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DESERTIFICATION

how people make deserts,
how people can stop
and
why they don't

by

Alan Grainger

edited by Jon Tinker

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Desertification was written by Alan Grainger, Secretary of the International Tree Crops Institute from 1977 to 1981. He is now at St Cross College, Oxford, researching tropical forestry policy. This report is based in part on research by Michel Baumer, was edited by Lloyd Timberlake and Jon Tinker and produced by Barbara Cheney and John McCormick.

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EXECUTIVE SUMMARY

One-third of the Earth's land is arid or semi-arid. Some 600 million people live there. More than 20% of the Earth - home of 80 million people - is directly threatened by desertification. Some 100 countries are affected. ..... Page 5

Desertification is caused by overcultivation, overgrazing, deforestation and bad irrigation - by people taking too much from the soil and putting too little back. Traditional rainfed cropping systems break down under pressure from growing populations and the increased planting of cash crops..... Page 10

Increasing herd sizes and decreasing pasturelands lead to overgrazing. New wells and improved veterinary services can mean more animals than rangelands can support. When drought comes, animals die of hunger, not thirst. ..... Page 19

Irrigation can increase cereal yields six-fold. If not designed and managed well, it can also make land a salty and waterlogged desert. Huge irrigation projects have gone wrong in Iraq, Pakistan and Soviet Central Asia. ..... Page 25

Woodlands are being cleared at the rate of four million hectares (10 million acres) a year in the arid tropics. Such deforestation can cause water tables to fall, soils to erode and land to become dusty and arid. About 90% of people in the Third World depend on wood as their main fuel..... Page 28

Populations are increasing as fast in arid lands as elsewhere - often faster. Fifteen out of 24 nations whose populations grew by 3% or more over 1970-78 were suffering from desertification. Population is increasing at 2.5% a year in the Sahel, while cereals production is increasing by 1% a year..... Page 34

The world's earliest civilisations - Sumerian, Mesopotamian, Persian - depended on irrigation. The Sahara, wet and fertile for 3,000 years, once supported powerful empires, and northern Africa was the granary of the Roman Empire..... Page 36

The 1968-73 Sahel drought killed between 50,000 and 250,000 people and some 3.5 million head of cattle. However, prolonged droughts are a "normal phenomenon" in the Sahel. New international agencies were formed to prevent another such disaster. Between 1975 and 1980, $7.46 billion in aid was committed to Sahelian countries. ..... Page 39

The 1977 UN Conference on Desertification (UNCOD) adopted a detailed plan for national, regional and international action. Transnational projects were to revolutionise stock rearing in the Sahel; establish greenbelts north and south of the Sahara; monitor west Asia and much of Latin America with satellites, and manage regional aquifers. Little that the plan called for has yet been accomplished. ..... Page 41

In the Sahel, there are few visible signs of progress against desertification. By 1980 only 1.4% of the aid money was going to ecology/forestry projects, 8% to rainfed cropping and 5% to

livestock raising. Irrigation projects are breaking down as fast as new ones are completed. Livestock numbers are almost at pre-drought levels..... Page 45

The Sahel is moving toward another disaster; and aid meant to prevent it is spent on the wrong types of projects. Cereal yields per hectare fell by 0.65% a year over 1970-78 in the Sahel. Food aid appears permanent, never below 100,000 tonnes a year. Food prices are kept low to please urban elites, giving farmers no incentive to grow for the market..... Page 53

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Tree planting - for fuel, for timber and to prevent desertification - is proceeding 50 times slower than the Sahel really needs. There are too few foresters. "Agroforestry" uses trees to enhance rather than displace crop and/or livestock production. Trees can fix nitrogen, can provide shade, firewood and fodder, and can improve the water table..... Page 76

Social forestry ("mass forestry") mobilises large numbers of people to plant and rear trees; foresters educate and encourage rather than do the work themselves. China and South Korea, despite different political systems, have made it work. In the Indian state of Gujarat, government tree-planting efforts have encouraged thousands of farmers to raise trees as crops.. Page 82

Trees can fix and then reclaim sand dunes. China does it by "mass mobilisation"; India and Somalia rely on less labour-intensive methods. Land which bad irrigation has turned into saline/alkaline deserts can be converted by multi-purpose trees into sources of fuelwood, fodder and other products..... Page 85

Desertification is low priority for politicians because the people who live in arid zones have little political power. Governments want aid spent in cities, where the results benefit the nation's elite. Aid donors want aid spent in cities and on "infrastructure" projects easy to identify and implement. Sahelian governments and aid donors say their goal is "food self sufficiency", but in reality neither is yet working toward that goal..... Page 88

INTRODUCTION

DROUGHTS AND DESERTIFICATION

A decade ago the 1968-73 drought in the Sahel was at its height. It killed thousands of people and millions of animals. It also focussed world attention on the process called "desertification": the man-made degradation of land so that it loses its fertility and its capacity to provide economic returns under cultivation or grazing.

- Following the drought, billions of dollars in aid were poured into the Sahel, and the United Nations held a major conference which proposed some precise and specific remedies for global desertification.

- But a decade after the drought, the Sahel was ripe for another disaster, and only the tiniest fraction of the 1977 UN Conference on Desertification's (UNCOD) recommendations had been implemented.

- In 1982 weather around the world conspired to remind mankind that the droughts which can trigger rapid desertification have not gone away. There were serious droughts in five continents during that year.

* Australia suffered its worst drought in half a century. Some 80,000 farms - 60% of the national total - had been stricken by mid-1982.

* Spain had its worst drought for at least a century. Italy had one of the hottest summers on record in 1982. A two-month drought devastated cereal, corn and sugar beet crops, especially in the southern regions of Sicily, Calabria, Basilicata and Puglia.

* Damage to Nicaragua's cotton and grain crops in 1982 was estimated at about $72 million as a result of a prolonged dry spell in August and September - usually the middle of the rainy season.

* Thailand's rice crop was expected to drop by at least 8% in 1982 following the summer drought, with the north east region hardest hit. India escaped drought but faced cuts in agricultural production due to the late start of the July monsoon.

* Africa also suffered. Botswana's grain production was expected to be down by 80%, and farmers were forced to slaughter cattle on a vast scale. Western Zimbabwe was seriously affected. Starving hyenas killed 20 children in drought-affected southern Ethiopia. The rains failed in Morocco for the third consecutive year. In Algeria the government asked the people to pray for rain and organised a massive operation to save seven million sheep and cattle from starvation.

- In the Sahel, the weather was as bad in 1981 as it was in the early 1970s. Dr Peter Lamb of the Illinois State Water Survey, USA, reported in the journal "Nature" in 1982 that the mean annual rainfall in the Sahel over the past five years had been no higher than in the 1968-73 drought, that there was as little rain in 1977 as in 1972 (the worst year on record) and that 1981 was hardly any better. He claimed that the continuation of the drought had been ignored because its socio-economic impact had been less than in earlier years.

- Drought is a result of weather systems, but desertification is a result of the actions of Man. Drought can trigger rapid desertification and can make its effects more keenly felt by those living in the affected area, but most scientists are agreed that changes in climate are not responsible for the vast areas of land going out of production each year.

- United Nations Environment Programme (UNEP) executive director Dr Mostafa Tolba wrote in 1982 that despite all efforts "there is no doubt that the process of desertification is accelerating, with millions of hectares (acres) of arable land being lost every year".

- Some 30 million square kilometres (12 million square miles) of arid and semi-arid land - over 20% of the Earth's surface - and the 80 million people who live there are under direct threat of desertification.

- Every year some 200,000 sq km (80,000 sq mi: an area larger than Senegal) deteriorate to the point of zero economic yield.

- Lost agricultural production costs $26 billion per year - equivalent to the 1979 Gross Domestic Product of Thailand.

- There are four causes of desertification, each made more acute by increasing human populations:

  * overcultivation;

  * deforestation;

  * overgrazing;

  * unskilled irrigation.

- The first three strip vegetation from the soil and deplete its organic and nutrient content, leaving it exposed to the eroding forces of the sun and wind. It can become as dry as dust, and blow away in the wind.

- The remaining subsoil can become hard and impervious. It can no longer absorb rain, and the water flows away over the surface, carrying away soil and cutting gullies which become deeper and wider year by year.

- Irrigation can do more harm than good if the water is not allowed to drain away from the soil. Poor drainage leaves the soil waterlogged. A high water table, and continual evaporation from the soil surface, can bring salt up from the subsoil and

leave it in the topsoil. This "salinisation" process eventually makes the soil unusable.

- Drought and the lowered resilience of the land initiate a vicious circle of degradation. Human pressures build up as people vainly try to maintain crop and livestock production while soil fertility declines.

- Desertification proper is confined to arid and semi-arid areas of the world. But it is part of a much larger picture of soil erosion in temperate regions, mountain watersheds such as the Himalayas, and tropical rainforest areas like the Amazon Basin.

- In all of these environments, Man is taking more from the soil than he should, and is not putting back nutrients, not allowing the land time enough to regenerate its fertility under fallow, not restoring the vegetative cover that can protect the soil from erosion.

- Desertification spreads slowly from small nuclei until it eventually lays waste large areas. It feeds upon itself, creating arid areas where previously rainfall was plentiful. Treatment in the early stages has a good chance of success. But if no action is taken, either because people are too poor or because of a lack of political will, halting desertification becomes increasingly expensive. Eventually recovery may be impossible.

- Recognition of desertification as a major international problem came with the UN Conference on Desertification (UNCOD), held in Nairobi from 29 August to 9 September 1977. That meeting, which produced a Plan of Action to Combat Desertification, was a direct response to the widespread concern about the tragic effects of the 1968-73 Sahel drought.

- Dr Tolba of UNEP said then that unless desertification could be halted by the end of this century it would be out of control.

- This briefing document looks again at the causes of desertification, and examines ways in which it can be brought under control.

* How has the problem changed?

* What was the UNCOD Plan of Action?

* How much of it has been implemented?

* What has happened to the promises, pledges and forecasts made in 1977?

CHAPTER ONE

WHERE, HOW MUCH, HOW FAST?

Desertification occurs in the arid and semi-arid regions of the world. It is not so much that the deserts are advancing by themselves, but that Man, by his actions, is pulling them out.

- The world has five main desert zones, which largely lie in two belts between latitudes 15 and 30 degrees both north and south of the Equator:

  * the Sonoran Desert of NW Mexico and its continuation in the desert basins of the SW United States;

  * the Atacama Desert, a thin coastal strip between the Andes and the Pacific Ocean, running from southern Ecuador to central Chile;

  * a great belt of desert running from the Atlantic Ocean to China and including the Sahara Desert, the Arabian Desert, the deserts of Iran and the USSR, the Rajasthan Desert of Pakistan and India, and the Takla-Makan and Gobi Deserts in China and Mongolia;

  * the Kalahari Desert in southern Africa;

  * most of the continent of Australia.

- Desertification occurs not in these natural deserts, but in the arid lands (200-250 mm; 8-10 inches, of rain per annum) and semi-arid lands (250-600 mm; 10-23 inches) that are nearby.

- One third of the Earth's land surface (47 million sq km, 18 million sq mi) is arid or semi-arid. This is the home of more than 600 million people - one-seventh of the human population.

- More than half of this area, 30 million sq km (12 million sq mi) or more than 20% of the Earth's surface, is under direct threat of desertification. Eighty million people live on this threatened land.

- Desertification is global. Two-thirds of the world's 150 nations are affected by desertification.

- Of the 30 million sq km (12 million sq mi) of land which UNCOD estimated was threatened by severe desertification:

  * 10.5 million sq km (four million sq mi) are in the US, Canada and Mexico;

  * 7 million sq km (2.7 million sq mi) are in South America;

  * 6.9 million sq km (2.7 million sq mi) are in Africa south of the Sahara;

* 1.3 million sq km (0.5 million sq mi) are round the Mediterranean, (eg Spain, Turkey, Iraq, Libya, Tunisia, Morocco);

* 1.7 million sq km (0.65 million sq mi) are in India and Pakistan;

* 2.6 million sq km (one million sq mi) are in Australia, West Asia and China, and other Asian countries.

- Dr Harold Dregne of Texas Tech University, USA, has estimated that over 200,000 sq km (80,000 sq mi) of agricultural land (an area the size of Senegal) are being desertified every year to the point at which they yield zero or negative net economic returns. These include:

* 180,000 sq km (72,800 sq mi) of rangelands;

* 20,000 sq km (8,100 sq mi) of rainfed croplands;

* 5,000 sq km (2,000 sq mi) of irrigated lands.

- The potential value of lost annual production is more than $26 billion - comparable to the 1979 Gross Domestic Product of Thailand.

- UNEP has estimated that desertification on the fringes of the Sahara is spreading at 1.5 million hectares (3.7 million acres) each year. Every 10 years, an area the size of Czechoslovakia is being turned into wasteland.

- Man's hunger for food is destroying the very land upon which that food must be grown. UNEP estimates that the world will lose one-third of its arable lands through desertification by the end of the century. Yet food production must be increased by one-third over the same period to feed the growing population.

- Irrigation can increase crop yields five-fold or more, and remove the risks and uncertainties associated with recurrent droughts. But poor management - notably poor drainage - is placing these benefits in jeopardy.

- Half of all irrigated farmlands in arid areas are thought to be affected by salinisation and/or waterlogging. For every hectare of newly irrigated land in the Sahel, another hectare of already irrigated land goes out of production.

CHAPTER TWO

THE CAUSES OF DESERTIFICATION

Desertification has four primary causes: overcultivation, overgrazing, deforestation and poor irrigation practices. These are influenced by three contributing factors: population changes, climatic changes and changing social and economic conditions.

- Populations are growing rapidly, making desertification more acute. Drought triggers off a crisis, but does not itself cause desertification, which usually arises as a result of a combination of two or more of the primary causes acting together.

- Arid and semi-arid lands have two key advantages as far as cultivation is concerned:

  * they are usually rich in soil nutrients;

  * they have long hours of sunshine throughout the year.

- But they also have three big disadvantages:

  * a short, uneven and irregular rainy season which allows at best for only one crop per year;

  * recurrent drought periods of one or more years when crops fail or give very poor yields;

  * a sparse covering of vegetation and low soil humus content that makes the land susceptible to erosion.

- Traditional systems of rainfed cropping have evolved over thousands of years to make the best use of whatever rain does fall. The peoples of the Sahel in West Africa developed a cropping system with five stabilising characteristics.

- First, rainfed cropping took place in areas where rain was most likely to fall in reasonable quantity and with regularity: in the south Sahelian Zone (350-600 mm; 14-24 inches of rain per annum) and the Sudano-Sahelian Zone (600-800 mm; 24-31 inches).

- The two northerly zones - the North Sahelian Zone (150-350 mm; 6-14 inches) and the Saharan Zone (less than 150 mm; six inches) - were generally reserved for the raising of livestock. Here, seasonal movements (transhumance) or irregular movements (nomadism) could best take advantage of pasture grasses, where and when they happened to be.

- Such flexibility was also the second key characteristic of rainfed cropping. A number of different crops were sown to reduce the risks of a complete crop failure.

- The third characteristic was the use of drought resistant crops such as sorghum and millet. These provided the basic

essential: food. More demanding but more profitable crops, like groundnuts and cotton, might be planted to give a second, cash crop if conditions allowed.

- Fourthly, long fallows were used to prevent stress on the land. After four or five years of continuous cropping, the land would be left idle or used as pasture for one to five or more years. In some areas, a type of acacia scrub was allowed to invade, and after five years these trees could be tapped for gum arabic for about seven years.

- During the fallow period, the soil would be protected by a vegetative covering, vital nutrients could accumulate in the topsoil, and the humus content would build up.

- Fifth, the pastoralists and sedentary farmers cooperated. They bartered cereals and meat: the cash economy is a recent innovation. The pastoralists were also able to graze their livestock on village fallow lands in the dry season when the more northerly pastures had been exhausted. Dung from the cattle was likewise important to the regeneration of crop lands under fallow.

Overcultivation - causes and effects

In recent years, traditional rainfed cropping systems have been breaking down, not only in the Sahel but in other parts of the world, such as the Indian state of Rajasthan.

- Population growth has created a demand for more food production. The need for foreign exchange has led to an increase in cash crop cultivation. Thus there has been an increase in the areas under rainfed cropping, an expansion of irrigated cropping, and a shortening of the fallow periods.

- The increase in the area under rainfed cropping has occurred at the expense of marginal lands which have traditionally been used for livestock. (In the Sahel those lie to the north of the agricultural zone.) The cultivation of these less productive and more drought-prone lands, together with diminishing returns from lands under shorter fallows, have resulted in a decrease in average crop yields per hectare (acre).

- Overcultivation of marginal lands and the consequent crowding of increasing numbers of livestock onto smaller areas of pasture has caused both crop and livestock productivity to fall and soil erosion to increase.

  * Average grain yields in Niger in the Sahel fell from 500 kilogram/hectare (445 pounds/acre) in 1920 to 350 kg/ha (312 lb/acre) in 1978 and are expected to fall even further to 250 kg/ha (223 lb/acre) by the year 2000.

  * Per capita grain production in Niger fell by 44% between 1951 and 1974. Mali, Upper Volta and Ethiopia also registered decreases. In Africa south of the Sahara,

production per capita (1951-74) increased only in Senegal and Sudan.

* North of the Sahara, per capita grain production fell in Morocco and Tunisia, and in Algeria the fall was a staggering 61%. Only Libya showed an increase (up by a half).

Overcultivation can lead to:

* declining soil fertility and falling crop yields;
* crusting of exposed topsoil by rain and sun;
* increased surface runoff, erosion of soil by water, and gullying;
* blowing away of exposed topsoil by wind;
* encroachment of sand dunes on arable land;
* destruction of crops by strong dust-bearing winds.

Overcultivation leads to desertification.

Example 1: Kordofan province, central Sudan

Between 1961 and 1973, sesame production fell by a factor of 20, and average yields of other crops dropped sharply: sorghum from one to 0.45 tonnes/hectare (0.4-0.2 tonnes/acre); maize from 0.8 to 0.37 tonnes/ha (0.3-0.14 tonnes/acre); millet from 1.3 to 0.17 tonnes/ha (0.5-0.07 tonnes/acre).

Five hectares (acres) were needed in 1973 in Kordofan to produce the same yield of groundnuts that had come from one hectare (acre) in 1961. But livestock numbers grew almost six-fold over 1957-73, limiting the available arable land.

In west Kordofan, there used to be a long-term cycle of cultivation, fallow, natural regrowth of gum arabic trees (Acacia senegal), felling and burning the trees, and cultivation once again. Jon Tinker described in 1976 the collapse of this traditional cropping system:

"The ecologically balanced cycle of gum gardens, fire, grain crops, and fallow is now breaking down. Under pressure of a growing population, the cultivation period is extended by several years and the soil becomes too impoverished to recover.

"Overgrazing in the fallow period prevents the establishment of seedlings. Gum trees are lopped for firewood. More and more widely, Acacia senegal no longer returns after the fallow, but is replaced by non-gum producing scrub. And

without the gum to harvest for cash, the farmers must repeatedly replant their subsistence crops until the land becomes useless sand."

Example 2: Oglat Merteba, Tunisia

This 200 sq km (77 sq mi) region in southern Tunisia on the fringes of the Sahara receives only 100-200 mm (4-8 inches) of rain in an average year. Transhumant grazing of sheep and goats on communal pastures has long been the dominant form of land use.

Cultivated land more than tripled in Oglat Merteba between 1948 and 1975, and the use of tractors and disc ploughs led to wind erosion of the dry, sandy soils.

Livestock numbers did not drop despite the decrease in the grazing area. Sedentarisation (the settling of nomads) meant the herds were concentrated around settlements and waterholes, increasing the pressures on both land and water.

The region could lose five cm (two inches) of topsoil by the end of this century. Degraded pasture lands by 1975 covered 25% of the total area, and desertified croplands covered 12%.

Men hoeing millet in Niger's Majia Valley. The windbreak of trees in the background keeps the winds from drying out the crop and blowing away topsoil. The trees have increased yields by 15%.

Example 3: Rajasthan, India

In 1972, almost two-thirds of India's 320,000 sq km (120,000 sq mi) of arid land lay in the state of Rajasthan. This accounted for 60% of the total land area of the state.

Although only 20% of Rajasthan's arid land is considered by FAO to be suitable for rainfed cropping, the area under cultivation virtually doubled from 30% in 1951 to nearly 60% in 1971, mainly at the expense of grazing lands and long fallows.

Both overall production and average yield per hectare (acre) fell between 1954 and 1970 for three out of the four important crops: jowar, sesame, and kharif. This is despite the fact that the area planted in sesame and kharif regularly increased over the period.

A third of the area of the Luni Development Block, 1,989 sq km (770 sq mi) of land in the east of Rajasthan's arid zone, was in 1976 classified as being under "very high" desertification hazard. The remainder is subject to "high" desertification hazard.

What do these terms mean? In 1972, 88% of the area was cultivated, the human population had trebled since the start of the century so that there were now 48 people per sq km (124 per sq mi), very high for this type of area. Natural vegetation only survived on 13% of the area occupied by common grazing lands; tree and shrub cover was sparse, and a third of the area was covered by a sand sheet 0.2-2 metres (8 inches-6ft 7ins) thick.

Things are not improving. Sand coverage was only a quarter in 1958. By 1972, existing dunes had grown in height by up to five metres (16 feet) at their crests. Wells were yielding less water, and a growing number were becoming saline.

- Reversing the trend towards expanded cropping on marginal lands in the world's arid areas will require government action. But while it is easy to make new laws, it is a very different matter to enforce them.

- Niger's government in 1962 prohibited cultivation north of the 350 mm (14 inches) rainfall limit. This has been ignored. Cropping takes place at least 100 km (60 mi) north of the legal limit, and the government seems powerless to stop it.

The peanut connection

The expansion of rainfed cropping onto marginal land is usually explained by the need to maintain or increase crop production in response to rising populations and declining yields. But the increasing cultivation of cash crops for export, rather than of subsistence crops for local consumption, may have played a big part.

- In fact, the large scale development of groundnuts (known in the West as peanuts or monkey nuts) in West Africa in the 1960s may have contributed significantly to the Sahel disaster of the early 1970s, according to Richard Franke and Barbara Chasin of Montclair State College, New Jersey, USA.

