COMMITTEE V
Problems of Third World Development:
The Case of Africa

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DESERTS OF AFRICA

by

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Deserts: An Inspiration and a Threat

The usual impression people have about deserts is that they are large limitless expanses of flat sand-covered lands, without any plant or animal life, any feature of civilization, in short, a lifeless land. While this is true of some large areas of rainless deserts, such as the Great Sand Sea between Egypt and Libya, it is not true for many desert regions where various landform irregularities and some rain allow the accumulation of meagre quantities of water, which in turn allow certain groupings of plant and animal life to exist, and some human activities to take place.

Deserts have always inspired Man. To the Ancient Egyptians they were the country of the dead and the source of evil. No wonder! since they threatened, as they do today, to smother life-giving crops with blowing sands and hot winds, not to mention the vipers and scorpions! Christ was tempted by the Evil One in the Wilderness (desert), and Coptic hermits took it upon themselves to challenge Satan in his homeland, and went deep into the desert to subdue him. To the present time, the desert remains to most people a fearful and a useless space, while to some others it represents a vital space for the expansion of excess population, hence we often hear political slogans such as "Invade the desert!", proffered as a solution for the burgeoning population crisis and as an encouragement for young people to make a living there.

Deserts are still a source of evil, but now it is massive and world-wide, not folkloric. They do not only "creep" into adjacent territories, but arise within the Oecumene itself, in spreading spots which eventually join with the advancing desert on the edge of the Oecumene. The evil this time is not solely from within the desert, but from within ourselves (as it has always been,

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anyway). To stop desert creep, we must understand both the desert and the causes of its growth, but we must also understand ourselves, for modifying our attitudes and actions, just as thoroughly. Know thyself ... if you want to vanquish thine enemy!

Deserts: A Resource for Humanity

In spite of humanity's mixed experience with deserts, we must emphasize that prospects of a world-wide expansion of food-producing lands will depend largely on our ability to stop desert creep, to reclaim territories that were earlier productive and have now become desert, and to utilize parts of the arid lands of the world. Nowhere is this need more urgent than in Africa, where the "Green Revolution" had utterly no effect. To achieve these objectives, governments will have to abandon certain destructive land use practices that have caused and are still causing breakdown of productive ecosystems in semi-arid and sub-humid regions.

First of all, we must admit that deserts creep not only because people in arid and semi-arid regions are over-exploiting the resources of their environments, as most authorities would now agree, but because this is the visible part of a much greater iceberg (or rather inselberg) of widespread over-exploitation and faulty exploitation of the resources of the whole world. Degradation is strikingly clear first in deserts simply because of their much greater vulnerability and greater impoverishment, so that a minor defect would easily translate into major effects, that show very strikingly in famines, mass migrations, refugee camps, food riots, etc., as we have been passively seeing for the past 15 years, and will most certainly continue to

see for many years to come. Over-exploitation and mis-exploitation of resources are everywhere rampant, but they are making their effects more dramatically felt around deserts and in other vulnerable ecosystems in particular because of the low resilience levels of arid and semi-arid ecosystems, which are easily perturbed, positively or negatively, by small changes in the system. An increase of say 100 mm in rainfall in a year, in a certain region, over the normal 100 mm/year, will cause the desert to become a green lawn, though for only one or two months. The same increase in a tropical rain forest with a normal rainfall of say 2000 mm/year, will make no appreciable difference. Similarly, the removal of say 20 shrubs for fuelwood in a desert, will involve the removal of the shrubs of an entire hectare of land, while in a tropical forest, this removal will not be perceptible. Thus what a regiment of bulldozers in the Amazonian forest will do to erase its trees, is matched in consequences by the destruction inflicted by a single axe in a desert; but there are bulldozers working in the desert too! They have already destroyed so many desert landscapes and have triggered large scale desertification everywhere they went into. Deserts therefore are said to have a limited capacity to absorb and assimilate inputs such as irrigation water, fertilizers, insecticides, energy (such as in bulldozers), etc.

The Ecology of Deserts

Sources of water in deserts and semi-deserts are: (1) rainfall, mostly in coastal and in mountainous areas, (2) underground water in oases and in wadi beds that can be extracted naturally or mechanically, (3) dew and mist, near coastal areas as in the Red Sea mountains, the coast of Mauritania, and the

Namib Desert, and (4) desalinized sea water, as in some coastal towns. Out of all these sources, rainfall is the most important spatially, while the other sources are undoubtedly extremely important locally. Rainfall absence or paucity is the main factor giving the desert its physiognomy, and its productivity characteristics. Some desert countries are traversed by allochthonous rivers (the Nile, the Niger) which bring life and allow the flourishing of civilization along their borders, resembling mega-oases. It is noteworthy that civilization, based on agriculture and urbanization, started precisely where rivers traverse deserts, not savanna or forests! This is perhaps because of the great contrast created by such a situation, forcing people to concentrate on river banks and to completely rely on their resources, avoiding any venturing away from them, to "a land that none passes through, where no man dwells" (Jeremiah 2:6).

