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Drought in Africa

It is a recurrent and often devastating feature of the sub-Saharan climate. If leaders were to treat it as recurrent, they could deal with it in ways that would stabilize the region's farm production

by Michael H. Glantz

Time and again photographs from sub-Saharan Africa show starving children, emaciated animals, crowded refugee camps and dry watering holes. These disturbing scenes represent the toll of recurrent drought, which over the past 20 years has made the region a focus of global attention and generated large outpourings of humanitarian concern and assistance.

During each drought governments, international relief agencies and charitable organizations muster emergency aid programs and much is written about the misuse of land and desertification. Yet when the rains return, as they did last year, the tendency has been to treat drought as an event of the past, and concern is relaxed. The fact is, however, that drought is part of the region's climate and will occur repeatedly. It is closely related to the problem of achieving sustained and adequate agricultural production in most countries of sub-Saharan Africa, and so it should no longer be ignored in planning for development. The first step toward taking the long view of drought is to be clear about its causes. Then one can ask what its effects are and how they can be alleviated.

Searching for a single cause of African droughts is probably futile. There are many different regimes of local and regional climate, resulting from different atmospheric processes and topographic features. There are also many different societies in the region, employing different patterns of land use that require varying amounts of water resources.

On a global scale droughts are quite common. The pattern varies considerably from year to year; a year with few droughts may be followed by one with many. On a regional scale some areas have one season of rainfall and others have two. In some areas it rains in winter, in others during the summer. For example, the West African Sahel (the transition zone between the Sahara and the humid savanna to the south) has an eight-month dry season and a four-month wet season, which coincides with the Northern Hemisphere's summer. At the local level the variability of rainfall in both time and space within the rainy season can be quite high.

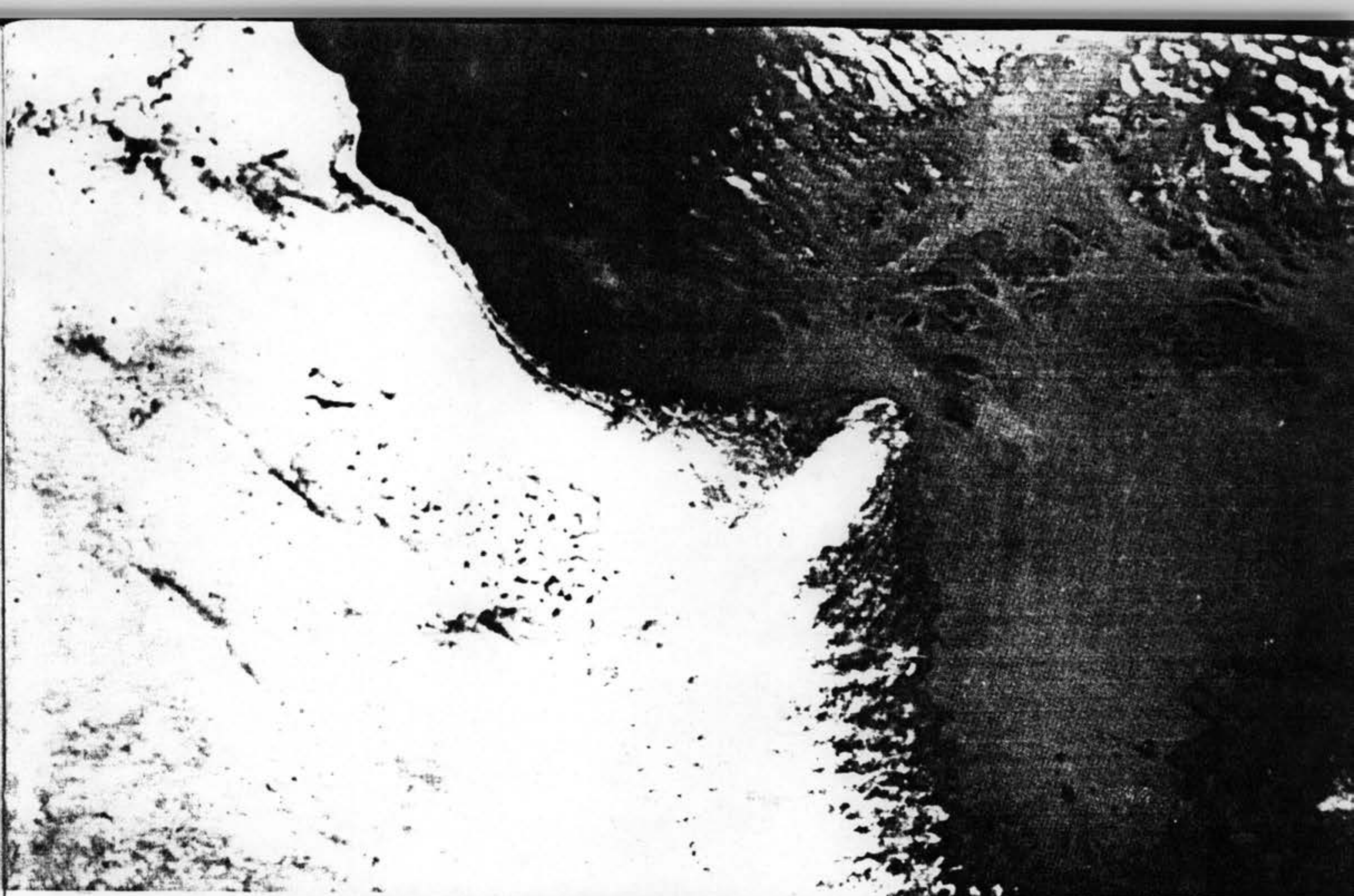
One of the major difficulties in dealing with drought is that it is a creeping phenomenon. Both its onset and its end are often hard to identify because it does not differ sharply from ordinary dry spells. "The first rainless day in a spell of fine weather contributes as much to the drought as the last day," Ivan R. Tannehill of the U.S. Weather Bureau once noted, "but no one knows precisely how serious it will be until the last dry day has gone and the rains have come again."

