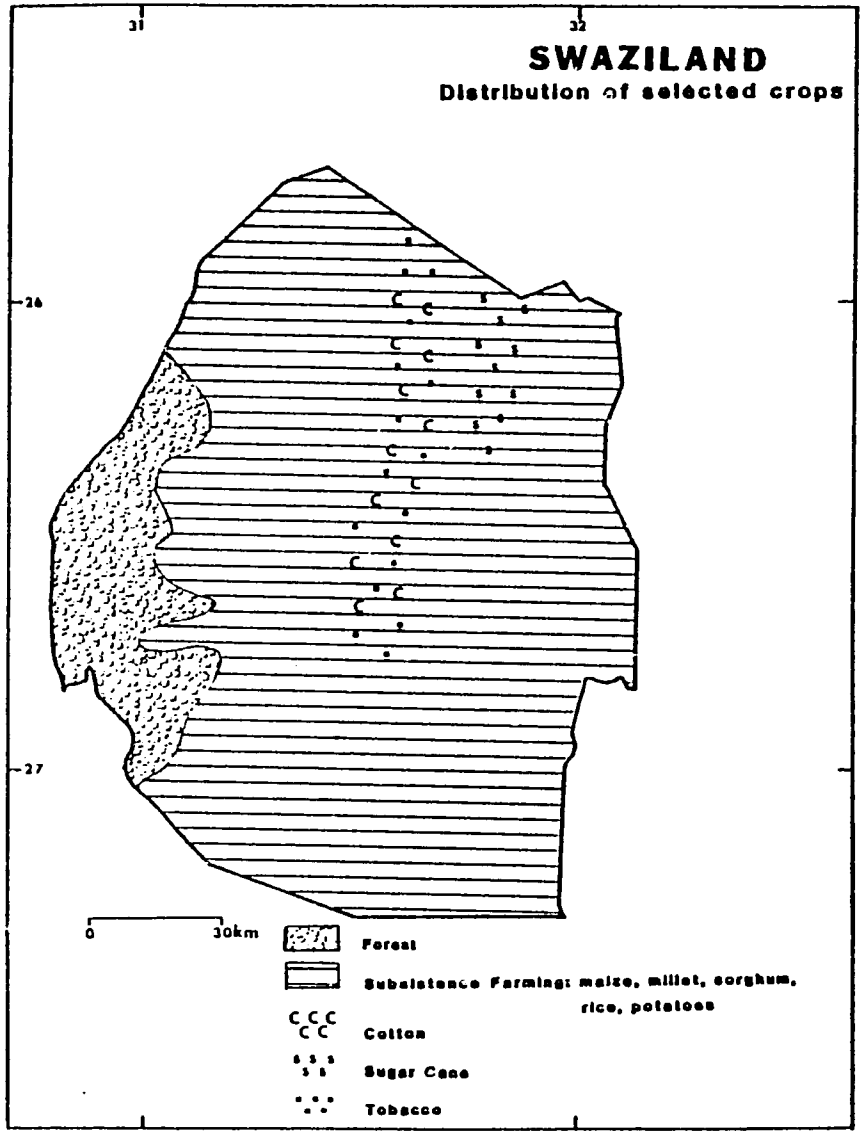


Figure 6.96.

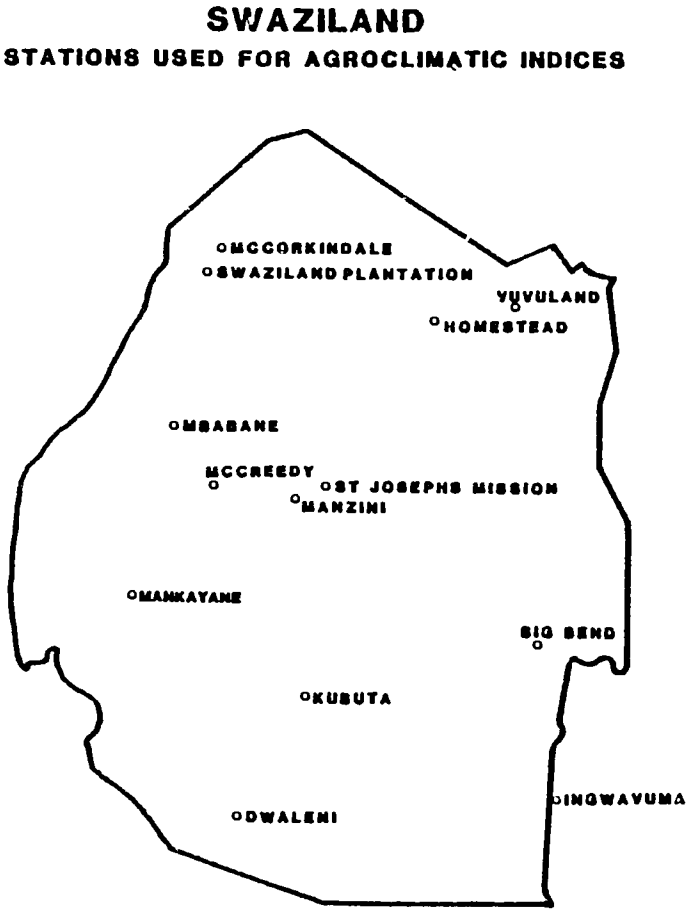


Figure 6.97.

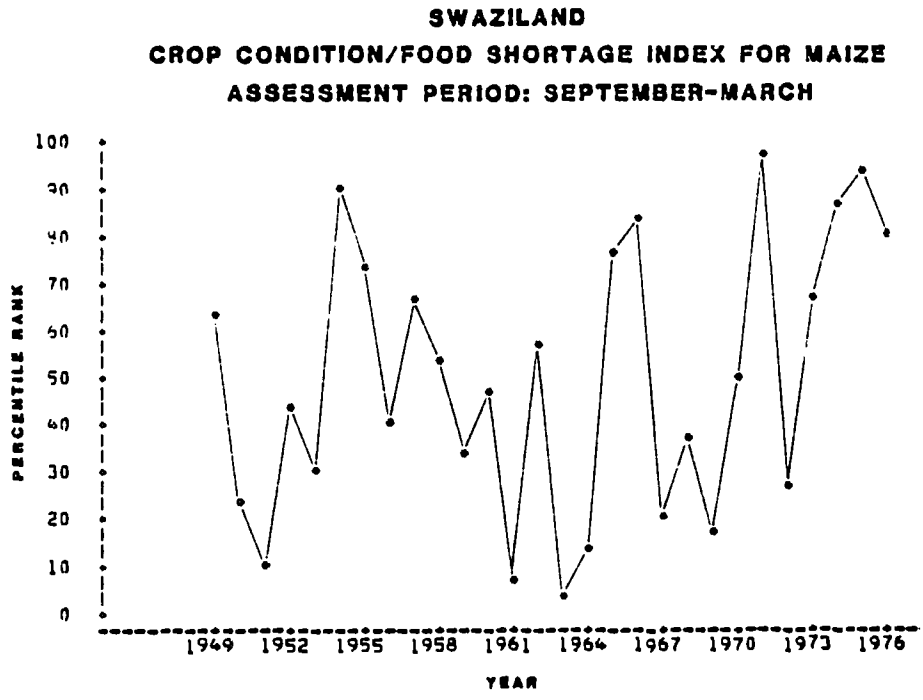

SWAZILAND
CROP CONDITION/FOOD SHORTAGE INDEX FOR MAIZE
ASSESSMENT PERIOD: SEPTEMBER-MARCH
PERCENTILE RANK
100
90
80
70
60
50
40
30
20
10
0
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
YEAR

Figure 6.98.

Table 6.57. Mean monthly and annual rainfall (mm) at selected stations in Swaziland

STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
McCorkindale	760	203	209	142	85	41	18	21	26	60	105	172	201	1284
Swaziland Plantation	945	198	178	127	81	34	15	18	24	57	108	177	198	1214
Homestead	250	120	120	64	49	33	12	11	13	32	66	98	110	727
Vuvuland	300	131	135	85	65	34	17	15	17	42	70	109	129	848
Mbabane	1145	229	215	138	91	38	19	18	31	65	128	185	220	1377
McCreedy	762	182	156	111	65	32	16	14	23	55	104	163	163	1083
Manzini	610	139	135	96	68	29	14	13	20	46	88	129	130	908
St Josephs Mission	518	103	105	81	56	27	11	11	19	34	71	106	109	734
Mankayane	1009	129	128	86	60	28	13	13	11	41	80	122	126	838
Big Bend	155	98	84	52	42	25	11	10	14	34	56	81	84	591
Kubuta	533	112	114	80	61	27	13	11	19	36	72	116	123	785
Dwaleni	975	110	98	65	56	21	10	12	15	39	81	115	112	734
Ingwavuma, R. S. A.*	610	130	126	82	61	29	10	16	17	50	77	104	104	806

*The station is located in a neighboring country, and may be used for Swaziland assessments.

Table 6.58. Harvested area, yield and production of selected crops in Swaziland

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	69	54	69	1,415	1,159	1,483	98	63	103
Wheat	–	–	–	3,250	3,250	3,250	1	1	1
Maize	65	50	65	1,385	1,100	1,462	90	55	95
Rice (paddy)	2	2	2	2,632	2,632	2,632	5	5	5
Sorghum and millet	2	2	2	833	778	667	2	1	1
Roots & tubers, total	5	5	5	3,191	3,404	3,404	15	16	16
Potatoes	3	3	3	2,000	2,000	2,000	6	6	6
Sweet potatoes	2	2	2	5,294	5,882	5,882	9	10	10
Pulses, total	2	2	2	545	682	682	1	2	2
Beans (dry)	2	2	2	545	682	682	1	2	2

Table 6.59. CROP CALENDAR FOR SWAZILAND

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
This country constitutes one agroclimatic region	Rainfall		155	140	115	57	28	15	17	18	46	82	126	148
	Maize				00	000000	000000	00			///	//////	//////	
	Sorghum					000000	000000	00			///	//////		
	Rice		//////					00	000000	000000				//////

TABLE 6.60.

SWAZILAND

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1977, January	Maize Affected by Very Dry Weather that Started Last December
1977, December	Maize Sown in September and October is Affected by Dry Weather
1979, March	Drought in Louveld and Lubombo Areas Reduces Maize Yield by About 75%
1979, May-June	Drought in Early 1979 Reduced Maize Production by About 40% as Compared with 1978, Potatoes by 50%, Beans by 90%, Squash by 75%
1982, May	Late Rains, Drought in February and Severe Hailstorms, Reduced the Maize Crop by About 50% of Last Year's
1982 -	The 1981/82 Drought Considerably Reduced Maize Yields in Many Areas of the Country
1982, December	A Devastating Hailstorm Damaged Crops in Motshane and Forbes Reef Areas
1983, January	Current Season Drought Expected to Reduce Considerably Maize Yield

N. TANZANIA

1. Agroclimatic Conditions and Regions

There are four major geographic regions in Tanzania:

- Coastal plain. This is a strip of land, 50 to 150 km wide, along the Indian Ocean coast. The altitude is from sea level to about 200-300 meters. Soils are relatively good and adequate rainfall permits growing various agricultural crops.
- Inland plateau. Most of the country is a vast plateau, consisting of rolling plains with altitude rising steadily from east to west (Figure 6.99). The greater part of the plateau has an altitude of about 1,200 m. The quality of the soils varies from poor to medium to good.
- Mountains. Most are located along the borders. To the north are Kilimandjaro (the highest in Africa at 5,895 m), Meru, Loolmalasin, Ngorongoro and Usambara. To the south is the Kipengere Range, to the west is Mahali Mountain. The Nguru, Uluguru and Rubeho mountains are in the central section of the country. Mountain foothills usually have good soils and adequate rainfall for growing crops.
- Islands. The largest is Zanzibar, 80 km long and 40 km wide. Others are Pemba and Mafia. They are inhabited, have relatively good soils, and are one of the world's biggest producers of cloves.

The country has been divided into six agroclimatic assessment regions (Figure 6.101). Driest is the Central region with mean annual rainfall of about 600 mm. The other regions receive between 950 and 1250 mm annually. The islands are not included in the East region because of climatic differences - they receive much larger rainfall amounts and air humidity is much higher. Within the regions, rainfall varies depending mainly on topography. Thus, Bukoba in the Northwest and Musekera in the Southwest regions receive much larger amounts than the other areas in these regions (Table 6.61 and Figure 6.99).

The seasonal variations of rainfall are similar all over the country. The rainy season normally begins in November and lasts until May (Figure 6.101). Highest monthly amounts in the two northern and in the East regions occur in April. In the two southern and in the Central regions the peak of the rainfall occurs earlier, between December and March. The period with mean monthly rainfall of 100 mm or more is between 0 and 3

months in the northern one third of the country, and 4 and 6 months in the other areas (Figure 6.100; see also Chapter VII, E). The rainy season during March, April and May is known as the "long rains", that during November and December the "short rains" season.

2. Agriculture

The most important food crops in Tanzania are maize and cassava (Table 6.62). Also very widespread are sorghum, millet, beans, bananas and rice. The most important commercial crops are coffee, cotton, cloves and sisal. The areas with more intensive subsistence farming, and the distribution of some crops, are shown on Figures 6.103 and 6.104. Unlike some other countries where most of the agricultural activities are concentrated in one or two agroclimatic regions, the area planted to various crops in Tanzania is more evenly distributed (Table 6.63). Cereal crops, however, are little grown in the eastern coastal region where the humid climate is more suitable for cassava.

The crop calendar depends on the rainfall regime, altitude and variety. Sowing normally starts soon after the beginning of the rainy season, except in areas with a long rainy season where sowing is delayed in order for harvesting to coincide with the arrival of the dry season. The data on Table 6.64 indicate the most common crop calendars.

3. Factors Affecting Yield and Their Assessment

As the episodic event data indicate, drought is the most important meteorological factor affecting crop yields (Table 6.65). The years with drought, as well as with good rainfall, are shown in Figure 6.105. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Tanzania and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.106. In addition to the stations with common period of records (used for the assessments), Tanzania has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop infomration are often reported for the administrative regions of the country, their boundaries, together with those of the agroclimatic regions, are shown on Figure 6.102.

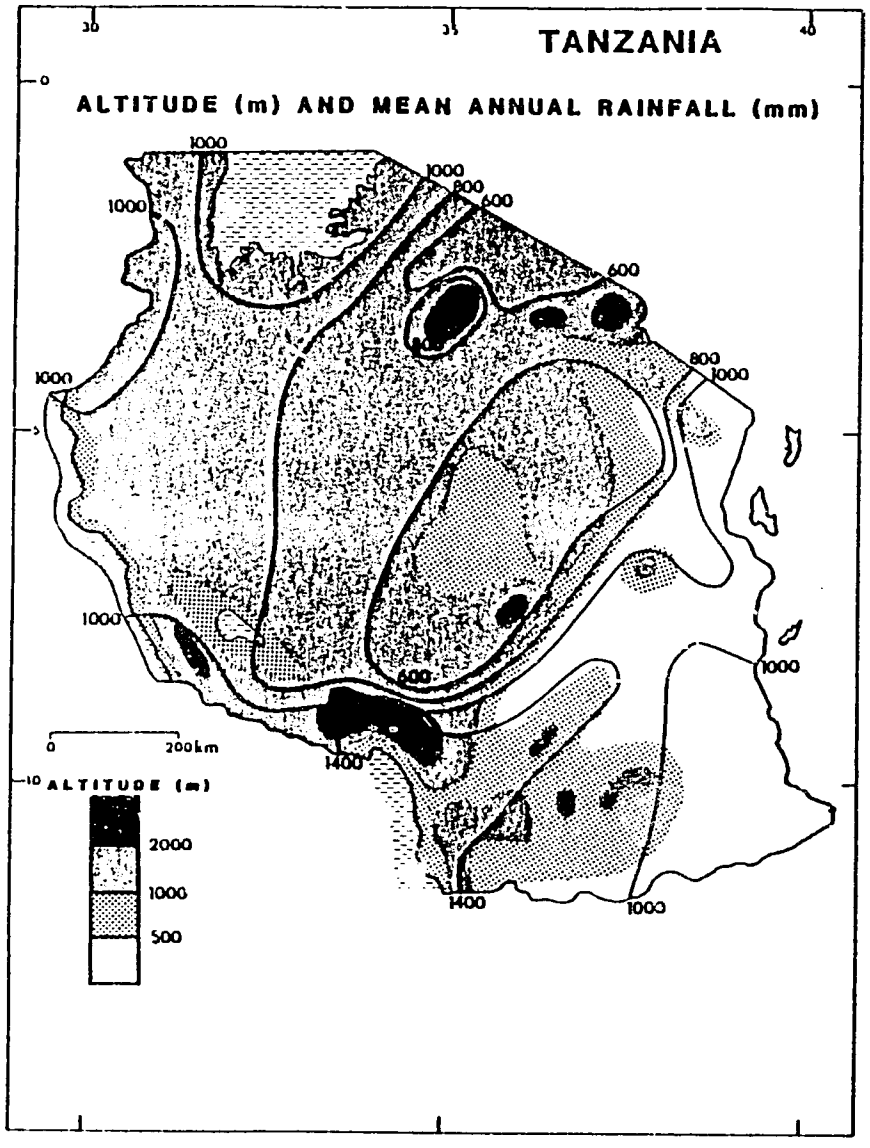


Figure 6.99.

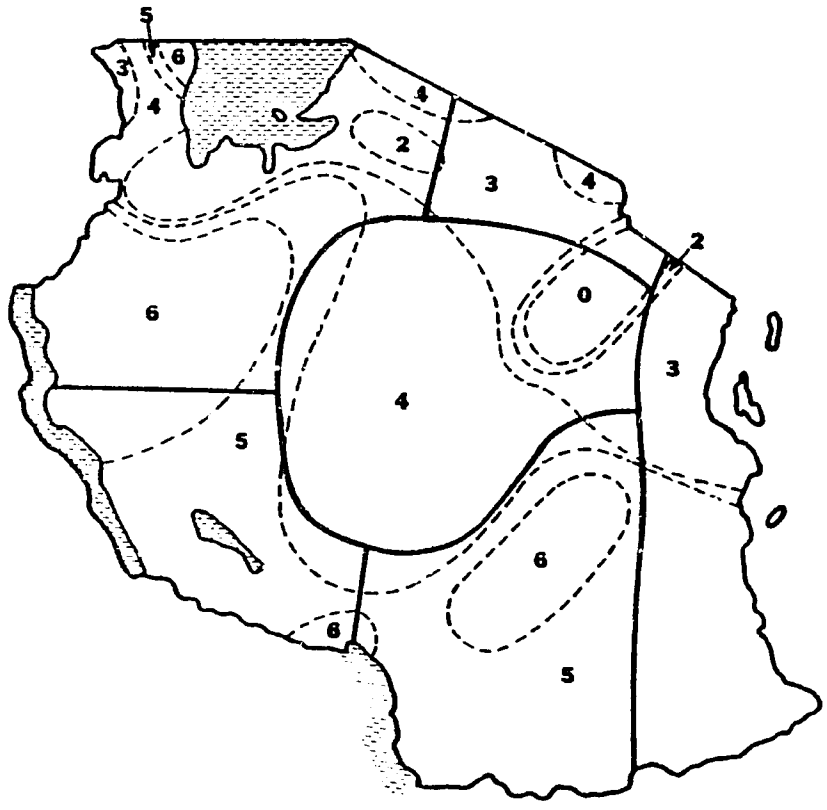


Figure 6.100.

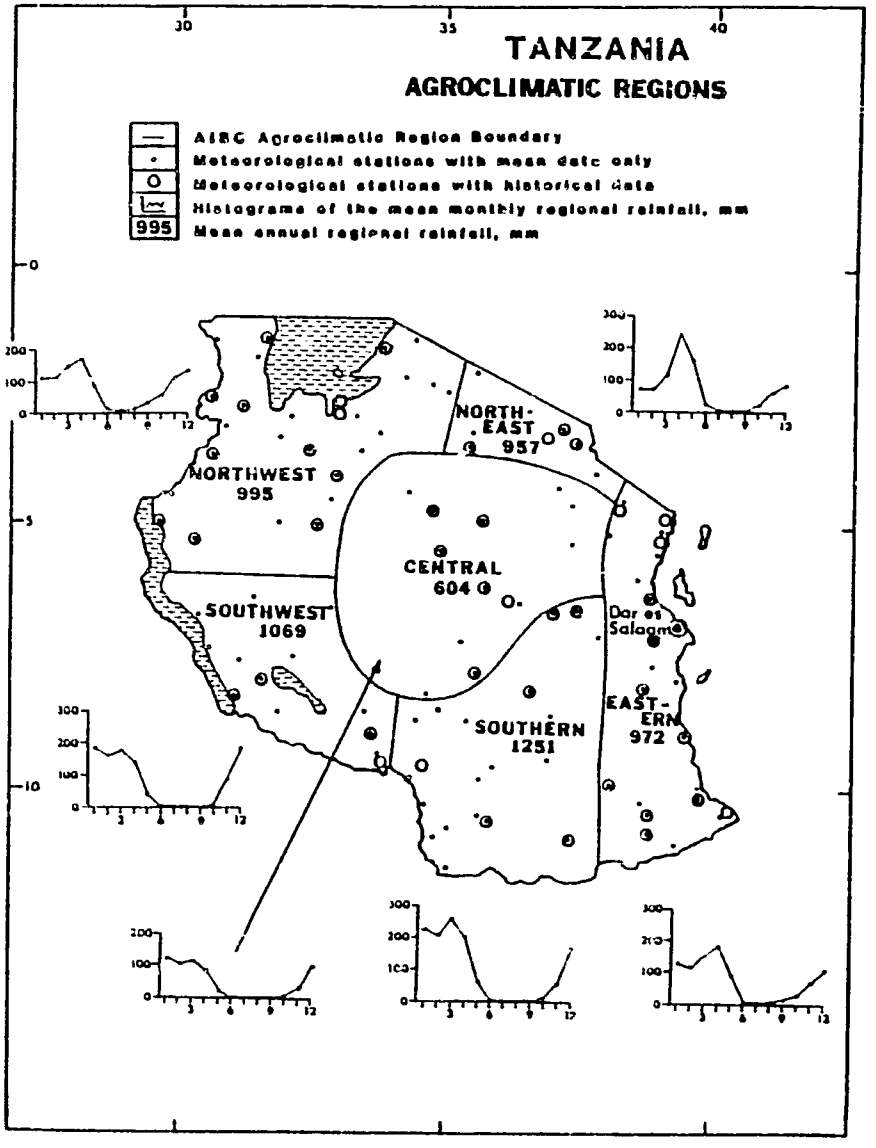


Figure 6.101.

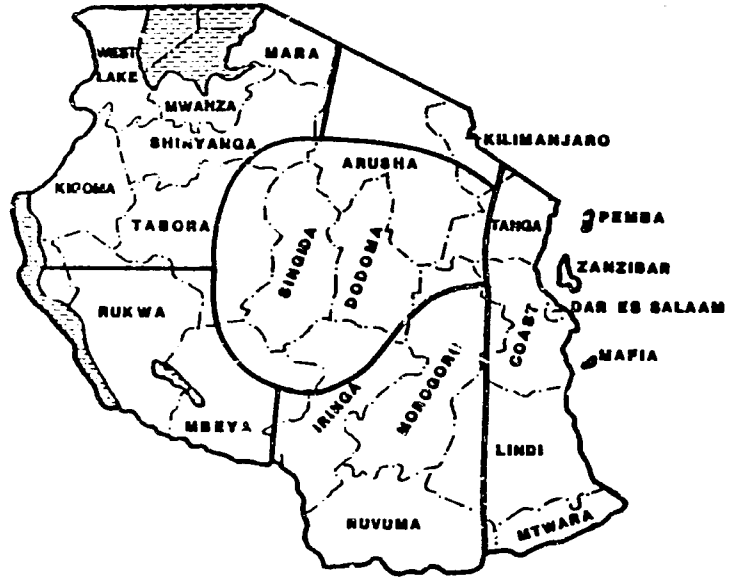


Figure 6.102.

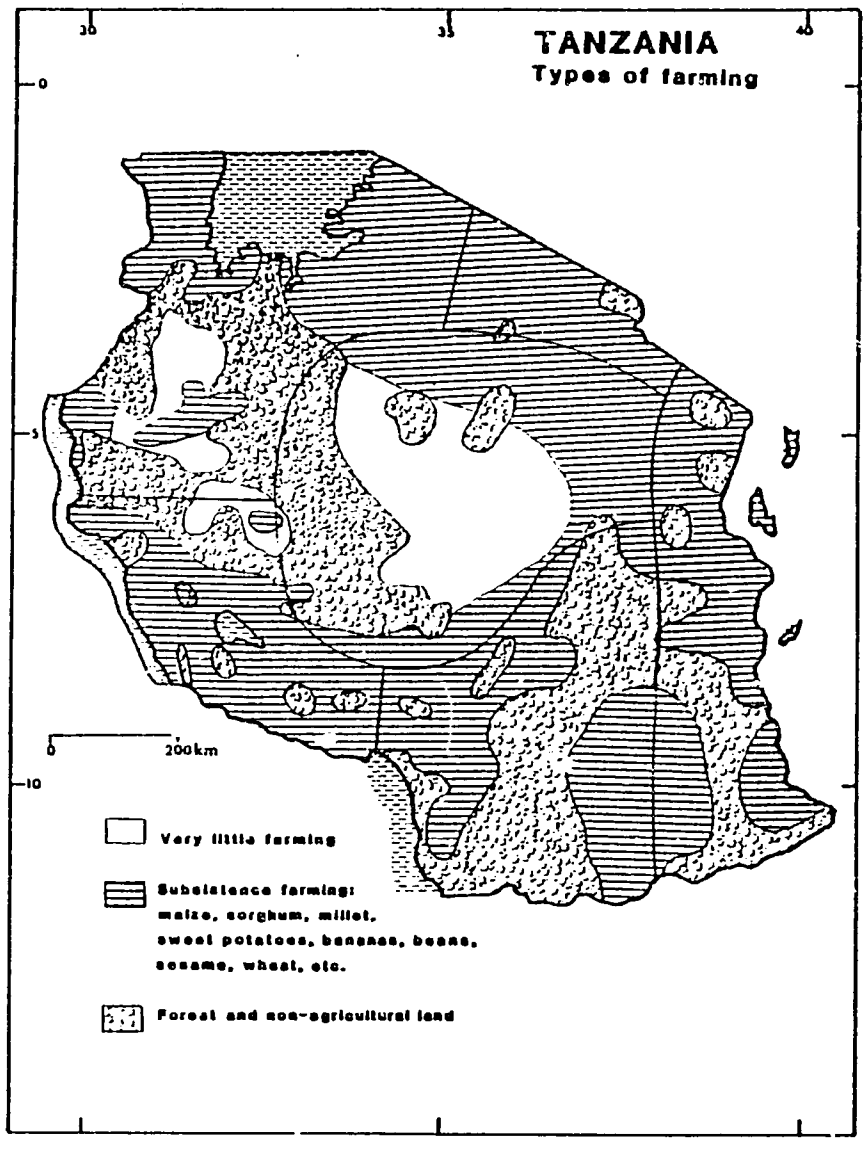


Figure 6.103.

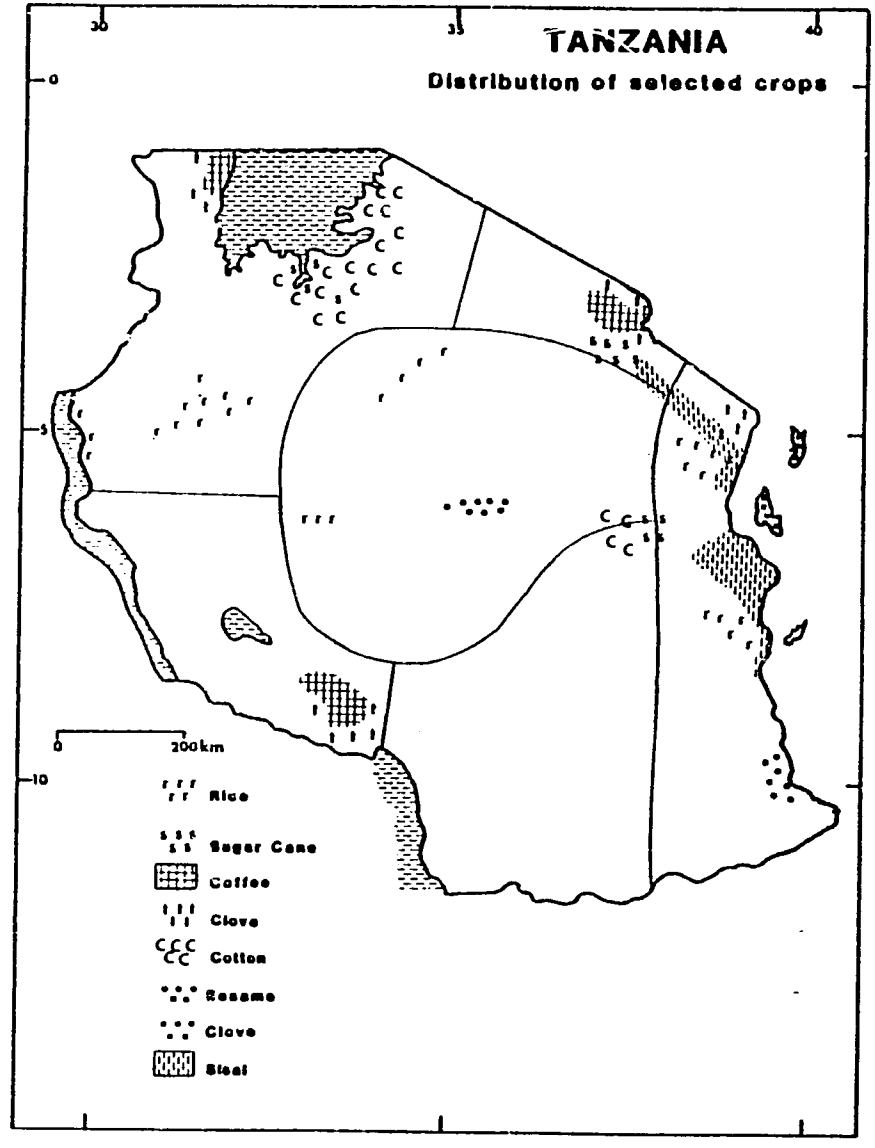


Figure 6.104.

