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THE PHYSICAL RESOURCE BACKGROUND TO AFRICAN DEVELOPMENT

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Biographical Sketch

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Biographical Sketch

Mustafa Mohammed Khogali is a Sudanese national on the permanent staff of the University of Khartoum (Department of Geography and Institute of Environmental Studies). He has also been appointed Institutional Coordinator of the United Nations University in Khartoum Unversity. At present Dr. Khogali is a Fulbright fellow as a visiting professor to Clark University. He studied at the University of Khartoum, (B.A., Ph.D.) Edinburgh (Diploma in Education, 1962), University of Wales (M.A., 1964) and Cairo Demographic Centre (1971). Dr. Khogali is the author of a number of papers on Sudan transport nomadism, natural resource and population and development.

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EXECUTIVE SUMMARY

This paper summarizes the main characteristics of the African Environment as those characterisitcs affect the development of the area. It also attempts to identify the most important issues which face Africans and donors with respect to the physical environment. It does not deal with the important, but separate issue of mineral resources, but concentrates on factors of climate, water supply, soils, vegetational resources and land use.

It is important to emphasize early that Africa is a distinctive continent, both in terms of its resource base and in relation to the historical sequence of use of, and management of, that resource base. Africa is different, Africa is a special case.

Climatically Africa is a dry continent, more so than any other (unless South West Asia is defined as a continent). Two thirds of the area can be classified as arid, semi-arid or dry sub-humid. In this "dry zone" the length of the dry season, the variability of rainfall and the high intensity of rainfall, are all important factors. To a greater or lesser degree, crop and pasture failure is an annual possibility over this large area. The current and recent droughts are unusual in recent history, but similar events have occurred in the past. There is no clear indication as to whether the last 10 to 15 years has marked a turn to long-range drier conditions or not. It is certainly prudent to

plan for continued uncertainty in rainfall in all these dry areas.

Countries and regions with significant dry zones (most of the countries in Africa) must develop clear strategies, long and short term, to deal with the problem of drought. Such strategies should include the collection of better data, an early warning system for localized drought, a policy for managing the consequences of drought when it occurs and longer run strategies for the development and use of drought resistant varities of grains. Better assessment of areas suitable for grain production are needed. Supplemental watering and irrigation are important national strategies, but these need to be carefully integrated with other aspects of resource management, especially grazing. Donors have a special role to plan in assistance with the monitoring and feedback of weather information mixing global and local technology, in the research for appropriate crops and in the development of regional as well as national drought strategies.

Surface and sub-surface water resources development is one obvious pathway for dealing with problems of drought and the need for increased productivity. Africa does have considerable potential for river basin development, as typically rivers flow from wet upland areas through dry lowland zones. Hydropower and irrigation potential is found in most regions of the continent. Current development of these resources is localized with 80 per cent of Sub-Saharan irrigated land being found in Sudan and Madagascar. A doubling of irrigated land in Africa is, from the technical viewpoint, a clear possibility.

The problems with surface water development have been that various factors, including some physical ones, have led to most projects being in the form of large multi-purpose dam and reservoirs. The typical cost of such projects now runs in the billions of dollars. Such large investments demand large returns and these are predicated on good management and high value enterprises. The cost per irrigated hectare in Africa is $10,000. It is hard to make the level of cost economic. Problems of siltation and negative environmental impacts have also plagued river basin developments.

It is recommended that river basin development is viewed as a multi-resource activity and that careful sequencing of the process over quite long-term periods may be necessary. Irrigation is an important technology for Africa but farmers in each major region of the continent need to begin irrigation at scales of management which make the transition from their previous systems easier. As river basin development is often an international process in Africa,iIt is clear that most basin developments have to be viewed both as national and as international projects. Donors can be very helpful in assisting the planning stages.

Sub-surface water development is a relatively neglected area in Africa, except where water has been provided (sometimes inappropriately) for livestock. Sub-surface water supplies even on a small scale may be an initiating factor in improving crop security particularly for vegetables and fruit trees and every effort should be made to bring this resource back into focus.

African soils are not inherently the most fertile in the world and the judgement of the FAO is that only 19 per cent of the continent has soils with no fertility limitations - the lowest percentage for an area this size. Although the paper reviews the characteristic of the soils on a continent-wide basis, the regional and local picture is more important in terms of crop and animal production. In the West African Savanna 9 per cent of the soils are totally unproductive but an additional 60 per cent is of low to moderate productivity. Only seven or eight per cent of the area is highly productive.

A major problem in Africa is loss of soil and soil productivity because of poor management practices and the intense tropical rainstorms. The FAO suggests that a loss of 16.5 per cent of rainfed agriculture is possible by the year 2000. Governments need to be much more active in assessing the extent of this problem in their countries, especially as it affects their high potential land. Donors and governments need to work together to promote land use systems and crop mixes that reduce the problem and to develop other low cost means of reducing soil and productivity loss.

Vegetation in the form of grasses and trees constitutes a major economic good for much of Africa. Livestock are integrated into almost all land use systems in Africa and are a vital part of the national wealth in many countries. Increase in livestock numbers and the reduction in grazing land as well as prevailing dry conditions have together led to significant degredation of pastures in some areas, very little in others.

Woodland in all ecological zones has been greatly reduced in area and availability in the last two decades. In areas of tropical rainforest outside the Zaire basin the loss of forest has been mainly the result of expanding agriculture. In the drier zones, the loss of woodland has been due to increased demands for fuel and to some alienation of woodland from the public domain.

Reforestation programs in the dry areas of Africa have generally been successful only when local people have been involved and identified with the activity. The concept of agro-forestry in its simplest context; that is of farmers planting trees along the margins of their land, planting fruit trees near the home and generally fitting trees into their land use is one which may work well in many parts of rural Africa. The need of fuel for towns involves a different scale of wood production and appropriate location for woodlots have to be worked into the land use in the urban margins.

There is a different kind of problem and need related to the removal of natural ecosystems from large parts of Africa. The two systems for which there is concern are the rainforest ecosystems and the savanna wildlife systems. Rainforest is rapidly being removed from West Africa and important pockets are being steadily reduced in East Africa. There is less of a problem in the Zaire basin. Donors and governments need to work together to ensure rainforest protection. This is important for several reasons. Many forest areas protect catchments, most rainforest areas provide a uniform flow of water in the rivers they generate. Lastly, tropical rainforest includes over half of the world's

species of plants and animals. While all rainforest is clearly not sacrosanct, some areas must be preserved in each part of the continent.

Similarly much of the savanna wildlife has already disappeared from West Africa and in East Africa is increasingly being confined to game parks and preserves. Further work is needed to define the appropriate ecological areas to be conserved for wildlife and to help governments in the task of maintaining this resource in the face of many other legitimate pressures.

Land Use Trends in Africa reflect the dramatic pace of change in that continent. In the period 1860-1920, conversion of natural land to cultivation involved about 16 million hectares in Africa out of a world total of 432 million. From 1920 to 1978 such conversion involved 90 million hectares in Africa out of a world total of 420 million. Much of that latter change has been compressed into the last 20 - 30 years and estimates indicate that Tanzania, for example, has increased its cultivated area more than 50 per cent since 1965. Even in the Sahel, Niger has increased its area of cultivation 30 per cent in the same time period. Land use change has tended to bring into cultivation more marginal land and also to increase the intensity of cultivation on used land. Old management systems are breaking down and new systems are only slowly taking shape.

Final recommendations involve seven sets of issues (p 52-62). They are set in the context of a general statement that resource issues need to be much more clearly integrated with plans for

economic growth. Governments and donors have much to remedy in this regard. Highlights of the recommendations are:

....the need for governments and donors in most countries to have a clear policy for short and long run approaches to drought, drought avoidance and drought management.

....management of grazing and woody resources are vital parts of the rural economy. They can only be done well with the full involvement of local communities.

....desertification is a deeply rooted problem in wide areas of Africa and development activities need to be set in this context.

....water development presents some real opportunities but these have to be well thought out in the context of both the physical and management systems involved. For the latter, all levels including that of the farm and livestock management unit are important.

....the problem of loss of productivity is a real one and incentive structures for governments and farmers alike are needed to deal with it.

In conclusion, we emphasize the fact that we are only now beginning to fully understand the destructiveness of the African environment. In emphasizing the importance of linking resource issues with economic issues in Africa, we also should emphasize the need for much more work in understanding that resource environment.

INTRODUCTION: The Distinctiveness of the African Setting

In attempting a brief overview of African resources and environmental issues, it may be helpful first to summarize what is different about Africa, what if anything distinguishes it from other parts of the developing world. Clearly factors of human history and the pattern of evolution of the world trade and power are important, but the task of this paper is to focus most directly on issues related to the physical landscape. Resources of climate, water, soils and vegetation and the related patterns of land use form the core subject matter.

The distinctive nature of African climate, soils and environment history together form the key to the special character of the African resource base. It is different in definable ways from much of the rest of the developing world.

The environmental history of the continent is a long one; Africa has been a continent throughout much of geological time. Apart from localized mountains in the North (atlas) and the cape ranges in the south, it is an old and relatively undisturbed landscape. Because of this great age, many of the soils of Africa have evolved over long periods of time, several hundreds thousand years at least, compared with a few thousand years for much of Europe and North America.

Climatologically, Africa is one of the driest of continents. About 50 percent of the land surface has a rainfall deficit season sufficiently long to restrict agriculture; 20 percent of the land area is classed as arid. Areas where rainfall is surplus to local needs of vegetation and animals are quite small; the Zaire basin,mountains and highlands in northwest, east and central Africa and the uplands and coast of west Africa make up the bulk of water surplus territory. From these areas, most of the large rivers generate their flow and for the rest of their courses are mere conduits of water between the hills and the coast.

Outside these water surplus areas rainfall variability, from place to place, from season to season and from year to year, is the biggest problem of agriculture. It is also a problem in the utilization of river water resources.

The vegetation of the continent is a product of physical conditions and of the role of people over long periods of time. Outside remaining rainforest areas, the "typical" African vegetation is very much modified from its "natural" state.

Land and water resources in Africa are "managed" under many different systems. The small farm holder or herder is the main manager. These small farm holders have grown rapidly in numbers in the past 20-25 years and there has been a spread of farming into new areas. Large farms occupy a much smaller part of the management system except in Kenya, Zimbabwe, and Liberia. This predominance of small holders distinguishes Africa from most other parts of the world.

Another important distinguishing feature is the large number of countries (46 in sub-Saharan Africa) which together have the responsibility of managing the resource base. These countries vary greatly in size and population and often are separated by boundaries which follow no logical people or natural boundary. Resource management in Africa often needs an international component.

Last and quite significantly, a large number of African countries have operated as independent entities for less than 25 years. At this still early stage of statehood, the new national systems for resource management have not had long to evolve. In this sense, too, Africa is different.

In the succeeding sections, we shall try to summarize the most salient of Africa resource characteristics and discuss what appears to us to be the most critical policy issues concerning them.

I CLIMATE AND DEVELOPMENT: A Major Constraint?

The availability of water is a determining factor in the development of the African continent. Water is needed for:

(a) the domestic requirements of the human population, annual rate of increase at about 2.8 percent, (UDO, 1982, pp. 60-61)

(b) agriculture (crop production and livestock raising) which in most of the African countries employs between 70-80 percent of the working population.

(c) the development of industry, presently at an infant stage, but which all African governments give high priority.

(d) the rapid urban growth in almost all African countries.

However, it is estimated that about 2/3 of Africa can be classified as arid, semi-arid or dry sub-humid, (Figure I). This means that extensive areas in Africa suffer in various degrees from shortage of water. For this reason it is important to understand the nature of the water resource, and to develop the right techniques for the use, the management and conservation of water.

The main sources of water are:

(a) rainfall.

(b) surface sources, which include water courses, natural and manmade lakes.

(c) sub-surface water.

Rainfall

Africa is essentially a tropical continent with most of it lying within 35 of the equator. Temperature is high everywhere

except in areas of considerable elevation (table I). As expected the range of temperature is low along the equator and increases north and south. Temperature is therefore not a limiting factor in agricultural development; and with the varying range of temperature tropical and sub-tropical crops can be grown. However, the high temperature increases evapotranspiration, and thus reduces the effectiveness of rainfall in areas of low rainfall, especially as over most of Africa rainfall occurs in the summer months.

Three aspects of rainfall are important: total rainfall, distribution of rainfall and variability or dependability of rainfall. Total rainfall and distribution of rainfall is adequate in many parts of Western Central Africa and in the East and Central African highlands. Outside this region vast areas of Africa experience dry periods ranging in length from 3-9 months (Figures 2 & 3). This dry period is emphasized by the problem that the lower the rainfall the more variable it is. There are however some exceptions to this rule; for example Beira and Durban on the east coast have high annual rainfalls and high variability (Grove, 1968, p. 13).

There are two related types of variability (i) variation in the total amount of rainfall from one place to another, and (ii) variation in the distribution of rainfall in the season. Both types are experienced over extensive areas in Africa and have

serious impacts on African agriculture and settlement. Grove, 1968, estimated that the chance of the rainfall total in any one year being within 10 percent of the mean is less than 40 percent. Three examples from the Sudan will illustrate clearly the point about variability.

The first example is Khartoum. Depending on the definition of a desert climate,[1] Khartoum with an average annual rainfall of 168 mm. (Sudan Meteorological Department)[2] can be said to have either a desert or semi-desert climate. However, in 1973 the city had 174 mm. that occured between May and October, but June and August were dry (figure 4). In 1974 there was only 50 mm. total annual rainfall distributed almost evenly between June to September. Thus, in both years the pasture, so vital to the camel nomads of the region west of Khartoum failed.

The town of Bara with an average annual rainfall of 298 mm. (Sudan Meteorological Department)(2) is the second example. The economic activity of the region around Bara is a mixture of rain

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1The word desert is variously defined. Scholars that follow Koppen's classification or any of its derivatives define hot desert in terms of its climate, but, that is where annual rainfall is less than 250 mm. (Udo, 1982, p. 25). However most of the literature in the Sudan Republic refer to desert as an area with annual rainfall less than 75-100 mm. This is because according to the dictionary definition a desert sustains very litte or no life. But areas with rainfall between 75-250 mm. in the Sudan are occupied by camel nomads who have large animal wealth.

2These average for the period 1931-60.

cultivation and animal raising. In 1983 the town had only 85 mm. total rainfall distributed as follows:

July 15	24 mm.
August 2	5
August	56
Total	85 mm.

As a result of the rain failure, pasture and crops, except for watermelon, failed. Consequently, a large number of people from the provinces of North Kordofan and N. Dar Fur were forced to emigrate. The FAO/Sudan Government Mission of February 1984 estimated that at least 1.8 million persons were dislocated from these two provinces. A large percentage of the emigrants headed for Southern Kordofan and S. Dar Fur provinces. But those provinces themselves were hit by drought as example 3 illustrates.

The third example is the savanna belt of Western Sudan. The area near Bahr el Arab is a land of mixed sand and clay soil.[3] The zone is utilized by both cattle nomads and rain cultivators. Noting that the zone has comparatively high rainfall, on the average about 650-700 mm., the Sudan government established a number of experimental stations of which Umm Agag

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3This zone is referred to in the Sudanese literature as Baggara Repeating pattern, a term coined to mean to the alternation of soil and vegetation types in the land occupied by cattle, Baggara, nomads.

(Southern Dar Fur) and El Fuda (Southern Kordofan) are the most important. But in 1983 the zone received total rainfall of 380 mm which fell between June and September. The last rain was on September 21. An agricultural expert in El Fuda station informed the writer that if there had been only one more rain, even of moderate intensity of about 10-20m. in the second week of September, crops would have succeeded. But rains stopped early and plant growth was stunted. Figure 5 for El Fuda experimental station shows total rainfall for 1983. It would be noticed that rainfall is spotty even in a radius of less than 10 miles, where the three rain gauges of El Fuda are situated.

Policy Aspects

The people in rural Africa are rather accustomed to fluctuation of rainfall if the divergence from the mean is small. For such expected occasions the people have developed strategies, such as food storage, use of types of seeds that mature in a short period, and supplementing their earning from occupations other than agriculture, (Hildore, 1982, pp. 132-140).

But the fluctuation may be so severe as to cause floods or drought,[4] and droughts may continue for a number of years with cumulative effects. Then the effect of drought is not restricted to the annual vegetative cover, but has an impact on the hydrology in general and on the socio-economy of the area. Such was the case with the famous Sahelian drought of 1969-73 and Africa is now experiencing another drought that started in 1983. These droughts cause large scale human suffering and dislocation of population.

