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**The Problem of Desertification
in The Republic of The Sudan
With Special Reference to
Northern Darfur Province**

BY DR. FOUAD N. IBRAHIM

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THE PROBLEM OF DESERTIFICATION

IN THE REPUBLIC OF THE SUDAN

WITH SPECIAL REFERENCE TO NORTHERN DARFUR

PROVINCE

BY

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ABSTRACT

In the Republic of the Sudan a some of 500000 km² (which equals double the area of Great Britain) is directly affected by desertification. More than half of the Sudanese population lives within this zone which is and always has been the most active economic region with the largest towns of the country.

Although desertification in the Sudan cannot be explained sheerly by the word drought, the drought period which has been going on for 11 years in the Sahelian zone of the Sudan has greatly enhanced the processes of desertification. The increase of population by 40% in the same span of time led to exhausting the limited natural potential of the semi-arid zone of the Sudan. Thus cultivation has advanced by about 200 km north of the agronomic dry boundary, i.e., the climatically controlled border of cultivation. Although this climatically conditioned boundary of millet cultivation lies at about the 500 mm - isohyet the areas of dense millet cultivation extend as far as the 250 mm-isohyet. Besides, millet is sporadically grown far deep into the semi-desert. It is a confirmed fact that the transgression of millet cultivation over the agronomic dry boundary is the main cause of desertifications in the Sudan. Table 1 displays the decrease of millet crop per hectare by about 50% between 1960 and 1975. That this decrease is not necessarily correlative with a decrease of precipitation can be easily shown by comparing the years 1963 and 1974 which have similar precipitation figures but very different yields per hectare (630 kg and 370 kg respectively).

In the Sudan, as in the whole Sahelian zone, the high variability of rainfall, typical of the semiarid zone, affects a high vulnerability of the ecological systems to the danger of desertification if the land is excessively used by man. This excessive utilization of soil takes the form of overgrazing, overcultivation and deforestation. The uncontrolled cutting of trees takes unimaginative dimensions. It has been estimated that 548 million acacias are being cut down or uprooted yearly as fire-wood for cooking purposes only. The tree stock of the savannah is especially endangered by the expansion of cultivation which is usually preceded by a complete clearing of the vegetation of the savannah.

Compared with the damages caused by the expansion of rainfed cultivation in areas of poor precipitation the damages caused by nomadic pastoralism and partial overgrazing are relatively small.

Through their high degree of mobility nomads have a wide radius of action and therefore their exploitation of soil is much less intensive than the sedentary cultivators. Overgrazing damages are mostly limited to water holes and main cattle routes. Nevertheless, the number of animals has increased by fourfold in the last few decades (Fig. 1) alongside a simultaneous degradation of the grazing possibilities.

There exists a close connection between overgrazing overcultivation, deforestation and the problems of water supply for man and animal. In a zone of 8 - 10 arid months a year water supply takes usually place by means of boreholes. Owing to the fact that the geological structure does not always allow the formation of aquifers, land use is concentrated in areas where they exist.

In the last 20 years, that is to say nearly since achieving independence, a large number of boreholes has been dug. The seasonal grazing lands have thus been turned into permanent pastures. This led to an irreversible destruction of palatable grasses at an early stage of growth. Generally, the balance between water supply and soil productivity has been disturbed through the erection of water yards. The surrounding areas have become so densely over-populated both by humans and animals that the economic space has been narrowed far under the existence minimum. As a result of this, constant conflicts between the sedentary land cultivators and the nomadic cattle - breeders occur all over the zone. Through the sedentarisation of the nomads one hopes to attain an easier control. One should not, however, forget that nomadism is the way of living which is most suited to the natural conditions prevailing in the Sahelian zone.

Measures To Combat Desertification In The Sudan

For more than 30 years the Sudan has recognized the problem of desertification and tried to fight its causes. The most recent programme to combat desertification, which is still at the stage of planning, is the "Sudan's Desert Encroachment and Rehabilitation Programme". The state hopes for financial and technical help from friendly countries. Another project aims at establishing a "College Of Veterinary, Natural Resources and Arid Zones Studies " in El Fasher, the capital of Northern Darfur Province. This college is being sponsored by the United Nations University.

Other measures to stop the further encroachment of the desert, could include : -

- a) Improving the central places on the margin of the Sahara to enhance and control animal husbandary in the Northern Sahelian Zone.
- b) Combined Millet / Acacia - senegal - cultivation.
- c) Keeping fire - wood plantations in the vicinity of settlements.
- d) Rotation of pastures by rotating the use of Water Pumping Stations.
- e) Improving the infrastructure.
- f) Establishing labour intensive factories on the basis of agriculture and animal wealth.
- g) Organizing an enlightenment campaign on the causes and consequences of desertification.

I N T R O D U C T I O N

As the drought disaster of 1970 - 1973 in the Sahelian zone occupied the headlines of the World press, very little was known about the thirst and hunger crises in the Sudan, although it is part of the same zone. The World Press mainly pre-occupied itself with the Sahelian zone of West Africa up to the borders of the Chad with the Sudan. The lack of information about the affected areas of the Sudan, especially in Darfur is due to some extent to the bad means of communication to and within the affected region. It is a part of the country which is 1100 - 1700 km away from Khartoum. This desert distance with no paved roads and no railway in its northern part imposes an economic isolation. The truck journey from Khartoum to El Geneina (1700 km.), e.g., takes a fortnight in the dry season and about 4 weeks in the wet one, if the wadis are crossable at all.

The term "desert encroachment" is more current than the term "desertification"(1) in the Sudan. The latter term, however, has prevailed internationally and should gradually replace the term "desert encroachment" which is somewhat misleading, because it implicits that nature (the desert) is to blame for creating the problem. The fact is, however, that man's misuse of semiarid lands in the real reason for "desertification" or "desertisation". The advance of

(1) One can translate it into Arabic with "tashir".

The desert through desertification is not a desert encroachment from north to south but is the expansion of man's destructive activities northwards into the arid and semiarid fringes of the Sahara. "Desertification is a process of the destruction of the ecological potential of land use through incompatible utilization of land in the desert marginal zones, which ultimately leads to desert extension through man himself" (1).

The problem of desertification in the Sudan is often mixed up with other accompanying phenomena, such as drought or sand accumulation. The problem-complex embraces far more than thirst or the formation of sand dunes on settlement sites. Drought is a typical part of the climatic pattern of semiarid regions, and sand accumulations are part and parcel of the arid morphodynamic system. But desertification, i.e., the degradation of vegetation and soil of the steppes and savannah turning them into deserts in a short span of time of few decades, is the work of man. Desertification leads to the destruction of vulnerable ecosystem which forms the basis of living for the inhabitants of the semiarid zone. It is mainly caused by overpopulation.

Diagram 1 displays the rapid increase of the Sudanese population since 1917. In 60 years the population figures have risen fivefold. The animal stock increased even more rapidly : the number of cattle became 16-fold, that of camels 10-fold, that of sheep 9 - fold and of goats 8-fold. At the sametime grazing lands became narrower and less productive.

- 1) H. Mensching and F. Ibrahim: Paper on the United Nations Desertification Conference, Nairobi 1977.

An exact quantification of the stock grazing in the Sudan is not available so far. Animal census has been mainly dependent on animal taxation registers which embrace only a small part of the actual number of animals. A control sample in an area in Kordofan has shown that the actual number of animals is 10 times as high as the official figures. Similar results were obtained in Northern Darfur through our investigations there. The diverging curves (Diagram 1) displaying the development of stock figures and population of animals per person are always increasing.