Desert rainfall, if it occurs, is both erratic and unpredictable, in time as well as in space. Variability of rainfall is higher the lower is the rainfall. There are long gaps between one rain shower and the next, occasionally filled in by hot dry winds, drying whatever seeds have germinated. Rain in deserts is caused by local convectional cells with a diameter of no more than 10 kms, which explains why rain is spotty (Evenari 1986).

Other factors giving local variations in the moisture regime are relative humidity (which may vary from 10 to 90%, on the same day), temperature (which also shows great fluctuations, 40°C in some cases, narrowing to 20°C in coastal areas), solar radiation (very intense), evaporation and evapotranspiration (high rates), strong and hot sand-laden winds, type of soil deposit (usually skeletal coarse sands, gravels, or denuded rock, and rarely clay pans, with very low organic matter). All these factors determine together the soil

moisture availability to the growing plants, and consequently to the animal and human life these plants support.

Since deserts are determined by lack of free surface water, and cover a variety of landscapes, they encompass a wide range of environmental complexes. We can distinguish: (a) rainless deserts where rainfall is not a recurring event, roughly coinciding with "hyper-arid" regions, and represented by the Central Sahara Desert of Africa, (b) run-off desert where annual rainfall is variable and does not exceed 100 mm/yr, coinciding with "arid" regions (here rugged topography may help accumulation of run-off water in wadis and collection basins, permitting some perennial plant life), (c) rainfall desert where rainfall is below requirement for sustained crop production (100-200 mm/yr), and where perennial plant life is not confined to run-off collection basins, but diffuse over the landscape, roughly coinciding with "semi-arid" regions, which may merge with regions of higher rainfall, up to 400-500 mm/yr, according to topography and temperature. A fourth type of desert, added recently by ecologists, is man-made deserts, parts of the semi-arid steppe country (200-400 mm/yr rainfall) that have lost their characteristic plant cover and clay particles, and have had their soil and vegetation resembling those of deserts, or have been completely denuded of vegetation, and have had their soil eroded. These have thus been transformed to deserts due to over-exploitation by man, i.e., have been desertified (Kassas and Ghabbour 1976).

The total arid areas of Africa constitute 36% of the surface area of the Continent, while semi-arid areas constitute 23% of its surface area, adding up together to 59%. The total area exposed to desertification is 35%. Table 1 gives a breakdown of the arid and semi-arid areas for each country, and

Table 2 gives a country by country breakdown of areas exposed to desertification.

The Deserts of Africa

Africa has three main deserts: the Sahara Desert, the African Horn Desert, and the Namib Desert. We may also add the Malagasy Desert. The Sahara Desert, being so large and diverse, can be tackled as consisting of four regions: the coastal Mediterranean Desert between Egypt and southern Tunisia, the Maghreb, the Sahel, and the hot desert of Egypt and the Sudan. The African Horn Desert extends from Eritrea to northern Tanzania, with its bulk in Somalia. The Namib Desert obviously occupies "Southwest Africa", with extensions into the Kalahari and the Karoo.

According to Evenari (1986), hot deserts exist roughly in the latitude belt 20-40° north and south of the Equator. These are the belts of the subtropical anticyclones which create high pressure systems. Some of the major terrestrial arid areas in the western parts of continents are correlated with much larger arid regions located over the oceans to their west, and are thus extensions thereof into the land. Other factors modify this picture so that we do not have exactly rectangular blocks on maps, representing the deserts. These modifying factors are: cyclones, monsoons, jet streams, convective storms, topography (orographic rain and rain shadows), continentality, and sea currents.

The reason for the existence of the great Sahara Desert is the shifting balance between two air masses, one hot and dry, the other cool and humid, in addition to the excessive continentality of this northern part of Africa.

In summer, the permanent Azores high pressure system prevents cyclonic depressions from entering this area of North Africa. In winter, western jet streams blowing over the Mediterranean cause successive cyclonic depressions thus bringing the little rain they do. High albedo over the Sahara leads to air sinking everywhere. Removal of vegetation increases albedo and this is thought to exacerbate desertification. In southern Africa and Madagascar, mountain barriers add to the action of sub-tropical anti-cyclones, but are counter-balanced, though to a small extent, by fog formation along the coast, thanks to cold sea currents. Table 3 shows a summary of the characteristics and causes of these African deserts.