- The expansion of groundnut cropping in Niger and other Sahelian countries caused a large reduction in the amount of fallow land in the agricultural zone. Nomadic pastoralists had traditionally used the land for grazing their animals in the dry season. Instead, they were forced to intensify use of grazing lands to the north. This caused further desertification, and increased the nomads' exposure to the risks of drought.

- Groundnuts grow well in areas with an average annual rainfall of about 500 mm (20 inches). In the early 1950s, the largest groundnut producers were Nigeria and Senegal, two countries which normally receive at least this much rainfall.

- In the 1950s, a major expansion of groundnut production took place in Niger and Sudan. In Niger, production rose from 160,000 tonnes per annum in 1955 to 290,000 tonnes in 1965, and in the Sudan rose from 120,000 to 310,000 tonnes.

- These increases were mainly for export. By 1964, 68% of Niger's exports were groundnuts or groundnut products. Production also increased in Senegal, Mali, Upper Volta and Chad.

- After World War II, France encouraged its West African colonies to increase groundnut production in order to combat the US campaign to dominate the European market for vegetable oils with the soya bean. The incentive to expansion was an artificially high guaranteed price which protected West African producers against shifts in the world market price.

- After independence in 1960, farmers in Niger received more highly productive seeds that had been developed at the Bambey Research Station in Senegal.

- From 73,000 hectares (180,000 acres) in 1934, groundnut cultivation increased to more than 142,000 hectares (351,000 acres) in 1954 and to 349,000 hectares (862,000 acres) in 1961. It reached 432,000 hectares (one million acres) in 1968 on the eve of the Sahel drought.

- Southern Niger is on the edge of the 500 mm (20 inches) rainfall zone, where rainfall is very variable. Most farmers did not wish to become too reliant on groundnuts. So the nuts were grown on the fallow lands that were traditionally used by nomadic pastoralists as seasonal grazing.

- By 1961, half of all the farmers in the Maradi district of Niger depended upon groundnuts for 50-60% of their incomes, with the remainder having a lesser but significant dependence.

- But in spite of the guaranteed price, living standards declined. The returns from growing a kilogram (pound) of

groundnuts could be exchanged for a decreasing weight of staple foods.

- So farmers had to grow more and more groundnuts to maintain their living standards. They did this by using improved seeds needing shorter growing cycles and less rain. This further decreased fallow periods in southern Niger and enabled cultivation to spread north of its previous boundaries into drier areas normally used mainly for grazing. Thus the areas available to pastoralists were further reduced, and increasing pressure was placed on the more sparsely vegetated lands most vulnerable to desertification.

- How significant was the "Peanut Connection" in the events leading up to the Sahel disaster? Experts disagree. Mauritania, Mali, Upper Volta and Chad did not experience anything like the same expansion in groundnut cultivation as did Niger.

- Senegal, on the other hand, now has one million hectares (2.5 million acres) under groundnuts - half of all cultivated land in the country. Senegal derives about one-third of its export earnings from groundnuts, and is the world's fourth largest producer.

- Continuous cultivation for up to 90 years in places has led to soil degradation and declining yields. Pressures on farmers to maintain production result in neglect of fallows and consequent loss of fertility.

- At Thyss-Kaymore in Senegal, for example, groundnut yields have fallen from 2.5 tonnes per hectare (one tonne per acre) in 1940 to one tonne per hectare (0.4 tonnes per acre) today.

- Other countries in the Sahel considerably expanded cultivation of cotton in the 1960s. In Mali the increase was 82%; while in Upper Volta cotton growing more than trebled. Chad, the biggest producer, increased cultivation by nearly 90,000 hectares (222,000 acres).

- In southern Chad, a "showcase" project tripled the cultivated area to 144,000 hectares (356,000 acres) and also tripled the average yield to 900 kilograms per hectare (800 pounds per acre). But a joint report by the Sahelian states' organisation CILSS (Permanent Interstate Committee for Drought Control in the Sahel) and the donors' group Club du Sahel comments that the project "was implemented partly to the detriment of foodcrop production and, in particular, the extraordinary growth of cotton production was achieved without any particular concern for the maintenance of soil fertility".

- There are signs that cash cropping in the Sahel is on the decline, because of peasants' concern with maintaining production of their subsistence food crops. In Niger, for example, the area under groundnuts fell from 400,000 hectares (990,000 acres) at the start of the 1970s to 165,000 hectares (408,000 acres) in 1977-78.

- Some of the land taken out of groundnut cultivation is now under millet and sorghum, and there has been an expansion in the area under niebe, a valuable subsistence bean which enriches the soil with nitrogen.

Livestock

There are three main pastoral systems in arid and semi-arid lands:

* nomadic (or transhumant);
* sedentary and village-based;
* ranches.

- Nomadic grazers make the best use of marginal arid lands where rains may or may not come, and where the vegetation is low in quantity and sparsely distributed. The herdsmen know the best places to take their livestock, and leave for the next grazing ground when one has been used up.

- There are two kinds of nomadism. In true nomadism the animals move more or less continuously, following no set pattern. In transhumance, the herdsmen move their livestock along more predetermined routes; they move each year from the same wet-season grazing lands in the arid zone to dry-season grazing fallow lands and stubble in the semi-arid agricultural zone.

- "True" nomadism, such as that practised by the Moors in northern Mauritania, usually involves the herding of drought-hardy camels, goats and sheep, with perhaps a few cattle. Transhumance, as for example practised by the Fulani people in Niger, consists chiefly in the herding of cattle over shorter distances.

- As a UNEP expert has said: "Herdsmen have found many ways of coping with the climatic stress that typifies their arid landscapes. Ordinarily, they spread their stock thinly over large areas so that grazing pressure is lightened and they can take advantage of the patchwork ecosystems of arid lands where topographical variety yields good pasture only here and there.

- "They are mobile, often traversing great distances to reach seasonal pastures. Pastoralists, including nomads, must not be thought of as 'wandering'. Familiar with the land and what it provides, they have a clear idea of where they are headed."

- Keeping a diverse herd of animals is an important way of insuring against drought. Sheep and goats continue to lactate during dry periods and have high reproduction rates. Goats and camels will survive droughts better than sheep and cattle.

Cash crops and growing populations are pushing subsistence crops onto marginal land once used for grazing. Growing herds are forced onto shrinking rangelands. The production of pasture grasses falls. When drought comes, animals die of hunger, not thirst.

- Rainfed farmers in the semi-arid areas will usually keep some animals as well, grazing them on fallow and on communal village grazing lands. The relatively limited areas of such pastures within reach of villages mean that they are usually used quite intensively and suffer a considerable amount of degradation.

- Nomadic grazers and sedentary farmers have long had a symbiotic relationship. Meat and milk are exchanged for grains and legumes. Fallow lands are grazed by nomadic herds in return for the fertilizing value of the dung, for cash or other goods. The nomads may take the villagers' animals off to seasonal pastures. They may also provide seasonal labour in oasis settlements or even own some cropland themselves.

- There is another important symbiotic relationship in West Africa, that between the pastoralists (herdsmen) in the Sahel and urban people in the coastal states to the south.

- Raising livestock in the humid coastal forest belt is virtually impossible, owing to the debilitating tsetse fly. Countries like Nigeria and the Ivory Coast therefore depend heavily on meat from animals raised in the dry northern zones. These animals have often trekked for hundreds of kilometres

(miles) - losing weight in the process before slaughter, in order to save on transport costs. By 1970, Niger alone was exporting 170,000 cattle every year.

- The development of lucrative markets in countries like Nigeria and the Ivory Coast has encouraged the establishment of cattle ranches in the Sudano-Sahel. As in similar ranches in the USA and Australia, overgrazing and consequent desertification are prevalent.

Overgrazing

Nomadic grazers were widely blamed for causing the Sahel disaster. By keeping too many animals, it was said, they spread desertification through fragile land.

- Overgrazing is indeed a major cause of desertification, but the syndrome is not quite as simple as was first thought. Although the nomads are the main exploiters of arid land, desertification takes place throughout the arid and semi-arid zones and not just on the edge of the desert. Nomads are also affected by overcultivation by farmers in higher rainfall areas.

- There are two main reasons for widespread overgrazing in the drylands:

  * increases in the sizes of herds;

  * decreases in the areas of pastures available to them.

- Livestock density has gone up, and so the pressure on the land has increased.

- The number of cattle in Niger increased by four and a half times between 1938 and 1961, when it reached 3.5 million, and then by a further 29% by 1970.

- There were nine mil[illegible] sheep and goats in Niger in 1970, a third more than in 1961 and over three times the number in 1938. The number of camels went up by a factor of seven between 1938 and 1966 and the number of donkeys doubled.

- The Sahel drought hit the herds hard. One estimate, from the UN Food and Agriculture Organization (FAO), was that 39% of the cattle and 10% of the sheep and goats were lost between 1970 and 1974.

- In the worst affected districts, mortality was much higher. Niger's Agadez department lost 88% of its cattle, 80% of its sheep, 70% of its goats and 45% of its camels in 1968-74.

- Despite the depredations of the drought, these large stock losses were not used to reduce stocking levels to those nearer the carrying capacity of the land.

- In Sudan's Kordofan province, for example, the number of cattle more than quadrupled from 600,000 in 1957 to 2.4 million

in 1977 (after the drought). The number of sheep and goats went up by a factor of nine in the same period; the number of camels increased by a factor of 5.5.

- In the Sahel as a whole, the numbers of cows, sheep and camels are 70% of their pre-drought (1968) levels, while the numbers of goats, horses and donkeys are equal to pre-drought levels, according to a 1980 UN Development Programme report.

- In Niger, there were 4.2 million cattle and eight million smaller animals (sheep, goats, donkeys) before the drought. In 1982 there were 3.2 million cattle and eight million smaller animals, according to government officials, who said the national livestock policy since the drought had been simply to rebuild herds.

- According to French rangeland expert Michel Baumer: "The situation has become extremely precarious in the Sudan as in all countries in the region, and is today much more delicate than in the late 1960s. The next serious drought might well entail more severe consequences than the last one."

Village waterhole, Niger. Livestock graze around waterholes, stripping bare the soil and trampling it, sealing it against rain. But left alone for a while, such land, fertilized by high concentrations of dung, can recover rapidly.

- Overgrazing is not just a problem in the Sahel:

  * large areas of semi-arid grasslands in Kenya, Tanzania and Ethiopia have been degraded;

  * in northern Iraq, the rangelands carry one million sheep-four times their sustainable capacity;

  * Syria's rangelands have three times as many sheep as they can safely carry.

- However, not all experts agree on overgrazing and range degradation. The concept of "carrying capacity" is not precise, and it does not follow that an "expert" can calculate it better than a herdsman.

- There is evidence that damage to rangeland from overgrazing is often not permanent. Land near water holes which has been denuded of all grass by heavy grazing and trampling has often been observed to recover rapidly when rains come, often fertilised by the high concentration of dung. And in many arid zones, fencing off small areas of degraded pasture from livestock produces dramatic recoveries of pasture in a matter of months.

Overgrazing can lead to:

* a decline in the annual production of pasture vegetation;

* a decline in palatable grass species, particularly perennials which are also good at holding the soil together;

* an increase in ephemeral plants, which spring up with the onset of the rains rather than having a permanent presence, decreasing the durability of pastures;

* soil compaction and sealing as a result of trampling by stock near waterholes and overgrazing wet-season pastures;

* damage to vegetation on crests of formerly stable dunes, so that the sand becomes bare and starts to move;

* a decline in the health of livestock and a fall in the production of milk and meat.

Overgrazing causes desertification.

- What has caused such dramatic increases in herd sizes? The growing human population is a major factor: there are more mouths to feed.

- Of the six main Sahelian countries (Senegal, Mauritania, Mali, Upper Volta, Niger and Chad) four have annual population growth

rates of 2.5% or more, and one other has a growth rate greater than 2% per annum.

- The current annual increase in population in the region is around 1.5 million, or 2.5%. This is up to 10 times the death toll in the Sahel drought, estimated variously as between 50,000 and 250,000.

- The populations of nomads are increasing as fast as sedentary farmers and city dwellers.

- In the Sahel and probably in other areas also, nomads have become increasingly impoverished as a result of the decline in the 20th Century in their traditional trading role in salt, slaves, arms and gold.

- Richard Franke and Barbara Chasin wrote in "The Ecologist" (July/August 1981) that in northern Niger at the beginning of the 20th Century a camel laden with salt "could be converted into 15-20 loads of millet. By 1945-50, the same salt brought only 6-10 loads of millet. By 1974, the salt was worth but two loads of millet in a good year, but often would bring only an equal weight. Overall, this amounts to a 95% drop in terms of trade for the nomads."

- This also led to the nomads losing their main source of acquiring valuables, such as arms, gold and jewels, which could be stored against hard times such as droughts. So increasing herd sizes was the only way in which they could save for the future.

- Thus the livestock itself is regarded as the resource base, instead of the land and its vegetation.

- Overgrazing of the land is often of less concern than having enough animals to maintain viable herds in the aftermath of drought.

- In good years with plenty of rain and good pasture growth, the herds are allowed to increase. When the first signs of drought appear, herdsmen are reluctant to reduce stock numbers, and so the drought-stressed pastures become overgrazed and degraded. After a drought, herd sizes are increased more rapidly than rangelands can regenerate.

- Improved veterinary care has decreased livestock mortality (in normal circumstances) just as modern medicine has improved human health. Departments of animal production developed out of colonial veterinary services whose main object was to supply disease-free meat, saddle animals and draught animals to the armed forces. The emphasis until recently has therefore been on vaccinations against rinderpest and other infections, rather than on breeding strains suitable for dryland conditions.

- The other factor contributing to an increase in livestock density, and thereby also to increased overgrazing, is a decrease in the area available for grazing.

- The expansion of rainfed agriculture in semi-arid and arid zones has meant the ploughing up of marginal lands previously used as grazing for livestock.

- In Rajasthan, India, the area of arid land used for rainfed cropping almost doubled from 30% to 60% between 1951 and 1971, at the expense of grazing lands. Despite the decrease in the area of pasture, both animal numbers and livestock density increased, the latter by 75%.

- There are three other ways in which the impact of livestock is being increased in arid lands:

  * settlement of nomads;

  * new waterholes;

  * the liberation of the vassals and slaves of the nomads.

- Most governments are "encouraging" nomads to settle and give up their itinerant lives. Nomads are difficult to tax and control. They cross frontiers and carry arms. Their constant movement hampers the provision of education, health care and other social services. And the expansion of rainfed cropping is causing conflicts between farmers and herdsmen which governments are anxious to avoid.

- Voluntary or enforced settlement of nomads breaks up large herds into smaller units. These tend to become concentrated around villages, causing degradation of vegetation and soil erosion.

- Livestock also congregate around wells and boreholes, overgrazing vegetation and compacting the soil up to 20 km (12 mi) from the well itself.

- Thousands of new wells and boreholes have been constructed in the Sahel since the end of World War II. More than 600 were dug in Mauritania, Mali, Upper Volta and Niger between 1949 and 1954 by one organisation alone (Fonds d'Equipment et de Developpement Economique et Social).

- A well-digging programme in Senegal caused violent conflicts between herdsmen and farmers, both of whom were attracted by the new water supplies. Moreover, the new wells reduced the previous diversity of herding routes. Frank and Chasin described the repercussions: "The nomads, who were being driven by the expanding peanut cultivation, were gathering in greater numbers along the trek routes, where the wells were providing water. But this very increase in herd density led to a destruction of vegetation along the trek routes and has thus contributed to soil erosion."

- In Niger, many of the wells in the region north of Tahoua were attracting up to four times the numbers of animals for which they had been designed.

- A study of the Agadez and Azawak regions in Niger prepared for UNCOD showed: "Strategies envisaged to restrict grazing around these points did not work. Grazing loads were 2-3 times those envisaged... It proved impossible to refuse water to herdsmen in an effort to restrict grazing pressure or to reserve certain pastures...

- "The cumulative effects of trampling and of grazing during the wet season resulted in devastated areas extending 10-12 km (6.2-7.4 mi) around watering points... It was the failure of pastures, not of waters, that led to deaths of stock."

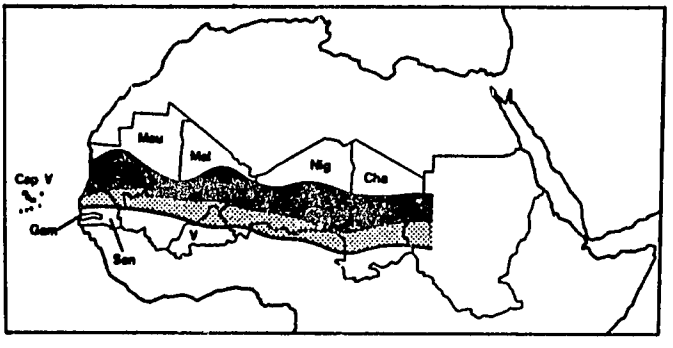
- Extensive grazing in the Sahel has been possible for many centuries because of the social control exerted by the nomads themselves over the movements of their animals. These controls have broken down more as a result of outside interference than from any other cause.

- In the Sahel, the nomadic Tuaregs, for example, have become impoverished as their commercial and trading functions have been sharply reduced. The expansion of cash crop cultivation and the introduction of the cash economy generally have had serious impacts on their access to pastures. The digging of wells has caused a disintegration of the previous sharp divisions between the territories which could be grazed by different peoples.

- The liberation of their former slave and vassal groups, now having their own herds to graze, has exacerbated the problem of growing human populations.

- Tunisia - unusually among governments - wants nomadic grazing to continue, and is looking at new ways of integrating it with other land uses so that it becomes again a sustainable practice.

- One idea is to link nomads with oasis farmers. The oasis produces the forage (lucerne, date and olive wastes) for the livestock, and animals reared on the ranges can be fattened there.



Throughout the Sahel nations, the northern or Sahelian zone (hatched) has an average annual rainfall of 100-400 mm (4-16 inches): the southern or Sudanian zone (dotted) a rainfall of 400-800 mm (16-32 inches).

Ranchers or nomads?

Large ranches are the more typical kind of pastoral system in the dry areas of developed nations like the USA and Canada, but are not without their problems. In the US, more than half of the privately owned rangelands are, owing to overgrazing and consequent soil erosion, producing forage at half their potential, or less.

- A survey of a 64,000 sq km (25,000 sq mi) area in the Gascoyne Basin of northwest Western Australia in 1969-70 showed that, after 60 years of heavy sheep grazing, 15% of the area was so badly degraded and eroded that continued grazing was expected to result in irreversible deterioration. More than half of the area was degraded with some erosion and in need of proper management.

- Too little advantage has been taken of good years, to keep stock numbers down and regenerate pastures. Many of the less productive properties in the Gascoyne Basin region are likely to be abandoned during the course of this decade because their owners cannot afford to run them at sustainable carrying capacities.

- Western-style ranches are springing up in Africa. Between 1964 and 1968, 110,000 hectares (272,000 acres) of land was closed to traditional transhumant herders at Ekrafane, 300 km (185 mi) north of Niamey in Niger, for the establishment of a cattle ranch producing beef for export.

- Ranches in Africa have not been very successful. Comments the Club du Sahel: "Results on the whole have not been satisfactory: the investments called for were too heavy; the farms, placed in regions poor in resource, resulted in mediocre productivity; and finally, marketing of production was hampered because the ranches were too far from the large commercial centres."

- Another major reason for the failure of most commercial ranches in Africa has been their orientation towards meat production, among peoples who use livestock mainly to produce milk. Moreover, commercial ranches have rarely even attempted to integrate their work with the pastoralists already there.

Bad irrigation

For many years, irrigation has been the developed world's single-minded and often simplistic recipe for growing more food in the arid tropics.

- Irrigation can lead to a six-fold increase in the yields of cereals and up to five-fold increases for root crops. Some 250 million hectares (618 million acres) of irrigated farmlands exist at present, accounting for about 13% of all land under cultivation in the world.

- As well as improving yields, irrigation can remove arid lands' susceptibility to crop failure during droughts. It also can, in

theory, help to stem the vicious circle of desertification, in which the area of (often marginal) land under cultivation is constantly increased to compensate for falling yields caused by poor farming practices.

- Irrigation also means big money for construction and other companies in developing and developed nations. In 1980 the World Bank and its soft loan affiliate, the International Development Association, lent $1.2 billion (over a third of all Bank lending for agricultural development) to developing countries for irrigation schemes with budgets totalling $2.6 billion.

- But if not properly designed and managed, irrigation can turn land into desert.

- Throughout the world's arid zones, 500,000 hectares (1.2 million acres) of irrigated land becomes desertified every year, roughly the same area as is newly irrigated each year.

- If irrigated land is not drained properly, the soil becomes first waterlogged, and then salinised or alkalinised with formation of a salt crust on the surface. But too often the building of dams and irrigation channels gets most or all of the attention. The need for adequate drainage is neglected or forgotten.

- If irrigation water cannot drain off, the soil becomes waterlogged and salts are not leached away. (These salts come either from the soil itself or from the irrigation water.)

- Waterlogged soil is itself difficult to cultivate. When the dry season comes, high temperatures encourage evaporation of water from the soil. This produces a "pumping" action which brings water from lower soil levels up to the surface. As the water evaporates, the soil water becomes saltier nearer the surface.

- Saline soils still have relatively good structure which allows fairly easy leaching of the salts they contain, so they can often be reclaimed. But alkaline soils are very compacted; they are not good for leaching, and the roots of trees and shrubs cannot penetrate. This makes them difficult to reclaim.

- Salinity is a problem in two other situations not directly connected with irrigation. The first is where deforestation or excessive use of wells has caused a lowering of water tables, allowing encroachment of sea water in the subsoil of coastal or estuarine environments. China's coasts have been much affected this way.

- Deforestation around river estuaries in Senegal has led to the extensive formation of salt flats that are expanding in size every year. A quarter of the area of one department near the town of Fatick is occupied by salt flats.

- Secondly, deforestation of watersheds increases stream flow, flooding, and the concentration of salts such as sodium chloride dissolved out of the soil.

- In Western Australia this has led to an increase in the salinity of rivers and reservoirs, and caused waterlogging and salinity in lowland agricultural areas, affecting a total of 170,000 hectares (420,000 acres) of agricultural land.

