ASSESSING CLIMATIC IMPACT ON REFUGEES/ DISPLACED PERSONS AND AGRICULTURE IN

THE HORN OF AFRICA REGION

SEPTEMBER 1983

RITA TERRY

ASSESSING CLIMATE IMPACT ON REFUGEES/DISPLACED PERSONS AND AGRICULTURE IN THE HORN OF AFRICA REGION[1]

to

International Development Cooperation Agency
Agency for International Development
Office of U.S. Foreign Disaster Assistance
Washington, D.C. 20523

by

National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service
Assessment and Information Services Center
Climatic Impact Assessment Division-Models Branch
Columbia, Missouri 65201

prepared by

Rita B. Terry[2]

NOAA/AID PASA Document Number BOF-0999-P-CC-2042-00

September 30, 1983

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Executive Summary

Assessing Climate Impact on Refugees/Displaced Persons and Agriculture in the Horn of Africa Region

Rita B. Terry[1]

The agriculturally oriented economy of the Horn of Africa region is highly vulnerable to climate variability; historically, severe drought and flooding have led to crop failures, economic losses and famine. The already fragile economies of this area are further taxed by the large numbers of refugees and displaced persons who have fled their homes to avoid war, political turmoil and environmental disasters. The Agency for International Development (AID) has supplied relief to many of these people. To obtain reliable early warning of potential food shortages to make decisions affecting this and many other of its programs, the AID/Office of U.S. Foreign Disaster Assistance (OFDA) has sponsored the project "Agroclimatic Analysis and Development of Climate/Crop Yield Models for the Horn of Africa Region" in cooperation with the Assessment and Information Services Center (AISC), National Environmental Satellite, Data and Information Service (NESDIS), National Oceanic and Atmospheric Administration (NOAA).

As a result of this project, an inexpensive Early Warning Program was developed to provide reliable, timely information on potential food shortages triggered by climatic events, particularly as related to refugees/displaced persons. 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 basis during the project.

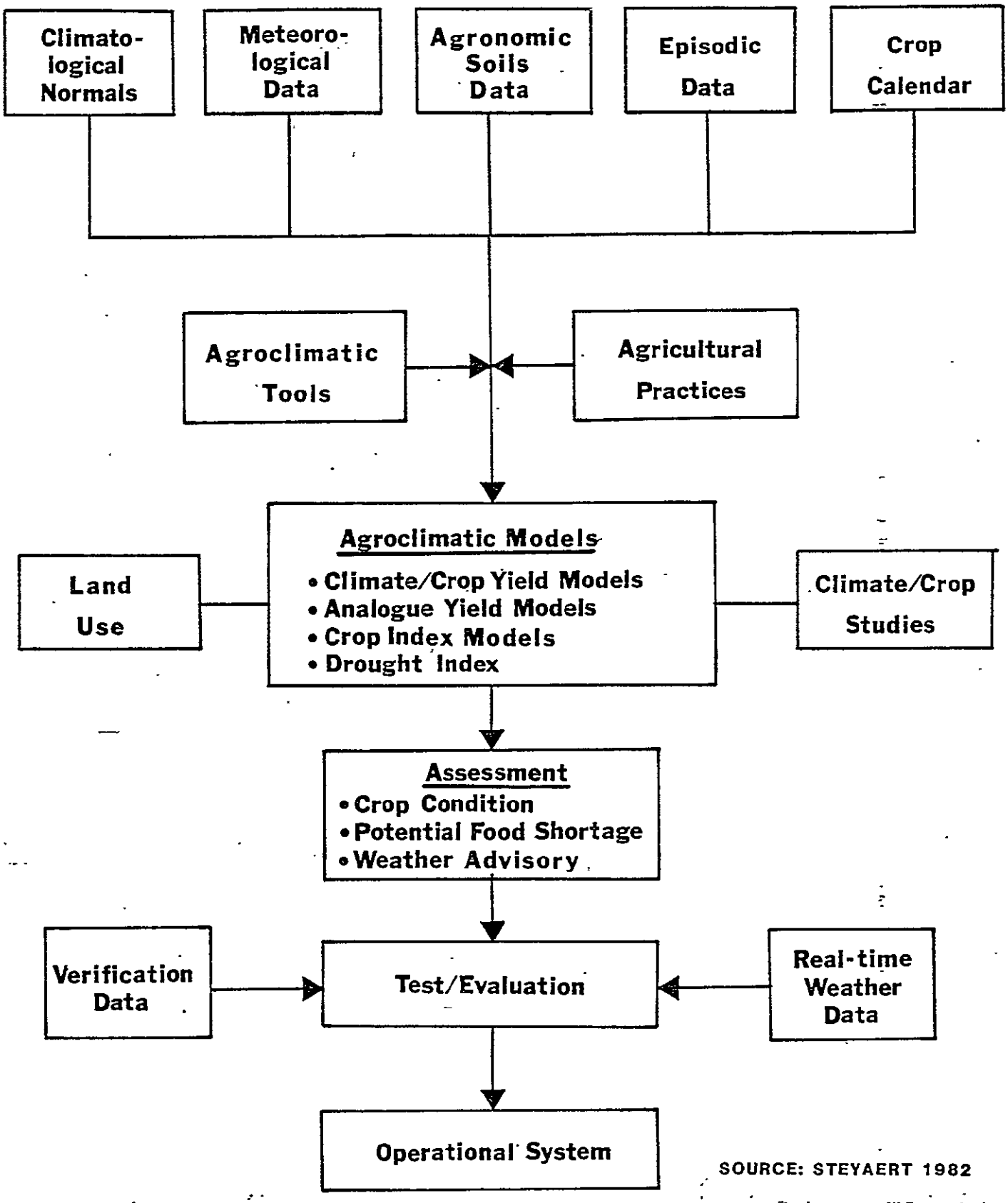
1/ Writer/Editor, AISC/CIAD-Models Branch of NOAA/NESDIS, Columbia, Missouri

The Early Warning Program is based on 1) biweekly 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 subtropics. 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 regions where weather data are sparse and unreliable. Weather data are then interpreted by agroclimatic indices which indicate potential crop production in relative terms. Finally, the potential for abnormal food shortages is identified from these indices (Steyaert, 1983).

Regional agroclimatic indices are the core of the Program (see Figure a). These indices have two forms: statistical climate/crop yield models and crop condition indices. Various historical data bases were developed to determine the appropriate index for each region. Local agricultural practices, historical episodic reports and results of experimental studies were incorporated in the choice of each index. Episodic reports on documented occurrences of famine, drought, crop failure and other events were used to establish critical thresholds for potential food shortages and to interpret indices. Agroclimatic indices and associated crop calendars for major food crops were defined for agroclimatically homogeneous regions in the Horn of Africa area.

The Early Warning Program for the Horn of Africa is operational, following successful testing of the assessment methodology. In addition to regular test assessments during July 1982-September 1983, a special assessment report on 1982 drought impacts was prepared for AID/OFDA and the Department of State Refugee Affairs Bureau (Todorov and Steyaert, 1982). The regional extent

NOAA/UMC AGROCLIMATIC ANALYSIS FOR DROUGHT IMPACT



SOURCE: STEYAERT 1982

Figure a

and magnitude of drought impacts in Ethiopia, NE Uganda and SE Sudan were reported in late September 1982. The NOAA/NESDIS/AISC assessments have been subsequently verified by reliable ground-truth information on food shortage conditions.

Natural resources in the Horn of Africa region countries are scarce. Drought has not only decreased agricultural production but has also decimated the livestock, the economic base for the nomadic population. Sources of energy for cooking are inadequate, as are living conditions in the refugee camps. Balance has shifted from the self-sufficiency of the past to the current dependence on international sources for food. One supplier of relief commodities is AID and the U.S. Department of State.

This assessment program can benefit the AID/OFDA relief programs by:

1) increasing lead-time for planning food assistance strategies to refugees and displaced persons and

2) enhancing the U.S. capacity to identify disaster conditions, thus improving recommended measures for disaster avoidance and mitigation.

The methods proposed in this report provide inexpensive and timely information which is consistent with known local agricultural practices. This Early Warning Program can provide reliable information 30-60 days before harvest of the crop. This could represent a 3-6 month warning prior to drought-related food shortages.

Assessing Climate Impact on Refugees/Displaced Persons and Agriculture in the Horn of Africa Region

I. INTRODUCTION

The agriculturally oriented economies of countries in the Horn of Africa region are highly vulnerable to annual variations in climate.. Severe drought and abnormal flooding can lead to crop failures and economic losses; historically these anomalous climatic conditions have been associated with disastrous food shortages and famine. This vulnerability to adverse climate is frequently compounded by other complex factors such as soil erosion leading to decreased agricultural productivity and population pressure. Food security problems are compounded by the approximately 1.2 million refugees who live in the Horn of Africa region, including Sudan, Ethiopia, Djibouti, Somalia, Kenya and Uganda (Figure 1). Refugees have fled their homes for other countries not only because of drought or flooding but also because of war, political turmoil, oppression, cultural conflict and other environmental disasters. These same factors have affected people classified as "displaced persons" because although they have not crossed international boundaries they have been forced to leave their homes to survive.

Although Uganda, Chad and Zaire have contributed to the refugee population, Ethiopia is the source for the majority of the Horn of Africa refugees (see Figure 2). In east-central Sudan there are 360,000-419,000 Ethiopians from Eritrea and Tigrea Provinces in northeast Ethiopia who have fled from the war for independence since 1967 (Putlizer, 1982a). Those in Somalia have fled the fighting in the Ogaden region of eastern Ethiopia, an area inhabited by Somali's when it was ceded to Ethiopia by Great Britain after World War II. The war began in 1978 when the Somali National Army was expelled when attempting to reclaim the territory. The refugee movement began in 1979 about the same time

AFRICA

HORN OF AFRICA REGION

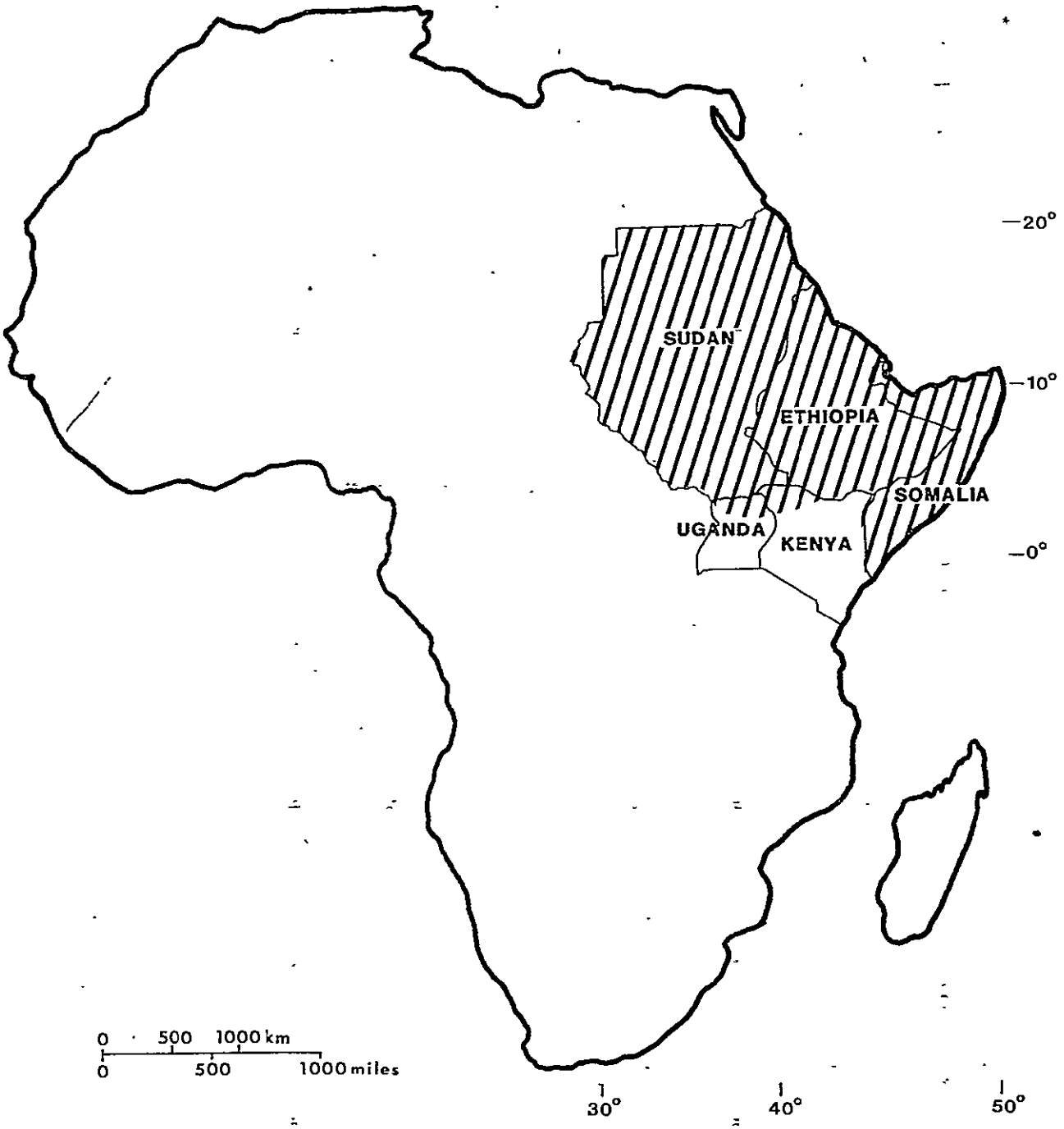


Figure 1

Refugee Movement in the Horn of Africa Region

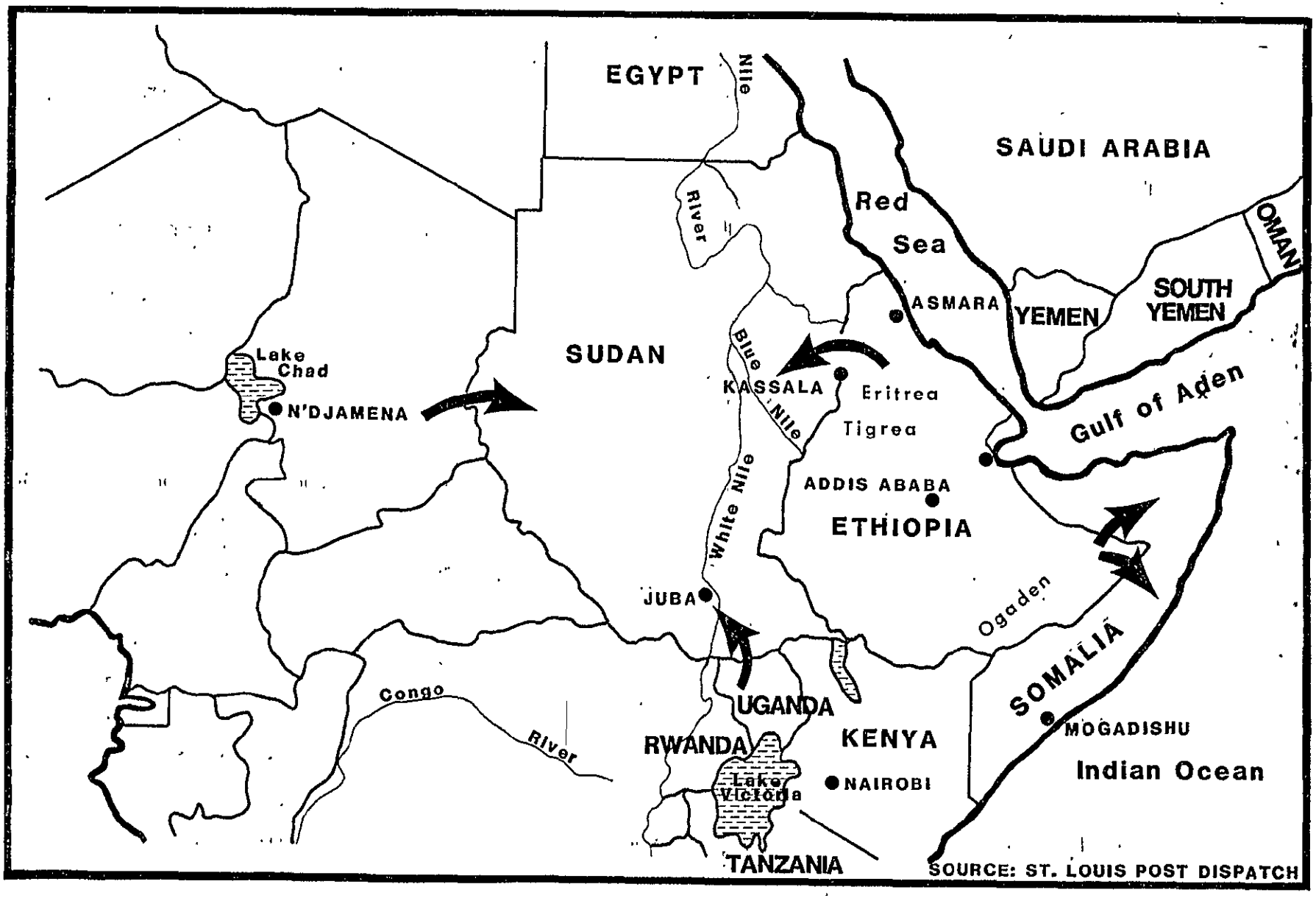


Figure 2

that drought occurred. Djibouti harbors the smallest number of refugees; they are from both the Ogaden and Eritrea. Eritrea, Tigrea, Wello, and Gondar Provinces in Ethiopia are currently suffering drought conditions which are contributing to large displacements of the native population to more favorable regions within the country.