The Afro-Mediterranean Coastal Desert. If we move on to details of the characteristics of African deserts, beginning with the part of the northern Sahara that is adjacent to the Mediterranean coast, we find that most of the northern Sahara is actually part of the "mediterranean" region both climatically and biologically, with winter rains and with floristic and faunistic affinities with northern Mediterranean countries. These affinities are most prominent in the narrow band of the Afro-Mediterranean Coastal Desert. They are weaker south of that coast, and reach their ultimate limits in the area of Khartoum, the Tibesti, the Air, and the Hoggar Mountains. The southern Sahara, south of this line of overlap, is climatically and biologically part of the Ethiopian (i.e., Afro-tropical) realm, with summer rains and floristic and faunistic affinities related to the Sahelian, Sudanian, and Guinean zones of tropical Africa. Therefore, speaking of two Africas, north and south of the Tropic of Cancer, is justifiable only on these grounds.

Rainfall in the northern Sahara may reach up to 360 mm/yr (Tripoli). A record of 477 mm/yr at El-Marj (Cyrenaica) tends to place this site outside the Sahara proper. Rains occur from Sep.-Oct. till Apr.-May, with maxima in autumn (usually in the lowlands), in spring (usually in the highlands), and in winter (in Egypt and Libya). In the Central Saharan Belt, the few mms of rain may be due to a succession of both Mediterranean and tropical clouds, and usually follow sandy thunderstorms in autumn and spring. The 100 mm isohyet almost touches the coasts of Egypt and Libya, crosses southern Tunisia, runs south of the Atlas Mountains, and meets the Atlantic coast south of Morocco. South of this isohyet, human settlements are impossible, except in oases, or near mountains. Human settlements north of this isohyet rely almost exclusively on sheep and goat husbandry, in addition to some limited barley cultivation. The flora here is exceptionally rich with no less than 1200 species in each country of North Africa, for that belt alone. Human occupation of this belt took place in four phases: (1) the Tehenu cattle breeders till the late New Kingdom of Egypt, (2) Phoenician and Greek settlements before Alexander the Great, (3) Ptolemaic and Roman rule, followed by Byzantine rule, and (4) Arab rule. With every wave of civilization penetrating into the desert, from the early Greeks to the Byzantines, woody plant cover was removed to be replaced by farms for cereals and tree crops (especially olive, vine and fig). The belt completely reverted to grazing in the 10th century A.D. with the advent of the warring Beni Hilal and Beni Suleim Tribes, who destroyed all artefacts of agriculture, "They shall eat up your vines and your fig trees" (Jeremiah 5:17). Soil exhaustion during the agricultural period, and its erosion during the subsequent pastoral period, jeopardize

present day attempts at rehabilitating the lands of this belt, extending from Alexandria to Sfax (Le Houerou 1986).

The Sahel Desert. The Sahel Desert, between Senegal and Chad, is an eco-climatic zone constituting a band 200 to 500 km wide. The Sahelian situation is a rainfall gradient between the hyper-arid north of, say the southern Saharan 50 mm isohyet, and the tropical savanna (Monod 1986). It depends essentially on the shifting balance between two air masses: one dry, initially cool and then warmed (the harmattan), and the other humid and cooler, of Atlantic origin (the SW "monsoon", thought of as a "continental trade wind"). In summer, a tongue of oceanic air displaces the trade wind towards the north, to meet the northerly trade winds, resulting in rain-storm. The amount of rainfall will depend on when and where this encounter will take place. The isohyet limits of the Sahelian belt are 100 to 400 mm, but because of the higher temperature of the rainy season, it may extend to the 600 mm isohyet. These isohyets shift considerably northwards and southwards from one year to the other, for about 100 to 350 km in the same year, depending on local topography and coordinates. This frequent shifting was even more marked during the past millenia, and could extend for over 600 km. The plant cover increases as one proceeds southwards, with increasing number and height of woody plants and increasing density and height of herbaceous cover. One may distinguish a "steppe", followed by a summer "prairie" of tufted grasses higher than in the previous zone (1.5-2.0 m instead of an average 80 cm). Under such conditions, the Sahel is the domain par excellence of pastoral nomadism, with large livestock, moving limited distances, and clearly different from the more southerly savanna zone which can be cultivated by sedentary farmers (Monod

1986).