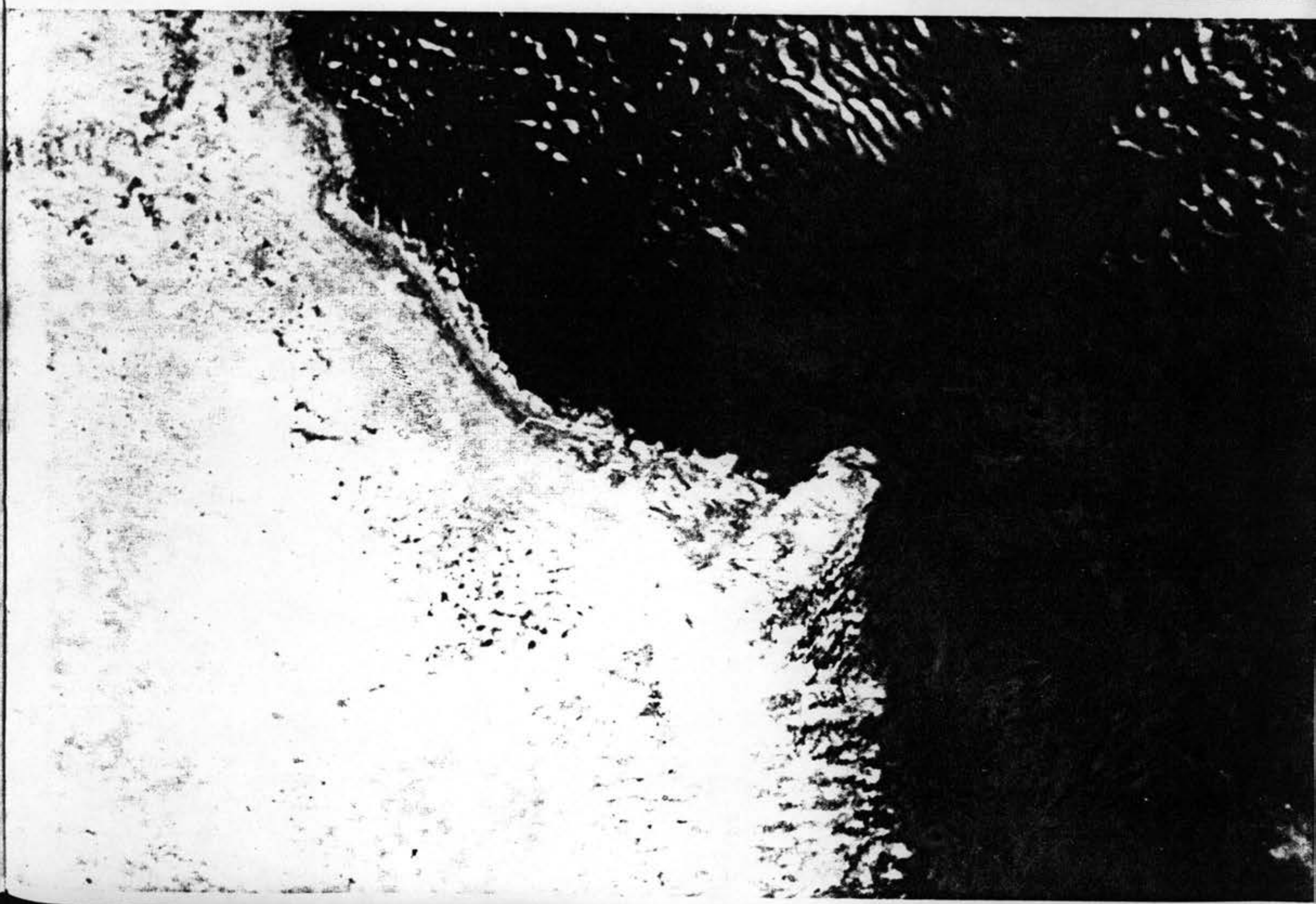
Drought means different things to different people, depending on their interest in rainfall or their need for it. The most popular conception of drought is that it is a meteorological event. Yet agricultural and hydrological droughts also occur. The terms are not synonymous.

Meteorological drought can be defined in terms of the degree of dryness (stated as a percentage reduction in relation to the long-term average annual or seasonal rainfall) and of the duration of dryness in a given region. There are scores of variations on this definition because the meaning is often specific to a region and depends on the human activity for which rainfall is being measured. A meteorological drought is sometimes difficult to identify with any degree of reliability, in part because of the nature of the phenomenon and in part because meteorological and climatological information in many African countries has been available for only a few years or is of poor quality. Moreover, information on rainfall alone is often not of immediate, direct or prime use to policy makers and agricultural planners because of other variables that can affect the usefulness of the rain that does fall—among them soil moisture, ambient temperature and rates of evaporation.