TANZANIA: NORTHEAST AGROCLIMATIC REGION
CROP CONDITION/FOOD SHORTAGE INDEX FOR MAIZE
ASSESSMENT PERIOD: JANUARY-MAY

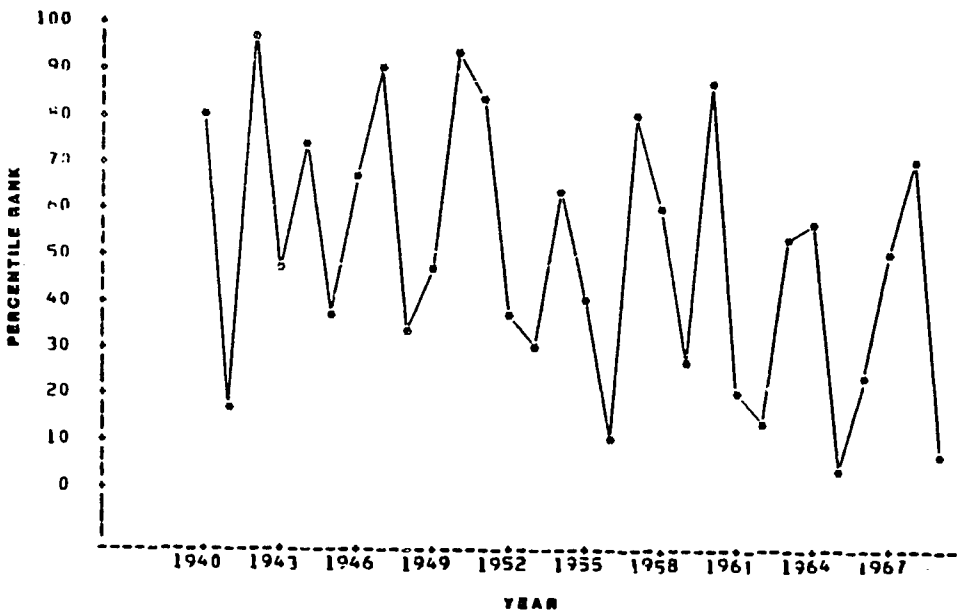


Figure 6.105.

TANZANIA
STATIONS USED FOR AGROCLIMATIC INDICES

Figure 3.106.

Table 6.61. Mean monthly and annual rainfall (mm) at selected stations in Tanzania

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Northwest	Bukoba	1137	152	162	232	373	323	81	51	71	110	145	185	194	2066
	Musoma	1147	76	81	127	182	113	26	30	20	29	43	102	68	897
	Ngara	1798	97	110	128	191	95	15	6	14	65	82	137	110	1049
	Mwanza	1140	101	106	153	185	79	19	17	19	41	90	124	146	1081
	Kibondo	1518	168	156	185	224	83	8	3	5	32	70	187	195	1118
	Kahama	1219	134	132	179	162	60	4	1	1	14	45	136	157	1025
	Nzega	1219	120	118	136	127	29	3	0	1	4	22	101	150	810
	Kigoma	885	142	119	140	168	67	6	2	2	18	52	132	148	996
	Tabora	1190	146	137	160	132	25	0	1	0	3	23	111	183	922
Northeast	Mbulu	1737	97	98	153	184	62	4	2	1	4	27	106	131	868
	Arusha	1387	70	82	142	362	150	22	13	15	12	24	112	112	1115
	Moshi	831	39	46	99	255	164	28	20	14	18	34	68	57	842
Central	Singida	1497	148	123	115	82	15	0	0	0	2	10	55	140	690
	Kondoa	1386	114	134	128	86	25	2	1	0	0	6	29	132	657
	Manyoni	1250	141	109	123	75	11	1	0	0	1	5	47	124	636
	Dodoma	1120	127	125	101	49	4	0	0	0	0	2	20	117	545
	Kongwa	1020	106	109	100	57	9	0	0	1	1	1	15	109	508
	Iringa	1428	139	120	139	80	13	1	0	0	1	4	27	141	665
Southwest	Sumbawanga	1722	154	144	150	103	21	3	0	0	5	13	78	163	834
	Kala	792	205	223	183	77	9	1	0	0	3	12	113	253	107[illegible]
	Mbeya	1707	202	174	164	110	15	1	1	0	2	16	50	192	
	Musekera	1450	242	211	379	637	315	92	64	43	26	54	166	248	[illegible]
South	Morogoro	526	96	105	132	226	81	19	16	13	19	36	64	89	898
	Ifakara	900	169	172	301	353	113	14	11	6	11	11	59	104	1323
	Njombe	1889	217	199	246	148	23	3	2	1	5	18	51	199	1111
	Songea	1067	251	235	255	111	15	1	3	2	2	7	57	198	1135
	Tunduru	701	248	256	213	79	13	2	2	1	2	4	39	176	1035

continue.....

Table 6.61. Mean monthly and annual rainfall (mm) at selected stations in Tanzania (continued)

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
East	Tanga	35	27	29	104	252	277	80	69	73	76	102	144	82	1314
	Bagamoyo	9	78	76	102	259	184	48	29	35	28	57	96	116	1106
	Ruvu	37	74	86	138	261	116	20	15	20	33	70	108	72	1013
	Dar es Salaam	58	58	70	110	255	191	35	32	29	29	58	83	72	1020
	Utete	52	110	95	139	198	75	11	7	8	13	32	92	114	895
	Kilwa	40	139	108	137	221	72	11	11	11	9	19	61	129	927
	Liwale	457	188	177	177	98	21	2	1	2	6	9	47	122	849
	Lindi	134	148	145	166	169	36	11	8	8	12	16	59	137	914
	Masasi	457	185	174	178	125	20	4	3	2	5	11	60	121	887

Table 6.62. Harvested area, yield and production of selected crops in Tanzania

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	2,124	2,127	2,110	841	757	678	1,786	1,609	1,430
Wheat	52	55	48	1,399	1,397	1,409	73	76	68
Maize	1,300	1,300	1,300	801	692	615	1,041	900	800
Rice (paddy)	200	200	190	1,300	1,250	947	260	250	180
Millet	220	220	220	727	727	727	160	160	160
Sorghum	350	350	350	714	629	629	250	220	220
Roots & tubers, total	986	1,006	1,017	4,941	4,942	4,941	4,873	4,973	5,024
Potatoes	22	22	22	3,864	3,864	3,818	85	85	84
Sweet potatoes	53	53	54	6,226	6,226	6,206	330	330	332
Cassava	910	930	940	4,890	4,892	4,894	4,450	4,550	4,600
Pulses, total	481	482	500	441	441	439	212	213	219
Beans (dry)	300	298	300	500	500	500	150	149	150
Soybeans	5	5	5	207	220	220	1	1	1
Groundnuts in shell	20	20	22	900	1,000	1,000	18	20	22

Table 6.63. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Tanzania (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
Northwest	260,000	35,000	100,000	8,000	39,000	185,000
Northeast	390,000	35,000	40,000	26,000	6,000	90,000
East	60,000	17,000	4,000	-	39,000	445,000
South	330,000	105,000	22,000	13,000	33,000	90,000
Southwest	250,000	105,000	22,000	5,000	58,000	90,000
Central	10,000	52,000	33,000	-	20,000	18,000

Table 6.64. CROP CALENDAR FOR TANZANIA

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northeast	Rainfall		75	76	123	252	169	32	15	13	13	27	70	91
	Maize		///	//////	///			000000	000000					
	Sorghum		//////	//////			000	000000						
	Wheat		///	//////	///			000000	000000					
Northwest	Rainfall		109	108	148	169	81	17	9	17	34	57	111	136
	Maize		//////	//////				000000	000000					
	Sorghum	Single					000000	000000					//////	//////
	Sorghum	Long Rains		//////	///			000000	000					
	Sorghum	Short Rains	000000	000000								//////	///	
	Millet	Single					000000	000000					//////	//////
	Millet	Long Rains		//////	///			000000	000					
	Millet	Short Rains	000000	000000								//////	///	
Southwest	Rainfall		188	166	182	148	46	9	6	6	7	19	99	192
	Maize		//////	///			000	000000	000					///
	Sorghum		//////				000000	000000						//////
	Wheat		//////	///			000	000000						//////
South	Rainfall		230	209	261	202	64	10	6	6	7	18	64	175
	Maize		//////				000000	000000						//////
	Sorghum		//////				000000	000000						//////
	Wheat		//////	///			000	000000						///
Central	Rainfall		125	103	118	83	22	3	1	1	2	9	37	101
	Sorghum		///			000	000000	000						//////
	Millet		///			000	000000	000000						///
East	Rainfall		129	115	155	184	95	19	16	17	21	38	71	113
	Maize		//////	//////			000	000000						
	Rice						000000	000000					//////	//////
	Sorghum		//////				000000	000000						//////

TABLE 6.65.

TANZANIA

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1964, May	Flood in the Pangani River Basin
1967, May	Drought Nationwide and Especially Around Kilwa
1968, March	Flood in the Rufiji River Valley
1974, May	Flood in the Ulanga District
1974, May	Poor Rainfall Lowers Production by 50%
1974, November	Dry Weather Endangers 1975 Maize and Rice Crops
1976, March	Maize in Lake Victoria Area Affected by Diseases and Pests
1977 -	Drought Around Tanga
1979, June	Floods in 9 Regions
1980, March	The 1979-1980 "Short Rains" Maize Crop has Failed in Northern and Eastern Areas Due to Late and Insufficient Rain
1980, May-June	The 1980 "Long Rains" Season's Acreage has been Reduced Due to Late Rains. The Maize Crop is in Poor Condition Due to the Dry Weather. Wheat and Rice Also Affected
1981, March	Crops in Most Regions Affected by Drought. So Far, the "Long Rains" Performance has been Worse than in 1980.
1981, July	Food Production has been Sharply Below Normal for the Second Consecutive Year
1982, March	Crop Production Reduced Due to Drought
1982, March	Drought Seriously Affects Arusha Region
1982, March	Crops in Singida Region Attacked by Armyworms
1982, May	Floods in Kyela District, Mbeya Region Wash Away Crops
1982, August	Drought in Mtwara Region

O. UGANDA

1. Agroclimatic Conditions and Regions

Most of Uganda is a vast flat plateau with an altitude of 800 to 1300 meters (Figure 6.107). Lower lying areas are found only along the coast of Lake Mobuto Sese Seko and along the Nile River valley north of the lake. Higher areas are found in the southwestern hilly corner of the country and around the mountains, the highest being Ruwenzori (5,119 m) and Mount Elgon (4,321 m).

The country has been divided into three agroclimatic assessment regions (Figure 6.109). The Southwest and Northcentral regions receive similar mean regional rainfall amounts - 1,110 and 1,256 mm per year, respectively. Within these regions, the area around Lake Mobutu Sese Seko receives around 700 mm annually, while the Lake Victoria coast and some other isolated locations receive over 1,400 mm (Figure 6.107 and Table 6.66). The driest areas of the country are in the Northeast, where annual amounts at the border with Kenya drop to about 500 mm.

The seasonal variations of rainfall differ over the country. The Southwest region has two distinct rainy and dry seasons (long rains during March-May and short rains during September-November). In the Northcentral region the second dry season (June-July) is not well pronounced, while the Northeast region has only one long rainy and one dry season. Another difference between the regions is the earlier arrival of the short rains in the Northcentral region.

The period with mean monthly rainfall of 100 mm or more is mostly between 3 and 7 months (Figure 6.108; see also Chapter VII, E).

2. Agriculture

The most important food crops in Uganda are millet, maize, beans, cassava, sorghum, groundnuts and plantains (Table 6.67). They are grown all over the Southwest and Northcentral regions. Fewer crops - mainly millet and sorghum - are grown in the Northeast (Figure 6.111 and Table 6.68). The most important commerical crops are cotton, coffee, tea and sugar cane (Figure 6.112).

Most farmers in the Southwest and Northcentral regions grow two crops per year - one during the long rains and a second during the short rains (Table 6.69). Only one crop is grown in the Northeast.

3. Factors Affecting Yield and Their Assessment

Drought is the most important meteorological factor affecting crops in Uganda (Table 6.70). The years with drought, as well as those with good rainfall, are shown on Figure 6.113. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Uganda and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.114. In addition to the stations with common period of records (used for the assessments), Uganda has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative districts of the country, their boundaries, together with those of the agroclimatic regions, are shown on Figure 6.110.

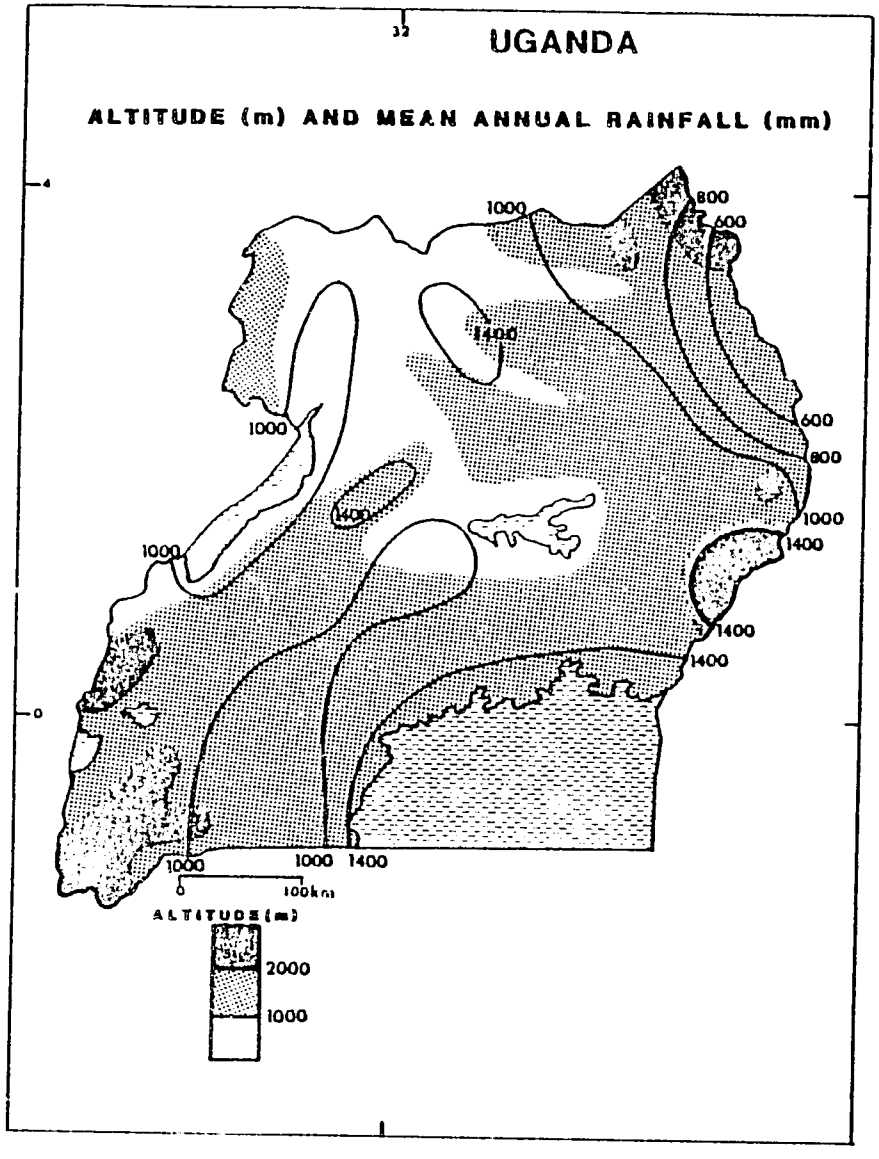


Figure 6.107.

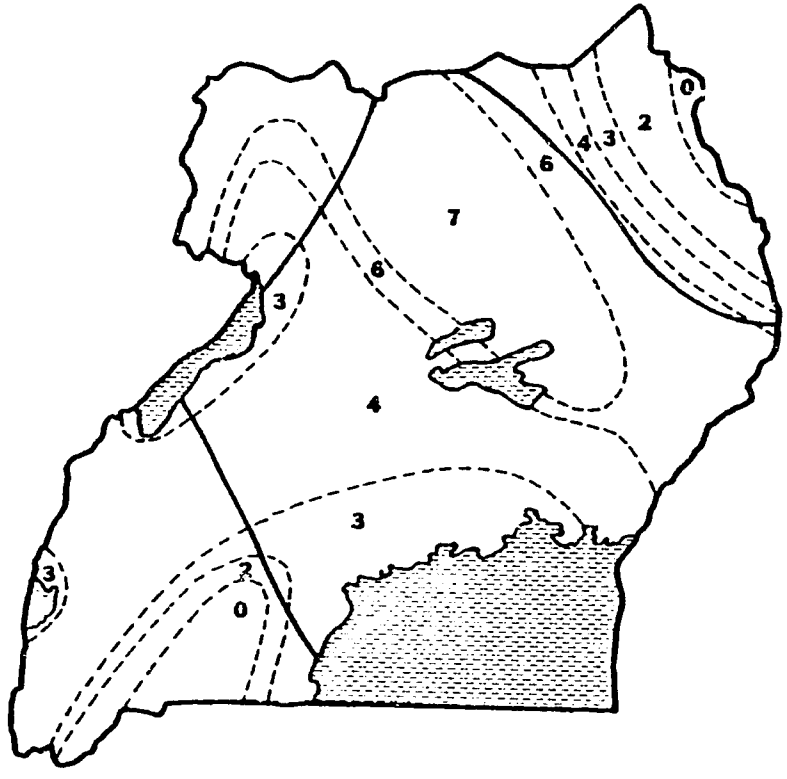


Figure 6.108.

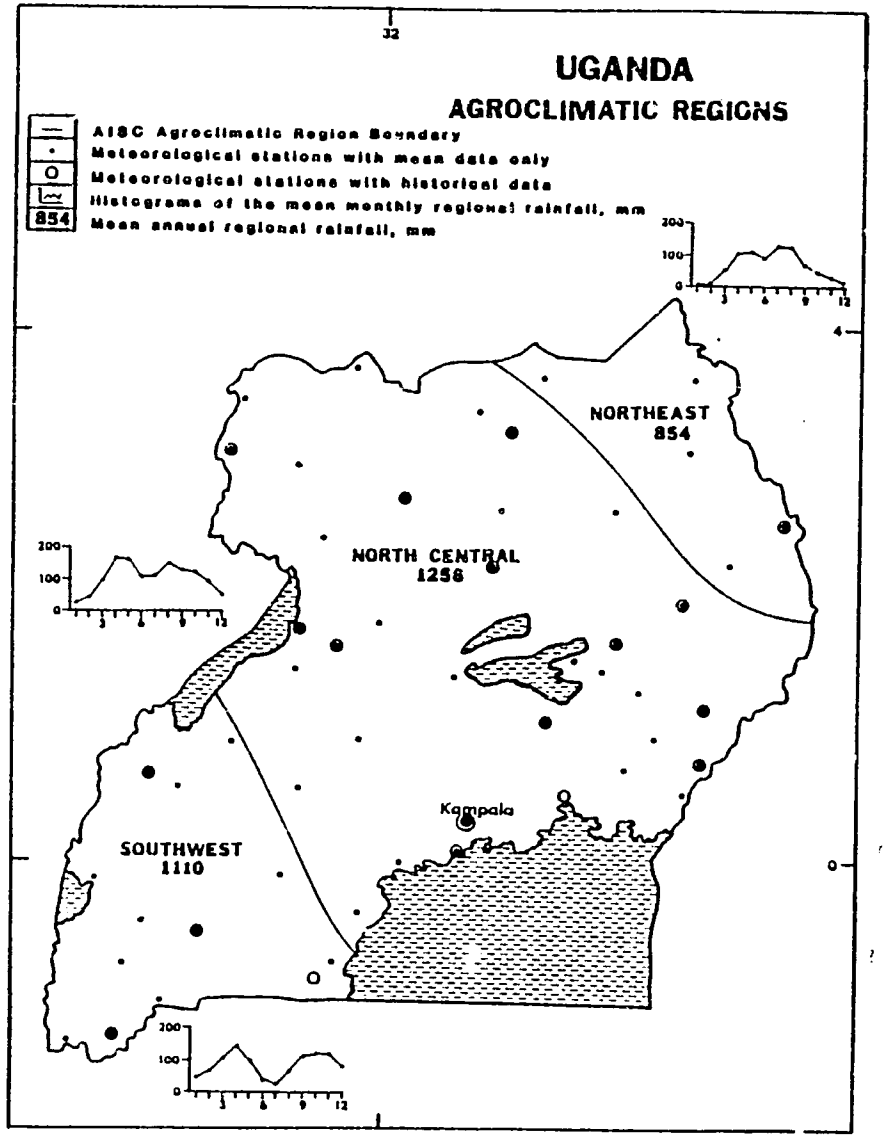


Figure 6.109.

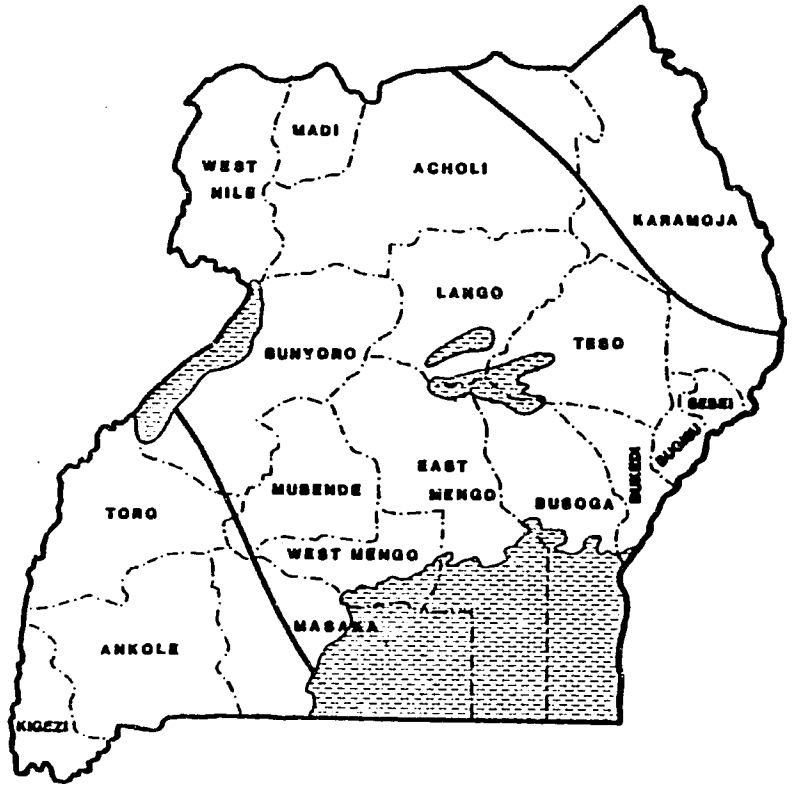


Figure 6.110.

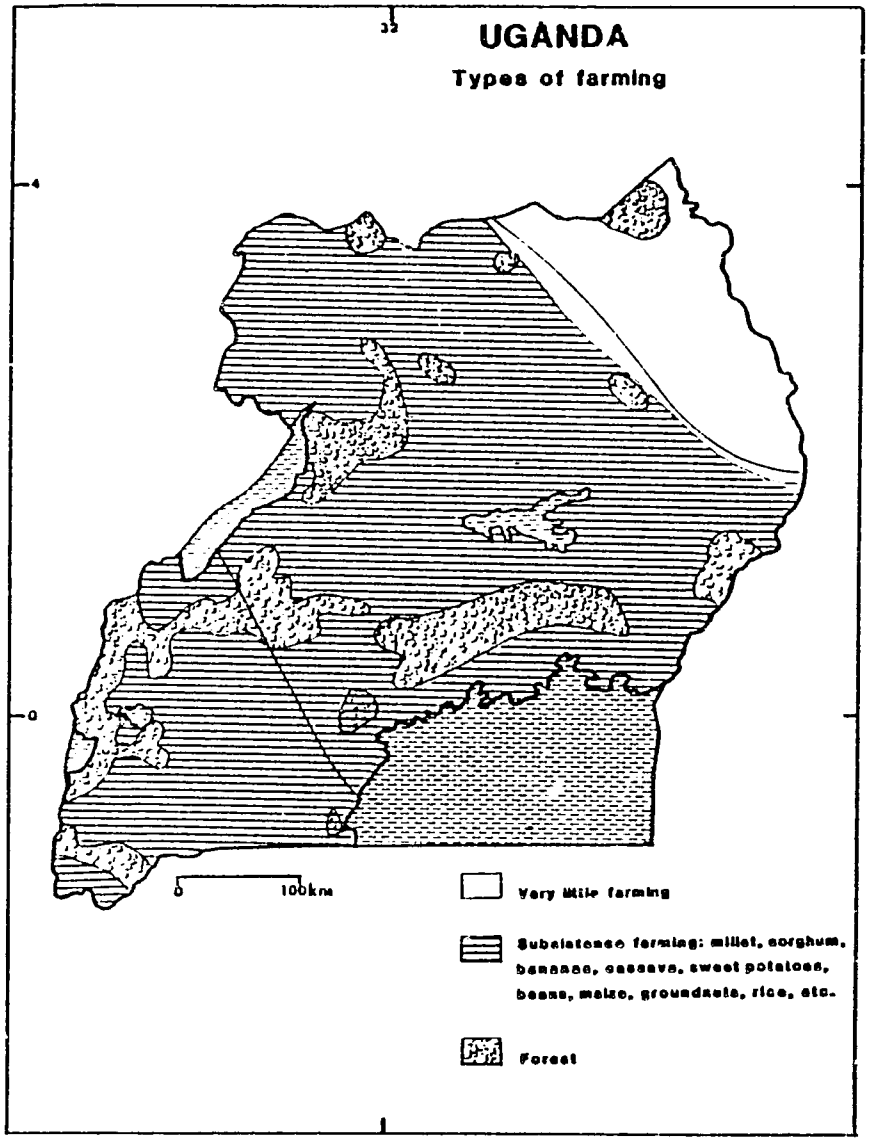


Figure 6.111.

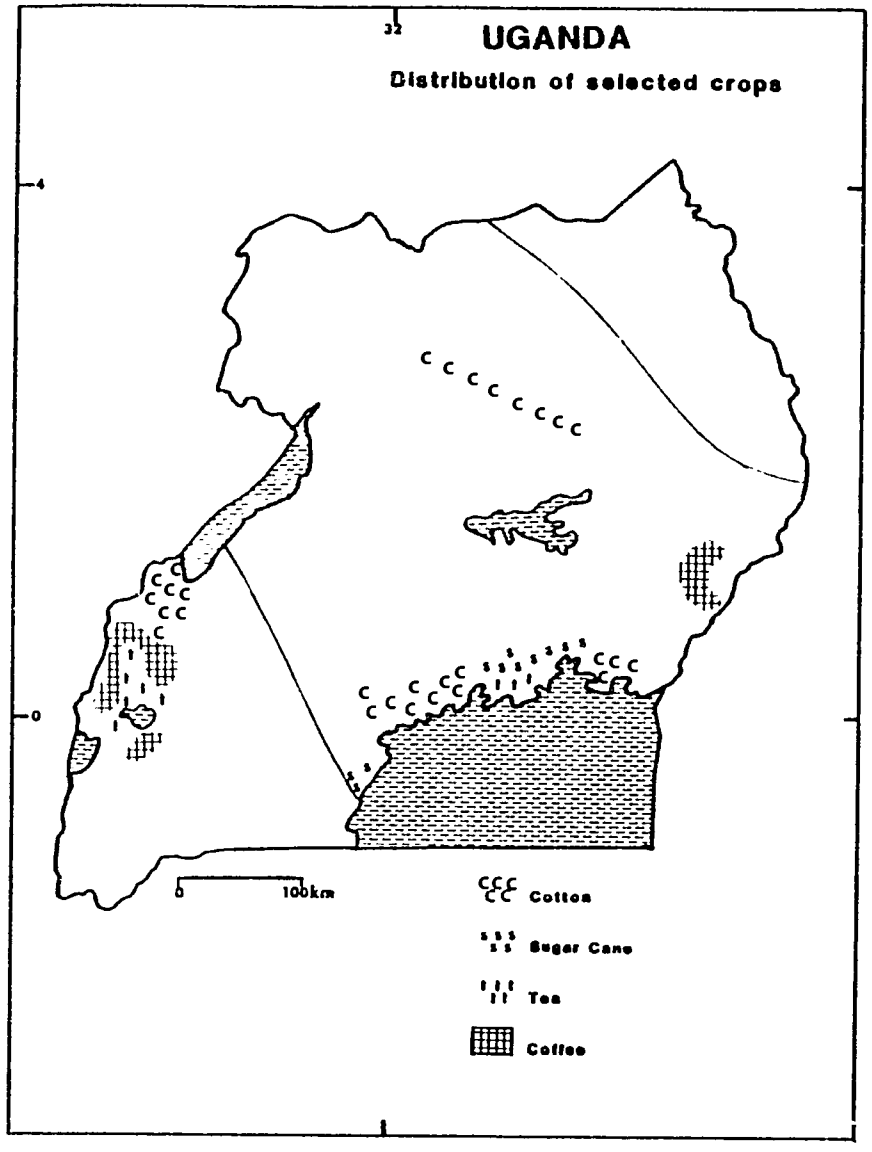


Figure 6.112.

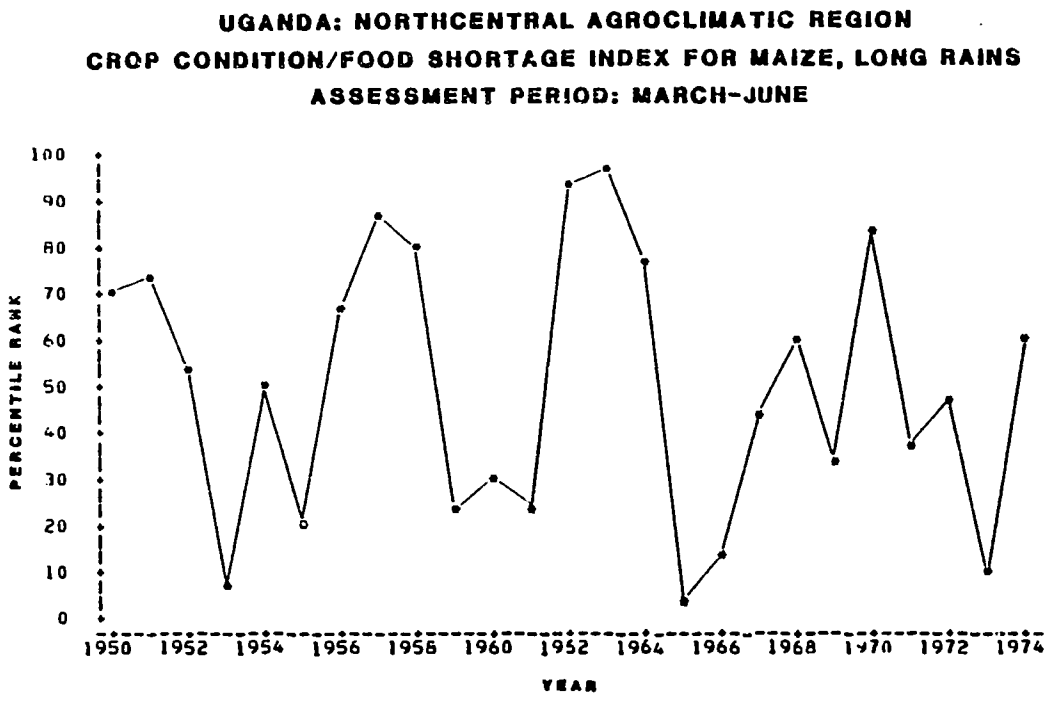


Figure 6.113.