Drought is essentially a climatic phenemenon, but it also has a human component in that human activities may intensify drought, (Hidore, 1983, p. 293). However, droughts are not new to Africa. Nicholson, and Flohn (1980) stated that within the last 20,000 years three major episodes occurred in which the climate of Africa differed significantly from that now prevailing over the continent.....climatic fluctuations expressed themselves in terms of changes in the hydrological balance among precipitation,

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4Drought can be defined differently by people of different disciplines. For climatologists drought is severe reduction in the annual average rainfall. This will have its effect on the plant growth as well as on the amount of water flowing in water course, or water soaking under the surface to enrich surface and subsurface sources. A slightly different definition is in terms of usual supply and demand for water. Thus a drought occurs when the supply from rain is below the usual demand.

evaporation and run-off. Grove, 1967, indicated that the climatic changes can be deciphered in the soils and drainage systems of the present day. Lake Chad showed expansion and contraction as humid and dry periods alternated; the sand dunes of the Sahel and Kalahari deserts were deposited during a dry period, but they were stabilized during a wet period; and drawing of elephants on rocks in the volcanic rocks of Tibesti indicated that a large part of the present Sahara was inhabited by large numbers of human beings and big game. Droughts in recent history were also common and knowledge about them have been recorded by travellers and remembered by old people. The example of Khartoum, figure 4 and El Fuda, figure 5, shows that there were years of low and others of high rainfall. Garcia (1983, p. 182) stated that rainfall variability and drought were so engraved in the Sahelian Societies that they were essential elements already incorporated in the organization of production and social structure.

The important questions therefore are:

(i) whether the recent droughts in Africa point to a trend towards a drier period similar to those in the prehistoric periods or are mere short term fluctuations.

(ii) If they are mere fluctations is there any indication of a cyclic pattern by which future droughts can be predicted?

These questions cannot be answered at the present because so far the real cause of the fluctuations is not known (Bach, 1982, p. 3). Also the network of meteorological stations in Africa is not yet developed enough to give a good regional picture as the stations are few and scattered. At the same time, and as the cause of climatic fluctuation is not yet known, it seems that droughts are unavoidable and the present one may be an indication of others in the future (Yevevich, 1983, p. 4). Thus, effort should be directed towards:

(a) (i) discovering and developing a system of prediction of drought, and,

(ii) to develop policies that will reduce the adverse effect of drought.

To achieve these two points we need to intensify climatic research. The purpose here is to enable scientists to predict periods of low and high rainfall. For this reason it would be desirable:

(i) to increase the number of the meteorological stations all over Africa.

(ii) to modernize the existing network of stations.

(iii) to develop a modern system of weather-record-keeping data.

(iv) to train the needed personnel.

(v) to initiate a programme of research to discover the impact of the main human activities on climate in general and on the rainfall aspect in general. It is known that the increase in the CO_2 and SO_2 in the air have local effects on rainfall. How far has this affected African climate? and what will happen if and when the African countries develop industry? More urgent however is the impact of the wide scale cutting of wood and removal of the vegetation cover in general on the soil moisture and on local rainfall.

(vi) to initiate and encourage more international cooperation in matters of free flow of weather information and research. At the present this is partly done by some world organizations most important of which is WMO. But more is needed.

(b) Reducing the effects of drought

The following proposals are meant to reduce both the severity of drought and its effect on the population:

(i) For each country to develop a national policy to deal with drought.

(ii) It was previously suggested that we should initiate a programme for studying the effects of human activities on rainfall. However, this is a long term programme intended to put us on firm ground so far as the human activities are concerned. But at least there is one established fact: that wide scale removal of the vegetation cover increases run-off and thus reduces the amount of moisture that generates life in the soil consequently, the effectiveness of rain is reduced. Appropriate land use policies to improve land cover are urgently needed.

(iii) To encourage the cultivation of quick maturing and drought resistant plants.

(iv) To initiate projects for studying and implementing schemes for storing, spreading, managing and conserving water.

(v) To study and upgrade the African techniques of storing food, both at family, village, local and central government levels.

The role of donors and government in combating drought:

Some of the foregoing suggestions have already been implemented but in a rather fragmented way. The problem of drought needs a comprehensive and integrated programme that covers wide areas in Africa. The financial and technical implications of programmes as the ones suggested here are beyond the ability of most African countries. The role of donors is therefore to help in providing the necessary facilities. To make sure that the suggested programmes will be treated in their totality and to cover extensive areas in Africa irrespective of the political orientation of government in the different countries. The WMO and FAO are key institutions.

The role of the governments falls in areas:

(i) To provide some financial commitment for the implementation of the programme according to their financial abilities

(ii) to coordinate with and facilitate the work of international organizations.

(iii) to initiate and put into force a scientific policy for the proper utilization of the dry lands that are most commonly hit by drought. It may be necessary for example to prevent cultivation in areas that have average rainfall less than 250; or it may be important to suggest to the people to reduce the number of their livestock. Such measures will certainly be opposed. If these are put into practice by coersive methods the results may be more serious than droughts. What is important is to find other means of living for the population and give them the needed training to enable them to carry out the new activities.

II SURFACE AND SUB-SURFACE WATER RESOURCES: A Major Opportunity?

As large areas in Africa have annual or seasonal water deficits, additional water for people or agriculture is needed. Egypt was referred to by the ancient Greeks as the gift of the Nile, it still is. South of the Sahara, water control has only relatively recently become an important strategy for development. In the past water was used for domestic purposes and for irrigation, although this was on a limited scale. At the present irrigation and the generation of hydro-electric power are assuming increasing importance (Table 2). Thus, the need for developing the water resources, even in humid Africa (Zaire is a case in point) is becoming clear.

A. Rivers

Africa has a vast number of water-courses of different discharge, sizes and pattern of flow. The typical African pattern is for large river basins, most rivers being generated from a small upper catchment area with surplus rainfall. From the humid headwaters these streams then flow through more arid regions in long tributary-less channels to the sea.

Important small rivers include the Juba (Somalia) and Volta (Ghana), while the large continent scale rivers include the Nile, Congo, Zambezi, Niger, the Orange, and the Senegal.

River development

In the past, it was mainly in Africa north of the equator that the rivers were used for domestic and irrigation purposes (in addition to navigation along certain stretches). Thus, important ancient settlements and kingdoms developed along the Nile, the Niger and the Senegal rivers. But because the methods of lifting water were crude, the settlements and irrigated areas were restricted to narrow zones along the water channels. Egypt was a pioneer in using the Nile waters. The topography near the river allowed the development of basin irrigation, where comparatively extensive areas were seasonally flooded by the Nile, and consequently most of these areas were put under winter cropping. In the Sahelian-Sudano countries some people used other methods such as the geref (floodplain); temporary swamps, shadouf (counter-balanced levee device) and the sagia.[1] In a few areas such as Jebel Mara and Kilimanjaro (Tanzania) the people developed intricate network of ditches to lead water from its natural channel to fields at lower levels.

Flood recession irrigation is a feature of many West African rivers (Senegal, Niger, Volta, Benere, Chan, Longre) and may encompass an area of 350,000 ha. Apart from this, the total area

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1Sagia is Persian wheel.

under irrigation is quite small, though estimates vary widely. About 2.5 million ha are irrigated in formal schemes in Africa, south of the Sahara, but 1.65 million ha (65%) is in Sudan and a further 0.375 million ha (15%) is in Madagascar: (World Bank 1981). Table 3 describes irrigation potential for the major rivers and projects.

In the long-run, the greatest potential from African rivers may be power. Most African rivers have well-defined rapids or waterfalls and there are many sites where this has, or can be, turned into hydro-power. The Aswan High Dam generates power for much of Egypt, the Volta Dam for Ghana and Table 2 lists the major power projects for East Africa as an indication of one region's picture. The great cost of utilizing hydro-power potential and the subsidiary investments needed to utilize the energy have greatly slowed the use of African rivers for power.

Apart from the relatively few countries where rivers are used for irrigation and/or for generation of hydro-electric power, the African rivers are as yet only utilized to a small fraction of their potential. This may be due to a number of problems which include:

a. inherent problems in the the physical conditions
b. shortage of capital, and
c. shortage of technical and management skills

<u>Inherent problems of the African rivers</u>

Most African rivers discharge from direct rain that falls in the upper catchment areas. As the annual rainfall is seasonal and variable, the discharge of the rivers is subjected to seasonal and

annual variations (Figure 6). The catchment areas of many of the rivers have suffered from the substantial removal of the vegetation cover, and as a result such rivers carry heavy loads of silt.

The only river that has a comparatively small variation is the Congo which has most of its catchment in regions of heavy equatorial and semi-equatorial rains. Moreover, the river gets part of its water from the northern hemisphere and the other part from the southern hemisphere. The result is somewhat even flow. All other African rivers have marked seasonal flow and annual fluctuation. The Orange River flow at Boegoeberg is fourteen times greater in February than in August. Some parts of major African rivers including the Orange River near its mouth and the Senegal are dry in years of severe drought. Below is a comparison of the average total annual, average maximum and average minimum flow of two major rivers -- the Nile and the Zambezi. (See Appendix A for a discussion of the flow).

Average annual and seasonal flow of the Nile and the Zambezi, in acre feet.

River	Total average Annual flow	at lowest Period	at highest Period	Remarks Season of Low and High
Nile	68×10^6	37×10^3	57×10^4	May & Sept.
Zambezi	37×10^6	64×10^4	8×10^6	Oct.-Nov. & March-April

Note and source: Measurement of the Nile at Aswan and that of Zambesi at Maramba (formally Livingstone). The source is Encyclopaedia Britannica Vol. 19 p. 1127 and Vol. 13, p. 107.

The wide variation in flow means in most cases that river control schemes have to involve major storage reservoirs. As Appendix A illustrates in the case of the Nile, the year to year flow became a critical factor and the huge Aswan High Dam is designed to even out the variation in water supply from one period of years to the next -- the so-called "century storage."

A consequence of these physical conditions, aided by other forces favoring large projects, has been to allow a focus on large dam projects. These projects, although quite numerous in Africa, have hardly begun the process of river development outside the Nile basin, though the Senegal River and the Cora Bassa projects have made major steps in the development of those areas. The costs are enormous in terms of dollars and the technical and managerial skills needed to run such enterprises. For example, the cost of water development works and associated infrastructure for the comparatively small Kagera River in East Africa is currently estimated at 4-6 billion dollars <u>without</u> much investment in agriculture.

The problem of utilizing some of the potential of African rivers, but keeping that development in pace with the rest of a particular national or regional economy and society is a particularly tough one that will face most African countries and donors. The fact that most African rivers are international and that their development necessitates a high degree of coordination and cooperation adds to the problem, but should not be allowed to hide the long-run opportunity.

Some policy issues

A whole range of policy issues flow from the problems and opportunities of African river development. They include:

a. overall national and donor policy about the priority given to river basin development vis-a-vis other development investments.

b. the issue of large versus small projects where there are feasible alternatives.

c. the strategy to be followed in international basin development.

d. the solution of technical problems of catchment control and siltation and the like.

Priorities for basin development

These will obviously vary from country to country, but by our estimate, at least forty African countries have river basin resources as an important part of resource endowment. An important factor to consider is the integration of water development planning with the general pattern of development investment. Too often donors and host countries have seen water development as a separate issue. Water development is only really

effective when it is accompanied by parallel investment in agriculture, infrastructure (both physical and human), forestry and industry; though not all of these in all places. The most important policy issue then, is to ensure appropriate linkage. As water resource developments typically take place over long time periods, up to 25 years, continuity and consistancy at least of general purpose is important.

Large versus small projects

Most African countries do not have a long history of water management, so an important constraint on irrigation is the availability of managers to run large irrigation projects. There is, therefore, a strong case where physical conditions are appropriate to develop small, more easily managed and worked projects as a first step in a national trend towards higher input agriculture. When larger projects are attempted, a strong emphasis on training at all levels is needed. The economic issues of farming under irrigation are also very important, but not dealt with here.

The strategy to be followed in international basin development

As so many African basins are international (more than 57 major river or lake basins are shared by two or more countries, of which five are shared by six or more, the Nile by nine, and the Niger by ten, for example) most donors and countries need policies about the development of international rivers. The most effective situation is when countries can agree on common policy and donors

support that. More frequently an interactive planning process is needed in which the needs and opportunities of the whole basin development are traded off against the needs and opportunites of segments of the basin in various countries. Even so, an agreed upon plan is necessary for effective progress even if the planning and discussion process takes several years (Berry and Berry, 1984).

Technical problems of catchment control and siltation

In the very large catchments typical of African rivers, it is very difficult to adopt basin-wide control measures. However, it is foolish to hope and plan for the best in this area. Very careful steps must be taken to identify the key source areas of sediment and the priority areas for catchment control and there must be agreement between donors and countries that preventative or remedial measures will be taken before major dam construction takes place. Equally, donor guidelines need to be set down about the procedures needed to prevent negative environmental side effects, and also to remedy such important negative impacts which may occur.

B. Underground Sources of Water

Rivers do not run everywhere in Africa; nor can water from rivers be transported to very long distances where it is needed. Therefore, sub-surface water is an important resource for much of Africa. Sub-surface water is found in large reservoirs beneath

the southern Sahara and the Sahel, and in a few locations in central and southern Africa, where rock conditions are favorable. Elsewhere it is found in more localized water bodies generally within 100 meters of the surface.

The utilization of underground water has been important in that it provided year round water for domestic, human and animal use. As such it became instrumental for social and economic development in many parts of Africa. For further utilization of the source a number of measures must be taken. These include:

(A) A detailed study of the geological formation with the view to:

(i) delineate more accurately the boundaries of the various acquifers.

(ii) to discover fractured and weathered areas within the Basement Complex Formation.

(iii) to measure the amount of water available in the various acquifers.

(B) To monitor carefully the in-and-output of underground water.

Most sub-surface water is obtained from wells and water drawn by hand or by pumps. Well water serves very large numbers of people and animals in dry Africa and is quite often used for small-scale agriculture.

Modern technology has begun to make well drilling simple and a large number of wells and boreholes have been drilled in arid or semi-arid areas in the last twenty years. It is important that donors and host countries alike plan such provision of water in connection with the other resources of grazing, fuel and cultivated land. Well drilling is a technology which helps several aspects of African development including nutrition, and health, rural living standards, animal husbandry and agriculture. It will only do so efficiently if its provision is much better coordinated than it has been in the past.

3. SOILS: A Limited Resource

There are all kinds of myths with regard to African soils. At one end of the range the early explorers had a notion that tropical rain forest areas were necessarily fertile, and there is still a current idea that all you have to do is bring water to the desert and all will be well. At the other end of the scale de Vos (1971), an experienced FAO worker in Africa, writes a book entitled "Africa a devastated continent" in which he sets out to prove the validity of his title.

In the authors view of reality, African soils are so varied that no generalized statement for an area 3-1/2 times larger than the U.S. will suffice.

Table 4 lists the main soil types in Africa in terms of their scientific classification and their potential. The simple table still hides the great complexity of such a large continent. Yet some generalizations have to be attempted. The Food and Agriculture Organization in a recent publication estimated that only 19% of the continent had soils with no fertility limitations (FAO, 1984). This compared with 44% in Central America, 36% in Southeast Asia, 20% in South America. In a simple combining of percentages of areas with suitable climates with areas of suitable soils Africa has the lowest index of all major developing regions with the exception of South-west Asia.

COMBINED INDEX SOIL AND CLIMATE

South America	95
Central America	110
Southeast Asia	120
Africa	72
Southwest Asia	26

Table 4 provides a rough breakdown of the continent by soil types with comments on the agricultural potential of each, though there are clearly wide variations within each group.

Nearly 30% of the continent has little or no agricultural value though some ares which have little or no value because they are desert could have varying degrees of value if irrigated. But contrary to some beliefs, by far the largest part of the desert would not flourish if it were watered.

Another twenty percent of the continent has weakly developed soils for the most part because soil development has been slow in dry but not true desert zones. Within this category there are localized fertile soil materials especially those developed on new volcanic soils and there is potential in some areas currently covered by mangrove.

The next group of soils the calcareous clayey soils are dominated by a group called vertisols. This soil type is found over larger areas in Africa than elsewhere in the world and about one third of the total area of these soils, 300,000 square km., is potentially highly productive. The other 600,000 km. is found in lowland depressions and could be productive when drained. Large areas of these soils have not yet been brought into production because under small farm technology they are hard to work.

Another 9-10 percent of Africa is covered by reddish-brown soils which are typical of the Sahel and also of the Mediterranean regions. In those latter areas these soils can be quite fertile but in the Sahel zones this group of soils in generally of low productive capacity.