The large numbers of refugees/displaced persons severely tax the resources of economies based primarily on subsistence agriculture. International assistance is needed to supply food and shelter. Decisions on international relief assistance must be based objectively on an evaluation of all available information to determine the magnitude of the problem and human needs. A reliable early-warning program designed to alert decision makers to potential problems is a key element of disaster preparedness, as well as a basis to support decisions for assistance. Knowledge of the antecedent conditions associated with the disaster is also important. The sources of information, particularly the data, necessary to develop an operational early-warning system frequently are quite limited in developing countries where the potential for climate-related food shortages is greatest.

Because of these considerations, the NOAA/NESDIS Assessment and Information Services Center (AISC) was asked by the Office of U.S. Foreign Disaster Assistance (OFDA), Agency for International Development (AID), to investigate early-warning procedures for disaster assistance needs associated with refugees in the Horn of Africa region. This multi-discipline effort is being conducted by the AISC Climatic Impact Assessment Division (CIAD)-Models Branch, Columbia, Missouri, and the Climatic Assessment Branch (CAB), Washington, D.C., in cooperation with the University of Missouri-Columbia (UMC).

The goals of this project for the Horn of Africa region include:

1) providing AID/OFDA with qualitative biweekly weather assessment reports on the impact of anomalous weather events,
2) developing agroclimatic and other data bases to investigate the impact of weather and non-weather factors on crop failures and food shortages,
3) determining background information on refugees/displaced persons and how climate influences their activities, and
4) developing a low-cost Climate/Subsistence Food Early Warning System based on agroclimatic analyses to provide timely, reliable information on potential food shortages due to drought and the impact of climate on refugees/displaced persons.

This report summarizes and discusses the accomplishment of the above goals. It is written to provide background information for those potentially involved with weather/crop condition assessment analysis. Country profiles in Section II provide information on refugees/displaced persons, agriculture practices and basic agroclimatic background. Section III summarizes international assistance and current problems. The proposed early warning program for the Horn of Africa region is discussed in Section IV, followed by a summary and recommended future investigations in Section V.

II. COUNTRY PROFILES

A. Sudan

Physical Environment

Sudan's 419,000 Ethiopian, 5,000 Zairian, 16,000 Chadian, and 110,000 Ugandan refugees and more than 18 million Sudanese live in the largest country in Africa.* Most of the 2,505,823 square kilometers are composed of sparsely populated plains bounded by plateaus and mountains in the west, southeast and along the Red Sea. Most of northern Sudan is barren desert with narrow belts of cropland along the Upper, White and Blue Nile and Atbara Rivers. Intermittent streams contribute to the Nile system and supply water for irrigation in the northeast. In the south, a 6 to 9 month rainy season creates lush vegetation and permanent swamps; a large volume of the White Nile is carried into the swampy area of South Central Sudan.

Climate

Sudan has a tropical climate. Rainstorms develop from April to July; annual rainfall in southern Sudan is about 1,200mm, 400 to 500mm in the central plains, and almost non-existent in the northern border areas. The annual rainy season lasts from June-October in the East and April-October in the South. Histograms of average monthly rainfall in the different agroclimatic regions are shown in Figure 3.

Temperatures in the south are slightly lower than the maximum 40°C in December to 48°C in June in the Khartoum area, representative of the north and central regions. Mean minimums range from 15°C to 27°C throughout the country.

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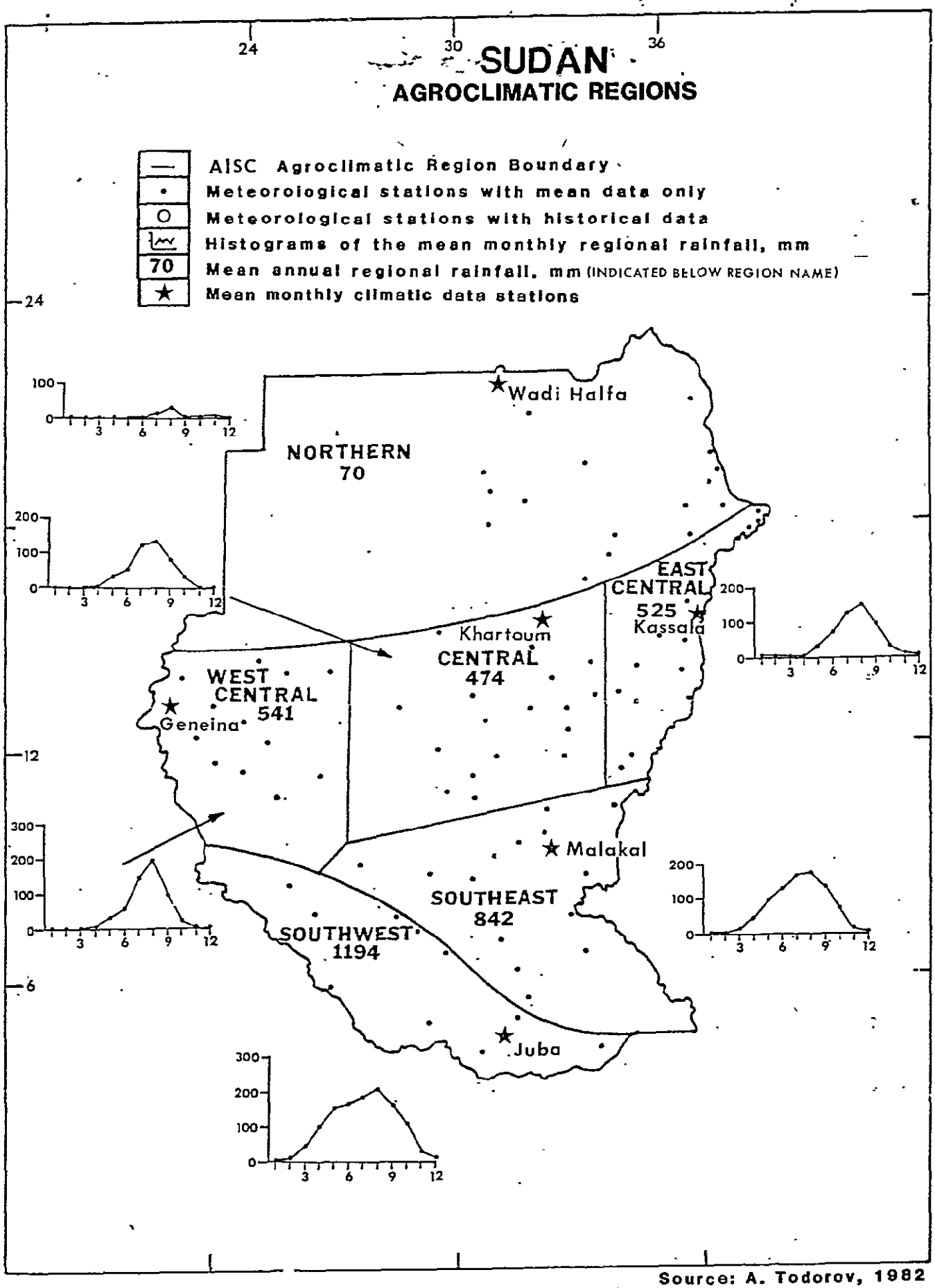
*The total numbers of refugees and displaced persons are somewhat arbitrary in all cases since census counts are difficult; the figures in this report represent the approximate situation in late 1981 based on United Nations High Commissioner of Refugees (UNHCR) figures.



Source: A. Todorov, 1982

Figure 3

Evaporation rates are high throughout the year. Humidity is higher in the south. Sun and desert wind create desert conditions in the North and Central regions except during the winter months. Mean monthly climatic data for stations in each agroclimatic region are shown on Table 1.

Agriculture

Agriculture is the major element of the economy; one-third of the total land area of 252 million hectares is devoted to agriculture, representing 40% of the GDP and employment for two-thirds of the labor force (Phillippi and Mango, 1981). Types of agriculture are shown on Figure 4. Crop calendars indicating approximate harvesting dates in Sudan are shown in Table 2. Major crops are cotton, groundnuts, wheat, sorghum, beans and rice. Livestock are an important resource which needs to be expanded. Staple foods are cereals, roots and tubers, pulse crops, oils, vegetables, fruits, meat, fish and fowl, and dairy products.

Sedentary agriculture is the lifestyle for a large percentage of the native population. However, the availability of water governed by the rainfall patterns creates the necessity for seasonal moves. Depletion of the soil is also a factor in the nomadic patterns. Shifting cultivation and overgrazing have destroyed the orginal savanna of the central plains where rainfed agriculture is common. Desertification is moving south. Deforestation is also a problem; the native acacia trees are being uprooted for firewood, causing erosion and reduced retention of the water supplies of Central Sudan.

Refugee Areas

The general locations of the refugee camps in Sudan are shown in Figure 5. The refugee population is split between 102,000 in the Eastern camps in Kassala Province and 75,000 in the southern in Equatoria. Both of these areas are more

TABLE 1. MEAN MONTHLY CLIMATIC DATA FOR SELECTED STATIONS IN SUDAN

Months	JUBA Lat. 4°52'N Long. 31°36'E Elev. 460 m			KASSALA Lat. 15°28'N Long. 36°24'E Elev. 500 m			KHARTOUM Lat. 15°36'N Long. 32°32'E Elev. 380 m			MALAKAL Lat. 9°33'N Long. 31°39'E Elev. 385 m			WADI HALFA Lat. 21°50'N Long. 31°18'E Elev. 160 m		
	Temp. (°C)		Pcp. (mm)	Temp. (°C)		Pcp. (mm)	Temp. (°C)		Pcp. (mm)	Temp. (°C)		Pcp. (mm)	Temp. (°C)		Pcp. (mm)
	Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
Jan	37	20	5	35	16	0	32	16	0	36	19	tr.	25	8	0
Feb	38	21	10	36	16	1	34	17	tr.	37	20	tr.	27	9	0
Mar	37	23	43	39	19	1	37	19	tr.	39	22	3	31	13	0
Apr	35	23	107	41	22	5	40	23	1	39	24	24	36	17	0
May	33	22	157	42	25	14	42	26	5	36	23	95	41	22	1
Jun	32	21	116	40	25	27	42	27	7	33	22	115	42	23	0
Jul	31	20	136	36	23	100	38	26	48	31	22	153	41	24	1
Aug	31	20	154	34	22	124	36	25	72	31	21	167	41	25	0
Sep	32	20	105	36	23	60	38	25	27	32	22	144	39	23	0
Oct	34	20	101	39	23	7	40	25	4	34	22	77	37	20	1
Nov	35	20	35	38	21	2	36	21	tr.	36	20	6	31	15	0
Dec	36	20	13	35	17	0	33	17	tr.	35	18	1	26	10	0
Annual	31	21	982	37	21	341	37	22	164	35	21	783	35	17	3

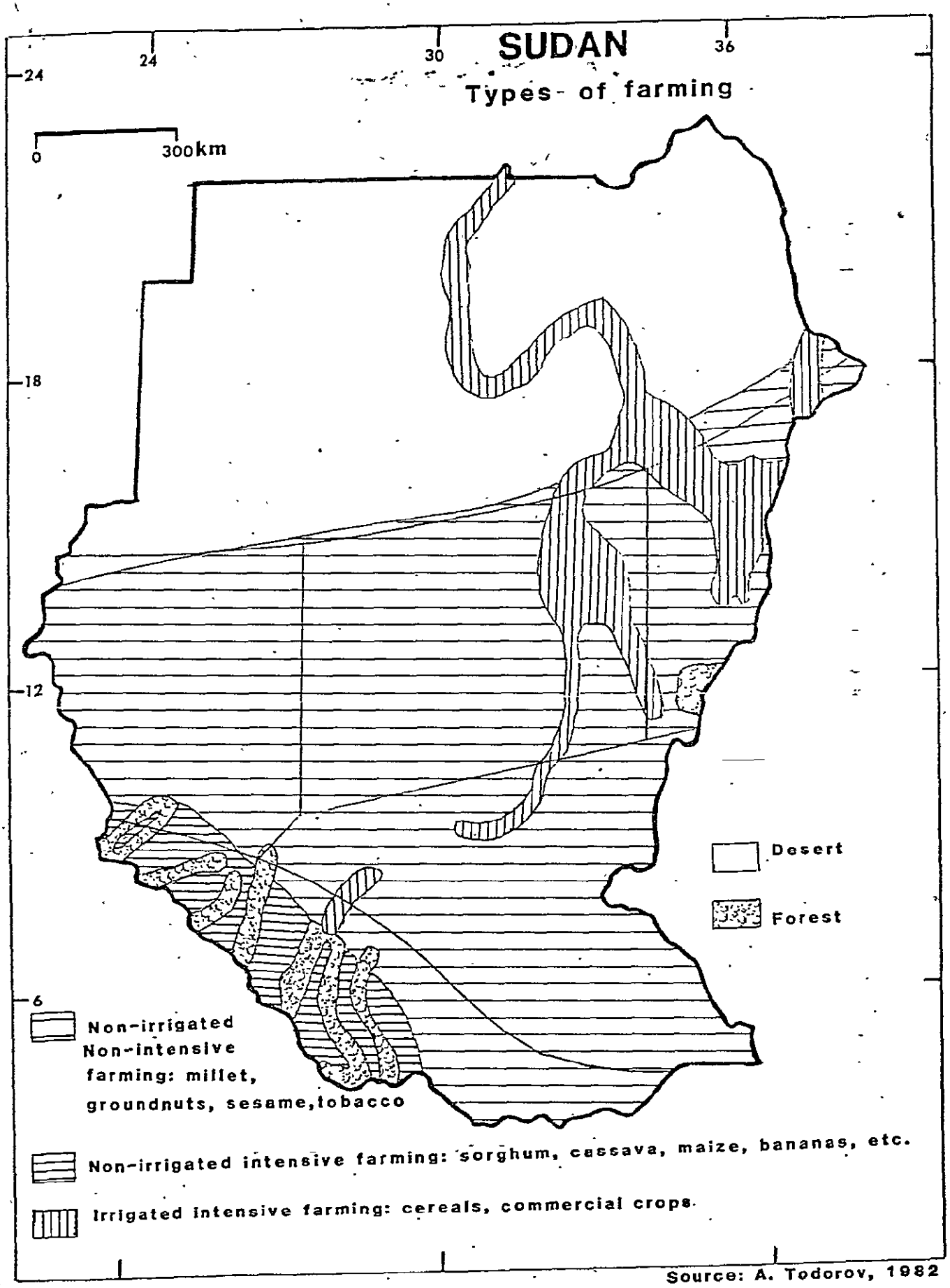

SUDAN
Types of farming
24
30
36
24
18
12
6
0
300km
Desert
Forest
Non-irrigated
Non-intensive
farming: millet,
groundnuts, sesame, tobacco
Non-irrigated intensive farming: sorghum, cassava, maize, bananas, etc.
Irrigated intensive farming: cereals, commercial crops.
Source: A. Todorov, 1982