Agricultural drought results when there is not enough moisture available at the right time for the growth and maturation of crops. The timing of

LAKE CHAD, which forms part of the borders of Cameroon, Chad, Niger and Nigeria, has shrunk considerably since the 1960's because of prolonged drought in the Sahelian zone of West Africa. When the top photograph was made from a Landsat satellite in 1972, the lake encompassed some 25,000 square kilometers. When the bottom photograph was made from another Landsat satellite in 1979, after several years of below-average rainfall, the size of the lake had shrunk to less than 2,000 square kilometers. Many ancient dunes long covered by the waters of the lake are visible in the bottom view.





precipitation throughout the growing season is as important as the absolute amount per month or season because crops have varying needs for moisture as they develop. M. D. Dennett of the University of Reading and his colleagues Jeremy Elston and J. A. Rogers recently showed that the seasonal distribution of rain in the West African Sahel has changed, primarily because of a reduction of rainfall in August, which on the average is the wettest month. Such a shift is detrimental to agriculture. As a trend it can be detected only in retrospect.

Hydrologic drought results when streamflow falls below a predetermined level for a specified period of time. Most often such drought is defined as the level at which the reduction in streamflow is sufficient to significantly hinder certain human activities, such as irrigation and the generation of hydroelectric power. In West Africa the discharges of the Niger, Chari and Senegal rivers have declined sharply since the late 1960's.

In terms of meteorological drought West Africa has had a 17-year run of "dry years." Historical records show this to be the region's third major drought of the 20th century. Looking further, one finds that the climate varies on several time scales. The three that are of interest here are the millennium, the decade and the year.

On the millennial scale several investigators cite what is known as the Milankovitch mechanism in order to explain the trend toward aridity that apparently exists in sub-Saharan Africa. In 1930 the Serbian astronomer Milutin Milankovitch proposed that changes in the elliptical orbit of the earth around the sun could affect the climate. Such changes, which occur over periods of thousands of years, are due to the gravitational pull on the earth by the major planets.

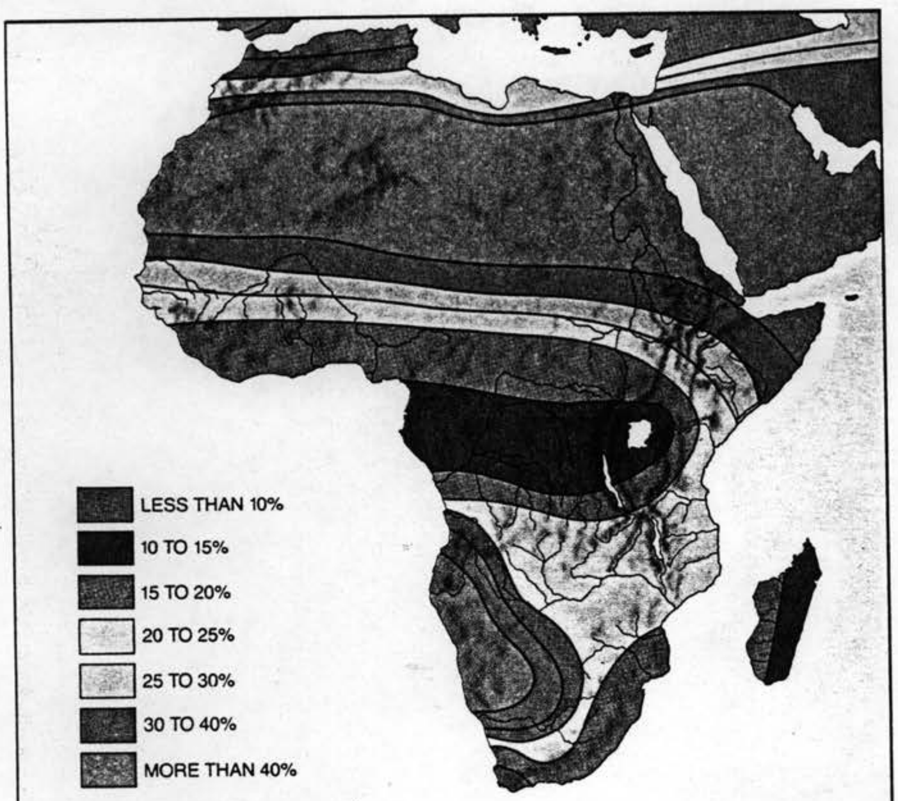
A net result was that some 10,000 years ago the Northern Hemisphere received about 8 percent more solar radiation in the summer and 8 percent less in the winter than it does now, making the summers generally warmer and the winters generally colder than they are at present. The effect of this increased seasonal amplitude in the Northern Hemisphere was to amplify both the summer and the winter monsoon circulation. It is those circulations, particularly the summer one, that account for the rainy season in the subtropics.