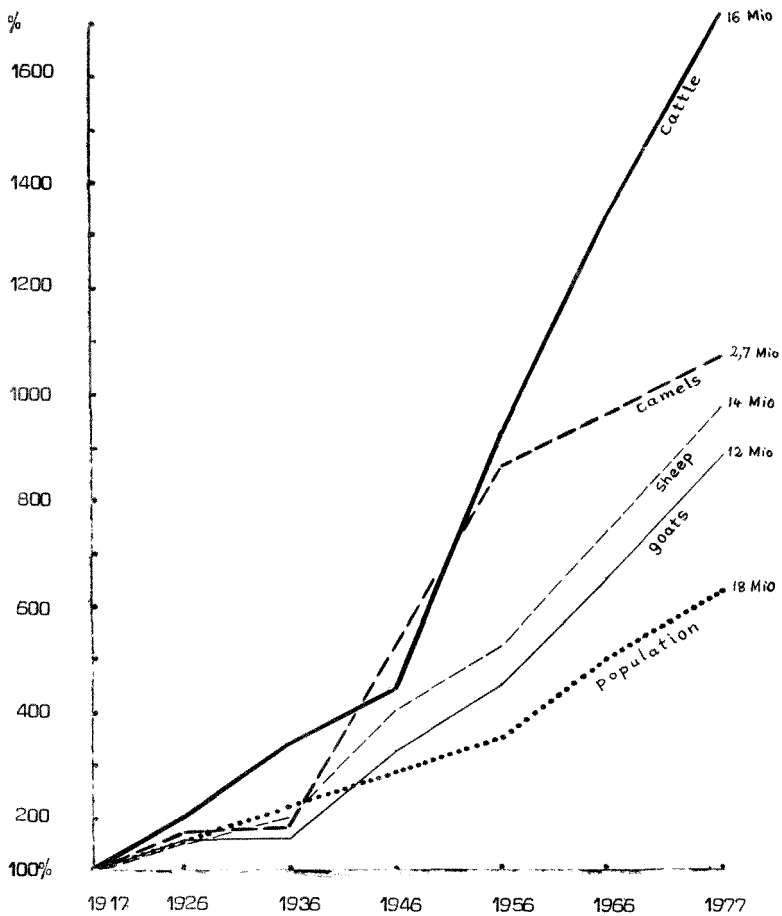


Diagram 1 : Increase of population and animal stock in the Sudan 1917 - 1977.

Negative results of this trend are : -

- The space of living for man and animal is diminishing.
- Thus the nomads are obliged to go north into the more arid zone.
- Population and stock density leads to overstocking, overcultivation and deforestation, which ultimately leads to the destruction of the basis of existence by man himself.

The following proceedings aim at throwing light on the causes and consequences of desertification in the Sahelian zone of the Sudan, especially in the Provinces Darfur and Kordofan.

CHAPTER 1

DESERTIFICATION AS A RESULT OF TRANSGRESSING OVER THE AGRONOMIC DRY BOUNDARY

The actual northern boundary of millet cultivation in the West of the Sudan has been pushed about 200 km. too far north. While the agronomic dry boundary (1) fairly coincides with the 500 mm - isohyet, the relatively dense millet cultivation extends as far as the 250 mm - isohyet (cf. Map 1). Farther north, we find sporadic cultivation in wet years. Besides, in edaphically favourable wadis, cultivation takes place after rainfall on wadi fringes ('araish or terus - cultivation).

Field study in West Sudan has convinced us that the transgression over the agronomic dry boundaries is the main cause of desertification there. For the preparation of the fields for millet cultivation means the felling of all the trees and the extraction of all the fields. The soil is then loosened **and** made exposed to strong

-
- 1) Agronomic dry boundary = 4 humid months (with precipitation sufficient for cultivation); about 500 - 550 mm in zones of summer precipitation (Sudan) or about 350 mm in zones winter precipitation.

deflation. The repetition of this process leads finally to an irreversible destruction of the natural vegetation cover and enhances the erosion of fertile topsoil. Soil degradation leads to the diminution of productivity. The land cultivator is thus obliged to shorten the rotation of cultivation and fallow, and ultimately plants the land continuously. The soil becomes gradually exhausted, because all plant nourishment is used up.

The following table (cf. also Diagram 2) illustrates the decrease of millet yield per hectare from year to year :

Table 1 : Decrease Of Millet Yields In The Sudan
 From 1960 to 1975

Year	Area Cultivated 1000 hectare	Total Yield 1000 t	Yield Kg./ hectare	Precipitation mm (El Obeid)
1960	392	226	580	318
1961	334	204	650	447
1962	463	291	650	512
1963	609	374	630	316
1964	599	354	590	540
1965	603	353	580	359
1966	540	252	460	217
1967	605	269	440	267
1968	598	267	440	190
1969	626	385	610	164
1970	723	439	600	261

Year	Area Cultivation 1000 hectare	Total Yield 1000 t	Yield Kg./ hectare	Precipitation mm (El Obeid)
1971	873	441	500	333
1972	1070	355	330	332
1973	1109	281	250	275
1974	1110	400	370	397
1975	1055	403	380	232

Reference : Yearbook of agricultural statistics,
Khartoum 1974 , 1976.

The decrease of millet yield per hectare down by one half within the last 15 years and the increase of population in the same span of time by about the same percentage has necessarily led to the expansion of the area cultivated (from 964,000 acres in 1960 to 2,609,000 acres in 1975).

From the table it becomes clear that though the fluctuations of the crop obviously correlates with precipitation, the amount of precipitation is not alone responsible for the decrease of crop. Soil degradation here plays a significant role.

The figures given in the table refer to the whole country. In the zone north of the 300 - mm isohyet, however, the yields lie far under the country's average. In dry years, which constitute 52% of all years (cf. Diagram 2), the yield varies from 0.0 to 0.5 kg./acre . A great part of the population in the affected area is suffering under a permanent nutrition crisis. The millet consumption of an average family of 6 members is about 1,200 kg. (12 shiwal) yearly. The average area cultivated per family is about 10 acres yearly, mostly millet. According to these figures a family's crop can cover its yearly needs only in the specially rainy years. But as the millet cultivator cannot forecast the rainfalls of the wet season he prepares the fields as needed, sows the millet and hopes for sufficient rain. This speculative cultivation means that in dry years in which the millet crop fails completely, the natural vegetation is also destroyed.

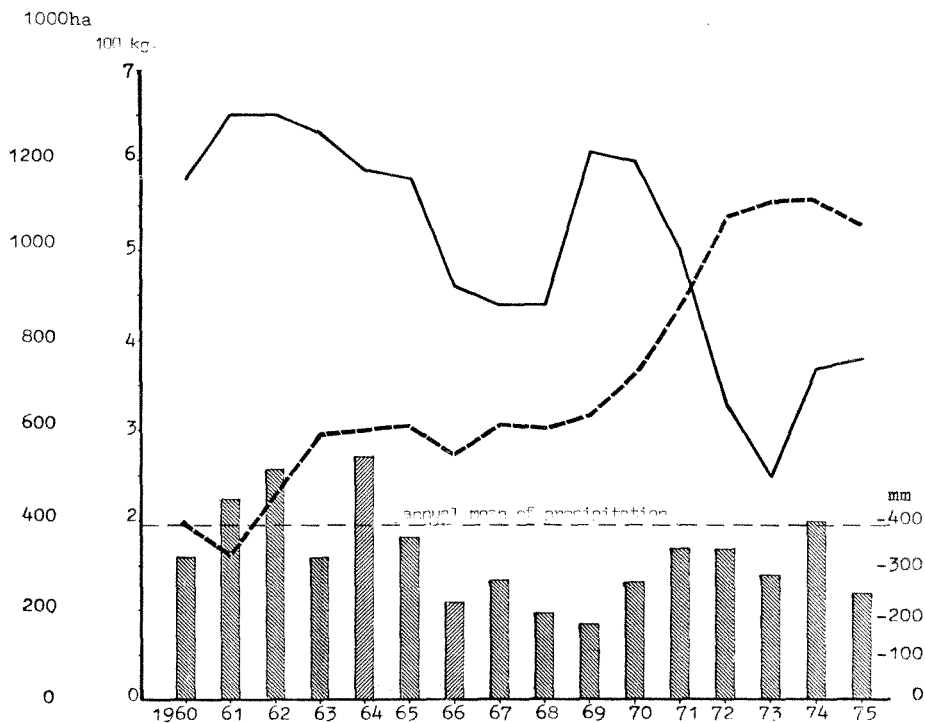


Diagram 2 : Decrease of millet yields per hectare (—) accompanied by the increase of area cultivated in the Sudan (- - -). Columns : precipitation in El Obeid (main area of millet cultivation)