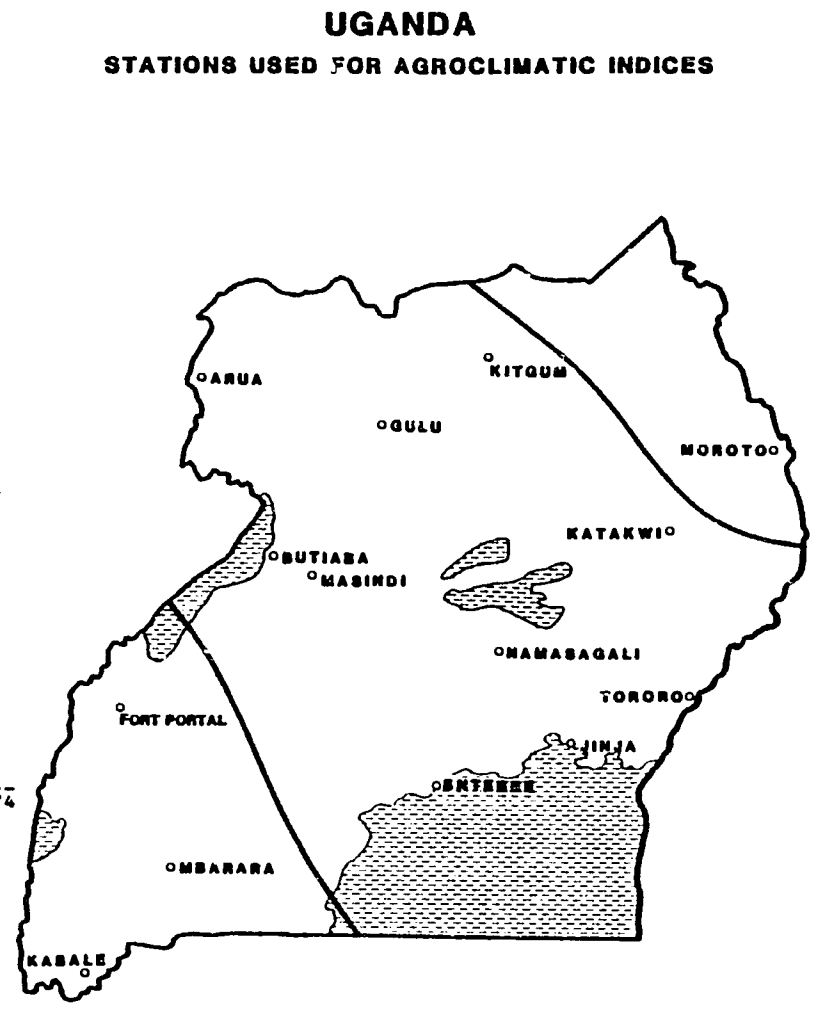


Figure 6.114.

Table 6.66. Mean monthly and annual rainfall (mm) at selected stations in Uganda

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Northcentral	Kitgum	914	14	25	74	150	166	105	167	186	129	124	67	23	1229
	Arua	1211	24	41	97	143	150	146	153	196	183	230	119	44	1525
	Gulu	1105	18	31	98	178	178	153	155	232	229	190	104	66	1631
	Katakwi	1158	22	39	70	134	138	100	117	153	100	101	61	34	1070
	Butiaba	621	17	27	61	102	72	40	59	65	70	82	75	30	700
	Masindi	1147	44	44	117	179	142	76	107	139	144	179	125	50	1345
	Namasagali	1036	34	63	122	192	148	78	65	107	136	140	120	73	1279
	Tororo	1171	60	87	138	230	223	101	76	110	117	138	116	87	1483
	Jinja	1173	64	76	120	196	131	64	59	75	98	132	147	88	1251
	Entebbe	1155	87	95	169	269	255	109	74	85	81	115	172	112	1624
Southwest	Fort Portal	1537	46	64	144	203	132	90	66	118	176	230	174	96	1539
	Mbarara	1413	57	63	100	140	83	24	16	59	86	113	127	80	949
	Kabale	1869	62	89	110	151	100	30	18	48	92	97	116	96	1008
Northeast	Moroto	1524	11	28	82	130	99	80	118	113	46	51	63	29	850

Table 6.67. Harvested area, yield and production of selected crops in Uganda

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	1,477	1,478	1,478	1,142	932	964	1,686	1,378	1,425
Wheat	10	10	10	1,500	1,500	1,500	15	15	15
Maize	550	550	550	1,200	1,200	909	660	500	500
Rice (paddy)	17	17	18	647	722	556	11	13	10
Millet	550	550	873	818	818	480	450	450	450
Sorghum	350	350	350	1,486	1,143	1,286	520	400	450
Roots & tubers, total	554	559	564	3,971	4,025	4,078	2,200	2,250	2,300
Potatoes	45	45	45	7,333	7,333	7,333	330	330	330
Sweet potatoes	139	139	139	4,820	4,820	4,820	670	670	670
Cassava	370	375	380	3,243	3,333	3,421	1,200	1,250	1,300
Pulses, total	556	568	575	480	491	491	267	279	282
Beans (dry)	357	360	360	484	500	500	173	180	180
Soybeans	5	5	5	600	600	600	3	3	3
Groundnuts in shell	250	260	230	880	873	870	220	227	200

Table 6.68. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Uganda (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
Southwest	135,000	140,000	110,000	5,000	7,000	95,000
North Central	390,000	140,000	412,000	5,000	9,000	280,000
Northeast	25,000	70,000	28,000	-	-	-

Table 6.69. CROP CALENDAR FOR UGANDA

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northcentral	Rainfall		28	45	96	167	160	101	107	148	129	123	95	55
	Maize	Long Rains			//////	//////		000	000000	000000				
	Sorghum	Long Rains		///	//////			000000	000000					
	Sorghum	Short Rains							//////	///		000000	000000	000
	Millet	Long Rains		//////	//////		000	000000	000					
	Millet	Short Rains							//////	//////		000000	000000	000
Southwest	Rainfall		53	73	109	149	107	42	34	76	120	133	128	86
	Maize	Long Rains		//	//////			0000	000000					
	Maize	Short Rains	000000							//////				000
	Sorghum	Long Rains		///	//////		000	000000	000					
	Sorghum	Short Rains	000000							//////	//////		000	000000
	Millet	Long Rains		///	//////		000	000000	00					
	Millet	Short Rains							//////	//////		000000	000000	00
Northeast	Rainfall		9	19	53	108	118	96	138	129	74	51	38	20
	Sorghum	Long Rains			//	//////			000000	000000	000			
	Millet	Long Rains			//	//////			000000	000000	000			

TABLE 6.70.

UGANDA

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1967 -	Drought in Karamoja
1979, November	The Failure of the Seasonal Rains ("Short Rains") Seriously Affecting Crops
1980, February	Due to the Failure of the "Short Rains" in 1979-1980, Crop Production is Basically Lost, which Aggravates the Already Serious Food and Water Shortages in the Northern and Eastern Areas. Famine Conditions Reported in Karamoja Region (NE Uganda)
1980, April	Drought
1980, May-June	The Delayed Start of the First 1980 Rainy Season ("Long Rains") Caused Reduced Agreage of the Main Season Crops. The Dry Spell in the Second Half of May had an Adverse Effect. Another Year of Drought Reported in the Karamoja Region
1980, December	Recent Harvest in the North was Poor Due to Drought
1981, January	About 250,000 Ugandans Faced with Famine, Due to Drop in Crop Production - About 2/3 from Previous Year
1981, June	A Dry Spell from End of April to Early June in Eastern and Northern Regions, has Damaged Millet, Sorghum, Maize and Groundnuts
1982, January	The Karamoja Area is Suffering from a Two-Year Drought

P. ZAIRE

1. Agroclimatic Conditions and Regions

There are three major geographic regions in Zaire:

- Zaire River Basin. This is a low area (300-500 m altitude, Figure 6.115) covered with tropical forest and swamps. Locally, the Zaire River Basin is referred to as the cuvette.
- Plains. These are the areas with altitude mostly between 500 and 1,000 meters. The relief is either flat or undulating, cut by shallow river valleys. The natural vegetation consists mainly of savanna and woodlands.
- High Plateaus and Mountains. These are most of the areas with altitude above 1,000 m, located along the eastern border of Zaire and in the south. The vegetation varies with altitude.

The country has been divided into seven agroclimatic assessment regions (Figure 6.117). Wettest is the Northcentral, with mean regional rainfall of 1,926 mm per year. Driest is the South region with about 1,200 mm. The dry season in the North and Northeast regions is in December, January and February, while in the southern regions it occurs during June to September. The period with mean monthly rainfall of 100 mm or more is 5 months in the south, gradually increasing to 12 months in the Northcentral region (Figure 6.116; see also Chapter VII, E).

2. Agriculture

The most important food crop in the more humid central and northern areas is cassava. In the south, as well as in some eastern areas, maize, groundnuts and beans predominate (Table 6.72 and Figure 6.119). Rice is grown widely along many rivers. The area planted to the food crops grown in each region are shown in Table 6.73; Figure 6.120 indicates the distribution of some important commercial crops.

Due to its large size and the existence of different rainfall patterns, the crop calendars in Zaire vary considerably (Table 6.74). In areas with two pronounced rainy seasons, farmers normally grow two crops per year, while in the south only one crop is usually grown. It should be noted that unlike many other countries where sowing of the crops begins with the onset of the rainy season, sowing in the humid areas of Zaire is often delayed in order for harvesting to coincide with the arrival of the dry season.

3. Factors Affecting Yield and Their Assessment

Crop yield in Zaire is affected by various meteorological and non-meteorological factors. As the episodic event data indicate, drought is one of the most frequent phenomena reducing crop yield, especially in the drier southern areas of the country (Table 6.75). The years with drought, as well as with good rainfall, are shown on Figure 6.121. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Zaire and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.122. In addition to the stations with common period of records (used for the assessments), Ziare has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative provinces of the country, their boundaries, together with those of the agroclimatic regions, are shown on Figure 6.118.

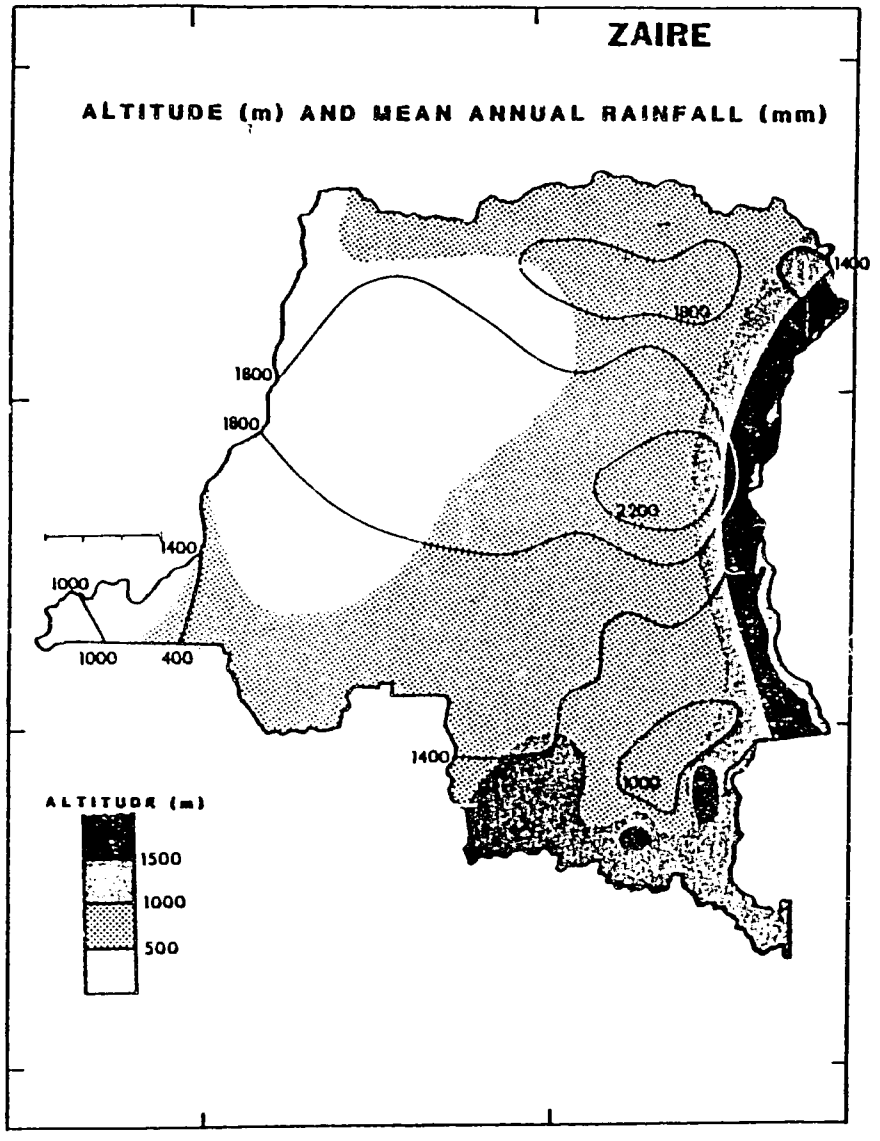


Figure 6.115.

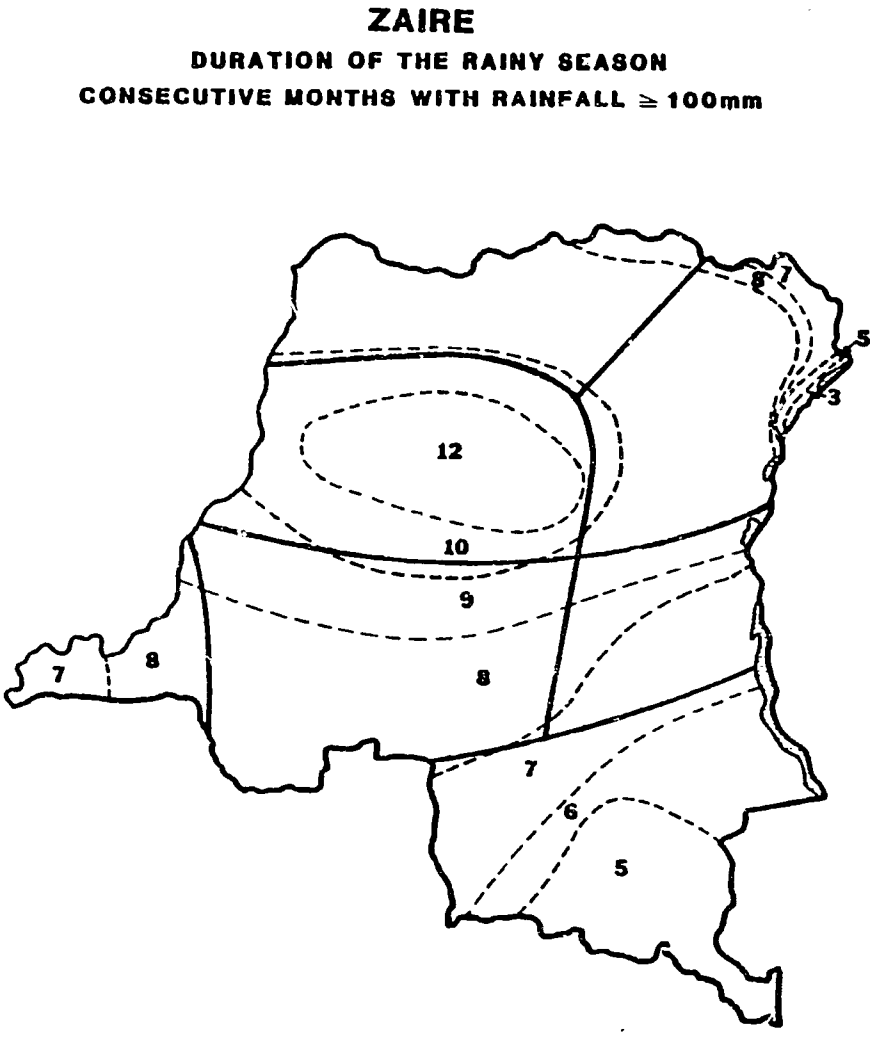


Figure 6.116.

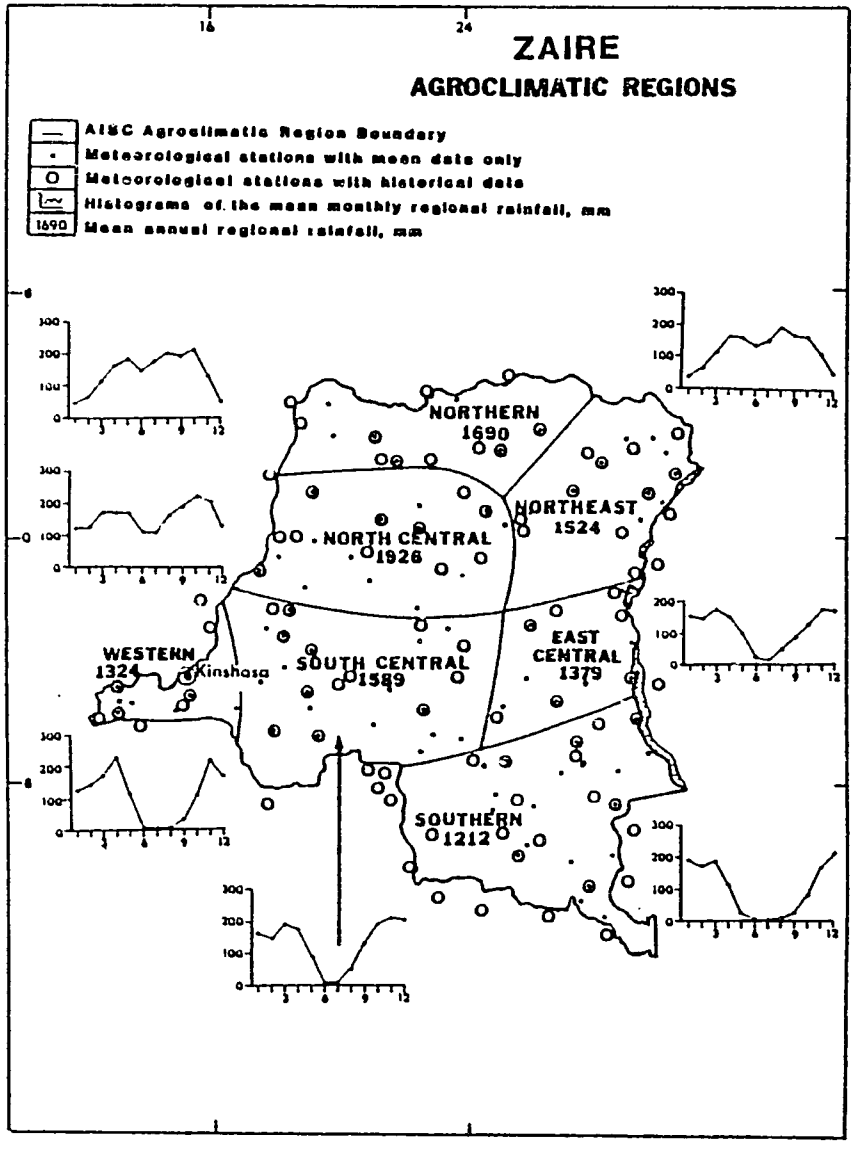


Figure 6.117.

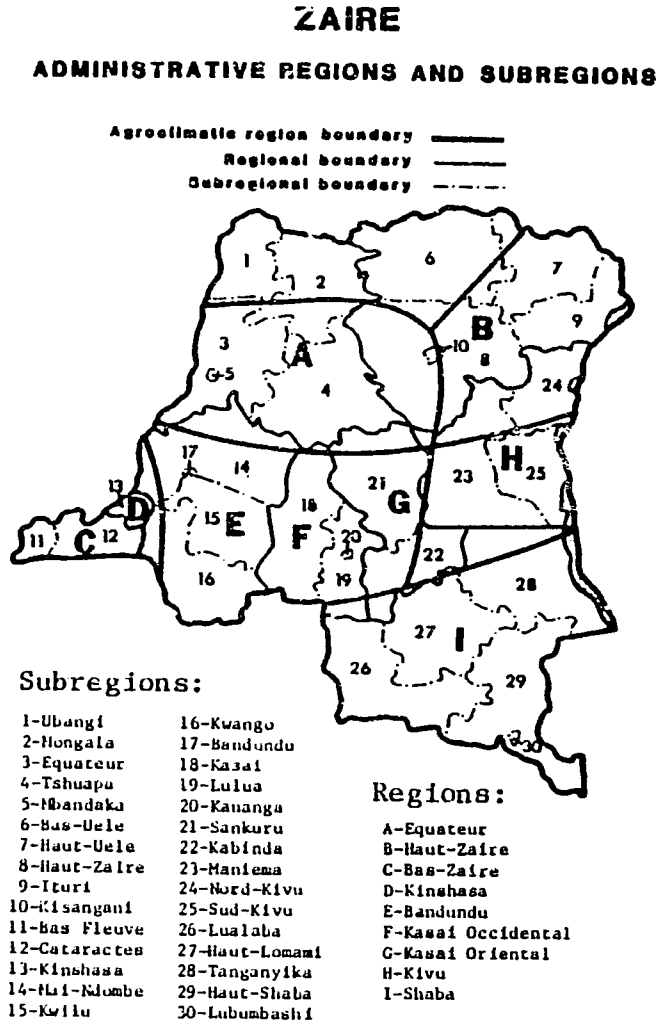


Figure 6.118.

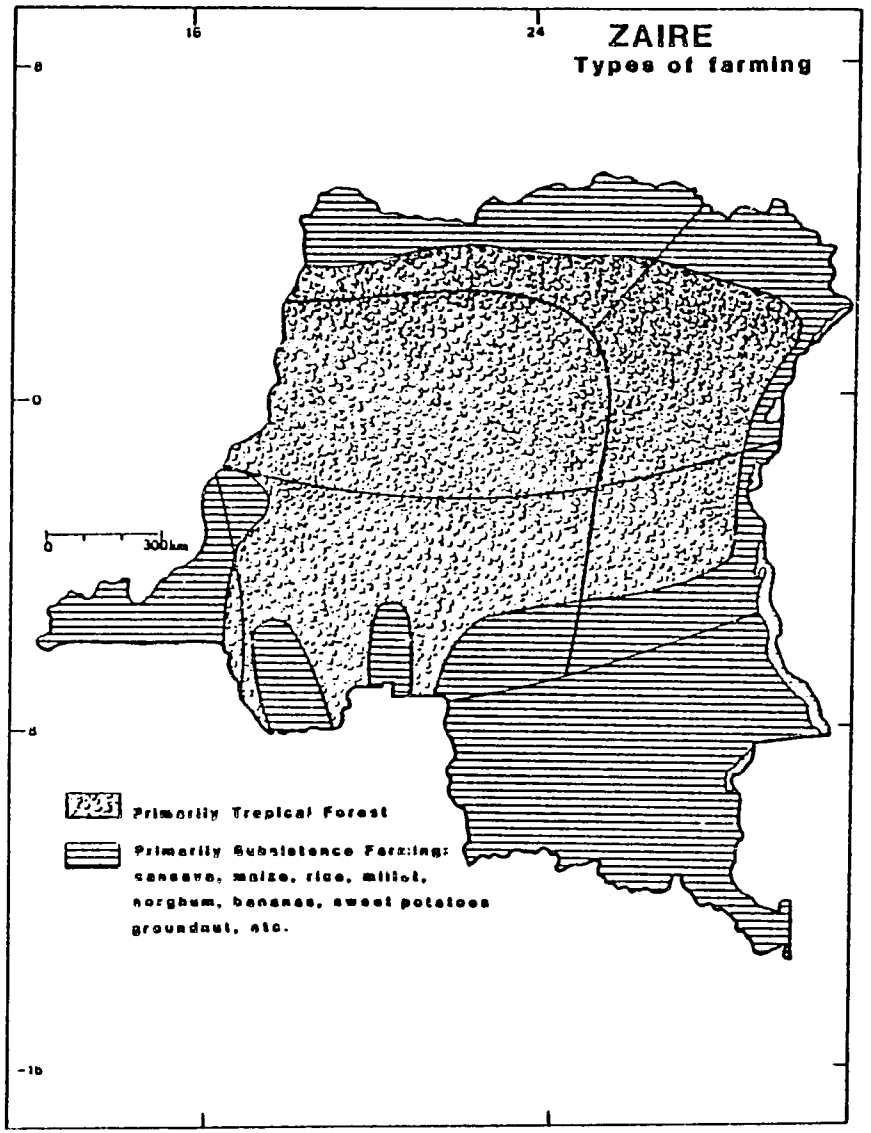


Figure 6.119.

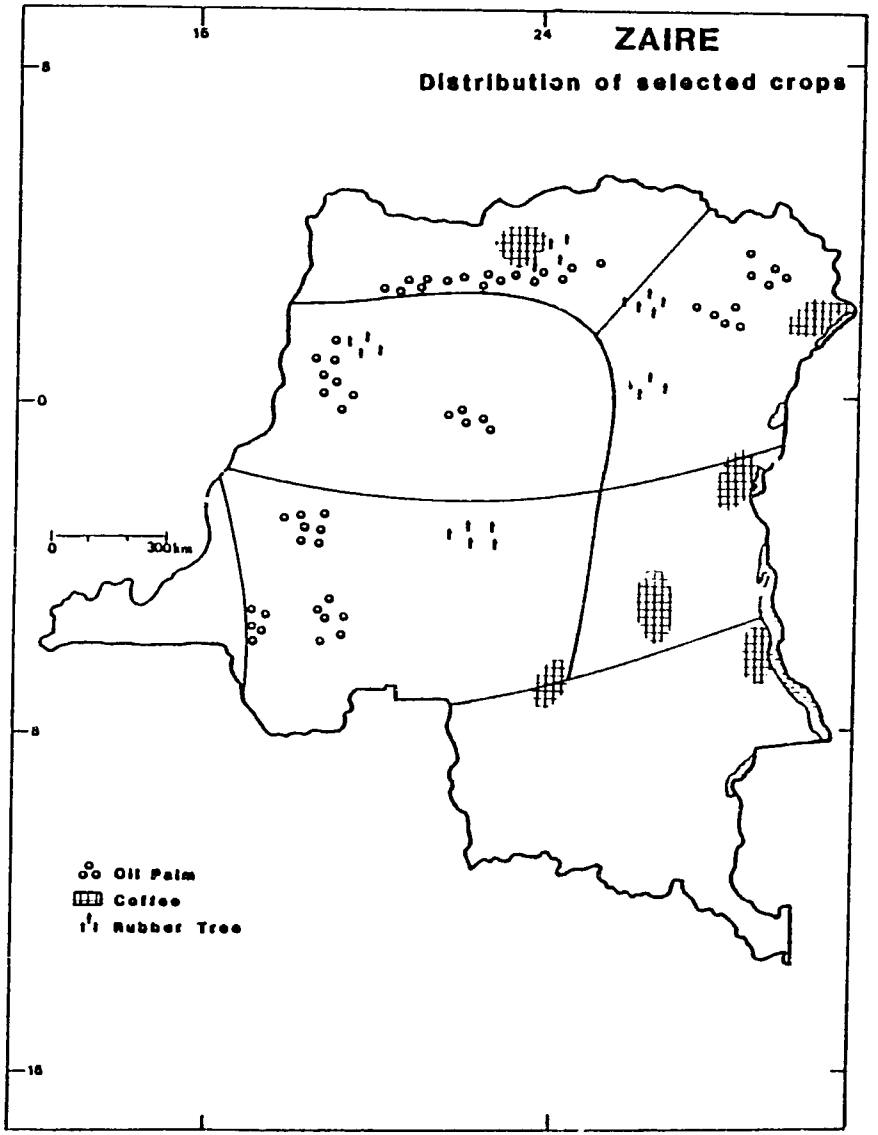


Figure 6.120.

ZAIRE: SOUTH AGROCLIMATIC REGION
CROP CONDITION/FOOD SHORTAGE INDEX FOR MAIZE
ASSESSMENT PERIOD: OCTOBER-JANUARY

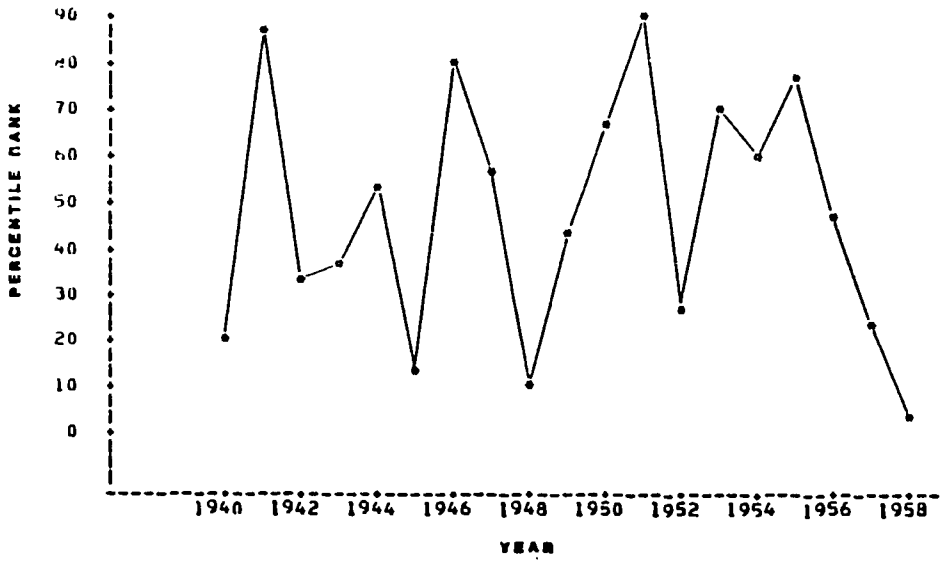


Figure 6.121.

ZAIRE
STATIONS USED FOR AGROCLIMATIC INDICES

Figure 6.122.