The hot deserts of Egypt and the Sudan. Four rainfall belts can be distinguished in these deserts: (1) the Mediterranean coastal belt, with 100-150 mm/yr rainfall, caused by the extension of the Atlantic westerlies, (2) The accentuated arid province of middle Egypt with 0-100 mm rainfall, (3) The almost rainless hyper-arid belt of the Nubian Desert south of Egypt and in the northern Sudan, where Mediterranean and tropical rainfall regimes may merge or alternate, and (4) The central Sudan summer rainfall belt, 0-600 rainfall. The Red Sea coastal mountains allow the effective overlap of belts (2) and (4) in the Gebel Elba and Erkoweit Mountains, and the Mediterranean regime penetrates to Port Sudan (along with Mediterranean fauna), investing the Coastal Red Sea plain. The inter-tropical convergence zone (ITCZ) also penetrates northwards along this mountain chain. The Ethiopian Plateau acts as a barrier which intercepts the SW winds and prevents them bringing their summer rainfall to the coastal land. Other local modifications are produced by Gebel Marra and the Nuba Mountains, which intercept SW winds. Rainfall and temperature allow the recognition of fourteen climatic provinces, apart from the Coastal Mediterranean (Ayyad and Ghabbour 1986), which harbour 19 vegetation types associated with the climatic-geomorphologic units present (coastal plains, wadis, plateaus, mountains, gravel deserts, etc.). The Gebel Marra massif acts as a watershed between the Nile and Lake Chad waters, and with the Darfur Highlands, separate the Sahel proper from the Sudan arid zones. The Cameroon Mountain Chain acts as a formidable rain barrier, creating a deep penetration of desert conditions in Central Africa, as does also the Lakes Plateau in Uganda.

The deserts of the Horn of Africa. These deserts deserve special attention because of the droughts and famines that have inflicted heavy losses of life in Ethiopia, Sudan, and Somalia, from the early 1970's. The terrain of Somalia consists mainly of dry savanna plains. In the north, narrow arid coastal plains stretch at the foot of an escarpment which rises to 2000 m. In the south, the plain is dissected by shallow valleys and seasonal rivers, with precious watering holes to which migrating herds return in the dry season. The climate is hot, semi-arid to arid, with some amelioration at the coast and in the highlands. Rainfall is bimodal and influenced by the prevailing SW (Apr.-May) and NE (Oct.-Nov.) monsoons. Rainfall is 50-200 mm/yr over the greater part of the country, reaching 500 mm in the south. Distribution patterns of rainfall vary greatly, with serious droughts occurring every 5-7 years. Both high temperatures and torrential rainfall contribute to the aridity of the land, especially that evaporation rates are high (UNSO 1979 a).

By contrast, the high altitudes of Ethiopia provide for a considerable variety of temperatures, of which three main regimes can be distinguished: the temperate plateau, the hot lowlands, and the intermediate frost-free lands. Highlands are well watered, receiving at least 1000 mm/yr, with the exception of the Eritrean and Tigrean Plateaus. The lowlands generally receive less than 500 mm/yr, with the exception of the Baro and Akobo River plains in the SW, which lie in the path of autumn rain-bearing winds. The majority of the rain falls from June to August. Climatic events in recent years have demonstrated the extreme vulnerability of Ethiopia to drought conditions, negating what was thought of before. High evapotranspiration rates and unevenly distributed rainfall deplete the soil moisture to levels unsuitable for crop

production in the low-lying pastoral areas and along the eastern escarpment. Recent development of cultivation has accentuated this problem (UNSO 1979 b).

While desertification of pasture lands in the Sahel and the African Horn have resulted in refugee camps near the big cities, where docile women and children await the distribution of food rations, the situation in northern Kenya is quite different. Tribes from Somalia and from northern Kenya move south with force of modern arms and engage in daring cattle raids, forcing the weaker tribes to concentrate on the safer, but poorer pasture (Lamb 1982).

The Namib Desert. The Namib Desert is the result of air currents blowing from the eastern to the western coast, losing their moisture on the eastern side of the Drakensberge Mountains, thus rendering the Namib a rainless desert, with a rainfall gradient of 400 mm/yr at its eastern edge, decreasing to less than 100, or no rain at all, at its western edge. The Atlantic coast enjoys, however, locally important fog conditions brought about by the cold Benguele Current. Only the central Namib is ecologically known. The "outer" Namib; nearer to the Atlantic coast, is an extreme rainless desert, but with high relative humidity. The cold air above the Benguele Current blocks the warm air currents from the east. Temperature variations are quite small. Most rains fall in summer, thus losing much of their effectiveness. In the southern Namib, rain falls in winter, associated with moving cyclones. The vegetation of the Namib is closely linked to the dominant geomorphological features. The following biotopes may be distinguished: (I) in the "Outer" Namib"; 1, the peneplains, 2, monadnocks and rocky ridges, 3, rivulets and smaller riviere, 4, the oases of the large "alien" riviere, 5, vegetation-less dunes with litter accumulations; (II) in the "Inner" Namib, 6, large grasslands,

7, the Welwitschia biotope of the transition zone, 8, monadnocks and riviere, 9, the "pre-Namib" along the escarpment. Lying south of the high Namib Plateau which slants towards the Cape, forming a number of steps, are the Great and Little Karoo, in basins stretching between these steps. The Kalahari is in the north, receiving 400-600 mm/yr rainfall, draining off in the Kalahari sands, to such a dgree that there are only a few water holes supplying drinking water, so that it is called a "thirstland" (Walter 1986), not to be compared with the "Thirst Belt" of the Sudan.

