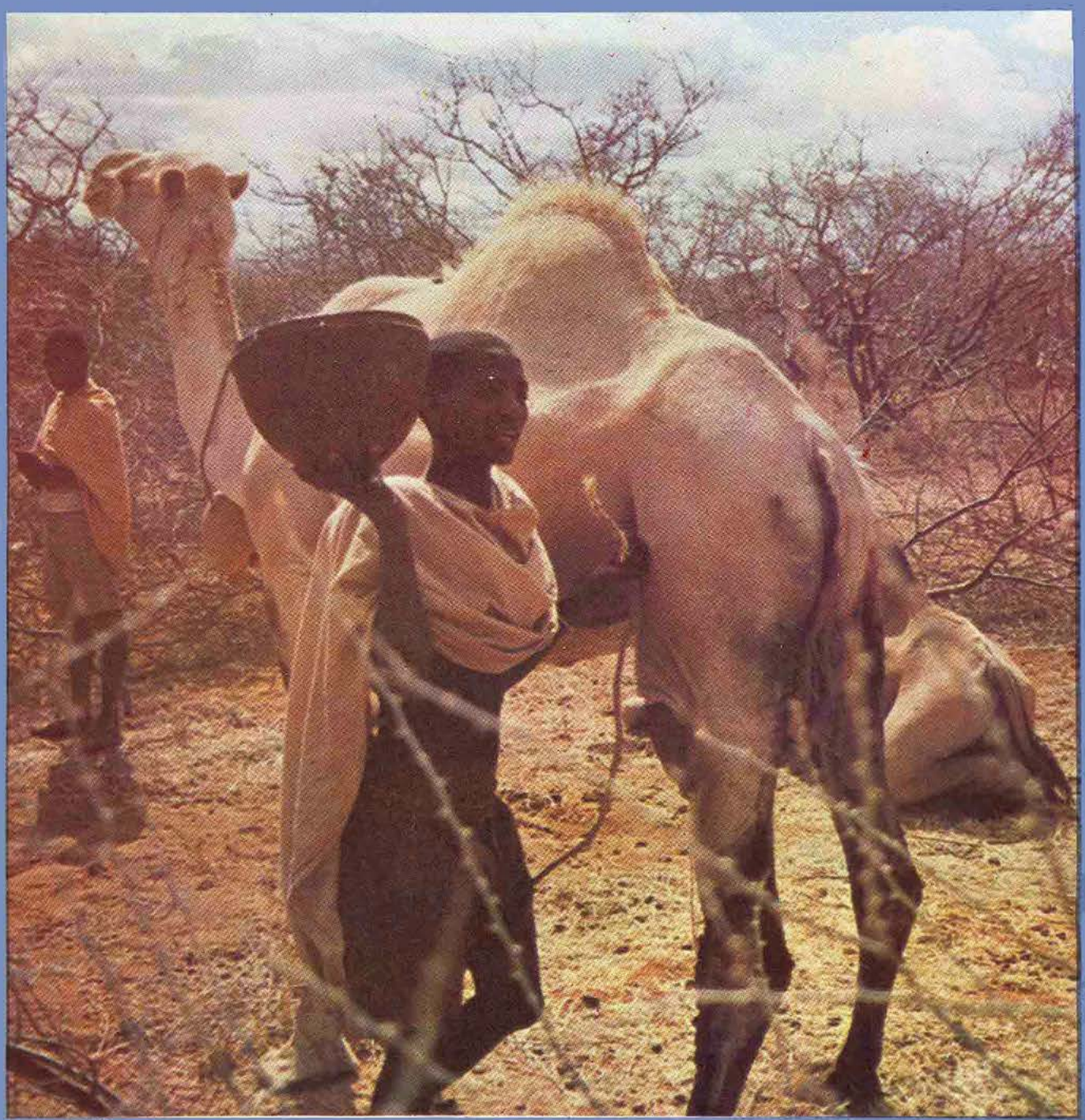
United Nations Environment Programmme

ISSN 0379-2455

Desertification Control Bulletin

A Bulletin of World Events in the Control of Deserts, Restoration of Degraded Lands and Restoration