In especially dry years, with delayed rainfall, the farmer clears and prepares double the usual area for millet cultivation thus hoping to cover his need that year. Hence, a large scale destruction of the natural vegetation occurs particularly in the years in which the regeneration capability of vegetation is especially weak owing to the lack of rain. The loosened sandy soil of the cleared fields is immensely exposed to the eolian influence and so soil erosion is strongly enhanced.

The correlation between population growth, extension of the area cultivated with millet and eolian soil erosion - which is apparent in the increase of dust particles in the air is clearly displayed in diagram 3 which shows that the number of days of poor visibility range (under 100 m) is fairly parallel to the increase of the area cultivated with millet from year to year.

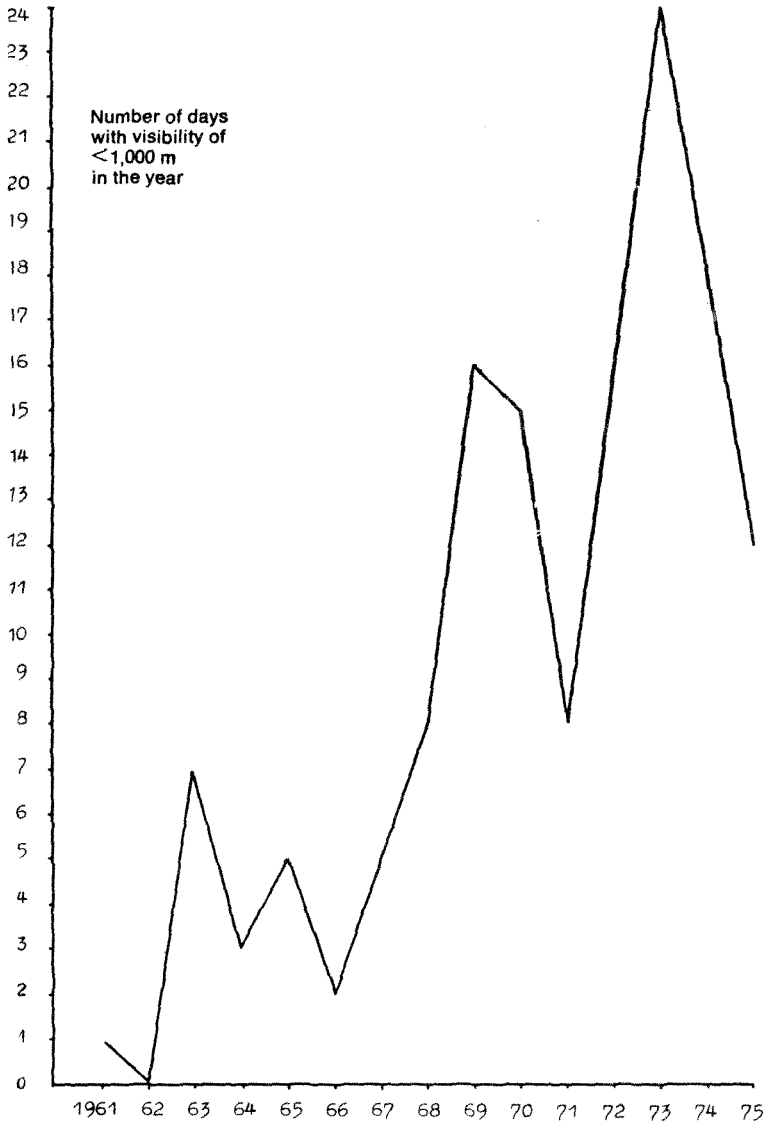


Figure 3 - Increase of the amount of dust in the air as reflected by the number of days in the year with visibility of < 1000 m in El Fasher
 Source of data: Meteorological Department, Khartoum

CHAPTER II
FLUCTUATIONS IN PRECIPITATION
AND THEIR EFFECTS

The yearly divergence of precipitation from the long - term annual mean amounts to 30% in the semiarid zone of the Sudan. The diagram of the variability of precipitation in El Fasher (Diagram 4) shows a maximal fluctuation of 120%. Catastrophic conditions prevail in land use and water supply when a run of dry years occurs, such as in 1940 - 1944 and 1947 - 1949 and also 1966 - 1970. The last eleven years have seen a long persisting drought period with an annual mean of 220 mm and a precipitation deficit of 24%. Similar figures have been registered in the last eleven years in most stations of this zone: 38% deficit in El Obeid, 41% deficit in Mellit, 22% deficit in Kutum and 21% deficit in El Geneina. During this dry phase the climatically controlled agronomic dry boundary has been pushed by about 100 km southwards. As millet cultivation does not stick to the agronomic dry boundary, but has already advanced about 200 km to the north, the effects of desertification are dissatrous within a broad belt of about 300 km which fairly corresponds to the zone between Sodri: and El Fula in Kordofan.

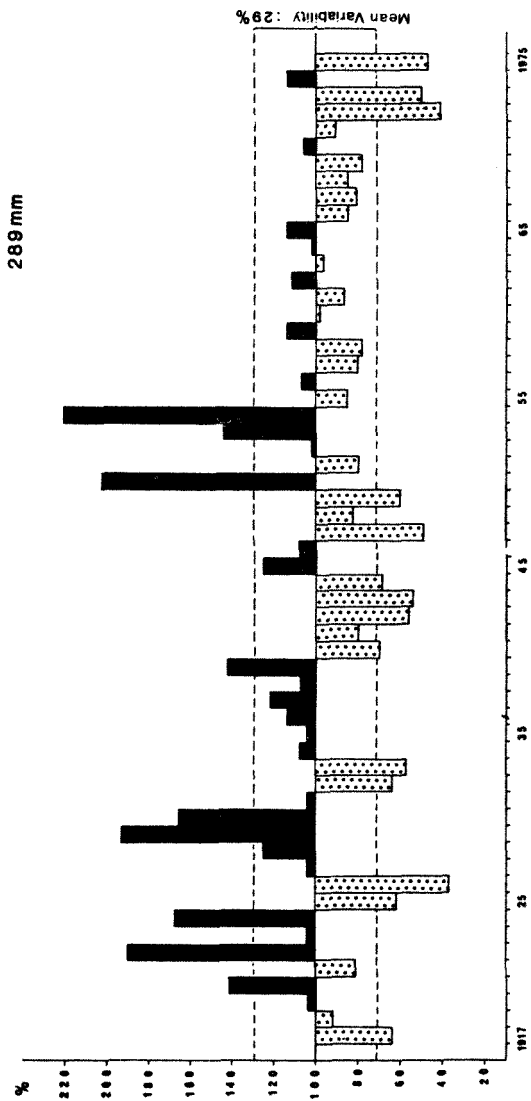


Figure 4- Variability of precipitation in El Fasher (730 m)

The disaster which lasted from 1970 to 1973 in the major parts of the Sahelian zone is still going on in the Sudan up till now. Whether a wet period would follow is uncertain. It is sure, however, that the ecosystem of that zone is in dire need of rehabilitation, if the zone is not to fall irretrievably as a prey to the desert. The consequences of the high rainfall variability on millet cultivation will be analysed below :

Diagram 5 illustrates this connection. Three climate diagrams of the Kutum station are displayed. One represents the pentad annual mean; the second, represents the dry years of 1949; and the third, the wet year of 1950. Underneath the diagrams the rhythm of the millet cultivation period is projected. This period takes about 100 days. Sowing takes place after the first rich rainfalls in June/July. The main period of growth lasts for more than 2 months between July and September. Ripening time lies in September/ October. A shifting of rainfalls signifies great risks for the millet crop:

- A) If the rain falls too early, in May or at the beginning of June and then again only late in August, as happened in Northern Darfur in 1976, the seeds do not sprout at all or the small sprouts wither very soon.