Table 6.71. Mean monthly and annual rainfall (mm) at selected stations in Zaire

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
North	Impfondo, Congo*	326	79	76	150	171	187	143	147	167	170	209	173	107	1779
	Zemio, C. A. R.*	589	17	29	81	137	185	177	187	231	232	223	73	25	1595
	Bangui, C. A. R.*	365	26	42	111	125	179	133	186	198	182	195	108	31	1517
	Businga	400	48	57	119	146	190	158	177	224	179	201	120	53	1672
	Bambesa	620	32	61	132	183	195	143	194	201	232	219	125	37	1757
	Ekwangatama	450	33	60	125	176	177	151	154	152	194	225	136	51	1634
	Boyange	400	56	72	117	152	169	145	178	204	208	236	136	63	1733
Northcentral	Nouvelle Anders	375	71	61	133	157	141	137	146	206	173	215	153	96	1688
	Barumbu	420	84	74	150	189	168	126	175	174	175	224	191	106	1835
	Yangambi	420	75	89	150	157	151	115	133	161	173	213	185	105	1708
	Befale	390	106	113	168	182	170	161	168	193	226	231	217	137	2072
	Befori	400	117	125	206	184	180	144	166	213	242	255	199	150	2182
	Eala	350	123	124	148	144	151	105	86	131	194	209	201	132	1747
	Mondombe	500	124	107	171	174	143	125	147	176	202	232	224	156	1980
	Lukolela	318	144	129	179	139	134	63	33	72	189	184	158	162	1584
	Opala	450	111	115	161	176	160	114	120	152	182	219	206	179	1895
Northeast	Adi	1000	20	22	74	119	131	139	157	179	157	121	64	18	1200
	Wamba	625	64	65	168	214	207	174	171	219	212	218	138	81	1932
	Nioka	1749	29	49	104	143	128	115	123	188	199	139	92	52	1360
	Bafwasende	575	70	87	179	185	188	132	152	215	171	209	165	83	1836
	Irumu	999	53	62	117	155	125	129	135	145	144	110	109	74	1358
	Lula	500	75	117	163	161	169	110	111	169	183	234	153	110	1755
West	Ganda	500	134	159	216	229	112	3	2	6	13	92	249	174	1389
	Kinshasa	311	123	135	166	210	124	4	0	3	37	151	242	162	1358
	Lemfu	625	115	148	190	253	135	10	1	2	41	147	289	192	1522
	Boma	25	90	104	123	173	63	1	1	3	10	60	148	91	866
	Tumba	400	108	110	150	262	108	4	1	2	22	92	202	174	1235

continue.....

*The station is located in a neighboring country, and may be used for Zaire assessments.

Table 6.71. Mean monthly and annual rainfall (mm) at selected stations in Zaire (continued)

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Southcentral	Selenje	320	160	164	169	157	142	45	24	92	204	255	203	175	1789
	Mongobole	330	138	149	171	206	134	25	12	43	168	239	229	196	1708
	Bambinga	330	171	133	173	137	71	17	11	40	133	215	245	227	1573
	Basongo	450	164	143	179	167	101	17	15	56	142	196	221	190	1590
	Kikwit	449	165	112	205	222	99	7	12	39	160	195	223	161	1598
	Kananga	657	127	123	205	174	90	19	17	48	116	166	234	243	1561
	Feshi	899	168	161	192	199	91	17	17	57	121	220	202	208	1653
	Tshikapa	481	172	110	166	196	69	6	3	35	115	177	225	194	1468
Eastcentral	Bugasa	1000	172	143	172	244	245	68	32	74	149	196	202	216	1913
	Congomeka	700	204	168	263	237	154	73	88	91	138	218	303	288	2225
	Fizi	1249	127	139	150	214	113	17	12	17	37	81	139	162	1205
	Mitombe	700	170	162	166	177	54	8	18	62	134	174	226	208	1559
	Kongolo	570	142	143	153	162	60	12	8	20	58	138	162	163	1220
South	Nyunzu	800	149	136	135	126	32	2	3	10	49	109	188	199	1138
	Ankoro	956	160	122	154	95	16	2	0	7	54	94	148	171	1023
	Kabongo	1024	209	187	206	114	12	1	1	18	67	132	197	223	1368
	Kisamba	900	179	151	198	201	51	4	3	38	79	164	210	213	1489
	Kamina	1106	235	201	223	125	12	1	0	11	48	114	193	255	1418
	Luanza	937	162	127	215	225	43	0	1	0	8	53	161	213	1210
	Kanene	900	213	179	193	74	9	0	0	6	18	118	162	217	1189
	Kawambwa, Zambia*	1324	228	212	231	132	20	0	1	0	7	76	167	249	1321
	Sandoa	950	194	185	212	116	7	1	0	5	42	122	176	237	1298
	Kolwezi	1526	179	156	206	73	6	1	0	3	20	81	192	203	1120
	Lubumbashi	1276	249	285	219	60	2	0	0	0	2	24	166	259	1264
	Ndola, Zambia*	1270	300	241	196	41	5	0	0	1	1	19	127	243	1175

*The station is located in a neighboring country, and may be used for Zaire assessments.

Table 6.72. Harvested area, yield and production of selected crops in Zaire

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	1,220	1,105	1,215	871	722	745	1,063	798	905
Wheat	5	5	5	667	1,000	1,000	4	5	5
Maize	706	600	700	708	717	714	500	430	500
Rice (paddy)	279	280	280	765	821	821	213	230	230
Millet	35	30	35	737	667	714	26	20	25
Sorghum	32	30	35	866	667	714	28	20	25
Roots & tubers, total	1,883	1,905	1,987	6,557	6,607	6,593	12,350	12,587	13,102
Potatoes	6	6	6	4,905	4,921	4,891	31	31	31
Sweet potatoes	63	63	64	4,733	4,762	4,767	298	300	303
Cassava	1,778	1,800	1,880	6,624	6,667	6,649	11,779	12,000	12,500
Pulses, total	248	250	251	587	606	607	146	151	153
Beans (dry)	164	165	166	549	564	564	90	93	94
Soybeans	9	9	10	857	889	947	8	8	9
Groundnuts in shell	457	460	460	672	685	702	307	315	323

Table 6.73. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Zaire (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
North	67,000	2,500	2,500	-	70,000	270,000
North Central	13,000	-	-	-	84,000	270,000
Northeast	100,000	8,000	8,000	2,000	15,000	90,000
West	20,000	600	600	-	15,000	270,000
South Central	134,000	5,000	5,000	-	28,000	550,000
East Central	134,000	8,000	8,000	2,000	35,000	90,000
South	200,000	8,000	8,000	1,000	13,000	270,000

Table 6.74. CROP CALENDAR FOR ZAIRE

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northeast	Rainfall		39	63	118	162	160	138	153	192	168	162	113	55
	Maize	First		//////	///		000	000000	000					
	Maize	Second							//////	///			000000	000000
	Sorghum	First		//////	///		000	000000	000					
	Sorghum	Second	000						//////	//			000000	000000
	Millet	First		//////	///		000	000000	000					
	Millet	Second	000						//////	//			000000	000000
	Rice	First		//////				000000	000					
	Rice	Second							//////				000000	000
Eastcentral	Rainfall		156	141	177	169	99	24	16	44	84	124	177	169
	Maize	First	///	//////			000000	000000						
	Maize	Second	000000	000							//////	///		000
	Sorghum	First	///	//////			000000	000000						
	Sorghum	Second	000000	000						///	//////	//////		000000
	Millet	First	///	//////			000000	000000						
	Millet	Second	000000	000						///	//////	//////		000000
	Rice	First	///	//////			000	000000	000					
	Rice	Second	000000	000000						///	//////	///		
South	Rainfall		198	173	191	117	22	2	1	6	28	83	172	220
	Maize		000	000000	000							//////	//////	
	Sorghum					000000	000000					///	//////	///
	Millet					000000	000000					///	//////	///
Southcentral	Rainfall		162	146	187	178	88	17	15	54	132	191	218	201
	Maize	First	///	//////			000000	000						
	Maize	Second	000000	000000							//////	///		
West	Rainfall		126	145	170	225	119	6	1	5	32	106	220	178
	Maize		000	000000								//////	///	
North	Rainfall		46	64	115	163	184	151	178	201	189	216	130	53
	Maize		000000						///	//////	///		000	000000
	Rice	First		//////				000000						
	Rice	Second							//////					000000
Northcentral	Rainfall		121	125	174	173	172	115	112	168	197	221	208	136
	Rice	First	///	//////				000000	000					
	Rice	Second							//////					000000

TABLE 6.75.

ZAIRE

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1975, May	Cassava Disease Exists in Southern Regions
1976, February	Cassava Bacterial Wilt Disease Persists in Southern Regions
1977, January	Cassava Affected by Disease in Bandundu and Bas-Zaire Regions
1977, March	Cassava Disease Spreading to Eastern and Western Kasai Regions
1978, August	A Prolonged Severe Drought has Affected the Food Crops in Bas-Zaire and Bandundu Regions
1978, October	Kivu and Kasais Provinces Also Affected by Drought
1979, February	Famine Conditions in Lower Zaire and in Bandundu Province. Sowing has been Delayed. Crops Attacked by Disease
1979, March	Cassava and Plantains Production in Bas-Zaire Reduced by the 1978 Drought. Irregular Rains South of the Equator Hinder the Growth of January Planted Maize and Cassava
1982, May	Drought Affects Crops in Kivu Region

Q. ZAMBIA

1. Agroclimatic Conditions and Regions

The topography of Zambia is quite uniform. Most of the territory is a plateau, either flat or undulating, with an altitude mostly between 1,000 and 1,500 meters (Figure 6.123). Areas with lower altitude are found along the Zambezi River Valley in the south, the Luangwa River Valley in the southeast (dropping to below 500 m), and in a narrow strip in the northern agroclimatic region. There are no high mountains in Zambia - only one peak reaches 2,000 m.

The country has been divided into five agroclimatic assessment regions (Figure 6.125). Mean annual rainfall in Zambia decreases from north to south (Figure 6.123 and Table 6.76). The Northwest and North regions receive about 1,200-1,300 mm, while the other three regions receive about 900-950 mm annually. The seasonal variation of rainfall is the same over the whole country. The rainfall season normally begins in November and lasts until the end of March. The period with mean monthly rainfall of 100 mm or more is 6 months in the extreme north, decreasing gradually to 3 months in the southern areas (Figure 6.124; see also Chapter VII, E).

2. Agriculture

Maize is the single most important crop in Zambia, grown on an area twice as large as the combined area of all other agricultural crops (Table 6.77). Other important food crops are groundnuts, millet, sorghum, cassava and beans. Most food crops are grown in the Central agroclimatic region, followed by the Southeast and North regions (Table 6.78 and Figure 6.127). Cotton, tobacco, coffee and sugar cane are important commercial crops (Figure 6.128).

The crop calendar in Zambia is nearly the same all over the country. Sowing of the crops begins soon after the onset of the rainy season in November, while harvesting normally starts in April and continues until the end of May or beginning of June (Table 6.79).

3. Factors Affecting Yield and their Assessment

As the episodic event data indicate, drought is the most important meteorological factor affecting crop yields (Table 6.80). The years with drought, as well as with good rainfall, are shown on Figure 6.130. The

proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Zambia and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.126. In addition to the stations with common period of records (used for the assessments), Zambia has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative provinces of the country, their boundaries, together with those of the agroclimatic regions, are shown on Figure 6.129.

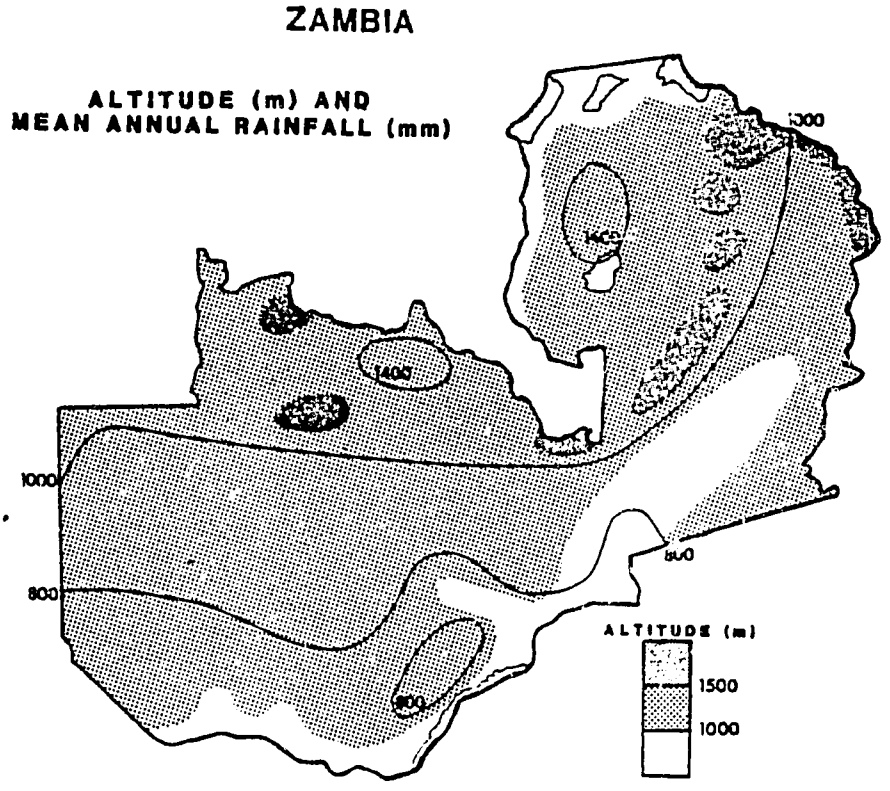


Figure 6.123.

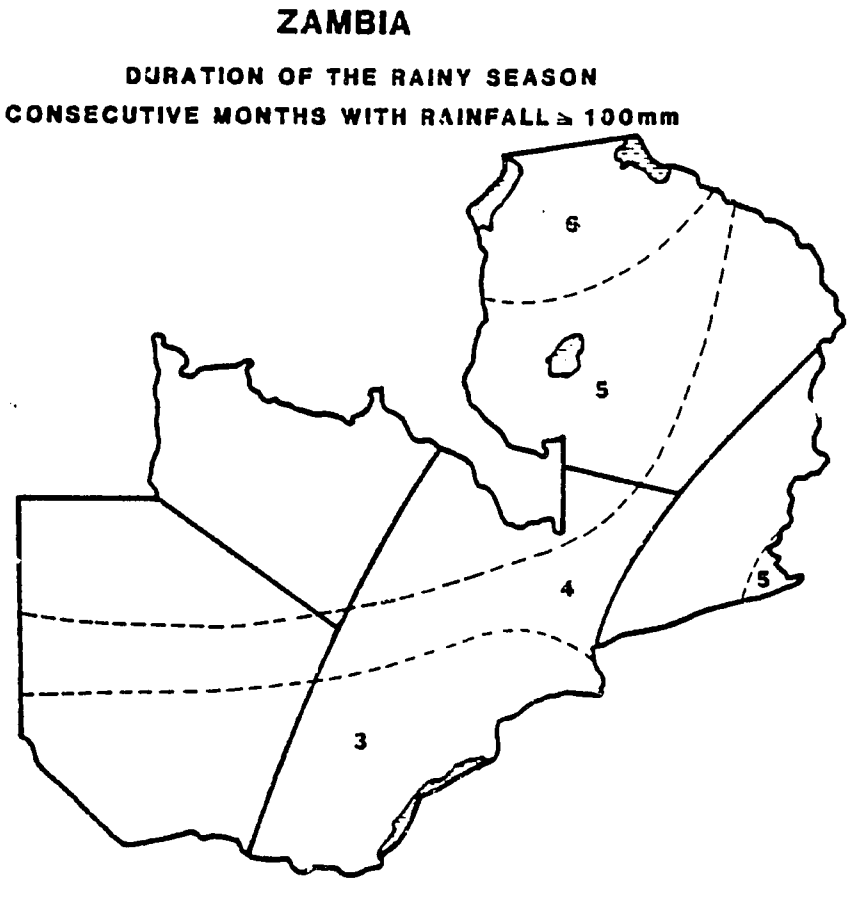
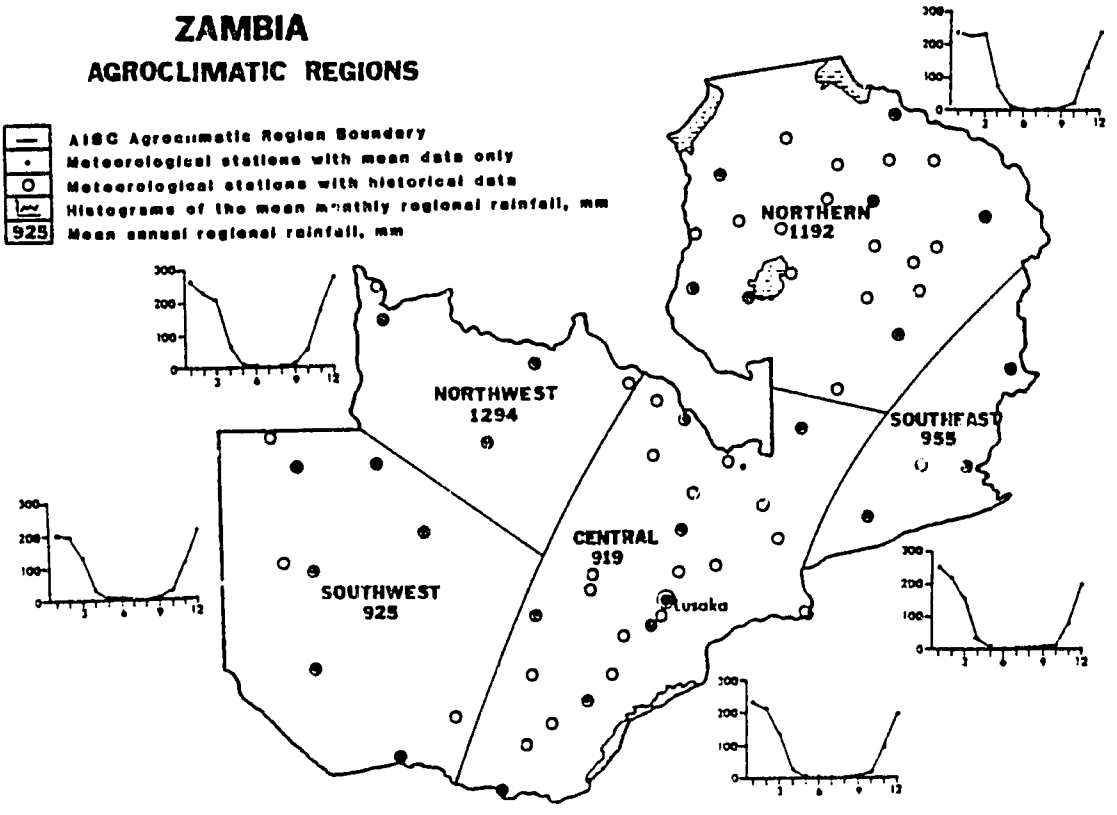


Figure 6.124.



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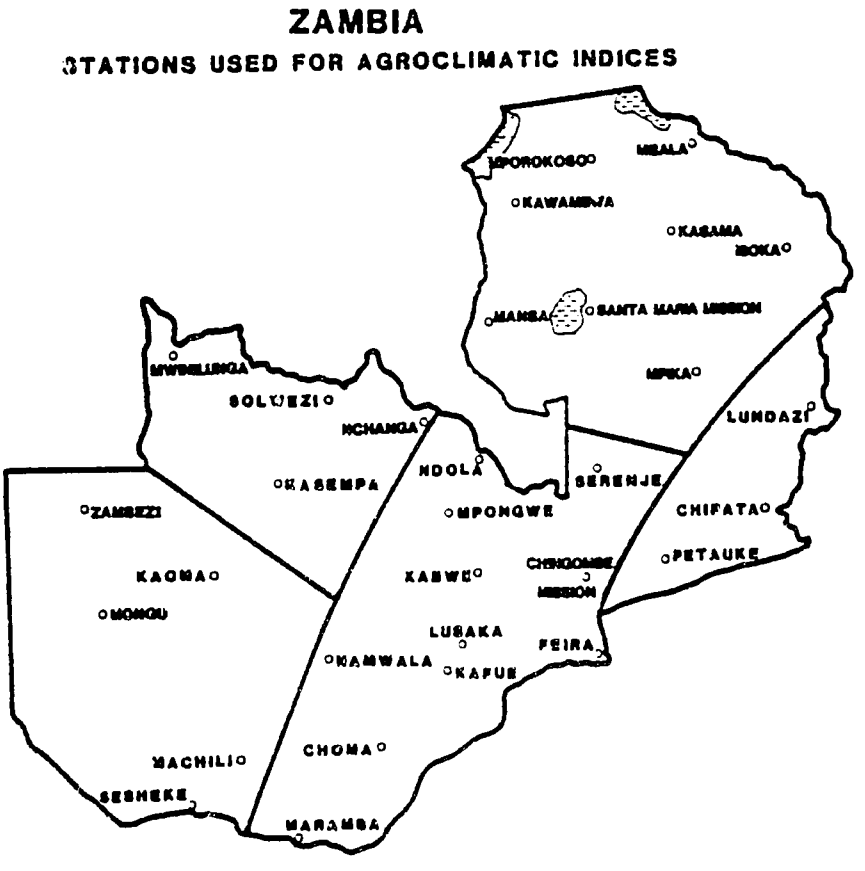

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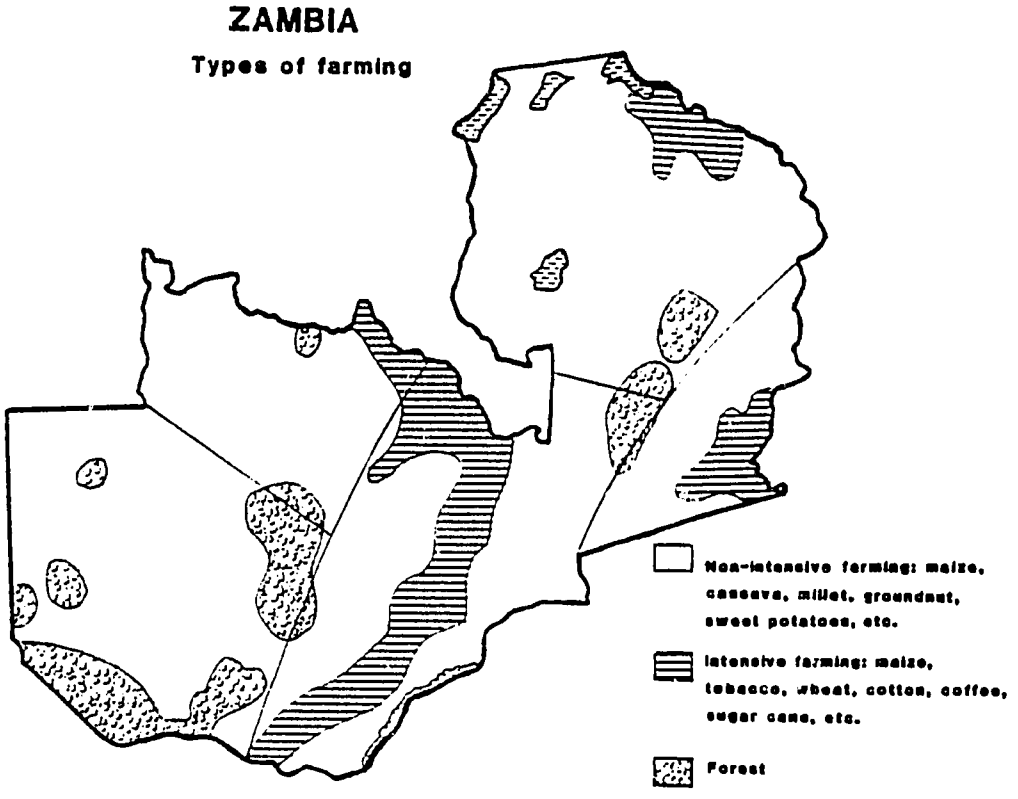


Figure 6.127.

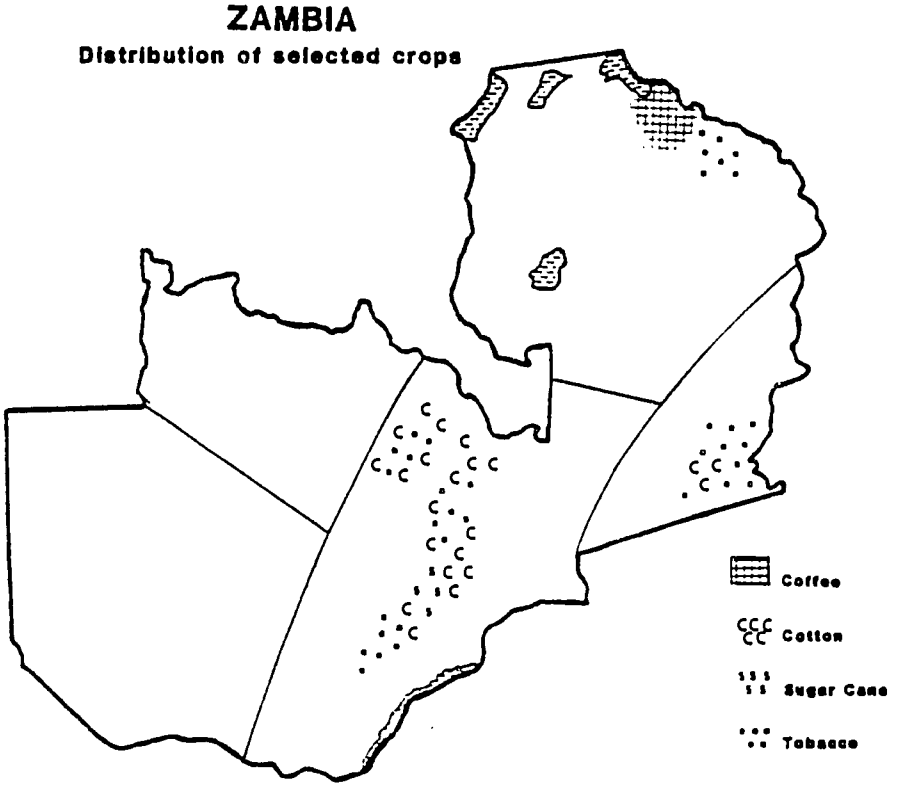


Figure 6.128.

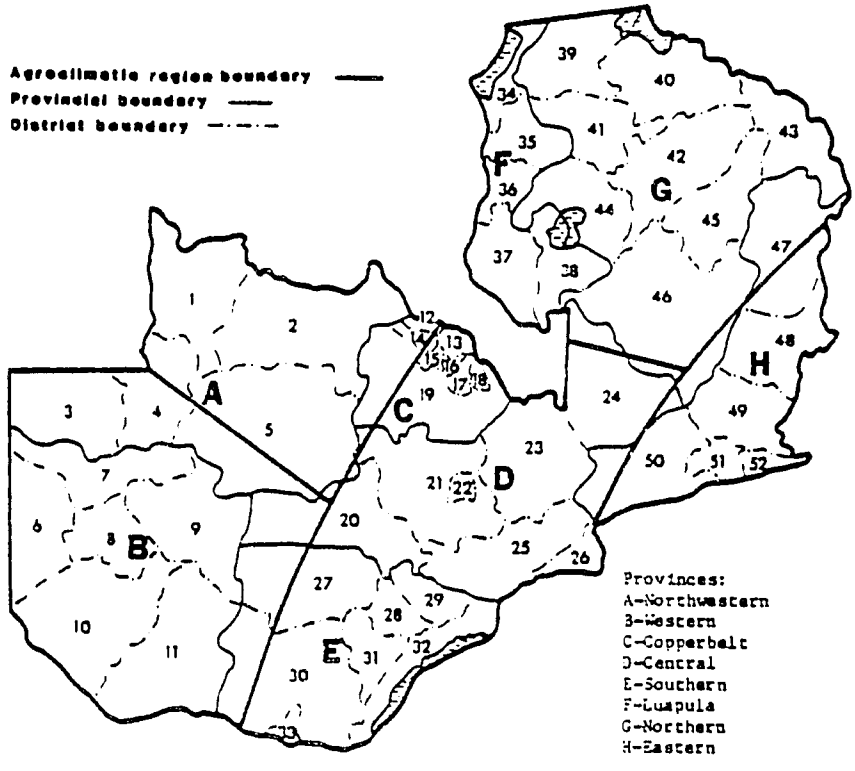

ZAMBIA
ADMINISTRATIVE PROVINCES AND DISTRICTS
Agroclimatic region boundary
Provincial boundary
District boundary
A
B
C
D
E
F
G
H
Provinces:
A-Northwestern
B-Western
C-Copperbelt
D-Central
E-Southern
F-Luapula
G-Northern
H-Eastern
Districts:
1-Mwinilunga
2-Solwezi
3-Zambezi
4-Kabompo
5-Kasempa
6-Kalabo
7-Lukulu
8-Mongu
9-Kaoma
10-Senanga
11-Sesheke
12-Chililabombwe
13-Mufulira
14-Chingola
15-Kalulushi
16-Kitwe
17-Luanshya
18-Ndola
19-Ndola Rural
20-Mumbwa
21-Kabwe Rural
22-Kabwe
23-Mkushi
24-Serenje
25-Lusaka Rural
26-Luangwa
27-Namwala
28-Monze
29-Mazabuka
30-Kalomo
31-Choma
32-Gwembe
33-Livingstone
34-Nchelenge
35-Kawambwa
36-Mwense
37-Mansa
38-Samfya
39-Kaputa
40-Mbala
41-Mporokoso
42-Kasama
43-Isoka
44-Luwingu
45-Chinsali
46-Mpika
47-Chama
48-Lundazi
49-Chipata
50-Petauke
51-Katete
52-Chadiza

Figure 6.129.