Figure 4

TABLE 2. HARVESTING DATES FOR MAJOR CROPS IN SUDAN

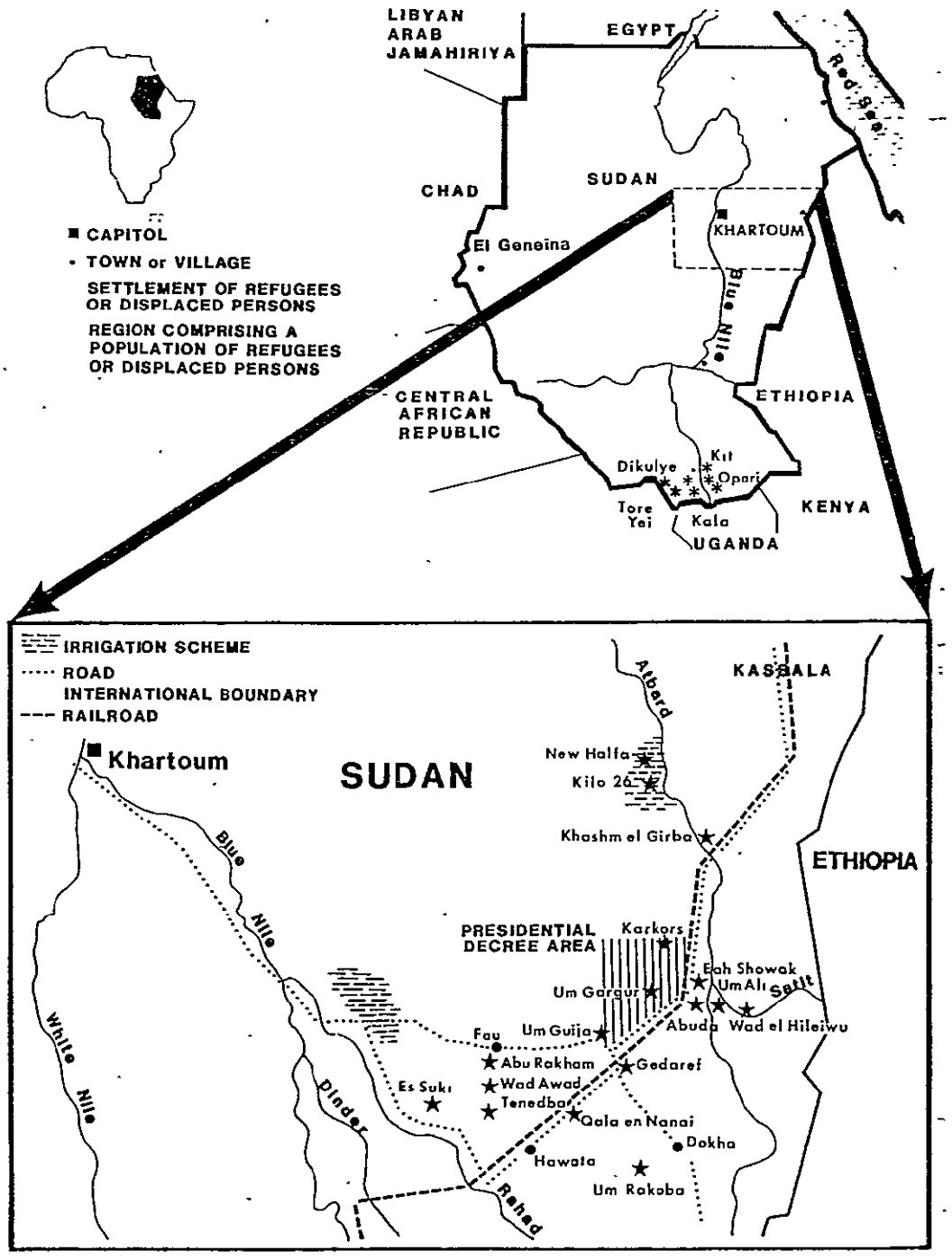
Crops	Harvest Period	Bulk of Harvest
Wheat	Feb - Apr	Mar - Apr
Barley	Feb - Apr	Jan - Feb
Maize	Feb - Apr	Sep - Oct
Millet	Oct - Dec	Oct - Nov
Sorghum	Oct - Dec	Dec - Jan
Potatoes	Oct - Dec	Apr - May
Cassava	Whole year round	Apr - May
Onions	Whole year round	Apr - May
Dry beans	Jan - Mar	Jan - Mar
Broad beans	Jan - Mar	Jan - Mar
Chick-peas	Jan - Mar	Jan - Mar
Lentils	Mar - Apr	Mar - Apr
Lupins	Mar - Apr	Jan - Feb
Oranges	Mar - Apr	Nov - Mar
Lemos	Whole year round	Nov - Mar
Dates	Jul - Nov	Jul - Aug
Bananas	Whole year round	Jul - Aug
Mangoes	Whole year round	Apr - Aug
Groundnuts	Whole year round	Nov - Dec
Sesame Seeds	Oct - Dec	Oct - Dec 1/ &
Cotton	Oct - Dec	Nov - Dec 2/

1/ Irrigated
2/ Rainfed

Source: Philippi and Mango, 1981.

SUDAN

REFUGEE AREAS



SOURCE: UNHCR

Figure 5

favorable to agriculture than the northern or north-central areas. There are three types of eastern settlements: 1)rural based on individual farming; 2) rural based on employment in the large irrigation projects, and 3) semi-urban. Agriculture is common to all the eastern settlements to varying degrees. In the south, all of the settlements are rural agricultural. In addition to these major camp areas, a care and maintenance program has been established at Geneina in western Sudan for 10,000 refugees from Chad.

Food Supplies

Although Sudan has a rural economy with 87% of the working population involved with agriculture and animal husbandry, the country is not currently self-sufficient in food production. From 1960 to 1981, the total imports of wheat tripled from about 100 to 300 thousand metric tons. For the same period of time, exports of sorghum and coarse grain varied up to 200 thousand metric tons (Todorov, personal communication).

Generally, food is supplied from the immediate area varying according to the region and social customs. The nomads in the west and north supplement milk and clarified butter from their animals with grain. Southern pastoralists obtain protein from fish and eat wild fruits, roots and seeds during the dry season. The diet in the central plains is based on sorghum and millet. In the south-west, sorghum and millet are also grown, as well as cassava in drought-prone years; this is supplemented with fish, rodents, insects and groundnuts. Dietary imbalances between carbohydrates and proteins exist in all areas.

Refugee Policy and Cultural Problems

The policy of the Sudanese government is to relocate unemployed refugees in urban areas. Organized settlements are the first stop for newly arrived refugees; there they are given the opportunity to learn skills necessary for the end goal of self-sufficiency, the underlying aim of the refugee program. These urban camps are the most crowded, composed of squatter's huts with no access to water or sanitation facilities. Once moved from these urban camps, the refugees live in resettlement villages with small plots of land to farm. The shelters are still temporary, but water sources are being developed by drilling wells.

Sudan has one of the more positive attitudes towards refugees, granting asylum to all who seek it regardless of their reasons. Although there are strict regulations against granting Sudanese citizenship and land owning rights, some effort has been made to integrate them into the Sudanese economy. However, the ultimate aim is for the refugees to return to Ethiopia, as refugees from the Zaire civil war in the mid-1960's and 20,000 Chadians have already done.

In all of the settlement areas, an attempt has been made to establish schools and training programs to promote skills which will create money-earning jobs for the refugees. Teachers are trained from the refugee population. Support from UNHCR for the eastern camps is expected to taper off by the end of 1983 when the programs already established should incorporate the refugees into the Sudanese economy. The southern camps, where Ugandans are currently receiving UNHCR aid, are not expected to become self-sufficient that soon.

Separate problems exist on the western border with Chad. Although the number of refugees from Chad is smaller, varying at times from 9,000 to 16,000, problems have been greater. One is the difference in the semi-nomadic customs

of the refugees. Their competition for the local market, need for land and water for animals, and ability to buy at inflated prices because of international aid has caused the native inhabitants hardship. The political situation in Chad remains unstable; it might be some time before the Chadians are able to become repatriated. Some of the problems have been lessened by use of UNHCR aid for the local inhabitants when drought conditions taxed the already dwindling supplies of staple foods, water and grazing land, but the ethnic conflicts can be expected to continue in the confined areas of the camps at El Geneina and Karantina.

Cultural problems result in other areas in Sudan because the main source for a large percentage of the refugees are Eritrea and Tigrea Provinces in Ethiopia, urban rather than rural areas. The refugees are sophisticated, knowledgeable about world affairs, many speak English, many are Christians. They have no desire to be integrated into a rural existence in an Islam culture. Their lifestyles differ from the native population, sometimes causing confrontations. One camp was bombed by the Moslem Brotherhood. Bad feelings also are created because camp conditions, as bad as they might be, are sometimes better than those of the nomadic or urban Sudanese. The Ethiopian refugees also experience difficulties with the change from a cool, highland existence to the hot conditions they find in Sudan.

B. Somalia

Physical Environment

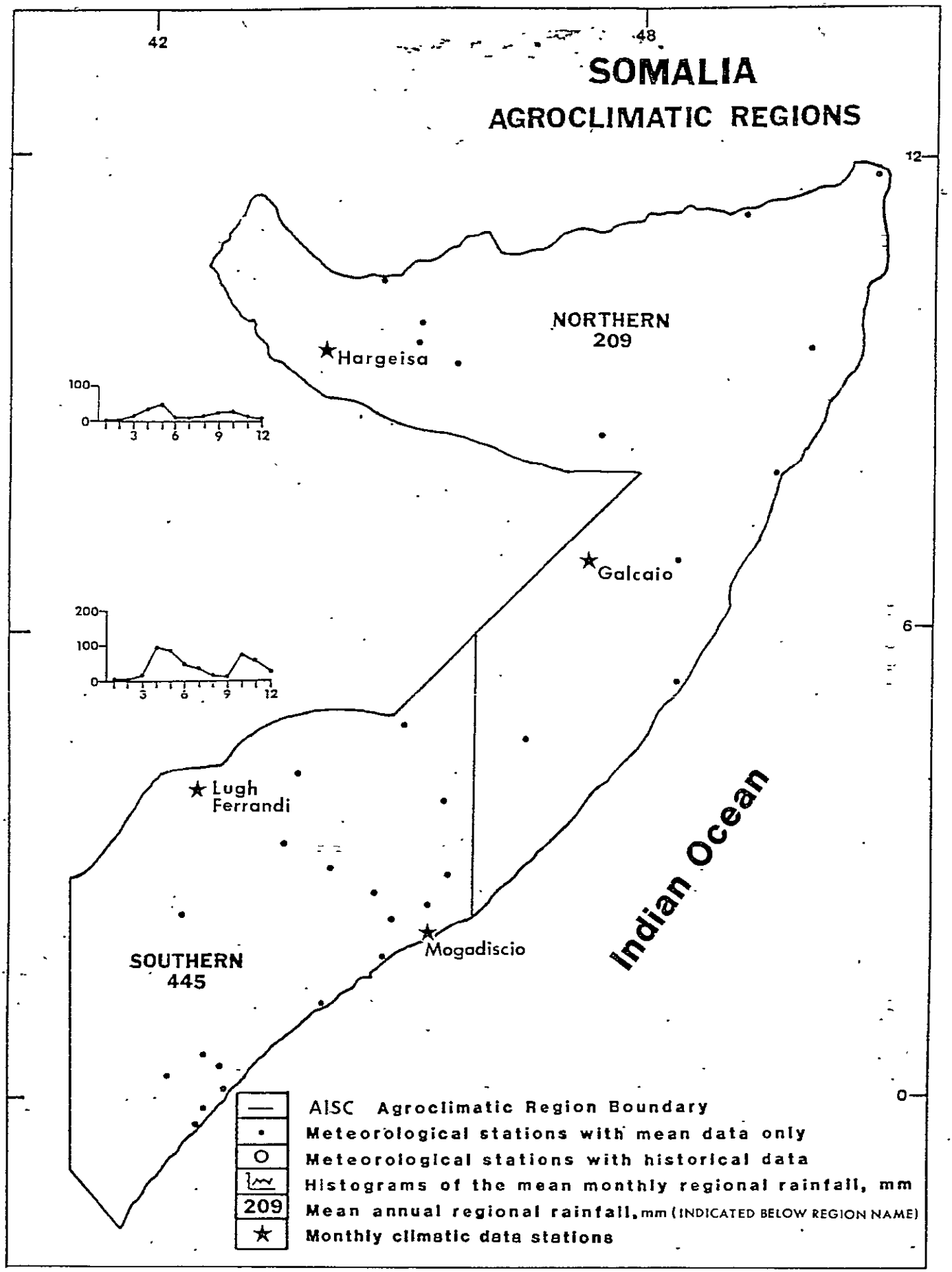
Somalia, 637,660 square kilometers, is bounded by Kenya to the southwest, Ethiopia to the west, Djibouti to the northwest and has a 3,000 kilometer coastline on the Gulf of Aden and the Indian Ocean. Coastal plains are non-agricultural in the north (scrub-covered, semi-arid, hot and dry with no rivers

and very little rainfall) and suitable for agriculture, especially for irrigated crops along rivers, in the south. Rugged mountain ranges extend gradually from the coast to the Ethiopian border in the northwest and east to Cape Guardafui. In the south an elevated plateau slopes towards the Indian Ocean. Eastern Somalia is particularly arid and drought-prone. The western regions receive more rainfall and can support some farming. The best pasture land is on the western plateau which slopes southward into a broad undulating plain which extends into the Ogaden area of Ethiopia; depressions in this area flood during the rains to become seasonal lakes. The only two rivers, the Juba and Shebelle, flow through southwestern Somalia. This is the most fertile agricultural area because of soil conditions and favorable rainfall.

Climate

Rainfall, as in Sudan, is the major influence on life in Somalia. Less than 500mm of annual rainfall is common in most of the country. Northern Somalia receives 50-150mm annually, except in the higher elevations which are closer to the national average. The southwest receives 350-500mm; some coastal areas receive more than 500mm. However, as indicated by the rainfall histograms in Figure 6, these rainfall totals are spread over two distinct rainy seasons, generally April-June (Gu) and August-November (Der). It is seasonally dry during July. Evaporation rates are high and irrigation is usually required to successfully grow crops.

Mean monthly climatic data for a station in each agroclimatic region are shown on Table 3.