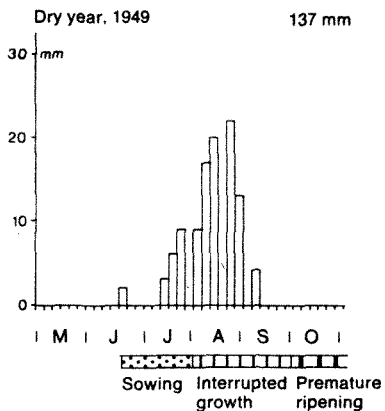
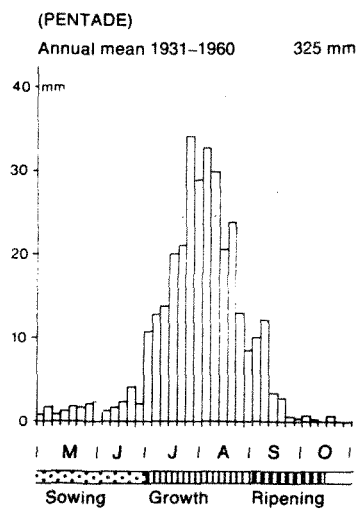
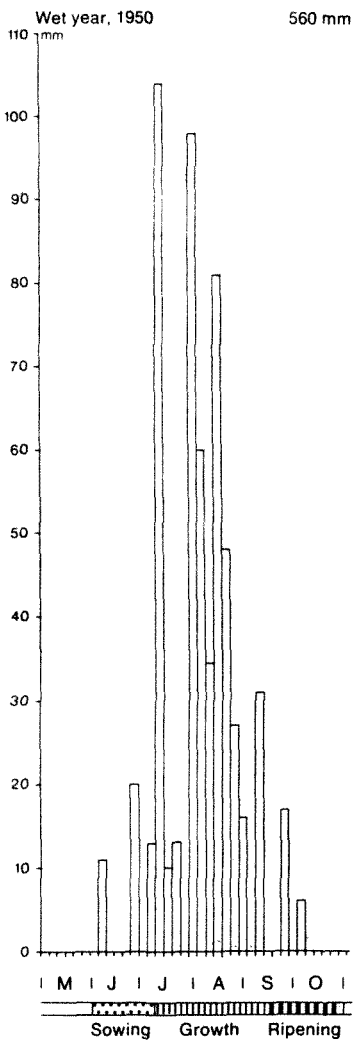


Figure 5 - Variability of precipitation and millet cultivation in northern Darfur (Station of Kutum, 1160 m)

- b) In case of very little precipitation, as in the year 1949 (137mm) the growth of millet is rendered impossible or a premature ripening of the crop takes place.
- c) If strong rainfalls follow the sowing immediately, as in 1950, the soil will be eroded, which means the loss of all the seeds.

As a form of adaptation to the variability of rainfall the inhabitants of the marginal zone store a part of their millet crop of the wet year for a possible dry year. This storage system can function well only when the succession "wet year - dry year" actually takes place. But in case of a succession of dry years hunger and disaster is inevitable.

CHAPTER III

DESERTIFICATION AS A RESULT OF

DESTROYING THE VEGETATION OF THE SAVANNAH

Natural vegetation of the zone affected by desertification forms the natural potential for pastoralism and the supply of energy (fire-wood). Two vegetation zones run through this affected belt : the thorn - scrub savannah and the dry savannah (low rainfall wood land savannah). The transition between the two zones fairly concurs with the agronomic dry boundary (500 - 600 mm). A brief description of the plant associations and their use is given below. Reference is specially made to Darfur and Kordofan, the regions which are particularly affected by desertification.

- 1) The major wadis are the main lines of nomadic pastoralism, for here permanent wells are to be found and surface water is gathered in the wet season. In and alongside wadi beds grow the different acacia species till far deep into the full desert. They enable the camel nomads of the Kababish and the Rezeigat, for instance, to wander more than 500 km into the desert, up to the north of Wadi Howar, at the beginning of the dry season. They seek the Jizu grasses and herbs which grow in the dry season, provided, of course, that some rainfalls have occurred in the "wet season". Thanks to the water stored in the Jizu plants, the herds can do without drinking water so long as they graze on these plants.

In and along the wadis of Northern Darfur and Northern Kordofan there are dense stocks of *Acacia reddiana* (Seyal), *Acacia arabica* (garad), *Acacia mellifera* (kitir), *Acacia senegal* (hashāb), *Acacia albida* (haraz), *Balanites aegyptiaca* (hejlij or la'ub), *Maerua crassifolia* (sareh), *Boscia senegalensis* (mukheit), *Capparis decidua* (tundub) and *Ziziphus spinachristi* (sidr).

- 2) The goz vegetation: The stable old dune belt (goz) is the main rain-ged cultivation zone in Darfur and Kordofan. Of great significance is the capability of the sandy soil to store all rain water and make it accessible to the plants. The natural vegetation of the Goz is an association of *Acacia senegal* and *Cenchrus biflorus* (haskanit) as a grass cover. Besides, there are stocks of *Acacia senegal* which are partially sown in connection with the recent afforestation measures. From *Acacia senegal* arabic gum is being won. In 1970, the Sudan exported 70% of the world production of arabic gum which comes mainly from Kordofan and Darfur. Through excessive cultivation, overgrazing and deforestation of the goz lands a secondary thornscrub vegetation is formed in which *Acacia senegal* has almost disappeared.

For a better evaluation of the goz vegetation the author surveyed the plant cover at different sites. On a fallow field, 3 km. north of El Fashir 51 bushes per hectare have been counted.

All bushes show deformation through animal bite, fire and wood cutting. The division into species was as follows : -

<u>Species (Name)</u>	<u>Arabic</u>	<u>Number</u>
Acacia raddiana	Seyal	18
Balanites aegyptiaca	hejlij	12
Ziziphey mauritiana	nabag	8
Colotropies procera	iusher	5
Maerua crassifolia	sareh	4
Acacia albida	haraz	4
		<hr/>
		51

On an area of one hectare which was grown with millet the season before only 5 bushes were to be found : -

<u>Species (Name)</u>	<u>Arabic</u>	<u>Number</u>
Balanites aegyptiaca	hejlij	3
Acacia raddiana	seyal	1
Maerua crassifolia	sareh	1
		<hr/>
		5

Grass and herbs were sparse on both sites. However, on the first field ~~there~~ were more grass species of the edible kinds, such as Cenchrus biflorus (haskanit), Eragrostris tremula (banu) and Aristida species (gau, bayad). On the second, more degraded field grew cacia

acutifolia (sena sena) Sesamum alatum (semsem el djamel) and others (irgesi, adān el far , djubbein) which are not palatable for the animals.