Two major groups make up the typical red and yellow soils which cover nearly 30 percent of the continent; the yellow ferruginous tropical soils (Ultastalfs) are one reason why soil erosion is seen as a problem in Africa. These soils occupy 11 percent of the continent, are often cultivated, and moderate yields can be obtained when they are first cultivated. However, they deteriorate rapidly unless they are allowed long periods of fallow and can erode rapidly.

The other group which reinforces Africa's "poor soil" reputation are the Ferrallitic red soils. A few areas of this very extensive (18%) group can be very productive but their normal pattern is of low productivity, and low degree of recovery from overuse.

In summary the good soils of Africa are found in the alluvial basins and clay plains of Africa. Many of these soils are hard to work but have good long run potential. Other very fertile areas are in the new volcanic soils of upland areas of East and Central Africa.

Zones of moderate to good fertility are found within most soil groups and occur everywhere from the Mediterranean to the southern tip. But the overall picture is of vast areas of low

productivity per hectare but with massive total productivity because of the large areas involved. The future of Africa's agricultural production will depend on high levels of use of the fertile zones and effective use of the large areas of low-moderate productivity.

Soil -- The Regional and National Picture

The above statistics and comments deal with the soil resource at the continental level. It is instructive to examine a regional or national level in terms of soil resources. Kowal and Kassam (1978) review the status of soil resources for the important area of the West African Savanna; the area between the dotted lines on Figure 7.

The relative distribution of soil types
in the West African Savanna

Soil Type	Area(%)
1. Ferruginous tropical soils and associated soils	60
2. Ferrallitic soils	10
3. Ferrisols	7
4. Brown and Reddish-Brown soils of Arid and Semi-Arid Areas	5
5. Vertisols	2
6. Other soils (mainly Hydromorphic)	7
7. Rock, debris, ferruginous crusts	9

(from Kowal & Kassam, 1978)

The percentage of each soil type in this area is given above.

Analytical data of major Savanna soils (0-15cm depth)

Soil Type:	Clay(%)		pH		Organic C(%)		TEB(m/100g)		P(- ?)	
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Av
1. The Brown & Reddish-Brown Soils of the Arid & Semi-Arid Regions	4-20	7	5.9-7.2	6.8	0.07-.44	.25	1.1-9.3	4.3	40-194	9
2. Ferruginous Tropical soils	0-34	9.2	4.8-8.2	6.2	0.09-2.84	.62	0.7-11.8	3.1	13-560	12
3. Ferrallitic soils	0.4-28.1	10	4.8-7.3	6.0	0.21-1.79	.83	0.4-10.5	2.3	44-314	12
4. Vertisols	22-75	50	4.6-8.8	7.1	0.35-3.47	1.0	8-57	26	75-590	19

Total exchangeable bases

Kowal & Kassam, 1978.

In this region there is a lower percentage of totally unproductive soils (item 7 total 9%) than for the whole continent but there is a much higher proportion of Ferruginous tropical soils (60 per cent) than for Africa as a whole (11 per cent). Some generalized analytical data for the soils of the area are presented above. The Brown and Reddish Brown soils are found in the drier north Sahel and this five percent of the area has an optimal use for grazing. The Ferruginous tropical soils are found in wetter rainfall zones. But they are fairly shallow with a quite low organic content. Most of these soils are highly erodible and/or form surface crusts which slow water infiltration and make hand cultivation more difficult. Their agricultural

value ranges from poor to moderate as nutrient levels especially phosphate are low.

Ferrallitic soils which make up 10% of the area are found in forested or formerly forested areas. They have better physical qualities than the group just discussed but maintenance of a good nutrient level is dependent on new organic matter being added to the top soil. Otherwise they can deteriorate fast. They are of moderate fertility but in sand or degraded areas can have very low fertility. Ferrisoils occupying 7 percent of the one area are more fertile and have good nutrient status; these are the best group of soils in the West African Savanna. The vertisols with only two percent of the area are clayey soils with moderate potential in this zone. They are expensive to work but produce moderately well when investment is made in their cultivation. Of the other soils in the region some of the hydromorphic soils in valley bottoms have good potential. Generally in all savanna soils the available plant nutrient content is low; there is a near universal phosphate deficiency and available nitrogen is low also.

In summary in this important area including all of cultivable Senegal, Niger and much of Ghana, Nigeria, Ivory Coast and Chad over two thirds of the soils have only a poor productive capacity and only seven or eight percent are judged to be highly productive.

Each country perspective in Africa is different so that the choice of Kenya for a short review of soils and land potential provides just a case study of the difference between a national and a regional viewpoint.

The various assessments of Kenya's land use and soil potential are agreed that only a small percentage is of high potential. Maina (J.W.) in Morgan (WTW 1968) estimates that of the countries 225,000 sq. miles (569,000 K2) only 17 percent gets a rainfall of 25 inches regularly and is thus suitable for arable farming. This 12 million hectares is concentrated in the highlands around Lake Victoria and along the coast. Senga (W.M. 1975) assessing soil quality estimates that 7 percent of the country is good agricultural land with good rainfall, moderate or gentle slopes and productive soils; another 4-1/2 percent is suited for crop production but is in areas where in some years rainfall will provide inadequate and crop failures may ensue. Sixty percent of Kenya is semi-arid with very low levels of productivity and the remainder is basically best suited for stock rearing.

Soil Degradation in Africa

The description of soil types and characteristics includes a mention in several cases of the erodible nature of some widespread African soils. The current FAO study (1984) of Third World resources suggests that without conservation measures the loss of rainfed agriculture in Africa by the year 2000 would amount to 16.5 percent of the resource. Because much of Africa is gently sloping the average amount of soil loss per ha is lower than in steeply sloping parts of the world such as S.E. Asia. But the impact of soil loss on African agriculture has been made very clear in a number of studies. The UNEP/FAO evaluation of the extent of desertification showed that Africa was the part of the

world most at risk. Work quoted by Charneau (1974) long before the present drought indicates the magnitude of losses as vegetation cover is reduced (Table 5). Similiar data are available for E. Africa from the work of Peirera, Rapp and Berry (1972) and others. Losses 20 to 100 times greater than under natural vegetation cover are common.

Kowal (1970) made one of the few studies in Africa that directlty links such soil loss with loss in fertility. Losses of about 22.7 Kg/ha of sodium, potassium, calcium and magnesium, 13.7 ka/ha of nitrogen occurred annually. Given the relatively small amounts of nutrients in the soil such losses would severely reduce fertility over a 5-10 year time span. The high intensities of African rainfall and the susceptibility of at least some of the soils combine to make soil degradation a major issue both in low potential areas and in the more productive zones. In some countries it is likely that losses from the more productive soils, not currently being given much consideration, are the crises of tomorrow. In countries such as Kenya where so much depends on the productivity of the high potential areas this should become a high national and international priority.

4. VEGETATION: A Degrading Resource

Climatic elements mainly rainfall and temperature are the principle causes for the distribution of vegetation in Africa. Broadly speaking therefore the vegetation zones are those of climate. These are: the humid forest, types of savanna, short grasses and shrubs of the semi-desert and desert, mediterranean types and montane vegetation. However, there are other physical and human factors that modify this climate-vegetation relationship. Soil variation, (in terms of chemical composition, and ability to hold moisture for plant use), slope and availability of water from sources other than rainfall (water-courses or sub-surface sources) are the main physical factors. Peoples activities also modify vegetation distribution. Hunters and nomads burn vegetation for different reasons; cultivators clear vegetation to plant crops, nomads may overgraze the pasture, and different people may cut wood for energy or for building and furniture. Because of this interference, it has been said that the present plant cover is not natural (Mountjoy 1965, p. 70). What is known as derived savanna in west Africa was really part of the humid forest. Vast areas that look like desert were until recently parts of the semi-desert. Thus it can be said that vegetation is dynamic and never static. Figure 8 illustrates the distribution of the main zones.

The importance of the vegetation cover for the economic development in Africa.

The ecological and economic importance of the vegetation cover cannot be overstressed. There is a strong relationship between climate, soil and vegetation. Disturbing one should affect the other two. It is known that the removal of the vegetation cover from wide areas leads to changes in climate, to more run-off and to the washing out of plant nutrients.

More clear to the eyes of the ordinary African is the direct economic benefits from vegetation, trees, grasses and herbs.

All vegetation zones of Africa, except desert, have trees. The humid forest is composed of dense tall trees that support dense canopies, but there is little undergrowth. The density of the trees decreases and that of undergrowth increases as one moves away from areas of heavy-year-round rainfall. Thus, in the savanna regions the vegetation cover is composed mostly of shorter and less dense trees and tall grasses, while in the semi-desert trees become short and scattered and short grasses and herbs cover wide areas.

Trees are used for a number of purposes. Building, furniture, and domestic energy are the most obvious uses. The different forms of the African hut as well as modern housing use large amounts of wood. Over 70 percent of domestic energy in Africa is derived from local wood. In some countries wood and tree products are important export items. Countries such as Nigeria, and Ivory Coast which have extensive stretches of humid forest export large amounts of wood, while Sudan derives a good

percentage of its foreign earning from exporting gum arabic. Furthermore, trees produce fruits, pods and leaves that are used for human and animal food and medicine.

The grazing resources of Africa support large numbers of animals, cattle, sheep, goats and camels. Livestock raising under settled and nomadic conditions is an important economic activity in all Africa except in the humid forest and in areas infested with tsetse flies. In general it can be said that almost all the livestock in Africa subsist on natural and unimproved grazing. The following table shows the 10 largest cattle producing countries in Africa.

Ten First Largest Cattle Producing Countries in Africa, 1982 (000)

	COUNTRY	CATTLE	SHEEP	GOATS	CAMELS
1.	Ethiopia	26,200	23,350	17,220	1,000
2.	Sudan	19,234	18,547	13,174	2,570
3.	Tanzania	13,150	3,937	5,906	-
4.	Nigeria	12,600	12,400	25,600	18
5.	Malagasy	10,150	633	1,474	-
6.	Kenya	1,200	5,500	5,500	610
7.	Zimbabwe	5,600	360	1,000	-
8.	Uganda	5,000	1,078	2,165	6
9.	Mali	5,134	6,350	7,000	173
10.	Chad	3,800	2,358	2,358	446

Source: FAO, FAO Production Yearbook, Rome, 1982 vol. 36, pp. 214-27.

Most of the African countries meet their needs for meat from their own livestock wealth. In addition, some countries such as the Sudan, Somalia, Kenya and Botswana have some surplus for export. The importance of livestock wealth is bound to increase as the African human population is increasing and needs meat, and that many countries in Africa are trying to increase and diversify their export items.

Problems:

The first and main problem is that the vegetation cover in Africa suffers from degradation as a result of human use especially by clearance of land for agriculture, woodcutting for fuel and overgrazing.

Wood Cutting

Cutting of wood is done in all ecological zones except the rainforests at rates exceeding natural regeneration. There are two main reasons for this. The first is that cultivators remove trees so to prepare land for cropping. This is a historical process that was accelerated with the increase of human population and the need for food. In west Africa extensive tracks of land of humid forest has been turned into derived savanna. Grove (1967) stated that "everywhere the rate of encroachment on high forest has accelerated in the last few decades to such an extent that little will remain by the end of this century unless they are deliberately preserved" p. 24. This case is not confined to countries of high human density nor to zones in the humid forest.

The eastern part of the Sudan central clay plain (550-750mm annual rainfall) was until the end of the second World War, covered by fairly dense stands such as species of Acacia seyal, Balanites aegyptiaca, and Acacia mellifera. In 1945, however it was decided to introduce mechanized rain fed cultivation to produce sorghum and other grains needed to feed the increasing population. Presently, between 2 and 3 million ha are annually under cultivation in this zone. The problem in this case is that cultivation is of a "mining" type. A farm usually has an area of between 1000 to 1500 acres. An owner clears the farm, cultivates it for a number of years until the soil loses fertility. The owner then moves to another farm leaving the first farm to be occupied by inferior types of grasses.

The shortening of the fallow period is a phenomenon observed in almost all the Sahelian countries, and many other counties such as Kenya and Tanzania.

The second important reason for wood cutting is to use wood for domestic energy. In the majority of the African countries firewood and charcoal are the dominant sources of domestic energy. Prior to 1973, there was a growing tendency among some classes of the growing urban population to use energy sources other than firewood and charcoal. This tendency however diminished as such sources became difficult to obtain and more expensive. It can be said that presently over 70 percent of domestic energy in Africa is derived from wood. The last two decades in particular have seen a pattern of degradation of wood, resources in relation to nearly all major urban areas whatever ecological zone they may be

in. Dar es Salaam, Ougadongu, Dakkar, Ibadhan all show this phenomenon. (Figure 9 illustrates the trend in the situation around Khartoum.)

Overgrazing:

Livestock are raised in most of Africa either as a main activity as by the nomads or as a secondary activity to augment earnings from cultivation as in the case of farmers. Furthermore, animals act as safeguards in case of crop failure; and they are ready at hand to be sold in case of urgent need for money. The stock subsist mainly on natural and unimproved grazing and in some cases supplement that food by using crop residues. Water is also free or semi-free. Thus, it costs little to raise animals. For all these reasons the rural people in Africa like to raise animals whenever that is possible.

In recent decades the number of livestock began to increase rapidly. This has been due to a number of factors. First, veterinary services were introduced and consequently animal mortality was reduced. Secondly, there has been marked improvement in the provision of water supply. Thirdly, there has been an increase in the number of people. Consequently, this led to an increase in the absolute number of animals whether the number owned by each family increased or not.

But the increase in animals, maybe threefold since 1950, has not been matched by increases in the grazing resources. It is true that the opening of water points opened the grazing of some areas that were out of the reach of the animals because of lack of

water. But the grazing added is much smaller than the increase in animal numbers especially as some areas were taken out of grazing and converted to crop production. But this worked in two ways. In some areas crop residues and water became available for livestock. This more than compensated for the loss of natural grazing. A good example of this is what is happening in Mali. Cultivators invest in digging wells and invite nomads to bring their animals to the field, graze crop residues and use well water. In return the animals give manure to the land (Toulmin, 1983). The opposite case is what is happening in the mechanized crop production areas in the Sudan. There, scheme owners deny entrance of animals to the fields claiming that animals spread seeds of weeds such as the of buda (witch weed, striga hermonthica).

The increase of livestock has resulted in widespread overgrazing. The signs of overgrazing are first, that some of the most palatable and nutritive plants such as Blepharis spp. disappeared partially or totally from most areas. In their place, some unpalatable or less palatable species such as Cymbopogan nervatus or Aristida spp appeared. Second, in many places, some perennial plants disappeared and have been replaced by annuals. Third, in some places, especially around water points, the vegetation cover disappeared altogether allowing sand to become mobile.

Policy Issues

Two facts should be recognized: first that the vegetation cover almost everywhere in Africa is being degraded. Second, that the degradation that has taken place is basically to satisfy some basic human needs. People cut wood because they need energy, they clear land because they want to cultivate food crops, and they overgraze the pasture because they need livestock. It would be futile to try to prevent people from cutting wood as long as it is the basic source of domestic energy. The following proposals therefore are not based on a policy of prevention, but they are based mainly on better management and preservation.

(1) That well studied programs for reforestation on agro-forestry should be initiated. The best programs are those which gain the support of the local population. People will co-operate if the programs are of direct benefit to them. For this reason a program should be multi-purpose according to the needs of the different local groups. Where both pastoralism and crop production are practiced the program should be of silvo-agro-pastoral. Trees that are planted should be of the type to give pods or leaves that are used by the animals. There are many indigenous types of trees that serve this purpose. The acacia family and in particular, A. tortilis, A. senegal and A. albeda are good examples. Where the need arises exotic types such as mesquit rieties can be introduced. The acacias are known to be nitrogen fixers, they give pods and leaves to the animals, and they provide good wood, and A. senegal yield gum arabic. In the humid forest where animals are not raised the suggested program

should be based mainly on trees of economic value, for wood or fruits and other products.

(2) In the past the work of the various forestry departments in Africa was based on reserved forests. This should continue but in addition, local people should be encouraged to plant trees for commercial purposes wherever possible, on infertile land, on irrigation canals, etc.

(3) The conflict between trees and crop production has many angles, and many of these can be tackled and solved. One conflict is farmers claim that trees harbor birds which attack the unharvested crops. The solution should be in finding methods of combating birds without removal of the forest. A second conflict is that land is needed for crops so forests have to be cleared. The solution is in proper rotation and not "mining" cultivation as practiced in the Sudan and elsewhere.

(4) The antagonism between crop production and pastoralism, where it exists, should come to an end. This is easy to say but hard to accomplish. But crop residues are valuable pastures and they should be used. The manure from animals is essential to continued productivity under decreasing fallow.