Source: A. Todorov, 1982

Figure 6

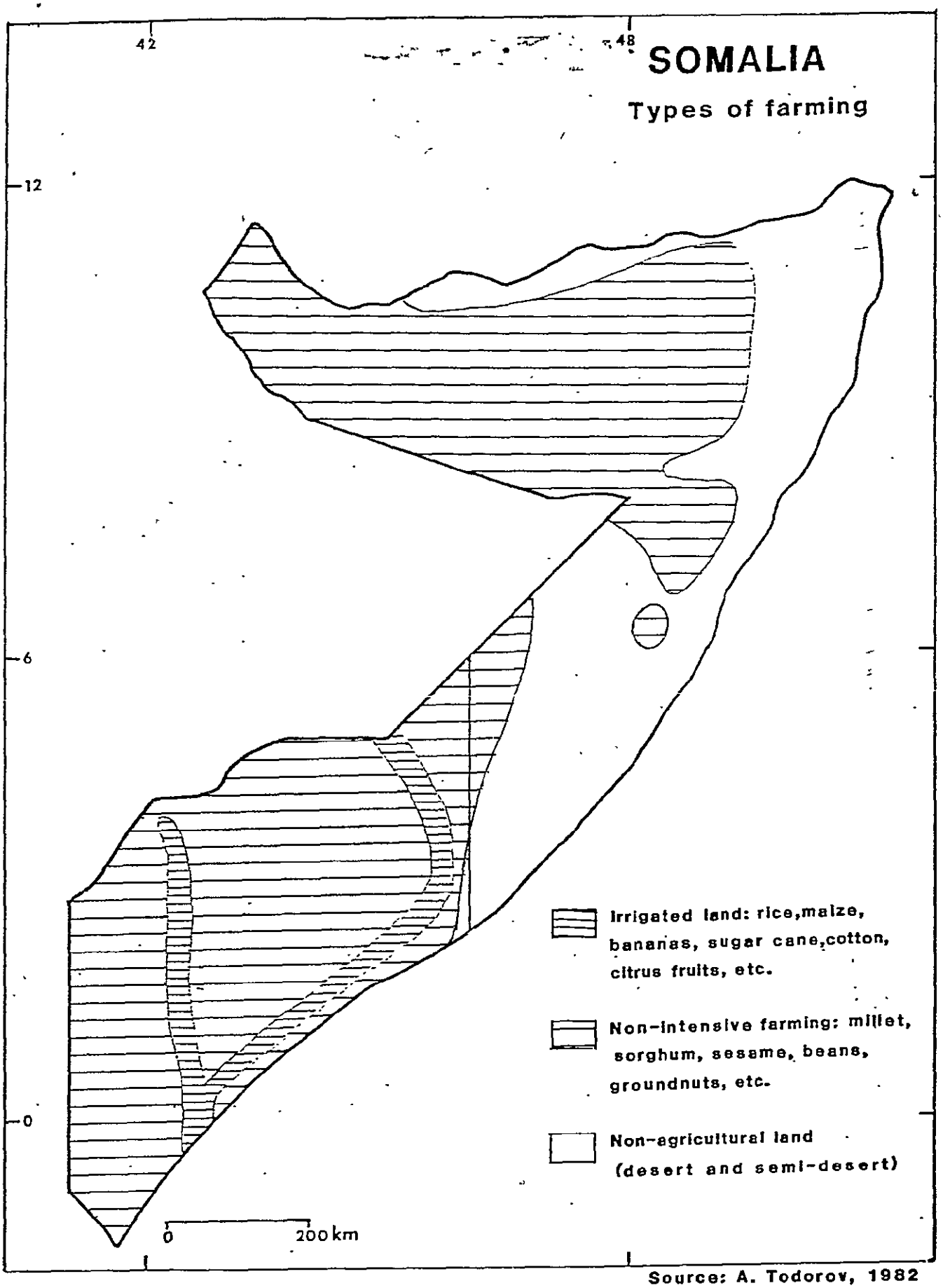
TABLE 3. MEAN MONTHLY CLIMATIC DATA FOR SELECTED STATIONS IN SOMALIA

Months	GALCAIO Lat. 6°46'N Long. 47°25'E Elev. 240 m			HARGEISA Lat. 9°31'N Long. 44°06'E Elev. 1,370 m			LUGH FERRANDI Lat. 3°45'N Long. 42°35'E Elev. 193 m			MOGADISCIO Lat. 2°02'N Long. 45°21'E Elev. 17m		
	Temp. (°C)		Pcp. (mm)	Temp. (°C)		Pcp. (mm)	Temp. (°C)		Pcp. (mm)	Temp. (°C)		Pcp. (mm)
	Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
Jan	32	18	0	24	12	3	39	24	2	30	23	1
Feb	33	19	3	27	13	8	40	25	4	30	23	0
Mar	35	20	1	29	16	25	41	25	28	31	25	9
Apr	36	22	24	29	17	61	38	25	113	32	26	58
May	35	23	60	31	18	61	36	25	40	31	25	56
Jun	34	23	2	31	18	58	35	24	1	30	24	82
Jul	33	22	0	30	17	42	34	23	3	29	23	58
Aug	33	22	2	29	18	81	34	23	0	29	23	40
Sep	34	22	1	31	17	58	36	24	1	29	23	23
Oct	34	22	41	28	15	10	37	24	47	30	24	27
Nov	34	20	14	28	13	8	37	24	56	31	24	36
Dec	33	19	1	25	12	1	38	23	15	31	23	9
Annual	34	24	149	28	15	416	37	24	310	30	24	399

Temperatures are lower in the higher elevations and along the Indian Ocean coast. Mean monthly maximum temperatures range from 24°C at Hargeisa to 41°C at Lugh Ferrandi. Mean monthly minimum temperatures range from 12°C at Hargeisa to 29°C at Mogadiscio. The highest temperatures in the North occur in June or July and the lowest in December-January. Winters with occasional frosts and fog occur in the northwestern highlands. The southern climate is equatorial. Extreme monthly temperatures range from 16°C to 50°C at Lugh Ferrandi. Southern temperatures are hottest from February-April and coldest in July. Coastal temperature ranges are 2-3° cooler. The annual range of monthly temperatures is 3-4°C for most of the country.

Agriculture

Most of Somalia is suitable only for livestock grazing except in the southern areas with sufficient reliable rainfall and irrigation. Types of farming are shown in Figure 7. About 60% of the population lives by nomadic grazing; the government has developed an established network of wells and watering places for the stock to alleviate long migrations and overgrazing. However, 40% of the country is of little economic value because of lack of rainfall. In the south where the rains are fairly reliable, rainfed (550,000 hectares) and irrigated (118,000 hectares) agriculture are practiced. Principal crops are sorghum(55%), maize and sesame grown under rainfed conditions; crop calendars are shown on Table 4. Irrigated crops are bananas, sugarcane, fruits, vegetables, and small amounts of groundnuts, cotton and pulses. Staple foods are grains, fish, meat, fowl, dairy products, fats, fruits, vegetables and beverages such as milk, coffee and tea.



Source: A. Todorov, 1982

Figure 7

TABLE 4. PLANTING AND HARVESTING DATES FOR CROPS IN SOMALIA

Commodity	Planting Season	Harvesting Season
Cereals & grains:		
Corn (Gu) 1/	Mid-April	July
(Der) 2/	Mid-October	February
Millet & Sorghum (Gu)	April	July
(Der)	Mid-October/Mid-November	February/Mid-February
Rice	May-June	August-September
Fibers:		
Cotton (Gu)	April	Mid-August-October
(Der)	September	February/Mid-February
Fruits:		
Bananas	n.a.	Throughout year
Dates	n.a.	Mid-June/Mid-July
Grapefruit	n.a.	May-June
Lemons	n.a.	Throughout year
Oilseeds:		
Peanuts (Gu)	April	August
(Der)	October	February
Sesame (Gu)	April	August
(Der)	October	February
Sugarcane	July-September	Throughout year
Tobacco (Gu)	March-April	September-October
(Der)	September	February-March
Vegetables:		
Beans, dry (Gu)	April	August
(Der)	November	February
Cassava (Manioc)	April	Throughout year
Onions	April-October	June-December
Tomatoes	April-October	June-December

1/ "Gu" season, April-June; season for planting and sowing of most crops.
2/ "Der" season, September-November.

Source: Philippi and Mango, 1981.

The diet varies considerably between the nomadic and southern sedentary agricultural populations.

Refugee Areas

The refugee camps, containing ethnic Somalis, are primarily located in the southern part of Somalia, along the rivers (see Figure 8). The areas surrounding the refugee camps are fast becoming dust bowls; every available twig and branch has been scavenged for fuel. Rainfall during the two rainy seasons turns the dusty roads to mud. Shelters are bush huts with tarpaulins to keep out the rain. Prefabricated building units have helped to alleviate some of the housing problems. Refugees supply the labor. Water and health facilities have been developed by UNHCR; the same level of support from that organization is continuing through 1983. Conditions in the camps have improved to the point where they exceed the living conditions of the general population.

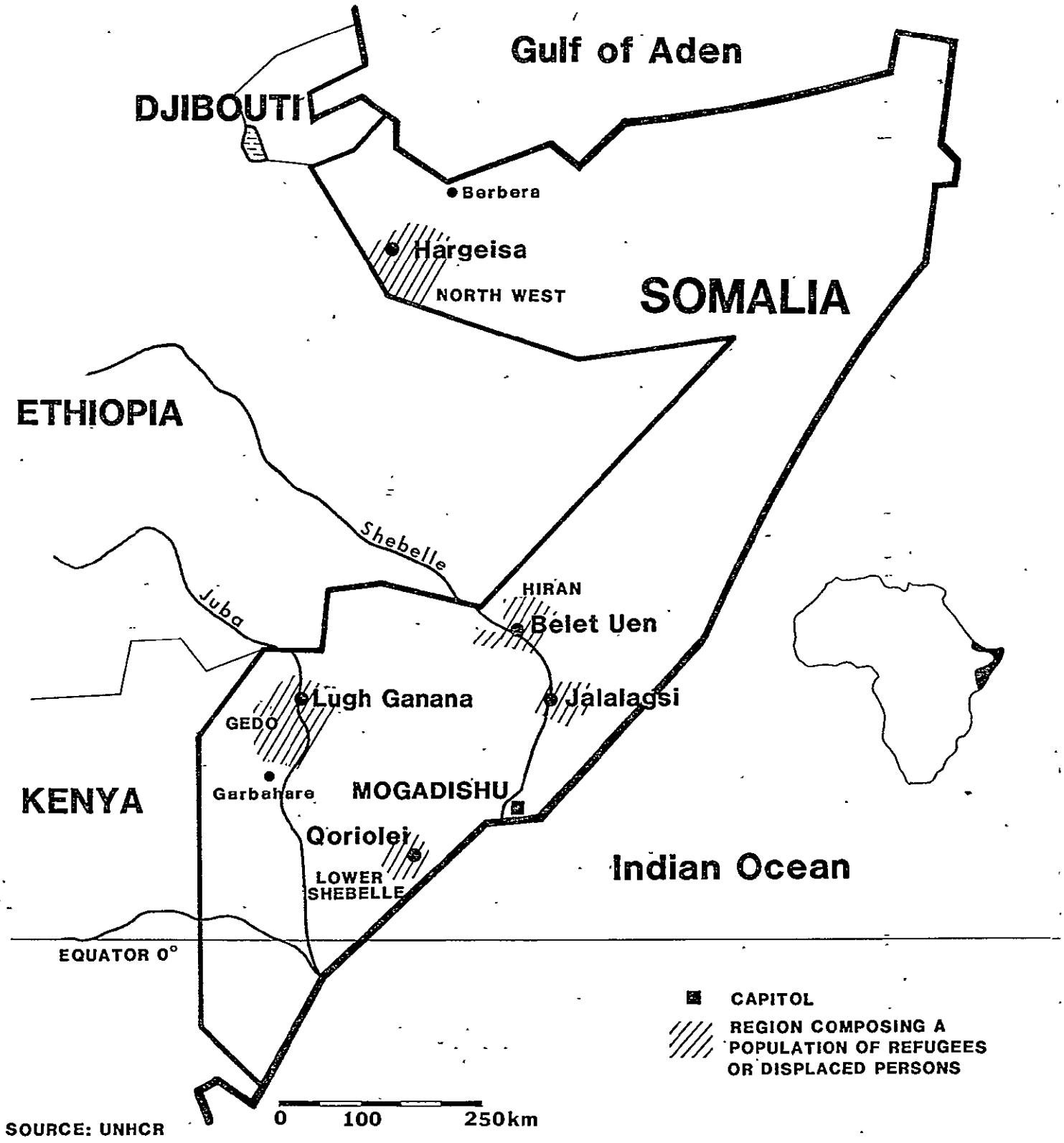
Food Supplies

Somalia is not self-sufficient in food production. Programs organized to promote self-sufficiency suffer because of frequent droughts which cause crop failures and make rational, consistent grazing patterns impractical. However, recent weather has been favorable for crop production which should improve the overall situation in Somalia. Financial aid is supplied by Italy, the United States and the U.S.S.R. to enable importation of food. Cereal consumption is about 350,000 tons/year; 15-30% of that amount has to be imported. However, with proper management, Somalia could be self-sufficient in food production.

Refugee Policy and Cultural Problems

The primary emphasis of the refugee programs is on self-reliance by expansion of farming and other income generating acitivities. More land is being cultivated to increase farming activities. Teachers are being trained from

SOMALIA
REFUGEE AREAS



SOURCE: UNHCR

Figure 8

among the refugee population; volunteers are also being used to teach farming techniques. The practical skills of soap and brick making and leather and metal work are also being taught by volunteers. A reafforestation program has been initiated to offset the serious ecological damage resulting from the use of all available wood surrounding the camps for energy. Solar cooking programs are being tried.

Since the refugees entering Somalia from Ethiopia are ethnic Somalis, one of the major problems experienced in Sudan is not relevant here; the nomadic tribesmen historically have paid little attention to the administrative boundaries crossing their pasturelands. However, other problems exist. Somalia has the highest number of refugees of any country in the world; estimates range from 1.3 million by the government in 1980 to 700,000 by the UN in 1982. The Somali government claims 650,000 addditional refugees live with friends and relatives outside of the camps. The vast numbers are taxing the limited environment. The aid the country has been receiving for the refugees has been a major source of revenue for the country which it does not want to lose. Although self-sufficiency is stressed, permanently settling the refugees would result in losing the Somali claim to the Ogaden. There is also fear that the cultural nomadic character of the people will be changed by the receipt of international aid; it will be hard for them to return to a nomadic existence after living in camps and receiving free food.

C. Djibouti

Physical Environment

With an area of 21,783 square kilometers, Djibouti is the smallest Horn of Africa country receiving refugees. It also has the smallest number of refugees at 31,600, both from the Ogaden and Eritrea areas of Ethiopia. This represents

approximately 10% of the population of this country. Desert comprises 89% of the landscape, pastureland 10% and less than 1% of the total land area is cultivated.

Climate

Rainfall is erratic, varying from an annual average of 508mm in mountainous regions to 86mm in coastal areas. In coastal areas, there are on the average only 26 rainy days each year, mostly in March and November. Drought is common, as are floods resulting from sudden, excessive rainfall.

Some of the hottest temperatures in the world are experienced in Djibouti. The mean daily maximum is 28.7°C in January, varying to as high as 43.4°C in July. The mean daily minimum varies from 22.5°C to 30.5°C for the same period. Relative humidity varies from 43% in July to 80% or more in January, increasing with the decrease in temperature. Two main seasons are determined by prevailing winds. Winds from the Indian Ocean bring moisture and rains from October to March or April. During the rest of the year, from May to October, continental winds from the north bring hot, dry conditions. The hottest period lasts about 50 days in the summer.

Mean monthly climatic data for Djibouti City appear on Table 5.