Another site surveyed near El Geneina revealed a huge proportion of Guiera senegalensis which is likewise unpalatable. The survey of one hectare gave the following results :-

<u>Species (Name)</u>	<u>Arabic</u>	<u>Number</u>
Guiera senegalensis	obbeish	561
Boscia senegalensis	mukheit	184
Acacia senegal	hashab	58
Combertum cordofanum	habil	14
Calotropis procera	'ushar	11
Acacia amara	'arad	11
Balanites aegyptiaca	hejlij	3
Acacia arabica	garad	3
		<hr/>
		845

Comparing these three surveys one can firmly conclude that the tree stock of the thornscrub savannah of the Sudan has still the capability to regenerate itself if effective conservation measures are taken. Relicts of Adansonia digitata (tabeldi) still exist in areas ranging between 300 mm and 400 mm precipitation, such as the area of El Obeid and that south of Um Kaddada. The Goz sand is a favourable location for both grasses and trees.

3) The Pediment Vegetation :

On the mountain pediments, where merely a thin veil of sediments cover the stoney bedrock one finds a thin tree stock, mostly rowed in the direction of surface run off. The species represented are commonly *Acacia mellifera* (Kitir), *Acacia nubic* (la'ot) and *Acacia raddiana* (seyal). Grasses and herbs are sparse. Although some pediments are covered with sandsheets which have been recently blown in, they do not carry any grass cover owing to the lack of seeds in the fresh sands.

As pediments have shallow sceletical soils they do not belong to the areas utilized for cultivation. For this reason the degree of the ecological damage through man is much less on them than on Goz areas. Here, too, measures for the conservation of soil and vegetation can be carried out less problematically, because these areas do not belong to the principal areas of human settlement. A regulated winning of fire-wood and controlled browsing rotation on the pediment areas could contribute to solving the problem of desertification.

4) The Mountain Vegetation :

Apart from the large mountains, such as Jebel Marra and the Nuba mountains the highlands are covered with thin forests composed mainly of *Commiphora* and *Acacia* species. Cultivation and browsing are not commonly practised on those highlands. Only on slopes,

which are covered with eolian and fluvial sands small settlements of the sedentary tribes are to be found there.

Any future planning should take into consideration that mountains are of limited natural resources. Evaluations and recommendations of big investments in that respect, such as big agricultural projects in peripheral mountain regions should therefore be more cautious. Such areas could meet the needs of their inhabitants only and could not produce also for the markets in Khartoum and abroad. The transport costs alone would go beyond the limits of rentability.

5) The Deforestation Of Savannah:

In a country in which, apart from wood, there is no other fuel and where the purchase power does not allow the use of imported fuel the deforestation of the tree stock reaches unimaginable dimensions. Not only the nomads and the villagers use wood daily for cooking but also the urban population and even the town bakeries. In El Fasher, in Nyala, in El Obeid and other towns the daily sight of nomads and villagers with camels and donkeys heavily laden with wood and charcoal is quite common.

Investigations on wood consumption in Darfur show that the family's average weekly consumption of wood is a donkey's load which amounts to a tree of middle height. One also tends to underestimate the amounts of wood which are used for building huts and enclosures. While a hut (ghottia) has an average duration of 6 years the enclosure lasts no more than one year on the

average, because the latter is not well built and is more exposed to the encroachment of animals and the influence of winds. If a small tree or bush is required to build a metre's length of these enclosures, the annual need of each family of enclosure wood alone will reach quite a few hundred bushes (cf. Table 2).

Table 2 - Annual Consumption Of Wood
Per Family In Northern Darfur

<u>Purpose</u>	<u>Tree or Bush</u>
Hut building (2huts require 16 trees in 6 years)	2½
Enclosure for the huts (80m)	80
Enclosure for the field (600 m) for nearly one third of the families, 600 : 3 =	200
Fuel - wood (1 tree weekly)	52
Total	334½

According to other estimations quoted by Ali Darag Ali in his paper " The Sudan Experience in the Field of Desert **Encroachment** Control and Rehabilitation" (Khartoum 1977). "The nomads uproot a minimum of 548 million acacia scrubs per year just for cooking". It would be much less disastrous of those who uproot trees tried to plant some to make up for the loss. The recent afforestation undertaken in the Sudan so far

are of limited scope and are by no means intended to meet the enormous traditional consumption of wood. For the great part they are conceived as a "green belt" to protect the major towns against sand accumulations. Some afforestations have been undertaken to produce good timber, others, in Darfur and Kordofan plant *Acacia senegal* to get arabic gum. Although the Forestry Department forbids the cutting down of some species such as *Acacia senegal* and *Acacia albida* the population of the savannah does not follow these laws, especially because no suitable alternative is being offered.

The reduction of the wood consumption of the population is one of the most important measures to be undertaken to combat desertification in the Sudan. A rational use of wood could reduce consumption by two thirds. A better method of building enclosures could make them much druable. Field enclosures could be done without, if animals were put under control. The problem of fire-wood is rather more difficult to solve. As long as the population is able to get its fire-wood from the wadis and highland "for nothing", it will not buy any fuel, however, low the price may be.

6) The Degradation Of Vegetation Through Overgrazing

The degradation of the natural vegetation through excessive grazing in the semiarid Sudan does not affect the whole zone equally, but rather selectively. The strongest impact is to be found in

the perimeters of settlements and the surroundings of water yards and along the cattle routes. A rational reorganisation of pastoralism aiming at an equal use of the available pastures is unthinkable without controlling the wells and the water pumping stations.

Range management can only be based on an exact knowledge of the number of grazing animals and the productivity of the available pastures. But it is absolutely difficult to know the number of animals grazing in certain region. The cattle-breeders are usually disinclined to give the right number because they do not like to pay the due taxes. Besides, they are superstitious and fear the danger of "evil eye ". For this reason, too, it becomes impossible to rely on the registers of the water pumping stations. On the one hand, the keeper of the pumping station is hardly allowed to count the animals, on the other hand friendly relations with the animals owner makes him fairly generous. Added to this, in wet years in which the number of animals increases rapidly and control is of vital importance, the animals do not frequent the water yards, because there is enough surface water in wadis and depressions and also because the juicy plants contain much water then.

The degradation of vegetation on overstocked pastures takes place both quantitatively and qualitatively, Useful species disappear and are replaced by unpalatable species. Thus, today, we find that the poisonous scrub *calotropis procera* ('ushar) has spread everywhere on the exhausted soil. Unpalatable plants, such as *Cacia acutifolia* (sena sena) ,

Acanthospermum hispidum (horab hausa) and Guiera senegalensis ('obbeish) occupy vast areas and replace former, palatable pasture grasses, such as Cenchrus biflorus (haskanit), Eragrostris species and Aristida species.

In Northern Darfur and Northern Kordofan there prevails three forms of animal husbandary. Each has its own particular impact on the processes of desertification :

- a) Keeping a small number of sheep, goats and one or two donkeys which graze within the narrow surroundings of the village. In order to protect their animals for the night the villagers build the above-mentioned enclosures. These animals are kept mainly to supply the family with milk. This type of animal husbandary on a limited area is responsible for the fact that each **settlement** in Darfur and Kordofan is surrounded with a bright ring on the aerial and satellite photos. These bare rings have been completely degraded through overgrazing and wood cutting.

- b) Keeping of herds of a middle size, which graze within a farther ring surrounding the settlement, making a one - or two - days **journey**. This is responsible for the constant widening of desertified ring around the settlement.

- c) Nomadic pastoralism. While in Northern Darfur and Northern Kordofan camel breeding prevails, in Southern Darfur and Southern Kordofan cattle breeding is dominant. Camel nomadism is the system of land use which is most suitable for the climate of the north Sahel. A better organization of this would solve many standing problems between the nomads and sedentary population.