Number 14 1987



- The United Nations Conference on Desertification (UNCOD) was held in Nairobi from 29 August to 9 September 1977.
- This was the first worldwide effort ever initiated to consider the global problem and responsibilities posed by the spreading deserts.
- 95 States, 50 United Nations offices and bodies, 8 intergovernmental organizations participated.
- The United Nations Conference on Desertification prepared and adopted a worldwide Plan of Action to Combat Desertification (PACD) with 28 specific recommendations.
- The Plan of Action was approved by the United Nations General Assembly at its 27th session on 19 December 1977.
- Recommendation 23 of the Plan of Action invited all relevant United Nations bodies to support, in their respective fields, international action to combat desertification and to make appropriate provisions and allocations in their programmes.
- Recommendation 27 gave the responsibility for following up and coordinating the implementation of the Plan of Action to the United Nations Environment Programme (UNEP) with its Governing Council (GC) and administrative Committee on Co-ordination (ACC).
- Immediately after approval of the Plan of Action, the Desertification Unit was established within the UNEP Office of the Environment Programme and ACC in carrying out their tasks in the implementation of the Plan of Action.
- One of the main functions required by the Plan of Action from the Desertification Unit was to prepare, compile, edit and publish at six-monthly intervals a newsletter giving information on programmes, results and problems related to the combat against desertification around the world.

Editors:

Daniel Stiles, Editor-in-Chief
Desertification Control
Programme Activity Centre

Stanislaw Sangweni
Desertification Control
Programme Activity Centre

Seifulaziz L. Milas
Information Service

Desertification Control Bulletin

United Nations Environment Programme No.14 198

Contents

		Page
Shifting Sands and Human Sorrow: Social response to drought and desertification	*Prof. Michael Mortimore*	
Camel Vs Cattle Pastoralism: stopping desert spread	*Daniel Stiles*	1
African Drought and its Impacts: Revived interest in a recurrent phenomenon	*Michael H. Glantz* *Richard W. Katz*	2
Rethinking Forestry Strategy in Africa: Experience drawn from USAID activities	*T.M. Catterson* *F.A. Gulick* *T. Resch*	3
Grassland Revegetation by Land Imprinting: a new option in desertification control	*Ray Anderson*	4
News from UNEP		4
News of Interest		5

COVER PHOTOGRAPH

Camel milk is the most secure form of food in drought-prone areas of Africa. Here two Gabbra boys in northern Kenya milk one of the family herd. (UNEP/Danie Stiles)

Desertification Control Bulletin is an international bulletin published at six-monthly intervals by the United Nations Environment Programme (UNEP) to disseminate information and knowledge on desertification problems and to present news on the programmes, activities and achievements in the implementation of the Plan of Action to Combat Desertification around the world.

Desertification Control Bulletin is published in English. Enquiries should be addressed to:

The Editor
Desertification Control Bulletin
UNEP P.O. Box 30552
Nairobi, Kenya

SHIFTING SANDS AND HUMAN SORROW: Social Response to Drought and Desertification

Professor Michael Mortimore
Bayero University
Kano, Nigeria

Editor's Note: The text of this article was first presented as a lecture to the Society of Fellows, Durham University Research Foundation. The Editors are grateful for having received permission to reprint the lecture in full here.

My title is amply justified, I think, by an African tragedy that has been brought to every home by able and compassionate film-makers. The scale of generosity shown by the public in Europe and America has demonstrated the breadth of international concern. The relations between man and nature have surely acquired a new relevance for those who struggle to help the livelihoods of millions of fellow human beings in Ethiopia, the Sudan, the Sahel and other parts of Africa.