John E. Kutzbach of the University of Wisconsin at Madison and Alayne Street-Perrott of the University of Oxford showed that a theoretical climate model, supplied with these variations among others, is able to simulate quite well the changes in subtropical rainfall in northern Africa, southern and southeastern Asia and Central America that are evidenced by the changing levels of lakes over the past 18,000 years. The lake levels were generally highest in the period from 10,000 to 5,000 years ago; most of them have been declining since then, suggesting a very gradual trend toward aridity. Today the earth is closest to the sun during the Northern Hemisphere winter. In coming millenniums it will again be closest to the sun during the Northern Hemisphere summer. That relation should intensify monsoonal activity (and therefore rainfall) in the tropical regions.

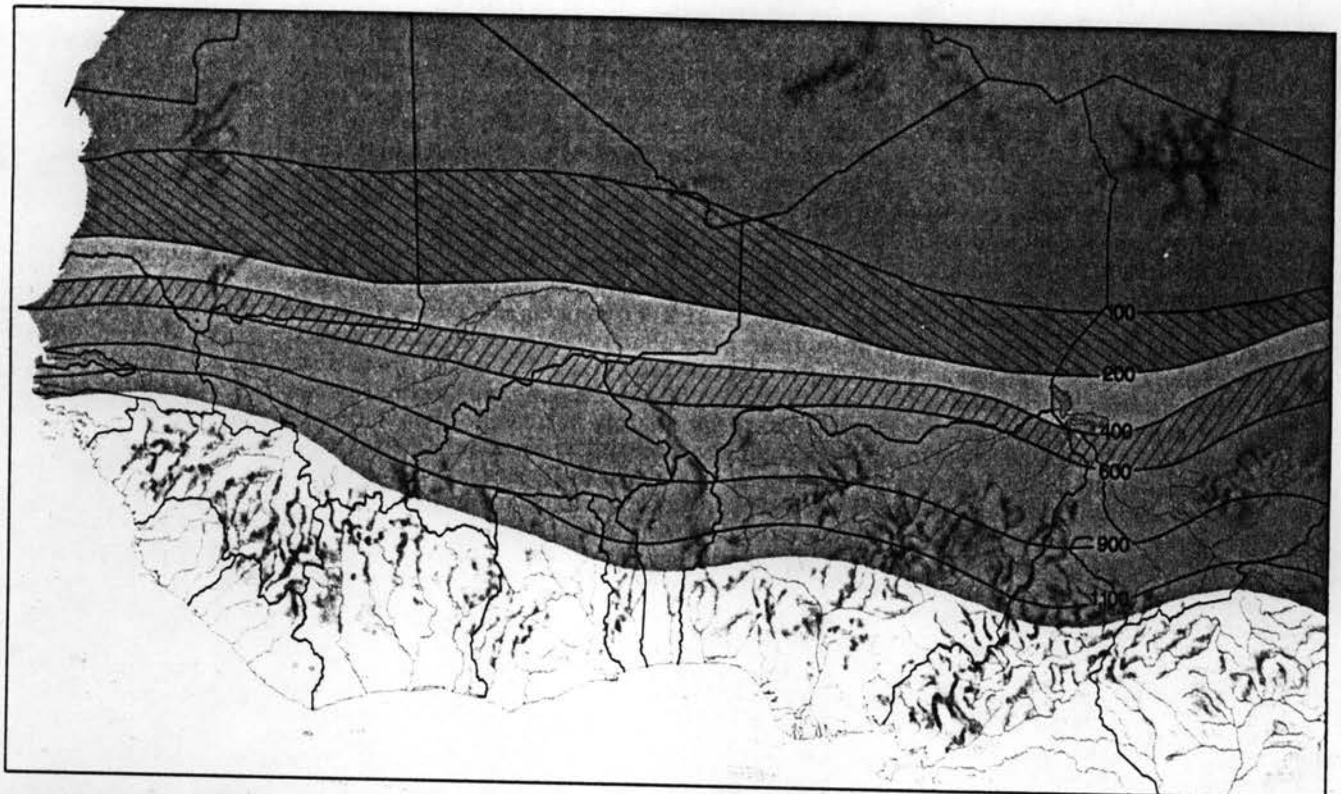
On the scale of decades and individual years the speculation about the causes of drought in Africa centers on both natural and human factors. The natural factors include random short-term fluctuations in climate, long-term climatic change, sea-surface temperature changes in the Atlantic Ocean, El Niño–Southern Oscillation (ENSO) events and ENSO-related climate anomalies, which are an example of what meteorologists call a teleconnection, meaning linkages over a great distance. The suggested human factors include both increases in atmospheric carbon dioxide and other radiatively active trace gases resulting from human activities and the modification of land surfaces.

Among short-term climatic fluctuations, droughts in arid and semiarid regions can be seen as part of the "normal" climate. In such areas the statistical description of average annual rainfall is skewed because a small number of years with high rainfall is averaged out by a larger number of low-rainfall years. There are not many years when the annual rainfall is near the average. To discuss drought in these regions simply in terms of departures from annual rainfall averages is therefore misleading. One must look at other statistics, such as the median rainfall (the value in the middle of an ordered range of recorded rainfalls), the range (the highest and lowest amounts) and the mode (the most frequently occurring amount) to describe adequately the rainfall characteristics of a particular African region.