(5) In some pastoral areas the land degradation has gone very far. The remedy is partly in closing some of these areas until they regain their vegetation cover.

(6) The nutritive and palatable plants that have disappeared because of overgrazing have to be reintroduced.

(7) In all programs, cooperation between local people, local authorities, regional and central governments and donors is highly

needed, and without such cooperation it is doubtful that any program can work.

(8) A large part of the problem of desertification in Africa is in relation to overgrazing and inappropriate mixes of agriculture and grazing. For more than a third of African countries this may be their major production problem. It should be given high priority by donors and governments.

5. ECOSYSTEMS IN AFRICA: Problems of Development and Conservation

The ecology of the various bioclimatic zones within Africa is both an important resource and is a constraint to certain kinds of development. The resource potential and problems are best summarized in terms of the main bioclimatic systems; the rain forest, the Savanna, the Sahel and the arid and semi-arid areas. Already, each of these has several sub-divisions.

The Rainforest

The rainforest bioclimatic zone occupies most of Zaire, Gabon and parts of a large number of countries including Cameroon, C.A.R., Nigeria, Togo, Dahommy, Ghana and Ivory Coast. Upland rainforest is important in Kenya, Uganda and Zimbabwe. The rainforest ecology reaches its climax where there are near equatorial conditions of high rainfall totals and year-round distribution with high temperatures. The profusion of vegetation suggests high levels of productivity and indeed some of the world's largest amounts of biomass per hectare occur under these conditions.

However, the considerable store of nutrients held in the system are mostly held within the vegetation itself not in the soil. This fact may create problems of a productive transfer to agriculture. When forest is cleared for cropping, major changes in micro-climate and in nutrient flows occur and in some cases, low levels of productivity result. Where crops with a good cover

such as tea replace the forest, very productive use of rainforest land occurs.

At lower elevations, tree crops such as coffee and cocoa also thrive. In its natural state, the rainforest is an important lumber resource though the diversity of species creates problems of economic exploitation. Rainforest has decreased rapidly in extent in all parts of Africa except in the Zaire (Congo) basin. Ivory Coast has, for example, less than 10 per cent of its 1960 area of forest.

The critical issues of rainforest development include those of concern to the nations involved which tend to center on how to maximize the economic value of this resource. But they also include more global concerns of:

preservation of the multitude of species
found in this ecosystem

problems of climatic change which might be
associated with global removal of this forest

Savanna

The Savanna ecosystems are characterized by a dry season which may vary from two to seven months in length. The natural vegetation is typically a mixture of wood and grassland and the various sub-divisions of Savanna relates to the relative proportions of trees and grasses. The Africa of most people's perception is the Savanna Africa. Large parts of the Republic of

Sudan, Ethiopia, Kenya, Tanzania, Zimbabwe, Nigeria, Ghana, Senegal, and Cameroon fall within the Savanna zone.

This ecosystem is well known for its distinctive wildlife, the large game park mammals; elephant, giraffe, deer and the like, but analyses of its biomass highlight other important facts. It is, for example, the ecosystem with the highest proportion of insects in its biomass. Termites are numerous enough to affect the topography of some locations with their large and frequent termitaria. Grasshoppers and locusts and similar insects are also common. Lastly, birds flock in the Savanna regions in numbers seldom seen elsewhere on earth. Millions of quela quela, for example, are killed each year to restrict grain loss.

The nature of the Savanna ecosystem helps in the process of clearing land for agriculture, though the wooded Savanna is hard to clear. The climate is generally suitable for growing crops and in some locations agriculture involves large scale mechanical farming. But pre and post harvest losses tend to be high (30 percent is estimated) because of the readily available animal and insect pests. A survey of farmers in Tanzania, however, (Porter 1972) revealed that animals were regarded as the number one enemy with wild pig top of the list. For the small farmer in the bush, monkies, pigs, birds and insects combine formidably to restrict the harvest. The spread of agriculture and the development of appropriate species of millets and maize may help to alleviate such hazards.

Some governments in Africa are faced with difficult decisions with regard to land use in the Savanna areas. In East Africa, the

governments of Kenya and Tanzania have since independence placed a strong emphasis on the establishment and maintenance of national parks and preserves. In part, this has been in response to international appeals for the preservation of unique ecosystems, in part because of their clear use as a tourist attraction. However, as numbers of people grow, conflict arises between the need for new land and the maintenance of the parks. Already in West Africa, little of the Savanna ecology remains; it will be more than locally important that viable ecosystems are retained in East and South Africa.

The Sahel

The Sahel bioclimatic zone is the transition zone between the Savanna and the desert. Rainfall occurs over a three or four month season and is usually under 500 m.m. per year. The typical vegetation of the Sahel is grassland with a dominance of annual grasses but with scattered to locally numerous trees (Acacia species predominating). Trees generally occupy less than 5 percent of the area. Large parts of Senegal, Nigeria, Mali; Chad, Sudan, Somalia, Ethiopia, Botswana and Kenya fall in this ecological system. The Sahel is the zone where changes in amount and duration of rainfall and where changes in the human ecology of the area can have great impact. The droughts of the 1970's and 1960's and the underlying desertification which the drought emphasized have been most severely felt in the Sahel.

Under natural conditions, the Sahel ecosystem is best characterized as low productivity but good resilience, meaning

that the vegetation and animal life of the area has evolved in such a way that it can survive periodic drought. However, the steady deterioration of the system under changing land use which involved both a northward (for the W. African Sahel) spread of agriculture and an increase in livestock numbers has resulted in some drop even from the already low levels of basic productivity. A recent detailed study (Penning des Vries & Djiteye, 1982) suggests that in the short run at least, it may be uneconomic to make major efforts to restore some areas of dryland Sahel.

The Arid & Semi-Arid Ecosystem

The Sahara desert and its margins and the Namibia desert and its margins make up the two large dry areas of Africa. In each of these, the ecosystems are responsive to the previously dry conditions and there is a range from true desert where there is no vegetation, except in oasis, and semi-desert where short annual grasses and shrubs along seasonal water channels are found. This is an area of low potential despite some popular notions that only water is needed to make the desert green. Some localities are suitable for irrigation and high level productivity and these tend to be along the margins of major rivers where or in a few depressions where salinization is not a problem. The economy of Egypt and some part of that of Sudan depend on production from this zone.

Policy Issues

The major policy issues arising from this brief analysis of the African ecosystem relate to questions of the balance between development and conservation.

The tropical rainforest is globally a resource which is reducing steadily. Already rainforest has been very largely removed from a large part of W. Africa. Yet the great complexity of the various ecosystems and the fact that they include well over half the global species of plants and animals makes it important to preserve. Donors should make every effort to work with host governments to find effective ways and best locations for rainforest preserves.

A similar situation arises with the savanna game parks. These are important national, regional and global resources. It is important to better determine what are the natural areas and units which should be preserved and to encourage economic ways of achieving such preservation. Involving the local people in the analysis and the process is a necessary first step. Issues of conservation of grassland and woodland more generally are dealt with in the preceeding section.

6. LAND USE TRENDS: A Continent-wide and Regional Picture

Data for land use over such a large area as Africa is hard to collect and quite hard to assess once it has been collected. Two tables (6 and 7) help to provide an overview of continent wide trends but we shall rely on some national or regional illustrations as well to better define the situation. Table 7 is derived from a detailed study of the conversion of land to agriculture (Richard et al 1983). The study focussed on a comparison between two time periods of comparable length 1860-1920; 1920-1978. During the latter period a total of 90,419,000 ha was transformed from unused land into crop land. As the FAO estimated (Table 6) that in 1977 there were approximately 180,000,000 ha of arable land on the continent, it appears that about half of the arable land in Africa has come under cultivation since 1920. The regional breakdown of Table 7 indicates quite different rates of growth of arable land by region in the two time periods. South Africa has a comparatively low rate of growth of clearance of land. The countries of West Africa (8.6), African countries in Southern Africa (x16), East Africa (x8.6) and most importantly the Sahel (x12.2) have considerably higher rates. it is particularly noteworthy that over 8,000,000 ha of land was converted in the semi-arid regions of the Sahel during this period. Another 6,600,000 ha were converted in Sudan mostly in the same climatic zone.

Looking at the rates of change in land use at a world level Richards (et al) estimate that for 1860-1920 African spread of

arable land was a small 16 million hectares out of a world total of 432 million. For the period 1920-1978 African land conversion was a large 90 million hectares out of a world total of 419 million. In one era Africa accounted for four percent of world conversion, in the next 23 percent.

The general analysis suggests that about 10-20 percent of this conversion was from tropical forests, 20-30 per cent from drier woodlands, 20-30 percent from savanna and 20-30 percent from dry grassland.

The pattern of continent wide change is further illustrated in Table 6. Over the approximately ten year time period, land in arable and permanent crops has increased by about 7 percent, permanent pasture has remained about the same and the forest and woodland has decreased by 32 million hectares or roughly five percent. Other estimates confirm this order of magnitude of change. it is estimated (FAO 1983) that closed broadleaved forests in Africa were being cleared at a rate of 1.3 million hectares a year (0.6% annually); other woodland was being cleared at a rate of 2.6 million ha a year (0.5% annually).

Some selected country figures help to focus our attention on changes in land use over the last twenty or thirty years (Table 8). In Sudan this period has seen a three fold increase in land under arable cultivation including about the same magnitude of increase in land irrigated. In Somalia land under cultivation has increased 10 percent in the last decade, in Uganda cultivated land has doubled since 1950 and in a 15 year period in Tanzania land under cultivation increased by over fifty percent. Even though

the period included the drought years of the early 1970's land under cultivation in the three Sahelian states listed in the table increased by nearly 2 million hectares over a fifteen year period, a growth of 22 percent.

It is clear from these numbers that in general population increase and some economic growth in Africa has been accommodated by the expansion of land under cultivation at least through the 1970's. The period of the sixties and seventies has seen a massive increase in land cultivated in many African countries. Despite this increase, the FAO estimates that output growth in Africa has been accomplished 73 percent by growth in productivity per hectare and only 28 percent in expansion of land area (FAO 1979, p. 62)

Patterns of land use change can only partly be gained from statistics, other patterns can be detected from changes in migration movements, changes in crops, changes in food habits. Kenya may be taken as an example of a country with limited land resources and a very high rate (4 percent) of population growth. In Kenya, various trends have been identified in a recent-detailed study (Berry & Ford 1984, in press). These include:

-- a reduction in forest by up to 10 percent in the last 10 years

-- a movement of arable agriculture onto drier land and a raidly growing population on the wetter margins of the dry zone

-- an increase in conflict of land use between game parks and nearby herders and cultivators
-- an increase in the area devoted to potatoes in highland areas (this is a sign of intensification)
-- fewer game animals outside preserves
-- a drop in per capita food production.

In Sudan, in some comparison and contrast, the last two decades have witnessed:

-- a major increase in irrigated land involving 325,000 new hectares cultivated
-- a major increase in mechanized rainfed argiculture
-- at the same time much land going out of rainfed agriculture
-- desertification becoming visible as a major problem in Khordofan and Darfur, significant movement of people occuring as a result
-- new cultivation and large numbers of new people in East Sudan as a result of refugees coming from Ethiopia
-- escalating problems of fuel and firewood provision in the center and north of the country
-- the beginning of rehabilitation (much needed) of the older irrigation projects

In both countries, the pattern is one of dynamism and change which could be repeated elsewhere in Africa. Land use and economics are in a state of change partly due to increased numbers of people and livestock and partly due to the widespread dry conditions which have provided over significant parts of the last fifteen years.

As a general trend in Africa, it can be stated that old management sytems for land and animals are breaking down under the impact of many different forces. New systems are beginning to be worked out but have not in many cases begun to have an impact.

Some Policy Issues

Land and other resource use is the center of the economics of most African countries. Yet the land resource is currently underused and not as productive as it should be.

Appendix B is a quotation from a recently published FAO study of land, food and people and sets out some of the context. The following are needed:

1. The creation of incentives for appropriate land use for each of the main ecological zones of the country. Agreement between donors and host country on guidlines for overall crop and land use development.

2. The development of infrastructure that allows the more efficient movement of commodities between production zones
3. Monitoring of patterns of change and an understanding of the dynamics
4. Policies for increased intensification of production in certain areas, extension in others. Development of appropriate infrastructive in relation to these.

7. POLICY ISSUES: A REVIEW

The overall policy issue is how best to manage the resource base in Africa. The management of natural resources for productive purposes is essential to most national economies. A recent FAO assessment of the carrying capacity of developing countries (FAO 1984) concludes that without a much higher level of productivity 22 African counries will have difficulty feeding themselves by the end of the century. The current awful drought and famine are partly a problem of abherant weather conditions but it is a problem compounded beyond measure by mismanagement of resources. Understandable mismanagement perhaps but also reversible mismangament provided that the right mix of political will within countries, international co-operation between countries and wise and long ranging donor assistance is put in place.

The following seven sets of topics form the heavy agenda of such a program.

Managing drought and desertification

National and International issues of Water Development

Irrigation as a means of increased production

Maintenance of soil resources for Agriculture

Issues of conservation of ecosystem and wildlife

Management of Livestock and Grazing Resources

Fuel and Energy in relation to Natural Resources

Managing Drought & Desertification

We have highlighted the fact that almost 2/3 of the continent has a defined dry season. A large proportion of sub-Sahara African countries (and all of those north of the Sahara) have all or a significant part of their territory in such dry zones.

This basic fact has been underscored twice in recent years; first in the widespread drought of the early 1970's and now again in the current drought which is affecting in varying degrees more than twenty countries.

How do countries and donors respond to this threat? There are clearly many different situations but the following apply in most cases.

1. Have a policy. Many governments or donors do not have a well articulated policy on what to do about drought then try hastily to improvise one when drought strikes.

In 1980, a national symposium on drought in Botswana was an important forum which provided the government of this small (in population) country information and perspectives upon which to build a national policy. This preplanning was very useful a year later when a drought began.

2. Develop longer range agricultural research to produce grains and other crops to withstand droughts.

3. Attempt to limit crop production in unsuitable areas mostly through incentive and disincentive schemes.

4. Develop supplemental watering sources for as many small farmers as is possible.

5. Develop drought marketing strategies to deal with the problems of a flood of animals to the market when drought occurs.

6. Arrange co-ordinating groups to deal with problems and/or supply of food, relief where needed. As as far as possible use relief in ways which will not distort food production and marketing patterns for long periods.

7. Develop an early warning system to allow drought plans to be initiated in a timely fashion. This will need to include new meteorological information as well as field reports of crops and animals.

Appendix C lists the conclusions from the "Drought in Bostwana" symposium.

Desertification

While drought is defined as a shortage of water over a period of time, desertification is a term which encompasses several types of land deterioration. The U.N. 1978 COD identified range deterioration, sand dune encroachment, salinization, loss of woodland and soil degradation as components of desertification. This literal "making desert of productive land" has been identified as a major problem for 20-25 African countries. Table 9 sets out the trends in desertification for 19 countries. What should policies be towards this kind of pervasive problem which tends to get a lot of attention in droughts and dry years and less when rains are at or above normal?

It has been shown that problems of resource degradation including those under this heading have developed over long

periods of time and are unlikely to be remedied quickly. If desertification is a major national problem, donors and governments need to work together to develop approaches towards it. The tendency is to agree that there is a problem and then find other short-term priorities which need prior funding.

Some aspects of desertification are amenable to direct action, sand dune encroachment and salinization for example, and countries and donors alike need to set aside a portion of resources for those activities. For many other aspects, development activities need to be set in the context of the desertification problem, with emphasis on

-- making sure development doesn't make the problem worse. Every so called development project in affected countries needs to be examined for its impact on this basic problem. It can be agreed that a large proportion of water development projects in the Sahel have helped degrade the resource base.

-- the development of land use guidelines within which projects can be designed. It is remarkable how many projects are developed without a proper appreciation of basic resource potentials in the area.

-- As desertification is so often a problem of resource management means need to be found of incorporating the basic knowledge of local

people into activities for agricultural and potential development.

As under the sequence of colonial and independent governments the old system of resource management has largely broken down new patterns of responsibility shared by the private and public sector need to be established.

National and International Issues of Water Development

Given the aridity of much of Africa and given the need for improved levels of productivity better water management is an obvious priority. The link between identifying the need and fulfilling the promise is often a hard one to make in Africa. Part of the problem of water resource development has been the scale of the project attempted, part of the problem is that experience of irrigiation is limited in Africa.

River development planning needs long time horizons and often sequential investments of all kinds. It is a priority for Africa and the following recommendations would help make the process a beneficial one.

1. Plan water development in conjunction with the other key resources of the basin especially soil and vegetation.
2. Invest considerable time in working out the most effective stages of river development and test those plans against the needs of the

whole basin and against the needs and plans of major parts of the basin.