- Poor irrigation practices can have two other harmful effects. Too many wells can cause the water table to fall drastically. Eventually, if the wells become dry, the land may have to be abandoned. Groundwater is only used in about a tenth of all irrigation projects, but is extremely important in the most arid areas.

- Groundwater is liable to be saltier than surface water. Heavily exploited water may become increasingly saline owing to being continually recharged with salty water. This will lead to salinisation of the soil.

- The installation of many slow-moving irrigation canals may also spread debilitating diseases by encouraging the breeding of malarial mosquitoes or the snails which act as hosts for the bilharzia fluke.

- Iraq has depended upon irrigated agriculture for 4,000 years. The Mesopotamian, Assyrian and Babylonian civilisations rose and fell as crop production in the "Fertile Crescent" of the Tigris and Euphrates river basins successively increased as a result of irrigation and declined owing to salinisation of the soil and the silting up of irrigation canals.

- Iraq's Greater Mussayeb Irrigation Project started in 1953. At the outset, 60% of the land was saline; irrigated land was poorly surveyed and levelled; there were no field trials to determine the water requirements of different crops; managerial staff were inadequate; irrigation canals silted up; and drains were badly maintained.

- By 1969 waterlogging was common, and two-thirds of the soil was saline. Yields fell, and barley was substituted widely for wheat. Many farmers reverted to the traditional "nirin" system: cultivating cereals under flood irrigation until the land becomes saline, then leaving it fallow so that the rain can leach salts out of the soil.

- In 1965, a $10 million rehabilitation scheme started, with FAO and UNDP support from 1970. Improvements included more technical staff, tile drains to prevent waterlogging, the repair of canals, and reclamation of saline lands.

- But problems persisted. By 1974 one-third of the saline land had been reclaimed, but inadequate extension services meant that within five years from the start of the scheme, many farmers were reverting to the "nirin" system again. The canals were still silted up (2,700 tonnes of silt were deposited each day); drainage ditches filled up with windblown silt; and few tile drains were installed.

- UNCOD was told that in 1976 the project remained a failure: 64,000 hectares (158,000 acres) supporting only 32,000 people. Farm income represented less than a 5% return on capital

invested, and most farms still grew subsistence rather than cash crops.

- Pakistan has one of the largest irrigation systems in the world: 42 principal canal systems covering 62,000 sq km (24,000 sq mi). By 1976 water tables which were originally 24-27 metres (79-89 ft) below ground were at or near the surface. In Pakistan as a whole, almost 50% of soils were more or less saline, and 20% were highly saline. In Sind, 98% of soils were saline, of which 50% were highly saline.

- Land use on the Golodnaya Steppe in Soviet Central Asia was once similar to that of the Sahel - dominated by nomadic cattle grazing. Irrigation of the fertile loess-type (fine, dusty) soil began in 1902, and the subsequent history of salinisation has many lessons for developing countries wanting to develop their agricultural production by means of more irrigation.

- By 1908 the water table had risen from 10-20 metres (33-66 ft) to 1.2-1.6 metres (4-5 ft) below the surface, and 44% of the irrigated land was saline. Some 6% was irretrievably lost to salinity and the remaining 38% was severely saline.

- Drainage construction to cure salinisation began in the 1920s (by which time more than 20,000 hectares (50,000 acres) had been irrigated) although the main drains were not completed until the 1950s. By 1953-54, 92% of the irrigated land was saline. During the 1960s, up to 20,000 hectares (50,000 acres) of new land was irrigated every year; between 6,000 and 10,000 new settlers arrived annually, and energetic efforts were made to drain the soil. Despite this effort, 86% of the more than 250,000 hectares (618,000 acres) of land which had been irrigated by 1970 was saline.

- Irrigation has caused problems in many other countries. In Jordan, excessive demands on wells have lowered the water table, made wells saline, and thus salinised the soil. The story in the United Arab Emirates is similar.

- The costs of failing to design and manage irrigation projects correctly are huge, both in human terms and in the effects on the land and environment in general. Rehabilitation of failed irrigation schemes can be expensive.

- In Algeria, the first stage of a rehabilitation project involving some 18,500 families in the Cheliff Basin is costing $13.3 million.

Deforestation

Clearance of open woodlands in the arid tropics is taking place at the rate of four million hectares (10 million acres) per year, according to FAO estimates.

- Africa is the worst affected continent, losing 2.7 million hectares (6.7 million acres) every year.

- The removal of trees benefits cropping and grazing in the short term. But soon the water table may start to fall, the unprotected soil may erode, and the area becomes more arid and dusty.

- "When trees go, deserts come", said Richard St Barbe Baker, founder of The Men of the Trees organisation.

- It is not easy to measure the loss of open woodlands in the drylands. When animals die of starvation, their carcasses can be counted. But nobody counts every tree that is chopped down to make way for agriculture or to be burned as fuel.

- One way of assessing the absence of tree cover is by looking at the availability of fuelwood in different areas. However hot the days may be in the drylands, the nights can be very cold. Wood is needed to provide warmth and for cooking the evening meal.

- Half of all the wood used in the world is burned as fuel, mainly in developing nations. Four-fifths of all wood harvested in the tropics (825 million cubic metres; 30 billion cubic feet every year) is used for fuelwood or for making charcoal.

- About 90% of people in developing countries depend upon wood as their main source of fuel. Perhaps half of the fuelwood is used for cooking, a third for heating water and providing general warmth, and the remainder for agricultural and other processing purposes (making bricks, baking bread, etc).

- The average citizen in a Third World country burns as much wood every year (one cubic metre; 35 cubic feet) as a North American consumes in the form of paper.

- In South Asia, West Asia and North Africa, where wood is scarce, annual per capita consumption may fall to half a cubic metre (18 cubic feet) or even less.

- FAO recently published a survey which suggests that the current deficit of fuelwood supplies in arid regions is equivalent to the sustained production of 25.8 million hectares (64 million acres) of intensively managed, fast growing fuelwood plantations. This deficit will more than double by the end of the century.

- Fuelwood shortages are common throughout the Sahel, and in Sudan, Ethiopia, Somalia, India, Pakistan, Bangladesh, Central America and such arid parts of South America as NE Brazil.

- Growing urban populations need fuelwood and charcoal, exerting a tremendous pressure on nearby woodlands. Dense acacia woodlands were common around the Sudanese capital of Khartoum in 1955, but by the 1970s only isolated woodlots survived within 90 km (55 mi) of the city.

- A USAID report states that if the present rate of overcutting in the Sahel persists until the year 2000, native woodlands will then be able to supply only 20% of the regional fuelwood demand.

- In Upper Volta, demand for wood already exceeds the regeneration capacity of forests and woodlands, according to CILSS.

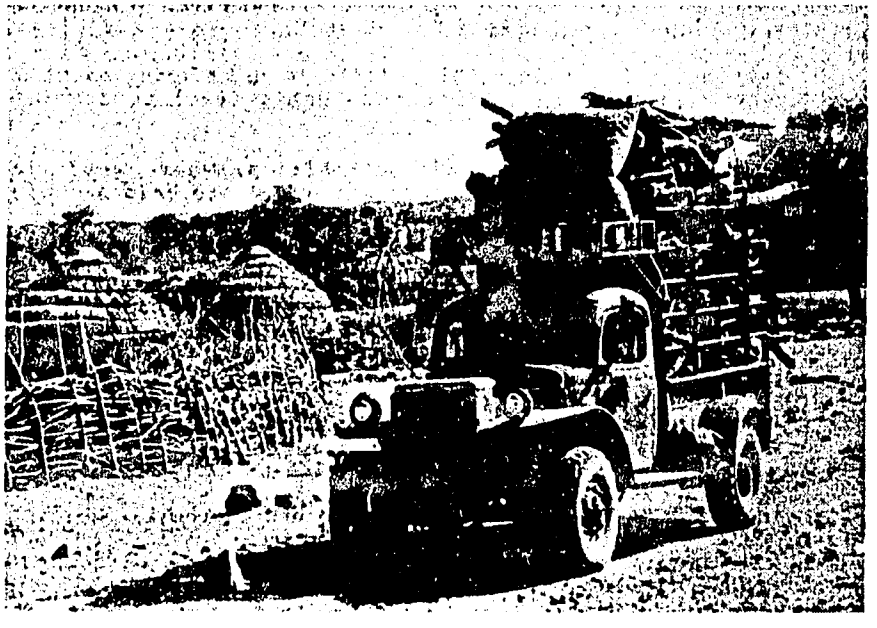
- Ouagadougou's fuelwood consumption accounts for 95% of national forest production. Almost all of the trees within 40 km (25 mi) of the city have been felled.

  * Women in Upper Volta may have to walk for 4-6 hours, three times a week to gather wood to cook the evening meal.

  * In central Tanzania it may take 300 man-days (usually woman-days) per year of work to provide the wood for an average household.

  * In urban areas, families spend as much as a quarter of their income on buying fuelwood or charcoal.

- Prices of fuelwood are rising rapidly, even more steeply than the price of kerosene, the most common alternative. A load of wood that could be bought for the equivalent of $1.20 in one town in Upper Volta in 1970, cost $5.90 in 1979.



Fuelwood is so expensive that it is worth a lorry owner's time to collect it and transport it to the cities. Thus many Sahelian capitals are surrounded by treeless wastelands. The price of fuelwood in the Sahel increased five-fold between 1970 and 1979.

- Erik Eckholm, in his book Down to Earth (W W Norton and Co, New York; and Pluto Press, London, 1982) describes the racketeering that is perhaps inevitable in such situations: "Well organised syndicates bring fuel by truck, camel and donkey into cities like Ouagadougou in Upper Volta and Niamey in Niger, damaging the landscape in a widening circle".

- "In Sudan, forest rangers have accosted armed crews as they fill trucks with illegally cut wood that will be converted into charcoal for sale in the cities. Shoot-outs reminiscent of the American Wild West have occurred."

- "Rising firewood prices can tempt desperate individuals as well as greedy big-time entrepreneurs into cutting live trees. Near Bhopal, the capital of India's Madhya Pradesh State, the forest department has granted people the right to collect headloads of dead wood in the forest reserves for personal use. Yet throughout these reserves are signs that 'dead wood' is being actively manufactured: trees with their bark girdled and trees axed outright."

- Where trees are scarce, people are forced to collect the dung dropped by livestock for use as fuel, thus further depleting the soil's fertility. In India, 60-80 million tonnes of dried dung are burned as fuel each year, providing 10% of national energy.

- The use of dung as fuel is increasing in many arid countries, even those considered to be relatively prosperous - in Morocco and parts of Turkey.

- Dr Michael Arnold, an FAO fuelwood expert, estimates that the loss of grain production in Asia, Africa and the Near East which results from the diversion of dung from the soil to the fire could be as much as 20 million tonnes per year.

- Enough food to feed 100 million people is lost by burning dung: one third as much again as the annual increase in population in Africa, Asia and Latin America.

- Farmers on semi-arid plains can be affected by deforestation taking place hundreds of kilometres (miles) away - on the watersheds of the rivers upon which they depend for irrigation water.

- Forest cover on the Himalayan watershed in India is down to 25%, too little to hold back the monsoon rains and release them in an orderly flow over a period of months. In autumn 1978, when the waters raced down to the lowlands, they flooded 66,000 villages, killing more than 2,000 people and 40,000 cattle. The value of lost crops in just two states - West Bengal and Uttar Pradesh - was put at $750 million. Direct expenditure in India to offset flood damage averaged $250 million a year between 1953 and 1978.

- There are other costs. Soil erosion on deforested watersheds leads to constant silt deposition in the multi-million dollar reservoirs that are seen as the lynch-pins of both irrigation schemes and flood control.

* Silt build-up will make the Ambuklao Dam in the Philippines useless just 32 years after it was built.

* Pakistan's new Tarbela Dam has an estimated life of 50 years, and probably less.

* Seventeen of India's major reservoirs are silting up at three times the expected rate.

- On 12 August 1979 a dam above the industrial town of Morvi in Western Gujarat, India, was so full of sediment that it was unable to hold back flood waters pouring down from the Himalayas. The dam burst, unleashing a five-metre (15-foot) high wave of water and mud on the town, killing some 15,000 people.

The climatic trigger

Ten years ago, some took the 1968-72 Sahel drought as an indication of a long term trend towards greater aridity in West Africa and other parts of the arid and semi-arid zones. The Sahara, it was said, was spreading south because the various rainfall belts were moving south.

- However, in a detailed study for UNCOD, Professor Kenneth Hare of the University of Toronto, Canada, stated, after reviewing all the available evidence: "There is no firm basis for claiming that the extreme weather events of the 1970s are part of a major climatic variation."

- E G Davy reported similar findings in a report prepared for the World Meteorological Organization: "No serious analysis of available data is known to show a falling trend of rainfall in the zone over the periods for which records are available." This applies to the Sahel, and also to arid areas in India and the Middle East.

- There is overwhelming evidence to suggest that droughts are a regular occurrence in the lands. When they will occur, how long they will last, and just how large an area will be affected cannot be predicted at the moment.

- Anders Rapp, a Sahel expert at the University of Lund in Sweden, has analysed data on the rates of flow of the rivers Senegal and Niger. The minimum levels of both rivers between 1910 and 1914, and also in 1940 and 1944 in the case of the Senegal river, confirm the occurrence of two other major droughts this century.

- The Niger River had minimum flows between 1907 and 1908 and between 1913 and 1917. This would seem to suggest that drought was more prolonged between 1907 and 1918 than it was in the most recent drought between 1968 and 1973.

- However, Dr Peter Lamb of the Illinois State Water Survey has challenged the view that the Sahel drought is over. He wrote in the journal Nature in 1982 that the mean annual rainfall over the past five years had been no higher than in the period from 1968

to 1973. Rainfall in 1981 was little better than in 1972, the worst year on record. He suggested that the continuing drought had been ignored because it did not produce the same human suffering as over the 1968-73 period.

- Drought triggers a crisis, but does not cause it. Overcultivation and overgrazing weaken the land, allowing no margin when drought arrives. Thus high human pressure will continue during the drought, leading ultimately to even greater and more visible damage to the land and the deaths of large numbers of animals.

- When rainfall returns to more "normal" levels, as it did in the Sahel in 1974, there is a natural tendency to intensify farming again. Michael Glantz and Richard Katz, of the National Center for Atmospheric Research in Boulder, Colorado, USA, question this notion of "normality".

- They point out that the most important aspect of Sahelian rainfall is its variability. Referring to "average" rainfall in terms of the mathematical mean ("the average") is highly misleading. "Rainfall observations close to the mean do not occur often in the Sahel.

- "Recent weather tends to influence perceptions more heavily than earlier weather, and wet spells more heavily than dry ones. On this basis it has been suggested that the inhabitants of the Sahel have adopted practices during the abnormally wet years which end in disaster during the dry years. After a period of abnormally high rainfall in the Sahel which ended in 1965, the inhabitants considered a return to average conditions for rainfall to be a drought."

- Planning for the probable occurrence of drought is therefore more important than commissioning expensive research to predict when drought will recur.

- Most parts of the world experience fluctuations in climate. But semi-arid regions are more vulnerable to the effects of such fluctuations. As a UNEP expert put it: "In general, the drier the climate, the greater the rainfall variability and the higher the drought risk."

- What of the future? Climatologists are divided over predictions of the general trend of world climate, now being greatly affected by man-made as well as natural factors. There are two counteracting trends.

* Global cooling. Volcanic eruptions, plus an increase in airborne dust as a result of man's industrial activities and of desertification, contribute to this cooling by reflecting back into space more of the sun's heat radiation than previously. This is the albedo effect, which some believe will lead ultimately to a new Ice Age.

* Global warming. More carbon dioxide (along with some other gases) is being released into the atmosphere from burning fossil fuels and the clearance of tropical forests. Carbon dioxide allows incoming sunshine to heat up the earth, but

holds back the heat that would otherwise be radiated back out into space. The heat stays in the atmosphere, and average global temperatures rise. This is called the greenhouse effect. Most climatologists believe it will be causing a significantly warmer global climate by the early 21st Century.

The population explosion

The world's drylands are not immune to the population explosion.

- Every year the population in the six main countries of the Sahel (Senegal, Mauritania, Mali, Upper Volta, Niger and Chad) increases by 1.4 million - slightly more than the entire population of the city of Algiers.

- Out of 24 countries whose populations grew by an average of 3% or more between 1970 and 1978, no less than 15 were suffering from desertification: Algeria, Ecuador, Iran, Iraq, Jordan, Kenya, Kuwait, Libya, Mexico, Mongolia, Saudi Arabia, Syria, Tanzania, Uganda, and Zambia.

- Urban expansion can have detrimental effects on adjacent lands and particularly on nearby tree cover. Among cities in or dependent upon dryland areas, the population of Cairo increased by 70% between 1960 and 1974; Addis Ababa by 140% (1961-74); Ouagadougou (Upper Volta) nearly tripled between 1961 and 1979; and Niamey more than quadrupled in population between 1959 and 1975. Khartoum (Sudan) increased by 150% between 1962 and 1973, and by a further 200% between 1973 and 1980.

- Anders Rapp of the University of Lund in Sweden has estimated that since the beginning of the century the population in arid zones of North Africa has increased roughly sixfold, and the area cultivated for cereals has increased by almost the same factor. Every additional person requires one more hectare (2.5 acres) of land to supply him or her with the 250 kg (550 lb) of grain per year needed for basic subsistence.

- Increasing the area under cultivation does not necessarily mean that yields will increase. Figures released by the US Department of Agriculture show that per capita cereal production fell between 1950-52 and 1973-75 by 61% in Algeria, 22% in Morocco, and 15% in Tunisia, while there was an increase of 7% in Libya.

- South of the Sahara, per capita grain production fell by 45% in Mali, 44% in Niger, and 7% in Upper Volta. Only Senegal (+31%) and Sudan (+47%) showed significant increases.

- Growing populations have forced - and are still forcing - cultivation to expand onto marginal lands. This, and the increase in livestock density as a result of a declining area of pasturage, has contributed substantially to desertification.

- Cereal production in the Sahel is increasing at only 1% every year while regional population rises by 2.5%. Put another way,

the Sahel's population will have doubled by 2010, but its food production will have only grown by 30%.

- Nationally, this means more food imports and food aid. Such aid now never falls below 100,000 tons per year for the region. Locally, the shortages of food lead to more pressure on the land and greater poverty, which results, in turn, in ever increasing desertification.

Southern Niger. The browsing goats will not hurt this young tree... but if forage is scarce the herdsman may cut down the tree so his goats can get all of the leaves. There are laws against such actions, but few foresters to enforce such laws.

CHAPTER THREE

THE SANDS OF TIME

Desertification, a characteristic of arid lands that have been overexploited, is not a new process. It has been occurring throughout human history.

- Early civilisations developed where fertile (mostly alluvial) soils allowed the production of an agricultural surplus. When soil fertility was not replenished or the soil was allowed to deteriorate, civilisations either declined or colonised other areas. It is no coincidence that many ruins of great temples and palaces are today found amid sandy wastelands.

- The Fertile Crescent flood plain of the Tigris and Euphrates rivers, once known as Mesopotamia, is now part of Iraq. The two rivers drain into the Gulf by means of the Shat el Arab waterway that has recently been a battleground for Iraq and Iran. An area that once supported 17-25 million people now has a population of 10 million. Much land has been abandoned, while the rest is so poor that crop yields are among the lowest in the world. Some 20-30% of Iraq's potentially irrigated land is unusable.

- Sumerian civilisation, the first recorded in the world, developed in the southern part of the valley of the two rivers before 4000 BC. Reeds and other vegetation were cleared, and a canal system built to drain the waterlogged lands. The canals later served to irrigate the crops grown on the alluvial soils, but were not sufficient to prevent the land becoming increasingly waterlogged and saline over the next 2,000 years.

- The gradual rise in salinity is evident in the remains of crops found by archaeologists. In 3500 BC, equal areas of wheat and barley were cultivated. After a thousand years the saline-tolerant barley covered more than 80% of the farmland. By 1700 BC no wheat was being grown in southern Iraq. Similarly, grain yields fell from an average of two tonnes per hectare (0.8 tonnes per acre) in 2400 BC to 0.7 tonnes per hectare (0.3 tonnes per acre) by 1700 BC.

- Splendid Sumerian cities like Uruk and Ur, which had seen the invention of writing and mathematics, shrunk to mere villages or were abandoned to become ruins.

- The spirit of Sumeria survives in the Epic of Gilgamesh, perhaps the oldest story in the world, dating from before 2000 BC. It tells of the coming of a great flood that destroys mankind except for a favoured family which survives by building an ark and gives rise to a new race when the flood has subsided. It symbolises the conquest of the wetlands and the threat which floods posed to the Sumerian irrigation system.

- Upper Mesopotamia also had an irrigated system of agriculture but was not as prone to waterlogging and salinisation.

- The Sassanid Persians conquered Mesopotamia in the 3rd Century AD and built a complex irrigation system that allowed almost all of the region to be cultivated. Populations continued to grow, and a powerful centralised state was necessary to maintain the irrigation system and prevent it from becoming clogged with sediment.

- The system started to break down owing to lack of attention in the middle of the 7th Century before the Islamic invasion. Despite a recovery immediately afterwards, degeneration continued so that it was in a state of complete disrepair by the 12th Century, by which time populations had plummeted. Without the will to maintain the irrigation system, civilisation once again crumbled, leaving only a few villages and silted-up canals.

- The climate of the Sahara began to turn cooler and moister in the 9th Century BC. Pastures appeared and rivers began to flow. For some 3,000 years (5500-2500 BC) there was a wet period when forests flourished and the plains were populated with wild game, which can still be seen on cave paintings in the Saharan mountains. More people settled there, initially as pastoralists, but after about 3500 BC primitive agriculture began. Much of what is now desert was well vegetated and highly populated.

- Great empires once existed in what is now the northern Sahel, when conditions must have allowed the production of a sufficient quantity of food and wood.

  * The Ghana Empire was flourishing in the 11th Century AD at the time of the Norman Conquest of England. Centred on Audagost and Kumbi, two cities west of Timbuktu and now no longer existing, it shares but a name with the present nation of Ghana. Its wealth and power were based on the caravan trade in gold and ivory across the desert to North Africa, and the movement of salt in the opposite direction.