Paleoenvironmental research findings show that both extended wet periods and extended dry periods have occurred in various parts of sub-Saharan Africa for thousands of years. Many investigators have searched statistical and historical records in an effort to



CLIMATIC VARIABILITY in Africa is depicted in terms of the average annual departure from normal rainfall. In areas of the continent where the variability in rainfall is high and the amount of rainfall is low the likelihood of drought is a permanent feature of the climate. That is the case particularly in the regions of the continent shown in red.



WEST AFRICAN REGIONS are, beginning with the red area and reading down, the Sahara zone, the Saharo-Sahelian subzone, the Sahel zone, the Sudano-Sahelian subzone and the Sudan zone. The average annual rainfall in millimeters is shown at the right.

identify drought cycles in specific regions, but their claims of having found such cycles have gained little scientific support. Indeed, they have served to suggest the absence of strong periodicities. Hence drought appears to be an aperiodic phenomenon as well as a recurrent one.

As for long-term climatic change, in the early 1970's climatologists debated whether average global temperatures were increasing or decreasing. Supporters of the cooling hypothesis contended that a new glacial period was imminent because the current interglacial period had lasted for approximately as long as interglacials usually last (between 10,000 and 15,000 years). They pointed out in addition that in only about 25,000 of the past 500,000 years was the earth as warm as it has been in the 20th century.

About 10 years ago the dominant view shifted toward the warming hypothesis. Detailed observations revealed that the cooling trend in the Northern Hemisphere beginning in about 1940 had reversed by the mid-1970's. The longer global trend toward warming, which began in about 1900, has been attributed mainly to the increase in atmospheric carbon dioxide. It is not clear whether a global warming will bring more or less rainfall to the African regions that are currently viewed as drought-prone.

El Niño is the temporary invasion of warm sea-surface water into the eastern equatorial Pacific off the coasts of Peru and Ecuador. It is a local manifestation of the phenomenon called the Southern Oscillation, which is the seesawing of mean pressure differences (at sea level) between the western and the eastern equatorial Pacific. ENSO events have been associated with droughts and other anomalies of climate around the world. The ENSO event of 1982–83 was the most intense one in at least a century with respect to the large rise in sea-surface temperature, the geographic scope and the societal impacts. Eugene M. Rasmusson of the University of Maryland at College Park sees a strong correlation between ENSO events and rainfall in southeastern Africa (the region of Mozambique and Zimbabwe), where he has found that 22 of the past 28 events have coincided with reduced rainfall. He finds much weaker correlations, however, between ENSO events and rainfall in Ethiopia, the West African Sahel and East Africa (the region of Tanzania, Kenya and Uganda).

West African droughts may be better explained by sea-surface temperature variations in the Atlantic. Climate-modeling work by D. E. Parker, C. K. Folland and T. N. Palmer of the British Meteorological Office supports the view that, as they put it, "warmer than normal waters in the tropical south Atlantic, especially in the Gulf of Guinea, have tended to favour dry conditions in the Sahel wet season, as a result of changes in the atmospheric circulation and moisture transport in the Tropics."

The principal human activity of concern is the burning of fossil fuels in historically unparalleled amounts. A growing number of scientists support the view that the increased loading of the atmosphere with carbon dioxide and other radiatively active gases such as methane, ozone, fluorocarbons and oxides of nitrogen is heating up the lower atmosphere. They are the "greenhouse gases," meaning they are transparent to shortwave (visible) solar radiation but absorb or radiate back to the earth the long-wave (infrared) solar radiation returning to the atmosphere from the earth's surface.

A warming of the lower atmosphere will affect hydrologic processes and the location of rainfall regimes, although the regional effects are not yet well understood. Nevertheless, some atmospheric scientists have speculated that the recent prolonged drought in Africa may be a first manifestation of the regional impact of such a warming.

The second human activity of concern is the modification of land surfaces by deforestation, overgrazing and desertification as well as woodcutting for fuel and construction. Such activities can increase the surface albedo of the earth—its tendency to reflect sunlight. The result is that the surface absorbs less sunlight and hence becomes cooler. This effect in turn causes changes in the lower atmosphere. With cool air at the earth's surface and warm air above, the convective activity in the atmosphere is reduced. The effect is to suppress cloud formation and precipitation.

Jule G. Charney of the Massachusetts Institute of Technology, among others, suggested a decade ago that an increase in the surface albedo reinforces drought on a regional scale. According to Charney's hypothesis, drought becomes self-perpetuating and severer as progressively more people have to support themselves on a dwindling land resource and thereby further denude the land surface of vegetation. The Charney hypothesis has recently been challenged. Historical research on ecological changes in the West African Sahel has revealed that the changes in albedo have been much smaller than has been assumed in models worked out by computer. This finding means that although albedo changes may be appearing, they are not likely to have a pronounced regional effect.

It has also been suggested that changes in the land surface might affect rainfall in other ways. For example, they could reduce the number of ice nuclei in the atmosphere that result from the decomposition of leaves and other vegetative debris. Such nuclei help to initiate precipitation. Research has suggested that the organic nuclei are better rainmakers than inorganic ones such as dust because the inorganic nuclei need much lower cloud temperatures to initiate freezing.