3. In international basins ensure that the various countries are generally agreed upon goals and upon the way to divide costs and benefits.
4. Allow for phased implementation of projects over a time period and provide flexibility in project design.
5. Include training at all levels especially managerial training as an essential element of the program.
6. Donors should be prepared to subsidize recurrent costs on decreasing scale to allow a phase in of all components of the project.

Irrigation as a means of increasing production

Irrigated agriculture in the strictest sense of the word is the major agricultural activity associated with large scale water development projects. Africa has a low percent of its land under irrigation and increased irrigation is one way of providing the needed improved productivity. To improve the possibilities of irrigation becoming more widespread and effective in Africa the following need to be considered.

1. Experiment with ways in which the need for rigid management of projects is reduced.

2. Create small scale irrigation projects in areas with very high levels of extension service and make these a success for the farmers as well as for the government before moving on to larger schemes even if this takes some years.
3. Allow as great a variety of crops to be grown as is feasible.
4. In planning involvement of African farmers in irrigation expect that they will still keep a set of activities outside the project, allow for this in labor projections.
5. If the cost per hectare of irrigation continues to be so high ($10,000 ha) do not expect to get a return on this investment except over the very long run.
6. Although irrigation on a medium to large scale will probably be the largest method of supplemental watering encourage a range of other methods. These can be as simple as supplemental hand watering of fruit trees to small well watered vegetable gardens. Small scale methods of supplemental watering may be as great a revolution in Africa as formal irrigation.

Maintainence of the Soil Resource for Agriculture

Soil loss and consequent productivity decline in humid as well as arid (see desertification section) is a critical loss of resources in resource poor Africa.

Government and donors need to address this issue in highly productive as well as marginal lands though the current problem may be more obvious in the latter. Among the more important steps needed are the following:

1. Set up a simple low cost monitoring of the problem in the key agricultural production zones of the country.
2. Provide incentives to farmers in these areas to increase soil productivity (such as government assistance for farms which conserve soil and produce highly per ha).
3. Further experimentation and dissemination of results of best technologies for Africa of managing soil resources in difficult conditions.
4. Where all else fails restriction of the crops planted and the use made of various grades of steep slopes.

Conservation of Ecosystem and Wildlife

The important concepts here are:

1. further research to delimit important ecosystems and the pattern of movement of savanna wildlife.
2. International support to countries to provide incentives to preserve both rainforest and savanna ecosystems.
3. The development of land use practices which allow easy interaction between natural life and human activity. Subsidies to local people may be one form of encouraging this.

Management of Livestock and Grazing Resources

One of the most intractible (to donors) of development sectors in Africa has been livestock. Efforts to modernize the livestock economy have not generally been successful and in the meantime the grazing resources on which livestock depend have deteriorated at least in some areas. A few phrases here are not going to solve the problem but there are some hopeful possibilities, including the fact that livestock appear to have become much more part of the modern economy in Somalia and Sudan in the face of good markets in the gulf states.

Recommendations include:

1. Accept the close integration of livestock and agriculture in most areas and

encourage joint development of both sectors.

2. Work patiently with local management systems to gain acceptance of better management practises for grasslands. Where feasible provide incentives for this.
3. Create demonstration areas for rangeland regeneration and find ways of transforming these into rotational grazing areas perhaps based on older seasonal movements.
4. Use market mechanisms to improve off take.

Fuel and Energy in Relation to Natural Resources

Specific recommendations are found in the text. In general it is important not to equate deforestation with reforestation if the process of reforestation is accompanied by the concept of a government forest. In many areas catchment control and lumber demand mean that large areas need to be planted in trees. For most fuel and energy purposes the more important priority is the increase in trees available to the farmer or herder. A variety of methods can be used to create this resource but all have to be set in the context of the management system of the local community. There are encouraging signs that precisely in those areas where the problem is worse communties are beginning to plan their own

responses. Most communities need help to turn this initiative into sustainable energy supplies.

Concluding Remarks

The general conclusion we reach is that resource issues need to be much more closely integrated with plans for economic development. Governments in Africa have tended to generate plans and activities without too much analysis of the inter-related resource issues. Donors have not generally been helpful in redressing the balance. Most development activity needs to be set in the context of the problems and opportunities of the resource base. An understanding of that context is the essential first step.

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TABLE 1

Temperatures (°C) and rainfall data for selected stations (mm)

Station	Elements	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year	Climatic type
WARRI															
6·0 m (20 ft)	Temp. max.	31	33	33	33	31	30	28	28	29	30	32	31	31	Equa-
5°31'N	Temp. min.	22	22	23	23	23	22	22	23	22	22	22	24	23	torial
5°44'E	Rainfall	32·5	52·5	132·5	225	270	372·5	385	295	427·5	427·5	110	10	2,659	
KINSHASA															
325 m (1,066 ft)	Temp. max	30	31	31	32	30	28	27	28	30	30	30	30	30	Sub-
4°20'S	Temp. min.	22	22	22	22	22	19	17	18	20	22	22	22	21	equa-
15°15'E	Rainfall	127·5	139·4	180·5	208·6	133·5	4·9	1·0	3·5	32·5	136·5	235·5	170·5	1,374·5	torial
BOUAKE															
338 m (1,110 ft)	Temp. max.	33	34	35	35	33	31	29	29	30	31	32	33	32	Humid-
7°41'N	Temp. min.	21	22	22	22	22	21	21	21	21	21	21	21	22	tropical
5°02'W	Rainfall	10	37·5	102·5	145	132·5	150	80	115	205	130	37·5	25	1,170	
KANO CITY															
472 m (1,549 ft)	Temp. max.	30	32	36	38	37	35	31	29	31	34	34	31	33	
12°02'N	Temp. min.	13	16	19	22	24	23	22	21	21	20	17	14	19	Dry-
8°32'E	Rainfall	0	0	2·5	7·5	67·5	112·5	200	310	127·5	12·5	0	0	840	tropical
DAKAR															
32 m (105 ft)	Temp. max.	28	28	28	27	28	31	31	31	31	31	31	28	29	Dry-
14°39'N	Temp. min.	18	18	16	18	20	23	25	24	25	24	23	20	22	tropical
17°25'W	Rainfall	0	0	0	0	0	30	87·5	260	142·5	42·5	5	0	567·5	coast
KAYES															
56 m (183 ft)	Temp. max.	35	38	41	44	43	40	34	32	33	35	38	34	37	
14°24'N	Temp. min.	17	19	22	25	28	26	24	23	23	23	18	18	18	Sahel
11°26'W	Rainfall	2·5	0	0	0	25	95	157·5	237·5	185	42·5	0	0	745	
AGADEZ															
520 m (1,706 ft)	Temp. max.	28	33	42	42	44	44	41	39	41	41	34	32	38	
16°59'N	Temp. min.	10	12	21	21	25	24	23	23	23	20	15	12	18	Desert
70°56'E	Rainfall	0	0	0	0	5	7·5	50	92·5	17·5	0	0	0	172·5	
ADDIS ABABA															
2,451·6 m (8,083 ft)	Temp. max.	23	24	25	25	25	23	20	20	21	22	22	22	23	
9°02'N	Temp. min.	6	7	9	10	9	10	11	11	10	7	4	5	8	High-
38°42'E	Rainfall	16	44	70	86	95	136	282	294	192	21	15	6	1,237	land
EQUATOR															High-
2,762 m (9,065 ft)	Temp max.	20	21	21	19	18	17	16	16	18	19	19	18	18	land
0°11'S	Temp. min.	8	8	8	9	9	8	8	8	8	8	8	8	8	equa-
35°33'E	Rainfall	33	34	72	168	142	123	163	205	111	53	63	53	1,222	torial

TABLE 2 a.

SUMMARY OF MAJOR RIVER BASIN DEVELOPMENT SCHEMES IN EASTERN AFRICA

Country	River	Irrigation Scheme	Irrigation Area	Hydroelectricity Scheme	Hydroelectricity Mw	Other
Sudan	Nile	Gezira	1,114,000 feddans	Roseires Dam	90	Transportation
	"	Managil	946,000 feddans	Sennar	15	
	"	Rahad	250,000 feddans	Khashm el Girba	13	
	"	New Halfa	400,000 feddans			
Kenya	Tana	Mwea	6,000 hectares	Kamburu	94	
	"	Hola	860 hectares	Ataru	216	
	Perkerra	Perkerra	200 hectares	Masinga	100	
	Nyando	Ahero	1,470 hectares	Kindaruma	n.a.	
	Nzoia	Bunyala	360 hectares			
	Lake Victoria	West Kano	883 hectares			
Somalia	Juba	Juba I	11,000 hectares			
	Shabelle	(several)	details n.a.			
Ethopia	Awash	Awash Valley Basin	24,300 hectares	Awash I, II, III Koka Power Sta.	440	
Tanzania	Pangani	details not available		Kidatu	100	
	Rufiji			Hale	21	
				Pangani Falls	17	
				Nyumba ya Munga	8	
				Moshi	20	
				Ruvu	7.5	
Uganda				Owen Falls	154	

SOURCES: See text under each country.

TABLE 2 b.

SUMMARY OF PROPOSED DEVELOPMENT SCHEMES

Country	River	Scheme (Agricultural)	Hydro-electric Schemes
Sudan	Nile	Jonglei I Marshar Marshes Jonglei II Bahr-el Ahazal	Rosieres dam expansion 250 MW Sennar dam 75-100 MW Jebel Aulia dam 25 Settit dam 20
Tanzania (with Rwanda, Burundi)	Rufiji Kagera	Rufiji Basin Irrigation Scheme Kagera River Basin Develop.	Stiegler's Gorge 850 MW Rusumo Falls Dam 80 MW
Uganda	Nile	n.a.	n.a.
Ethopia		n.a.	n.a.
Kenya		n.a.	n.a.
Somalia	Juba	Juba Valley Dev. Scheme	Baardhese Dam 260 GWH

TABLE 3 -- Major irrigation potential, Sub-Saharan Africa

Region, country, and project	Estimated newly irrigable area
	Hectares
Sahel:	
Chad--	
Logone	16,000-27,000
Gore	95,000
Koumbam Dam	120,000
Chari	80,000
Gambia, Gambia River	60,000
Mali, Selingue Dam	62,000
Senegal--	
Manantali Dam	340,000
Diama Dam	50,000
Upper Volta, White, Black and Red Volta Rivers	50,000-65,000
West Africa:	
Cameroon, Pende	8,000
Ghana, Lake Volta	25,000
East Africa:	
Kenya--	
Tana River	115,000
Lake Victoria	35,000
Sudan, Gezira and other	1/up to 652,000
Tanzania	16,000
Southern Africa:	
Mozambique--	
Massengir Dam	90,000-341,000
Cabora Bassa Dam	1,000,000 plus

1/ Calculated by USDA/ESCS on the basis of 1959 Nile Water Sharing agreement with Egypt, completion of Jonglei Canal, and estimated increased efficiency of water management.

Source: Various reports
(From Food Problems and Prospects in Sub Saharan Africa USAID 1980)

TABLE 4

Main African Soil Types and Potential

General Name	Type	African Soils %	Area $10^3 km^2$	Agricultural Value
Rock	7.92	2322	none	
Desert		20.15	5913	none
Water		0.76	222	none
Sub Total		28.83	8457	
Weakly Dev. Soils				
	Entisols Atidsols & Ithosols	11.00	3366	low
Sub-Desert		7.00	2000	low
Juvenille Soils		2.00	535	med-high
Mangrove			56	med
Sub Total		20.00	5957	
Calcimorphic Vertisols	Vertisols	0.70	200	low-med
		3.00+	961	1/3 High 2/3 Good
Brown and Reddish Brown Soils in Arid Semi-Arid		9.00	2705	low except in med region
Etrophic Brown Soils		0.5	148	good
Ferrugenous Trop Soils	Ultastalfs	11.0	3295	Mod-poor, Deteriorates Erodable
Ferrisols	Ultisols	3.0	917	mod
Ferrallitic		18.0	5338	low, a few areas good
Halomorphic		1.0		Poor, none
Hydromorphic		.5		High

TABLE 5

Magnitude of accelerated erosion under various vegetative cover (Charreau 1974a)

Country	Locality	Period of study	Slope (%)	Mean rainfall (mm)	Soil erosion (tonne/ha)			Source†
					Natural vegetation	Cropped land	Bare fallow	
Upper Volta	Ouagadougou	1967–70	0·5	250	0·1	0·6–8·0	10–20	1
Senegal	Sefa	1954–68	1–2	1300	0·2	7·3	21	2
Ivory Coast	Bouake	1960–70	4·0	1200	0·1–0·2	0·1–26·0	18–30	3
Ivory Coast	Abidjoss	1954–70	7·0	2100	0·03	0·1–99·0	108–170	4
Nigeria	Samaru	1965–68	0·3	1070	Negligible	4–21	4	5

†Sources are as follows: 1. ORSTOM Ivory Coast and CTFT Upper Volta; 2. ORSTOM and IRAT in Senegal; 3. ORSTOM and IRAT in Ivory Coast; 4. ORSTOM in Ivory Coast; 5. IAR Nigeria.

TABLE 6

Land Use in Africa

	000's hectares			
	1967-71	1974	1977	1980
Total Land Area	3033103	3033103	3033103	3033103
Arable and Permanent Crops	169282	174346	179416	181164
Permanent Pasture	785849	785950	784527	784265
Forest and Woodland	727917	715585	705853	696027
Other Land	1283484	1290606	1296651	1304991

FAO 1982

(FAO Production Yearbook 1981 v 35 p 45)

TABLE 7

Land Converted to Agriculture

		1860-1920		1920-1978	
	000 ha.	000 ha.		000 ha.	
	Land Area		Sub-total		Sub-total Rate of change 2nd period/first
N. Africa					
Morocco	44630	200		5368	
Algeria	238174	900		4515	
Tunisia	15536	557		1558	
Egypt	99545	546		560	
Libya	175954	.00	2203	564	12587 x 5.7
E. Africa					
Sudan	237600	100		6745	
Ethiopia	110100	1000		3720	
Somalia	62734	Neg		666	
Djibouti	2198	Neg		Neg	
Kenya	56925	300		1476	
Uganda	19971	300		4710	
Burundi	2565	Neg		577	
Rwanda	2495	Neg		300	

Tanzania	88604	200		3140	
Zambia	74072	Neg		1000	
Malawi	9408	100		2198	
Mozambique	76553	Neg		2080	
Zimbabwe	38767	600		1480	
Madagascar	58154	757	3457	1672	29764 x 8.6
S. Africa	122104	5115		9312	x 1.8
Swaziland	1720	60		100	
Lesotho	3035	Neg		100	
Botswana	58537	60		1260	
Namibia	82329	11	131	645	2109 x 16
<u>S.W. Africa</u>					
Angola	124670	200		1230	
Zaire	226760	500		3200	
Rep. of Congo	34150	100		267	
Gabon	25767	Neg		349	
CAR	62298	300		1910	
Eq. Guinea	2805	50		349	
Cameroon	46944	1000	2150	3695	11000 x 5.1
<u>W. Africa</u>					
Nigeria	91077	1000		4990	
Ivory Coast	31800	100		3100	
Dahomey	11262	100		2106	
Guinea	24586	Neg		2500	

Ghana	23002	200		1720	
Sierra Leone	7162	300		800	
Liberia	9632	100		271	
Togo	5360	100		1000	
Guinea Bissau	2800	Neg.	1900	Neg.	16487 x 8.6
<u>Sahelian Africa</u>					
Mali	122000	100		850	
Upper Volta	27380	Neg		3633	
Niger	126670	Neg		2212	
Chad	125920	200		950	
Mauritania	103040	Neg		160	
Senegal	19200	300		1240	
Gambia	1000	50		115	
W. Sahara	26600	Neg	750	Neg	9160 x 12.2
<u>Total</u>:			15906		90419 X 4
			15.9		90.5
WORLD TOTAL:			432.2		419.3

TABLE 8

Changes in Total Land Cultivated

in Selected Countries 1950-1978

(in 000 ha.)