  * The Mali Empire was founded in 1240 after the sacking of Ghana by Berbers from Mauritania.

  * Mali in turn was eclipsed by the Songhay Empire, which developed around the ancient trans-Saharan trading centre of Gao. Songhay conquered Mali in the mid-15th century, making Timbuktu a base for the control of the western part of the West African grasslands. It lasted until 1591 when it was conquered by Morocco.

- Little data exists to show how much the Sahara has expanded as a result of Man's actions over historic time.

- Deforestation since earliest times has left many of the hills surrounding the Mediterranean barren, eroded and covered with scrub.

- Mount Lebanon is referred to in the Epic of Gilgamesh (before 2000BC) as a vast green mountain with tall cedars. Felling of the cedars of Lebanon had begun as early as 3000 BC, after which they formed the cornerstone of the Phoenicians' international trade.

- The Pharaohs imported 40 ships full of cedar in 2600 BC. Fifteen hundred years later the temples and palaces of Assyria, and subsequently Babylon, were built of cedar extorted as tribute from a subjugated Lebanon. King Solomon used cedar for his temple in Jerusalem, and Alexander the Great used the wood to construct his Euphrates fleet in the 4th Century BC. Not until the Roman emperor Hadrian in the 2nd Century BC was any attempt made to protect the remaining trees.

- Greece also cleared large areas of hill forests for ships' timber, fuel or grazing land. The early deforestation of Attica was commented upon by Plato in the 4th Century BC: "Our land, compared with what it was, is like the skeleton of a body wasted by disease." Athens was forced to build a vast commercial fleet to trade wine and olive oil for wheat and other items of food that its eroded soils could not supply.

- Following the fall of Carthage in 146 BC, Rome colonised a large part of North Africa, from Tunisia to Morocco. Between then and the 6th Century the fertile coastlands raised large numbers of cattle and were the "granary of Rome". Cultivation was also extended into the drier lands south of the Atlas Mountains by irrigation. Today, much of Rome's granary is desert.

- Deforestation, overgrazing and overcultivation leading to desertification have also occurred in the United States. Increased mechanisation of wheat production on the Great Plains after World War I meant that farmers could no longer afford to leave lands fallow for a year if they were to keep up the payments on their tractors. Rising demand for wheat led many farmers to put more and more marginal land - previously used for pasture - under the plough.

- The 1930s began with two successive years of drought. Dessicated topsoil was blown away from the land by the winds. In 1933, millions of hectares (acres) of wheat were so poor that the crop was not worth harvesting. Cattle died. Farmers could not meet their mortgage and tractor payments, and left in their thousands for the new frontier - California.

- Then in 1934 a wind of retribution blew across the nation, carrying with it 350 million tons of dust that had once been topsoil in Kansas, Montana and the Dakotas. The cloud of dust obscured the sun on the East Coast, plunging cities like New York and Washington into a gloom reminiscent of a solar eclipse.

CHAPTER FOUR

THE SAHEL DISASTER

The great 1968-73 drought in the Sahel region of West Africa killed thousands of people and millions of animals. The tragedy focused the eyes of the world upon the problem of desertification, and led the United Nations to convene the UN Conference on Desertification (UNCOD) in Nairobi in 1977.

- Years of exceptionally good rains in the Sahel during the 1960s had encouraged the extension of rainfed cropping onto marginal lands and the growth of herds on poor arid lands close to the edge of the desert.

- Both cropping and grazing intensities were far in excess of sustainable levels. When the rains began to fail, not only was the land left in a poor condition, but big herds were left with shrinking pastures. When pasture growth plummeted, animals began to die in their thousands, from a lack of food rather than a shortage of water.

- The 1968-73 drought most directly affected Chad, Mali, Mauritania, Niger, Senegal and Upper Volta - an area two-thirds the size of the United States.

- In 1968 the Sahelian rains were early and heavy, but then stopped early in May. Seedlings died before the rains returned in June. By the end of the dry season in early 1969 the first animals were dying of hunger.

- The rains failed again in 1970, with farmers and herdsmen who had moved farthest north during the period of good rains being most affected. When the small 1970 harvest was exhausted, an estimated three million people in the six nations needed emergency food aid.

- The 1971, 1972 and 1973 rains were below average, but it was not until 1973 that the true extent of the disaster became widely recognised.

- Between 100,000 and 250,000 people died in the region as a result of the drought, according to an UNCOD report. (A report by the Club du Sahel and the Permanent Interstate Committee for Drought Control in the Sahel (CILSS - the Sahelian governments' organisation) puts the figure at 50,000-100,000.)

- Among livestock, cattle and sheep suffered most, with goats and camels faring better. The UN Food and Agriculture Organization (FAO) estimated that 3.5 million head of cattle, about 25% of the total, died in the Sahel in 1972-73 alone. Cattle losses were estimated at 20-50% in Mauritania and Niger, 20-40% in Mali and Chad, and 10-20% in Upper Volta. This does not include the deliberate slaughtering of animals as herdsmen realised that their stock would not survive the dry season. In some areas stock loss was 100%.

- Losses in Niger's Agadez province over 1968-74 were 88% of all cattle, 80% of sheep, 70% of goats and 45% of camels, according to Niger government figures.

- According to a joint Club du Sahel/CILSS report: "Prolonged drought is, in a way, a normal phenomenon in the Sahel. The 1968-73 drought was not exceptional historically. The 1910-14 drought was more severe. The Sahel must be prepared to confront new periods of drought in the future."

- The crisis led to the creation of several new international agencies. CILSS was formed in 1973 by Mali, Mauritania, Niger, Senegal, and Upper Volta, primarily to represent the needs of the region to donors. These countries were quickly joined by Chad, and later by Gambia and Cape Verde.

- The drought also caused an inflow of aid in the forms of food and money. Donors have committed $7.46 billion in "official development assistance" to CILSS members over 1975-80. Over 1975-79, per capita aid in the Sahel rose from $23 to $40, while in the rest of Africa it rose from $17 to $19.

- CILSS proclaimed in 1974 that its objectives were:

  * to ease the consequences of future emergencies;

  * to secure basic food self sufficiency;

  * to accelerate economic and social development, especially in the least developed countries of the region.

- The United Nations responded to the drought in two ways. In 1973 it established the UN Sudano-Sahelian Office (UNSO) as the central mechanism to coordinate efforts to aid the Sahelian countries in carrying out their recovery programmes.

- Secondly, the UN General Assembly called in 1974 for an international conference on desertification (UNCOD) to be held in 1977. It was to agree on a "Plan of Action to Combat Desertification". UNEP was asked to provide the secretariat, headed by Dr Mostafa K. Tolba, UNEP's executive director.

- UNSO was also to assist the 19 countries of the Sudano-Sahelian region and adjacent areas (Benin, Djibouti, Ethiopia, Guinea, Guinea-Bissau, Kenya, Nigeria, Uganda, United Republic of Cameroon, Somalia and Sudan, together with the eight CILSS countries) in implementing the UNCOD Plan of Action.

- The Club du Sahel was formed in Dakar in 1976 by representatives of a number of Western development aid agencies, which realised that the Sahel was a case for a special and prolonged effort.

- The Club, headquartered at the Organisation for Economic Cooperation and Development (OECD) in Paris, has no resources itself and only a small secretariat. It works to increase cooperation between the Sahelian countries and international donors, and has the basic objective of attaining regional food self sufficiency.

CHAPTER FIVE

UNCOD AND ITS "PLAN OF ACTION"

Representatives from 95 nations, 50 UN agencies and offices, eight intergovernmental organisations and 65 non-governmental organisations gathered in Nairobi, Kenya, between 29 August and 9 September 1977 to discuss and agree a Plan of Action to Combat Desertification.

- The plan, as approved at UNCOD, consists of 28 recommendations. These are paraphrased in Appendix 1 and summarised below.

- The UNCOD recommendations can be divided into three sections. Section 1 dealt with the national, regional and international organisational actions required to halt desertification:

* Governments were recommended to set up national machinery to assess the extent of desertification, monitor the rate at which it is spreading, prepare national plans of action to deal with priority issues, and implement/coordinate anti-desertification action (Recommendations 1,11,16 and 21).

* Governments were invited to cooperate on wise management of shared resources, such as regional aquifers, especially through six transnational projects recommended by UNCOD (Recommendation 24).

* UN agencies, other intergovernmental organisations and non-governmental organisations were invited to participate in the implementation of the Plan of Action and to give due consideration to its recommendations when formulating their own programmes of work for arid and semi-arid areas (Recommendations 22 and 23).

- Section 2 gave guidelines for priority measures against desertification:

* Introduce methods of planning land-use in ecologically sound ways (Recommendation 2).

* Improve livestock raising by means of new breeds of livestock and better range management (Recommendation 2).

* Improve rainfed farming by introducing more sustainable techniques (Recommendation 7).

* Rehabilitate irrigated cropping schemes that have failed owing to waterlogging, salinisation and alkalinisation (Recommendation 8).

* Manage water resources in environmentally sound ways (Recommendation 5).

* Protect existing trees, woodlands and other vegetative cover and restore tree cover and vegetation to denuded lands (Recommendation 9).

* Establish woodlots as sustainable sources of fuelwood and encourage the development of alternative energy sources (Recommendation 19).

* Conserve flora and fauna (Recommendation 10).

* Ensure fullest possible public participation when undertaking measures to combat desertification (Recommendations 3 and 12).

- Section 3 suggested ways by which national development planning may be used to influence social factors leading to desertification and also to improve local capacity to deal with the problem:

* Investigate the social, economic and political factors connected with desertification (Recommendation 12).

* Introduce measures to control population growth, as appropriate (Recommendation 13).

* Improve health services (15).

* Improve scientific capabilities (Recommendation 18).

* Expand local awareness of desertification and skills with which to combat it by training and education, both by means of mass media and courses at various educational institutions (Recommendation 20).

* Assess the impacts of settlements and industries on desertification, and keep desertification in mind when planning or expanding new settlements and industries (Recommendations 4 and 15).

- The Plan of Action listed four main priorities requiring immediate action between 1978 and 1984:

* The establishment by each government of appropriate machinery to assess, monitor and combat desertification, and the preparation of a National Plan of Action.

* The organisation of regional workshops and seminars to discuss and coordinate technical aspects of the Plan of Action.

* The organisation of consultants and studies for selecting sites for a number of regional research and development centres and demonstration stations for improved techniques in each of the main types of land use: rainfed cropping, irrigated cropping, livestock and rangeland management, and afforestation/revegetation.

* The organisation of six transnational projects which would link up action in a number of countries in different

regions, providing inspiration by the sheer size and conception of the projects, and allowing mutual support and the pooling of experience.

- The transnational projects were undoubtedly ambitious in scope. UNCOD did not set up any special international body to coordinate action against desertification, so the transnational projects offered the main prospect of continuity and momentum. They would also provide "living laboratories" for the development of vital new techniques of reclamation and sustainable land use. The six transnational projects were:

* 1. The SOLAR project (Stratification of Livestock in Arid Regions), aimed at stratifying livestock management in the Sahel in order to increase beef production. Calves would be reared by nomadic herdsmen in the traditional manner, and then moved south for fattening either on farms in the semi-arid agricultural zone or on feedlots in more humid coastal areas. Finally, they would be marketed in the cities and coastal zones.

* 2. The management of regional aquifiers in NE Africa and Arabia required intensive studies to fill in the considerable gaps in local knowledge of these two major water sources, both of which are facing serious problems. Pumping and other discharges of the sandstone aquifer underlying Egypt, Chad, Libya and Sudan were in 1976 seven times higher than the estimated natural recharge. Overpumping in the Arabian Peninsula is causing falling water levels in the Arabian aquifer underlying Bahrain, Oman, Qatar, North Yemen, South Yemen, Saudi Arabia, and the United Arab Emirates. Salinity is rising, owing to the practice of pumping saline water down oil wells to raise oil pressure.

* 3 & 4. Regional monitoring: Two projects were intended to use US LANDSAT satellites to monitor desertification on a regional basis. One project was to cover the West Asian countries of Afghanistan, India, Iran and Pakistan; the other would cover arid areas of Argentina, Bolivia, Chile and Peru.

  Reliable data on both the extent and rate of spreading of desertification are very scarce; the manpower and equipment is just not available to make continuous ground measurements over vast areas of the countries most severely affected. LANDSAT satellites pass over each part of the Earth once every nine days, collecting images of areas of 34,000 sq km (13,000 sq mi) at any one time, and with a resolution of 79 metres (260 feet), improved in 1982 to 40 metres (130 feet) by the launch of the new LANDSAT-D satellite.

* 5 & 6. Green belts: The two remaining projects consisted of establishing "green belts", each running from the Atlantic to the Red Sea. One would run along the northern border of the Sahara (Morocco, Algeria, Tunisia, Libya and Egypt) and the other through the Sahel (Cape Verde, Senegal, Gambia, Mauritania, Mali, Upper Volta, Niger, Chad and Sudan).

The green belts were not intended to be solid shelterbelts of trees to physically stop the advance of the desert. Instead, the idea was to protect and rehabilitate major belts of land in each zone, providing mosaics of well managed cropland, rangeland and forest.

- Of all the six projects the North African green belt scheme seemed to have had the best chance. Tunisia and Libya already had green belts; Morocco had a large scale afforestation programme; and Algeria was establishing a 1,500 km (940 mi) continuous green belt 20-40 km (12-25 mi) deep right across the country.

- But since UNCOD almost no progress has been made on any of these transnational projects.

CHAPTER SIX

PROGRESS SINCE UNCOD

Over the years since the UN Conference on Desertification (UNCOD), little progress has been made in halting desertification.

- Two organisations were given special responsibility for coordinating the follow-up plan:

  * UNEP was given overall responsibility for coordination, and specific responsibility for all areas outside the Sudano-Sahelian region;

  * UNSO (the UN Sudano-Sahelian Office) was given specific responsibility for coordinating action in the Sudano-Sahelian region. UNSO also administers a UN Trust Fund for Sudano-Sahelian activities under the direction of the UN Development Programme (UNDP).

- Little data has yet been published by UNEP concerning global progress in implementing the Plan of Action.

  * Only a few governments - including Burundi, Gambia, Mauritania, Peru and the United States - are preparing or have prepared national plans of action.

  * There is no indication that the six transnational projects have progressed any further since UNCOD.

  * Only two regional research and development centres have been established: the Sahel Institute at Bamako in Mali, and the Regional Agrometeorology and Hydrology Centre (AGRHYMET) at Niamey in Niger.

- UNEP Executive Director Dr Mostafa Tolba reported in May 1981: "Progress (since UNCOD) has been slow; and in addition to making the required resources available, governments and regional and international organisations, not least within the United Nations system, need to intensify their efforts... The actions taken are still very far from demonstrating a comprehensive concerted effort."

- At UNCOD, Dr Tolba had called for $2.4 billion to be spent annually over the next 20 years to halt desertification in the developing world. Latest estimates indicated that implementing the Plan of Action would cost about $4.9 billion a year.

  * UNCOD set up a Special Account within the UN to finance anti-desertification activities. In five years this has received just $5,000, from Mexico.

  * Only $13.4 million (8%) of the $162 million of aid channelled through UNSO to the Sahelian countries has been directed to specifically anti-desertification activities.

* The Club du Sahel, an informal organisation of donors to Sahelian nations, reported that $7.45 billion in official development assistance had been committed to the region over 1975-80, but by 1980 only 1.4% of this money was going to ecology/forestry projects.

* The Consultative Group for Desertification Control (DESCON), organised by UNEP, contains representatives of donor and recipient nations and UN and multilateral organisations. It acts as a preliminary screening body for potential anti-desertification projects, but has so far had little influence on project funding.

- Although other funds for fighting desertification are received through bilateral or multilateral mechanisms, they are nowhere near the level which UNCOD proposed.

Progress in the Sahel

The only real information on progress in halting desertification is for the Sahel. While aid to this high priority region has been increased dramatically, progress has been slow. There are many lessons to be learnt from the events of the last five years.

- Visible signs of progress in the Sahel are few:

  * no giant shelter belts;

  * no large scale village woodlot schemes;

  * no signs of any increase in food self sufficiency;

  * no widespread improvement in farming and herding methods.

- On the contrary, the expansion of herd sizes and cropping areas continues to spread desertification, laying the foundations for another disaster of the kind experienced over 10 years ago.

- Only two countries in the Sahel are preparing National Plans of Action. Work began in Mauritania in May 1980 and in Gambia in December 1981. Although Mauritania created a national committee to fight desertification in 1980, by the end of 1981 it had yet to hold its first meeting.

- Most Sahelian countries have designated various bodies to be responsible for coordinating action, but whether coordination is effective is a very different matter.

- UNSO, CILSS, and the Club du Sahel convened a seminar in November 1979 to prepare a regional Plan of Action.

- Two of the many regional centres proposed at UNCOD have been established:

  * the Sahel Institute was founded in 1977 in Bamako (Mali) as a specialised agency of CILSS. It will undertake, coordinate and disseminate research and proven technologies for the

recovery and rehabilitation of degraded lands, and train research workers and technicians;

* the Regional Centre for Agrometeorology and Hydrology (AGRHYMET) at Naimey in Niger will train technicians and engineers, carry out applied research into the region's climatic and hydrological problems, and produce long range forecasts.

- Little has been done to monitor the extent and rate of spread of desertification in the Sahel - another UNCOD immediate priority.

* USAID has sponsored a remote-sensing project in Mauritania.

* A joint CILSS/Club du Sahel project to analyse satellite imagery of the region (coordinated by Dr Ichtiaque Rasool, a NASA scientist now teaching at the College de France in Paris), has produced preliminary results showing that tree cover in Senegal and Mali has decreased.

Aid

Aid to the eight CILSS nations increased by 80% from $817 million to $1.5 billion per annum between 1975 and 1980. A total of $7.45 billion in aid was committed by donors in that period. The donor nations preferred to work through established bilateral and multilateral mechanisms rather than the UN Special Account set up at UNCOD.

- Aid grew twice as fast as the average for developing countries, with a 3.1% per annum increase in real terms between 1975 and 1980.

- Per capita aid for the Sahel is $40 per year - twice as much as the African average and 6.5 times as much as the Asian average.

- Half the Sahel's aid comes from the OECD countries; a quarter from the European Development Fund, the World Bank and other multilateral agencies; almost a fifth from OPEC, and just 5% from UN agencies.

- France, West Germany and the United States account for almost three-quarters of bilateral (country-to-country) aid to the Sahel.

- Two-thirds of aid money is in the form of outright grants; 86% of bilateral aid and 50% of multilateral aid are given this way .

Rural development

Where is the aid money going in the Sahel? One might have expected that, with the exception of emergency or general relief aid, most of the funds would be used for priority areas such as

improving the productivity and sustainability of rainfed cropping, irrigated cropping and livestock raising, extensive reforestation and revegetation, fuelwood plantations, irrigation and water supplies.

- In fact, only 24% of aid is directed towards agriculture and forestry. And less than 40% of all agriculture and forestry projects are rural - the rest of the money for farming and forestry is spent on support activity in the towns.

- Altogether, 8% of aid is directed towards the intensification of rainfed cropping. But out of $100 million committed for this sector between 1975 and 1978 by France, the European Development Fund, USAID and West Germany (the major donors), only $28 million went to subsistence food crops. The remainder - 28% of agricultural aid - went to cash crops, mainly grown for export.

- This is, however, an improvement on past performance. Between 1960 and 1970, virtually all assistance to rainfed cropping went to cotton and groundnut projects.

Irrigation

Given the potentially dramatic increases in yield of food crops grown under irrigated conditions, it is not surprising that almost one-tenth of all aid and one-sixth of project aid goes towards the development of irrigated agriculture. (Project aid excludes general budgetary assistance and food aid.)

- Yet while about 5,000 more hectares (12,400 acres) of irrigated land come into cultivation in the Sahel every year, the same area goes out of cultivation owing to salinisation and waterlogging caused by poor management.

- Some agencies are thinking of shifting more aid towards rehabilitation of such lands, instead of continuing the present "one step forwards, one step backwards" approach. In 1979 there were estimated to be 17,000 hectares (42,000 acres) of irrigated land in need of rehabilitation in Mali, and over 5,000 hectares (12,000 acres) in Senegal.

- New irrigation schemes cost as much as $17,000 a hectare ($6,900/acre) - money which can be justified only if big increases in yields are obtained. In Niger, only one rice crop is grown every year instead of the two which are recommended. Yields average 1.7-2.6 tonnes per hectare (0.69-1.1 tonnes/acre) compared with the 5-6 tonnes (2-2.4 tonnes/acre) theoretically possible.

Livestock

Livestock raising gets 5% of all aid. Little attention is being paid to improving productivity through better breeding and the cultivation of high yield forage crops.

- It appears that the same pattern is developing as before the last drought, with more water points being opened and livestock numbers moving steadily towards their pre-drought, over-stocked levels.

- UNCOD took a divided position on nomads. Its "Overview" document, drawn up by scientists, found that nomadism "spreads pressure on the land and dilutes risk". Mobility is the nomad's "principal weapon against a harsh environment.... Sedentarisation, whether voluntary or enforced, has resulted in severe degradation around permanent settlements where former nomads continue to herd livestock."

- But the UNCOD Plan of Action found that nomads' mobility "made it difficult to provide them with adequate health and social services. These and related disadvantages must be remedied, with measures to assist sedentarisation and resettlement where appropriate." Governments' traditional dislike of nomads was probably behind this call for sedentarisation.

- Although a number of intensive ranches have been established in the Sahelian and Sudano-Sahelian zones, their performance has so far not justified the heavy investment. Productivity is low, and the large distances from markets in major commercial centres inhibits marketing of produce.

Forestry

A recent Club du Sahel report expressed concern at the low priority given to reforestation in the Sahel: "Do Sahelian governments and the donor agencies understand the gravity of the situation in the Sahel? International aid for reforestation is still so low that to evaluate its impact would be an exercise in vain."

- In 1975, reforestation/ecology accounted for only 0.35% of all aid to the Sahel. Funds rose from $2.9 million in 1975 to $23.3 million in 1980, a growth rate five times as great as for aid as a whole. But forestry/ecology still receives only 1.4% of aid.