Agriculture

Volcanic terrain, lack of rainfall and high temperatures result in little cultivation of crops in Djibouti. Some dates, green vegetables, tomatoes and fruits are grown at oases or in gardens near wadis, temporary rivers that are wet for only part of the year. The cultivated areas are located in the towns bordering the Gulf of Tadjoura and in the south of the country. There are no permanent rivers or major streams. The lakes are either temporary and brackish or salty. The major source of water is temporary and permanent springs that

TABLE 5. MEAN MONTHLY CLIMATIC DATA FOR

DJIBOUTI CITY, DJIBOUTI

Months	DJIBOUTI Lat. 11°36'N Long. 43°09'E Elev. 7 m		
	Temp. (°C)		Pcp. (mm)
	Max.	Min.	
Jan	29	23	10
Feb	29	24	13
Mar	31	25	25
Apr	32	26	12
May	34	28	5
Jun	38	30	1
Jul	41	31	2
Aug	39	29	8
Sep	36	29	8
Oct	33	27	10
Nov	31	25	22
Dec	28	23	13
Annual	32	27	129

give the wadis enough moisture for dense vegetation.

Livestock raising is practiced more widely than farming, with sheep and goats more predominate because they can withstand the climatic conditions and are more tolerant of the grazing conditions. Camels, cattle and asses make up a comparatively small percentage of the herds. The nomadic movements of the herders are controlled by the abundance of rainfall in the pasture areas. The most favored areas are around the Mabla and Gouda Mountains and in the Dorra and Gobad regions. The nomads include millet, meat, milk and fat as staples in their diet. Fish is eaten only by urban and coastal groups. The remainder of the diet in Djibouti includes rice, corn, beans, vegetables, dates and melons and milk, tea and coffee.

The economy of Djibouti is based entirely on the railway line linking Addis Ababa, Ethiopia to the port of Djibouti. The outside influences of the war in Ethiopia, the closing of the Suez Canal from 1967 to 1975 and competition from other Red Sea ports, have greatly curtailed the port activity. Unemployment is about 50%. The Ethiopian wars have also made train shipments unreliable.

Food Supplies

The refugees are completely dependent on outside sources for food. The nomadic population has also been dependent on outside aid because of occurrences of drought; they have been displaced from their grazing land into temporary camps to receive aid from the government and international organizations. There were 30,000 displaced nomads as of September 1982.

Traditionally 95% of food, all food grains and most animal protein, has been imported from Ethiopia. War and drought in Ethiopia have forced a search for new suppliers. Kenya and France have become new sources. The refugee camps at

Ali Sabieh, Dikhil and Djibouti City receive monthly distributions from P.L. 480, Title II (Philippi and Mango, 1981).

Refugee Policy and Cultural Problems

The lack of resources and agriculture and high unemployment have strongly influenced the attitude of the government against refugees. Resettlement is actively discouraged. Refugees are not permitted to work. Training programs to integrate the refugees into the fragile economy have not been well received. The situation has not been helped by the prevailing attitude that the refugees live better in the refugee camps than does the native population. An attempt has been made by the government to move the refugees out of the town of Djibouti to the camps in the south of the country, shown in Figure 9. Approximately 85% of the refugees are women and children.

D. Ethiopia

Physical Environment

Ethiopia's 1.2 million square kilometers can be characterized by three geographical areas with wide variations in altitude and terrain. The Ethiopian Plateau comprises most of the country and is divided into the High Plateau in the north, with 4,300-4,600m peaks to deep chasms, and the flat Somali Plateau in the southeast. The Great Rift Vally runs north to south in the Central Plateau; it varies from 600m above sea level in the south to 1,800m in the northern area near Addis Ababa. Lowlands surround the highland mass, forming the Danakil Plains in the north where the Danakil Depression 116m below sea level is located, and the Sudan Plains in the west. Soils are formed by the decomposition of volcanic rocks and are fertile although deficient in phosphorous; erosion has been caused by heavy seasonal rainfall and deforestation.

DJIBOUTI
REFUGEE AREAS

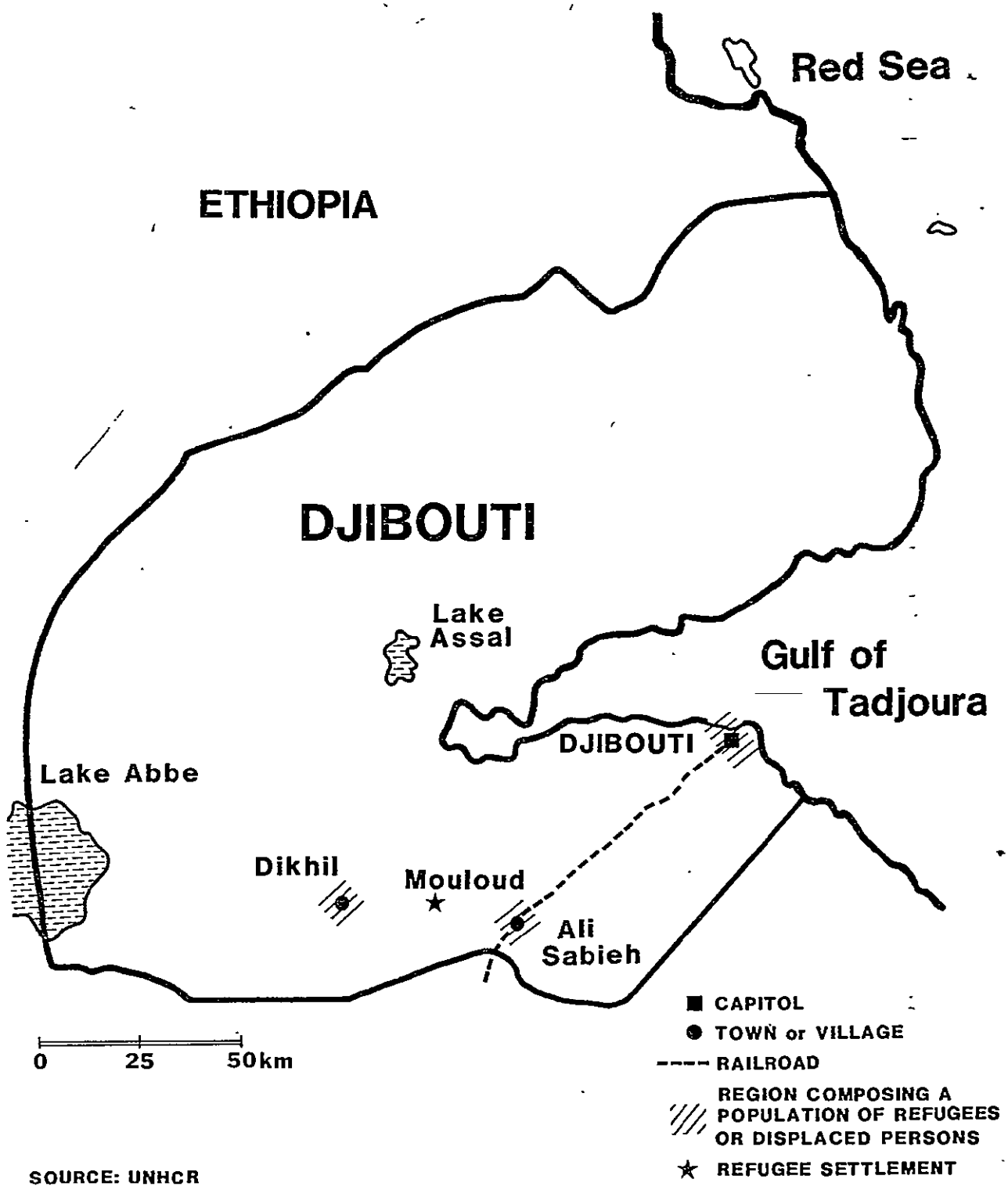


Figure 9

Several rivers drain from the central highlands (Figure 10). The Blue Nile, Baro, Omo, Wabi Shebele, Awash and Atbara are perennial. Others are short-lived, torrential only during the rainy season and intermittently dry the remainder of the time. The discharge of all the rivers differs drastically from the wet season in July-September to the dry season, as much as $2m^3$/second to $600m^3$/second on the Awash before a dam regulated the flow. Irrigation and water control are difficult because the rivers are deeply incised in their upper courses. There are several lakes, some natural and some created by hydro-electric stations and dams.

Climate

Three general rainfall patterns exist: short Belg from February-May, heavy Kremt from June-September, and scarce, dry-season Bega from October-January. The rainy season characterizes the winter, dry the summer. Humidity decreases from south to north. Histograms of mean annual rainfall amounts are shown in Figure 11. The highlands receive more annual rainfall than the rangelands. Failure of the Belg rains causes the drought which has been a recurring problem in recent years.

Wide variations in temperature are caused by the differences in elevation, from cool through temperate to hot. The cool zone is generally found above 2,400m with temperatures from 16°C to 0°C and the hottest months March-May. The temperate zone covers most of the high plateau between 1,500-2,400m with temperatures from 27°C to 16°C, the greatest variations occurring between November and January. The hot zone occurs below 1,500m in the areas of the Danakil Depression, the Eritrea lowlands, eastern Ogaden, the Blue Nile and Atbara River valleys and along the Sudan-Kenya border; 27°C is the zonal average, but temperatures soar as high as 49°C along the Red Sea Coast and 38°C in the Ogaden.

ETHIOPIA
PROVINCES

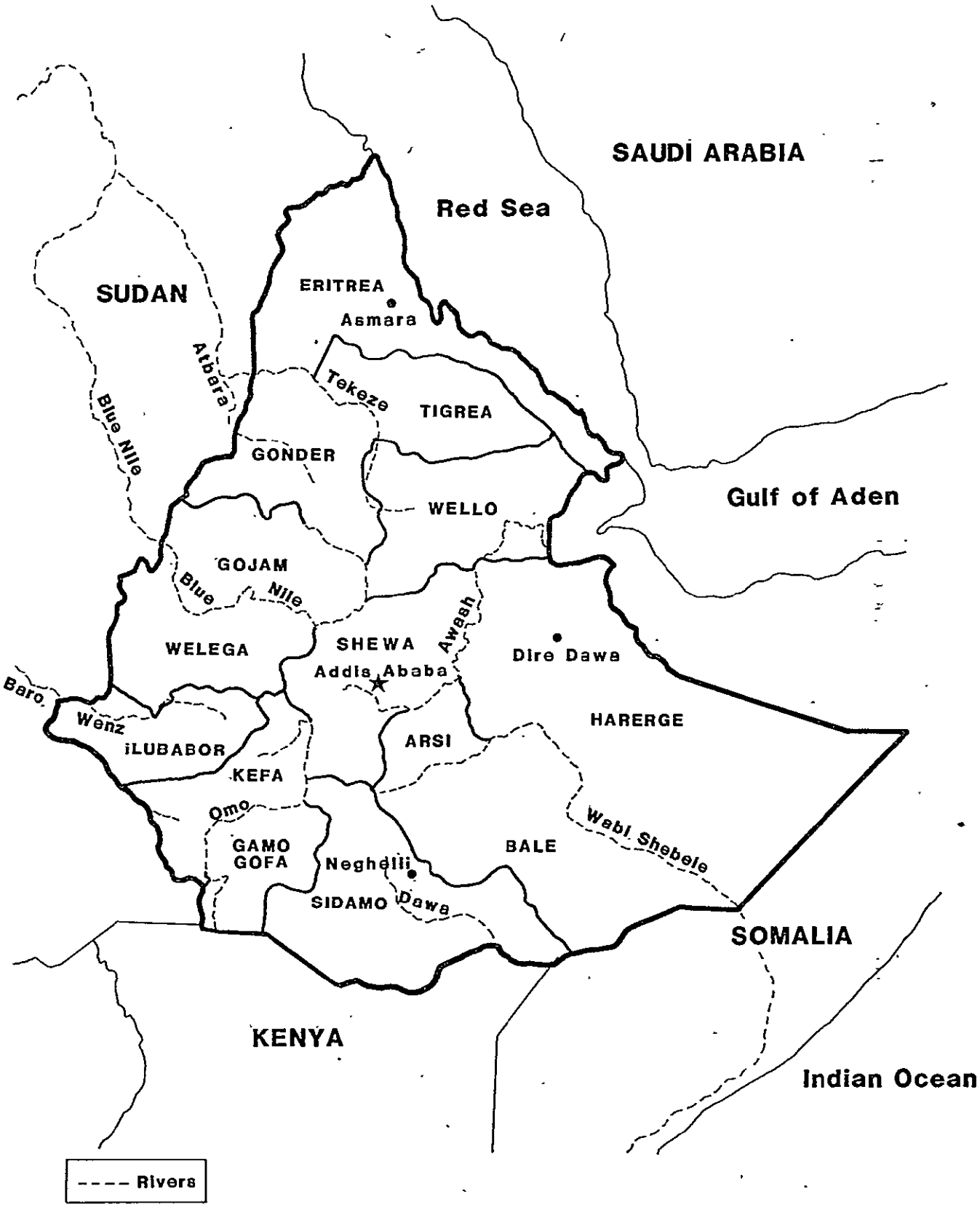
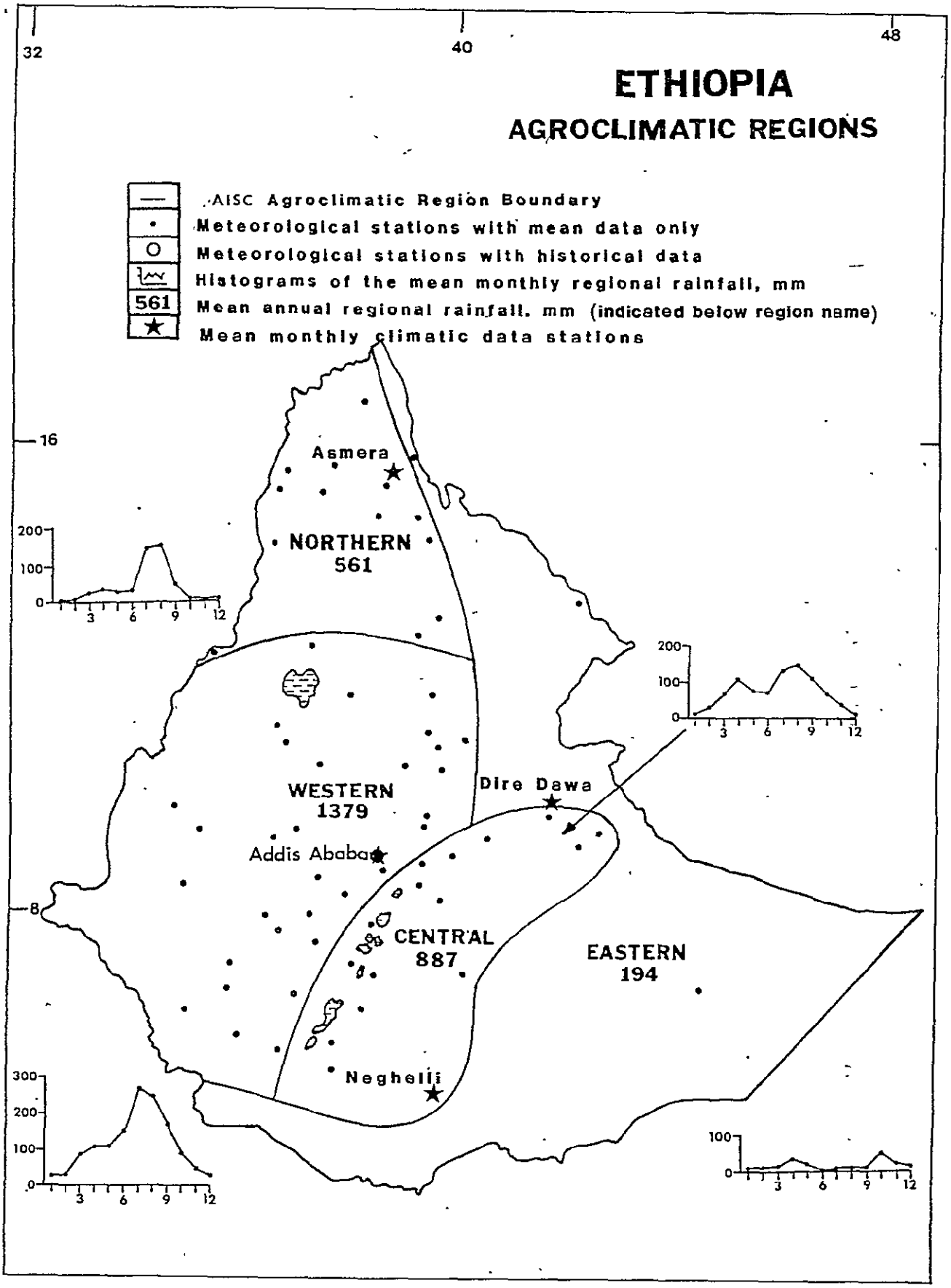


Figure 10



Source: A. Todorov, 1982

Figure 11

Mean monthly climatic data for a station within each agroclimatic region are shown on Table 6.