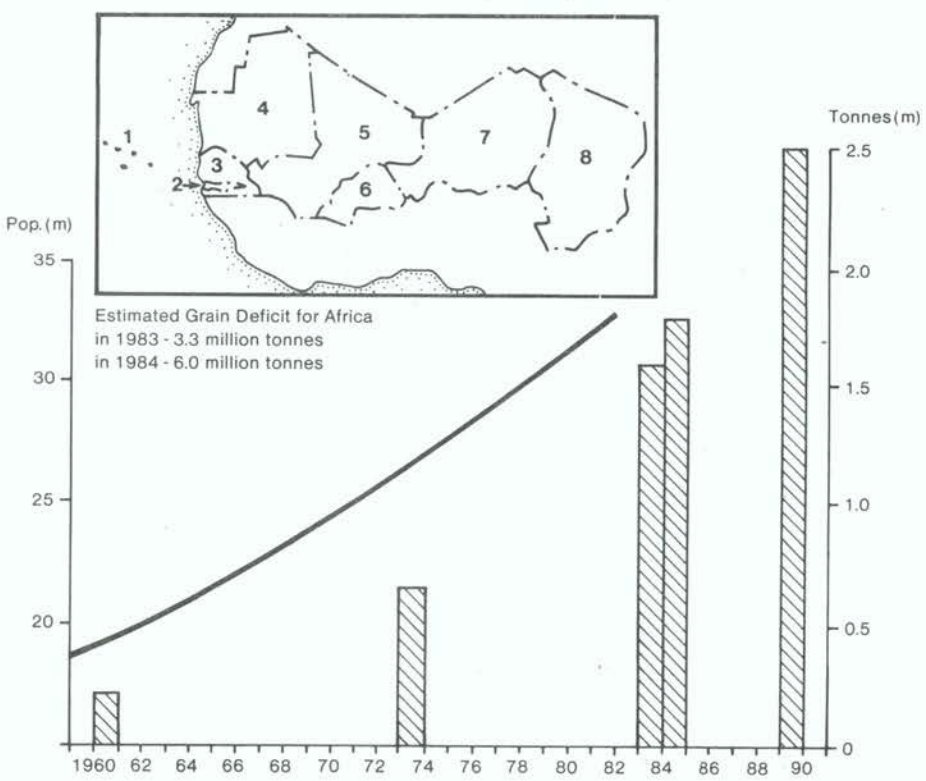
This study relates not to demographic response (increased mortality and—possibly—reduced fertility); nor to physiological response (loss of body weight, increased vulnerability to infection); nor to psychological or philosophical response, but to what I have decided to call social response: social, economic or ecological behavior observable in space and time. My objective, after briefly defining drought and desertification, is to illustrate, from studies in northern Nigeria, the nature of adaptive response to drought, the indigenous mechanisms for insuring against its occurrence, and the implications of a diminishing autonomy in land use management. In conclusion, some guidelines will be suggested for the review of assistance and development policies.

Food production and the loss of the soil

Millet *(Pennisetum typhoides)* eventually grows to a height of one and a half to two metres in as little as 55 days and produces a head of grain over half a metre in length. It can be grown with only 200 to 250 millimetres of rainfall in light, sandy soils, but when devoured by drought, the plant fails to reach its full height and the head does not develop; birds or insects eat what there is. This crop is the major staple in the Sahel Zone of West Africa. The longer season crop known as Guinea Corn (*Sorghum bicolor),* which becomes dominant further south, needs 120 to 135 days and about 600 millimetres of rainfall. It normally grows three or four metres tall and produces a bunch of grain in the head, which may be compact or dispersed, according to the variety. Guinea corn matures for a month or more after the end of the rains. However, in drought the plants may reach but a metre in height, and the heads are dwarfed and worthless. Grasshoppers, starved of wild grass, descend on the only green matter avaible: the crops.[1]

Millet and guinea corn provide more than 80 per cent of the rural diet. In November 1984, the cereal deficit for the Francophone countries of the Sahel was officially estimated to be 1.75 million tonnes, even greater than that for 1983 (Fig.1). At the same time the deficit for Africa grew from 3.3 to 6 million tonnes.[2] Given a total

Figure 1. Population growth and estimated grain deficit in eight Sahel countries.



population for the Sahel of 33 million, and some rough and ready conversions,[3] this deficit is equivalent to about two-fifths of the annual grain requirement, or 85 days without a minimal meal for everybody; if we assume, more realistically that the shortfall will affect only half of the population (the poorer half), it is equivalent to 170 days in the twelve months following the "harvest" of 1984, barring aid, imports and alternative sources of food.