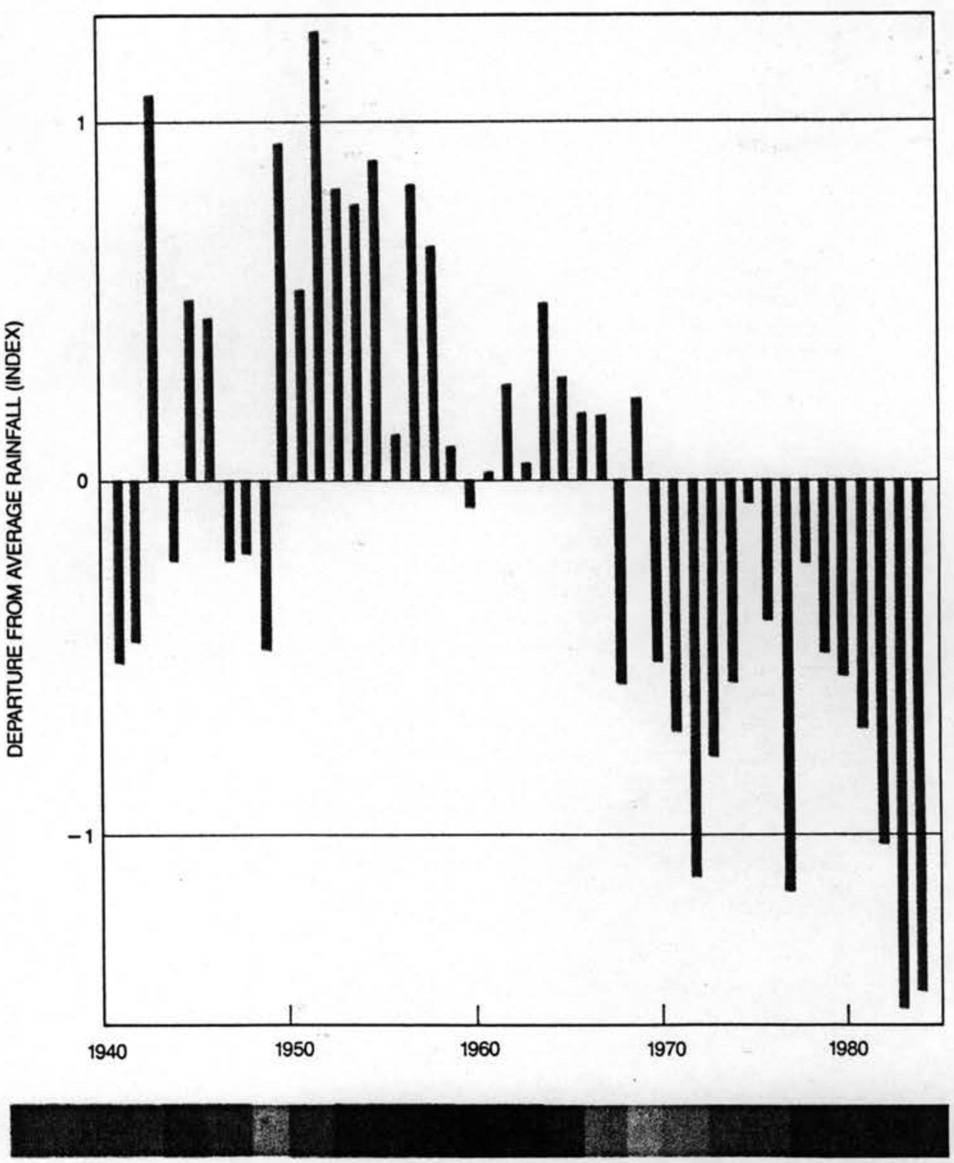
Desertification is another change in the land's surface that might affect rainfall, because it can increase the amount of dust in the lower atmosphere. Such dust absorbs and scatters sunlight, warming the upper part of the dust layer and preventing some of the solar radiation from reaching the relatively cooler surface of the earth. Again the atmospheric activity that leads to rainfall is reduced.

Studies of these geophysical conditions deal with only one set of causes of prolonged African droughts and famines. They neglect an important component of the picture: the complex interactions of climatic variability and human activity. These interactions must be taken into account if one is to understand how droughts affect agriculture, ecosystems and the economy.

In sub-Saharan Africa, where the welfare of more than 80 percent of the population is directly affected by rainfall because the people are engaged in agriculture, the impact of drought is pervasive. Some of the effects are obvious: dried-up watering places, withering crops and reduced forage for livestock. Several less obvious effects may be equally important. They include price increases, rising imports of food, changes in the nutritional status of populations at risk and surges in migration from the countryside to urban centers.

The migrations reflect the fact that crop failures and sharply increased grain prices in the marketplace resulting from prolonged drought are devastating at the village level. The hardest hit are the poorest peasants, whose reserves of grain are often low and whose debts are high. If agricultural drought persists for more than a few seasons, people abandon their villages. The men go away first, searching for work in order to earn wages to buy food. The women and children follow later to reunite families or just to get food. If drought continues for a long time, as it has in parts of sub-Saharan Africa, migrants often end up in refugee camps in a weakened condition, totally dependent on food relief. Many of these dislocations become permanent, leaving progressively less of the population engaged in agriculture and thus accelerating the decline in food production per capita.