Agriculture

Agriculture in Ethiopia varies considerably with the topography and climate. Above 2,400m barley and wheat are the important crops. Between 1,700 and 2,400m teff, a type of millet grown only in Ethiopia, is the major crop. Sorghum and maize are also grown in this area and to the lower altitude of 1,500m. The types of farming are shown in Figure 12. Harvesting dates are shown on Table 7. Livestock accounts for 20-25% of the agricultural output. This is an important part of the lives of the nomadic population. Large areas of land suitable for cropping and grazing are not utilized because of malaria and tsetse fly infestations.

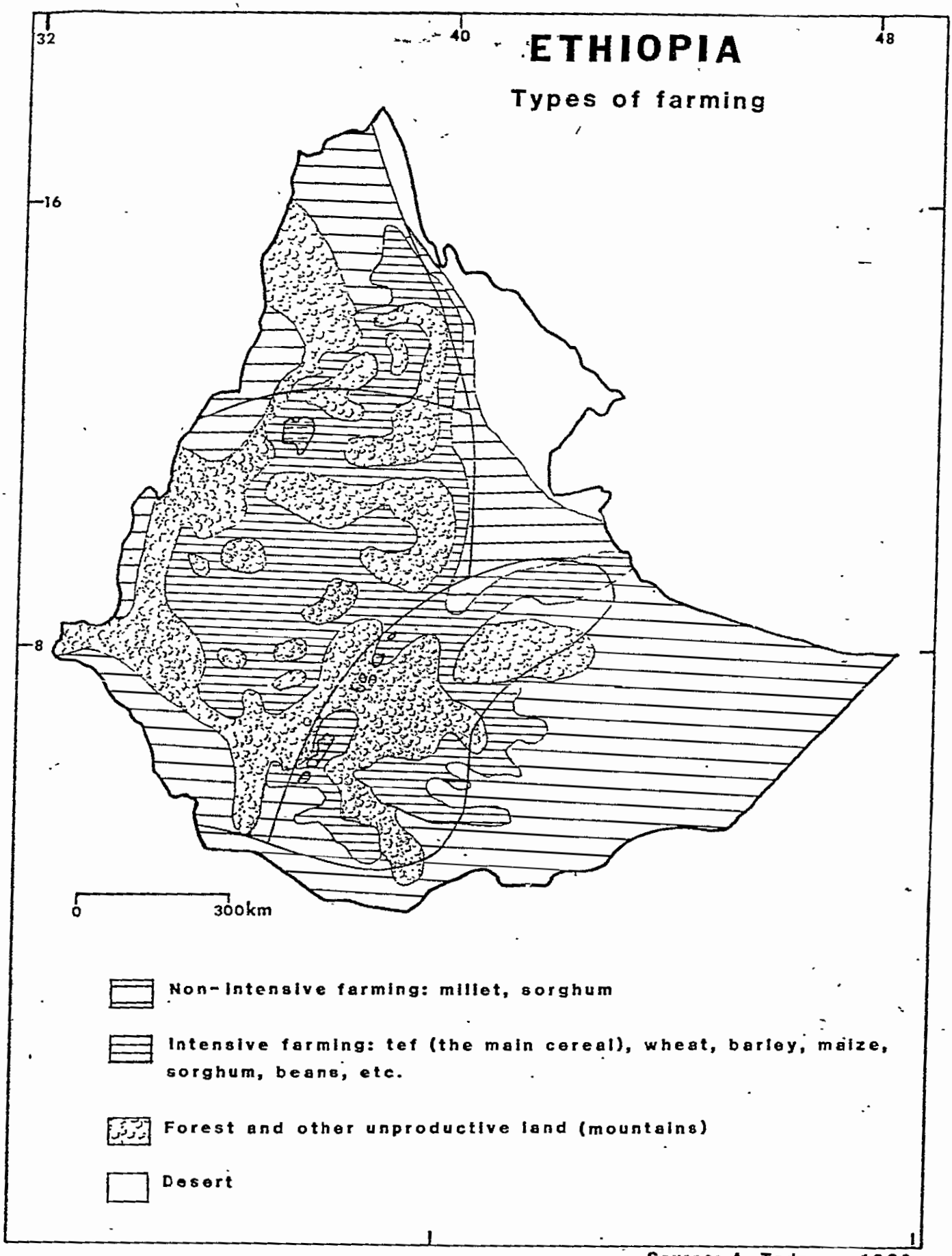
Even so, sixty-five per cent of the total land area of Ethiopia is used for agriculture. Slightly less than 90% of the total labor force contributes about one-half of the total GDP. Most of the farms are 2 hectares or less in size; 98% of production is from these small holdings. This contributes to the use of primitive cultivation techniques, poor seed selection and lack of the management techniques which could improve agricultural output. The tenant feudal system practiced before the 1974 revolution has changed to small independent holdings. This might result in higher productivity and living standards for the individual farmer since one-half of production previously had to be paid to the landlords.

As in the other Horn countries, the staple diet is dependent on the location and occupation of the population. There are four major areas:

1. highland: teff, barley, wheat and millet made into injera (a type of bread made from flour mixed with water and yeast and steamed in a pancake shape after one or two days).

TABLE 6. MEAN MONTHLY CLIMATIC DATA FOR SELECTED STATIONS IN ETHIOPIA

Months	ASMARA Lat. 15°17'N Long. 38°55'E Elev. 2,300 m			DIRE DAWA Lat. 09°02'N Long. 41°45'E Elev. 1,200 m			ADDIS ABABA Lat. 09°02'N Long. 38°45'E Elev. 2,450 m			NEGHELLI Lat. 05°07'N Long. 39°26'E Elev. 1,500 m		
	Temp. (°C)		Pcp.	Temp. (°C)		Pcp.	Temp. (°C)		Pcp.	Temp. (°C)		Pcp.
	Max.	Min.	(mm)	Max.	Min.	(mm)	Max.	Min.	(mm)	Max.	Min.	(mm)
Jan	23	7	1	29	15	20	23	6	16	28	12	8
Feb	24	9	1	30	16	29	24	7	44	28	13	4
Mar	25	10	10	32	18	43	25	9	70	28	13	33
Apr	25	11	37	31	19	83	25	10	86	25	14	172
May	26	12	38	34	20	30	25	9	95	24	12	102
Jun	26	12	32	35	20	23	23	10	136	24	13	8
Jul	22	12	170	33	18	108	20	11	282	24	12	6
Aug	22	12	127	31	17	165	20	11	294	24	12	7
Sep	24	10	33	32	17	70	21	10	192	26	12	16
Oct	22	9	7	33	17	12	22	7	21	25	13	119
Nov	22	9	10	31	16	17	22	4	15	25	12	52
Dec	22	8	2	29	14	10	22	5	6	26	11	23
Annual	23	10	468	32	17	582	23	8	1,256	28	13	550



Source: A. Todorov, 1982

Figure 12

TABLE 7. HARVESTING DATES FOR CROPS IN ETHIOPIA

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Barley	*	*	*						*	*	H	H
Maize	H	*								*	*	H
Millet	H	*								*	*	H
Sorghum	H	*	*					*	*	*	*	H
Teff									H	H	H	H
Wheat	H	*	*	*	*					*	*	H
Chick Peas	*	H	H	*							*	*
Lentils	*	*								*	H	H
Coffee	H	H									H	H
Cotton	H											H

H = Main Harvest, * = Period of Harvest

Source: Philippi and Mango, 1981.

2. mid-and low-land: corn, sorghum and teff (injera, porridge or bread).
3. central and southern: ensete or false banana.
4. nomadic: milk, meat and cereals.

Other foods, eaten according to group and availability, are pulses, vegetables, fruits, meat, dairy products, fish, oils, and beer, other distilled liquors, and highly sweetened coffee as beverages. Chat, a stimulant with little food value that is used as an appetite suppressant, is widely chewed.

Food Supplies

Although Ethiopia was self-sufficient in the past and was even able to export agricultural commodities, drought, civil strife and insect infestations have made the country dependent on outside sources for food. Since 1974 the country has moved from cereal exporter to self-sufficiency to food deficits. The emphasis has changed from production of food for export to subsistence agriculture. A large percentage of the needed imports are being supplied by the FAO/WFP and the United States.

Drought has been the worst in Wello and Tigrea Provinces, two of the arable provinces in the central zone of the western high plateaus, and in the Ogaden. The rains which are beneficial to farming are also detrimental because they create favorable breeding conditions for the locusts which destroy the crops. The Ethiopian government has estimated that 3.5 million people will suffer food shortages in 1983 because of drought and insects. In addition to those 3.5 million in Wello, Eritrea and Tigrea, another 1.7 million have been displaced by war and will need food and shelter. The nomads lost their stock, a mainstay of the Ethiopian economy, at the beginning of the war and are completely dependent on camps. Even if normal rains do return to the drought-stricken areas, the soil is depleted and eroded by deforestation, the oxen have died, and the seed

supplies have been consumed for food, making a return to productivity in the area almost impossible. The planting of new crops has been delayed by the lack of rain. Secondary crops are fairing better than the main crops but are not adequate to return production to the self-sufficient level.

Refugee Policy

The Relief and Rehabilitation Commission of the Ethiopian government has sought aid for 129,000 and 71,000 refugees that they claim have returned from Somalia and Sudan, respectively. These numbers cannot be verified, however. Similar problems exist in other refugee areas with discrepancies in the numbers needing food aid estimated by international organizations and the government of the countries seeking aid. There is a definite change in the attitude of the new Ethiopian government from the previous government which failed to report the drought conditions in 1973-74 which resulted in the deaths of 200,000 from famine. The Commission has made every attempt to help the starving. One solution to alleviate the problem of vast numbers needing assistance might be to move the drought-stricken to the more fertile southern and western areas. The primary location for refugee/displaced persons are Hararge, Gamo, Gofa and Kefa provinces (see Figure 10).

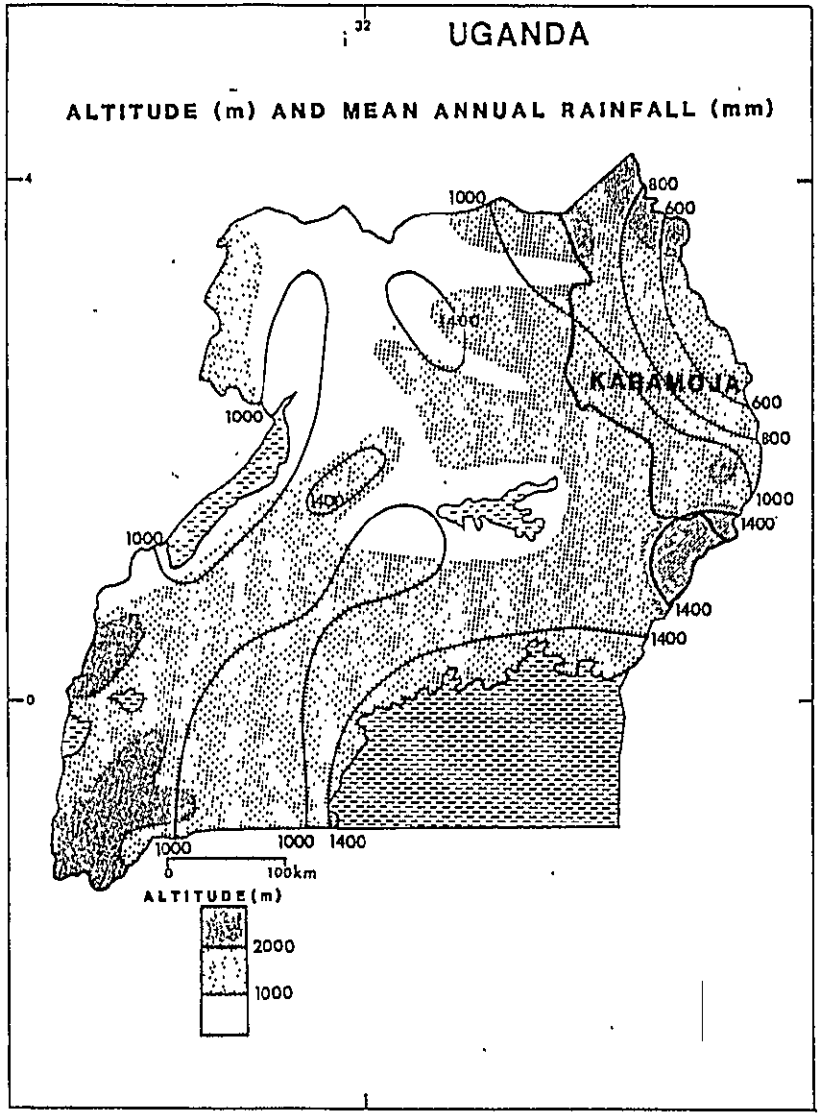
E. Kenya and Uganda

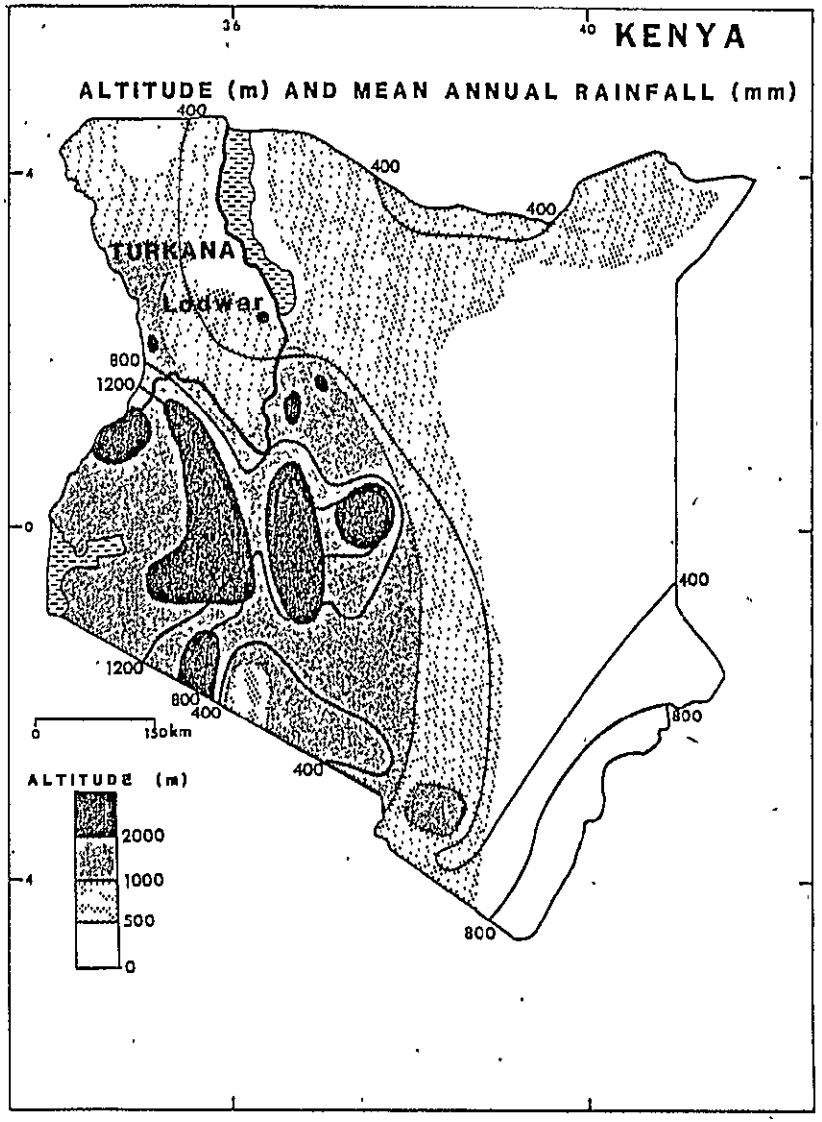
The refugee population in Kenya is small compared to other countries in the Horn of Africa region, numbering 6,000 in 1980 and 3,838 in 1982. Of the latter number 1,519 were Ethiopian, 1,173 Rwandan and 749 Ugandan, driven to Kenya because of war and civil disorders. Drought in the northern three-fifths of Kenya, notably Turkana in the northwest, has caused famine among the nomadic pastoralist population; the livestock which is their sustenance was decimated in 1980 by lack of the rains in October-November 1979. Problems of seasonality of

rainfall are compounded by the lack of arable land. Approximately 15% of the land area receives reliable rainfall adequate for cultivation. There are two rainy seasons, March-May and October-December. Thunderstorms cause rapid run-off of the rainfall that does occur.