- Says the Club du Sahel: "All studies on this topic come to the same conclusion: the pace of reforestation in the Sahel today is too slow. Up to the year 2000, 150,000 to 300,000 hectares (370,500-741,000 acres) on average will have to be planted. The efforts to be deployed for reforestation bear no comparison with present efforts, which are 50 times too small."

- In 1981 FAO estimated that in Chad, Mali, Niger, Senegal and Upper Volta, the reforestation rate over 1976-80 was about 4,900 hectares (12,000 acres) a year. It projected a rise to 7,280 hectares (18,000 acres) per year for 1981-85.

- "A study presented by the World Bank in 1978 states that the area reforested must be increased seven- or eight-fold to meet domestic needs in Niger and Mali by the year 2000", continues the Club.

Where the money goes

So where has all the money been going? One-fifth of all aid and one-third of project aid is used for building "infrastructure", of which the largest share goes to road construction and repair. The Club questions whether all these new roads are necessary for agricultural development, and whether existing roads are being maintained and rehabilitated on schedule. It sees road construction as a "soft option": easy to implement and rarely without merit. But should it consume as much aid as it does?

- Road construction accounts for more than two-thirds of the $62.4 million of aid received by CILSS countries through UNSO between 1975 and 1980.

- By January 1981, 955 km (590 mi) of feeder roads had been constructed and were in use in Gambia, Senegal, Mali, Upper Volta and Niger. Some 700 km (435 mi) of these roads had been constructed with UNSO's direct participation.

- At a 1981 meeting of donors to examine progress, the participants were surprised to learn that many of the new roads they had been funding did not link up.

- Mauritania is building the "Road of Hope" between Nouakchott on the coast and Nema near the eastern border. The aim is to ensure rapid transport of food aid from the coast to the interior in times of famine, and of export goods from the interior to the country's main port.

- Is the Road of Hope necessary? French consultant Michel Baumer comments: "There does not exist a single product the value of which would be worth transport by road. As for famines, if not precisely predictable, they are nevertheless certain, and it would be wiser to build up stocks of food and fodder long in advance, using camel transport. This would give jobs to hundreds of nomads, who are particularly affected by exceptional drought."

- Water development projects have the second largest share of UNSO-directed funding, with 8%. Some of the projects are fully justified. Cape Verde, for example, has a $291,400 scheme to improve soil and water conservation in the San Joao Baptista Valley, including the reforestation of water catchment areas, and the construction of flood control dams, dikes, embankments and terraces.

- The majority of the projects, however, involve sinking boreholes to provide water for humans and livestock. Little account seems to have been taken of the possibility that the new boreholes may themselves cause desertification.

- Mauritania has a $5.9 million project, which commenced in 1977 with activities beginning in earnest in February 1979, to equip 36 new deep boreholes with pumping stations. It was not until November 1979 that UNSO sponsored the visit of a consultant to report on ways of protecting the environment around the boreholes.

- Agricultural (rainfed cropping and livestock) development and reforestation (excluding watering points and forest protection) represented only 2.7% of aid channelled through UNSO between 1975 and 1980.

- Why is so little of the aid directed through UNSO used for anti-desertification, or agriculture or forestry?

  * UNSO has a dual role: it is supposed to assist in economic rehabilitation, as well as to combat desertification.

  * Besides the eight CILSS countries, UNSO is also responsible for Benin, Cameroon, Djibouti, Ethiopia, Guinea, Guinea-Bissau, Kenya, Nigeria, Somalia, Sudan and Uganda.

- UNSO sees itself as a middleman between the donor nations and the countries which it serves. Project proposals are matched with funding sources, the funds often, but not always, being channelled through the UN Trust Fund for Sudano-Sahelian activities which UNSO administers under the direction of the UN Development Programme (UNDP). (In the UN, "trust funds" are contributions which are earmarked for specific purposes by the governments which have given the money.)

- Lee MacDonald of the University of Michigan at Ann Arbor is critical of UNSO's funding programme: "UNSO is based in New York and has more experience with technical assistance than the problems of desertification. There may be a tendency to simply term a project "anti-desertification" because it is politically expedient, when in reality the project is not substantially different from many other technical assistance projects."

- UNSO does have a regional office in Ouagadougou and can also call upon the expertise of local UNDP field personnel when necessary. But since economic development in the region is one legitimate way of combating desertification, it is not easy to judge whether or not UNSO is really fighting desertification, or whether it just functions as an additional regional development agency.

- UNSO could give a much higher priority to anti-desertification projects if it chose to. In recent years there has been an encouraging increase in the number of UNSO feasibility studies for anti-desertification projects, and this trend may continue.

- As is unfortunately often the case among international agencies, anti-desertification work in the Sahel is hindered by personal and organisational antipathies, especially between UNSO and CILSS, but also involving UNDP, UNEP, the Club du Sahel and some of the bilateral donors. This has sometimes resulted in agencies working almost openly against one another.

- What effect has all the aid over the past five years had towards implementing the UNCOD Plan of Action? The clear fact is that the needs identified by UNCOD have not been given priority either by the donor nations or by the Sahelian governments.

- In fact, the opposite has often happened. The increase of herds to pre-drought levels and the expansion of the area under

rainfed cropping will have made desertification worse without really improving the region's self sufficiency in food.

- Moreover, even the limited progress in irrigation and reforestation may not be sustained. Donors provide funding to cover project establishment costs (purchase of pumps, digging canals, planting trees) but rely on the host country to cover maintenance.

- At a dune-fixation project at Yegalalane in southern Niger, funded by the US voluntary agency CARE, rows of young trees have been planted to stabilise huge dunes which were spilling into a lush river bottom where millet, sorghum and vegetables are grown. In 1983 CARE will stop paying the wages of the villagers who now guard the trees from camels and goats. Don Atkinson-Adams of CARE hopes that the villagers will continue to guard the trees on their own, but admits that they probably will not. And central government finance seems unlikely.

- Anne de Lattre of the Club du Sahel spells out the problem: "New projects generate very heavy recurrent budget costs, which cannot be met, and so the project deteriorates. Phase 2 and Phase 3 of the project then have to be rehabilitation, not expansion."

- "Since 1976 there has been a 35% increase in real aid flows" to the Sahel, says de Lattre. "But there is actually massive disinvestment taking place, because of those rehabilitation costs."

- The Club du Sahel, the World Bank and USAID are now talking of changing their policies, to give higher priority to maintenance schemes and to projects with little or no recurrent costs.

CHAPTER SEVEN

THE SAHEL TODAY

Ten years after the climax of the catastrophic 1968-73 drought, the nations of the Sahel were moving steadily towards another disaster.

- Experts disagree whether the next crisis is just around the corner or some years away, but past experience dictates that it must come. The huge amounts of aid at present pouring into the region are unlikely to prevent it, because the aid, as described in the previous chapter, is going to the wrong types of projects.

- The Sahel's population grows at an annual rate of 2.5%, while its cereal production grows at 1% per year. The annual increase in population has been 0.3% higher than the increase in cereal production.

- At that rate, the Sahel's population will have doubled by the year 2010, but its cereal production will have grown by only 30%.

- Despite the urgent need to increase food production (in ways which will not lead to more desertification, nor will collapse when the next drought occurs) less than a quarter of aid to the region goes to agricultural development.

- The Club du Sahel estimates that self sufficiency in food has decreased rather than increased since the mid-1970s.

  * Niger now has to import 25% of all its food.

  * Upper Volta is now 90% self sufficient in grains, but has considerable deficits in fruits, vegetables, meat and fish.

- One reason why food production has not even kept up with population growth is the drop in yields per hectare (acre) as cultivation expands onto marginal lands.

- Between 1955 and 1979, the area of land under millet and sorghum increased at an average rate of 3.4% per year. But production rose only 2.5% per year. After the drought the expansion in cultivated land quickly resumed.

- The area under rainfed cereal cultivation in Niger is now more than 40% greater than it was immediately before the drought. But production is only 4% higher, and yields per hectare (acre) are averaging only three-quarters of their 1968 values.

- Similar trends are seen in the whole of the region. Between 1970 and 1978 the Sahel's cereal production increased to 4.95 million tonnes. But the rate of increase was only 2.45% per annum despite a 3% per annual increase in the area cultivated. As a result, average yields declined by 0.65% per annum.

- Irrigated grain crops might have provided extra food. Unfortunately, demands for rice and wheat are growing faster than irrigated production, and self sufficiency in irrigated cereal crops is only about 33%.

- Rice production in the Sahel is one-third higher than it was at the beginning of the 1960s. But demand has risen by two-thirds as a result of population growth and urbanisation, according to a CILSS/Club du Sahel study. European food habits - white bread and rice - are replacing foods based on traditional Sahelian grains.

- As a result of the booming demand for French-style bread, the Sahel is only 4% self sufficient in wheat, most of which is grown by rainfed farming methods. Consumption rose by 11% per annum between 1975 and 1978. Wheat imports are now running at 200,000 - 300,000 tonnes a year - about the same level as rice imports.

- Although food aid has fallen (its peak was over 700,000 tonnes a year at the height of the drought) it seems to have become a permanent fixture in the Sahel. It never falls below 100,000 tonnes a year, and uses up about one-tenth of all aid to the region.

- Unfortunately, most of the food aid in the early 1970s stayed in the towns. Urban people became used to imported wheat and rice in preference to home-grown millet and sorghum. So food aid was one of the main factors pushing up demand (and imports) so rapidly in recent years.

- At the same time, says a recent World Bank report on sub-Saharan Africa, local farmers have been inhibited from increasing crop production because of the low official prices for grain, prices kept artificially low to please the urban elite - civil servants, army, police - upon which governments rely.

- Livestock numbers, which during the drought fell to 75% of their previous levels, are at about 90% of their pre-drought levels. Indeed, in Niger there are more sheep, goats, horses and donkeys now than there were in 1968. This is putting tremendous pressure on the fragile rangeland.

- Little has been done in practice to improve livestock productivity, although there are plenty of pilot schemes and experiments. Unfortunately, most livestock projects simply increase herd size (through supplying water) or reduce mortality (via vaccination) without increasing production of meat or milk.

- Dr Ibrahima Toure of Mali, a senior UNESCO rangeland expert, charges that veterinarians, hydrologists, ecologists and economists all compete for funds for their projects. One effect of boreholes, for example, has been to bring large numbers of cattle together and thus spread disease among them. "We must get vets talking to ecologists. It is pure laziness," says Dr Toure.

- What are the prospects for the Sahel?

- There has not yet been another disaster like 1968-73. "Aid and the will of the Sahelian nations have prevented another major crisis", says George Bourgoignie of the Club du Sahel. That in

itself is an achievement. But trying to improve agricultural productivity is a race against time.

- "It takes an enormous time to change the thinking of peasants", says Bourgoignie. "Yet we need a complete change in thinking by everybody."

- "Even in the US West, with all our educated farmers, it took 25-30 years to get irrigation right", agrees Larry Dash, director of USAID's Sahel Programme.

- Meanwhile, the people of the Sahel try to survive as best they can on a land with fragile soils and an uncertain climate. Rainfall in 1977 was as low as in 1972 (the worst year on record). The rains failed again over parts of the region in 1979: Cape Verde, Mauritania and Senegal all experienced droughts, while insufficient rainfall reduced crop yields in Gambia, Mali, Chad and parts of Upper Volta. The year 1981 was almost as dry as 1977.

- "I think that the area is slowly deteriorating," says Don Atkinson-Adams of the US voluntary relief organisation CARE, which helps to run soil erosion and dune stabilisation projects in Niger.

- "Whether you see the desert as advancing or the Sahel as losing ground, a real catastrophe is on the way," believes Mamadou Mahamane, director of a Niger forestry aid project.

- Meanwhile, each year more people produce less food. The fragile drylands deteriorate. And no one really knows what to do about it.

CHAPTER EIGHT

HOW TO STOP DESERTIFICATION

Land use in the world's drylands seems increasingly to have entered upon a vicious cycle of over-use: soils are over-exploited; thus soil fertility and tree cover diminish; thus yields fall; thus more land must be over-exploited to make up for falling yields.

- The land gets progressively worse, and signs of erosion and eventually desertification appear. Every few decades, drought brutally interrupts the cycle of attempts to extract more and more from a deteriorating environment. After the drought, things improve briefly; then the cycle begins again.

- Can the spread of desertification be halted, or is it beyond control? Events in the Sahel do not give rise to much optimism. Livestock numbers are approaching pre-drought levels; hardly any attention has been paid to improving agricultural production, and the rate of afforestation is 50 times too small.

- Desertification is a man-made phenomenon. Thus its control requires modifications in the ways in which man uses the land.

  * The productivity of rainfed farming on good land needs to be increased so that the expansion of cropping onto marginal land is halted.

  * Livestock raising will benefit from an end to invasions of traditional pastures by farmers and by a resumption of fallows that have also been used for grazing in the dry season. Better range management and development of new livestock breeds will improve productivity and reduce pressures on the land.

  * Restoring tree and woodland cover will stabilise cropping and pastoralism by reducing soil erosion and providing improved supplementary fodder. Tree planting can enable desertified land to be reclaimed and made productive again. And the present widespread deforestation for fuelwood must be halted by means of sustainable woodlots.

- This chapter looks at the possibilities for improving farming, pastoralism and forestry. But first it examines the potential for using satellites to monitor both the spread of desertification and the progress of attempts to bring it under control.

Satellite monitoring

Combating desertification will require data on where the problem exists and how fast it is increasing. Such data can be obtained through remote-sensing satellites. The UN Conference on

Desertification included two satellite monitoring programmes (for S W Asia and South America) in its list of transnational projects. No progress has been made in either.

- Satellite monitoring is best achieved when there are ground stations in the regions being studied to receive the most recent images. Otherwise the data from the US National Aeronautics and Space Administration (NASA) LANDSAT satellites are limited by US priorities for recording data at NASA's own ground stations.

- At present there are ground receiving stations in Hyderabad, India (covering most of S W Asia), and in Cuiaba, Brazil, and Mar Chiquita, Argentina (covering all but the north west tip of South America). So the transnational monitoring projects recommended by UNCOD are perfectly feasible, although they have not been implemented.

- Unfortunately, while the European ground receiving station at Fucino in Italy covers the northern fringe of the Sahara, there is no corresponding station in West or Central Africa to cover the Sahel, although one has been proposed for Ouagadougou in Upper Volta.

- How precise is satellite data on desertification? G H Griffiths and W G Collins of the University of Aston in Birmingham, England, have been studying desert encroachment in the Marsabit district of northern Kenya. They found that it is difficult to separate vegetated from non-vegetated areas, since the high intensity of light reflected by soils in arid zones can, when it is recorded by a satellite, easily overwhelm the weak reflectance of thin, dry scrubby vegetation. This may cause analysts to erroneously classify a certain area as desert.

- Ulf Hellden of the University of Lund in Sweden compared satellite photos with a 1958 vegetation map of the Sudan and estimated that over 1958-76 the desert moved south by 30-120 km (19-75 mi) in Sudan's northern Kordofan province.

- Hellden has also shown that in northern Kenya, computerised analysis of LANDSAT images gives slightly higher accuracy than by using photographic versions of the images. But photos can achieve an accuracy of 85%, and are more appropriate for workers in developing countries lacking sophisticated equipment.

- Hellden and colleague Mikael Stern found that using a computer enabled them to monitor automatically the occurrence of new patches of desert in the El Hamma and Medenine areas of southern Tunisia. Some of the desert patches already evident in 1972 had increased in size by 1979, and new ones had formed by that time.

- The 1982 launch of NASA's latest satellite, LANDSAT-2, may bring improvements in the monitoring of desertification. It has equipment on board designed specifically to monitor vegetative cover and agricultural areas.

- LANDSAT satellites can record an image of a 34,000 sq km (13,000 sq mi) area in just 25 seconds. Nevertheless, despite the large area which can be covered in one image, comprehensive monitoring of the state of the Sahel zone at any one time would

require analysis of 150 such images. This might both prove costly and slow down the frequency of regular monitoring.

- In order to overcome such limitations, John Townshend of the University of Reading and Compton Tucker of NASA's Goddard Space Flight Center at Greenbelt, Maryland, have been looking into the possibility of using two weather satellites operated by the US National Oceanographic and Atmospheric Administration (NOAA). Called NOAA 6 and 7, these satellites have a much coarser resolution than LANDSAT, and this enables them to image much larger areas, thereby cutting down on the computer processing of data. The images are potentially available every one or two days, a higher frequency of monitoring than with LANDSAT.

Improving crop production

The Sahelian nations, like other arid areas in the world, have been able to increase crop production in the last few decades only by expanding the area under cultivation. Declining fertility and the low productivity of the new marginal lands have resulted in lower average yields. Grain production in particular has not kept pace with the growth in population. Food self sufficiency has fallen, and imports have risen.

- The major priority of the Club du Sahel is to achieve regional food self sufficiency. The aim is to double grain production by the end of the century, by which time the population of the region will also have doubled.

- But if present trends continue, rainfed crop production will increase by only 30% by the year 2000. Can more intensive but sustainable cropping techniques be introduced on the better soils, to halt the continual expansion onto easily degraded marginal lands?

- Irrigation schemes, capable of increasing yields six-fold, have received massive funding. But only 5,000 extra irrigated hectares (12,300 acres) have been added every year in the Sahel since the mid-1970s , and this has barely exceeded the rate at which irrigated lands have gone out of production owing to salinisation and waterlogging - the result of bad project design and management.

- "Although a large share of aid has been allocated to irrigated farming", says the Club du Sahel, "its development has been slower than the Sahelians and the international community would have wished."

- Some 4,000 hectares (9,900 acres) of the 5,000 (12,300 acres) additional irrigated hectares every year are for the cultivation of rice, rather than staple grains like millet and sorghum.

- The substantial food aid to the Sahel since the drought has been largely in the form of rice and wheat, encouraging a shift in consumption patterns, especially in urban areas.

- Does "food self sufficiency" mean meeting the real needs of the rural poor, faced with shortages of staple grains? Or is all of the effort to go towards satisfying the demand of urban consumers for products whose "necessity" was recognised only after their inflow as food aid?

- It is not surprising that it is the "luxury" foods which are grown on irrigated land. Justifying the huge investment of up to $17,000 per hectare ($6,900 per acre) requires not only high yields (which are often not obtained) but also the prospect of high prices.

- Today, 95% of cereal production in the Sahel still comes from rainfed systems. The Club du Sahel concludes that "until the turn of the century, cereals will still be grown throughout the Sahel mainly using rainfed farming methods."

- "It is probable that to attain food self sufficiency, the share of development assistance for rainfed cereals farming and especially for intensified farming will have to be increased substantially," says the Club.

- Possible components of intensified rainfed cropping schemes might be:

  * improved, drought resistant varieties;

  * fertilizers;

  * better grain storage facilities;

  * integrated systems including rotations and fallows;

  * improved cultivation techniques;

  * small scale irrigated gardens and orchards near wells;

  * new crops.

- Improved varieties of conventional crops like sorghum and millet would have higher yields under average rainfall conditions. But they would need to be as resistant to drought as traditional varieties, so as not to cause a catastrophe for farmers in dry years.

- Studies by the World Bank and the European Development Fund confirm that little work has been done so far to develop improved varieties of sorghum and millet.

- Improved varieties often require fertilizer. Even with conventional varieties, yields of millet and maize can be doubled by applying fertilizers. Manure also helps. The use of both artificial and natural fertilizers is fairly common, especially among those farmers growing groundnuts, which require fertilizer for good yields.

- Fertilizer and improved seeds, however, must be bought, often on credit. The precarious nature of dryland farming means that yields and income are uncertain even under the best conditions. A

1980 survey of one village in Senegal found that in the previous year, 25% of villagers were unable to repay their loans, and therefore could not afford to buy sufficient seed for the following season.

- Financial over-extension and crop failures have brought a sour note to the Green Revolution in many countries. Independent farmers have lost their lands to money lenders and have been forced to become either tenant farmers or casual farm labourers.

- Farmers will be unwilling to commit themselves to investment in intensified cropping without firm assurances from the government not only on credit but also on the prospect of attractive prices for their crops.

- Greater productivity will be meaningless unless there are good facilities in the area for storing grain as a reserve for drought years when crops fail. Mauritania has just completed a national network of grain silos in a $10.5 million programme co-financed by the African Development Bank and the Netherlands government through UNSO.

- Higher yields can enable farmers to break out of the vicious circle of reducing fallow periods and constantly expanding the area under cultivation in order to maintain production at previous levels.

- It could therefore be possible to satisfy increased demand for food at the same time as reverting to traditional rotation systems such as the four-year sequence of fallow, millet, cowpeas and groundnuts that is common in the Sahel.

- Yields can also be increased by improved methods of cultivation such as deep tillage. Often farmers do not turn under organic matter because they are reluctant to incorporate potential fodder material into the soil. This could be overcome by the growing of trees like Gliricidia, which produce plentiful foliage that can be used for both fodder and "green manure".

- Villagers' nutrition and overall food production could be improved by establishing irrigated vegetable gardens or fruit orchards near wells. An experimental project in Mauritania is investigating this approach by promoting the creation of small market gardens in the vicinity of 36 deep wells drilled as part of a joint UNSO/African Development Bank project.

- Greater diversity of crops could also be obtained by trials of underexploited drought resistant species such as those recommended by the US National Academy of Sciences: grain crops like grain amaranth (Amaranthus hypochondriacus) and Pima-Papago 60-day maize (Zea mays), and vegetables like Hopi mottled Lima bean (Phaseolus lunatus), and Papago Cushaw squash (Cucurbita mixta).

- Whether such advances in rainfed cropping do take place depends as much on the will of governments as on the courage and imagination of farmers.

- A 1981 USAID report states: "Research and development of export crop technologies has resulted in significant returns to governments in the form of increased foreign exchange earnings. However, research and development of technologies for food crops have been relatively neglected, with the result that the potentially large returns in the form of increases in real incomes for the small farmers have not been realised."

- The controversial 1981 World Bank report "Accelerated Development in Sub-Saharan Africa" criticised the low, government-controlled crop prices, which are aimed at maintaining the political support of urban populations, especially the civil servants, army and police. But low prices discourage farmers from investing in intensified production.