Pastoralists are often the first to feel the impact of a drought because they usually live along the desert's edge. In



RAINFALL INDEX (*left*) for a region of West Africa including the Sahel was constructed by Peter J. Lamb of the Illinois State Water Survey on the basis of data from 20 rainfall stations. It shows below-average rainfall from 1968 through 1985. The rains improved

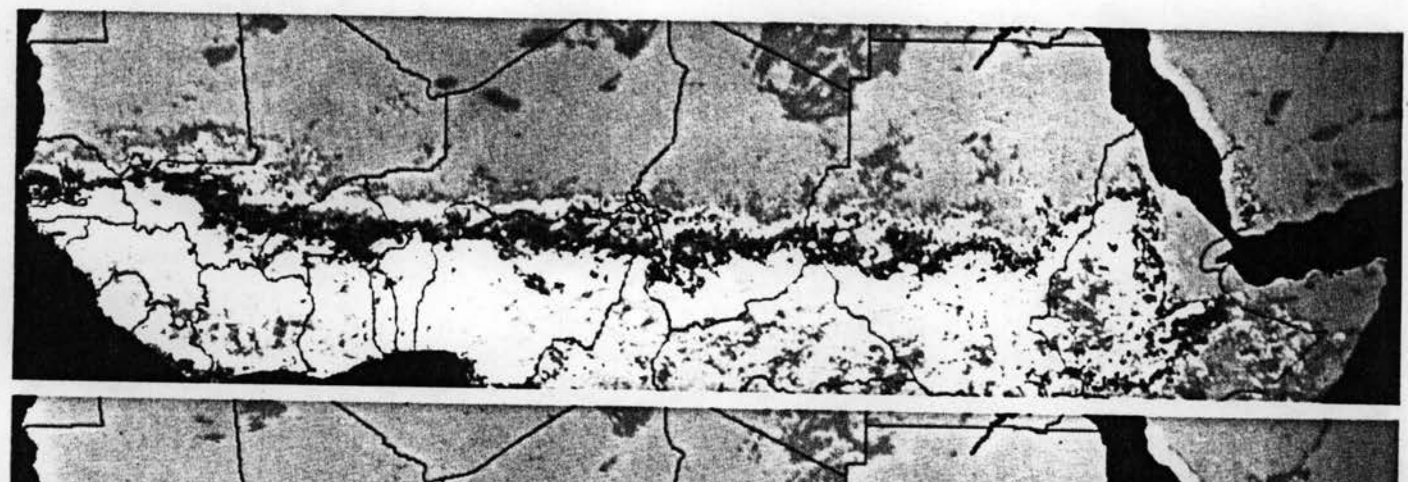
the Sahel, as the rains fail to move as far north as usual, the rangelands deteriorate and there is less forage for the herds. The pastoralists are forced to find new areas for grazing their livestock. In extreme drought conditions many animals die, as much for lack of vegetation as for lack of water. This condition often arises because livestock overgraze the vegetation around permanent and semipermanent watering points and the balance between vegetation and water resources is destroyed. Many pastoralists end up in refugee camps along with the poor farmers, or in urban centers where they become accustomed to urban life and lose interest in returning to the rangelands and the struggle with the vagaries of climate.

In the urban centers and refugee camps they and other refugees acquire a taste for imported grain such as wheat and rice instead of the traditional crops such as millet and sorghum. Hence a long-term and sometimes hidden effect of drought is an increased demand for food-grain imports, which causes a heavy drain on a developing country's precarious reserves of foreign exchange.

To support such costs the governments must devise ways to generate foreign exchange. One of the major ways to do so is to grow cash crops such as cotton, peanuts and coffee for export. These ventures take place at the expense of the traditional food crops, inasmuch as the cash crops are usually grown in areas that have good soil and adequate water supplies and that previously supported food-crop production. It is noteworthy that even during the severe droughts in the West African Sahel and Ethiopia in the early 1970's and 1980's the production and export of cash crops were maintained and even increased at the same time that the production of food crops declined sharply.

Droughts occur in many parts of the world every year, but they do not necessarily result in famines or severe food shortages. Brazil, India, Indonesia and Kenya are examples of nations that have coped with difficult drought conditions in recent years by a variety of mechanisms.

Only a few of the African countries



somewhat last year, and the resulting effect on vegetation can be discerned in satellite data (*right*) assembled by the Food and Agriculture Organization and the National Aeronautics and Space Administration. The satellite photographs, from the top down, reflect the situation in August and September of 1984, 1985 and 1986. Light green represents the least vegetation, dark blue the most.

that registered food shortages in 1982–84 actually suffered famine. The countries that did have famine (Mozambique, Angola, Sudan, Chad and Ethiopia) were plagued not only by severe drought but also by internal war. It is evident from this relation that drought by itself does not determine whether there will be a famine. It does, however, heighten other problems within a society.

It is possible to improve the reliability of projections about a society's vulnerability to drought by employing historical information on similar situations and by studying analogous experiences in other places. There is a high probability that a country in which there are internal conflicts is at a considerable risk of famine if there is a drought. The recent experience of Ethiopia is a case in point. Moreover, but less obviously, governments that appropriate the best land for cash crops displace local farmers and herders, forcing them to eke out a living in the relatively more marginal areas. As arid and semiarid lands less suitable to rain-supported agriculture are put to the plow, the probability that drought will affect farming adversely and lead to desertification will increase. This will be the case not because patterns of precipitation and the probability distribution of rainfall have necessarily changed but because the new activities will require long-term water supplies exceeding what the rainfall can provide.