Drought in 1980 decimated 60% of the herds in the Karamoja district in northeastern Uganda. Turkana from northwestern Kenya, suffering from worse drought conditions, crossed the border into Uganda causing an even greater strain in an area already over-populated for the resources. Less than 2% of northern Karamoja is cultivated; the savanna is used for grazing. Rainfall is variable and unpredictable, ranging from as low as 510mm to not over 750mm annually. Thunderstorms also lead to run-off. Adding to the food deficits from drought are the needs of 265,000 Ugandans displaced by civil problems and 175,000 who have returned from exile after the fall of Idi Amin's government. Although the drought appears to have been broken in 1981, new outbreaks in 1982 indicate that aid to Uganda will have to continue to alleviate starvation and malnutrition. Some of this aid will also go the the long-standing 13,000 refugees (80,000 Rwandans, 32,000 Zairians and 1,000 Ethiopians) living in rural settlements in southern and western Uganda. There is also potential for greater numbers of Ugandan refugees to return to their country because of the liberal policy for reconciliation expressed by the new government.

Rainfall and elevation for Kenya and Uganda are shown on Figure 13. Mean monthly climatic data for Lodwar, Turkana appear on Table 8. Very little farming is done in Turkana and Karamoja provinces.





Source: A. Todorov, 1983

Figure 13

TABLE 8. MEAN MONTHLY CLIMATIC DATA FOR

LODWAR KENYA

Months	LODWAR KENYA Lat. 3°07'N Long. 35°37'E Elev. 506 m		
	Temp. (°C)		Pcp. (mm)
	Max.	Min.	
Jan	36	22	8
Feb	37	23	5
Mar	36	24	20
Apr	35	24	41
May	35	25	27
Jun	34	24	8
Jul	33	24	13
Aug	33	24	9
Sep	35	24	3
Oct	35	24	8
Nov	35	24	10
Dec	35	23	13
Annual	35	23	165

III. INTERNATIONAL AID AND CURRENT PROBLEMS

Countries in the Horn of Africa region have the common problems of starvation and inadequate relief facilities for large numbers of people, whether they qualify as refugee or displaced. Emergency food aid has come from international organizations such as UNHCR, the World Food Program of the Food and Agriculture Organization, UNICEF and the International Red Cross. UNHCR alone has supplied the following (in thousands of U.S. dollars):

	1981	1982	1983 (proposed)
Djibouti	5,056.9	4,594.4	4,535.0
Somalia	49,078.2	37,629.1	42,057.1
Sudan	20,139.4	23,142.9	25,517.1

Food and other relief commodities as well as personnel have come from numerous volunteer organizations; some are listed on Table 9. The United States has contributed large amounts of food and other supplies through the AID Office of U.S. Foreign Disaster Assistance and P.L.480 Title II (Philippi and Mango, 1981).

In attempts to obtain funds necessary to supply the massive amounts of aid needed, special conferences have been held. One of these was the International Conference on Assistance to Refugees in Africa called by the UN General Assembly, the UN High Commissioner for Refugees and the Secretary General of the Organization of African Unity. The Conference, held in Geneva, Switzerland in April of 1981, was attended by 99 governments and 120 non-governmental organizations. Pledges of $558,408,058 were made; a breakdown by country is shown in Table 10.

TABLE 9

Some of the Volunteer Organizations Supplying Aid to the Horn of Africa

ACROSS
African Inland Mission
Africare
American Friends Service Committee
Baptist World Alliance
CARE
Catholic Relief Services
Consolation Society for Foreign Missions
Church World Service
Eastern Mennonite Board of Missions and Charities
Family Planning International
Food for the Hungry
The Ford Foundation
Foster Parents Plan
Inter-Church Response for the Horn of Africa
International Christian Aid
International Medical and Research Foundation
International Voluntary Services, Inc.
Lutheran World Relief
Map International
Mennonite Central Committee
Mill Hill Missionaries
Missionary Sisters of Verona
Operation California
OXFAM
The Pathfinder Fund
Salvation Army
Save the Children Federation
Seventh Day Adventists
Sons of the Sacred Heart
Sudan Interior Mission
U.S. Committee for Somali Refugee Relief
World Concern/Crista International
World Vision Relief Organization

TABLE 10

Countries Contributing to the International Conference on Assistance to Refugees in Africa, April 1981

Australia	$ 11,627,906
Belgium	2,492,754
Canada	18,823,529
China	1,000,000
Denmark	9,090.909
Egypt	1,000,000
Finland	2,962,963
France	2,474,747
Federal Republic of Germany	34,523,809
Italy	17,000,000
Japan	33,000,000
Netherlands	9,698,276
Nigeria	3,000,000
Norway	3,000,000
Saudi Arabia	30,000,000
Spain	1,000,000
Sweden	6,493,509
Switzerland	2,356,020
United Arab Emirates	2,000,000
United Kingdom	13,863,636
United States	285,000,000
European Economic Community	68,000,000
	$558,408,058

The relief funds have primarily been for emergency aid. The refugee and displaced populations are stabilizing rather than increasing, but there is little hope that the contributing factors of civil wars and natural disasters, e.g., drought 2 out of 5 years in Somalia, floods every 3-4 years in Sudan and regular periods of drought in Ethiopia, will disappear. Contributing organizations have therefore been looking towards more permanent solutions to improve the living conditions in the camps, introducing programs that will lead to self-sufficiency. The refugees and displaced are not going to disappear in the near future; some of the problems involved in caring for them will have to be better addressed.

One of the largest problems is transport of relief supplies. The road network in all of the Horn of Africa countries is sparse. Many of the villages in the currently drought-stricken areas of Ethiopia are accessible only by narrow mountain paths. Delivery of supplies can be made by truck but in some cases must be made by plane. The lack of roads is compounded by the shortage of trucks. One official estimated that transportation costs are sometimes 2 to 3 times greater than the value of the goods being delivered. This problem is not unique to Ethiopia; it also has been true in Uganda, Somalia, Sudan and Kenya. Part of the problem is that the available numbers of vehicles are inadequate to handle the amount of supplies, part is lack of roads, part is lack of fuel and parts to keep the vehicles operating. Weather is another element; the few tracks and unsurfaced roads that exist become impassable when it does rain.

Weather also becomes a problem in storing the supplies. Adequate facilities do not exist. Those that do allow spoilage, e.g., ergotism in Ethiopia that caused illness and death beyond that from starvation. Additional illness and fear of epidemics arises when large numbers of refugees are confined together in camps with inadequate facilities.

Lack of organization of aid efforts is the second largest problem. This includes failure of the UN to supply a mechanism for dealing with the displaced within a country; the system is organized to handle refugees (Wells, 1983). Better logistical organization would assure that aid reached both of these groups. A better organized system would also be able to react more efficiently when warnings of impending disasters are given; Ethiopia asked for help 5 months before the current crisis but was ignored by the international community.

Efficiency of the programs can be enhanced by foreknowledge of the impending situation. Since weather is so predominant a factor in a refugee/displaced person situation, contributing both as a cause of the situation and a hindrance to relief activities, knowledge of impending drought and the degree of the consequences is imperative. So is the ability to assess the duration of the problem. Food-for-work, reafforestation and distribution of poultry programs are feasible in Sudan and Somalia and are a viable solution to incorporating the refugees into the economy of those countries (UNHCR, 1982). Djibouti cannot support its own population, much less the refugees. Repatriation might be the only solution there and in Uganda and Kenya. In Ethiopia, mass movements of people to fertile areas might be the only solution where the land and lifestyles are decimated by drought. Planning for the moves to avoid similar decimation by over-population is imperative.

Civil disorders cannot always be anticipated but the resulting movements of thousands of people can devastate already precarious economies. Drought and the resultant food shortages can sometimes be anticipated.

IV. DROUGHT/FOOD SHORTAGE ASSESSMENTS

A. Overview

This early warning program is designed to use agroclimatic models for quantitatively assessing the impact of drought on agriculture, thereby providing information on the potential for abnormal food shortages as related to national and refugee populations. Assessments are based on a combination of biweekly weather assessments and agroclimatic/crop conditions forecast models, objectively determined for agroclimatic assessment regions.

B. Biweekly Weather Assessments

Biweekly weather assessments were initiated by AISC during the early stages of this developmental project to provide immediate assessment information to potential users. These assessments are primarily based on available real-time meteorological and satellite data which are statistically compared to long-term precipitation "normals," usually for the most recent two and eight week periods. The impacts of anomalous weather events such as flooding, high winds, and temperature extremes are also discussed.

Information sources include surface weather observations, climatological normals, historical data, surface and upper air analyses, and satellite imagery. Ancillary information sources include abstracts from the New York Times Information Data Base, the U.S. Department of Agriculture Foreign Attache reports, and reports from the Foreign Broadcast Information Service. Real-time meteorological data are obtained by NOAA through the World Meteorological Organization/Global Telecommunications System (WMO/GTS).

In many regions that are highly prone to disastrous drought, the availability of real-time precipitation data is quite limited because of very sparse station density and/or missing reports. Therefore, a major function is to

quality control and, as appropriate, estimate precipitation within each assessment region to assess areas of potential or ongoing drought and provide input for agroclimatic models. For example, surface and upper air weather analyses provided by the NOAA/National Weather Service are used to identify those regions in which atmospheric dynamics suggest the occurrence of precipitation. Additionally, satellite imagery from various meteorological satellites is also used as a tool to estimate precipitation.

Anomalous weather events such as reports of extreme wind and precipitation totals are summarized on a daily basis to provide a real-time, episodic event data base for use in assessment. Precipitation data are summarized on a weekly and monthly basis for use in biweekly weather assessments.

Three types of statistics are provided for each region: 1) weekly statistics which are used to obtain biweekly precipitation departures from normal, 2) eight week statistics and 3) drought statistics.

A drought condition is defined as eight weeks of precipitation which is less than 60 percent of normal. Severe drought conditions are defined as eight weeks of precipitation less than 40 percent of normal.

If conditions within a region fall into the drought or severe drought categories, the impact is determined according to the crop calendar, local agroclimatic conditions, and vulnerability of food security to drought. Climatological normals which are readily available are used as the basis for objectively analyzing regional rainfall conditions; thus, a consistent reference level is established.

C. Agroclimatic/Crop Condition Indices

Assessments to provide early warning information on the potential for drought-related food shortages are based primarily on the agroclimatic models discussed in this report. The models are run according to the countries, crop regions, and crop seasons indicated in the crop calendars.

The components of agroclimatic analysis used to develop agroclimatic/crop condition models are shown by Figure 14. Major components include the data bases, information on agricultural practices for agroclimatic regions, agroclimatic indices, and assessment procedures. Test and evaluation is required prior to operational implementation.

Data

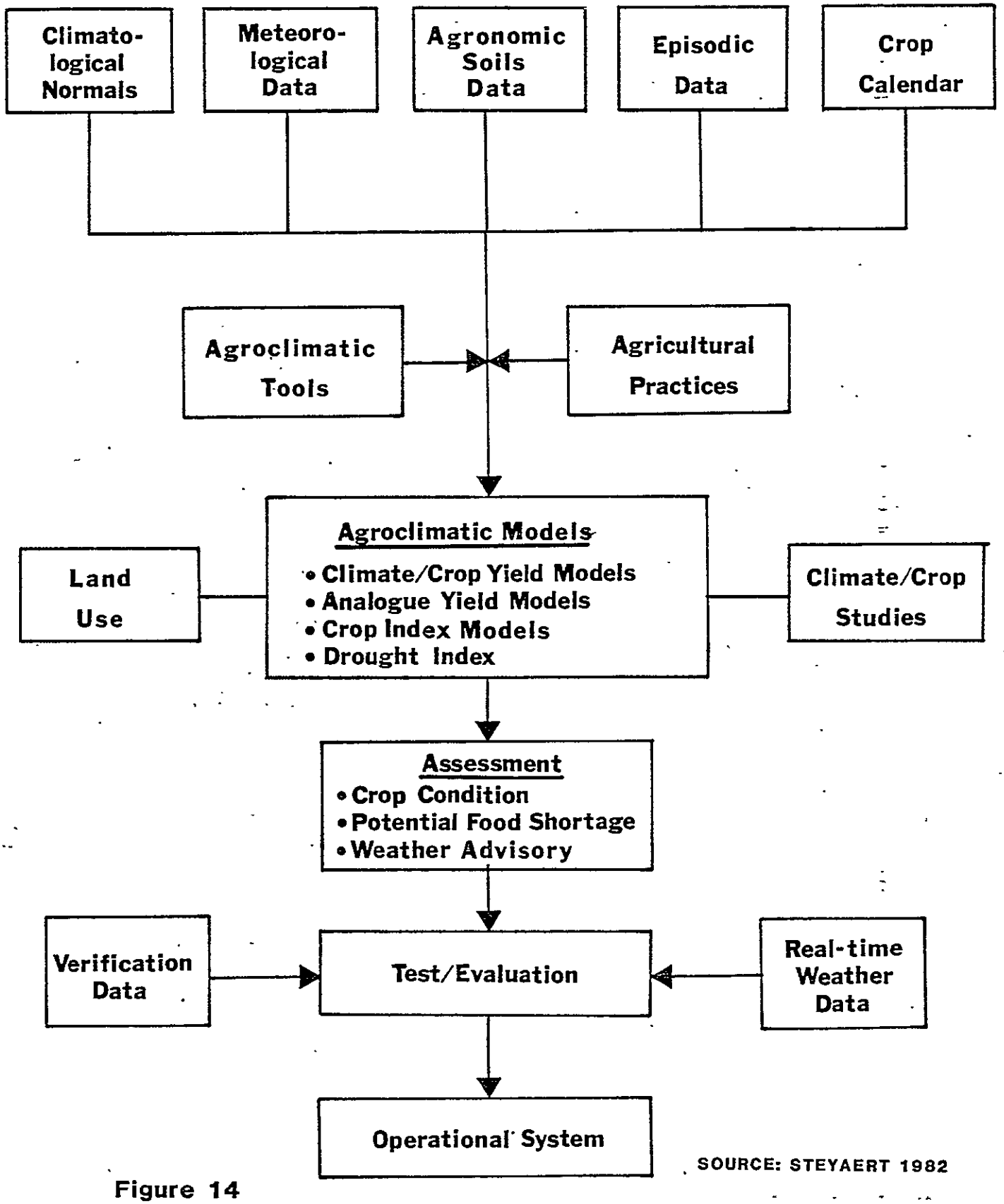
Five major data bases are essential: meteorological, climatological "normals," agronomic, episodic event and crop calendar.