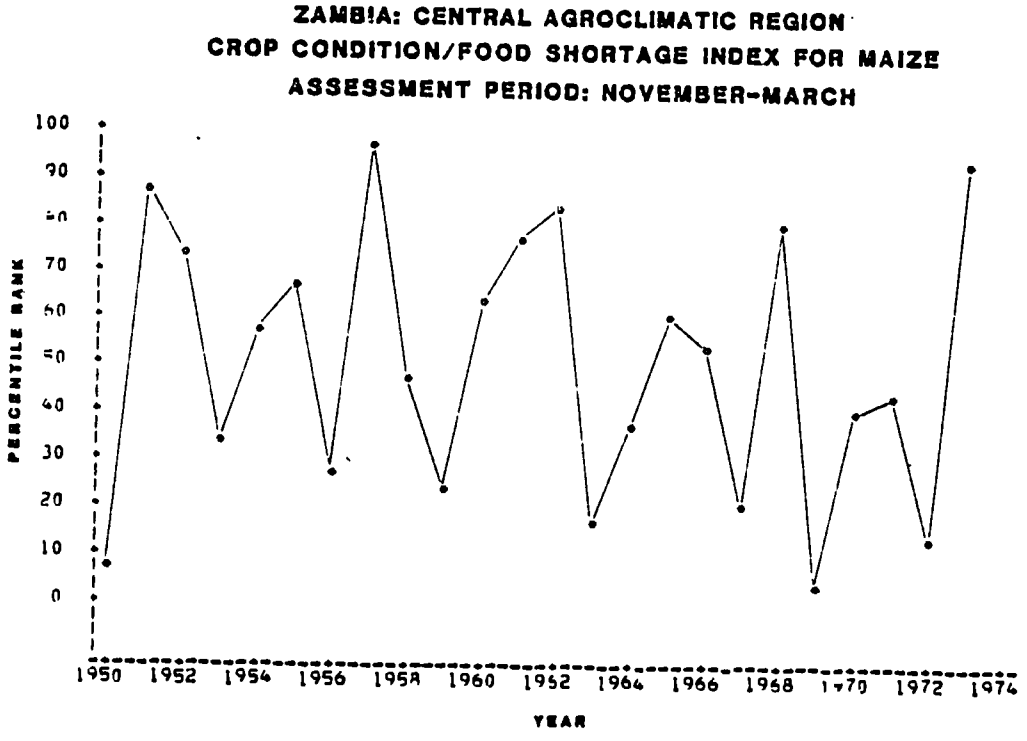

ZAMBIA: CENTRAL AGROCLIMATIC REGION
CROP CONDITION/FOOD SHORTAGE INDEX FOR MAIZE
ASSESSMENT PERIOD: NOVEMBER-MARCH
PERCENTILE RANK
100
90
80
70
60
50
40
30
20
10
0
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
YEAR

Figure 6.130.

Table 6.76. Mean monthly and annual rainfall (mm) at selected stations in Zambia

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
North	Mbala	1673	240	210	211	117	18	2	0	1	5	14	150	252	1220
	Mporokoso	1434	231	228	256	124	23	2	0	2	13	55	189	239	1361
	Kawambwa	1324	233	190	251	136	20	1	0	3	17	81	201	262	1393
	Kasama	1382	282	228	233	73	11	1	0	1	2	21	161	274	1287
	Isoka	1360	223	245	235	72	9	1	1	0	2	11	88	215	1089
	Mansa	1259	236	215	193	54	4	0	0	0	4	29	168	251	1157
	Santa Maria Mission	1144	324	305	290	72	13	0	0	0	0	16	151	300	1458
	Mpika	1402	249	244	162	33	6	1	0	1	1	7	86	266	1054
Northwest	Mwinilunga	1361	225	217	276	88	8	1	0	2	17	85	223	268	1410
	Solwezi	1386	288	220	223	67	5	0	0	1	4	46	194	263	1311
	Nchanga	1250	311	262	191	66	6	1	0	0	3	26	152	300	1318
	Kasempa	1234	256	225	156	30	3	0	0	0	5	36	159	267	1137
Southwest	Zambezi	1077	230	218	152	34	4	1	0	0	7	40	144	216	1046
	Kaoma	1213	229	219	110	27	4	0	0	0	3	25	113	228	959
	Mongu	1053	234	215	131	45	5	1	0	0	2	35	108	208	984
	Machili	1068	203	162	93	22	3	1	1	1	3	29	92	176	779
	Sesheke	949	180	172	93	25	2	2	0	0	2	29	83	158	746
Central	Ndola	1270	299	268	151	41	7	1	0	1	2	22	140	292	1224
	Serenje	1384	272	271	153	42	5	0	0	1	1	12	114	305	1175
	Mpongwe	1220	259	227	146	38	4	0	0	1	1	26	134	266	1103
	Kabwe	1206	258	203	108	24	4	0	0	2	2	22	99	254	976
	Chingombe Mission	519	229	220	107	25	3	1	0	1	1	12	76	242	899
	Namwala	1001	207	175	75	23	3	0	0	1	1	23	90	230	822
	Lusaka	1152	233	178	69	23	6	1	0	1	2	14	90	209	825
	Feira	345	182	182	73	13	3	0	0	1	1	8	65	173	687
	Kafue	978	211	180	57	18	3	0	0	0	1	14	95	236	816
	Choma	1213	210	185	79	24	8	1	0	0	3	19	101	200	831
	Maramba	985	209	169	81	26	1	1	0	1	3	26	84	201	800
Southeast	Lundazi	1143	217	179	156	43	6	1	0	1	1	8	68	192	871
	Chipata	1032	275	242	144	56	3	1	0	0	1	7	93	217	1039
	Petauke	1036	265	246	126	27	6	1	0	2	2	12	109	214	1010

Table 6.77. Harvested area, yield and production of selected crops in Zambia

	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	1,220	1,105	1,215	871	772	745	1,063	798	905
Wheat	2	2	2	5,250	2,701	4,063	8	4	7
Maize	1,000	900	1,000	950	778	800	950	700	800
Rice (paddy)	4	3	3	1,105	1,129	1,094	4	4	4
Millet	135	130	130	444	462	462	60	60	60
Sorghum	80	70	80	500	429	438	40	30	35
Roots & tubers, total	56	58	59	3,463	3,403	3,409	194	198	200
Potatoes	-	-	-	8,667	8,710	8,750	3	3	3
Sweet potatoes	3	3	3	6,923	7,143	7,250	18	20	20
Cassava	17	18	19	3,006	3,000	3,243	52	54	60
Pulses, total	13	13	15	903	923	933	11	12	14
Soybeans	2	2	2	1,293	1,245	1,364	3	3	3
Groundnuts in shell	138	138	145	533	533	552	74	74	80

Table 6.78. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Zambia (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Cassava
North	145,000	15,000	13,000	300	600	14,000
Southeast	195,000	12,000	13,000	400	600	5,500
Central	485,000	35,000	40,000	1,300	1,500	16,500
Northwest	48,000	4,000	6,500	-	200	5,500
Southwest	97,000	12,000	60,000	-	200	14,000

Table 6.79. CROP CALENDAR FOR ZAMBIA

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
North	Rainfall		244	227	236	73	10	0	0	1	2	23	132	243
	Maize					000000	000000	00					///	//////
	Sorghum					000000	000000	00					///	//////
	Millet					000000	000000	00					///	//////
Southeast	Rainfall		247	220	159	34	5	0	0	1	2	8	80	199
	Maize					000000	000000	00					///	//////
	Sorghum					000000	000000	00					///	//////
	Millet					000000	000000	00					///	//////
Central	Rainfall		231	211	133	25	3	0	0	0	2	19	96	198
	Maize					000000	000000	00					///	//////
	Sorghum					000000	000000	00					///	//////
	Millet					000000	000000	00					///	//////
Northwest	Rainfall		266	235	207	63	6	1	0	1	7	57	177	274
	Maize					000000	000000	000					//////	//////
	Sorghum					000000	000000	00					///	//////
	Millet					000000	000000	00					///	//////
Southwest	Rainfall		200	196	136	30	2	1	0	0	4	33	114	208
	Maize					000000	000000	00					///	//////
	Sorghum					000000	000000	00					///	//////
	Millet					000000	000000	00					///	//////

TABLE 6.80.

ZAMBIA

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1974, July	Maize Crop Heavily Damaged by Fungus
1978, February	Flood Around Lusaka
1978, February	Heavy Rains Caused Some Damage on the Agricultural Crops
1979, January	Drought Reduced the Main Maize Production (to be Harvested in Mid-1979) by 25-40 percent
1980, February	A Three Week Dry Spell in January and February has Caused Substantial Losses to the 1980 Maize Crop in the Southern Province
1980, May	Heavy Rains at Ripening Time Damaged the Maize Crop
1982, March-April	Poor Rainfall Reduces Crop Production by Half of 1981's. Drought is Worst in 50 Years. Most Affected are Gwembe, Kalomo, Namwala and Maramba Areas
1982 -	Drought During 1981/82 Season Struck Luano Valley in the Central Province, Causing Famine. Also Affected by Drought were the Eastern, Southern and Western Provinces. In the Southern Province Worst Affected were Kalomo, Maramba and Gwembe Areas
1982, January	Prolonged Drought in the Eastern and Southern Provinces During the Current Season, Affects Maize Crop

R. ZIMBABWE

1. Agroclimatic Conditions and Regions

The central one-third of Zimbabwe consists of several plateaus with an altitude mainly between 1,000 and 1,500 m (Figure 6.131). To the north the altitude decreases towards the Zambezi River Valley. To the south are the valleys of the Shashi, Limpopo and Sabi rivers: the central highland plateaus gradually turn into lowlands. The most pronounced mountains in Zimbabwe are along the eastern border with Mozambique, with many peaks around 2,300-2,500 m high.

The country has been divided into four agroclimatic regions (Figure 6.133). The Northeast is wettest with about 800 mm annual rainfall, the South driest with only 472 mm. Within the regions rainfall amounts are quite uniform, with the exception of the mountainous areas along the eastern border where rainfall is much higher (Table 6.81). The seasonal variations of rainfall are the same all over the country - the season normally begins in November and lasts until the end of March. The period with mean monthly rainfall of 100 mm or more is 3 or 4 months over the greatest part of the country (Figure 6.132; see also Chapter VII, E). The southern areas where months with such rainfall may range from 0 to 2 are notable exceptions.

2. Agriculture

Maize is the most important food crop in Zimbabwe (Table 6.82). Part of the maize produced is exported every year. Other important food crops are millet, sorghum, groundnuts, wheat, beans, soybeans and cassava. Maize and wheat are grown mostly in the Northeast agroclimatic region, while groundnuts and more drought tolerant crops like sorghum and millet are grown mostly in the south (Table 6.83 and Figures 6.135 and 6.136).

The crop calendar in Zimbabwe is the same throughout the country. Sowing of the crops begins soon after the onset of the rainy season in November, while harvesting normally starts in April and continues until the middle of May (Table 6.84).

3. Factors Affecting Yield and Their Assessment

As the episodic event data indicate, drought is the most important meteorological factor affecting crop yields (Table 6.85). The years with

drought, as well as with good rainfall, are shown on Figure 6.137. The proposed Early Warning Assessment Program is described in Chapter VII. It requires selection of representative stations with data for individual years for each agroclimatic assessment region. The number of these stations in Zimbabwe and their common periods of record are shown on Table 7.1. The location of the stations is shown on Figure 6.138. In addition to the stations with common period of records (used for the assessments), Zimbabwe has historical meteorological data for some other stations. They are not used for the assessments because of various reasons - primarily due to incomplete or short time series. All stations in the country are described in detail in the "Directory of Stations" - Appendix A.

Since agrometeorological events and crop information are often reported for the administrative provinces of the country, their boundaries, together with those of the agroclimatic regions, are shown on Figure 6.134.

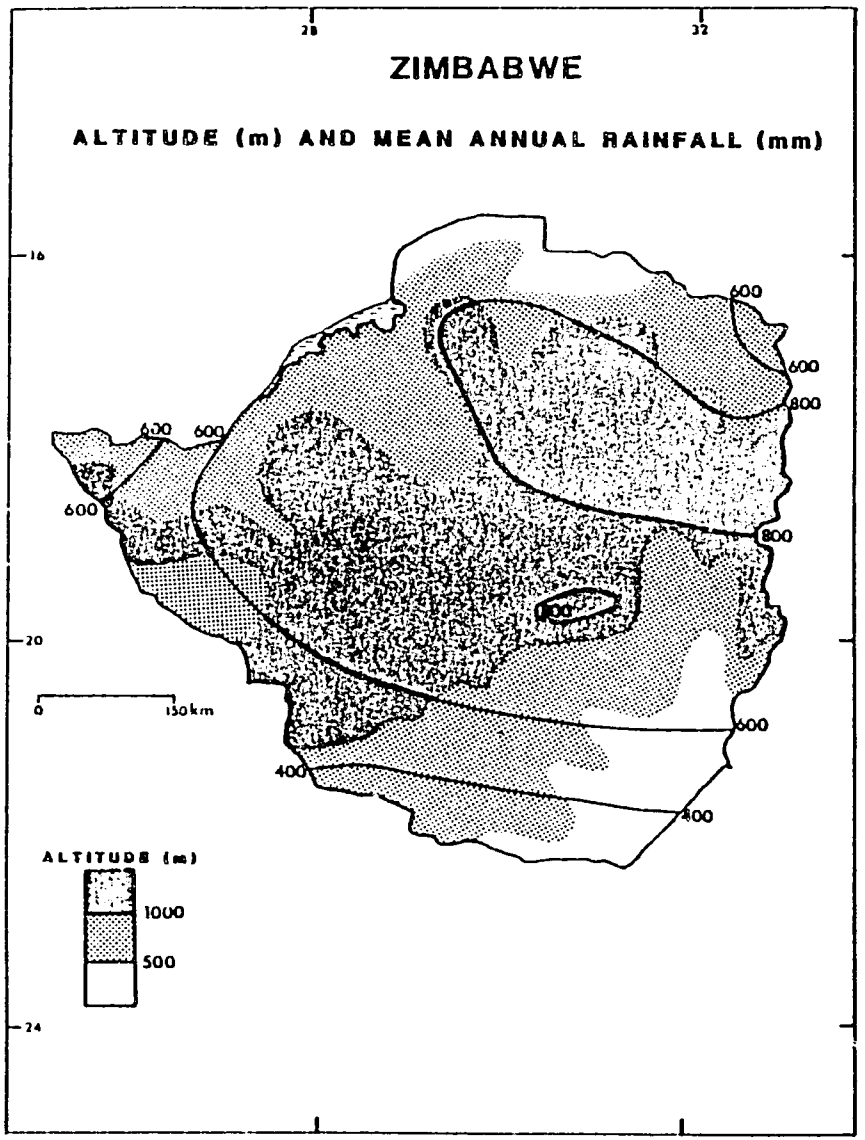


Figure 6.131.

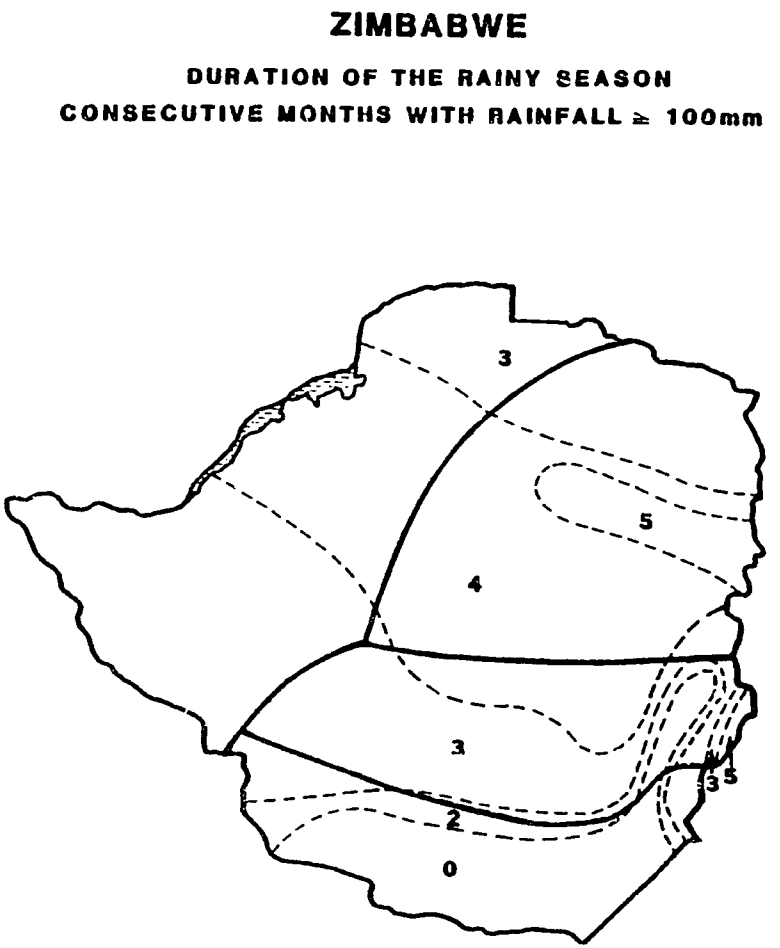


Figure 6.132.

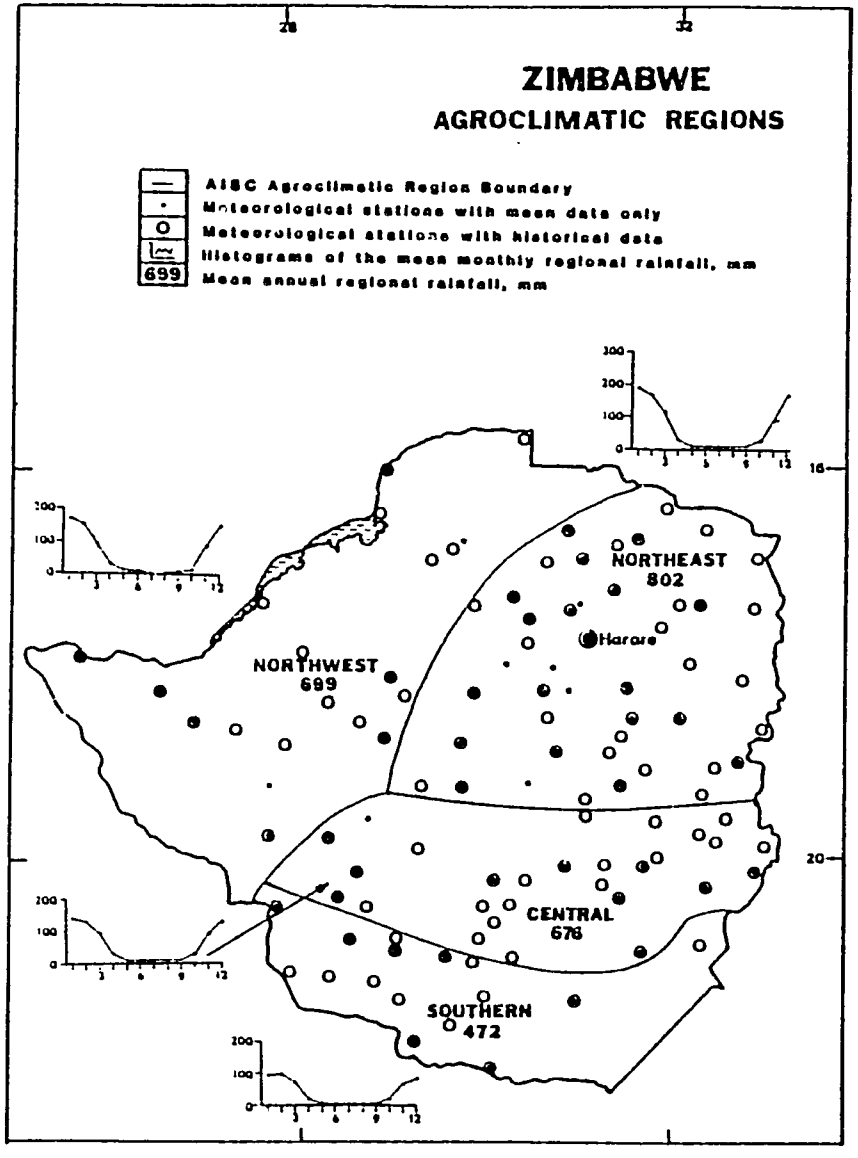


Figure 6.133.

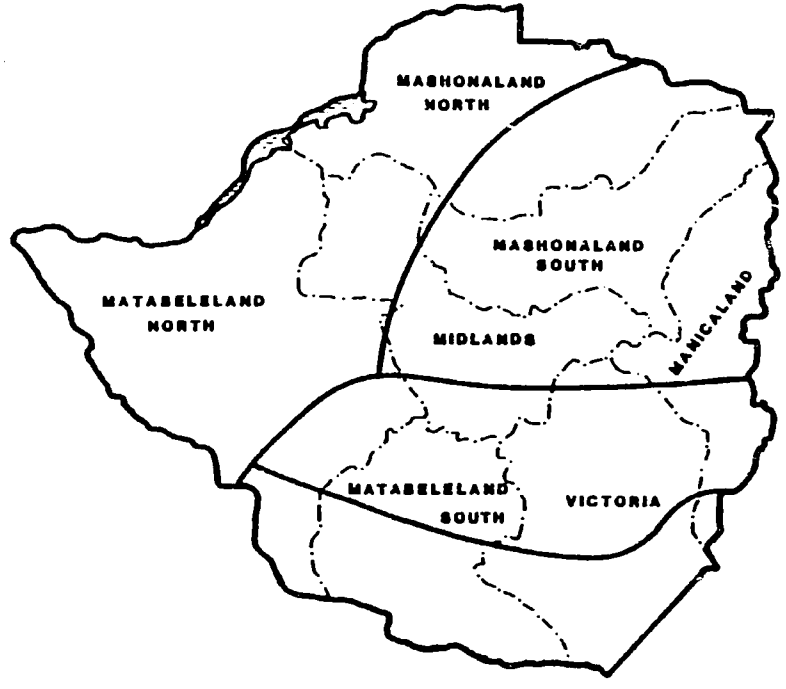


Figure 6.134.

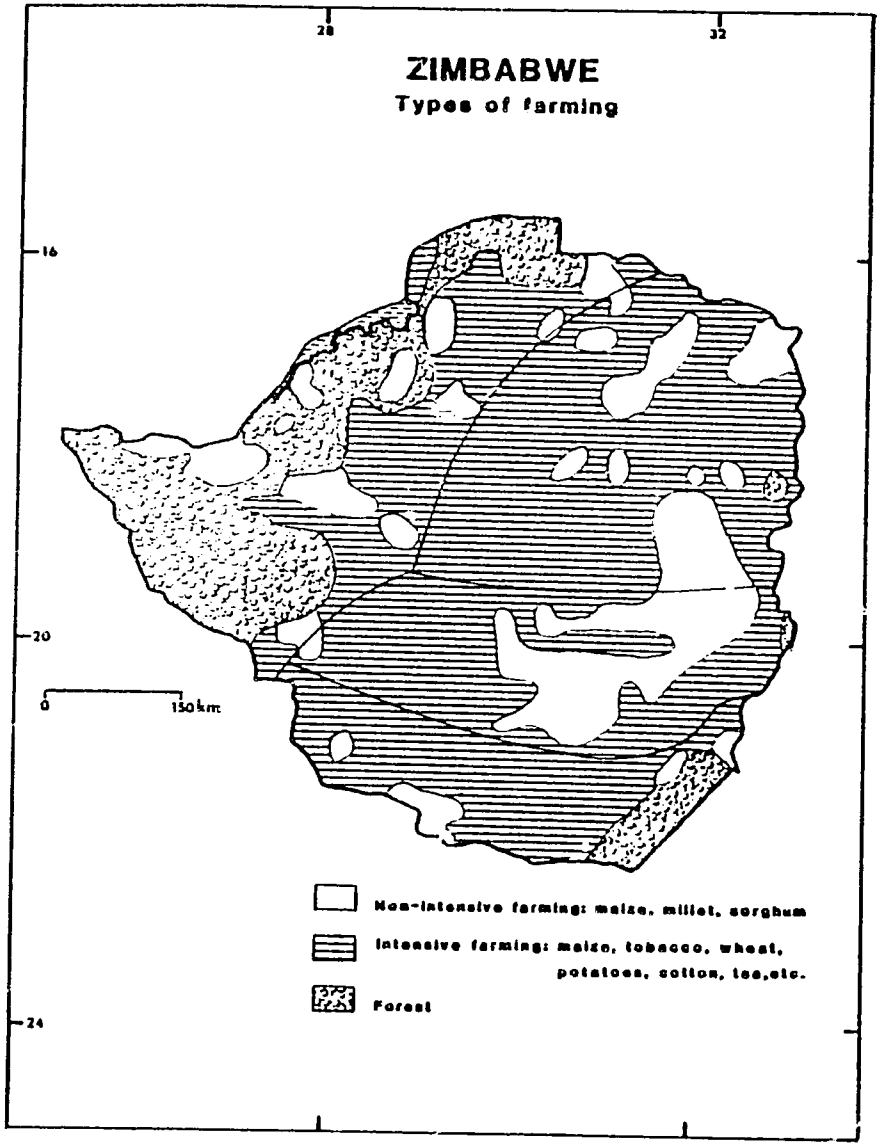


Figure 6.135.

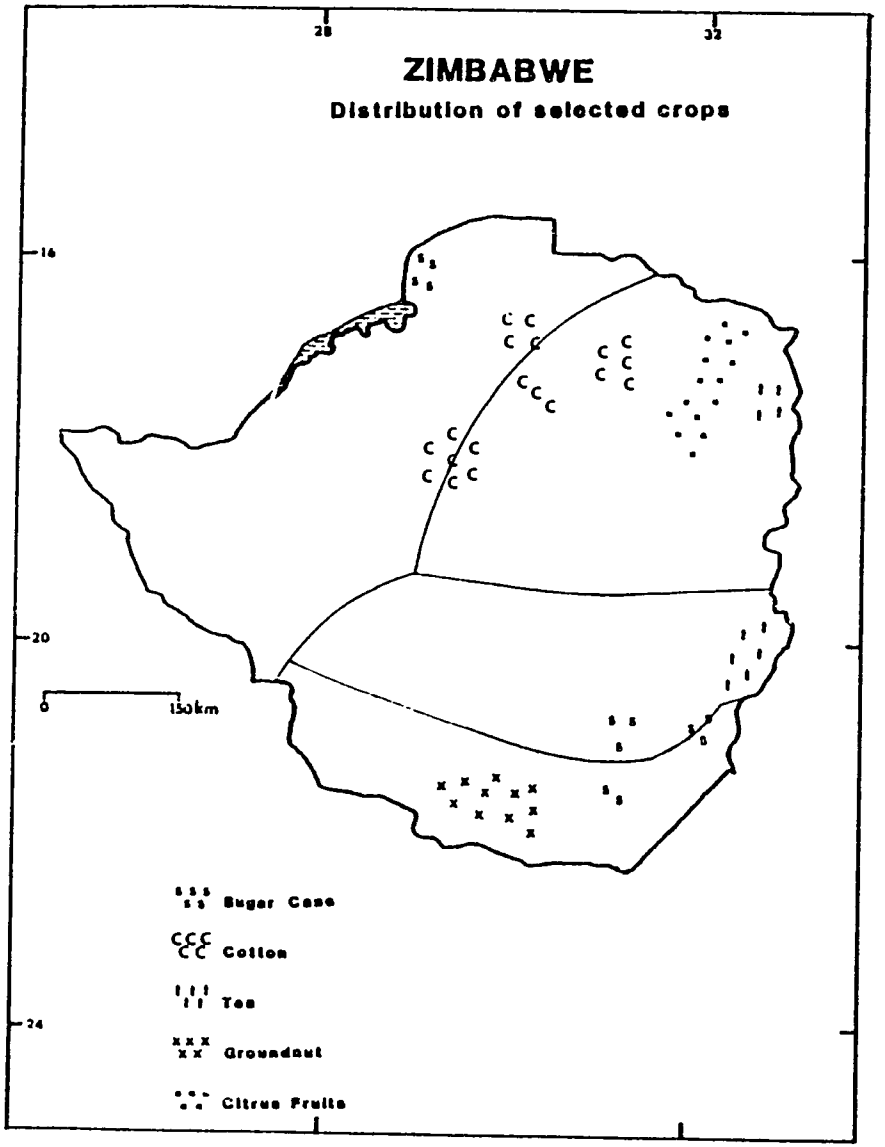


Figure 6.136.

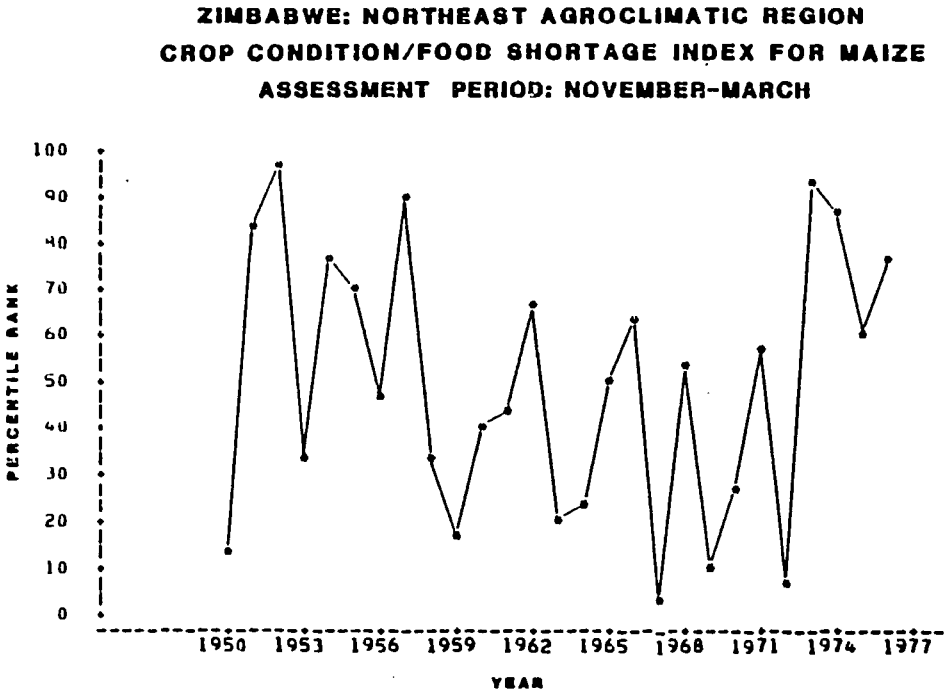


Figure 6.137.