	1950	1961-1965	1978
Sudan	2383		7515 (1550 irrigated)
Ethiopia	11000		13720
Somalia		969	1066
Kenya	1600	1723	2270
Uganda	2400		5610
Burundi		952	1277
Tanzania	3000	3349	5140
Zambia		4820	5058
Malawi		1971	2298
Mozambique	2000	2669	3080
Zimbabwe	1548	1996	2480
Botswana	152	1000	1360
Mali		1650	2050
Upper Volta		4989	5633
Niger		2178	3112

TABLE 9

DESERTIFICATION TRENDS

Countries	Sand Dune Encroachment	Deterioration In Rangelands	Forest Depletion	Deterioration Of Irrigation Systems	Rainfed Agriculture Problems	General Assessment
Benin	0	+	+	0	+	+
Cape Verde	+	+	0	+	++	+
Chad	++	++	+	++	++	++
Djibouti	+	++	+	+	NA	+/++
Ethiopia	+	++	++	+	+	+/++
The Gambia	+	+	++	++	+	+
Guinea	0	0	+	+	++	+
Guinea-Bissau	0	0	+	+	+	+
Kenya	0	++	+	0	+	+
Mali	+	++	++	+	+	+/++
Mauritania	+	++	++	+	+	++
Niger	+	++	+	++	+	+/++
Nigeria	0	+	++	0	+	+
Senegal	+	++	+	+	++	++
Somalia	+	+	+	++	+	+
Sudan	++	+	+	+	0	+
Uganda	0	++	0	0	+	+
United Rep. Cameroon	0	+	+	0	+	+
Upper Volta	0	+	+	+	++	+

KEY: 0 = stable, + = some increase, ++ = significant increase

SOURCE: United Nations Environment Programme 1982 and analysis of questionnaire letter that was sent to colleagues.

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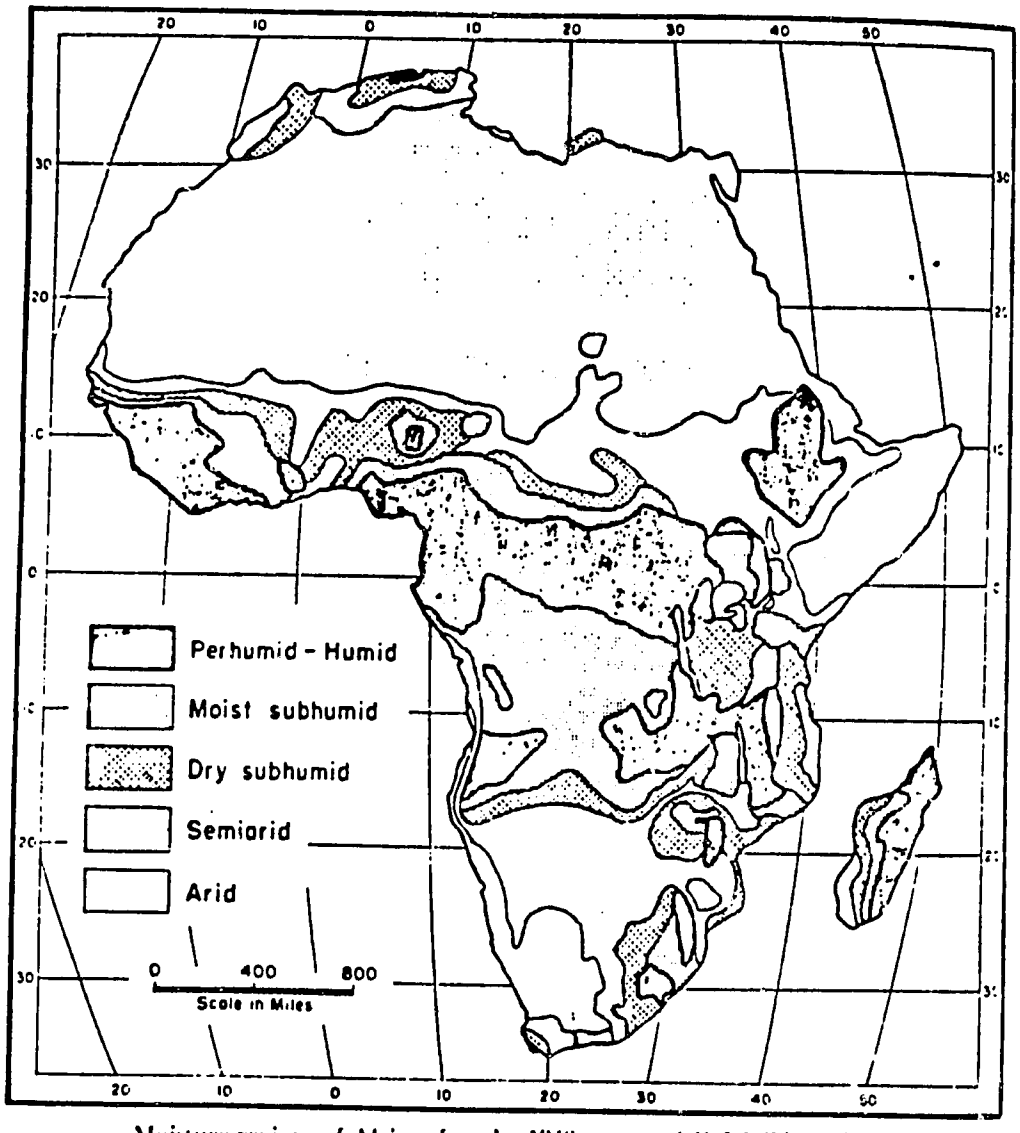
Figure 1. Moisture Regions of Africa



Moisture regions of Africa after the 1948 system of C. W. Thornthwaite. (Simplified from map by Douglas B. Carter in The Johns Hopkins University Laboratory of Climatology, *Publications in Climatology*, Vol. VII, No. 4, 1954).

Figure 2. Length of the Rainy Season

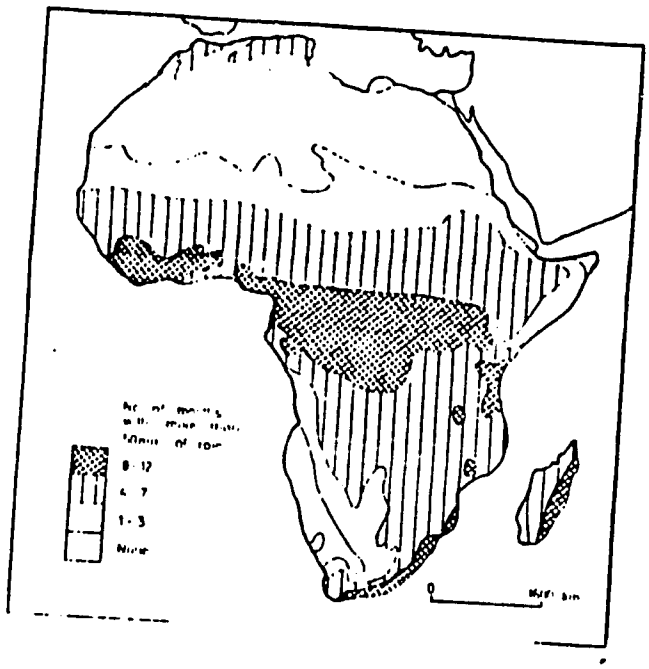


Figure 3. Mean Annual Rainfall

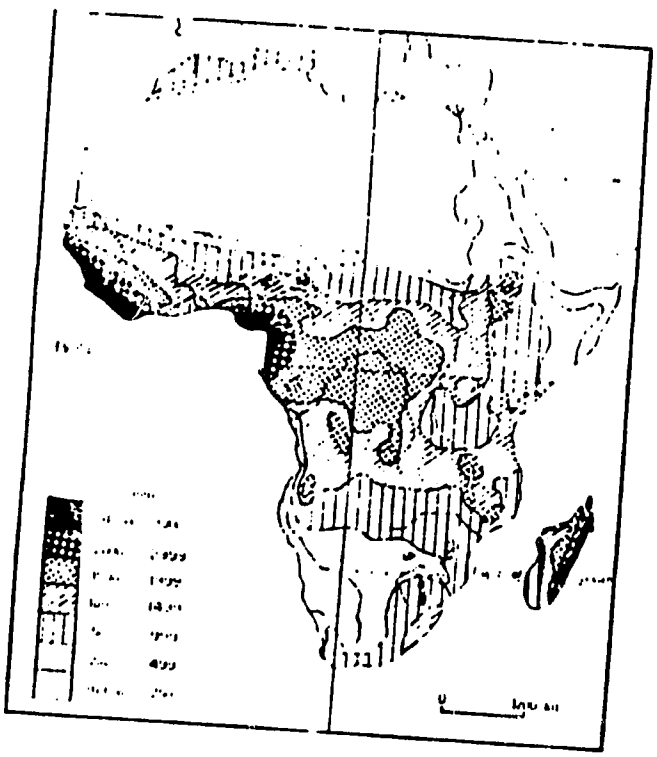


Figure 4 a. Khartoum Precipitation, 1973 and 1974

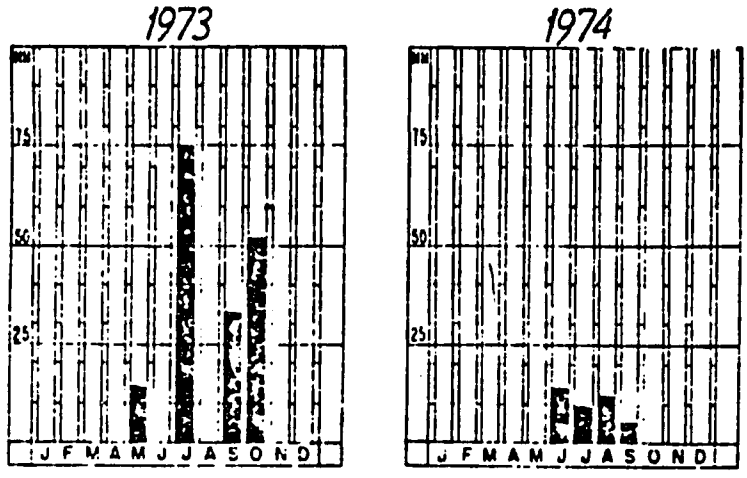


Figure 4 b. Khartoum Annual Rainfall, 1941-1974

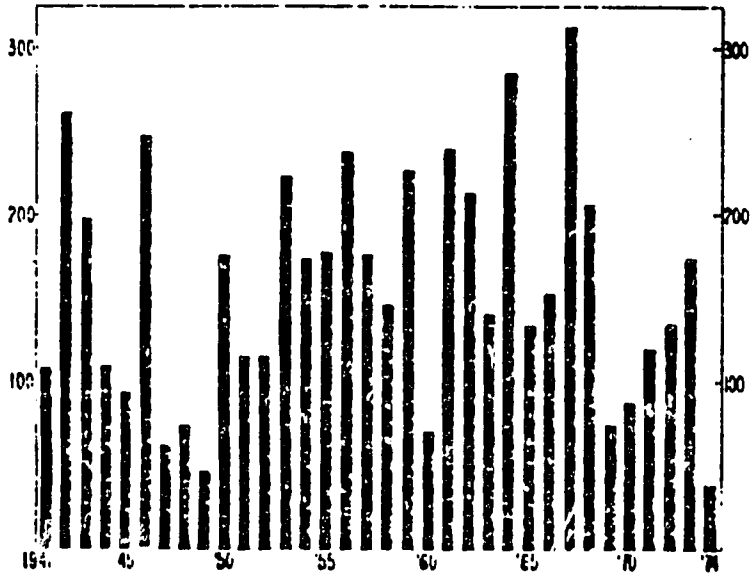


Figure 5. Rainfall in El Fuda Experimental Station, 1982 and 1983

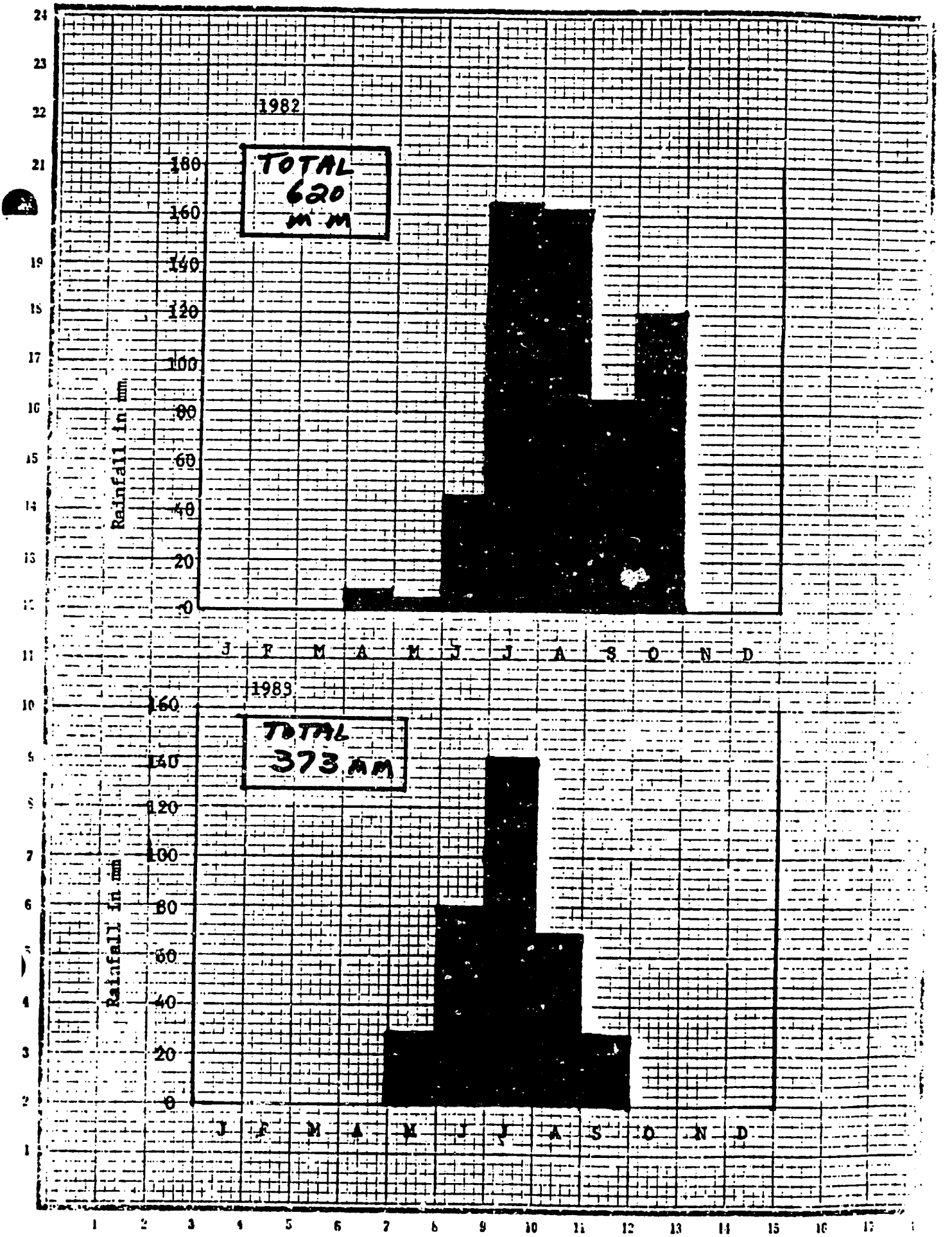


Figure 6. Mean Annual Discharge of the Nile at Aswan

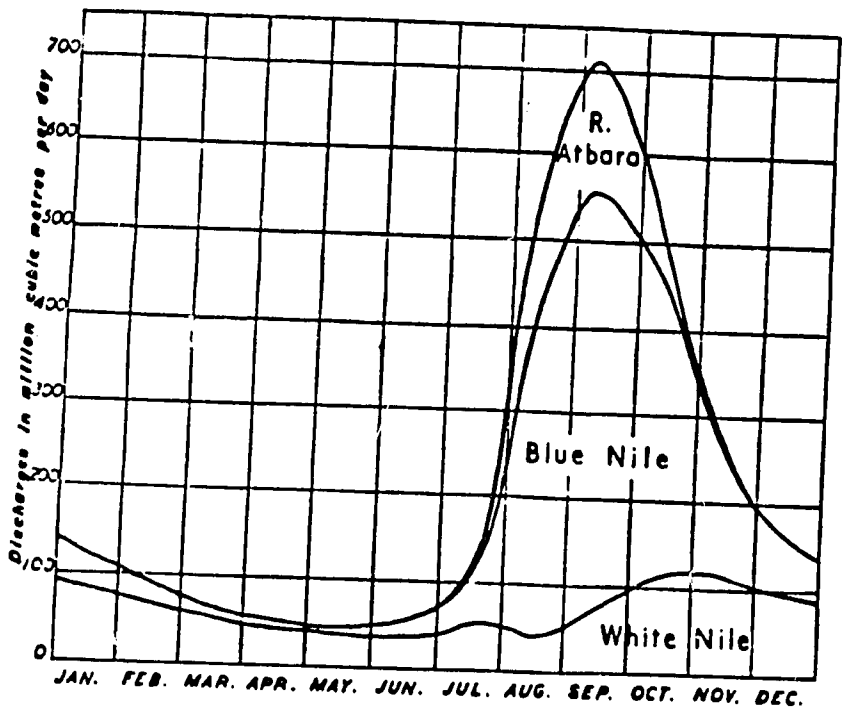


Figure 7. Approximate Northern and Southern limits of West African Savanna Region