Although irrigation has been seen by African governments and foreign donors as a buffer to drought, it often has been ineffective. Irrigation is expensive. The crops grown on irrigated land require not only the infrastructure of pumps, pipes and water channels but also such costly inputs as fertilizer, herbicides and pesticides. Traditional food crops are usually not able to bear the cost of such systems because food prices and the prices farmers get for their crops are kept artificially low by government policy in most African countries. As a result the governments typically develop irrigation schemes for cash crops such as cotton and sugar in order to generate much needed foreign exchange. Today irrigation encompasses only a small percentage of Africa's agricultural land, and it is not likely to be widely adopted for the production of traditional food crops.

Other proposals for providing a buffer against drought include various schemes to modify climate and weather. They can be classified according to whether they involve vegetation (the construction of tree belts and the revegetation of desertified areas), atmospheric circulation (the creation of inland seas in ancient drainage basins to increase the amount of moisture in the atmosphere by evaporation) or precipitation (the seeding of large-scale monsoonal fronts and local clouds). Such technological fixes based on scientific hypotheses are often of questionable value and may in fact serve only to conceal deeper ecological and social processes and to raise hopes falsely.

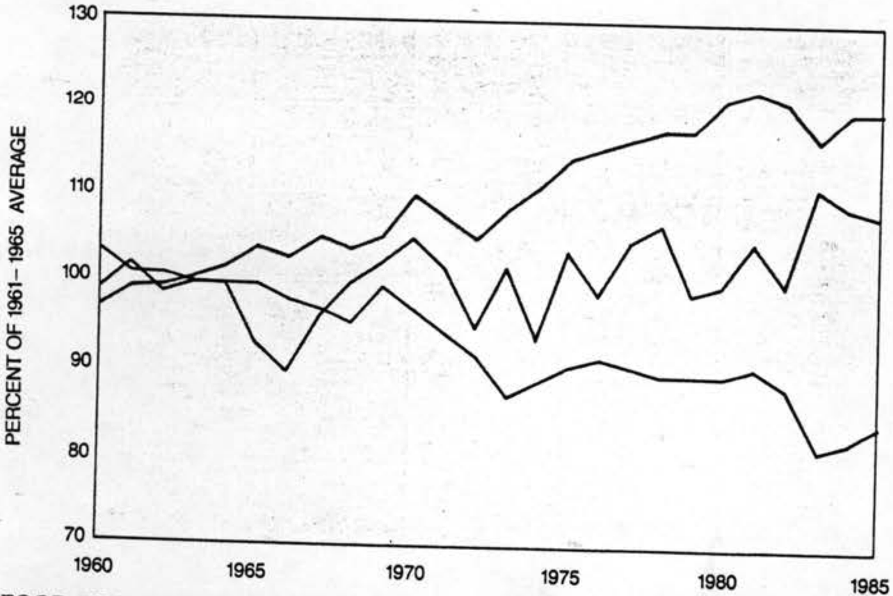
The only plausible medium-term options are those designed to alleviate the impact of drought on African societies. They include shifting from cash crops to food crops during a drought or ensuring that the foreign exchange derived from the export of cash crops goes to buy food for the affected populations; providing donor aid that is relevant to the needs of the recipients, and taking into account the agricultural and climatic situation in setting up new food-production schemes. Above all, such options must be based on an understanding that meteorological drought alone does not usually wreak the havoc often ascribed to it. The point to grasp is that the effects of drought can combine with underlying social, economic or political problems to devastate a society's food-production capability.

For the longer term there are other remedial steps. One step is a program of education and persuasion by agencies such as the World Bank on the theme that drought is a major and recurring disruptive force with which policy makers must reckon. It is also important to educate the leaders of vulnerable countries about the nature of drought as a constraint on development. Such an educational program will have to be carried on without interruption, since the tenure of leaders is often shorter than the interval between droughts.

For the governments themselves it is important to adopt policies that restrain the tendency to extend farming and grazing to marginal rainfall areas or unsuitable land. When farming and grazing are extended to marginal land, the results of agricultural drought (including withered crops and dusty soil) worsen food shortages and extend desertification.

Governments could in addition make greater use of their meteorological services in agriculture. Those services can help policy makers by showing how meteorological information can improve the soundness of their decisions relating to agricultural development. The services can also take part in early-warning systems to alert governments when prefamine conditions are in the offing.

It is increasingly clear that measures of only the physical aspects of drought (magnitude, duration, intensity and geographic scope) may in fact yield little insight into why droughts with seemingly similar physical characteristics have impacts that vary from one country to another and even from one time to another in the same region. Better insights will come only from multidisciplinary studies that delve into the social, economic and cultural factors as well.



FOOD PRODUCTION per capita in sub-Saharan Africa has declined since the early 1960's, reflecting in part the scant rainfall. Sub-Saharan Africa (*red*), exclusive of South Africa, is compared with Latin America (*brown*) and six nations of southern Asia (*gray*). The data are based on information assembled by the U.S. Department of Agriculture.