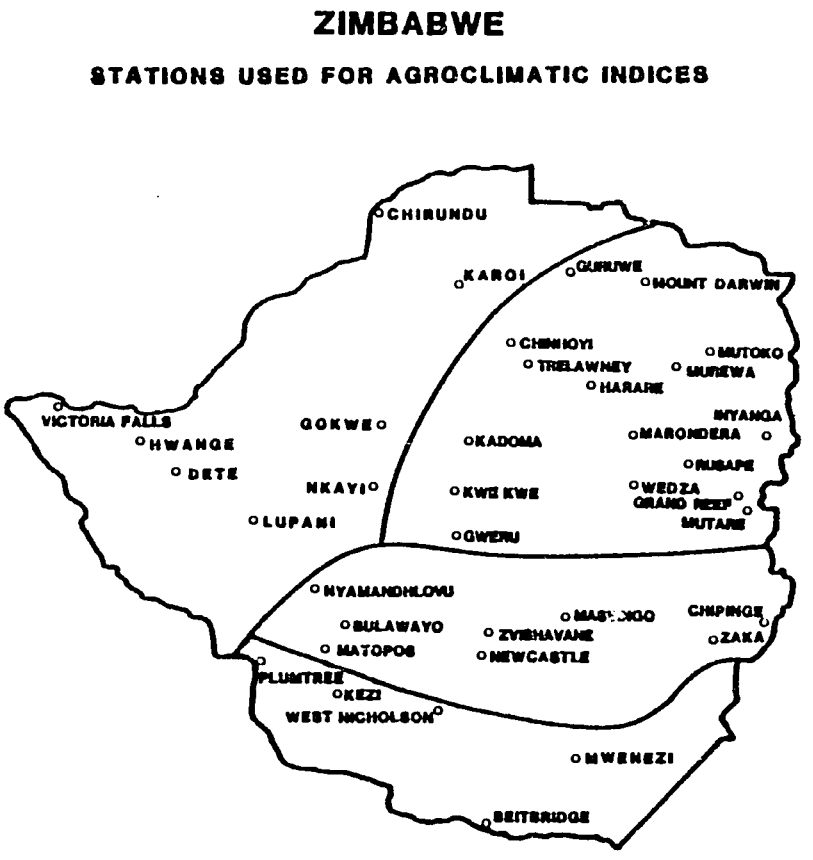


Figure 6.138.

Table 6.81. Mean monthly and annual rainfall (mm) at selected stations in Zimbabwe

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Northwest	Chirundu	395	185	150	73	23	3	0	0	0	1	7	66	174	689
	Karoi	1346	195	193	99	39	8	3	1	1	5	15	96	189	847
	Victoria Falls	925	196	142	77	23	3	0	0	0	2	21	73	196	731
	Gokwe	1284	205	175	83	36	7	1	1	1	3	22	105	187	822
	Hwange	728	151	121	63	17	2	0	0	0	1	9	64	136	566
	Dete	1077	162	139	72	26	5	0	0	0	4	22	68	160	655
	Nkayi	1131	172	131	61	29	9	3	0	1	7	17	90	160	676
	Lupani	994	162	137	74	26	7	1	0	1	5	22	69	154	658
Northeast	Guruwe	1184	199	179	86	33	12	3	1	1	3	14	69	191	792
	Mount Darwin	966	218	166	91	33	6	2	1	1	3	11	81	181	803
	Chinhoyi	1143	208	180	95	38	8	4	1	2	6	22	101	165	825
	Mutoko	1245	177	162	74	33	9	4	1	1	11	12	75	165	726
	Trelawney	1326	216	177	89	44	9	3	1	2	6	32	104	184	858
	Murewa	1381	218	178	104	47	15	5	1	1	8	22	94	203	889
	Harare	1471	187	159	80	48	12	4	2	3	10	36	109	186	835
	Kadoma	1157	189	164	75	33	5	1	0	1	4	30	97	160	755
	Marondera	1640	189	160	92	53	15	6	2	3	8	39	121	209	896
	Inyanga	1859	263	220	122	55	13	14	13	17	14	47	129	240	1154
	Rusape	1430	185	162	82	42	13	7	4	5	8	37	120	182	839
	Kwe Kwe	1215	157	135	63	28	7	4	0	1	4	30	104	175	702
	Tedza	1384	162	161	86	43	11	7	3	6	7	34	123	192	825
	Grand Reef	1018	169	149	79	33	12	7	2	8	11	29	100	177	769
	Mutare	1119	182	156	85	25	13	8	4	8	17	42	89	169	787
	Gweru	1429	137	126	71	30	7	4	0	1	9	33	100	176	693
Central	Nyamandhlovu	1219	139	113	59	27	7	1	0	1	6	21	80	127	574
	Masvingo	1097	138	112	70	25	11	7	1	3	7	22	89	170	645
	Chipinge	1132	220	222	137	62	29	28	15	27	22	52	119	230	1163
	Bulawayo	1345	132	107	52	32	9	2	0	2	8	29	94	149	616
	Zvishavane	975	135	103	62	26	7	7	1	3	8	22	83	134	587
	Zaka	774	151	147	79	35	21	13	4	6	9	26	103	200	780
	Matopos	1347	132	100	72	25	9	2	0	0	5	28	94	137	600
	Newcastle	1070	163	151	88	50	17	20	5	12	26	27	93	157	798

continue.....

Table 6.81. Mean monthly and annual rainfall (mm) at selected stations in Zimbabwe (continued)

REGION	STATION	ELEV (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
South	Plumtree	1390	124	121	64	30	7	2	0	0	8	24	84	125	588
	Kezi	1015	114	107	51	33	7	5	0	2	5	21	76	118	532
	West Nicholson	861	108	98	43	25	8	9	1	3	8	19	70	98	480
	Mwenezi	477	120	85	46	23	9	8	1	2	8	19	66	87	458
	Beitbridge	457	78	55	34	21	9	3	0	1	10	28	40	70	344

Table 6.82. Harvested area, yield and production of selected crops in Zimbabwe

Crops	Harvested area (in 1,000 hectares)			Yield (in kg/hectare)			Production (in 1,000 metric tons)		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Cereals, total	1,503	1,323	1,697	1,414	1,346	1,201	2,125	1,781	2,038
Wheat	48	37	34	4,450	4,352	4,521	212	160	155
Maize	931	800	1,146	1,736	1,500	1,396	1,616	1,200	1,600
Rice (paddy)	3	3	3	1,667	1,667	1,667	5	5	5
Millet	390	400	380	513	850	474	200	340	180
Sorghum	128	78	129	573	667	438	40	30	35
Roots & tubers, total	19	20	21	3,832	3,760	3,973	74	76	82
Potatoes	2	2	2	11,000	10,000	10,136	22	22	22
Sweet potatoes	-	-	-	2,982	2,867	2,917	-	-	-
Cassava	17	18	19	3,006	3,000	3,243	52	54	60
Pulses, total	44	50	50	472	476	476	21	24	24
Beans (dry)	42	48	48	476	478	479	20	23	23
Soybeans	25	33	35	1,800	2,101	2,348	44	70	81
Groundnuts in shell	217	161	120	700	700	700	152	113	84

Table 6.83. Estimated area (in hectares) planted to different agricultural crops in the agroclimatic regions of Zimbabwe (a hyphen means the crop is not grown in the region; a star means the crop is grown on very small areas and data of its size are not available).

Agroclimatic Region	Maize	Sorghum	Millet	Wheat	Rice	Casava
Northwest	135,000	28,000	117,000	4,000	700	6,500
Northeast	670,000	6,000	20,000	32,000	-	4,500
Central	125,000	22,000	60,000	4,000	700	5,500
South	25,000	56,000	195,000	-	1,500	1,700

Table 6.84. CROP CALENDAR FOR ZIMBABWE

Six symbols (//////) indicate a month; three symbols (///) indicate half month; two symbols (//) indicate ten days

////// = sowing 000000 = ripeness

Agroclimatic Region	Mean Regional Rainfall, Crop	Season	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northeast	Rainfall		186	162	112	27	7	5	2	2	5	25	98	172
	Maize					000000	000						///	//////
	Sorghum					000000	000						///	//////
	Millet					000000	000						///	//////
Northwest	Rainfall		173	152	91	23	4	2	0	0	2	18	84	148
	Maize					000000	000						///	//////
	Sorghum					000000	000						///	//////
	Millet					000000	000						///	//////
Central	Rainfall		140	135	97	25	10	10	6	5	8	23	88	129
	Maize					000000	000						///	//////
	Sorghum					000000	000						///	//////
	Millet					000000	000						///	//////
South	Rainfall		97	99	69	20	6	6	1	2	5	20	65	82
	Maize					000000	000						///	//////
	Sorghum					000000	000						///	//////
	Millet					000000	000						///	//////

TABLE 6.85.

ZIMBABWE

Summarized episodic event data on reported weather and non-weather factors having adverse impact on crop conditions and food security.

DATE	EPISODIC EVENT
1966, January	Flood Along the Umbeluzi River
1977, February	Unsatisfactory 1976/1977 Rainy Season. Some Areas had No Rainfall and Crops Suffered Irreparable Damage. Excessive Late February Rainfall Further Reduced Yield - Mainly Due to Rotting and Spread of Diseases
1979, January	A Long Dry Spell Affected the 1979 Maize Crop in Several Areas
1979, May	Drought Severely Affected the Maize Crop
1979, July	Drought Reduced Maize Production to About 30% of Normal
1980, January	Serious Mid-Season Drought During January and Early February Affected Maize Crop
1980, April	Drought Reduced the 1980 Maize Crop to About 70% of Normal
1981 -	Drought Caused $30 Million Damage on Communal Livestock
1982, February	Drought Affected Planting of the Maize Crop
1982, April	Cotton Production is 27% Lower than Last Year's, Due to Early Break in the Rains this Season, and Very High Day Temperatures
1982, April-May	Severe Drought
1982, October	Drought-Starved Cattle in the Midlands - Kwe Kwe
1982, November	Many Boreholes around Beitbridge Dry Up, Cattle Die because of Drought. Worst Hit are Siyoka-Dendele and Maramani-Machuchuta
1982, December	Only About 20% of the Crops are in Fair to Good Condition Due to the Late Beginning of the Rainy Season
1982 -	The Drought in Matabeleland was the Worst Since 1947
1982, January	Severe Drought Affected Southern and Central Agroclimatic Regions, and Very Serious Drought Affects the Northeastern Region. Cattle Dying Daily and Crops Withering Beyond Recovery

Chapter VII

PROPOSED EARLY WARNING ASSESSMENT PROGRAM

The primary purpose of this proposed Early Warning Assessment Program (EWAP) is to provide timely, reliable yet inexpensive information on the potential for food shortages caused by unfavorable weather. In most cases, food shortages in Subequatorial Africa are related to drought. In some years however, floods also cause food shortages. Damages from other meteorological elements, such as hail or strong winds, usually are on a smaller scale. The only exception perhaps is Madagascar, where frequent cyclones plague agriculture and in addition to the damages caused by heavy rains and floods, strong winds also harm the crops.

The preparation of this EWAP was carried out at different stages. Some of them are considered background information, and were reported in the preceding chapters. These are the studies on climate, agricultural practice, crop calendars, episodic events, physical environment, and population and food security. Further steps in the preparation of the EWAP involved determination of assessment regions, analysis and processing of the meteorological and crop data, determination of indices, determination of rainfall and drought assessment categories, guidelines for the preparation of the assessments. They are briefly discussed in the following sections.

A. AGROCLIMATIC ASSESSMENT REGIONS

1. Determination of Regions

As known, agroclimatic assessments can be made for areas of different size. If an assessment is made for a country as a whole, droughts or floods that occur only over certain areas of this country might not be detected and assessed. On the other hand, dividing a country into too many smaller size regions (for more detailed assessments) can overextend available project resources.

Another consideration to be taken into account when deciding the number of regions for a country is the type and amount of data (both meteorological and crop) available for assessments. The most appropriate solution was to divide the territory of each country into several agroclimatic assessment regions. The largest country in Subequatorial Africa, Zaire, has the largest number of regions (7). The smallest countries - Rwanda,

Burundi, Swaziland and Lesotho - each have only one. Gabon has two regions, while the rest of the countries have between 3 and 6. For convenience, the figures with the agroclimatic assessment regions for each country are placed in Chapter VI, while an overview of all regions in Subequatorial Africa is shown in Figure 1.2. Chapter VI also contains varied climatological and agricultural information for the assessment regions in each country.

The assessment regions were defined on the basis of common climate and agricultural practice and because of this they are completely different from the regions used by NOAA until recently. Among the climatic elements used to define the regions, the main emphasis was on the regime of rainfall - both the amount and the seasonal variations within the boundaries of a region are quite homogeneous. The homogeneity of the regions however, should not be considered as absolute. Within most regions there are smaller areas with specific climatic or microclimatic features.

2. Selection of Representative Stations

Two main sets of stations were selected for each assessment region:

a) Stations having only mean (normal) rainfall values. These stations were selected from Wernstedt's "World Climate Data" (1977), and were used to calculate the mean "Wernstedt" amount of rainfall (weekly, monthly, annual) for each region. The main reason for using this source of data is that "Wernstedt" normals are available for a very large number of stations. The number of stations selected for each region and country is shown in Table 7.1. A total of 842 stations were selected for Subequtorial Africa.

b) Stations with data for individual years. These stations are far more important because they have meteorological data for many years - in many cases up to 50-60 years - and represent the foundation for a very useful assessment tool. The total number of these stations in Subequatorial Africa is 689 (Table 7.1). ~~The names, coordinates and other information are shown in the Station Directory in Appendix A.~~

The assessment regions in all countries expect Madagascar are adequately covered with such stations. Despite all efforts to obtain more data, Madagascar has only eleven stations of this type; this allows assessments to be made but coverage is considered to be below the optimal. On the other hand, some countries have more stations than are necessary for the assessments. ~~and these stations were not included in the directory.~~

Table 7.1. Subequatorial Africa:agroclimatic assessment stations with rainfall data for the indices (a star (*) means some of the stations are located in neighboring countries)

Country	Agroclimatic region	Number of stations with normal values only (Wernstedt)	Stations with data for individual years			Crops to be assessed (2 or 3 of a crop means the crop is grown 2 or 3 times within a year)
			total number	with common period of records		
				number	period	
Angola	Northwest	7	11	10	1954-75	-
	North Central	19	31	18	1954-75	maize,sorghum,millet
	Northeast	10	11*	9	1954-75	maize,sorghum,millet
	Southwest	2	7	5	1954-75	-
	South Central	7	14*	12	1954-75	sorghum,millet
	Southeast	0	5*	5	1955-75	sorghum,millet
Botswana	North	2	3	3	1955-78	maize,sorghum,millet,beans
	Southwest	2	3	3	1958-80	sorghum,millet,beans
	Southeast	15	10	10	1945-80	maize,sorghum,millet,beans
Burundi	Burundi	39	9*	3	1940-59	2 beans,3 maize,3 sorghum,3 millet
Congo	North	5	3	3	1951-72	-
	Central	19	6	6	1951-72	maize,rice
	Southwest	16	5	4	1951-72	maize,groundnut,2 rice
Gabon	East	10	7	6	1951-74	maize,2 groundnut
	West	15	7	7	1951-74	maize
Kenya	Northeast	11	7	5	1950-75	sorghum,millet
	West	19	5	3	1950-79	maize,2 sorghum,2 millet,wheat
	Central	17	11	7	1950-79	maize,2 sorghum,2 millet,wheat
	Southwest	14	3	3	1950-71	maize,sorghum,millet
	Southeast	9	3	3	1940-71	maize
Lesotho	Lesotho	30	18*	16	1951-77	maize,sorghum,2 wheat
Madagascar	North	10	3	2	1951-74	2 rice,maize
	Northeast	10	2	2	1951-74	2 rice
	Southeast	10	2	2	1951-74	2 rice
	Southwest	16	1	1	1951-74	rice,maize,sorghum
	West	14	2	2	1951-74	2 rice,maize
	Central	22	1	1	1951-74	2 rice,maize
Malawi	North	5	7	4	1955-77	maize,sorghum,millet
	Central	5	13*	5	1954-73	maize,sorghum,millet
	South	10	16	9	1954-73	maize,sorghum,millet

(Second part of Table 7.1)

Country	Agroclimatic region	Number of stations with normal values only (Wernstedt)	Stations with data for individual years: total number	with common period of records: number	with common period of records: period	Crops to be assessed (2 or 3 of a crop means the crop is grown 2 or 3 times within a year)
Mozambique	North	22	27*	19	1943-68	maize,sorghum,millet
	Central	15	16*	14	1943-68	maize,sorghum,millet
	South	18	14*	13	1943-68	maize,sorghum,millet
	Northwest	7	16*	10	1947-68	maize,sorghum,millet
Namibia	Northeast	5	12	10	1940-76	maize,sorghum,millet
	Central	15	17	14	1940-76	maize,sorghum,millet
	South	12	13	9	1940-76	-
	West	2	4	2	1945-76	-
Rwanda	Rwanda	30	7*	3	1951-60	3 maize,3 sorghum,2 beans
Swaziland	Swaziland	40	14*	13	1949-77	maize,sorghum,rice
Tanzania	Northwest	25	12	6	1950-77	maize,3 sorghum,3 millet
	Northeast	6	4	3	1940-69	maize,sorghum,wheat
	Southwest	12	4	2	1950-77	maize,sorghum,wheat
	South	19	6	4	1950-77	maize,sorghum,wheat
	Central	12	6	6	1950-77	sorghum,millet
	East	19	13	9	1940-69	maize,sorghum,rice
Uganda	Northeast	5	1	1	1950-74	2 sorghum,2 millet
	North Central	33	14	10	1950-74	maize,2 sorghum,2 millet
	Southwest	12	4	3	1950-74	2 maize,2 sorghum,2 millet
Zaire	North	7	12*	7	1940-59	maize,2 rice
	North Central	14	12	9	1940-59	2 rice
	Northeast	9	13*	6	1940-59	2 sorghum,2 millet,2 maize,2 rice
	East Central	8	8*	5	1940-59	2 sorghum,2 millet,2 maize,2 rice
	South Central	18	15*	8	1940-59	2 maize
	South	19	24*	12	1940-59	sorghum,millet,maize
	West	9	9*	5	1940-59	maize
Zambia	Northwest	3	5	4	1950-74	maize,sorghum,millet
	North	7	22	8	1950-74	maize,sorghum,millet
	Southwest	6	8	5	1950-74	maize,sorghum,millet
	Southeast	3	4	3	1950-74	maize,sorghum,millet
	Central	9	26	11	1950-74	maize,sorghum,millet
Zimbabwe	Northwest	9	18	8	1950-77	maize,sorghum,millet
	Northeast	24	40	16	1950-77	maize,sorghum,millet
	Central	11	27	8	1950-77	maize,sorghum,millet
	South	7	16	5	1950-77	maize,sorghum,millet
Total	65	842	689	440		208

Also not included are stations whose data were either for a very short period or found to be unreliable.

Another approach worth mentioning is the use of stations from neighboring countries. In order to improve the coverage for some regions, nearby stations from adjacent countries were selected and added to the meteorological data base of the "host" country. This method is used mainly for Lesotho, Rwanda and Burundi, where very little data was available. One to four stations were also added to Zaire, Mozambique and Swaziland.

B. METEOROLOGICAL DATA ANALYSIS AND PROCESSING

1. Quality Control

The primary purpose of the quality control was to provide reliable meteorological data for the EWAP. The success of an EWAP depends not only on the quality and reliability of the meteorological data for the current year, but also on the quality and reliability of the whole time series of past meteorological data. This is because the assessment methods proposed in this report require comparison of the conditions existing during the current year with those in the past.

The entire time series of the 689 stations were subjected to quality control. The total number of checked individual meteorological values is about 400,000 (689 stations, each one with about 30 years of data, each year with 12 monthly and one annual rainfall values; about one-third of the stations have temperature data as well). The quality control of the meteorological data consisted of two main activities:

a) Filling in missing data. Few stations have a time series of 30 or more years with data for all months and years during this period. For assessment purposes a missing monthly value means missing the whole year. Missing a year for one station means putting more weight on the values of the other stations in the region when the average regional value is calculated for each year. The estimation of missing rainfall or temperature values was carried out by using the well known methods practiced in processing climatological data.

b) Correction of erroneous data. There is a large number of factors and reasons that might lead to incorrect meteorological data for individual months or even years. Besides human errors, some other reasons are due to

changes in the location of a station or its surroundings, malfunctioning instruments, change of methods for observations. As a result, many stations had some incorrect values in their time series which had to be corrected.

2. Determination of Common Period of Records

In an EWAP based on regional values, the meteorological data for all stations in the region should have the same period of record. It was therefore necessary to compare the time series, determine a common period, and omit those stations without data for it.

The main problem in determining a common period of record for each region was whether to select more stations (and thus having better geographical coverage) with shorter period of records or fewer stations with longer records. A typical example is the Western assessment region in Kenya, with five stations. Two of them have 21 years of data, ending in 1971. The other three have 30 years of data, ending in 1979. It was decided to use for assessment only the three stations with 30 years of data - not only because of the longer period, but also because the data cover more recent years.

The number of stations selected for each region and their common periods are shown in Table 7.1. The total number of stations in Subequatorial Africa is 440. The length of the common periods is mostly between 20 and 30 years, the only exception being Rwanda with 10 years of data.

3. Calculation of Regional Values

After the quality control of the data and the determination of common periods of record for each assessment region, an EWAP requires the preparation of regional meteorological data bases. This in turn requires the calculation of monthly and annual regional rainfall and temperature values - both for each year of the common period and an average value for the whole period. The data bases can further be used to calculate frequencies, percentile rankings, weekly values, etc.

An important parameter is the ratio between the mean monthly regional rainfall calculated from the two different sources: the Wernstedt data and the data from the stations with the common period of records. This ratio is used in the assessments and will be discussed in more detail later in

this chapter. The mean monthly and annual rainfall from both sources is shown in Table 7.2.

C. CROP DATA ANALYSIS AND PROCESSING

1. Quality Control

Crop data, in addition to the crop calendars discussed in Chapter VI, consist of harvested area, yield and production for each crop and year. The data come from two sources: FAO Yearbooks and USDA. The quality of the crop data is marginal. The main reason for this is that most of the countries do not report the area, yield and production of their subsistence food crops. As discussed in Chapter IV, in most cases these crops, unlike the commerical crops, do not reach the market. Farmers grow them around their homes, for their own needs, and no records are maintained. The FAO and USDA data are only approximate estimates, sometimes differing considerably. There are also cases where the same yield is reported for 7 or 8 consecutive years, despite the fact that the agrometeorological conditions during these years were quite different.

The quality control of the crop data consisted mainly of giving preference to one of the data sets (FAO or USDA) in cases when they were different and of discarding data considered to be unreliable. Unlike the quality control of the meteorological data, no corrections or filling of missing crop data was done.

2. Determination of Crops for Assessments

The EWAP, especially in the early stages of its implementation, cannot cover all food crops grown in a country. A selection was made for the crops to be assessed in each country and region. These are the most important subsistence crops, shown in Table 7.3.

D. AGROCLIMATIC INDICES

1. General

One of the most important assessment tools in EWAP is the use of agroclimatic crop condition/food shortage indices. They are determined for each crop to be assessed in each region. The indices and the criteria for their interpretation are established by: 1) agroclimatic background information including agricultural practices and historic vulnerability according to episodic event data, 2) agroclimatic analysis of the data

Table 7.2. Mean monthly regional rainfall calculated from Wernstedt (W), and from stationa with common period (C)

COUNTRY	REGION	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		ANNUAL	
		W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C
Gabon	East	116	104	147	126	220	215	188	197	178	201	48	60	9	15	17	30	132	147	279	285	222	233	146	128	1702	1743
	West	188	228	199	208	268	275	252	260	196	199	24	14	4	2	8	6	85	75	331	329	295	395	231	246	2181	2246
Congo	North	68	59	88	89	169	166	153	157	174	188	125	136	89	113	138	137	202	208	213	234	174	175	86	69	1678	1732
	Central	148	145	167	155	202	197	215	202	182	171	40	43	17	17	37	51	124	140	222	223	233	234	181	181	1769	1759
	Southwest	138	142	140	145	196	203	200	189	99	99	2	2	1	0	2	1	16	18	100	100	231	234	170	162	1294	1296
Zaire	North	46	42	64	57	115	119	163	156	184	183	151	150	178	175	201	197	189	200	216	215	130	124	53	52	1690	1669
	Northeast	39	52	63	67	118	134	162	163	160	158	138	133	153	141	192	186	168	178	162	172	113	120	55	70	1524	1573
	Northcentral	121	106	125	104	174	163	173	167	172	155	115	121	112	131	168	164	197	195	221	220	208	193	136	136	1926	1854
	Eastcentral	156	163	141	151	177	181	169	207	99	125	24	35	16	32	44	53	84	103	124	161	177	206	169	207	1379	1625
	Southcentral	162	158	146	137	187	183	178	182	88	100	17	19	15	14	54	51	132	145	191	208	218	223	201	199	1589	1618
	South	198	205	173	182	191	199	117	115	22	18	2	1	1	1	6	8	28	33	83	92	172	174	220	223	1212	1251
	West	126	114	145	131	170	169	225	226	119	108	6	4	1	1	5	3	32	25	106	108	220	226	170	159	1324	1274
Angola	Northwest	61	72	92	86	132	153	167	165	40	34	0	0	0	0	1	1	3	4	22	29	96	108	74	73	688	733
	Northcentral	168	158	159	131	216	218	157	163	29	22	1	0	1	0	3	4	33	31	120	127	199	206	195	189	1282	1250
	Northeast	207	205	180	182	223	215	131	141	26	25	1	3	1	1	12	16	43	57	109	116	186	202	219	218	1338	1382
	Southwest	9	13	19	16	49	68	34	41	3	1	0	0	0	0	0	0	1	1	6	8	10	13	12	16	142	182
	Southcentral	135	149	154	137	163	178	69	69	4	4	0	0	0	0	0	1	3	3	42	39	88	97	131	114	790	790
	Southeast	150	167	160	143	140	120	40	37	5	3	3	0	2	0	2	1	5	5	30	22	100	72	150	108	787	672
Namibia	Northeast	113	120	118	120	94	85	37	34	4	4	0	0	0	0	0	0	1	2	18	15	52	51	92	73	530	504
	Central	73	72	74	79	74	73	35	32	12	4	1	1	1	0	0	0	1	2	10	10	25	27	46	38	353	340
	South	27	26	37	37	40	37	14	14	5	5	2	2	1	1	1	1	2	2	5	5	10	9	16	11	161	151
	West	10	1	12	2	12	5	7	2	4	2	2	1	1	1	1	1	1	1	1	1	3	1	6	1	58	16
Botswana	North	137	149	129	131	92	82	26	31	6	3	1	2	0	0	0	1	2	3	17	14	58	56	113	117	580	589
	Southwest	69	81	72	68	62	63	35	34	10	10	5	3	1	1	1	1	5	4	17	15	35	38	54	43	368	361
	Southeast	88	98	84	85	70	64	27	37	11	11	5	4	3	2	2	2	9	11	32	35	60	62	85	87	477	497
Zimbabwe	Northwest	173	178	152	149	91	75	23	27	4	5	2	1	0	0	0	1	2	3	18	17	84	79	148	169	699	706
	Northeast	186	191	162	164	112	86	27	39	7	10	5	5	2	2	2	4	5	9	25	29	98	100	172	185	802	831
	Central	140	151	135	132	97	77	25	35	10	14	10	10	6	4	5	8	8	12	23	29	88	94	129	169	676	737
	South	97	109	99	93	69	48	20	26	6	8	6	6	1	0	2	2	5	8	20	22	65	67	82	99	472	480
Zambia	North	244	252	227	233	236	229	73	85	10	13	0	1	0	0	1	1	2	5	23	29	132	152	243	258	1192	1256
	Northwest	266	270	235	231	207	211	63	63	6	6	1	0	0	0	1	1	7	7	57	48	177	182	274	275	1294	1294
	Southwest	200	215	196	197	136	116	30	30	2	4	1	1	0	0	0	0	4	3	33	32	114	109	208	198	925	906
	Southeast	247	252	220	222	159	142	34	42	5	5	0	1	0	0	1	1	2	1	8	9	80	90	199	208	955	973
	Central	231	234	211	205	133	100	25	27	3	4	0	0	0	0	0	1	2	2	19	18	96	100	198	238	919	929

continue on next page

Table 7.2. (continued)

COUNTRY	REGION	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		ANNUAL	
		W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C
Mozambique	North	249	252	226	228	207	227	94	95	30	25	18	16	11	13	10	7	7	6	12	11	55	67	167	186	1086	1133
	Northwest	223	212	204	201	139	122	35	38	7	9	7	7	6	5	4	4	3	3	12	9	89	76	178	190	906	877
	Central	252	244	225	238	211	196	85	85	39	43	40	38	29	27	25	26	18	17	29	25	114	102	226	191	1291	1233
	South	126	129	124	153	104	91	48	53	34	32	28	28	20	20	16	19	25	25	34	39	83	74	102	113	743	775
Malawi	North	206	222	208	188	214	264	145	160	44	43	11	17	8	10	6	2	5	2	14	5	57	65	149	197	1066	1176
	Central	240	265	258	247	200	184	65	87	14	13	2	4	1	2	2	1	3	1	4	6	65	64	175	212	1029	1086
	South	232	243	218	193	163	159	73	79	24	21	21	20	14	16	13	10	9	9	25	21	103	101	196	221	1090	1091
Tanzania	Northwest	109	122	108	118	148	149	169	181	81	77	17	13	9	10	17	10	34	31	57	60	111	132	136	142	995	1044
	Northeast	75	69	76	75	123	131	252	267	169	125	32	18	15	12	13	10	13	11	27	28	70	95	91	100	957	942
	Southwest	188	178	166	159	182	157	148	106	46	18	9	2	6	0	6	0	7	4	19	14	99	64	192	177	1069	881
	Central	125	129	103	120	118	118	83	71	22	13	3	1	1	0	1	0	2	1	9	5	37	32	101	127	604	617
	South	230	221	209	215	261	254	202	173	64	41	10	5	6	4	6	2	7	5	18	10	64	51	175	169	1251	1151
	East	129	112	115	107	155	139	184	204	95	110	19	25	16	19	17	21	21	23	38	42	71	83	113	107	972	992
Kenya	Northeast	7	9	6	10	38	34	96	84	39	34	7	6	11	10	6	6	9	4	40	22	67	61	37	24	362	303
	Southeast	20	12	11	8	43	40	152	175	319	316	128	131	84	79	60	58	58	63	71	65	67	61	57	37	1072	1046
	Southwest	36	36	33	27	78	92	118	130	47	34	7	4	3	2	5	4	7	9	29	47	120	208	105	115	590	708
	Central	35	49	36	47	81	76	165	144	105	89	38	33	49	36	51	40	32	26	73	46	125	106	71	67	860	760
	West	41	68	55	91	103	140	185	232	184	202	128	140	139	133	164	169	113	138	83	116	83	121	65	94	1343	1644
Uganda	Northeast	9	11	19	28	53	82	108	130	118	99	96	80	138	118	129	113	74	46	51	51	38	63	20	29	854	850
	Northcentral	28	38	45	53	96	107	167	177	160	160	101	97	107	103	148	135	129	129	123	143	95	111	55	61	1256	1341
	Southwest	53	55	73	72	109	118	149	165	107	105	42	48	34	33	76	75	120	118	133	147	128	139	86	91	1110	1165
Madagascar	North	397	364	350	337	252	221	97	56	23	13	20	12	18	10	19	12	17	11	36	31	108	116	253	232	1592	1413
	Northeast	356	396	375	342	387	378	307	254	210	207	218	233	198	223	168	204	115	105	83	86	145	146	260	254	2823	2828
	Southeast	340	276	355	251	378	330	203	189	160	171	176	172	134	166	114	144	86	81	72	102	142	185	240	178	2398	2244
	Southwest	144	95	124	87	74	45	18	12	16	23	17	13	8	5	6	4	10	11	20	8	52	27	123	98	612	428
	Central	337	271	291	206	230	214	66	41	23	16	15	10	14	12	16	14	16	18	52	44	147	171	270	335	1476	1351
	West	393	390	313	319	230	211	57	48	8	9	3	2	3	2	5	5	10	3	36	17	110	80	224	237	1392	1323
Rwanda	-	97	91	109	109	134	135	176	166	132	87	29	21	13	12	34	41	84	78	114	103	122	129	112	124	1156	1094
Burundi	-	130	138	129	134	158	160	193	195	98	94	13	8	4	3	14	11	50	43	93	75	143	145	152	164	1177	1170
Swaziland	-	155	145	140	139	115	93	57	65	28	31	15	14	17	14	18	19	46	45	82	85	126	129	148	139	946	918
Lesotho	-	113	145	105	128	91	111	50	63	31	30	10	14	12	11	17	19	29	36	65	76	83	101	102	118	709	851

Table 7.3. Index periods and coefficients for calculating YMI (in percentage)*

Country	Region	Crop	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Gabon	E	Maize	40	60	90	75								
	E	Groundnut 1	60	90	80									40
	E	Groundnut 2									40	60	90	80
	W	Maize	40	60	90	75								
Congo	C	Maize	80									50	80	100
	C	Rice 1									50	80	100	80
	C	Rice 2	40	60	90	100	80							
	SW	Maize	80									50	80	100
	SW	Rice	100	100	80							40	50	70
	SW	Groundnut	50	80	90	80								
Zaire	N	Maize							30	50	80	100		
	N	Rice 1		40	60	100	90							
	N	Rice 2							40	50	90	100	90	
	NE	Maize 1		30	50	100	90							
	NE	Maize 2							30	50	100	100		
	NE	Sorghum 1		30	50	100	90							
	NE	Sorghum 2							30	50	100	100		
	NE	Millet 1		30	50	100	90							
	NE	Millet 2							30	50	100	90		
	NE	Rice 1		30	60	100	90							
	NE	Rice 2							30	60	100	90		
	NC	Rice 1	30	50	70	100	90							
	NC	Rice 2							40	50	90	100	90	
	EC	Maize 1	30	50	90	100								
	EC	Maize 2									30	60	100	80
	EC	Sorghum 1	30	50	90	100								
	EC	Sorghum 2								30	40	70	90	
	EC	Millet 1	30	50	90	100								
	EC	Millet 2								30	40	70	90	
	EC	Rice 1	30	50	90	100								
	EC	Rice 2								30	50	70	100	90
	SC	Maize 1	30	50	90	100								
	SC	Maize 2									40	60	90	100
	S	Maize	80									40	60	90
	S	Sorghum	90	100	90							30	50	70
	S	Millet	90	100	90							30	50	70
	W	Maize										40	70	100
Angola	NC	Maize	100	90	70							50	60	80
	NC	Sorghum	90	70								50	60	100
	NC	Millet	90	70								50	60	100
	NE	Maize	100	90	70							50	60	80
	NE	Sorghum	90	70								50	60	100
	NE	Millet	90	70								50	60	100
	SC	Sorghum	90	70								50	60	100
	SC	Millet	90	70								50	60	100
	SE	Sorghum	90	70								50	60	100
	SE	Millet	90	70								50	60	100

continue.....