The Malagasy Desert. This desert is somewhat unusual because it receives 300-600 mm/yr rainfall, yet it shows aridity symptoms because this rain falls in a very short period, leaving the rest of the year dry. Moreover, this rain is extremely irregular, so that some areas may remain rainless during the "rainy" season, thus experiencing 12-18 months of drought. Insolation is also very intense during the dry period. Dew and fog occur, however, at the coast. The plant cover is a bush-forest, green only after rains. If intact, it is made up of a tree layer 10-15 m high, and a dense bush layer up to 3 m high. Thorn-bushes and succulents are predominant. Annuals appear only in rainy years. Grasses are generally lacking and occur mainly after fires. In spite of the fairly recent date of human colonization of Madagascar (3rd-8th centuries A. D.), human impact on the vegetation is most destructive. A secondary vegetation created by pastoralism (the much cherished zebu cattle), and the associated annual burning of vegetation, cannot stop soil erosion and degradation, and large-scale desertification (Rauh 1986).

Why Are Deserts Growing?

The expansion of deserts is not confined to lands adjacent to them, since any lowering of biological productivity, by definition, is a form of desertification, which occurs wherever extraction of biological resources is at a rate higher than that of intrinsic regenerative ability, or is handicapped by newly established unfavourable conditions. At present, satellite photos of Africa show large patches devoid of vegetation within the Congo (Zaire) Basin as well as other formerly densely vegetated areas, in addition to the expansion of desert areas beyond their geographical limits explained above. Desertfication has therefore been defined as "the diminution or destruction of the biological potential of the lands, and can lead ultimately to desert-like conditions" (Karrar 1985).

There has been for too long a polemic between ecologists and the students of some other disciplines on whether desertification should be regarded as a man-made disaster, or a natural phenomenon. The effort spent in this argumentation for more than a decade was not in vain. It helped to clarify the issues and to convince both laymen and decision-makers of the facts put forward by ecologists, and of their true interpretation. Blaming climatic change, alone, as some well-intentioned scientists wanted us to believe, was an approach advantageous for the lazy and the indifferent, reluctant to take appropriate action and investing in long-term solutions, involving radical changes in social attitudes and institutional structures. It is useful to refer here to the clear demonstration by Monod (1986) of the situation in the Sahel. While drought and wet cycles are quite common in the Sahel and have a considerable impact on plant growth, they do not cause

shifting of vegetation belts northwards or sand dune belts southwards. Such shifting occurred only as a consequence of large scale climatic change, the Pluvial and the Inter-Pluvial Periods, on a geological time scale, in a period covering several thousands of years. This is the natural expansion or regression of deserts. For this process to take place in just a few years will require the combined effect of a succession of drought years, in combination with a long history of ill-advised land use practices by human society. The combination of these two mutually interacting factors was sufficient to telescope a geological process into a socio-historical news item for the mass media, within just a decade. For all intents and purposes, it is now shown beyond any doubt that a decade or two of drought is not in itself sufficient to cause the shifting of vegetation belts (in the Sahel as well as in the Sudan), for the distances observed during the same period. The shifting was noted in the 1930's and measured in the 1950's and 1960's, and attributed to human pressures. The drought came to make it a disaster.

According to Dregne (1983) drought acts by placing additional stress on the biological resources of the land. If resource management had been good, that is ecologically sound, little, if any, permanent damage is done by droughts. However, if it is unwise, a drought accentuates the adverse impact of this kind of management (or mis-management) and accelerates land degradation. This is what has occurred widely in the Sahel and elsewhere. All of the usual forms of desertification are present in Africa. Overgrazing has reduced range productivity virtually everywhere outside the tsetse fly regions (to the extent that some authors consider this dreaded fly a blessing for the conservation of reserve rangelands in Africa). Wind and water

erosion have devastated landscapes in the cultivated regions and in much of the rangelands. Shortened fallow periods, under population and economic pressures, have led to soil impoverishment in the shifting cultivation lands. Salinization and water-logging of irrigated land are substantially reducing agricultural production in the Nile Valley, North Africa, and elsewhere. Mining is leaving large potholes in the ground, and sand accumulations that have become sources of sand for winds blowing over cities and fields. The environmental degradation continues and is even accelerating rather than subsiding (Table 4).