Despite the great animal wealth of the Sudan it plays a relatively insignificant role in the market circuit. Cattle breeding should be more commercialized. The traditional disposition towards cattle as a constant possession and symbol of wealth should be departed from. The Sudan feeds 20 million cows and camels which play a relatively insignificant role in the market economy of the country. Meat production is extremely low and its price is very high compared with the purchase power of the peasants (1 kg. meat in El Fashir costs Ls.0.5 while the daily wages of a land labour there is about Ls.0.3). Meat production is about 0.3 million t. (1973). France, for instance produces 1.75 million t. of meat and has 24.7 million heads of cattle. The low production of meat and milk in the Sudan is not merely due to the bad condition of the animals which suffer from lack of fodder and water and also from diseases but mainly due to the unfavourable possibilities of marketing. Lack of planning and organisation in the field of cattle marketing leads to high price fluctuation from week to week so that the nomads has always the feeli that he is selling under price. This explains the traditional disposition of a "passive" possession of

cattle herds. Unless , one day, cattle marketing proves to be a lucrative business this conservative attitude will not be liable to be changed. Likewise, the preference of quantity (number of animals) to quality (meat production) will not be changed unless market prices are based on quality. This dependent on the means of transport to the consumption areas. No cattle merchant in El Geneina, for instance, would pay much money for expensive cattle to drive them then to the consumption market in Khartoum/ Omdurman, 1700 km. of desert route. The cows which have been bought fat and in good condition would reach destination completely meagre. Cattle transport is therefore of great importance Especially in drought periods there must be a way of marketing, transporting and canning great numbers of cattle within a short time.

A further issue is the protection of the producers (cattle breeders) from the monopoly of the cattle merchants (gallaba). This has been effected in the Sudan through encouraging the heads of the tribes to organize the transport and marketing of their animals by themselves.

CHAPTER IV

PROBLEMS OF WATER SUPPLY

Water deficit is the most serious problem in the arid and semiarid zone of the Sudan outside the Nile Valley. That is why the "Rural Water Corporation" is one of the biggest and most influential institutions in the West of the Sudan. Often there arises a conflict between politically based decisions (for instances to quench the thirst of the inhabitants of a certain area) and hydrogeologically based ones (showing the amount of water in the different aquifers). Although a great deal of hydrological survey has been accomplished in Darfur and Kordofan (cf. surveys by Ramsis B. Salama and Wilson Iskandar) the major part of underground water in the Sudan has not yet been made accessible. "Some 1381 million cubic meters are estimated to recharge the major basis annually, only 143 million cubic meters of this recharged water is used " (1).

The situation is especially critical in areas of the cristallin rock of the Basement Complex which contain no rich aquifers. Where the Basement Complex is covered with a layer of goz-sands or alluvial deposits, aquifers are to be expected between the cristallin rock,

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- 1) Salama, R.B., Ground Water Resources of the Sudan. publ. by Rural Water Corporation, Khartoum, 1977.

and the deposit layer. These recharge slowly. They may suffice for the traditional wells but not for the water pumping stations. Only if the deposit layers are some 100 m. thick or if they lie at the foot of big mountain messivs the aquifers can be of some significance. The layers of the Nubian sandstome series contain rich aquifers and therefore play an important role in **ground** water harvesting in western Sudan.

In the arid regions of the Sudan traditional water supply is mostly secured by a permanent well. In addition to it one uses seasonal run - offs which gathers as lakes into natural despressions (rahads), parts of wadi beds (berka, fula) or man-dug water reservoirs (hafir, khazzan).

In the last 20 years, a big number of boreholes supplied with kerosin - turned water pumping engines have been constructed in the semiarid zone of the Sudan. During the dry season the population becomes concentrated on the settlements, where water supply is fairly secured, so that the number of their inhabitants becomes much higher than in the wet season. In drought period the population figures of the towns jump very high. Nyala, for instance, grew from 12,000 inhabitants in 1956 to 60,000 inhabitants in 1973. In El Fasher the water supply broke down in spring 1977, when the water reservoir (Khazzan Golo) became empty. Over 70,000 inhabitants were affected, added to about 100,000 inhabitants of the surrounding villages, whose water reserves had been already exhausted. With the help of boreholes which were immediately drilled by the Rural

Water Corporation in the alluvial deposits at El Shagra (North - West of El Fasher) a catastrophe for El Fasher and its surrounding villages has been narrowly avoided. Nevertheless, the situation of the population was bad enough. Lack of water is usually accompanied by bad water quality(spread of diseases) and a drastic increase of water prices. It is disastrous enough when the greatest part of the family's income is paid to cater for water for domestic use and animals in periods of drought.

CHAPTER V
THE POPULATION OF THE ZONE AFFECTED
BY DESERTIFICATION

Despite the fact that the population density in the affected zone was only 5.8 inhabitant/km² in 1974 (Darfur :4, Kordofan 8.5, Kassala and the Red Seas : 5.5) one can speak of overpopulation there. Two reasons are responsible for this: the one is the low soil productivity, the other is the concentration of the population on settlements with permanent water supply. Thus, the population density in the area of El Fasher, for instance, has reached 70 inhabitants per km². This population impact on this ecologically vulnerable region (less than 300 mm) has led to the settlement of many nomadic tribes and tribal fractions. Up till the end of the 19th. century, this arid to semiarid zone was populated mainly by nomadic tribes, partly Arab and partly of non-Arab region. Among those mobile population groups there lived sedentary tribes, too, which were more represented in the Southern belt of that zone. Though the sedentary tribes have populated the zone for a very long time, this fact must be stressed that the nomads have lived there for many centuries now. From the symbiosis between nomadic cattle breeders and sedentary cultivators came for the transitional forms of the seminomads and the semi-settlers. It is significant that among the Arab nomads

of Darfur and Kordofan no group has changed completely into sedentary land cultivators. This would have involved a great loss of prestige for them, whereas they have so far enjoyed power and respect everywhere.

Today, there is no enmity between the different tribes of the Sudan. In drought periods, however, some conflicts arise especially on the issues of usage rights of water and pastures. In many cases the encroachment of nomadic herds into the freshly planted fields of the settlers develop into open fights.

CHAPTER VI

SOIL EROSION AND SAND ACCUMULATION

AS MORPHODYNAMIC ASPECT OF DESERTIFICATION

IN THE SUDAN

In wide-spread fallacy concerning "desert encroachment" is the belief that it is mainly caused by the encroachment of wind blown sands onto settlements, towns and fields. Though such sand accumulations are signs of desertification they actually affect only a small percentage of desertified areas. In fact they serve more as indicators of desertification somewhere else than as means of desertification. For the destruction of vegetation in the surroundings of a settlement lays bare a vast area of sandy soil which is then exposed to strong deflation and are finally accumulated on the fringes of the settlement.

The morphodynamics of desertification is to be interpreted in terms of soil erosion. Deforestation, overgrazing and overcultivation (all of them are done by man) lead to the deflation of the organic topsoil thus leading to the deterioration of soil and the creation of desert-like conditions. As indicator of soil deflation is the increase of the amount of dust in the air year after year. Diagram 3 shows the increase of the number of days with visibility under 1000 m in El Fasher since 1961. Visibility stands in inverse proportion with the amount of dust (wind eroded topsoil) in the air. Fine dust particles are transported for long distances and are detected,

for instance, in the Atlantic Ocean, where many million tons of dust are estimated to fall there yearly. The heavier sand fractions are blown by the wind only for a short distance. In case of sands which have a distant origin the transport medium is primarily fluvial in Wadi beds. These sands are then blown by the wind to form dunes and sand sheets. Eolian accumulation takes place wherever obstacles are : enclosures, buildings, hills and scrubs (specially Ziziphus or Capparis decidua which gather small dunes : gantur, tugur).