Table 7.3. (continued)

Country	Region	Crop	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Namibia	NE	Maize	80	100									30	40
	NE	Sorghum	80	100									30	40
	NE	Millet	80	100									30	40
	C	Maize	80	100									30	40
	C	Sorghum	80	100									30	40
	C	Millet	80	100									30	40
Bots-wana	N	Maize	100	80									50	80
	N	Sorghum	100	80									50	80
	N	Millet	100	80									50	80
	N	Beans	100	80									50	80
	SW	Sorghum	100	80									50	80
	SW	Millet	100	80									50	80
	SW	Beans	100	80									50	80
	SE	Maize	100	80									50	80
	SE	Sorghum	100	80									50	80
	SE	Millet	100	80									50	80
	SE	Beans	100	80									50	80
Zimbab-we	NW	Maize	90	100	80								40	50
	NW	Sorghum	90	100	80								40	50
	NW	Millet	90	100	80								40	50
	NE	Maize	90	100	80								40	50
	NE	Sorghum	90	100	80								40	50
	NE	Millet	90	100	80								40	50
	C	Maize	90	100	80								40	50
	C	Sorghum	90	100	80								40	50
	C	Millet	90	100	80								40	50
	S	Maize	90	100	80								40	50
	S	Sorghum	90	100	80								40	50
	S	Millet	90	100	80								40	50
Zambia	N	Maize	90	100	80								40	50
	N	Sorghum	90	100	80								40	50
	N	Millet	90	100	80								40	50
	NW	Maize	90	100	80								40	50
	NW	Sorghum	90	100	80								40	50
	NW	Millet	90	100	80								40	50
	SW	Maize	90	100	80								40	50
	SW	Sorghum	90	100	80								40	50
	SW	Millet	90	100	80								40	50
	SE	Maize	90	100	80								40	50
	SE	Sorghum	90	100	80								40	50
	SE	Millet	90	100	80								40	50
	C	Maize	90	100	80								40	50
	C	Sorghum	90	100	80								40	50
	C	Millet	90	100	80								40	50

continue.....

Table 7.3. (continued)

Country	Region	Crop	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mozam-bique	N	Maize	60	90	100								30	40
	N	Sorghum	60	100	100								30	40
	N	Millet	60	100	100								30	40
	NW	Maize	60	100	100								30	40
	NW	Sorghum	60	100	100								30	40
	NW	Millet	60	100	100								30	40
	C	Maize	70	100	90								30	40
	C	Sorghum	70	100	90								30	40
	C	Millet	70	100	90								30	40
	S	Maize	70	100	90								30	40
	S	Sorghum	70	100	90								30	40
	S	Millet	70	100	90								30	40
Malawi	N	Maize	60	90	100	80							30	40
	N	Sorghum	60	90	100	80							30	40
	N	Millet	70	100	90								30	40
	C	Maize	60	90	100								30	40
	C	Sorghum	70	100	90								30	40
	C	Millet	70	100	90								30	40
	S	Maize	60	90	100								30	40
	S	Sorghum	70	100	90								30	40
	S	Millet	70	100	90								30	40
Tanza-nia	NW	Maize	30	40	70	100	90							
	NW	Sorghum 1	70	100	100	80							40	50
	NW	Sorghum 2	30	40	60	100	90							
	NW	Sorghum 3										40	60	90
	NW	Millet 1	70	100	100	80							40	50
	NW	Millet 2		40	60	100	90							
	NW	Millet 3										40	60	90
	NE	Maize	30	40	60	90	100							
	NE	Sorghum	30	40	80	100								
	NE	Wheat	30	40	60	90	100							
	SW	Maize	40	70	100	100								30
	SW	Sorghum	50	80	100	90								30
	SW	Wheat	50	80	100	100								30
	C	Sorghum	60	90	100	80								40
	C	Millet	60	90	100									40
	S	Maize	60	80	100	90								40
	S	Sorghum	60	80	100	90								40
	S	Wheat	50	70	100	100								30
	E	Maize	40	60	90	100								
	E	Rice	80	100	100	80							40	60
	E	Sorghum	60	80	100	90								40

continue.....

Table 7.3. (continued)

Country	Region	Crop	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Kenya	NE	Sorghum 2			50	80	100							
	NE	Millet 2			50	80	100							
	SE	Maize 2			40	60	90	100						
	SW	Sorghum 2		30	50	90	90							
	SW	Sorghum 3	100									50	60	80
	SW	Millet 2		30	50	90	90							
	SW	Millet 3	100									50	60	80
	C	Maize 2			40	60	90	100	90					
	C	Sorghum 2		30	40	90	90							
	C	Sorghum 3										40	70	100
	C	Millet 2		30	40	90	90							
	C	Millet 3										40	70	100
	C	Wheat		30	40	50	80	90						
	W	Maize 2			40	60	90	100	100					
	W	Sorghum 2		30	40	90	90							
	W	Sorghum 3							40	70	100			
	W	Millet 2		30	40	90	90							
	W	Millet 3							40	70	100			
	W	Wheat		30	40	50	90	90						
Uganda	NE	Sorghum 2			30	60	90	100						
	NE	Millet 2			30	60	90	100						
	NC	Maize 2			40	60	100	80						
	NC	Sorghum 2		30	50	90	100							
	NC	Sorghum 3							40	70	90			
	NC	Millet 2		40	60	100								
	NC	Millet 3							40	60	90			
	SW	Maize 2		30	50	90	100							
	SW	Maize 3								30	50	90	100	
	SW	Sorghum 2		30	60	90								
	SW	Sorghum 3								30	50	90	90	
	SW	Millet 2		30	60	90								
	SW	Millet 3							40	60	90			
Mada-gascar	N	Maize	90	100									40	60
	N	Rice 1	40	40	40	40								
	N	Rice 2	70	100	90								40	50
	NE	Rice 1						40	50	70	100	100		
	NE	Rice 2	100	100								40	50	70
	SE	Rice 1						40	50	70	100	100		
	SE	Rice 2	100	100								40	50	70
	SW	Rice	90	100									40	50
	SW	Maize	90	90									40	60
	SW	Sorghum	90	90									40	60
	C	Maize	90	100									40	60
	C	Rice 1										70	100	100
	C	Rice 2	50	80	100									30
	W	Maize	90	100									40	60
	W	Rice 1	40	40	40	40								
	W	Rice 2	70	100	90								40	50

continue.....

Table 7.3. (continued)

Country	Region	Crop	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rwanda		Maize 1	100	100	90						30	40	60	80
		Maize 2	30	50	80	100								
		Maize 3									40	80	100	
		Sorghum 1	100	100							30	40	60	80
		Sorghum 2	30	40	70	100								
		Sorghum 3									40	80	100	
		Beans 2		30	50	80								
		Beans 3									30	50	80	
Burundi		Maize 1	100	100	70						40	60	70	90
		Maize 2	50	80	100	80								
		Maize 3									50	80	100	80
		Sorghum 1	100	100	70						40	60	70	90
		Sorghum 2	50	80	100	80								
		Sorghum 3									50	80	100	80
		Millet 1	100	100	70						40	60	70	90
		Millet 2	50	80	100	80								
		Millet 3									50	30	100	80
		Beans 2		50	90	75								
		Beans 3									50	80	90	70
Swazi-land		Maize	100	100	80						30	40	60	80
		Sorghum	100	100							30	40	60	90
		Rice	45	70	100	100							30	35
Lesotho		Maize	100	100	80							40	50	70
		Sorghum	100	80								40	50	80
		Wheat 1	40	40	40	40	50	80						
		Wheat 2	80								40	60	80	100

*Some countries grow a given crop two or three times a year, and this is shown by figures 1, 2 or 3, printed after the name of the crop. The exact names of the crop seasons are indicated in the crop calendar tables in chapter 6.

discussed in this report, and 3) results of climate/crop yield modeling for countries in Subequatorial Africa. These results indicate that drought-related food shortages are associated with cumulative precipitation and cumulative moisture stress defined for two to four months during the crop growing season.

Among the various indices, the yield moisture index (YMI) used by NOAA was modified (by assigning new coefficients) and selected for use in Subequatorial Africa during the first stage of this project. After the "Test and Evaluation" stage, other indices might be introduced as well.

2. Determination of Assessment Periods

The EWAP covers the entire crop season. The indices, however, should be used only for those months when moisture conditions are of greater importance to yield. In most cases, rainfall during the last 20-30 days of the growing period is of lesser importance, and therefore should not be used for the indices. The determination of the assessment periods is based on the crop calendars (see Chapter VI) and is presented in Table 7.3, where the assessment months are those which have an index coefficient.

3. Determination of Index Coefficients

Index coefficients indicate how much weight should be put on each monthly amount of rainfall. More weight is put on the rainfall during months when the crop demand for water is higher, and less weight during months when rainfall is less important.

When YMI was first used by NOAA, the index coefficients were the same as the crop coefficients, which as known, are the ratio between the actual and the potential evapotranspiration. Thus a crop coefficient of 0.35 for example, means that the value of the actual evapotranspiration is 0.35 (or 35 percent) of the potential evapotranspiration. The reference crop coefficients were those determined mostly in America and Europe, where at the beginning of the crop season (spring time) the weather is still cool and normally the soils are saturated with moisture up to field capacity. In Subequatorial Africa, at the beginning of the crop season the weather is much warmer and the soils much dryer - only the top soil is moistened from the first rains. Because of this, it was found appropriate to put more weight on the rainfall during the first two months of the growing season by

using index coefficients that are slightly higher than the crop coefficients for the same period. The coefficients to be used in the EWAP for Subequatorial Africa are shown in Table 7.3.

E. RAINFALL ASSESSMENT CATEGORIES

Another assessment tool is to assess the rainfall for each month, depending on its amount. For this purpose, monthly rainfall amounts can be grouped into five categories: very dry, dry, moderate, wet and very wet. These categories can serve as an approximate guide for the beginning and end of the rainy season, for the extent up to which the crop water requirements are satisfied, and for the effect rainfall has on field works and other agricultural activities. The description and interpretation of the five rainfall categories for the agroclimatic assessment regions in Subequatorial Africa is as follows:

Very Dry Conditions (0-50 mm). Very inadequate for the crops or field work. However, at the beginning of a new rainy season and in areas with sandy soils, monthly rainfall of about 40-50 mm allows farmers to prepare the agricultural fields (plowing, cultivating, etc.) for the coming crop season. In arid areas (with annual rainfall below 400-450 mm) farmers might even begin sowing the seeds, hoping that larger amounts of rainfall will follow soon. In the middle of a growing season, monthly rainfall below 50 mm indicates severe drought, leading to crop failure. The latter could be avoided only if there are substantial soil moisture storages (not less than 140-150 mm of available water in the 1 m soil layer) at the beginning of the "very dry month." At the end of the growing season, a "very dry month" will also have an adverse effect on crop yield. In most cases however, it will not lead to a crop failure because the water requirements of the crops are much smaller.

Dry Conditions (50-100 mm). Still inadequate for the crops, but sufficient for most field work. At the beginning of the growing season, monthly rainfall of 50-100 mm is considered sufficient for sowing most agricultural crops in Subequatorial Africa. During the growing season of the crops, and especially in the middle of it, monthly rainfall of 50-100 mm is insufficient and will essentially reduce the yield. At the end of the growing season, a "dry month" will have little or no adverse effect.

Moderate Conditions (100-150 mm). In the more arid areas of Subequatorial Africa (with annual rainfall below 700-800 mm) and for crops that do not demand large amounts of water (millet, sorghum), monthly rainfall of 100-150 mm could be close to adequate. In the rest of the region and for the rest of the crops, especially in the middle of their growing season, moderate conditions are still inadequate to satisfy the crop water requirement.

Wet Conditions (150-200 mm). Sufficient to satisfy the water requirement of most agricultural crops in Subequatorial Africa. Among the few exceptions could be sugar cane and maize in the middle of their growing season, if grown in areas with high air temperature. Irrigated rice also requires over 200 mm of rainfall per month.

Very Wet Conditions (over 200 mm). Sufficient for all crops grown in Subequatorial Africa. In some cases, large amounts of rainfall have an adverse effect on the crops by worsening the aeration of the soils or causing floods. Timely field work as well as pest, disease and weed control might also be adversely affected by very wet weather.

The rainfall categories can be used not only to assess the rainfall amount during a current month but also the mean rainfall amounts. This helps to better understand the existing agroclimatological conditions in the various assessment regions of Subequatorial Africa (Figure 7.1).

F. DROUGHT ASSESSMENT CATEGORIES

The categories discussed in the preceding section are used to assess the whole range (from very dry to very wet) of actual rainfall amounts. Another assessment tool is actual rainfall expressed as a percent of the normal amount. Although any amount of rainfall can be expressed in percent of the normal one, this section deals only with below normal amounts that have the potential to adversely affect agricultural crops.

Comparing actual rainfall with the normal amount for the same period is a well known method. However, many factors have to be taken into consideration before a drought situation is defined. Does a drought exist when the rainfall is 90, 70 or 50 percent of the normal? The interpretation of these percentages distinguishes a good assessment from a mediocre one.

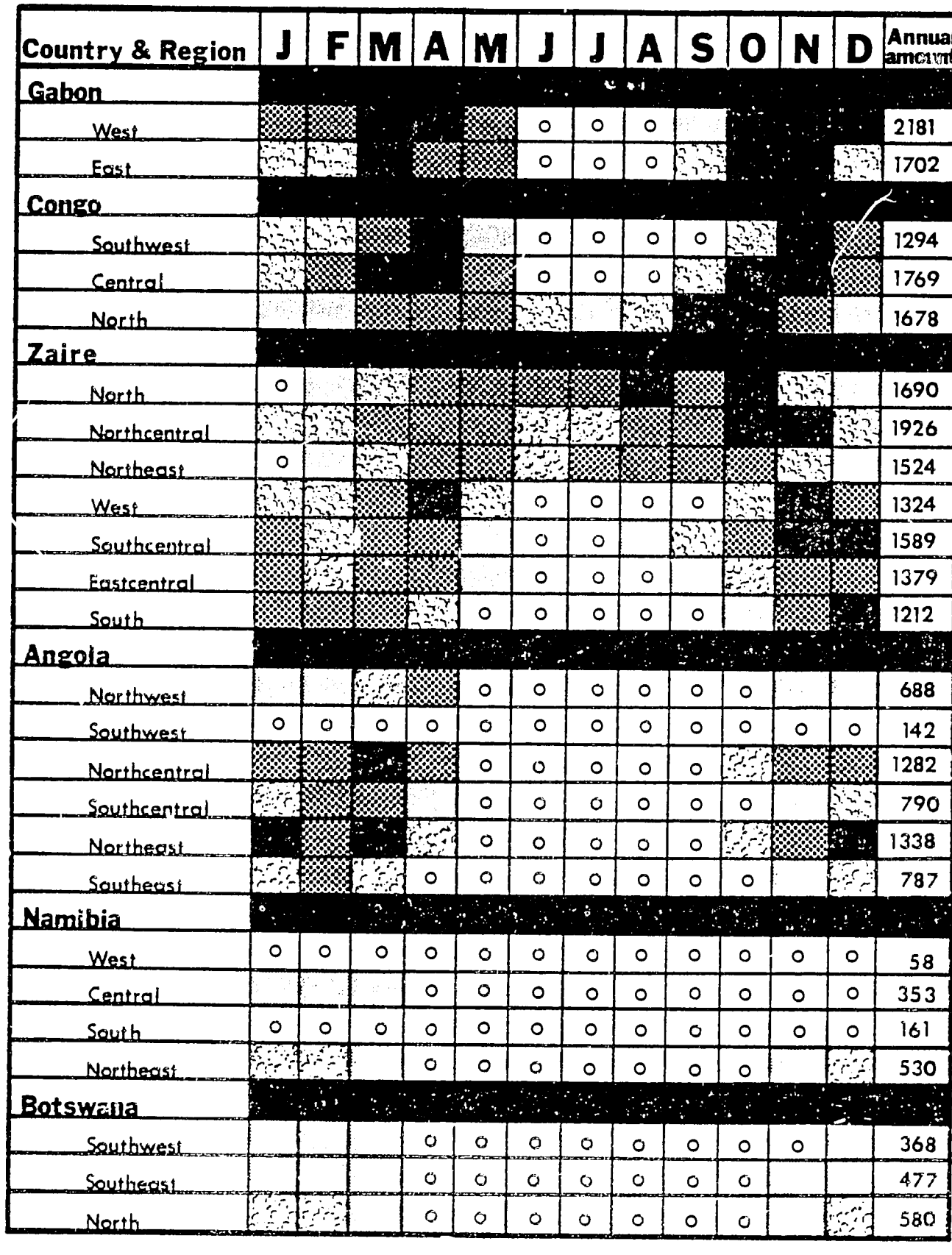
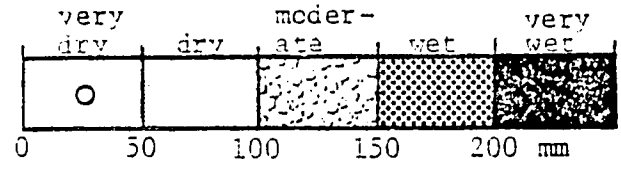


Figure 7.1. Agroclimatic regions of Subequatorial Africa: mean monthly rainfall classified by the five rainfall assessment categories (rainfall data are from Wernstedt).



Country & Region	J	F	M	A	M	J	J	A	S	O	N	D	Annual amount
Madagascar													
Northeast													2823
Southeast													2398
North					o	o	o	o	o	o			1592
Central					o	o	o	o	o				1476
West					o	o	o	o	o	o			1392
Southwest				o	o	o	o	o	o	o			612
Lesotho				o	o	o	o	o	o				709
Swaziland					o	o	o	o	o				946
Mozambique													
North					o	o	o	o	o	o			1086
Northwest				o	o	o	o	o	o	o			906
Central					o	o	o	o	o	o			1291
South				o	o	o	o	o	o	o			743
Zimbabwe													
Northwest				o	o	o	o	o	o	o			699
Northeast				o	o	o	o	o	o	o			802
Central				o	o	o	o	o	o	o			676
South				o	o	o	o	o	o	o			472
Zambia													
North					o	o	o	o	o	o			1192
Southeast				o	o	o	o	o	o	o			955
Central				o	o	o	o	o	o	o			919
Northwest					o	o	o	o	o				1294
Southwest				o	o	o	o	o	o	o			925
Malawi													
North					o	o	o	o	o	o			1066
Central					o	o	o	o	o	o			1029
South					o	o	o	o	o	o			1090

Figure 7.1. continued.

Country & Region	J	F	M	A	M	J	J	A	S	O	N	D	Annual amount
Kenya													
West	O												1343
Central	O	O				O	O		O				860
Southwest	O	O			O	O	O	O	O	O			590
Southeast	O	O	O										1072
Northeast	O	O	O	O		O	O	O	O	O		O	362
Tanzania													
Northwest						O	O	O	O				995
Northeast						O	O	O	O	O			957
East						O	O	O	O	O			972
South						O	O	O	O	O			1251
Southwest					O	O	O	O	O	O			1069
Central					O	O	O	O	O	O	O		604
Uganda													
Southwest						O	O						1110
Northcentral	O	O											1256
Northeast	O	O									O	O	854
Rwanda						O	O	O					1156
Burundi						O	O	O	O				1177

Figure 7.1. continued.

The proposed drought assessment categories differ from those used in NOAA assessments in three ways:

1) The percentages used to define a category of drought are not fixed for the whole continent of Africa but differ from country to country, even from region to region (Table 7.4). For example, for some regions in Botswana, Kenya and Namibia drought conditions exist when the actual rainfall is as high as 90 percent of the normal amount. In other regions - in Congo, Gabon, Madagascar and Zaire - drought begins only when the actual rainfall drops to 60-65 percent of the normal amount. These flexible percentages are justified by the fact that in dry, marginal areas the normal amounts of rainfall are small, inadequate to satisfy the crop water requirements. In such cases, even a small deviation below the normal amount will have an adverse effect on the crops. On the other hand, in wet areas the normal amounts of rainfall are so high (higher than the crop water requirements) that drought effect is felt only after significant drop in the actual rainfall amounts.

2) Unlike the previous categories which assess only 8 week periods, the proposed new drought assessment categories assess both one and two month periods. The farming experience in Subequatorial Africa, especially in the more arid areas, clearly shows that a dry spell of one month (even 20-25 days) can adversely affect the crops. The episodic event data for many countries (Chapter VI) illustrate the adverse effect of the so called "irregular" or "intermittent" rains, actually drought periods of shorter duration. Furthermore, as the historical meteorological data are on a monthly basis, it is more convenient to make the drought assessment for months rather than weeks.

3) There are three proposed drought assessment categories versus two in the old system: drought, serious drought and severe drought. This will enable agrometeorologists to assess the existing agrometeorological conditions in more detail.

G. PREPARATION OF THE ASSESSMENTS

As mentioned earlier, the primary purpose of this proposed Early Warning Assessment Program is to provide timely, reliable yet inexpensive information on the potential for drought related food shortages. The

Table 7.4. Proposed drought assessment categories during the growing season in Subequatorial Africa

Country & Region		One month rainfall (% of normal)			Two months rainfall (% of normal)		
		Drought	Serious Drought	Severe Drought	Drought	Serious Drought	Severe Drought
Angola:	NC,NE	70	55	45	75	65	55
	NW,SC,SE	75	65	55	85	75	65
Botswana:	N	80	70	60	85	80	70
	SE	85	75	65	90	85	75
	SW	90	80	70	90	85	75
Burundi	-	70	55	40	75	65	55
Congo:	N,C	65	50	40	75	60	50
	SW	70	55	40	75	65	55
Gabon:	E,W	65	50	35	70	60	50
Kenya:	W	70	55	40	75	65	55
	C,SE	70	60	50	80	70	60
	SW	75	65	55	85	75	65
	NE	90	80	70	90	85	75
Lesotho	-	70	60	50	80	70	60
Madagascar:	NE	60	50	35	70	55	45
	SE	60	55	40	70	60	50
	N,C,W	70	55	45	75	65	55
	SW	75	65	55	85	75	65
Malawi:	N,C,S	70	60	50	75	65	55
Mozambique:	N,C	70	55	45	75	65	55
	NW	70	60	50	80	70	60
	S	75	65	55	85	75	65
Namibia:	NE	80	70	60	85	80	70
	C	90	80	70	90	85	75
Rwanda	-	70	55	45	75	65	55
Swaziland	-	70	55	50	75	65	55
Tanzania:	C	75	65	55	85	75	65
	NW,NE,E,S,SW	70	55	45	75	65	55
Uganda:	NC,SW	70	55	45	75	65	55
	NE	75	65	55	80	70	60
Zaire:	N,NC	65	50	35	70	60	50
	EC,NE,SC,W	65	55	40	75	65	55
	S	70	60	50	75	65	55
Zambia:	N,NW	70	60	50	75	65	55
	SW,C,SE	70	65	55	80	70	60
Zimbabwe:	NE,NW,C	75	65	55	85	75	65
	S	80	70	60	85	80	70

assessments are made by using various analyses and interpretations of the rainfall data such as:

a) actual amount

b) departure from normal, in mm

c) rainfall expressed as percent of normal

d) agroclimatic indices and their percentile rankings.

Some statistical crop/weather models might be developed during the second phase of this project (Test and Evaluation). An attempt was made during the first phase, but due mainly to the poor quality of the crop data the results were not encouraging. Another drawback of the crop data and subsequently of the models is that they are at the national level, while the assessments are made for the agroclimatic regions in each country. As a result, the tools of primary importance for EWAP in Subequatorial Africa are the analysis and interpretation of the rainfall data mentioned above.

The assessments can be made for different periods of duration. The first three methods - the actual amount, the departure from normal (mm) and the rainfall expressed as percent of normal - are suitable for use for any period: one week, ten days, two weeks, one month, etc., including the whole crop growing season or the whole rainy season. The agroclimatic indices and their percentile rankings are suitable for use on a monthly basis, from one month to the entire crop growing (or rainy) season. Keeping in mind the amount and availability of data as well as the methods for communicating them from the stations to the national office preparing the assessments, it seems most appropriate to propose two types of assessments for each country:

1. Ten day assessments, using only actual, departure from normal (mm) and percent of normal rainfall data. They are to be prepared on the 11th and 21st days of each month.

2. Monthly assessments, using agroclimatic indices and their percentile rankings in addition to the actual, the departure from normal and percent of normal rainfall data. The monthly assessments are to be prepared as soon as the data for the month are available.

Both types of assessments can be more useful if an analysis is also made on the rainfall and indices for all months since the beginning of the

rainy season (or the crop growing season). Assessments can also be improved if other available information such as actual or estimated soil moisture data, phenological data, information on the state of the crops, the height of the plants, the density of the sowing area, the occurrence of pests and diseases, etc., is used by agrometeorologists in the individual countries.

CHAPTER VIII

TEST AND EVALUATION OF THE PROPOSED EARLY WARNING ASSESSMENT PROGRAM

The methodology for the proposed EWAP for Subequatorial Africa was completed by late December 1982. The crop growing season that was in progress was used to test and evaluate the impact assessment models and techniques on which the program is based. The 1982-83 rainy season represented a good test case because it offered a wide variety of agrometeorological conditions, ranging from well above normal rainfall to record breaking drought.

A. A RETROSPECTIVE LOOK AT THE 1982-83 SEASON

As previously discussed, the rainy season in most areas south of about 10-11°S (south of Tanzania and Zaire) normally begins in October or November and lasts until the following April. This is also the crop growing season.

The 1982-83 rainy season began on time, with normal to above normal rainfall in October and early November. Farmers throughout Subequatorial Africa tilled their fields and planted maize, sorghum, millet, wheat and other food crops under very good agrometeorological conditions. However, soon after the emergence of the new crops dry weather established itself over several countries in Southern Africa and persisted until the end of the growing season. Hardest hit were Zimbabwe, Mozambique, Swaziland, Lesotho and Botswana (as well as the Republic of South Africa which is not included in this study). Some areas experienced the worst, or one of the worst, droughts in recorded history. The impacts ranged from complete crop failures in some areas to sharply reduced yields in others. The potential for famine and starvation was established by December 1982 or early January 1983. In addition, pastures dried-up and thousands of domestic animals had died. It should be noted that the impact of the current drought was magnified by the fact that many areas were affected by drought during the previous crop season (1981-82) and certain food shortages already existed.

The total rainfall for the most important five months of the rainy season (November through March) in the countries affected by drought is shown on Table 8.1. Previous agricultural practice and experience have shown that rainfed farming of the most drought resistant crops, millet and sorghum, is economically feasible only in areas where total seasonal (or annual) rainfall

Table 8.1. Rainfall for the period November 1982-March 1983 in the drought affected areas of Subequatorial Africa

Country	Agroclimatic region	Actual rainfall, mm	Normal rainfall, mm	Percent of normal rainfall
Zimbabwe	Northeast	445	730	61
	Central	308	589	52
	South	195	412	47
	Northwest	595	648	92
Mozambique	North	774	904	86
	Central	620	1,028	60
	South	235	539	44
	Northwest	514	833	62
Malawi	South	820	912	90
Botswana	Southeast	267	387	69
Namibia	Northeast	417	469	89
Swaziland	entire country	583	684	85
Madagascar	Southeast	737	1,455	51
	Southwest	346	517	57
	Central	957	1,275	75
	West	925	1,270	73
Lesotho	entire country	507	494	103

is above 350 mm. It should be noted that during the 1982-83 season in Subequatorial Africa, six agroclimatic regions received less than 350 mm for the period November - March.