The Magnitude of Desertification in Africa

About 25% of the arid regions of Africa is severely desertified, with most of that area used as grazing land and rain-fed cropping land south of the Sahara. The other main desertified areas in this category are mountain slopes and plains of North Africa. Salinity affects about 30% and water-logging about 90% of irrigated land in Egypt (a small but highly productive area, needless to say). Several hundred sq. kms. of irrigated land in Algeria and Tunisia (on recent reservoir schemes), suffer from these two defects. Wind erosion is dominant in the drier regions, while water erosion is on the wetter sloping lands (e.g., Burundi), and both types of soil erosion alternate in semi-arid and sub-humid regions that experience flash floods in the wet season and long dry periods. It seems probable that losses in soi soil fertility, alone, have reduced crop yields in dryland farming regions by 25-50%, in the severely desertified areas. In many areas south of the Sahara, forage production may have declined by 25%. Animal productivity

may well have declined by at least 50% nearly wherever natural pasture is used (Dregne 1983). Table 5 shows the extent of moderately and desertified areas in Africa. Table 6 gives an estimate of the numbers of affected people in these areas. It is estimated that about 34% of Africa's rural population is directly affected by moderate and severe desertification. To these must be added townspeople who have difficulty in obtaining the products of the land, or who were themselves rural people and emigrated to the towns.

Table 6 shows clearly that rain-fall agriculture is the land use type whose desertification is affecting a larger number of people. This is not surprising since this allows more people to settle, compared with grazing lands, but it is also where factors of desertification are more intense. Rain-fall agriculture, as it is practised in Africa, involves removal of vegetation, fire, ploughing (often deep), erosion susceptibility, etc., which act together more than elsewhere, to cause severe desertification. Calculating the ratio of affected people to area of desertified land, using data in Table 6, one obtains the following rates:

For each sq. km. of moderately and severely affected land;

6.4 people are affected in rangelands,

96.9 people are affected in rain-fall croplands,

263.2 people are affected in irrigated lands.

It is thus evident that although desertification touches much smaller irrigated areas than it does either grazingland or rain-fall cropland areas, its impact is much more serious to irrigated land populations, density-wise. This is due to the higher densities of rural human settlements in irrigated lands. Dregne (1983) summarizes the factors that have increased land

degradation and the vulnerability of the African arid regions to desrtification, by grouping them in three categories: (1) increased human and animal population, (2) improved health services, and (3) injudicious use of technology and natural resources.

Due to the increased sedentarization of the population, pressures on cultivated land leads to extension of cropping into the more precarious dry regions, forcing nomads to even drier or unsuitable regions. Crop harvests become less reliable and more variable, usually towards the negative end, as desertification proceeds. As pastoralists are being pushed to unfavourble grazing lands, their own numbers, and that of their livestock, are increasing due to provision of undisputably needed medical and veterinary care, and the lack (and sometimes the greater availability) of marketing systems, that would cause (in both cases), overstocking. The result is not difficult to envisage: overgrazing, fuelwood depletion, erosion, and accelerated desertification. UNEP (1985) provided a detailed survey of the present situation of desertification in 30 African countries. It is gratifying to note that many African countries have become aware of the causes and the accelerative factors, and are trying to apply remedies, if that report should be something to go by.

It is difficult for many governments to accept the notion that development projects, laid down and implemented without due consideration for environmental factors, contribute to desertification. Some extremely "humanitarian" projects, no less than the drilling of wells to tap underground water resources in arid areas, aggravated desertification. The 700 wells drilled in Central Sudan in the mid-1960's, massively contributed to

the conversion of that region into the "Thirst Belt" of the late 1960's (Ghabbour 1972), which was the first phase of desertification that spread allover Africa in the 1970's and 1980's. This was a man-made thirstland, while that of the Kalahari referred to above is nature-made.

As a summing-up, we may note that desertification is most acute where rainfall is neither too small to support economic human activities (less than 100 mm/yr rainfall), nor too abundant to support these activities, if based on biological productivity, on a year-round basis (above 600-900 mm/yr). This critical band of isohyets is best suited for nomadic grazing. However, it is more and more abused at its wetter end by encroaching agriculture (both rain-fed and irrigated), due to pressures exerted by townspeople for the satisfaction of their food needs (staple crops, usually by rainfall agriculture), or by external markets for obtaining foreign currency (cash crops, usually by irrigated agriculture). Consequently, pastoralism becomes restricted to the drier end of the band (100-400 mm/yr), which incidentally and unfortunately has received less than expected rainfall in the past two decades, much less indeed.

A Political Will Needed

In the Sahel, as population density increased, fallow periods were shortened or even eliminated, and village perimeters became denuded of vegetation and of good soil beyond repair. Apparently, neither legislation nor public education (the first failed in Niger, the second in Tunisia), would stop the spreading of cereal farming into lower rainfall areas, nor would stop fuelwood cutting for that matter. The consensus is that any

attempt to combat desertification is doomed to failure unless it is integrated into an overall programme of socio-economic development (Dregne 1983).

It is therefore evident that desertification is not exclusively a problem of arid and semi-arid regions, but rather the first symptom of a more generalized malaise affecting the entire planet, in peril of over-exploitation and of excessive mis-management of resources, and I daresay, of mis-management of society itself. The urban population is swelling in every city on earth, more so in Africa, on the grossly false assumption that food needs will be automatically provided by the (increasingly frustrated) rural population, without whichever problem.