- Governments in the Sahel are gradually recognising the need to give a higher priority to food crop production:

  * Mali has major programmes to increase millet and rice production;

  * Senegal is trying to increase millet and sorghum yields in the groundnut-producing area of Sine-Saloum, and to eliminate the country's rice deficit;

  * Niger, Upper Volta and Chad have national programmes to expand cereals research and agricultural advice.

- The power to make changes rests with governments. Farmers need the incentive of higher crop prices, even though these may be unpopular with urban populations. Money could be saved by reducing the heavy subsidies to the inefficient public corporations responsible for centralised crop purchasing and marketing.

- Government spending could become more in line with the needs of the whole population.

  * Niger is proud that 20-25% of its annual budget goes to rural development, a high figure for the region. Yet nine out of 10 of Niger's citizens live in the countryside.

  * Upper Volta's 1982 budget grants the Ministry of Rural Development 4% of national funds, though 92% of the population is rural. Aid workers there claim that agricultural extension staff frequently do not have enough petrol to drive out of town.

What future for irrigation?

Some agricultural experts argue that the Sahel cannot achieve food self sufficiency without major investments in irrigated agriculture. Rainfed crop production will always be vulnerable to drought, and rainfall levels are too low and erratic to offer hope that high yielding, drought resistant farming systems can be developed.

- Grain yields without irrigation can reach 1.5-2 tonnes per hectare (0.6-0.8 tonnes/acre) in high rainfall years. With regular irrigation such yields could be more than doubled to 4-6 tonnes per hectare (1.6-2.4 tonnes per acre) and the vulnerability to drought removed. But such yields have never been consistently achieved in the Sahel.

- There are an estimated four million hectares (10 million acres) of irrigable land in the major river basins of the Sahel: the Senegal, Upper Niger, Gambia and Upper Volta rivers, together with the Lake Chad region.

- The Club du Sahel wants to double the area under irrigation to 1.2 million hectares (three million acres) by the year 2000 so that all of the rice, wheat and sugar needed in the region, as well as a substantial amount of corn, millet and sorghum, can be produced there on irrigated lands.

- However, in view of the many problems with irrigated agriculture and the high rate of debilitation of irrigated croplands, both the Club and USAID agree with the UNCOD Plan of Action in recognising that the first priority must be to rehabilitate existing irrigation projects that have fallen into disrepair or are not working at full capacity.

- As far as new irrigated lands are concerned, USAID intends to concentrate on small to medium-scale schemes that include large elements of farmer participation in construction and management.

- There is the prospect of expanding both irrigated and rainfed cropping onto the presently uncultivated lands of the more humid river basins of the southern Sahel. But first, the disease of river blindness must be controlled to make those areas habitable.

Improving livestock raising

During and immediately after the Sahel drought, a large part of the blame for desertification was placed on overgrazing.

- The truth is more complicated. Herd sizes had grown during the years of good rainfall when pasture was abundant. Indeed, building up large herds in good years is a deliberate strategy of arid zone livestock breeders. But overgrazing was as much a result of external factors as of the dynamics of pastoralism.

- Two factors reduced the amount of pasture available to the herds, and forced them onto increasingly marginal lands in search of food:

  * the first was the expansion of rainfed cropping onto marginal lands normally used for grazing;

  * the second was the increase in the cultivation of cash crops like groundnuts on fallow lands traditionally grazed by nomadic herds in the dry season.

- Attempts by governments and aid agencies to "improve" and "rationalise" nomadic practices have had a lot to do with the localised desertification caused by overgrazing around newly constructed boreholes, and near villages where nomads had been persuaded or forced to settle.

- Moreover, what is good for the land and for the nomads is not necessarily the same as what governments (usually prejudiced against nomads) and aid agencies (often convinced of the virtues of ranching and other western-style methods) may want.

- After the drought, herd sizes should have been reduced to a more sustainable level, and livestock productivity increased so that more meat and milk could be obtained from fewer animals.

- Instead the herd sizes of the Sahel have almost reached pre-drought levels, but as few animals are ever sold, there has been no increase in the production of meat. From 24 million before, the number of livestock in the Sahel dipped below 18 million in the early 1970s. But by 1980, it was back to 23 million. Goats and camels were back to their 1968 levels by 1977, and the number of sheep was more than 13% higher than in 1968.

- Can livestock in the Sahel be managed in a sustainable way to level out dramatic increases in herd size during good rainfall years and high mortality rates in bad years?

- Estimating the sustainable carrying capacity of rangeland is a difficult and often a completely academic exercise. But USAID experts have adopted a rule of thumb that livestock numbers should never significantly exceed those which could be maintained, however poorly, during the worst years and seasons.

- "A general rule is to stock at 80% of average capacity in order to have at least 20% forage reserve for drought years", says USAID.

- On this scale, the 1982 Sahel herd size of 23 million was about 5% more than the safe sustainable level.

- However, further increases in herd sizes are on the cards. Both CILSS/Club du Sahel and USAID think that increased livestock production is necessary to feed growing populations over the next 20 years.

- Before the drought, livestock exports accounted for up to half of total export income for some of the countries in the region. Today, the Sahel is a net exporter of meat but a net importer of milk and milk products. Since the start of the drought, meat exports have fallen and have only partially regained previous levels. Milk imports have increased six-fold.

- USAID estimates that between 1985 and 1990 the Sahel will become a net importer of meat, as well as milk.

- Already per capita annual consumption of meat has fallen from 17.2 kg (37.8 lbs) in the 1960s to 12.9 kg (28.4 lbs) in 1977, and that of milk from 54.8 litres (57.9 US quarts) to 53.6 litres

(56.6 US quarts) over the same period. The figures may fall still further.

- USAID thinks that a 50-65% increase in production by the end of the century is feasible. But this will require extensive projects to improve animal health and range management so that overall carrying capacity can be increased to 25.6 million animals by the year 2000.

- The larger herd, together with increased offtake and greater productive efficiency (as a result of higher fertility and growth rates and lower calf mortality) should allow meat production to rise by 68% and milk production by 50%, compared with 1977.

- This should satisfy domestic meat needs by 2000, but allows for virtually no meat exports. Some milk imports would still be required. And even these estimates, warns USAID, "depend on very large donor inputs, excellent host country cooperation and a bit of good luck."

- Better livestock management is desirable both to satisfy domestic demand and also to combat desertification. The area of available pasture is likely to be restricted by the continued cropping of marginal and fallow lands and by land lost owing to desertification.

- Unless greater productivity can be achieved, herd sizes are going to increase sharply, and overgrazing will become even more serious than it has been in the past.

- There are five ways by which livestock productivity could be increased, although not all experts agree on the value of all these steps:

  * improving the quality of animals by disease control, breeding, and stock reduction;

  * improving pastures by reseeding, allowing time for regeneration, planting new fodder/forage crops, and other measures;

  * increasing offtake (the number of animals sold each year for slaughter);

  * improving infrastructure by digging wells, making other improvements along routes to market, and establishing feedlots and abbatoirs;

  * changing the organisation of pastoralism by taking measures to restrict or regulate grazing in certain areas, encouraging the sedentarisation of nomads and their herds, establishing ranches, developing regional livestock raising schemes (stratification), etc.

- Disease control is the oldest established component of livestock programmes in many countries. It is readily accepted by herdsmen. Yet vaccination and other steps to reduce disaster often lead to livestock overpopulation, overgrazing and - when

drought strikes - disaster. The Fulani of Mali found this to their cost in the early 1970s.

- In the 1960s the World Bank supported a livestock disease control programme among the Karamojong of Uganda. It was supposed to be integrated with better marketing to counteract the increase in livestock population. But the marketing scheme failed; the herds overgrazed the land, and the Karamojong ended up worse off than before the programme.

- Other animal health schemes have aimed at increasing cow fertility, milk production and calf survival rates. However, since the methods used have depended largely on vaccinations, mineral and vitamin supplements, and concentrates, they are expensive and often beyond the means of owners once external payments stop.

- Breeding has received less attention than animal health. A lot of research has been directed towards the breeding of a tsetse-tolerant cow that would open up large areas of the more humid regions of West Africa for livestock raising. The hardy zebu cattle common in the Sahel are highly susceptible to the tsetse-caused disease trypanosomiasis when moved south to the higher rainfall zones. If a tolerant breed were developed it would have to be hardy enough to survive the tough environment of the Sahel.

- Too often, breeds and even species are not suited to their environment. Cattle are far less tolerant than sheep and goats to the droughts which regularly afflict the Sahel. More than a quarter, and perhaps one-third of the cattle herds were lost in the 1968-73 drought, about twice the mortality of sheep and goats.

- Some introductions of exotic sheep breeds into the Sahel have failed because the animals could not adapt to the environment.

- But other breeds have been neglected despite their potential:

  * the long-legged Kabashi desert sheep from Sudan is an excellent walker, produces good quality meat, and needs watering only every 3-4 days;

  * the small Moroccan ewes bred at the Royal Farm in the Souss region have a high twin-pregnancy rate but have not been introduced very widely.

Reducing stock levels

Implementing animal health programmes is relatively easy. Reducing stock levels is not.

- "Stock reduction schemes do not work because they operate on fiat, creating resentment and antagonism among a traditionally independent people," says Walter Goldschmidt of the University of California at Los Angeles.

- Nomads will fiercely, and if necessary violently, defend their right to mobility and to determine herd sizes. These are the two cornerstones of nomadic pastoralism. Thus any plans to increase offtake remain theoretical unless they fit in with the herdsman's point of view.

- Average offtake rates for Upper Volta, Niger and Mali were estimated to be around 9% in the late 1960s, a few percentage points higher than in the early 1950s but very low by western standards. Why?

- Nomadic herdsmen do not look upon their herds as potential beef to be sold. The herds are the nomads' chief means of storing wealth: more a form of capital than of income. The need to conserve such capital, especially as an insurance against bad years, is paramount.

Livestock market in Ayorou, Niger, on the Mali border. To nomads, cattle are a way of storing wealth, so few are sold for beef. Such sales average only 9% of herds in Niger, Mali and Upper Volta, far below western offtake rates.

- Livestock animals and milk are bartered for grain from farmers. Cash need not, and often does not, change hands. The herdsmen and their families rely upon their animals for their subsistence foods.

- In recent years the exchange ratio for livestock and grain has changed to the disadvantage of the herdsman. More animals are required to obtain the same amount of grain.

- Conditions have changed for the farmer too. Some of his grain is now sold on national and international markets, leaving less available for bartering. Indeed, there may be no grain available, whatever the price. The herdsman then has little incentive to sell his animals, if cash cannot buy the grain that he needs.

- The herd does not represent just another form of economics. It is central to all social negotiations - recording kinship links and creating patterns of alliance, dependency and support. "A herd is the monument and obituary of its owners, and a close reading of the animals in the kraal is a record of the major social interactions of a herder's life," writes Walter Goldschmidt of the University of California, describing the Sebei people of Uganda. The same is true for most pastoral societies.

- Cattle are commonly given as bridal payments. The Sebei calculate lineages of cattle to express social rather than biological continuity. "A Sebei wants to retain at least one representative of important sources of such cattle lineages, e.g. one from each aunt's and sister's and daughter's bride payment," writes Goldschmidt.

- Such attitudes are quite logical to the herdsmen, but difficult to represent in mathematical form in an equation of livestock supply and demand.

- More mundane reasons can lie behind limitations of offtake. The herdsmen who look after the livestock of farmers receive their payment largely in the form of milk from that livestock. This results in overmilking, high calf mortality and low rates of reproduction, allowing fewer animals to be sold for slaughter.

Improving rangelands

Few efforts have been made to improve arid/semi-arid rangelands, although the Sudanese government is preparing a project to reseed deteriorated land around the permanent water points of El Nahud and El Odaya in Northern Kordofan.

- Reducing livestock levels would allow regeneration of valuable perennial grasses and browse shrubs like Acacia albida. The rapid rise in livestock numbers after the Sahel drought left little opportunity for regeneration.

- Replenishing forage sources depends mostly upon localised action. One method would be to restore, if only in part, some of the village fallow land lost in recent years to cash crop cultivation. Increasing numbers of farmers are switching back

from cash crops as a result of falling returns, and more fallow could perhaps be further stimulated by appropriate incentives.

- A more elaborate strategy would be to encourage the growing of multi-purpose fodder trees and shrubs on marginal village lands, along roads and irrigation ditches, and around fields.

- Both the FAO and the International Livestock Centre for Africa in Addis Ababa have tried to encourage the greater use of trees and shrubs for livestock fodder.

  * Trees of the Prosopis genus are highly drought resistant and bear pods which are up to 14% protein and 45-55% carbohydrate. The foliage of P. juliflora and P. cineraria are lopped for fodder every winter in the arid and semi-arid zones of India. P. tamarugo is highly tolerant of saline soils and could help make abandoned irrigated lands productive.

  * The thorn tree Acacia albida is also valuable for fodder. It is highly drought resistant and often is the only remaining bit of greenery in the dry season. Like Prosopis, it is a soil improving, nitrogen fixing tree. It has the additional advantage of a relatively open canopy during the crop growing season and can be grown together with field crops like millet. Far from having any detrimental effects, crop yields under and around Acacia albida have been found to be equivalent to those in fertilised fields.

- The above suggestions assume the continuation of the Sahel's traditional division between nomadic pastoralist and sedentary farmer. But some livestock are already kept around villages, and so there is potential for intensifying village-based animal production by using high-yielding fodder trees and other sources of forage. Soil fertility would benefit from annual manure, and human nutrition from the extra milk and meat.

- But many villagers are sceptical about keeping animals. Efforts to widen the use of animal-pulled ploughs instead of hand-wielded hoes have made little headway, despite the obvious economic advantages.

More wells?

Much effort has been put into trying to "improve" the infrastructure of pastoralism, principally by the sinking of many new wells. The benefit of such projects is debatable. Often, they have contributed substantially to desertification by encouraging the growth of livestock beyond the available feed. The endless and unmanaged supply of water can lead to starvation for animals when local supplies of forage are exhausted.

- According to Walter Goldschmidt: "I have no indication of any instance in which the use of wells has had any positive effect." (He refers to wells in the arid and semi-arid zones, not village wells for domestic use.)

A village well in southern Niger. The thousands of new wells dug in the rangelands over the past three decades provide water for herds without providing more grass. Thus wells themselves can cause overgrazing. The sinking of wells with no parallel grazing improvement programme should cease, says a British expert.

- The phenomenal growth in the number of watering points, especially along routes to markets, has concentrated herds in limited areas along routes and around wells. This causes degradation and desertification through trampling, browsing and grazing.

- Although herdsmen do clamour for the construction of new wells, they are often aware of such dangers and prefer privately owned wells to which access is limited.

- The Bororo herdsmen from the Bermou region of Niger have urged the government not to sink new wells in their traditional grazing areas since this would attract outsiders and overload the pastures. They have suggested instead that wells be sunk in Tuareg country to the north, so that the Bororo could use these wells in the dry season but would not have to reciprocate by sharing their wells in return.

- On the other hand, the Tuareg also appreciate the threats which boreholes pose to their pastures. In the early 1970s the Illabakan Tuarag of Niger petitioned to have the pump at one well turned off because the well had attracted so many outside herds that pressure on pastures was severe, and relations between the Tuareg and nearby tribes were becoming very strained.

- Despite the great profusion of such examples and the clear warnings made at UNCOD of the dangers, Sahel governments, assisted by aid agencies, continue to sink new wells. Since the mid-1970s, almost $7.5 million has been spent on UNSO coordinated projects of this kind in Gambia, Mauritania and Upper Volta.

- Water Goldschmidt despairs: "Planners do not learn from their own mistakes. To see governments plan to make elaborate installations of waterholes or to launch stock-reduction programmes after these have been repeatedly branded as failures makes one wonder why writing was ever invented."

- "The indiscriminate sinking of boreholes with no parallel grazing programme should cease", says Randall Baker of the School of Development Studies at the University of East Anglia, UK.

- A moratorium on new borehole projects, if only on the part of aid agencies, may therefore be advisable.

- As in the changing priorities for irrigation, assistance in the immediate future could be given for the "rehabilitation" of existing projects. Many techniques need investigating.

  * Groundwater studies should be undertaken, where these were not made before the well was sunk.

  * Output from wells might be reduced by replacing pumps with more traditional hand-drawn and animal draught methods for raising water.

  * The watering point and adjacent areas could be redesigned both to regulate and decentralise access, to regenerate overgrazed pastures, and to incorporate shelterbelts of trees.
  * Reserves of native pastures and fodder shrubs and trees could be planted along the major market routes so as to reduce livestock pressure in areas adjacent to key waterholes.

  * The crowding of animals could be reduced by ensuring that watering points are not sited near villages.

- Unfortunately, once a watering point is established, regulating its use can prove very difficult and can lead to violence. According to Peter Hopcraft of the Institute for Development Studies at the University of Nairobi: "In areas where boreholes have been installed, attempts have sometimes been made to turn off the pumps before grazing destruction sets in. The results of these attempts have generally been such anger that pumping equipment is deliberately destroyed.

- "This has led to proposals that pumps and equipment be removed to the next block (grazing area), again forcing the livestock to move to where there is water. In general, as anyone who has been thirsty and without water in a hot and arid environment knows, tampering with what is regarded as a possible water supply is an explosive activity."

Regulating nomads

Four main types of interventions into livestock herding have been tried by governments and aid agencies. All have one thing in common - a reduction in the mobility of herds:

* grazing controls;
* sedentarisation;
* establishment of ranches;
* stratification.

- Despite strenuous efforts over the last 30 years, most such interventions have failed. This is largely due to the "experts'" ignorance or neglect of the traditional grazing controls exerted by pastoralists.

- It is easy to believe that just because grazing lands are communal, they are also unregulated. This is not usually so.

- Professor Michael Horowitz, a social anthropologist at the State University of New York at Binghamton, writes: "There is an emerging awareness among scientists...that strict regulation of access to scarce resources (water and grass) and limits on herd size may well be the rule rather than the exception among herding societies in semi-arid lands."

- Why do governments wish to control what has previously been self regulated by nomadic peoples? "With the exception of Mauritania in the Sahel and Somalia in East Africa," says Horowitz, "the ruling elites of these states are drawn from groups which are not only not pastoral, but which have historically viewed pastoral peoples with ambivalence at best, and often outright hostility."

- The dominance of the farming peoples in such countries was confirmed by the colonial powers, forcing the herdsmen to retreat in the face of constantly expanding cultivation.

- "The final insult," says Horowitz, "was the implantation of deep wells open to all comers, leading to chaotic competition for grazing land."

- Imposed government controls have aroused resentment and have often been resisted. One type of control is the grazing fee, which, while not limiting the herd's freedom of movement, has the motive of forcing the herdsmen to dispose of non-productive animals.

- "Enthusiasm for the notion of a grazing fee should not be anticipated," says Peter Hopcraft, "especially from the owners of relatively large herds of cattle. Paying for a resource that has such a long and culturally embedded history of being freely available (or at least free, even if not always available) is an innovation that is likely to have its legitimacy seriously questioned. Grazing fees were an integral part of a number of

grazing schemes in the colonial period, and they undoubtedly generated considerable antipathy."

- Another form of control is to separate the rangeland into blocks that must be used successively. Each block has a fallow period to enable regeneration of pasture. How is such a scheme to be managed? One way is to turn off or physically remove the pumps from waterholes in the block where forage is approaching exhaustion. This, as has been seen above, can lead to violent reactions on the part of the herdsmen. When tried out in Kenya among the Pokot and the Samburu, the block system failed dismally.

- The block system, like the enforced sedentarisation of nomads, limits the freedom of movement that is one of the key components of their way of life.

- Studies have shown that nomadic grazing is a sound technique for using scarce dryland pasture resources. If herds can arrive in a place when grass is still green, digestibility is of the order of 70% compared with 30% for dry grass. Without mobility, herds would gain increasingly poorer feed value from the pasture as its digestibility decreased through the season.

- Mobility also means freedom to search for areas where rains have caused grass to grow. Rainfall can fluctuate widely in the arid zones. At Maine-Sora in south east Niger, the average rainfall is 432 mm (17 inches). Between 1961 and 1970 (a good decade) the annual total only topped 500 mm (20 inches) twice, but fell below 400 mm (16 inches) four times.

- In 1949, when Maine-Sora had only 230 mm (nine inches) of rain, Diffa, 50 km (30 mi) further east received just 67 mm (2.6 inches). Herds would have suffered if they had not been allowed to move out of Diffa that year.

- Studies of cattle which annually trek more than 1,000 km (620 mi) between the Malian Delta and the Mauritanian Sahel indicate that they arrive back in better physical shape than the milking cows and calves which have remained in the village for the whole year.

- Nature does not run like clockwork in arid areas like the Sahel, and it would be difficult if not impossible to devise a block grazing scheme flexible enough to give as good productivity and insurance against poor rainfall as the traditional system.

- "Range management interventions can and should be based, where possible, on the system of controls already practised by the people", says Michael Horowitz.

- Sedentarisation of nomadic herdsmen has been seriously considered as an option for improving livestock raising in semi-arid areas. In practice it is difficult to consider sedentarisation in isolation from the strong political pressures against nomads.

- Many nomads, such as some of the Fulani people in Mali, settled spontaneously in the aftermath of the Sahel drought. They saw it as a temporary measure until their herds built up again, but many have not returned to the nomadic way of life.

- Sedentarisation may reduce the numbers of animals on diminishing pastures. But the increased concentration of livestock around a village will degrade nearby pastures.

- Such degradation may be exacerbated by an increase in herd size, since the settled nomads will tend to become more dependent upon grain and so require less meat and milk.

- The only really successful example of sedentarisation has been by the Fulani in Nigeria. Because the area being settled was previously underpopulated, and the climate is less arid than in other African countries with large nomad populations, the example might not be generally applicable.

- Mustafa Mohamed Khogali, of the Department of Geography at the University of Khartoum in Sudan, takes a middle-of-the-road approach. He thinks that nomads sould be encouraged to settle if they want to, but that previously planners have failed to really understand nomadic mentality and tried to urge them to become cultivators without animals.

- This may be too much of a break from past traditions. It may also not be as profitable as the old way of life. Mr Khogali has estimated that the nomads' average annual returns may exceed those of rainfed cultivators by at least 30-35%.