Several other regions received over 350 mm but still were well below the normal amounts for the period. Thus, although the Southeast region of Madagascar received 737 mm, it was only 51 percent of the normal amount. The Northeast region of Zimbabwe and the Central region of Mozambique received 445 and 620 mm respectively, but these amounts were only about 60 percent of the normal rainfall. For many years, the agricultural practice in these regions has adapted itself to the existing rainfall regime, and sharp reductions from the normal amounts usually have a devastating effect on the plants.

In addition to the total amount of rainfall for the 1982-83 season, the rainfall distribution during the season is of great importance agrometeorologically. Figures 8.1 and 8.2 illustrate that drought developed in different patterns. In Zimbabwe and South Mozambique, it was dry throughout the entire growing season. In Central Mozambique, the drought was interrupted by above normal February rainfall, when it was already too late to compensate for the damage caused by dry conditions in November, December and January. In the Southeast region of Botswana, unlike most other areas of Subequatorial Africa, drought struck during the second half of the growing season. In Swaziland, monthly rainfall alternated between normal and below normal. The agroclimatic regions affected by drought in 1982-83 are shown on Figure 8.3.

B. THE NOAA/AISC EARLY WARNING ASSESSMENTS

Inspite of the complexity of the agrometeorological conditions over Subequatorial Africa (including the record breaking drought in some regions), the assessments issued by the Assessment and Information Services Center (AISC) of NOAA, with the support of the Atmospheric Science Department of the University of Missouri in Columbia, MO, were accurate, objective and timely. Careful monitoring and scientific interpretation of the existing agrometeorological conditions in each agroclimatic region of Subequatorial Africa permitted early detection of unfavorable phenomena and assessment of the magnitude of the events and the potential for food shortages (Table 8.2). The methods for assessments described in Chapter VII proved correct and useful.

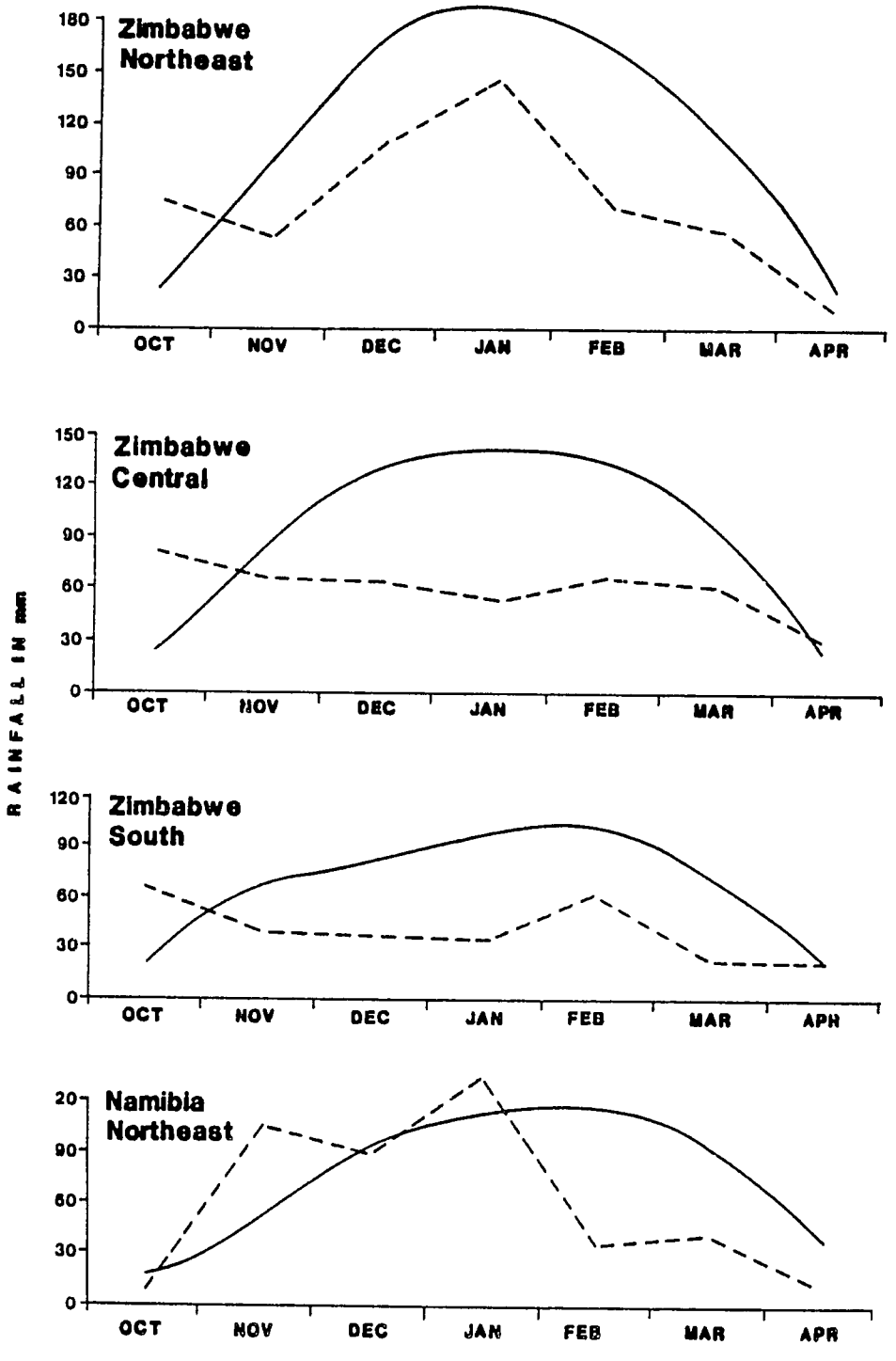


Figure 8.1. Actual (dotted line) and normal (continuous line) rainfall during the 1982-83 crop growing season in Zimbabwe and Namibia.

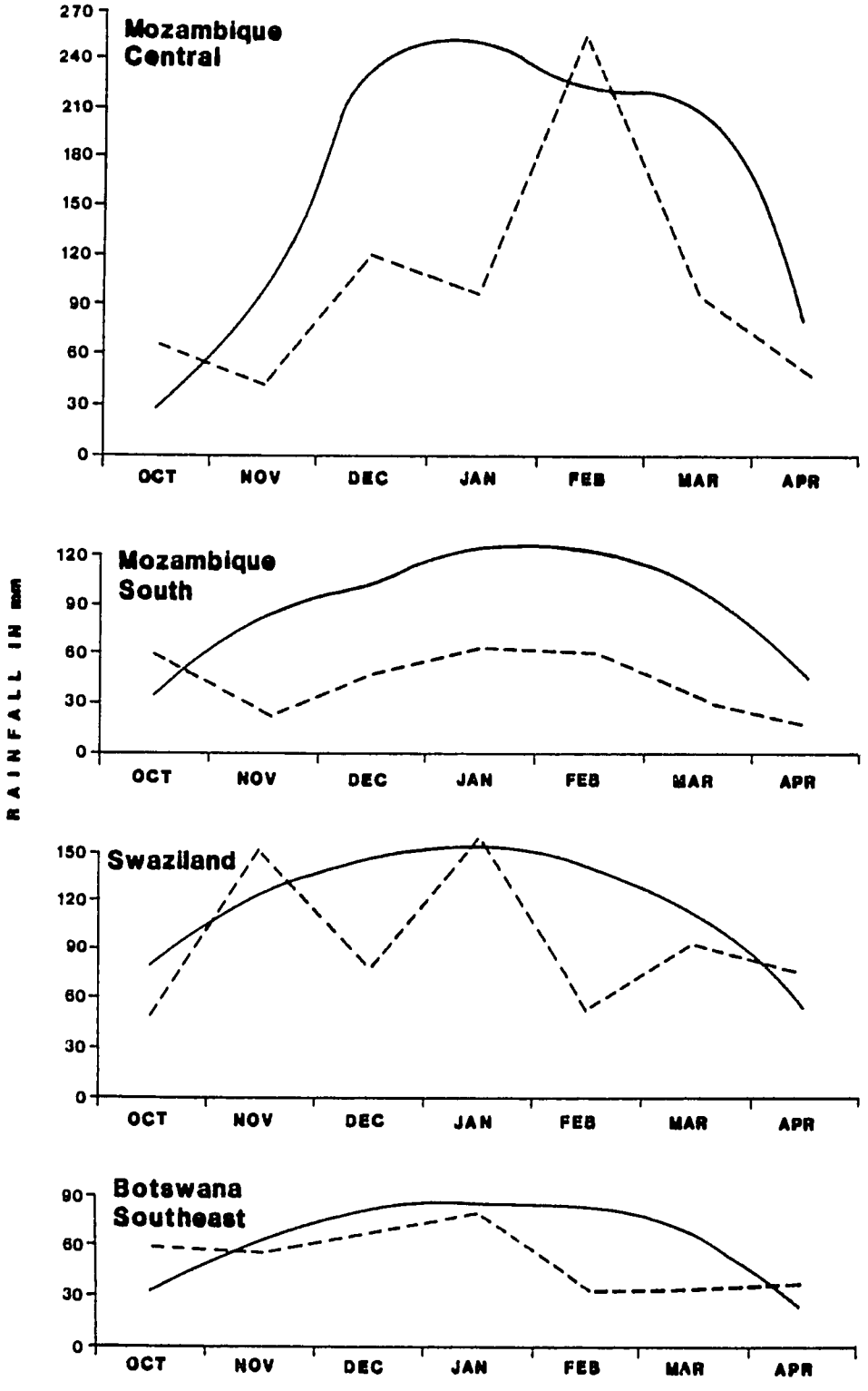


Figure 8.2. Actual (dotted line) and normal (continuous line) rainfall during the 1982-83 crop growing season in Mozambique, Swaziland and Botswana.

SUBEQUATORIAL AFRICA

AGROCLIMATIC REGIONS AFFECTED BY DROUGHT IN 1982-1983

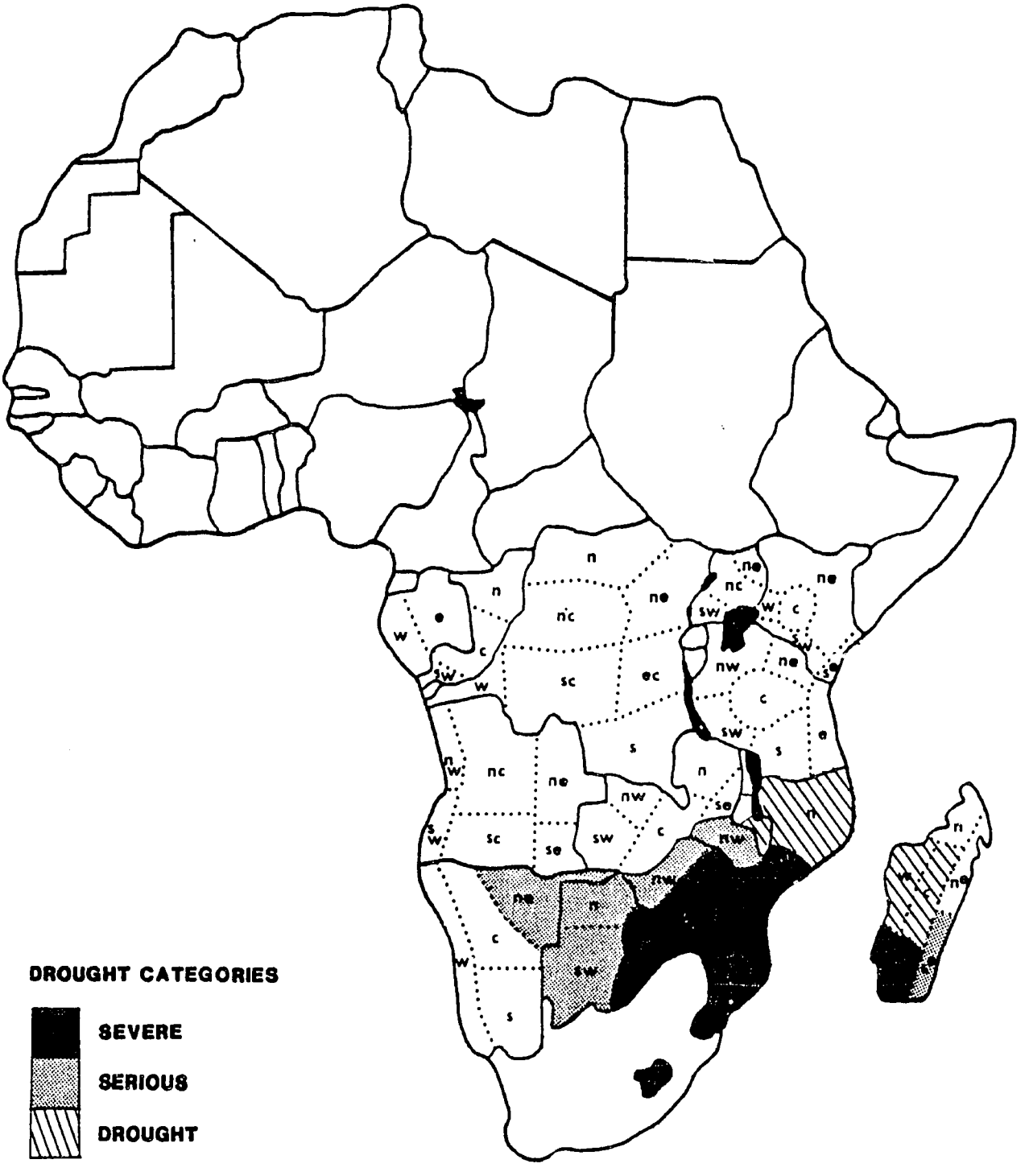


Figure 8.3.

Table 8.2. Summary of the NOAA/AISC Early Warning Assessments for the 1982-83 Season

Country	Agroclimatic Region	First NOAA Reported Drought	First NOAA Food Shortage Alert	NOAA Agroclimatic Crop Condition Index Percentile Rank					NOAA Drought Category	Verification
				Nov	Dec	Jan	Feb	Mar		
Zimbabwe	Northeast	Jan 13	Jan 13	23	13	20	6	6	severe	1.Crop failure and severe economic losses reported January 31, 1983 by Harare 759. 2.Emergency food aid requested June 7, 1983 by Harare 3850.
	Central	Dec 30	Jan 13	33	13	6	3	13	severe	
	South	Dec 17	Jan 13	24	13	6	10	10	severe	
	Northwest	Jan 15	-	56	25	62	58	41	serious	
Mozambique	North	April 2	n.a.	92	57	57	33	7	drought	FAO reports poor harvest outlook on January 14, 1983. Almost complete crop failure in southern and central regions reported by FAO on March 18, 1983.
	Central	Dec 17	Dec 30	5	3	3	18	11	severe	
	South	Dec 17	Dec 30	8	7	3	7	3	severe	
	Northwest	Feb 17	Feb 17	8	33	8	8	4	severe	
Malawi	South	Dec 30	Feb 17	43	47	23	47	28	drought	No food shortage reports, but FAO reports drought in southern areas on April 2, 1983.
Botswana	Southeast	Dec 30	Feb 17	48	31	37	32	-	severe	Disaster declared April 15, 1983 by Gaborone 101501.
Namibia	Northeast	Dec 30	n.a.	92	85	76	34	-	drought	-
Swaziland	entire country	Dec 30	March 8	61	32	39	19	19	serious	Severe drought impact reported by FAO March 18, 1983. Emergency food assistance approved by FAO/WFP on June 22, 1983.
Madagascar	Southeast	Dec 17	May 13	80	49	20	12	-	serious	FAO estimates 15-20 percent below normal paddy production in central and southern areas on April 15, 1983.
	Southwest	Dec 17	Feb 17	53	42	20	20	-	severe	
	Central	Dec 17	Feb 17	23	33	16	16	-	drought	
	West	Dec 17	Feb 17	53	42	20	20	8	drought	
Lesotho	entire country	Dec 30	Jan 3	96	82	78	57	57	drought	FAO/WFP emergency food assistance authorized May 19, 1983. Crop failure in southern areas reported December 1983 by Maseru 03452.

The NOAA assessments for October, November and December 1982 were made by the Climate Assessment Branch of AISC by simple rainfall analysis. The first assessment based on the proposed EWAP was issued on February 17, 1982. It covered the period October 1, 1982 - January 31, 1983. Similar assessments were later prepared at the end of February, March and April 1983. Some excerpts are provided below.

DECEMBER 1982 ASSESSMENT PERIOD (based on simple rainfall analysis)

Mozambique: Growing conditions were rapidly deteriorating in central and southern areas. Drought has developed over Southern Mozambique. Cumulative eight week rainfall for the region south of Beira is only 30-50 percent of normal, causing poor development of recently planted subsistence crops. Local food shortages are a strong possibility if dryness continues a few more weeks.

Zimbabwe: Hot and dry weather continued to hurt crops and grazing in central and southern regions. Water supplies, crops and grazing lands have rapidly deteriorated as rainfall during the past four weeks had measured only 1-12 mm in the region south of West Nicholson. Continued dry weather over the next two weeks would result in probable crop and livestock losses. Critically dry conditions harmed crop and pasture growth across large areas of Zimbabwe, with drought now well established across central and southern areas and moving northward into other areas. Unusually high temperatures increased the drought's intensity. Important crop and livestock losses are likely in the southern half of the country.

Lesotho: Parts of Lesotho have received negligible rainfall for three consecutive weeks and crops may be irreversibly damaged without rainfall during the next week. Dry weather had rapidly depleted soil moisture and would pose problems for agriculture.

Botswana: Near dry conditions have developed in Botswana, where below normal rainfall the past several weeks has harmed crop growth in some areas.

Madagascar: The main rice crop in Madagascar (November planted) needs rain to maintain optimum growth, as precipitation totals have been well under half normal during the past three weeks in some areas. Due to heavy rains in November, the situation is not yet urgent, but widespread drought development is possible without seasonal rains during the next few weeks.

OCTOBER 1982-JANUARY 1983 ASSESSMENT PERIOD (based on the EWAP)

Overview: There will be well below normal subsistence crop yields and the potential for abnormal food shortages within regions of Mozambique, Zimbabwe, Zambia, Malawi, Botswana and Madagascar. Rainfall during the first half of the 1982/83 crop growing season (October-January) was well below normal and drought is impacting large portions of Subequatorial Africa. Because this is the second consecutive drought year for most of these countries, the potential impact is magnified. Agroclimatic/crop condition indices are in the lowest three to ten percentile range (scale of 0 to 100).

Mozambique: Maize, sorghum and millet in the Central, Southern and Northwest agroclimatic regions will be well below normal due to severe drought. The Central and Southern regions are experiencing one of the worst droughts in history. Comparable years are 1953 in the Southern region with 1948 and 1967 in the Central region (Base index period 1943-1968). Agroclimatic/crop condition indices for the period of November, December and January are at the lowest 3rd percentile range. Drought conditions of these magnitudes have a probability of occurrence of about once in 33 years. Rainfall during these months was only 30-50 percent of normal, while monthly mean temperatures were about 2°C above normal. In the Northwest region, indices at the end of January are at the 10th percentile. Rainfall during the first two weeks of December benefitted crops in the Northwest, but was probably not sufficient to overcome severe drought. Conditions appear normal in the Northern agroclimatic region.

Zimbabwe: Conditions for maize, wheat and other crops are below normal in the Central, Southern and Northeastern agroclimatic regions due to severe drought. In the Central and Southern regions, agroclimatic/crop condition indices for the period of November, December and January are at the 5th percentile. Comparable drought conditions occurred in 1959, 1967 and 1972. Monthly rainfall amounts were between 30 and 60 mm, about 35 to 74 percent of normal. Monthly mean temperatures in December and January were 3 to 2°C above normal. In the Northeast region, agroclimatic/crop condition indices for November and December were at the 13th percentile. Monthly rainfall amounts were about 60 percent of normal (between 50 and 110 mm) and monthly mean air temperatures were about 3°C above normal. Relatively good rainfall occurred during the second half of January (about 150 mm), but it may have been too late to overcome the drought damage in earlier months.

Zambia: Maize and other cereal crops in the extreme southern areas have experienced drought impact.

Malawi: Subsistence food crops are being impacted by moderate drought in the Southern agroclimatic region. Agroclimatic/crop condition indices at the end of January were at the 23rd percentile. November, December and January monthly rainfall totals were 83, 97 and 73 percent of normal, respectively. Temperatures were above normal.

Botswana: Sorghum, millet and maize crops in the important Southeast agroclimatic region are experiencing moderate drought impact. Agroclimatic/crop condition indices through January are at the 37th percentile. Rainfall during November, December and January was about 92, 80 and 86 percent of normal, respectively.

Madagascar: The Southwest, Western and Central agroclimatic regions are experiencing drought impact on subsistence crops. In the Southwest, three consecutive dry months followed good rainfall in October. Agroclimatic/crop condition indices at the end of January were at the 20th percentile. Monthly rainfall totals were only between 30 and 85 mm, or 56 to 69 percent of normal. In the Western region, agroclimatic/crop condition indices at the end of January were at the 32nd percentile, indicating drought impact. The rainy season began late and the rainfall amounts were below normal for four consecutive months, October through January. Some drought is being experienced in the Central region, where the agroclimatic/crop condition index for maize was the 16th percentile and at the 40th percentile for rice.

Swaziland: Maize and rice crops are experiencing drought impact. Agroclimatic/crop indices were at the 32nd percentile in December due to 50 percent of normal December rains. Indices improved to the 40 percentile by the end of January.

OCTOBER 1982-FEBRUARY 1983 ASSESSMENT PERIOD (based on the EWAP)

Overview: There will be well below normal subsistence crop yields and the potential for abnormal food shortages within regions of Mozambique, Zimbabwe, Botswana, Zambia, Swaziland and Madagascar. Rainfall during the first two-thirds of the 1982/83 crop growing season (October-February) was well below normal, and drought is impacting large portions of Sub-equatorial Africa. Because this is the second consecutive drought year for most of these

countries, the potential impact is magnified. Agroclimatic/crop condition indices are in the lowest three to twenty percentile range (scale of 0 to 100).

Zimbabwe: Severe drought affects maize, wheat, sorghum and other crops in the Central, Southern and Northeastern agroclimatic regions of the country. Agroclimatic/crop condition indices for the period November-February are at the 3rd to 10th percentile. Comparable drought conditions occurred in 1967. Monthly rainfall amounts for four consecutive months were below normal (only about 50-60 percent of the normal amounts).

Mozambique: Maize, sorghum and millet in the southern agroclimatic region are nearly a complete failure this season. Agroclimtic/crop condition indices for each month since November 1982 were between the 3rd and 8th percentile, which makes it one of the worst droughts in history. The total rainfall amount for November-February was only 200 mm, or 45 percent of the normal amount. Not much better were the agroclimatic conditions in the Central and Northwestern regions of the country, where good rainfall in February came too late to improve the condition of the crops already damaged by drought in November, December and January. Agroclimatic/crop condition indices in the Central and Northwestern regions are at the 18th and 8th percentile rank, respectively. Comparable drought conditions occurred in 1948 in the Northwest, and in 1950 in the Central regions.

Botswana: Sorghum, millet, beans and maize in the important Southeast agroclimatic region are experiencing serious drought impact. Although agroclimatic/crop condition indices are at the 32nd percentile rank, moisture conditions there are marginal, and even slightly below normal rainfall has an adverse effect on the crops. During the current crop season, rainfall has been below normal since November, the driest month being February with only 42 percent of normal rainfall. Comparable drought conditions occurred in 1968 and 1978.

Swaziland: Maize and rice are experiencing drought impact despite the good rainfall in January. Agroclimatic/crop condition indices for the period November-February are at the 19th percentile rank. Comparable drought conditions occurred in 1963 and 1964.

Madagascar: The southwest agroclimatic region is experiencing drought impact

on subsistence crops. For four consecutive months (November-February) rainfall has been below normal. Agroclimatic/crop condition indices are around the 20th percentile rank.

Zambia: Maize and other cereal crops in the extreme southern areas have experienced drought impact.

Namibia: Dry conditions in February will have a moderate drought impact on the agricultural crops. Conditions during previous months were very good this season.

C. VERIFICATION OF THE NOAA/AISC ASSESSMENTS

Hardly any other drought in human history has received larger world attention and coverage than the 1982-83 drought in Subequatorial Africa for several reasons:

- Magnitude of the disaster. As mentioned earlier, for many areas this was the worst drought in recorded history.
- Number of people affected. Unlike the Sahel drought a decade ago which struck mostly scarcely populated areas the Subequatorial drought affected at least 15 million people.
- The ten African countries affected by drought belong to various political groups and this prompted responses from all corners of the world.

After the drought and the potential for food shortages became known - partly due to NOAA's assessments - numerous delegations from individual donor countries and several international organizations visited the areas affected by drought. By the middle of 1983, large amounts of food began pouring into the worst affected regions. This is the best verification that the NOAA/AISC drought/food shortage assessments made several months earlier were correct and timely.

Below are a few excerpts from US embassies and official AID mission communications. Information from host country newspapers is included only as a matter of interest, not as official verification. Furthermore, it should be noted that unlike some reports by national or international authorities who signal the probability, or existence, of food shortages resulting from a bad harvest from the previous crop season, NOAA's assessments of the potential for food shortages are based only on the effect of unfavorable weather during the current crop season.

JANUARY 1983

Zimbabwe: "The drought has already delivered a blow to the country's economic prospects in 1983. The maize crop has already been seriously damaged and the irrigated winter wheat crop will be considerably reduced unless substantial rains continue." (AmEmbassy Harare 759 of January 31, 1983)

Zimbabwe: "People in Mwenezi and Chiredzi have not been able to grow any crops and the extent of the drought in the whole of Masvingo Province is disastrous." (The Herald, 16 Jan 83).

Zimbabwe: "With more than 1,000 head of cattle reported dead within a forthnight, the Zvishavane and Mberengwa districts have become the worst drought-hit areas in the Midlands." (The Herald, 24 Jan 83)

FEBRUARY 1983

Zimbabwe: "About 60,000 people in the drought-stricken Chibi district - more than half the area's population - are now dependent on drought relief food aid." (The Herald, 21 Feb 83)

MARCH 1983

Swaziland: "The survival of hundreds of families and the whole farming community in the country is now at stake as the drought intensifies by the day. The drought has reached "disaster" proportions in parts of Manzini district. Swaziland faces its worst year ever in the agricultural sector." (The Swazi Observer, 12 March 83)

Zimbabwe: "The drought is tightening its grip throughout most of Zimbabwe. Drought termed "tragedy" for soybean growers." (The Financial Gazette, 25 March 83)

APRIL 1983

Zambia: "Farmers in the Southern Province would for the second successive season lose about half their maize crop." (Times of Zambia, 1 April 83)

Zimbabwe: "The extremely grave consequences of the present disastrous drought on all aspects of Zimbabwe's economy, from the cost of essential famine relief to loss of foreign currency, are now becoming apparent." (The Financial Gazette, 8 April 83).

JUNE 1983

Zimbabwe: "The Zimbabwe Government made a formal, urgent appeal to the US Government for emergency food aid to help alleviate food shortages resulting

from Zimbabwe's worst drought of the century. The provinces of Manicaland, Masvingo, Matabeleland North, Matabeleland South and most of Midlands, experienced total crop failure." (AmEmbassy Harare, 3850 of June 2, 1983)

Botswana: The US Embassy takes into account the disasterous drought and suggests to the US Government to offer emergency assistance. (AmEmbassy Gaborone, 2320 of June 15, 1983)

Mozambique: "The latest Government estimates indicate that this is the worst natural disaster of this kind (drought) ever to attack our country." (Noticias, 15 June 83)

Zimbabwe: "There is not doubt that without international assistance, famine will be a reality in Zimbabwe." (The Chronicle, 11 June 83)

JULY 1983

Zimbabwe: "The number of people receiving drought relief food is to be doubled immediately." (The Herald, 1 July 83)

AUGUST 1983

Zambia: "Northern Province permanent secretary Mr. Issac Manda has called for an airleft of emerergency food supplies to famine stricken Chief Nabwalya's area in Mpika district." (Sunday Times, 14 Aug 83)

OCTOBER 1983

Swaziland: "The drought is threatening the sugar industry with one of its worst seasons in years." (The Times of Swaziland, 6 Oct 83)

Swaziland: "The drought has forced the Swaziland Citrus Board to close its citrus estate at Nsoko. All the orange and grapefruit trees have died because of the drought." (The Times of Swaziland, 17 Oct 83)

D. FINDINGS

The test and evaluation of the EWAP revealed one essential shortcoming of the program. The size of some agroclimatic regions is too large. Because the assessments are made on a regional basis, drought or other unfavorable conditions existing only in a small area of a region can go undetected. For example, drought in some southern areas of Zambia was not evident in the regional analysis and only data from individual stations indicated the drought area.

Another problem with the EWAP occurred in Lesotho, where the drought impact was underestimated due to inaccurate rainfall estimates.

Chapter IX

CONCLUDING REMARKS

An Early Warning Assessment Program has been developed to provide reliable information on the potential for disastrous subsistence food shortages due to drought in developing countries of Subequatorial Africa. This proposed early warning program, based on a combination of weather and crop condition/food shortage assessments, is objectively determined by climate/crop relationships. It is also sufficiently economical for practical real-time operation.

These assessments have the capacity to provide useful information by about 30-60 days prior to the final harvest of the crop. This could represent a potential 3-6 months early warning prior to drought-related food shortages.

The data bases, background information, techniques, agroclimatic models, and computer software necessary to implement these assessments have been developed. It is recommended that this early warning program be tested and evaluated prior to implementation on an operational basis. This test and evaluation phase would provide experience in the preparation of assessment reports. Case study analyses and verification analysis would allow technical modification and recommended improvements in assessment procedures.

This program can potentially benefit AID in attaining the following goals:

1) to monitor and assess potential and actual disaster situations due to drought in Subequatorial Africa, thereby providing increased leadtime for planning strategies on food assistance,
2) to increase the U.S. technical capacity to define disaster-prone conditions and to recommend disaster-avoidance measures, and
3) to apply and transfer both technology and information to developing countries, international organizations and others.

Within the context of applying weather and climatic data to agroclimatic systems, the methods proposed are: 1) inexpensive, 2) timely, 3) consistent with known agronomic practices in these countries and 4) considered to be potentially capable of providing reliable early warning information.

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