Deforestation in the higher catchment areas of wadis has changed their hydrologic system and consequently their morpho-dynamics, The clearing of the woods led to a quicker drainage which means a concentration of run-off in the wadis. This has serious consequences for the terus cultivation of snuff (tobacco) in wadi beds. Added to this, there is obvious change in the ground- water streams in the wadis. The change of run off in the higher catchment areas, the increase of soil erosion and the consequent increase of deposition at the lower courses of the wadis led to the diversion of the groundwater streams in the lower courses of the wadis. Many wells became dry, others got a higher recharge.

CHAPTER VII
MEASURES TO COMBAT
DESERTIFICATION IN THE SUDAN.

1) Measures Undertaken So Far By The Sudan (1)

Already in 1942 the Sudan government built a commission to investigate desert encroachment on the irrigated lands on the Nile and rain-fed areas. The commission came to the following results :-

- Desert encroachment has been caused by the impact of man on arid and semiarid lands.
- The desert marginal zone has expanded southwards into the most active economic regions of the Sudan.
- Some indicators of this is diminishing productivity of both cultivated land and pastures, the increasing desettlement of population and the increase of tribal conflicts on the issues of nomadic routes and the usage rights of water and land.

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- 1) An abstract of the report given by El Sammani A. Yacoub at the United Nations University, Tokyo, in May , 1977.

- The situation is enhanced by the people's misuse of land in the form of overgrazing, mass cutting of woods for building purposes and fuel supply, overgrazing, savannah fires and shifting cultivation.

Some of the important measures taken by the Sudan government in the last 35 years to combat desertification are being summed up : -

a) Legislations :

in 1944 the Land Use Law was issued to regulate land tenures and land use systems in order to secure a rational use of land.

In 1956, immediately after the independence the "Rural Water Corporation" was legislatively established to supply the population of rural areas with water for human and animal use.

Many other laws regulating cultivation and pastures have been issued both by the central and the local authorities.

The establishment of the present Ministry of Agriculture, Food and Natural Resources has institutionalized the task of conservation of soil, vegetation and water.

Recently, the law of the National Committee for man, Environment and Development has been issued.

b) Studies And Surveys :

Many regional studies and surveys by national and foreign teams have been carried out all over semi-arid zone of the Sudan. A huge heap of reports and maps (geological, hydrological, soil, vegetation and land use maps) is already available. A new plan of action against desertification should make a synthesis of this bulk of work from the new point of view.

c) Training And Research :

In almost forth years the University of Khartoum has graduated a huge number of experts on agriculture, veterinary sciences, geography, geology, hydrology, botany, topography. Meteorology, social sciences, etc.. With little additional training of efficient staff of experts can be qualified to tackle the problems of desertification. It is advisable, however, to pay some attention to the training of unacademic field-workers to be send and stationed at smaller towns in the affected zone.

Research work in the field of natural resources is very active in the Sudan. Many scientists at the University of Khartoum are conducting research - work in the different regions of the Sudan. The Agricultural

Research Corporation is a well - equipped research institution with about 15 outer stations in the different vegetational zones. The National Council for Research Co-ordinates research in the whole country. It has adopted the latest programme of desert encroachment control.

d) Pilot Projects :

- Town perimeters in selected rural areas have been established and controlled for the last 20 years.
- Green belts have been planted on the fringes of Khartoum and other towns. Experience won there can be made use of in similar projects.
- Afforestation and sand dune fixation have been carried out in different parts of the country.
- A pilot farms has been established in Ghazala Gawazat 17 years ago to test the relationship between the ecosystem and its use by man and animal.

- Several areas in western Sudan have been fenced for the conservation of natural vegetation and to test the ability for natural regeneration in the savannah zone.
- Control of fire-wood and charcoal production is the aim of combined projects between the Forestry Department and the Ministry of Commerce.

- Desert sheep pilot projects.
- Fire-lines pilot projects.

e) The Most Recent Projects:

The Desert Encroachment Control and Rehabilitation Programme (DECARP). This project consists of nine parts which would cost a total of about 26 million US \$. Five sub-projects aim at establishing provincial development centres in the provinces affected by desertification: Northern Kordofan, Southern Kordofan, Northern Darfur, Southern Darfur, Nile and Northern Provinces. In addition to the general tasks each centre has specific activities to carry out. Further sub-projects are : Evaluation and Mapping of Natural Resources and Desert Encroachment Monitoring, Stock Route Improvement and Feasibility Study for the Establishment of a Wildlife Reserve. The D E C A R P has produced several documents on the problem of desertification and is supposed to start in 1978.

A further project which is being prepared in collaboration with the United Nations University is the establishment of a "College of Veterinary, Natural Resources and Arid Zones Studies" in El Fasher.

2) Further Suggestions For The Plan Of Action

To Combat Desertification In The Sudan.

The above-mentioned endeavours of the Sudan Government to fight desertification deserve the full support of the industrial countries as well rich ones. As these measures are long-term programmes they could be accomplished only if their running expenditure is secured. The following suggestions should be given priority : -

a) Enlargening And Stenghtening The Central Places

On The Southern Margin Of The Sahara

The small towns in the transitional zone between Sahara and Savannah should become stations for launching a wide campaign against desertification. Examples of these towns are El Geneina, Kebkabiya, Kutum, El Fasher, Mellit, Um Kaddada, En Nahud, Bara, Er Rahad and Um Ruwaba. The functions of these central places should be the following :

- Cattle marketing
- Meat conservation
- Veterinary service
- Means of transport to the large consumption areas.
- Providing the mobile nomads with basic food-stuffs, essential commodities and capital goods.

- Education and information (including technical advice)
- Medical care.
- Water supply.
- Land use planning.
- Control of land misuse.

b) Working Out A General Plan For Rational

Land Use.

Single measures taken on a provincial scale would not be effective enough to combat desertification. The Sudan is one of the Sahel countries which is in a happy position to master the problem because of its excellent agricultural resources. A general plan of land use should, however, be worked out to organize agricultural practices in order to secure a utilisation which is compatible with the natural conditions of each zone. This requires the regulation of agricultural production and establishing an efficient network of transport. Excessive land use in the semiarid zone will thus be stopped. Food supply must then be guaranteed from the centres of production in other regions of the country.

c) Observing The Agronomic Dry Boundary :

It has been made clear, so far, that the transgression of millet cultivation over the climatically set agronomic dry boundary is the main reason for desertification in the desert marginal zone. Though this

boundary lies at about the 500 mm - isohyet, cultivation is actually practised up to the 250 mm - isohyet. The zone between them, which is about 200 km; broad, is the zone of strong desertification. The withdrawing of millet cultivation back to the agronomic dry boundary seems unrealistic, but there is no other alternative, if desertification is to be stopped. However, any law forbidding cultivation in that zone should offer an acceptable alternative at the same time. Agricultural products (mainly dukhon and durra) should then be made available at prices which could be afforded by the population. The affected zone itself should be left to a controlled animal husbandry. The productivity of the pastures should be estimated and the number of animals should be accordingly restricted. In some cases, parts of the population would have to be moved and resettled in the more humid zone of the savannah. Moreover, the surplus labour could be consumed in labour intensive industries which could be established in places of population concentration.

d) Millet Cultivation Combined With Acacia

Senegal

(cf. Diagram 6)

The model of combined cultivation of millet and Acacia senegal aims at supplying the land cultivator with both millet and wood for the needs of his family. As explained before millet cultivation leads to a complete destruction of the tree and grass vegetation.

Diagramme 6: Millet Cultivation Combined With Acacia Senegal On The Sandy Soil Of The Goz In Western Sudan.