- The introduction of intensive livestock ranching to developing countries has rarely been a success. After World War II, "development" meant transferring western technology without adaptation to developing countries. Many aid agencies wanted to take Texas to the Sahara. The President of Niger and other Sahelian heads of state talked of exporting beef all over the world.

- Reality has proved less rosy. According to the Club du Sahel: "Results on the whole have not been satisfactory: the investments called for were too heavy; the farms, placed in regions poor in resources, resulted in mediocre productivity; and finally, marketing of production was hampered because the ranches were too far from the large commercial centres."

- Under colonial rule, Europeans had expropriated land and established commercial ranches. Where these were effective, they often utilised exceptionally favourable conditions and showed little regard for the welfare of the indigenous people.

- Post-independent regimes have sometimes replicated the actions of the colonisers. In the 1960s, the World Bank promoted commercial cattle ranching in south west Uganda with the construction of over 100 ranches, each of several thousand hectares (acres). The political elite of Uganda took control of the lands and succeeded in establishing themselves as absentee landowners over large tracts of Uganda's grasslands.

- Some countries have used the concept of the "group ranch", so-called because it is run as a cooperative by a several families.

- The government of Kenya succeeded in establishing 14 group ranches in the late 1960s, each averaging 19,000 hectares (47,000 acres) and 100 families, settling the people and registering land ownership.

- The Masai agreed to participate in these ranches, less out of enthusiasm than in fear of what the government might do if they refused. As one elder said: "If there is rain in Kenyawa and people have ranches there, I cannot move my cattle into that place." Some of the Masai arranged to have family members registered in different ranches so that they could still move to more favourable lands when drought threatened their own pastures.

- The experiment does not seem to have been a success. The cooperative has improved marketing and the acquisition of cattle dips, sprays and the like. But the ranches are still run basically on traditional subsistence lines. Moreover, the lands have often been invaded by outsiders, leading to armed clashes.

- The government of Tanzania has been trying for 18 years to integrate pastoralists into its Ujamaa (socialist community) villages. Various incentives and even coercion had failed, when in 1973 the government tried (with the help of USAID and the World Bank) to establish cooperative (group) ranches, but with communal herds. Members could bring in their own cattle if they wanted.

- But the people have been loath to contribute their own cattle, and unwilling to accept government subsidised communal cattle, because this ran contrary to their basic belief in self-reliance.

- A far more elaborate reorganisation of livestock management was the SOLAR project (Stratification of Livestock in Arid Regions), adopted as one of six transnational projects at the UN Conference on Desertification.

- The essential idea was to stratify livestock rearing in the Sahel. Calves would be reared, as at present, on arid rangelands in the north. They would then be moved south to more humid pastures for fattening either by peasants or on intensive feedlots. Finally, they would be sold in the cities and on the coast.

- With few very local exceptions, the SOLAR approach has been a failure.

- The lifestyle and culture of nomadic pastoralists severely limit the rate of offtake from the herd. Herdsmen have not previously been willing to sell large numbers of young stock for fattening. There are dozens of production zone abattoirs in sub-Saharan Africa which have been abandoned or operate at only a fraction of design capacity.

- Could such a scheme ever be economically viable? It has been estimated that the cost of feed and supplements in this grain-

deficient region would be two or three times the value of the weight gained.

- Intensive fattening would make livestock more expensive. But beef imports into West Africa are linking the Sahel with world markets, putting an upper limit on the prices of domestic livestock.

- Can livestock raising in the Sahel ever be improved?

  * Walter Goldschmidt of the University of California concludes: "The picture that emerges is one of almost unrelieved failure."

  * Michael Horowitz of the State University of New York talks of "the almost unblemished record of project non-success in the Sahelian livestock sector."

  * Dr Ibrahima Toure, a Dakar-based UNESCO range management expert, said, "There have been many livestock projects since the drought, but few positive results. Things go wrong in implementation. Planners don't have an overall view of the problem."

Nomad herders camping in central Niger. Nomads will fiercely defend their right to mobility and to determine their own herd sizes. Governments and livestock experts want them to sell more animals. Herd sizes throughout the Sahel are approaching pre-drought levels.

- Such experience has left its mark. Planners feel they cannot achieve anything with livestock. Only 5% of all development aid goes to livestock, even lower than the 8% for rainfed cropping.

- One result of decades of failure is that pastoralists are now suspicious of all government attempts to intervene in their practices. For their part, governments tend to label nomads as stubborn and inflexible. There are perhaps large elements of truth in both views.

- There may be less emphasis on stock reduction and well-digging in the future. The latest batch of projects submitted for consideration in 1981 to the UNEP-sponsored Consultative Group for Desertification Control (DESCON) gives rise to optimism. (DESCON contains representatives of donor and recipient nations and UN and intergovernmental organisations and acts as a preliminary screening body for potential anti-desertification projects. However, it has so far had little influence on funded projects.)

- In theory, it should be possible to improve livestock production in ways which do not result in overgrazed rangelands and which are compatible with the traditions and wishes of the pastoralists. In the Sahel, few projects, even at the pilot stage, indicate how this can be done.

Afforestation

About four million hectares (9.9 million acres) of woodland are being cleared each year in the world's drylands, 2.7 million hectares (6.7 million acres) in Africa.

- Niger's forests and woodlands, for example, will at the present rate of loss be exhausted within 23 years, according to a study carried out by the University of Arizona.

- Afforestation is needed on a massive scale to improve the environment in arid and semi-arid zones and reduce the shortfall in wood supplies, which is reaching crisis proportions in many of the world's arid areas: "the other energy crisis", as US environmentalist and author Erik Eckholm has called it.

- What use are efforts to improve food production if there will be no fuel with which to cook the food?

- A recent FAO study suggests that the current deficit of fuelwood in the tropics is equivalent to the sustainable production of 25.8 million hectares (64 million acres) of intensive fuelwood plantations (an area about the size of West Germany).

- By the year 2000 the deficit will be equivalent to 61.5 million hectares (152 million acres) of fuelwood plantations (an area the size of Spain and Portugal combined), if present planting rates are not increased.

- Just to supply the shortfall by the year 2000 in African countries south of the Sahara would require the establishment of plantations which, if collected together, would form a forest belt 6,000 km (3,700 mi) across the Sahel from Senegal to Ethiopia and 34 km (21 mi) deep.

- For many countries, afforestation is already a race against time, a struggle to overcome obstacles that are social as well as physical. Much of the land needed for the new forests is now used for growing crops or raising livestock. Farmers and herdsmen complain about the taking over of their lands, even though they know that unless new woodlands are planted, the soil will blow away and the water table will sink even further until the land is useless.

- Another handicap is the shortage of foresters. In Upper Volta, for example, there are not even enough foresters to look after existing forests properly. One office, responsible for administering 10,920 sq km (4,216 sq mi) of forests, has only one motor scooter and a ration of 30 litres (eight US gallons) of petrol every month.

- Without the active support and participation of local people, it will be difficult to meet tree planting needs. Foresters are having to develop new techniques in order to secure this popular involvement.

- Two main types of new techniques are being employed:

  * agroforestry, in which forestry is blended with agriculture so that tree crops are planted in such a way that crop and/or livestock production is enhanced rather than displaced;

  * social or community forestry (also called "mass forestry"), which mobilises large numbers of people to plant and protect trees, either on village or private lands, with the aim of producing wood and other products mainly for village rather than industrial uses. Foresters educate, supervise and assist rather than carrying out such schemes themselves.

Agroforestry

Agroforestry is tree planting with an understanding of the farmers' point of view, so it is also a form of social forestry. Social forestry and agroforestry often overlap. But while agroforestry is a set of techniques for growing trees together with other crops and livestock, social forestry gets ordinary people to participate in tree planting in ways that can improve their lives.

- High priority is being given to agroforestry and social forestry by FAO and the World Bank following major policy switches in 1977. The International Council for Research in Agroforestry (ICRAF), based in Nairobi, was established in 1978 to promote and coordinate research in agroforestry.

- Persuading farmers to stop growing crops or raising livestock would be almost impossible in areas subject to desertification. So agroforestry, a combination of forestry and agriculture, restores tree cover while agriculture continues.

- Farmers soon begin to experience indirect benefits in the form of higher crop yields and reduced soil erosion in the lee of windbreaks. Within a few years the trees can be harvested for a useful crop of fodder and fuelwood.

- At the very heart of any arid land agroforestry scheme are multi-purpose trees like Acacia, Leucaena, and Prosopis. They can be grown quickly on poor soils to yield food, fodder, fuelwood, building timber and other products.

- Interest in multipurpose tree crops has grown rapidly since the mid-1970s.

  * The US National Academy of Sciences has published compilations of tree crops with potential for development.

  * FAO has also been trying to promote interest in this field.

  * The International Tree Crops Institute was established in Braintree, England, in 1977 to search for high yielding varieties of multipurpose trees. It now has research centres in the USA, Australia and India.

- Acacia albida (also called Faidherbia albida) is intercropped with wheat, millet and other field crops in semi-arid regions of Africa. It is unusual in that it comes into leaf at the end of the rainy season and maintains its foliage during the hot dry season. This has two advantages. First, the growing of field crops beneath it is not hindered by shade in the rainy season. Second, its foliage shades the soil and also acts as a valuable fodder reserve in the dry season.

- The tree also fertilizes the soil by increasing levels of nitrogen and phosphorous. As a result, crop yields beneath the tree are as high as in fertilised fields. Studies in Senegal have shown that yields of millet near Acacia albida trees are two and a half times yields in open fields.

- Cattle benefit from the foliage and from the large crop of pods that are full of protein and carbohydrates. At Zalingei in Sudan each tree produced an average of 135 kilograms (300 lbs) of pods every year.

- The tree Prosopis juliflora plays a very similar role in India.

- Recently much effort has gone toward establishing plantations of fast growing fuelwood trees on odd bits of land in villages and on farms in the Sahel. One hectare (2.5 acres) of Acacia, Eucalyptus or Prosopis grown on a 6-10 year rotation could supply enough fuelwood and small timber to satisfy the annual needs of 7-15 people (two or three families). A large number of small

plantations sited near farms and villages may be more useful than a small number of large but remote "energy forests".

- In Niger, Canada's International Development Research Centre financed between 1974 and 1977 the planting of 165 hectares (400 acres) of woodlots in 59 villages at a cost of $141,200 can $$ The woodlots each covered 2.5-4 hectares (6-10 acres), and species included Eucalyptus camaldulensis, Azadirachta indica (neem) Albizia lebbek, Cassia siamea, and Prosopis juliflora.

- Many families cook their food or heat their homes using either open (usually three-stone) fires or fairly simple stoves that burn wood rapidly and inefficiently. There are a growing number of projects, sponsored by both large aid agencies and church groups, trying to persuade villagers to use more fuel-efficient stoves.

- Such stoves can in theory use one third less wood, thus reduce deforestation and make maximum use of wood produced by newly established village woodlots. Unfortunately, most stove projects fail to take into account the needs and wishes of the people who will use the stoves, which are usually abandoned after a subsidised project ends.

- Shelterbelts and windbreaks are another popular type of afforestation, protecting soil, crops and livestock from hot dessicating winds that in arid regions like Rajasthan in India blow at speeds of up to 150 km per hour (90 mph).

- Rajasthan is aiming to plant over 1,500 km (930 mi) of roadside shelterbelts over the next five years, choosing tree species which can be harvested for fodder and fuelwood.

- China has proved that such a target is feasible. In the northwest of the country, some 700,000 farmers established a shelterbelt 1,500 km (930 mi) long and 12 metres (40 feet) wide over two seasons.

- In Rajasthan, three rows of trees are planted on either side of a road, and attention is paid to aerodynamic design to achieve maximum benefits. Tall trees like Azadirachta indica (neem), Albizia lebbek, Acacia tortilis, Cassia siamea and Eucalyptus are planted nearest to the road. Species of Acacia and Tamarix are planted in the second row. For the third and smallest row nearest to the fields, trees like Acacia nilotica, Prosopis juliflora, Parkinsonia acculiata, and Zizyphus mauritiana are used. The double wedge-shaped design gently lifts the wind away from the field without causing harmful eddies.

- In Niger, the Majia Valley windbreak scheme sponsored by the US voluntary agency CARE, has since 1975 succeeded in establishing 250 km (155 mi) of windbreaks near Bouza (some 500 km - 300 mi - north east of the capital Niamey).

- Farmers are already feeling the benefits of the million dollar scheme. Cereal production has increased by at least 15% in the 3,000 protected hectares (7,400 acres) of fields, resulting in a yearly cash gain of $108,000. US forestry consultant Fred Weber

reports that other villages are asking for assistance to establish their own windbreaks.

- Weber is now designing a plan to harvest fuelwood from the windbreaks without detracting from their protective qualities. He estimates, fairly conservatively, that 250 km (155 mi) of windbreaks could produce 2,500 cubic metres (88,000 cubic feet), or 2,000 tonnes, of fuelwood with a local value of about $80,000 every year.

- The controlled grazing of tree crop plantations undersown with pasture grasses is very effective if well managed. Cattle and sheep benefit from the shade, the highly nutritious pods and the foliage.

- Experience in Niger has shown that 18-20 cattle may be grazed per sq km (47-52 per sq mi) where Acacia albida grows, compared with 10 cattle per sq km (26 per sq mi) of open pasture. The protein-rich pods may be dried and stored for later use.

- Leucaena leucocephala is not as drought resistant as Acacia albida, but grows very quickly, producing up to eight tonnes of edible dry matter per hectare (3.2 tonnes/acre) every year. The foliage is very palatable and full of protein. It can be browsed by cattle in a wooded pasture or cut by hand and fed as part of mixed rations. Cattle having Leucaena as part of their diets gain weight twice as quickly as those grazing only on good tropical pasture grasses.

Plantations

Tree crop plantations are not unfamiliar in the Sahel. The most popular tree crop is undoubtedly Acacia senegal, source of gum arabic and extensively grown in the Sudan (the main world supplier of gum arabic) and in other countries such as Senegal.

- Gum gardens are the basis for an ecologically stable agricultural system in which the A. senegal trees occupy agricultural land in the fallow periods of a 12-year rotation. The system has long assisted both in soil conservation and in giving a cash crop to local peasants. Gum arabic accounts for 25% of Sudan's agricultural income and is its third largest export commodity.

- In recent years, however, Sudan's gum production has plummeted. By 1980, production was only 22,000 tonnes per year compared with 45,000 tonnes in the early 1970s. Fallow periods have shortened in response to growing demand for land to grow food. There has been considerable livestock encroachment owing to poor pastures in the north Sahelian zone. Extensive areas of trees, weakened or killed by the 1968-73 drought, blew down in the wind.

- The Sudan government, mindful of the fact that its "gum belt" forms a natural buffer zone between the desert and the main agricultural zone to the south, has launched a $5 million scheme to restock 144,000 hectares (356,000 acres) of gum gardens in the provinces of North Kordofan, Northern Darfur and White Nile. The

A tree nursery, Niger. Tree-planting is proceeding 50 times slower than required in the Sahel. Thus Niger is turning to "mass forestry", in which foresters educate, supervise and assist rather than do the work themselves.

A World Bank financed eucalyptus plantation near Niamey, Niger. Diesel pumps bring water to each tree from the River Niger. Such a plantation should produce usable trees in three years. But in 1982 costs were running higher than expected and this "high technology" approach had yet to prove itself.

scheme forms a major part of its national anti-desertification programme, DECARP, which although well-conceived before the 1977 desertification conference, has been little implemented.

- A World Bank financed eucalyptus plantation at Namardegongou, near Niamey, represents a "high technology" approach to fuelwood supply. Some 240 hectares (600 acres) along the River Niger are drip irrigated by diesel pumps. Each of the 1,100 trees per hectare (445/acre) gets its own dose of water.

- Such a plantation is expected to produce trees for fuelwood and construction in three years, making it 10 times as productive as an unirrigated plantation in the same region. This plantation is meant to supply much of the capital's needs.

- The project was started in 1980, and by mid-1982 (when trees had yet to be harvested) the economics of the venture remained unclear. The expenses of diesel fuel, maintenance and spares for imported pumps, and labour to clean the filters daily were all adding up to more than had been expected. Experts familiar with the project were predicting large cost overruns.

- The drip technique causes trees' roots to grow out in one direction, toward the water source; as a result some trees were simply falling over. More time and data will be needed to prove whether this approach can become a significant part of the solution to the Sahel's wood requirements.

Social forestry

Given the tremendous fuelwood needs and the fact that national forestry departments are usually both incapable of looking after existing forests properly and already stretched by present afforestation commitments, the only longterm answer seems social forestry: mobilising the support and active participation of ordinary people.

- Even if the government forestry departments were able to plant the required numbers of trees, farmers and nomadic herdsmen might use the young trees for fodder or fuel.

- Until recently, most foresters have treated plantations as places from which local people must be excluded. They now have to learn how peasants view trees and forests, and to develop new practices from this understanding. For forest officers, who were previously little more than policemen, to change overnight into patient, inspirational "tree gurus" is quite a challenge.

- The most spectacular examples of mass afforestation campaigns carried out largely by ordinary people have been in China and South Korea.

  * China has been able to double its forested area in just 30 years - a phenomenal afforestation rate of 1.5 million hectares (3.7 million acres) a year.

* South Korea, a highly capitalist country, has been planting 40,000 hectares (99,000 acres) a year. On a per capita basis, this is nearly three-quarters the rate of China.

- These have been achieved in two countries with very different political systems, although both have a tradition of highly organised communal activity. Such an approach may not be transferable to many other countries. It also suffers from the disadvantage that the large plantations will not receive as much care and attention in the crucial early years as will, say, small woodlots. Only about 10% of the plantations which China established in the 1950s and 1960s survived.

- For most countries, village based schemes will prove to be the only practical option. The rate of planting is lower, but good extension work can insure a higher survival rate for the new plantations. This village based approach is referred to in the Sahel as "mass forestry" to emphasise that all citizens must take part to assure success.

- The state of Gujarat pioneered social forestry in India. A crucial initial phase was to establish multi-row shelterbelts alongside roads and canals. The forest department owns the land and planted the trees, but nearby villages have grass cutting rights, protect the saplings, and in return take a share of the profits.

- These mini-plantations were not planned or planted with much public participation but, according to B K Jhala of the forestry department: "They marked a critical psychological turning point... The new plantations also gave many people their first positive impressions of the forest department. They saw that our activities could benefit them directly."

- About 9,000 km (5,600 mi) of roads and canals had been planted with new forests by 1980, and every year another 1,500 km (930 mi) are added to this total.

- A number of villages were persuaded to establish plantations on communal grazing lands. Mixtures of seedlings for timber, fuelwood, fodder and fruit are supplied free of charge by the forest department. The villagers protect the plantations from grazing and fuelwood poaching, and share in the eventual returns from harvesting the trees.

- Within four years from 1973, almost one-fifth of the 18,000 villages in the state had joined. The slow, patient work of persuading village councils has paid off. Now the forest department is contacted by councils who have seen how neighbouring villages have benefited and want to do the same themselves.

- Private enterprise forestry has also started. Khalidas Patel used to grow cotton and tobacco on his 79-hectare (195-acre) farm near Ahmadabad. The forest department suggested he use some of their Eucalyptus seeds to establish a trial woodlot.

- The first trees were ready for felling within five years of planting. So impressed was Mr Patel by their rate of growth that he has converted over 80% of his property into a "tree farm".

- The power of his example has been astonishing. By 1977, 86 farmers in the state had asked the forest department for seeds, seedlings and technical advice on how to establish their own plantations. In 1978 this number rose to 300.

- Gujarat now has a $37 million World Bank loan to establish more than 100,000 hectares (247,000 acres) of fuelwood plantations.
- This effort is not without its critics. "The State of India's Environment: 1982", published by the Centre for Science and Environment, New Delhi, reports that 10,000 farmers in one Gujarat district have coverted prime, irrigated agricultural land to eucalyptus plantations.

- The resulting wood goes mainly for pulp and rayon production, not for fuelwood. Also, tree plantations require little labour; thus the poor are thrown out of work. The report quotes one critic who describes eucalyptus as an "ecological terrorist", providing neither fuel, fodder, green mulch nor shade.

- Social forestry in the Sahel is still at a very modest level compared with Asia. There are a number of small scale projects financed by church groups and other non-governmental organisations. These are often more active in promoting afforestation than governments themselves, although the forest services in Upper Volta in the 1970s and in Niger today have had some success with village plantations.

- The most popular village/town afforestation measure is the "green belt", a shelterbelt of hardy, drought resistant trees which protects the settlement from harsh winds, swirling sandstorms and encroaching sand dunes; and which can be harvested for fuelwood, poles and fodder.

- Examples include the 500-hectare (1,200-acre) green belt around Ouagadougou (capital of Upper Volta), and the expanding 300-hectare (740-acre) belt around Niamey (capital of Niger). Smaller green belts go into the centre of the towns, providing shade and cool in every street. The Niger town of Bouza is now famous for its cool, tree-lined streets.

- Afforestation proceeds most successfully in desertified areas when:

  * an integrated approach is taken so as to enhance crop production and/or livestock raising;

  * there is active public participation in order to save on costs and to help ensure that the new forest plantations will be protected and not abused after establishment.

- The integrated approach was at the heart of the two huge transnational green belt schemes that were proposed at UNCOD to stretch along the northern and southern fringes of the Sahara, from the Atlantic to the Red Sea. These mosaics of forests,

shelterbelts, and well-managed croplands and pastures were designed to resist the spread of desertification.

- These giant green belt schemes have been tacitly abandoned since UNCOD, and the pace of afforestation along the southern fringe of the Sahara has been very slow.

- But in North Africa, Algeria established 267,500 hectares (660,500 acres) of new forests between 1978 and 1981; and Morocco has afforested 19,500 hectares (48,000 acres) in the Rif region between 1977 and 1980. In Algeria at least, tree mortality after planting was high.

- If the countries of the Sahel are to plant enough trees to hold back desertification and to satisfy the need for fuelwood, governments will have to give a far higher priority to forestry. Social forestry is likely to be one of the only ways of overcoming the twin constraints of high costs and lack of qualified foresters.

Desert reclamation

Afforestation can be used to reclaim severely desertified lands that have been turned into sandy or saline deserts.