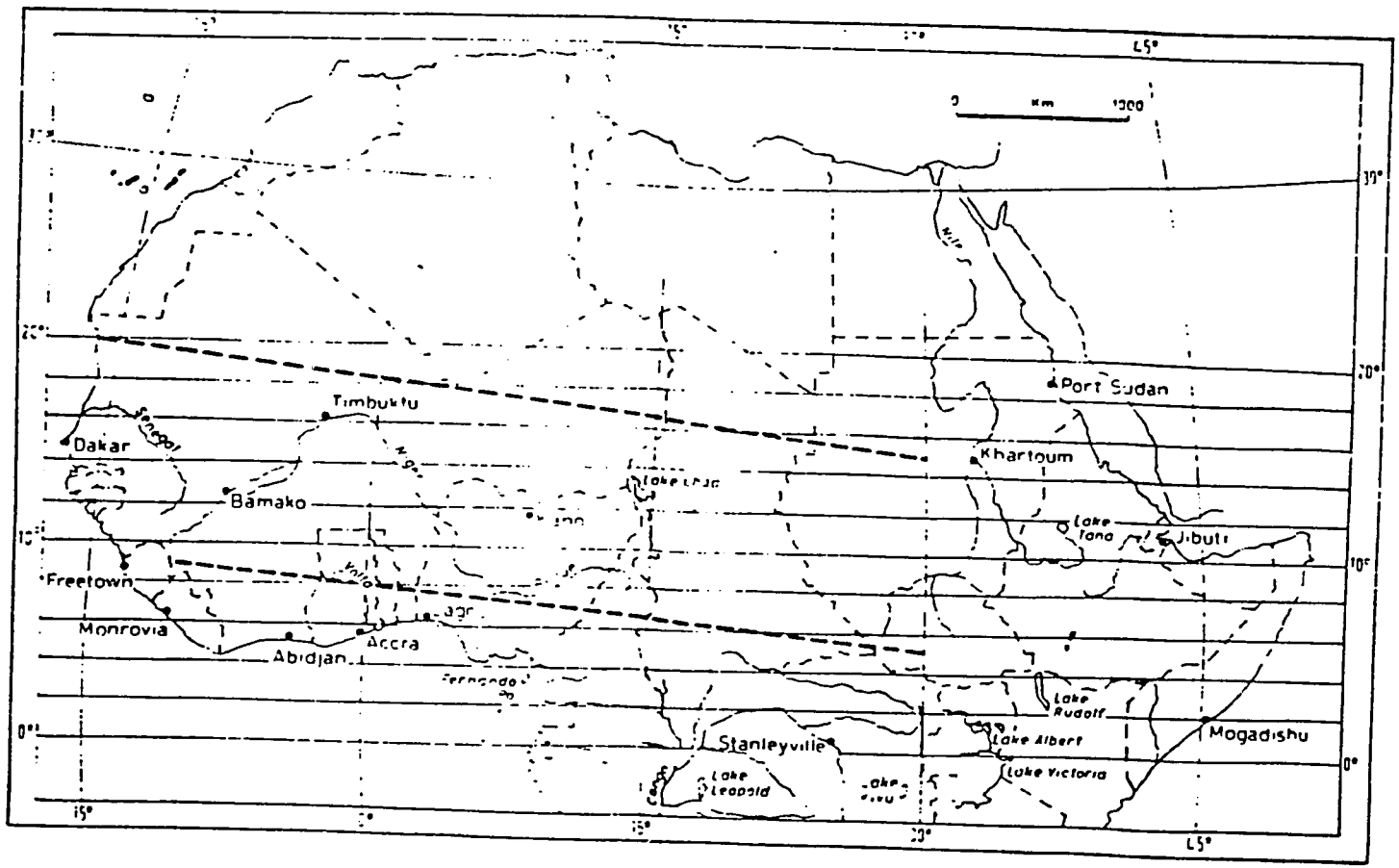
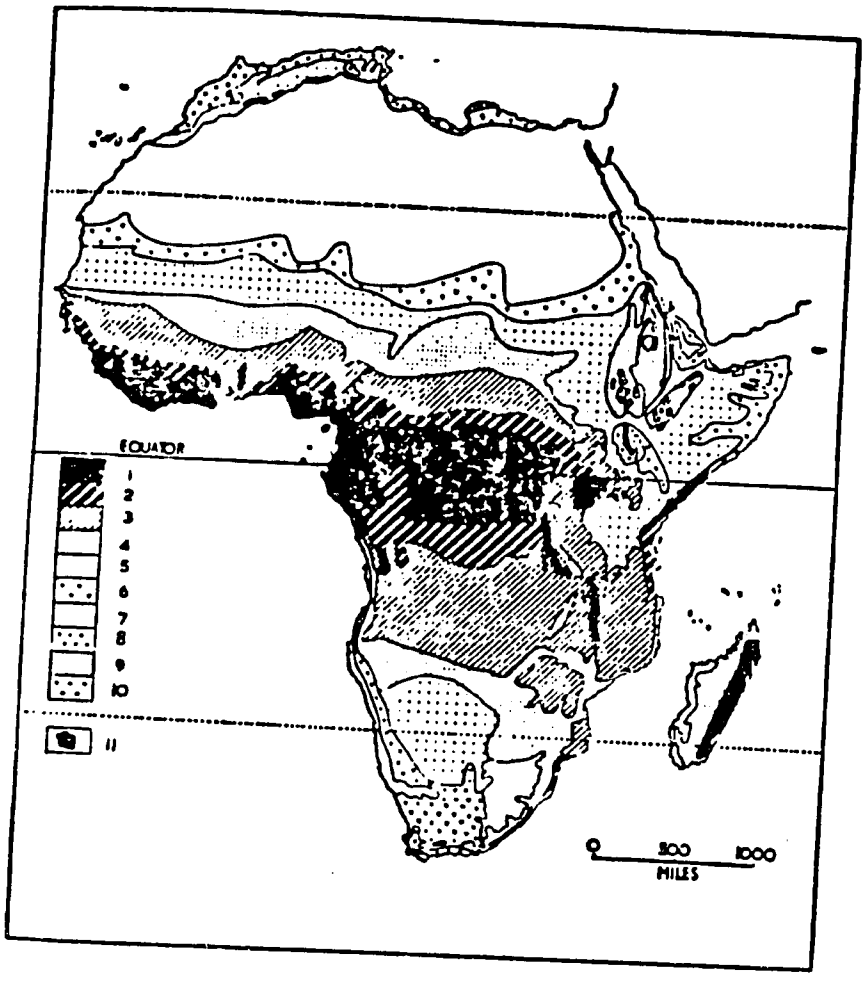


Figure 8. The Vegetation of Africa



1. Tropical rain forest. 2. Forest-savanna mosaic. 3. Wooded savanna. 4. Dry savanna. 5. Wooded and grass steppe. 6. Dry steppe, sahel, Karroo. 7. Desert. 8. Macchia. 9. Temperate and sub-tropical grassland. 10. Montane. 11. Lakes

Figure 9. Zones of Charcoal Production Around Khartoum

APPENDIX A

As there is a continuous record for the Nile floods since times before the birth of Christ up till now, the Nile can be taken as a good example to analyse the seasonal and annual fluctuations and to show how these affect the utilization of the Nile waters.

The Nile gets its water from two main areas, the Ethiopian and the East African plateaux. The Ethiopian plateau is an area of heavy summer rains that start to fall in about late April. These rains are the cause of the floods of the Sobat River (a branch of the White Nile) and of the perennial Blue Nile and the rather seasonal river Atbara. The peak of the flood in Khartoum is about the first week of September; and late September in Aswan. The end of the rains in Ethiopia leads to rapid subsidence of the flood in October and November, and by March-May the river falls to a very low level which causes obstruction to navigation. The smaller river Atbara disintegrates to scattered pools by December-January.

The floods of the Blue Nile and river Atbara, originating from the volcanic Ethiopian plateau carry large amounts of silt which was welcomed by the farmers of Sudan and Egypt as silt enriched the soil. However, silt is at the present the main serious environmental problems in the large water control works on the Nile.

The second source of the Nile is Lake Victoria, the third largest fresh water lake in the world. The region of Lake Victoria has a modified equatorial climate, with year round, but moderate rainfall. The lake acts as a huge water storage with only one exit, the Nile. Thus, the flow of the Victoria Nile tends to be even. The flow is further regulated by swamps of Lake Kioga, the storage at Lake Albert and the swamps of southern Sudan. As a matter of fact Bahr el Jebel (White Nile) loses about half of its water between the time it enters the Sudan and the time it joins with the Sobat River (from Ethiopia) and Bahr el Ghazal (from the watershed between Central Africa and Zaire.)

As a result of the different factors just discussed (rainfall patterns, the effects of the swamps and the lakes,) it can be said that during the flood period 86 percent of the Nile discharge comes from the Ethiopian highlands and only 14 percent comes from East Africa. During the low period, however, the situation is reversed with 84 percent from East Africa and only 16 from Ethiopia.

Due to the annual fluctuation of rainfall, the Nile experiences severe fluctuations in its annual discharge. The story of seven lean and seven fat years of the Nile referred to in

the Bible and the Quran is an indication of the possible fluctuation of the annual flood of the Nile. In this century there have been a number of low and high discharges. On the average the annual discharge of the Nile is about 84 milliards, (68 x 10^6 acre feet). But in 1913 the total annual discharge was only 46 milliards (37 x 10^6 acre feet) while in 1946 it was 153 milliards (174 x 10^6 acre feet). The 1983 flood was low, and the situation was aggravated by a very low flood in 1984. Flood figures for this year have not yet been released, but press reports spoke of very low water level in Lake Nubia (L. Naser) in Egypt/Sudan.

Regional survey

The country results were also aggregated on a regional basis. This level of analysis assumes a free flow of surplus food production and labour across national boundaries within a region. Although this, again, is not a realistic assumption, it does provide a clear indication of the potential for regional self-reliance in food production and, therefore, of the possibilities of intra-regional trade in food.

These aggregate regional results are given below, together with the individual country and length-of-growing-period zone results by region (see Table 1 and Map 1).

Africa

Africa's prospects of feeding its future populations seem most clouded. The continent has a massive land area of 2 878 million hectares (excluding South Africa), but 47 percent of the area is too dry for rain-fed agriculture and only 19 percent of soils have no inherent fertility limitations. Despite this, Africa has a very large area of potential rain-fed cropland — 789 million hectares, not including marginal land — most of this in the humid tropics. In 1975, only 168 million hectares were cultivated.

Africa's yields in 1979-81 corresponded roughly to the low level of inputs, while fertilizer use averaged only 10 kg per hectare, far below any other region.

The existence of large unused land reserves meant that the region *as a whole* was capable of supporting 1 120 million people in 1975 with low inputs — three times the actual population of 380 million.

With intermediate inputs, the land resources could support almost 12 times the 1975 population, and with high inputs almost 34 times. However, land reserves are very unevenly distributed, with central African countries very favourably placed, while many countries in North Africa, the Sahel and East Africa are already using a very high proportion of their potentially cultivable land.

This unevenness shows up clearly in the zone and country results. Almost half the total land area, or 1 355 million hectares, could not support its 1975 populations with low inputs; 184 million people — 48 percent of the regional population — lived in such zones, which were actually capable of feeding only 79 million people.

The critical zones extend across the Maghreb, in mountain and coastal areas. They stretch across the Sahel between latitudes 20°N and 12°N, taking in the northern savanna areas of Ghana, Togo and Nigeria. The most densely populated areas of Kenya are critical, along with a densely settled crescent along the great lakes from southeast Uganda through Rwanda and Burundi to parts of Malawi. In the south, critical zones straddle the continent, from the coast of Angola, through Botswana and Lesotho, to southern Mozambique.

Raising inputs to the high level reduced the critical zones to 30 percent of the area, containing only 12 percent of the population. At this level, the only large critical areas are found in the Atlas mountains, Mauritania, Somalia, southern Ethiopia, Kenya and Rwanda.

The country results are not encouraging. With low inputs, 22 of the 51 countries in the region would have been critical in 1975, with a population of 188 million (half of the African total). Of these, 67 million were in excess of the critical countries' supporting capacity. Use of intermediate inputs brought down the number of critical countries to seven, while high inputs left only two critical.

By the year 2000, the situation becomes very much more serious. The population is expected to more than double, to 780 million — averaging a growth rate of 2.9 percent a year between 1975 and 2000, the fastest of any region — while irrigation potential is not expected to expand very much.

By year 2000, the number of countries critical at the low input level will have risen to 29, with a total population of 466 million (60 percent of the regional total). These countries would be capable of feeding only 210 million people from their own lands.

Twelve countries, with a population of 110 million, will remain critical with intermediate inputs, while four will be critical even with the high level of inputs. (For individual countries, see Fig. 8 and Appendix 1.)

The prospects for most of Africa's potentially critical countries must give rise for concern. Most of them are facing very rapid population growth, while few are seeing industry develop as fast as in other regions. The capacity of many to finance the importation of their potential food deficits is not secure.

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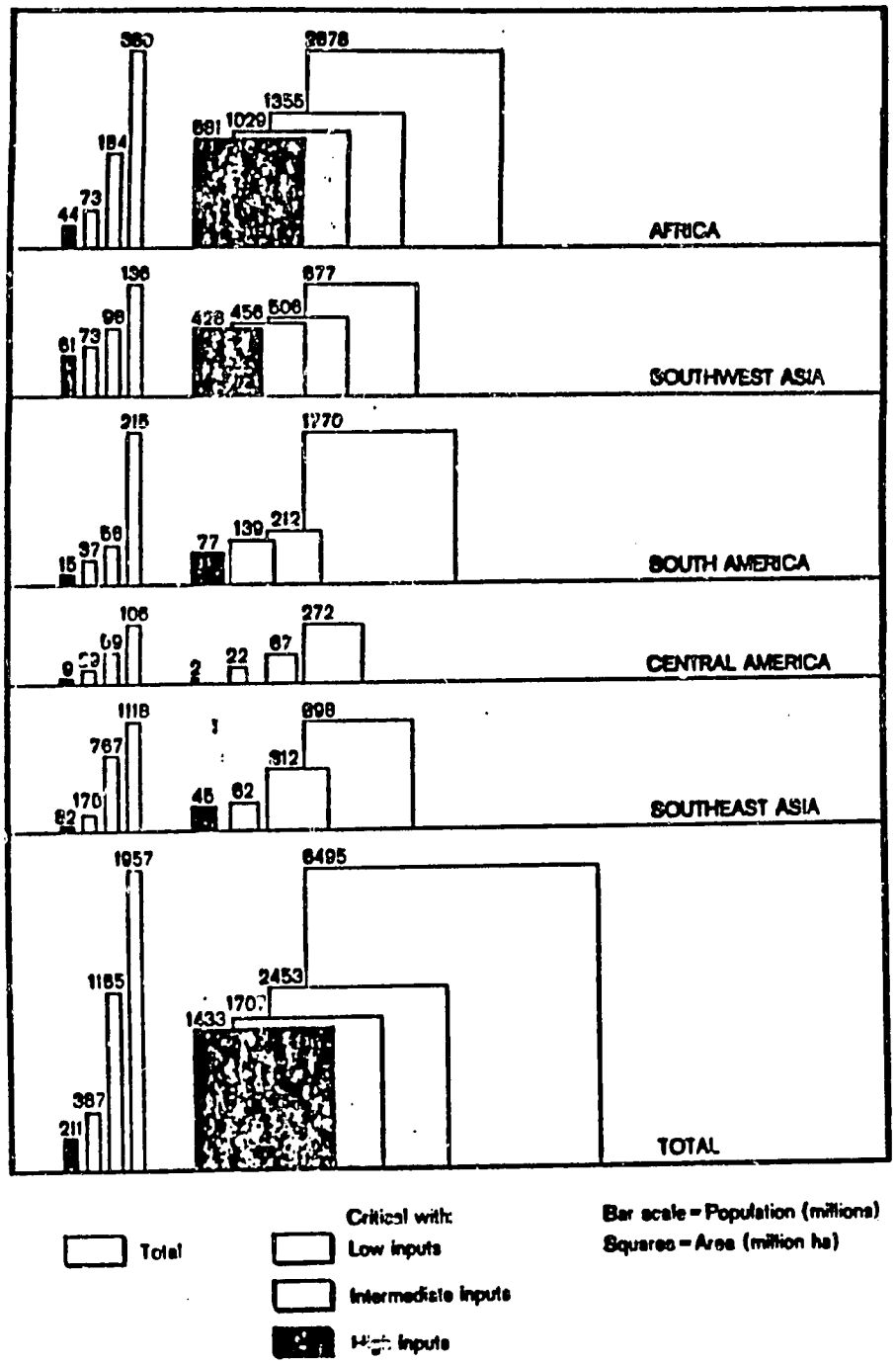
AREA AND POPULATIONS OF CRITICAL ZONES (Year 1975)



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Summation Speech

by Stephen Sandford

Mr Acting President, Mr Chairman, Ladies and Gentlemen: this speech cannot be a full or clear record of this meeting. It is intended merely to highlight the main themes as they appeared to me to emerge, and to try to show their relevance to drought contingency planning and relief in Botswana. Inevitably the result will be eclectic, idiosyncratic, and occasionally rather acid, because too much of this speech was written between midnight and dawn this morning.