This is of course an impossible feat under Africa's present conditions. What is actually happening is that food needs of the majority of Africa's urban population and a sizable proportion of its rural population are provided by a handful of rich temperate zone countries. It would be obviously naive to expect this situation to remain as it is for the next two decades. A deficit in wheat production has already become apparent in the U.S.A. Whether this is ephemeral or a sign of things to come remains to be seen. The whole world is waiting to know the answer to this most of all vital riddles. What should poor Africa do while its urban population is increasing beyond control and its rural population is leaving the land for good? Neglect and mis-government of rural populations should come to an end, and their desertified lands must be rehabilitated, and their natural resources conserved and developed. Unless this neglect of rural populations is stopped rural poverty and frustration will increase, and desertification will be exacerbated. It is a self-feeding process, with no way out for the affected

rural population except to leave it all and seek food aid and petty jobs in the big cities, waiting for a change, any change! Kassas (1983) explained that changes in political will, in socio-political systems, and in socio-cultural attitudes are vitally needed, if we want to remove obstacles from the way of combating desertification (as well as other environmental issues confronting us). At present, and for a long time in the foreseeable future, there does not seem any grounds to reasonably expect such changes to be effected. The Plan of Action to Combat Desertification (PACD), formulated by UNEP as a result of long years of consultations with governments and experts, did not succeed in mustering the necessary funds from those same governments which endorsed it (with a few notable exceptions, of course). By contrast, public action was encouragingly much more sympathetic. The funds raised by UNEP for PACD were a very small fraction of what was raised by BandAid, dependent on the efforts of individuals of good will and a responsive public.

Useful Plants and Animals

Literature abounds with information on useful plants and animals that can profitably be introduced into arid and semi-arid lands to raise their productivity and to make them economically viable ecosystems, together with the technologies of their husbandry, utilization, and processing. There is certainly no dearth of information about that aspect of the problem, and it would neither be possible nor interesting to recapitulate that literature here. A few main references may be mentioned, NAS (1974), Ayensu and Marton-Lefevre (1981), Ayensu (1983), among others. The problem now is

not which plants and animals to introduce, for what purposes, and how, but rather how to integrate this knowledge with the existing social, cultural and ecological sysyems. One point of view is that national programmes to combat desrtification must be designed "in harmony" with these "existing" three systems, as stated by the decision endorsed by the UNEP Governing Council in 1984 (Kassas 1985). Another, contradictory, point of view, is to harness local societies into accepting change, whether social, cultural, or ecological, by such measures as sedentarization of nomads, introduction of novel economic activities (e.g., agriculture, mining), or even settlement of alien populations, in numbers overwhelming those of the native populations. Past experiences have proven that such measures, in most cases, are costly, slow, and counter-productive in the long run. A great many number of such projects have provoked desertification rather than stopped it. The attempt to plan projects "in harmony" with existing systems is also impractical in reality, because such existing systems are themselves in conflict with one another, when we consider local versus central systems, rural versus urban, pastoral versus agrarian systems, etc. No one has yet come out with a formula for harmonizing these systems and the interests involved. This is something that rests with the balance of power in society and the kind of its leadership. We do not need to search for a technological formula, because the technological means are known and the scientific knowledge is available to solve the problems of desertification. The hindrance comes from a lack of political will, the kind of social set-ups we have. This is the area where the efforts of the scientific community (the doctors of science as ICUS puts it), should be directed.

In this connection, it is pertinent to point out that two major international documents were declared in 1980, the World Conservation Strategy, and the Lagos Plan of Action. These two contain the principles and guidelines for the rational management of biological and mineral resources, but these have not yet found their way into national development plans or land use policies. We cannot assume that there is lack of awareness or of adequate informing about them, because the first was handed personally to Heads of State, while the second was signed personally by African Heads of State. The most plausible explanation for the weak impact of these two documents is the conflict of interests and of short-term versus long-term objectives, or the economic view of profit maximization in the shortest time possible (quick turn-over), against the ecological view of maximum sustainable yield (maximizing time of utilization, and accepting lower but sustainable yields). The resolution of this conflict is no more needed than in the fragile arid and semi-arid African ecosystems. Here is where the Unity of the Sciences will be most useful and serviceable to humanity. It will be a difficult, perhaps impossible, task, but it is necessary to try, especially if we realize that almost no improvement will be perceptible in the coming 15 years as regards desertification trends in Africa.

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Table 1 - Arid and Semi-arid Areas of Africa, as % of Country, after Paylore and Greenwell (1979).