- China has reclaimed large areas that were formerly covered with sand dunes and shifting sands. On Nanshan Island in Guangdong Province, 57 km (35 mi) of coastal windbreaks varying in width from 1 to 5 km (0.6-3 mi) have been established since the mid-1950s. The Casuarina equisetifolia trees, tolerant of salty ocean winds, now protect agricultural lands from the sands and tidal water which threatened them. Crop yields have tripled.

- Agriculture in the Tungfanghung Production Brigade in Chifeng County had long been blighted by about 20,000 sand dunes, each covering an area of between 0.1 to 0.5 hectares (0.2-1.2 acres). In the 1950s, using what can only be termed "mass mobilisation", the brigade physically removed two million cubic metres (2.6 million cubic yards) of sand. After levelling, the land was flooded with silty water in order to form an alluvial soil. Once this had been completed, paddy fields were established together with protective shelterbelts to make sure the fields stayed sand-free in the future.

- Western Rajasthan in India has some 1.3 million hectares (3.2 million acres: half of the state's total land area) covered by sand dunes. The dune stabilisation programme is miniscule compared with similar programmes in China. According to Dr C M Mathur, the Director of Desert Afforestation and Pasture Development in Rajasthan, the major constraints are lack of finance, ineffective management, and "above all public apathy".

- About 10,000 hectares (25,000 acres) of dunes in Rajasthan are being stabilised each year. Under a programme assisted by the World Bank and World Food Programme, an area of 50,000 hectares (123,500 acres) was stabilised as part of the Rajasthan Canal Project area between 1975 and 1979.

- India cannot mobilise the large numbers of people that China can, so its methods have to be less labour intensive and are probably more typical of those used elsewhere in the world.

- The dunes are first fenced to protect them from further grazing by livestock and to assist natural regeneration of vegetation. Then initial stabilisation is achieved by fixing parallel strips of brushwood into the dunes. With this protection, it is possible to plant hardy trees like Acacia tortilis, Prosopis juliflora, Prosopis cineraria, and various species of Zizyphus, and to seed appropriate grasses. The dunes have to be carefully protected for at least two years, and no grazing is allowed for five years, although grass may be cut for forage after a couple of years.

- Somalia has substantial sand dune stabilisation activities. Agricultural land, villages and roads are threatened by an estimated 500 sq km (200 sq mi) of dunes along a discontinuous front of 2,000 km (1,200 mi) along the coast and reaching up to 25 km (15 mi) inland.

- Between 1973 and 1979, 500 soldiers, 60 full-time workers, and up to 5,000 part-time workers had stabilised 12 sq km (4.6 sq mi) of dunes, using methods similar to those employed in India. To speed up the scheme, Somalia asked UNSO to support a three-year, $2 million programme to stabilise a further 125 sq km (48 sq mi).

- Tree planting can be used to reclaim saline/alkaline deserts, covering an estimated 121 million hectares (300 million acres) in the tropics: 36 million hectares (89 million acres) in India and Pakistan; 31 million hectares (77 million acres) in Africa, and 54 million hectares (134 million acres)in South America.

- The area of new irrigated croplands in West Africa is barely keeping pace with the area of already irrigated land going out of production as a result of salinisation.

- Both the Club du Sahel and USAID are giving high priority to the rehabilitation of existing irrigation schemes. So far, however, no action is planned to reclaim saline/alkaline lands in the Sahel.

- After preliminary additions of gypsum to reduce soil alkalinity, merely planting salt-tolerant trees can produce considerable improvements. The increased transpiration of water from the trees reduces waterlogging and lowers the water table in areas where it is too high. The shade of the trees reduces surface evaporation, retarding the upward movement of ground water and the deposition of salts near the soil surface. The penetration of the roots opens up the soil, improving permeability and assisting the leaching of salts in the soil. Soil structure is further improved by fallen leaves.

- India has some seven million hectares (17 million acres) of saline lands and has considerable experience in their reclamation. A system developed in Haryana state uses Prosopis juliflora, Acacia nilotica and Eucalyptus, allowing highly saline and barren land to be reclaimed.

- Afforestation with multi-purpose trees can even make saline lands productive again, as sources of fuelwood, fodder and other products.

- Despite the efforts of such bodies as the International Council for Research in Agroforestry, Canada's International Development Research Centre (IDRC), Costa Rica's Centre for Tropical Agriculture (CATIE), and the International Tree Crops Institute (ITCI), there is a need for far more research and experiments in tree crops and agroforestry.

CHAPTER NINE

CONCLUSIONS

More than five years after the UN Conference on Desertification (UNCOD) emphasised the need for urgent action and agreed on a strategy for carrying it out, only very limited progress had been made.

* The idea of some kind of "automatic" funding mechanism - or international taxation - for producing the necessary billions of dollars has not been realised.

* In some nations, like Chad, civil war and political unrest have presented a major obstacle to progress.

* In others, lack of interest by governments, lack of concern by donor nations, general public apathy, and the sheer size of the problem have proved defeating.

- This is odd, for the technical means to combat desertification exist and are well understood. Methods of growing trees in arid lands, irrigating dryland crops and increasing agricultural productivity have been identified.

- But economic, social and political means to combat desertification have not yet been found.

- The mechanics of aid mean that Northern countries prefer physical "infrastructure" projects such as the construction of roads, dams and buildings. These produce highly visible results and can consume expertise and equipment from the donor nation, creating profits and jobs in that nation. Projects in the rural areas are "messier": harder to identify, plan and implement, the results less visible; and few of the Northern donors have arid land agriculture experts willing to spend several years in the rural Sahel.

- The Club du Sahel, USAID and some other donors have adopted clear strategies which place priority on rural development, forestry, agriculture and growing food crops rather than cash crops. Despite this often stated priority, these areas still absorb relatively little of external aid.

- The leaders of countries threatened by desertification rarely come from the arid regions or understand their problems. The arid land dwellers tend to be the politically weakest citizens. Thus desert encroachment rarely becomes a "political" problem threatening the future of a regime.

- All of this helps to explain why, despite the fact that 30 million sq km (12 million sq mi) are threatened by desertification, the threat is not high on the agendas of the leaders of either developed or developing nations.

- Change in the arid lands themselves can only be achieved by changes in the way the local people regard their environment. Literacy rates are low in arid lands, where low population densities, nomadic lifestyles and lack of political power all mean few and poor schools. Yet education will probably have to precede environmental improvements.

- For the present, serious droughts, famines and the sort of political instability which affects the delivery of desert oil, phosphate and other minerals at present appear the only events which focus world attention on the problems of the one-third of the Earth's surface which is arid and semi-arid.

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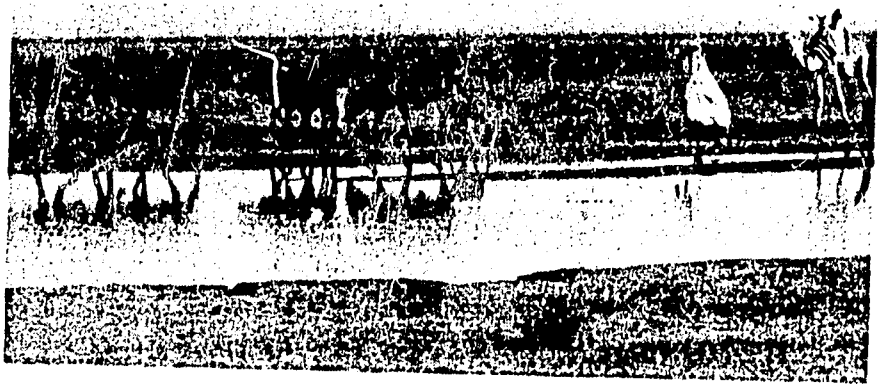
A Tuareg herder on the edge of the Sahara, near Agadez, Niger.



APPENDIX

The UNCOD Plan of Action to Combat Desertification

A. Recommendations for National and Regional Action

(1) Evaluation of desertification and improvement of land management

- RECOMMENDATION 1: Countries should assess the magnitude and extent of desertification, its causes and effects, by monitoring dryland dynamics, including the human condition. Satellite imagery should be used where appropriate. Atmospheric processes, soil cover, vegetation, shifting dunes, wildlife, crop yields, demography, human health and nutrition are among the items to be monitored. Desertification maps should be prepared.

- RECOMMENDATION 2: Techniques of land-use planning and management based on ecologically sound methods should be introduced into areas affected or likely to be affected by desertification, in conformity with social equity and geared to fostering social and economic development. In any area a pilot area should be used to test out plans, which should allocate within the area such uses as crops, livestock, wildlife, biosphere reserves, mining, industry, recreation, tourism, urbanisation and roads.

- RECOMMENDATION 3: Public participation should be made an integral part of action to prevent and combat desertification and account should be taken of the needs, wisdom and aspirations of people. Special educational packages and the full use of extension services are needed to increase general public awareness of the problem. Public discussion should be maximised, by making use of mass media and encouraging the expansion and strengthening of community organisations.

(2) The combination of industrialisation and urbanisation with the development of agriculture and their effect on ecology in arid areas

- RECOMMENDATION 4: UNEP, in conjunction with UNDP, UNIDO, and other UN organisations, are recommended to study and publicise positive and negative local and world-wide experience of the role which industrialisation and urbanisation play under different social and economic conditions in changing the ecological status of the environment and intensifying, preventing, or eliminating the processes of desertification in arid areas.

(3) Corrective anti-desertification measures

- RECOMMENDATION 5: Environmentally-sound management and development of water resources should be introduced as part of measures against desertification, and the UN Water Conference recommendations should be endorsed. Countries should develop local and appropriate water technologies, using local materials. Various appropriate technologies are mentioned, including rainwater collecting from roofs, sand filters, water harvesting, low-cost reservoirs, solar and wind pumps, and composting. There should be regional data banks, flood control and river pollution schemes. Revegetation of watersheds and other measures to reduce erosion, flood hazards and siltation are recommended. Appropriate methods for water purification, recycling, and pollution control, desalinisation and the use of brackish water should be introduced.

- RECOMMENDATION 6: Degraded rangelands should be improved, with better range management, wildlife management, and improved welfare for pastoral communities. Specific techniques suggested include deferred or rotational grazing; managed water points; new breeds and species of livestock; forage reserves; drought grazing reserves; use of crop residues and agro-industrial wastes as fodder; removing stock from drought areas; better livestock marketing; mobile abattoirs; irrigated production of forage; price stabilisation and marketing schemes for nomads; better land tenure and water rights; control of tourism; use of rangeland plants for fibre, alcohol, beverages, medicine; health, education and other social services for dispersed populations through radio etc; assistance with resettlement or partial sedentarisation. Regional centres should develop drought-resistant, high-yield and nutritious forage plants. Systems which combine forestry, agriculture and livestock raising should be studied, designed, and implemented so as to give rise to economically and socially stable systems.

- RECOMMENDATION 7: Rain-fed farming should be improved so as not to cause desertification. This could include cover crops, rational use of organic and chemical fertilisers, terracing, strip cropping, shelter belts, sand stabilisation, diversification of farming systems and better land tenure. Watersheds, upland pastures and woodlands should be revegetated and protected from grazing, cultivation or cutting for fuel where this entails a risk of desertification.

- RECOMMENDATION 8: Although new arid lands should be irrigated and each nation must determine its own priorities, "at the global scale the greater urgency is for the rehabilitation and improvement of existing (irrigation) schemes". Measures should be taken to combat waterlogging, salinisation, alkalinisation. Detailed suggestions are given as to how this should be done, including the development of salt-tolerant crops.

- RECOMMENDATION 9: Restore, maintain and protect vegetative cover so as to stabilise and protect soils in denuded areas, especially on watershed and mountain slopes, dunes, and where villages, roads and farms are threatened. The establishment of shelter belts and other tree plantations can be an essential part of the reclamation of degraded areas. Specific suggestions include restoring damage by mines, industry and tourism; fenced reserves around settlements; traffic control, especially of off-road vehicles; stabilising sand via matting, mulches, bitumen coatings, dune revegetation; restrictions on firewood gathering, and establishment of fuelwood plantations; green belts - "mosaics of revegetated areas". Regional cooperation will be needed for the production and distribution of plants for large revegetation campaigns.

Best Available Document

- RECOMMENDATION 10: Governments should take all necessary steps to conserve the flora and fauna in areas subject or likely to be subject to desertification. Regulations should be adopted governing the import, sale or use of threatened animal and plant species. Regional cooperation in conservation is desirable, especially on the fringes of national parks and where a certain ecosystem extends across international boundaries.

- RECOMMENDATION 11: National or intra-regional systems for monitoring climatic, hydrological or pedological conditions and the ecological conditions of land, water, plants or animals should be established or strengthened, as appropriate, in areas affected or likely to be affected by desertification.

(4) Socio-economic aspects

- RECOMMENDATION 12: The social, economic and political factors which have an important bearing on desertification should be analysed and evaluated, particularly inequitable relationships at national, regional, international levels, and methods to equalise them. New educational programmes are needed, that will allow the adult population especially to become fully aware of the ecological aspects of development, and to participate more fully in programmes aimed at combating desertificat'on.

- RECOMMENDATION 13: Countries which so wish should adopt demographic and economic policies that will ameliorate problems arising from population growth, eg increasing pressure on rural lands, and migration to urban areas which increases problems there as well as leading to labour shortages and poorer land use in rural areas.

- RECOMMENDATION 14: Peoples affected by desertification should be provided with health services, including family planning, comparable to the rest of the population. Services could include mobile health teams, paramedical personnel, air services. The resources of the local pharmacopoeia (ie local drugs) should be fully utilised. It should be remembered that "the problems of metabolism among rural dryland people... are quite different from those in urban areas."

- RECOMMENDATION 15: Human settlement in drylands should not conflict with land productivity; and should take full account of local climate, local building materials, local architectural traditions and social habits. Buildings should combine modern design with the principles that "made traditional abodes comfortable"; they should minimise energy demand for heating and cooling; use solar and wind energy where possible. Regional cooperation is needed to share the traditional experience and knowledge of design and materials which often crosses political boundaries.

- RECOMMENDATION 16: In lands subject to desertification, national systems should be established for monitoring the human condition. Such variables as population, health, food, settlements, education, production, should be recorded, especially of migrating streams and movements across borders during disasters.

(5) Insurance against the risk and the effects of drought

- RECOMMENDATION 17: There should be insurance schemes to cope with drought disaster; official relief action should recognise the indigenous strategies which people already possess to cope with drought, "rather than ignoring or damaging them". Techniques should include crop and livestock insurance; fodder, food, fuel and seed reserves; permanent breeding stocks of animals; refugee pasture areas; stockpiles of tools for relief employment. Regionally, movements of peoples across frontiers should be encouraged during severe drought, as this is a form of insurance against further loss.

(6) Strengthening science and technology at national level

- RECOMMENDATION 18: Indigenous scientific and technical capabilities should be strengthened. Imported technologies should be adapted to suit local conditions. Programmes to revive traditional techniques for combating desertification should be encouraged.

- RECOMMENDATION 19: Alternative and unconventional energy sources should be encouraged. "Collection of woody plants and charcoal manufacture are at present, and are likely to remain, the main source of energy for many arid land dwellers." Woodlots, forest reserves, new woody species, improved charcoal manufacture, could increase the supply of fuel; solar energy should be used for water pumps, water heaters, cookers, refrigerators, food dryers; wind energy should be used for pumping and energy production; biogas could be made from animal wastes, and charcoal, gas and oil via pyrolysis from grain husks, peanut hulls, crop stalks and palm leaves. Such devices should be subsidised and distributed.

- RECOMMENDATION 20: Training and education should be undertaken, especially via the mass media. This would include out-of-school education, communication with remote areas, radio, TV, cinema, pamphlets, posters, demonstration centres for farmers and nomads and in courses at schools and universities.

- RECOMMENDATION 21: Coordinated national machinery to combat desertification and drought should be established where none exists. This national body would analyse, evaluate and disseminate existing information on desertification; prepare a national plan of action and arrange the financing for its implementation; monitor the progress of anti-desertification measures; and liaise with regional and international organisations.

(7) Integration of anti-desertification programmes into comprehensive development plans

- RECOMMENDATION 22: Programmes to combat desertification should be formulated, whenever possible, in accordance with the guidelines of comprehensive development plans at the national level.

Best Available Document

B. Recommendations for international action and cooperation

(1) International action

* RECOMMENDATION 23: UN agencies and other international bodies (UNDP, UNEP, UNIDO, UNCTAD, FAO, WHO, WMO, UNESCO, World Bank and the UN regional commissions are specifically mentioned.) should revise and adapt their activities to incorporate the Plan of Action. The UN system should, before 1980, develop a methodology for assessing, monitoring and forecasting desertification; make available technical assistance to governments; publish a desertification atlas by 1978-82; promote rational management or arid and semi-arid rangelands; provide financial and technical support for the sedentarisation of nomads; increase the effectiveness of disaster relief organisations; research and develop simple, cheap, efficient alternative energy devices for drylands.

* RECOMMENDATION 24: The UN General Assembly should endorse the activities of the World Meteorological Organization, the International Council of Scientific Unions and interested UN agencies that are directed at understanding and resolving climate problems, and urge governments, international agencies, and other interested bodies to support and participate in the planning and execution of the World Climatic Conference, and the Global Atmospheric Research Programme.

* RECOMMENDATION 25: The UN should invite inter-governmental and non-governmental organisations to participate in the Plan of Action.

(2) International cooperation

* RECOMMENDATION 26: The processes of desertification at times transcend national boundaries. While recognising national sovereignty, it is recommended that countries should cooperate in the sound and judicious management of shared water resources as a means of combatting desertification effectively.

C. Recommendations for immediate initial action

(1) At national level

Governments are recommended to:

a. Establish or designate a national body to combat desertification (Recommendation 21).

b. Assess the extent of desertification in the country (Recommendation 11).

c. Establish national priorities for actions against desertification.

d. Prepare a national plan of action against desertification.

e. Select among national priorities those actions which could be taken nationally, with the support of regional and international organisations or other foreign sources, in the framework of regional or international cooperation, or only with foreign aid.

f. Prepare and submit requests for international support for specific projects within the above priorities, if required.

g. Implement actions in accordance with national plans of action.

(2) At regional level

a. Convene regional post-conference technical workshops and seminars.

b. Organise inter-regional consultations and studies for selecting sites for the establishment of regional centres such as:

   six regional anti-desertification centres, for Latin America, S Asia, W Asia, Africa south of the Equator, Sahel, N Africa, based on existing institutes or on new sites;

   a number of international rangeland and livestock management centres;

   five international sand dune fixation centres;

   management-training irrigation farms;

   rainfed agriculture demonstration farms;

   revegetation/afforestation demonstration stations;

   regional networks of biosphere reserves.

c. Organise and implement six transnational projects:

   an integrated scheme for management of livestock and rangelands in the Sudano-Sahelian belt;

   management of regional aquifers in NE Africa and Arabia;

   satellite monitoring of desertification in SW Asia;

   satellite monitoring of desertification in Latin America;

   establish a "green belt" - a mosaic of forest plantations and sustainable rangeland and cropland - on the northern border of the Sahara from Algeria to Egypt;

establish a similar green belt in the Sahel from Cape Verde to Sudan.

(3) At international level

a. UN agencies are requested to actively associate themselves with the implementation of relevant parts of the Plan of Action.

b. Governments are requested to put forward their needs for international support for their national plans of action.

c. Formulate specific actions by appropriate joint programming.

d. Mobilise the necessary financial resources.

e. Arrange, coordinate and design specific projects and strategies for financing and implementing anti-desertification programmes.

D. Recommendations for implementation of the Plan of Action

- RECOMMENDATION 27: UNEP with its Governing Council and Environment Coordination Board should be responsible for following up and coordinating the implementation of the Plan of Action. Regional commissions of the UN should be responsible for coordinating, catalysing, and executing intra-regional programmes adopted by member states. The regional commissions should in this regard actively participate in the Environment Coordination Board.

- RECOMMENDATION 28: The following forms of financing are recommended for consideration:

a. sub-regional cooperation;

b. bilateral, multilateral and multi-bilateral assistance;

c. consultative group/club or group-type financing;

d. special account;

e. additional measures such as funds in trust, fiscal measures entailing automacity, and an international fund.

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FURTHER READING

Lester R Brown: Building a Sustainable Society. New York, W W Norton, 1981.

James C Caldwell: The Sahelian Drought and its Demographic Implications. Overseas Liaison Committee, American Council on Education, OLC Paper No 8, December 1975.

Club du Sahel/CILSS: The Sahel Drought Control and Development Programme, 1975-1979. Paris, September 1981.

Harold E Dregne, editor: Arid Lands in Transition. Washington DC, publication No 90 of the American Association for the Advancement of Science, 1970.

Erik P Eckholm: Down to Earth. New York, W W Norton; London, Pluto Press, 1982.

Erik P Eckholm: Losing Ground. New York, W W Norton, 1976.

Richard Franke and and Barbara Chasin, "Peasants, peanuts, profits and pastoralists". The Ecologist 11: 156-168, 1981.

M H Glantz, editor: Desertification. Boulder, Colorado, Westview Press, 1977.

John Gribbin, Climate and Mankind. Earthscan Paperback, Earthscan, London, 1979.

Michael M Horowitz: "The Sociology of Pastoralism and African Livestock Projects". Washington DC, USAID Program Evaluation Discussion Paper No 6, May 1979.

International Tree Crops Journal (The Journal of Agroforestry). A B Academic Publishers, Berhamsted, Herts, UK.

P L Jaiswal, editor: Desertification and its Control. New Delhi, Model Press, 1977.

Anders Rapp, H N Le Houerou and B Lundholm, editors: Can Desert Encroachment Be Stopped?. Ecological Bulletin No 24, Swedish Natural Science Research Council, 1976.

Anders Rapp: A Review of Desertification in Africa - Water, Vegetation and Man. Stockholm, Secretariat for International Ecology, Sweden (SIES), 1974.

Mostafa K Tolba, "The United Nations Conference on Desertification: a review". Mazingira 6(1): 14-23, 1982.

James Walls, Land, Man and Sand. New York, MacMillan Publishing Co, 1980. (Based on the excellent case studies prepared for UNCOD. The full UNCOD papers are available from Pergamon Press, Oxford.)

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