I am not going to resist the temptation to abuse my position as the last speaker. Before getting on with the main topic, I would like to comment on what a remarkable institution the Botswana Society is, with its open meetings, where matters of great and current relevance and importance are discussed so freely and frankly between Government and other people in Botswana. This has been a most unusual series of meetings which I doubt is paralleled anywhere else in Africa. The results, I am sure, will be useful not only to the participants and to the Government of Botswana, but also—and I know this because I have frequently used material from previous symposia in my work—to people outside.

My fellow invitees from abroad have requested me to say how grateful we all are to those who organized this Symposium and who invited us to attend: that is, the Government of Botswana, the United States Government, Clark University, De Beers Botswana, the British Council, and above all, the Botswana Society. We thank you for inviting us to participate, for taking such good care of us during our stay, and particularly for providing such a splendid field trip before the Symposium itself began. We have learned alot, and we hope we, too, have contributed to what you have learned.

It is not possible to mention all the important points raised or to acknowledge all of the contributions upon which this speech is based, some of which were in fact made outside the hall in private conversations. Our discussions could be analyzed in many different ways, but because simplicity is necessary here I am going to divide them into three main themes: (1) the causes and effects of drought; (2) prediction, warning, and information on drought; and (3) prevention and alleviation of drought. What follows will come under these three main groupings.

Causes and effects

On the causes and effects of drought there were many papers: by Sandford, Grove, Cooke, Verstappen, and Prah, largely on causes; and by Hitchcock, Devitt, Wetherell, and Jones on its effects. Many other papers and comments from the floor, of course, also touched on these things. On the whole, concerning causes, we adopted a fairly traditional, orthodox, environmentalist approach. Drought, we thought, is caused by excess pressure on natural resources, coupled with fluctuations in the amount and timing of rainfall. There does not seem to be much evidence for current climatic change, either for better or for worse, although this may be a period of greater uncertainty. Whatever happens to the averages, greater uncertainty will tend to mean more occasions on which resources are inadequate for the demands put upon them and therefore more droughts. We thought that excessive pressure on resources was caused by growing human and livestock populations, by poor land management, and by increasing demands from other sources.

We flirted also with the new orthodoxy, in papers by Grove, Wetherell, and Prah, that

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drought incidence and severity has been aggravated by increased per capita demand—which we can describe as greed—by the international economic system's commercialization and penetration of traditional societies, and by colonialism's destruction of society's traditional institutions. There was a good deal of discussion on this point. This is indeed the new international orthodoxy, one might say, about environmental degradation.

I do not think there was sufficient recognition that this process of integration into the international system stimulated not only the harmful destruction of old responses to drought but also the substitution of old responses for new ones. In some respects the new responses have been very efficient. We have managed by new transport technology and financing arrangements greatly to spread the burden of drought. Botswana, for example, can and has already called on the resources of the American farming community to meet its drought-induced grain shortages. A hundred years ago it could not have done so. The Sahel drought of the 1970's was characterized by remarkably few, rather then by remarkably many, human deaths. On the other hand, this spread of risk-sharing has involved people with different interests and perspectives in the decision-making process. As events in Ireland in the middle of the last century, in India in the 1940's, and in Ethiopia in 1973 have shown, the attention of these outsiders, from their objective but concerned vantage point, is critical. If it wanders, tragedy ensues.

How significant was Liz Wily's comparison between Local Government interest and Central Government interest in drought in Botswana. Whereas Central Government has interests, obligations and priorities, for the entire country, each district recognizes only too clearly the hazards put to it by drought. A less orthodox environmental approach might have been adopted at the Symposium had we pursued one of its other main themes: that of drawing on ethno-science, or to put it more simply, that of listening to what people most affected by drought have to say. I think—indeed I know—that sometimes they have quite different conceptual models of drought causation than those of us versed in western science do. Like virtue, we all approve in theory of participation by the people, provided it does not inconvenience us. But I wonder if we are psychologically ready yet for this participation. Ford gave a splendid paper on this: the relationship between ethnoscience, western science and the bridge between them—the locally experienced technical man. I do not think Professor Verstappen will mind my saying that he who wants to take local participation into account has not yet given it one quarter of the thought that has been given to the interpretation of satellite imagery. But at least he is doing something; most of us pay no more than lip service to getting the participation of the local people in our studies of drought. This, of course, excludes anthropologists, who have a vested interest in doing so. A notable exception is the Botswana Government, with its radio learning campaign on the Tribal Grazing Land Policy. This was quite a remarkable exercise which, to my knowledge, is without parallel elsewhere in Africa. The question now is whether, having listened, Government will change or adopt its policy to the results.

Our general orthodox environmental approach was shaken at times by contributions, such as that from John Cooke in his description of very different past climatic regimes, and more especially that from Dr Webster about African droughts in the last eight hundred years. If his data and analysis are correct, it is clear that some droughts cannot be ascribed to population pressure but are almost entirely due to enormous climatic fluctuations. In the face of fluctuations of this magnitude, future tragedy is inevitable. Campbell and others reminded us that the effects of drought are often confused and compounded by other misfortunes, for example, by foot-and-mouth disease. We must assume that this confusion will be normal in future droughts and that plans should be made accordingly.

Papers by Wetherell, Jones and Devitt, in particular, focused our attention on the need to determine which regions and groups are peculiarly susceptible to drought and likely to be adversely affected by it. Wetherell noted that the driest areas may not be the most

drought-prone. Devitt said that groups with the most potentially stable ecological niche may suffer most in a drought when others squeeze them out of it. Jones reminded us, as did several others in the final session, that we must not become obsessed by livestock; various other people drew attention to other vulnerable groups. There was an interesting series of exchanges Wednesday on the problem of the temporarily destitute. The distribution of drought and its ill effects has geographical, ethnic, occupational, sectorial, social class, age, and sex dimensions, all of which must be taken into account. Concentration should focus on the most important and urgent, not merely on the most interesting and noisy.

Prediction, warning and information

Let us turn to the second group of themes. Good papers came from Cooke, Tyson, Rijks, Lee, and Masaya about prediction, warning, and climatic information. Kreysler, Wily, and Ford, in particular, talked about other sorts of information. The weathermen—climatologists—were for the most part humble about their ability to make really useful and accurate predictions. Debate on this group of themes basically acquired three dimensions:

1) What is the inherent usefulness of the information we collect?
2) What efforts and resources, including continuing administrative energy and commitment, have to be given to its collection and processing?
3) What use can actually be made of the information after collection and processing, as opposed to what use could in theory be made of it?

Perhaps I could illustrate this last point by observing that my report on drought, submitted eighteen months ago, had not been read as of yesterday by the person who prepared and presented the paper for that section of government most influential in getting it commissioned in the first place. There are real problems in getting information into the hands of the people who need it.

Tyson's twenty-year cycle and Lee's demonstrations of how to build up a sophisticated, vast and complex drought watch system from extremely simple and inexpensive origins which are useful at all these stages, were probably the most striking to most participants. A splendid exchange between two colleagues from Australia reminded us that drought watch information systems controlled by farmers can become, in time, loudspeakers demanding government relief. While information and participation from local farmers is important to an efficient drought watch system, one must recognize that, as they discover thier importance to it, farmers may also learn to alter the emphasis of information given and to dictate values to suit their needs. This apparently happened both in Australia and in India.

Prevention and alleviation

The third group of themes relates to the prevention and alleviation of drought. There were some interesting discussions on exploitative strategies in semi-arid areas, which tended to illustrate aptly the principle that the esoteric and noisy crowds out the merely important. The stage was set by Brian Wilson's footnote that money is easier to store than water. Silberbauer's paper on G/wi hunter-gatherers' group formation, dissipation, and social hibernation developed the theme further. With a conjuring trick involving insects, Sandford ended up during the discussion with three mutually exclusive policies: conservative, opportunistic or tracking, and merely foolish.

Actually, we need to come down this ladder, which reaches into the upper realms of sociobiology, and remember a few rather simple facts: Botswana has a crops sector, a

hunter-gatherer sector, a mineral sector, a livestock sector, and a services sector. Some individuals straddle two, three, or even four of these. Appropriate exploitative strategies must encompass each of these areas and not just the one for livestock. Although some pastoral societies, as I pointed out yesterday, appear from their livestock activities to practise opportunistic policies, they tend to combine such livestock activities with alternative fall-back positions in other occupations in time of drought. Hitchcock and Prah produced a number of examples of socities in semi-arid areas which do practise conservative policies. Perhaps these are the societies which do not have alternative niches or possibilities to turn to when an opportunistic policy fails. In other words, people, unlike insects, do not need to pursue just one strategy at a time, but can indulge in complex combinations; too stark a delineation, which I, among others, have indulged in, is in fact unrealistic.

From the discussion of other papers emerged the feeling that conservative policies aimed at maximum stability through both good times and bad sometimes have large costs in terms of profitable opportunities *not* pursued in good years. Some examples mentioned were: not stocking up with cattle and selling off the extra to the abattoir, and not planting in marginal areas during good rainfall years when a good crop could have been harvested. Many of these opportunities could have been temporarily and safely pursued without ecological damage. Another difficulty of the conservative policy is that it has to be forced on the society's citizens at precisely the time when they have the most to lose by adopting it (i.e., at the beginning of a good cycle of rain years). Government has to say to them, "Don't do any of these things as there is going to be a drought sometime in the future." When good rains then fall, they will say, "If only I had cultivated that field this year, if only I had put more oxen on my land this year, I could have really made a killing."

In contrast, an opportunistic policy may be easier to sell to one's citizens, since retrenchment is required at precisely the time when it begins to look inevitable. But an opportunistic policy of exploitation also has its costs. There are the possibilities of ecological damage if retrenchment is left too late, of substantial underuse of some overhead capacity for much of the time, and the important consideration of greater social stratification and polarization as the rich manage to get through drought better than the poor. The more risky policy may lead to more inequality. Moreover, the human being is not physiologically adapted to hibernation, and while his productive activities may indeed have to be curbed during drought, much of his consumption—particularly if he is already at or near subsistence level—cannot be. What will be required, therefore, if an opportunistic policy is pursued, will be not only storage on an aggregate level from good years to bad (i.e., national grain stores), but also assurance that each individual gets an adequate share in hard times. There will have to be free handouts, food-for-work for the poor, or some kind of income support.

A sensible government, therefore, will clearly try to pursue those kinds of strategies which have the highest benefit for the least cost. It needs to be aware of the consequences of its choice, however. My feeling is that Botswana is dangerously short of its capacity in the livestock marketing and processing system for the livestock population policy that it is de facto pursuing.

Climatologists held out few prospects of weather manipulation for the purpose of drought prevention or alleviation in the future. There was a marked, and no doubt correct, absence of discussion on cloud-seeding and the like. Bob Hitchcock's paper, and some contribution from the floor—I think by Helga Vierich—indicated that it is only a matter of time before someone shows that traditional rainmakers *did* in fact bring rain. As yet this has not been proven.

When it came to discussion of attempts by governments or societies in general to prevent and alleviate drought, our geographical and time horizons narrowed quite abrupt-

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ly. Prah did make some reference to Asian hydraulic societies, and there was some useful discussion on the policies and practices of chiefs' controls of grain harvests in southern Africa a century or so ago. What has struck me most, however, in writing notes on these papers are the experiences from which we did *not* benefit. A paper by Cecil Woodham-Smith could have been most enlightening on how the British Government allowed two million Irish to die in the middle of the nineteenth century. One on India's experiences in famine relief and drought-proofing which they do *every* year could have taught us a great deal. Excellent research in these areas has been done. Because he is here at this meeting, it is particularly unfortunate we could not hear from Solomon Bekure on post-drought rehabilitation of the crop sector in Ethiopia and on how to run, and even more important, how *not* to run a drought-relief programme.

As it is, the papers on this group of themes come from the Botswana Government itself. Campbell described the drought of the 1960's, saying that Government's ability to cope increased with its experience. Buck, Ward, Von Kaufmann, and Alidi talked about actual and potential activities which may help to drought-proof, mainly in the livestock sector, and Wilson raised interesting issues of risk and risk reduction in water supplies. Jones talked of possible post-drought help to the crop sector. Together these papers illustrated the essential interconnections between general development programmes, drought prevention, and drought relief, and the impossibility of compartmentalizing and separating these subjects.

Comments by Grove indicate how economists' analyses of programmes tend to vary as the drought comes or recedes. His points seem especially significant—that the typical kind of analysis applied to the economics of a programme are irrelevant if that programme is largely intended to reduce drought. Several people commented on the subject.

This group of themes, and perhaps this reflected my mental fatigue at the end of three days of papers, covered rather well-worn ground, and our comparative lack of experience did not enable us to evaluate them critically. The papers by Molosi and Wily raised the critical issue of administrative structure and resources, and how to implement policy. Molosi neatly pointed out that it is a good deal easier to devise an intellectually defensible policy than to apply it in the real world of day to day crises, of regional diversity, and of shifting policies which have to be justified to other parts of government as well as to the general public. His description of the difficulties of applying Sandford's 'sell' policy reminded me of the Irish railwayman's reply to an anxious traveller: "If you want to go there, you shouldn't start from here."

It is not enough to have a policy; the administrative resources and structure must be available to carry out that policy. In a country with Botswana's tiny population and resources, proposals for rapid policy shifts and great management complexity will not be viable.

Permit a more personal comment to come in at this point. Since my last visit eighteen months ago, much has in fact been achieved. In spite of Liz Wily's and Peter Molosi's frank self-criticism of achievements, attitudes and information—for example, in the Ministry of Local Government and Lands, in local government throughout the districts, and in Water Affairs—are scarcely recognizable descendants of what I found then, when drought was not a subject they really wanted to discuss. A system of drought reporting is clearly well on the way towards establishment, which is a great step forward.

In the Ministry of Agriculture and in the Botswana Meat Commission it is clear that my arguments have as yet failed to persuade many people. I wish that their arguments could have been as public as mine; only Buck has really indulged in open debate. Despite the best will in the world within government service, new policies will not be implemented, nor new administrative structures made effective, unless political will is mobilized behind them. This political will requires both the vision and the pressure of contemporary events.

What has emerged during our discussions is that in other places and at other times the

most far-sighted attention to drought gets focused at the local and not at the national level. Liz Wily's paper has suggested that this is true of Botswana's administration even now. Maybe the political vision to move more quickly can in fact be mobilized at a grass roots level. It is not necessary to push the issues of inequality and social stratification very far to show that a better system of drought relief is inhibited by existing income inequalities. The fact is that in many countries the better-off members of society can in fact be persuaded that they have to do something about the less well-off.

But what about the lack of pressure of contemporary events? After five years of good rainfall, is it too difficult to persuade people in Botswana that drought is around the corner? Returning to Professor Tyson's paper, and in spite of John Cooke's horror of predictions, let me remind you that if someone, using Tyson's twenty-year cyclical model, had predicted the changeover from a run of years of above-average rainfall at any time in the last seventy years, he would not have been off by more than two years. Tyson's model, if applied to eastern Botswana, predicts a changeover from the present run of good years to a run of bad years between 1981 and 1983. In Botswana, the best guess is that there are less than two to three years till the next drought because the livestock population in the east is too high to survive even a moderately below-average rainfall year. The drought could come earlier. Two to three years is a very short time to get prepared. Decisions must be made, for example, on transport facilities, on abattoir capacity, on to whom and on what terms to give relief; time is needed in which to implement such decisions before the start of the drought. Government must also tell its people what it has decided to do because, as Mr. Molosi pointed out, it cannot do everything. People also have to be involved and to make their own decisions which they cannot be expected to make sensibly until and unless they know what Government plans. Whatever strategy, whatever policies are adopted must be explained to the public by Government in good time before the next drought starts.

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