The meteorological data base includes long-term records of monthly precipitation and temperature. Meteorological data for some countries also include monthly records of maximum and minimum temperatures, percent cloud cover, relative humidity, and number of rainy days each month. Because these data are used to investigate crop/weather relationships, extensive historical records displaying a wide range of climatic conditions are essential to the development of crop/food shortage assessment techniques.

Climatological "normals" including monthly precipitation and mean temperature are used to determine the most representative "normals" for agroclimatic assessment regions used in weather analysis (see previous sections).

Agronomic data include available crop statistics (i.e., acreage, production and yield) and "technology" data. Crop statistics were assembled as available at the national and regional levels for primary and secondary crop seasons.

NOAA/UMC AGROCLIMATIC ANALYSIS FOR DROUGHT IMPACT



SOURCE: STEYAERT 1982

Figure 14

Available "technology" data include time-series of fertilizer application, percent area irrigated, and percent area in high yielding varieties. Generally these data are available only at the national level and are used primarily to analyze time trends in historic yield data.

Episodic event data include documented reports on the historical occurrences of drought, tropical storms and typhoons, flooding, and other anomalous weather events associated with crop failure or abnormal food shortages. Additionally, non-weather related factors which can have a disruptive impact on agricultural production/food supplies are also documented, for example reports of inappropriate application of improved technological inputs to agriculture, civil unrest, and others. These data are generally qualitative in nature and obtained primarily through extensive literature searches. They are used to help select, determine the role, and "calibrate" agroclimatic predictors of potential crop failure and food shortages. Summaries of episodic events for the Horn of Africa Countries appear on Tables 11-13.

The final major data base contains regional and national level crop calendars for various crops and crop growing seasons. An example for the Horn of Africa region is shown in Table 14.

Agroclimatic Background

Agricultural practices including crop seasons, crop regions, crop rotation and extensive background in cultural information are summarized on a regional basis. Other practices investigated include those factors which determine the decision to plant, the reasons for extensive planting over a 6-8 week period, the consequences of early or delayed planting, the types of varieties and length of crop cycle, applied "technology," tillage and harvest practices.

TABLE 11. EPISODIC EVENT DATA FOR SOMALIA AND SUDAN

Country: Somalia

Strike Dt	Declare Dt	Type	Title	Location
64/12/00	65/12/27	Drought	Somalia Drought	Nationwide, Galciao
69/00/00	69/09/04	Drought	Somalia Drought	E Burao, N Mudugh
74/06/00	74/12/10	Drought	Somali Rep Drought	NW to Central Areas
77/07/00	77/09/21	Civil Strife	Ogaden Conflict	Border Areas
77/01/00		Epidemic	Smallpox	
77/11/00	77/12/22	Flood		Shebelle, Juba Rivers
81/03/00		Flood	Flash Flood	Hiran/Juba Prov.

Country: Sudan

Strike Dt	Declare Dt	Type	Title	Location
65/02/27	65/02/27	Accident	Sudan Train Wreck	Near Port Sudan
65/04/00	65/06/05	Epidemic	Sudan Meningitis	Khartoum Prov
66/03/00	66/03/00	Epidemic	Sudan Cholera Threat	Nationwide
73/00/00	72/05/00	Civil Strife	Sudan Cvl Str	South
75/09/07	75/09/15	Flood		Gash River (C & E)
76/09/00	76/11/03	Epidemic	Ebola Virus	W Equatoria Prov
78/07/00	78/07/26	Flood		Gezira Province

Source: AID/OFDA.

TABLE 12. EPISODIC EVENT DATA FOR DJIBOUTI AND ETHIOPIA,

Country: Djibouti

Strike Dt	Declare Dt	Type	Title	Location
77/07/00	77/09/21	Civil Strife	Ogaden Conflict	Border Areas
77/10/00	77/10/24	Flood	Djibouti Flood	Djibouti City
78/02/00	78/03/02	Flood	Djibouti Flood	Djibouti City
79/10/30	79/11/08	Accident	Train Wreck	Holl-Holl
80/00/00	80/06/11	Drought		
81/03/00	81/03/19	Flood		Djibouti City

Country: Ethiopia

Strike Dt	Declare Dt	Type	Title	Location
65/00/00		Drought	Ethiopia Drought	Nationwide
68/05/07	68/05/14	Flood	Ethiopia Floods	Vicinity of Kelafo
69/03/29		Earthquake	Djibouti Earthq.	NE, Sardo
69/00/00	69/09/12	Drought	Ethiopia Drought	Hamasion Div
70/00/00	71/00/00	Epidemic	Cholera	
73/00/00	73/12/03	Drought	Ethiopia Drought	Tigre, Wollo, N Shoa
75/04/05	75/00/00	Drought	Ethiopia Drought	Kangra
76/04/00	76/04/30	Flood	S Ethiopia Floods	Gode, Kelafo, Mustahl
77/07/00	77/09/24	Civil Strife	Ogaden Conflict	Ogaden Region
77/00/00		Drought	Famine	Wollo, Tigre Provs
78/00/00	78/08/10	Civil Strife	Displace Persons	Bale, Sidamo Provs
78/00/00	78/04/10	Drought		Wollo, Tigre Provs
77/11/00		Flood		Awash River Valley
78/08/00		Flood		
78/00/00	78/11/24	Drought	Famine	Wollo, Tigre Provs
80/00/00	80/05/12	Drought		

Source: AID/OFDA.

TABLE 13. EPISODIC EVENT DATA FOR KENYA AND UGANDA

Country: Kenya

FY	Type	Location
1961-63	Drought and Flood	Ukambani; Masailand; Tana River lowlands
1964	Flood	Central and Western regions
1966	Drought	Kitui Thru Samburu to Turkana
1968	Drought	Central and Western regions
1971	Drought	Countryside
1980	Drought	Turkana

Country: Uganda

Disaster	Strike Date	Location	Number Killed	Number Affected
Bubonic Plaque	35	n.a.	2,000	n.a.
Earthquake	3/20/66	Bwamba County	104	60,000
Civil Strife	1978-79	Nationwide	n.a.	400,000
Drought	1980-81	Karamoja Province	n.a.	500,00

Source: Philippi and Mango, 1981.

TABLE 14. ESTIMATED FIXED CROP CALENDAR INFORMATION FOR CEREAL CROPS/PULSES[1]/OIL CROPS[2]

Country/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sudan						///.....	.....	.....	.....	000000	000	
Ethiopia[1,2,3]				//////////	.....	.....	.....	.....	.....	00000000	00	
Somalia[1,2]	0000		///	//	.....	.....	.....	00	00000	//////	.....	
Kenya	0000		//////	.....	.....	.....	.....	00000000		/////	.....	

[1]Extent of cowpea production in these countries is unknown at this time.

[2]Extent of groundnut and/or sesame production in these countries is unknown at this time.

[3]In Ethiopia, crop calendar inlcudes teff production.

[ ]	WET SEASON	CEREAL CROPS:	MILLET, SORGHUM, MAIZE, RICE
/////	PLANTING PERIOD	PULSES	: COWPEAS, PIGEON-PEAS
.....	GROWING SEASON	OIL CROPS	: GROUNDNUTS, SESAME
000000	HARVEST PERIOD		

Source: A. Todorov, 1982.

This information on agricultural practices is used in conjunction with climatological normals, information on the physical environment, and very general soils information to determine agroclimatic regions for each country.

Integration of Data/Information Sources

Because availability and quality of data can range from adequate to nonexistent, an attempt is made to supplement deficiences in one data set with information from an associated data set for an agroclimatic region given local agricultural practices. This is particularly useful if crop-yield data are considered unreliable. Important consideration is given to the integrated analysis of these data bases. This requires the consideration of: 1) the determinants of crop yield, 2) the relative importance of non-weather and weather factors to crop failure, 3) unique characteristics and problems associated with local agricultural practices, 4) the relationship between crop failure and abnormal food shortages and 5) the type of crop modeling approach best suited for a given region.

Predictor variables used to develop agroclimatic models are required to relate to the biological requirements of the crop. Ideally, these relationships are the primary factors associated with year-to-year variation in yield. The methodology provides a framework for model development, decreases the risk of chance correlations and increases the probability of success during the early stages of independent testing.

Agroclimatic/crop condition models are used to generate time series of relative yield from climatic data. Relative yield assessments are based on a comparison of the real-time estimates with historical indices (usually expressed in percentiles) which in some cases have been scaled according to the severity of known occurrences of abnormal food shortages and famine. In this respect

historical climatic data, which are expressed as a crop index, are linked with episodic event data to determine the degree of food shortage as well as the antecedent conditions (both weather and non-weather factors) which tend to be assocciated with a food shortage.

These historical relative yield indices, current rainfall data, and any episodic event information are used to make a qualitative crop condition assessment. A statement on the potential for abnormal food shortges would be included if appropriate. During the crop growing season, weather and crop condition assessments are combined for an integrated assessment on the impact of climate.

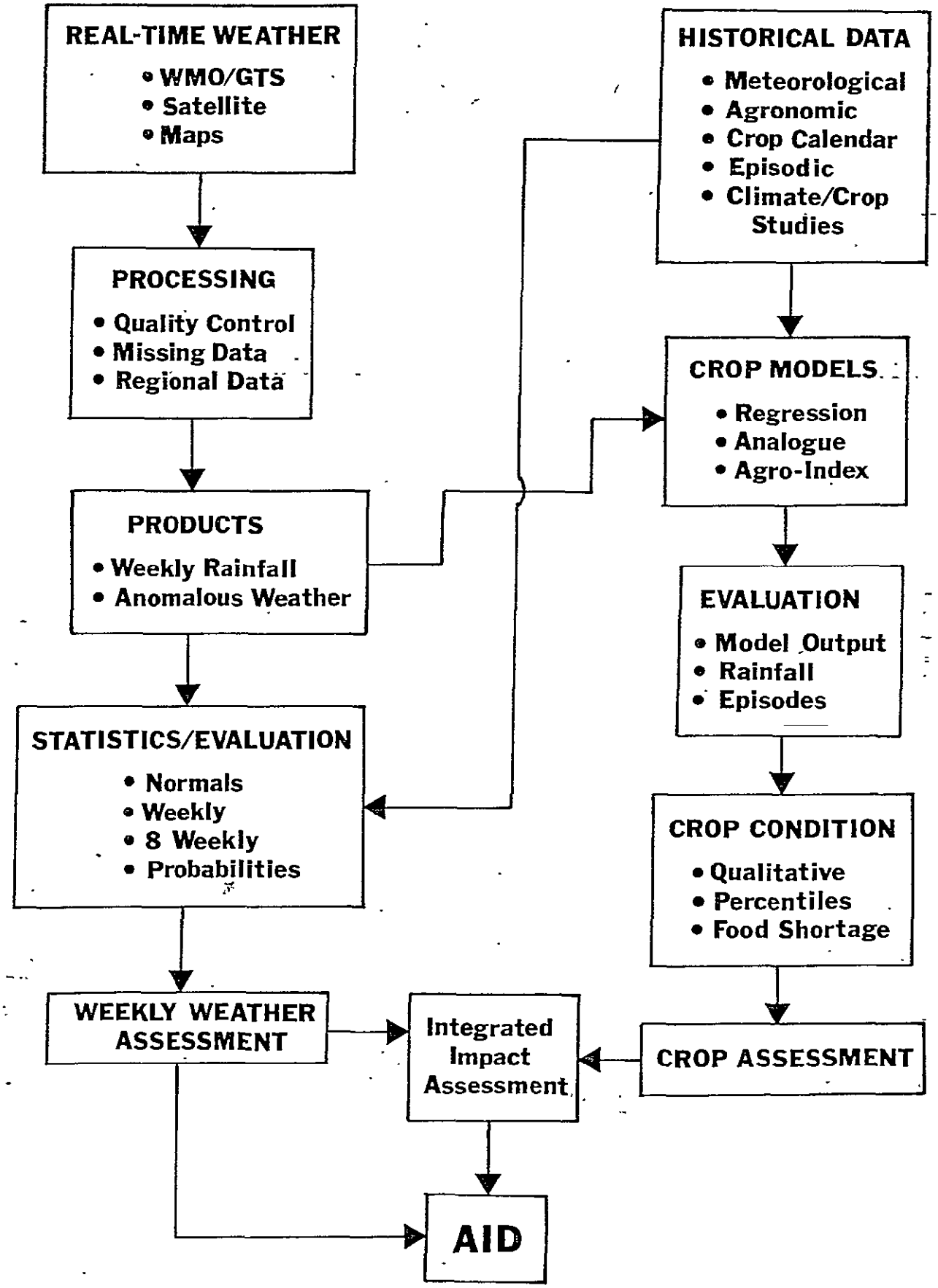
D. Drought/Food Shortage Assessment System

Figure 15 shows the combined components of the early warning assessment program; biweekly weather analysis (on the left) and crop condition/food shortage (on the right). An integrated impact statement is provided to the user.

Biweekly weather assessments are issued regularly through the year. These assessments are usually released within five days following the end of the reporting period. Special or update assessments are also provided as requested.

The agroclimatic models are based on monthly meteorological and crop calendar data. Therefore, assessments based on crop condition/food shortage indices are issued within about five days into the following month. However, this type of assessment is only released at selected times during the calendar year, for example following a critical crop development stage such as flowering. Assessments on the potential for drought-related food shortages can be made on the order of 30-60 days prior to the harvest of the crop. This could represent a potential 3-6 month early warning prior to drought-related food shortages.

EARLY WARNING ASSESSMENTS



SOURCE: STEYAERT 1982

Figure 15

E. Test and Evaluation

The early warning program for the Horn of Africa is operational, following successful testing of the assessment methodology. In addition to regular test assessments during July 1982-September 1983, a special assessment report on 1982 drought impacts was prepared for AID/OFDA and the Department of State Refugee Affairs Bureau. The regional extent and magnitude of drought impacts in Ethiopia, NE Uganda and SE Sudan were reported in late September 1982. The NOAA/NESDIS/AISC assessments have been subsequently verified by reliable ground-truth information on food shortage conditions.

V. SUMMARY

The goal of this project has been accomplished; an Early Warning Assessment Program has been developed to provide reliable information on the potential for disastrous subsistence food shortages due to drought in the Horn of Africa region. This proposed early warning program, based on a combination of biweekly 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 before to the final harvest of the crop. This could represent a potential 3-6 month early warning prior to drought-related food shortages.

It is suggested that 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 these developing countries, thereby providing increased lead-time 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.
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.

ACKNOWLEDGEMENTS

Louis Steyaert, Program Manager, Assessment and Information Services Center of NOAA/NESDIS, Columbia, MO, and Atanas Todorov, Reseach Associate, University of Missouri, Columbia, MO, were generous with information and results form their projects for AID/OFDA.

Paul Krumpe, Program Manager, AID/OFDA, Washington, D.C. was helpful with suggestions for resource materials at the onset of the project.

Special thanks to Jerry Wright and George Lozano, University of Missouri, for the artwork and tireless corrections of the final copy of the report, respectively.

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