		40 acres			
Year	10 acres				
1-5	millet + A.senegal	fallow (pasture)	fallow (pasture)	fallow (pasture)	
	1	2	3	4	
6-10	A.senegal	Millet + A.senegal	fallow (pasture)	fallow (pasture)	
	1	2	3	4	
11-15	A.senegal	A.senegal	Millet + A.senegal	fallow (pasture)	
	1	2	3	4	
16-20	Wood cutting				
	fallow (pasture)	A.senegal	A.senegal	Millet A.senegal	
	1	2 Wood Cutting	3	4	

This model tries to make millet cultivation less destructive. It could be practised in the goz belt with precipitation between 300 mm and 400 mm. The system become fully functioning after 15 years. The farmer is then able to harvest a wood stock of Acacia senegal (arabic gum) on an area of 10 acres. With it, he can fully satisfy the needs of his family of fire-wood and building material. At the same time he has 20 acres of land covered with Acacia senegal from which he wins arabic gum. Besides, he has 10 acres devoted to millet cultivation to meet his yearly needs. The remaining 10 acres of fallow land are suitable as pasture for a limited number of goats and sheep. Through the rotation of millet cultivation every five years after a period of five years fallow the soil is given a chance to regenerate. Millet is sown together with seeds of Acacia senegal. By the time the Acacias are five years old they are left to grow alone while millet shifts to the next patch of 10 acres and so on.

c) Rotation Of Pastures ;

To ensure an equal grazing of land so as to avoid the overgrazing of some areas while other areas are under-grazed a system of rotation of pastures should be practised. Much has been said about overgrazing around water points. A rotation of the use of water yards would be a successful means of controlling the use of grazing areas. Through rotation a natural regeneration of pastures could be obtained.

Experience has shown that water yards develop very quickly into permanent settlements. Once such settlements are created their closure brings about heavy social and political consequences. For this reason, the rotation of the use of water pumping stations can be carried out only if the establishment of permanent settlements around these water points is not allowed. This means that these water points would be erected only for the nomads and their herds.

f) Plantation Of Woods In The Vicinity
Of Settlements

It is extremely important that each village should have its own "wood" to secure its need of fuel and building wood. This "wood" could also be used as a grazing area for a limited number of animals. Such woods need not be new plantations but can be won from the savannah by fencing the area and conserving its vegetation. The example of Burush (260 mm), at the borders between Northern Darfur and Northern Kordofan shows that the regeneration of the tree stock of the thornscub savannah can take place relatively quickly. The conservation measures which have been taken by the villagers themselves have produced astonishing results after eight years. The decision to take such measures and the observation of their execution is specially easy in a region in which the traditional tribal system is still in function.

g) Establishment Of Labour Intensive Industries

Through the degradation of the land use potential as a result of progressing desertification a large number of land labourers is always arriving in the towns in the affected zone and aggravating the problem of unemployment there. To solve this problem several labour intensive industries and manufactures should be established to absorb the unemployed land labourers. The factories should be based on the processing of agrarian and animal raw materials, such as cereals, peanuts, sesame, arabic gum, wood, meat, milk, leather and wool.

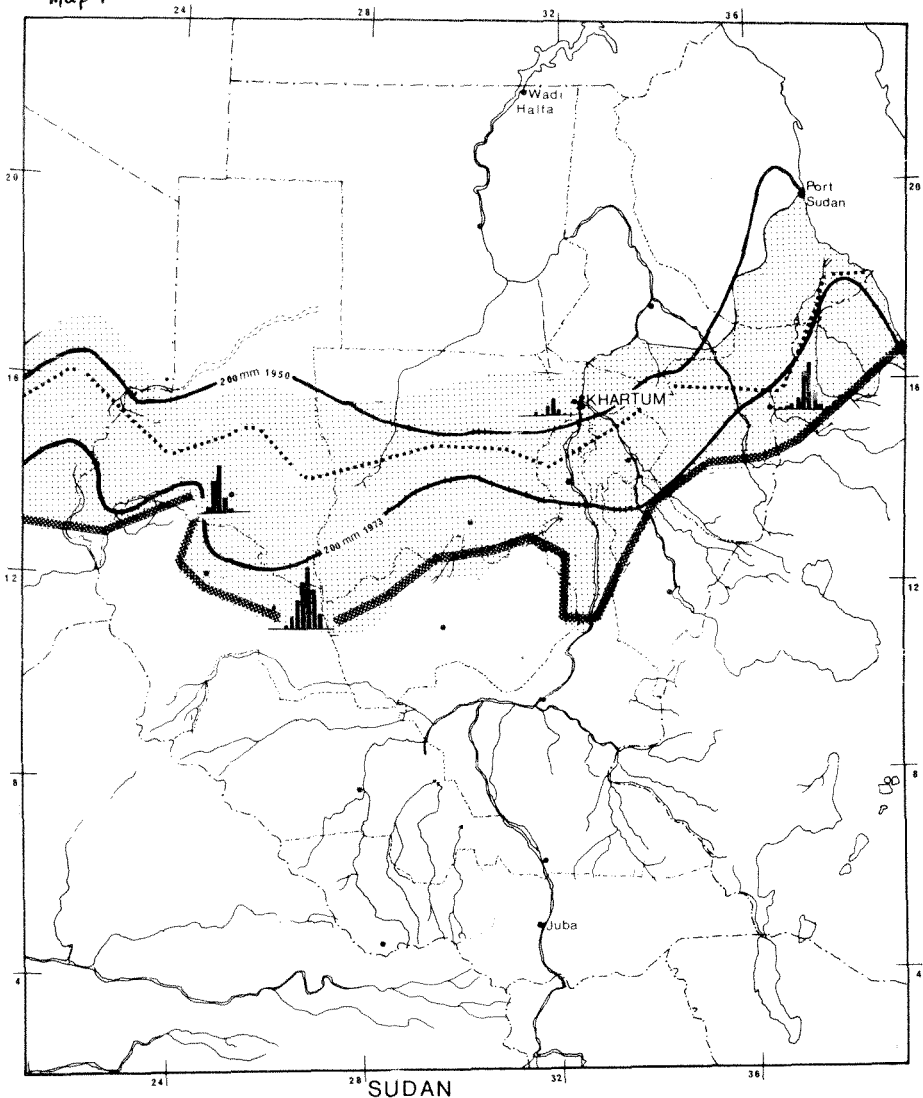
h) Organisation Of An Enlightenment Campaign

Against Desertification

All measures taken against desertification cannot bring forth the desirable results unless they are carried out by the population consumed itself. Desertification is the result of land misuse by man. The change for land use systems which are more suitable to the given conditions requires a turn over from traditional behaviours which have been practised over long centuries. This demands a long process of unlearning and learning.

The organisation which may be able to carry out this campaign on a large scale all over the desert marginal zone is the Sudan Socialist Union with all its small units. The SSU is represented in all parts of the country and stands in good contact with the heads of the different tribes. In any case, it is, always advantageous to involve the tribal chiefs in the plan of action against desertification. The education of the population to understand the causes of the problem and how to tackle it is the most important issue in any plan of action.

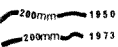
Map 1



Zone of strong desertification



Agronomic dry boundary (6 arid months in the year)



Fluctuation range of precipitation between the wet year of 1950 and the dry year of 1973.



Actual border of millet cultivation.

The Development Studies and Research Centre was established in September 1976 as a University body within the Faculty of Economic & Social Studies. Its aim is to act as an effective vehicle linking the Faculty and the University at large to the on-going developing effort through a mission-oriented programme of:-

- post - graduate studies and training
- applied research
- consultation
- publications and documentation.

The Centre will lay particular emphasis in its interdisciplinary programme on high - priority issues of socio - economic development with view to leaving, whenever possible, direct impact on policy making and policy implementation.