Country	Arid Zone	Semi-arid Zone	Country	Arid Zone	Semi-arid Zone
Algeria	85	10	Mali	60	35
Angola	10	15	Mauritania	100	0
Benin	0	20	Morocco	35	5
Botswana	25	60	Mozambique	0	15
Burkina Faso	0	90	Namibia	50	40
Cameroon	0	10	Niger	70	30
Cape Verde	30	50	Nigeria	0	20
Cen. Afr. Rep.	0	5	Rep. S. Afr.	35	25
Chad	50	35	Senegal	25	70
Djibouti	100	0	Somalia	60	40
Egypt	100	0	Sudan	50	40
Ethiopia	20	50	Tanzania	0	25
Ghana	0	10	Togo	0	25
Kenya	20	55	Tunisia	75	15
Lesotho	0	5	Zambia	0	5
Libya	60	30	Zimbabwe	0	5
Malagasy Rep.	8	12			

Total Area of Africa: 30,320,996 sq. km.

Arid Area %: 36 - Semi-arid Area % : 23.

Table 2 - Areas Affected by Desertification in African Countries, as % of Land Use Type, after Dregne (1983).

Country	(1)	(2)	(3)	Country	(1)	(2)	(3)
Algeria	22	89	92	Mauritania	1	67	98
Botswana	10	67	20	Morocco	20	80	97
Burkina Faso	0	93	97	Namibia	1	50	25
Cameroon	15	88	60	Niger	5	75	97
Cape Verde	3	67	-	Nigeria	5	95	93
Chad	5	94	99	Rep. S. Afr.	5	65	84
Djibouti	-	-	100	Senegal	1	83	93
Egypt	26	20	97	Somalia	9	95	90
Ethiopia	17	89	90	Sudan	16	74	98
Gambia	17	50	-	Tanzania	10	79	50
Kenya	6	90	95	Tunisia	39	70	89
Libya	8	80	95	Uganda	5	-	93
Malagasy Rep.	7	75	96	Zimbabwe	-	50	53
Mali	10	75	98				

(1) = Irrigated Cropland, (2) = Rainfed Cropland, (3) = Grazingland.

Total Irrigated Cropland in Africa, ... 77,560 sq. km., Area Affected 18%

Total Rainfed Cropland in Africa, ... 480,480 sq. km., Area Affected 82%

Total Grazingland in Africa, ... 11,822,120 sq. km., Area Affected 87%

Table 3 - Summary of the Environmental Characteristics of the Deserts of Africa and Factors Contributing to Their Existence, after Shmida (1986).

Region	Lat. (°)	Alt. (m)	Rainfall	Fog	Aridity	Landforms	Vegetation	Causes
Sahara	22–32 N	0–800	Winter & Sporadic	–	Hyper-arid to Semi-arid	Diverse with Huge Sand Dunes	Dwarf Shrubs & Short Grasses	Subtropical Anti-cyclones & Continentality
Sahel	13–22 N	0–1300	Summer, Bimodal & Sporadic	–	Arid to Semi-arid	Diverse Plains, Plateau	Thorny Savanna	Subtropical Anti-cyclones & Continentality
Somali	3–13 N	0–900	Summer, Bimodal & Sporadic	–	Hyper-arid to Semi-arid	Coastal Sands	Thorny Savanna & Desert Dwarf Shrubs	Subtropical Anti-cyclones & Continentality
Namib	18–30 S	0–1100	Winter & Sporadic	+	Hyper-arid to Semi-arid	Coastal Sands & Diverse	Succulent Desert Dwarf Shrubs	Subtropical Anti-cyclones & Continentality

Table 4 - Regional Trends of Desertification within Land Use Types in Africa, after Karrar (1984).

Land Use Type	Sudano-Sahelian Region (SSR)	Africa south of (SSR)	Mediterranean Africa
Rangelands	Accelerating and Continuing	Accelerating	Continuing
Rainfed Croplands	Accelerating	Accelerating	Continuing
Irrigated Croplands	Accelerating and Continuing	Continuing	Continuing
Forest and Woodlands	Accelerating	Accelerating	Continuing
Groundwater Reserves	Continuing	Unchanged	Continuing

Table 5 - Extent of Lands moderately and severely Desertified in Africa, in Millions of Hectares, after Mabbutt (1984).

Region	Rangeland		Rainfed Cropland		Irrigated Cropland	
	Area	%	Area	%	Area	%
Sudano-Sahelian Africa (SSR)	342	90	72	80	0.8	30
Africa south of (SSR)	200	80	42	80	0.6	30
Mediterranean Africa	68	85	15	75	0.5	40
Total	610		129		1.9	

The Total Moderately and Severely Desertified Areas of Africa Are thus: 7,410,000 sq. km., Constituting 59% of the Total Affected Area.

Table 6 - Rural Population Affected by Moderate and Severe Desertification in Africa, in Million Inhabitants, after Mabbutt (1984).

Region	Rangelands	Rainfed Croplands	Irrigated Croplands
Sudano-Sahelian Africa (SSR)	20.5	56	2
Africa South of (SSR)	12.5	52	1.5
Mediterranean Africa	6	17	1.5
Total	39	125	5