Most Sahelian soils, other than those found in river valleys, are derived from stabilised sand dunes whose formations are clearly visible under the grassland, wooded or thorn savannas that have become established on them since the last southerly advance of the Sahara 20 to 40,000 years ago.[4] The remobilisation of these freely draining sandy soils in the vicinity of villages may have considerable visual impact. Although exceptional, the experience of Kaska village in Nigeria is not unique. A dune system, somewhat more than 35 years old, has engulfed at least half of the village, and its western front proceeds inexorably down the village street at the rate of 2.75 metres each year, under the influence of the north-easterly winds which prevail for six or seven months of the year.[5]

Is this the advancing Sahara? In 1935 the forester, E.P. Stebbing, wrote:

> "And the desert is advancing! How, or how fast, I have yet to learn... The people are living on the edge, not of a volcano, but of a desert whose power is incalculable and whose silent and almost inevitable approach must be difficult to estimate. But the end is obvious: total annihilation of vegetation and the disappearance of man and beast."[6]

Not to be outdone, USAID, in an influential document, declared in 1972 that advance in some places, along a 2,000 mile southern front, was as much as 30 miles per year.[7]

The Executive Director of the United Nations Environment Programme has recently announced that in the world as a whole,

> "Currently each year some 21 million hectares is reduced to a state of near or complete uselessness."

Is such pessimism justified? First, a definition of terms.

Drought

Drought must be defined in the context of a specific land use system if it is to have any meaning. For Sahelian land users, provided that subsurface water is available for drinking (although often scarce and of appalling quality) drought is a rainfall deficiency of an order sufficient to diminish significantly the yield of either natural fodder or rainfed crops. Since the annual cycle of dry and wet seasons governs all economic activity, the amount of annual rainfall is the major defining parameter. However, the monthly distribution, during the short growing season, of three to five months, may decide between good and bad crop yields, irrespective of the total.[9]

Droughts are recurrent, and unpredictable. Major droughts occured in the 16th, 17th, 18th and 19th centuries, in 1913 to 14, the later 1920s and 1940s in many areas.[10] The Sahel drought of 1968 to 1974 was unusual in being the first to attract attention worldwide. It reached its climax in the two calamitous years 1972 and 1973.[11]

West Africa receives its rainfall from maritime air of high humidity and low pressure which originates over the Atlantic Ocean, and, during the northern hemisphere summer. surplants dry, dense continental air from the Sahara along a front known as the Inter-Tropical Convergence (ITC). Depending partly on the behaviour of the ITC—a fast or slow advance, a prolonged or short stay, and a northerly or less northerly penetration—the Sahel may receive a quick or hesitant start to the rains, a long or short rainy season, and a large or small volume of precipitation. In good or bad years, there is a significant correlation between latitude and annual rainfall (the coast of West Africa runs from east to west).[12] Intervals of up to seven weeks between falls in the early growing season can be critical in planting, germination and rooting of crops. Early cessation of the rains can inhibit crop development and reduce the growth of grass and herbs. Not withstanding a truly remarkable tolerance of drought and sandy soils, millet still needs a growing season of 55 to 75 days. Guinea corn needs much longer, although it ripens on residual soil moisture for a month or more. Thus the farmer gambles with early planted millet—the penalty being resowings, often repeated—and with late maturing sorghum—the penalty being the loss of his crop; while the pastoralist cannot be sure of his pasture from year to year.

Drought leads to famine where three conditions are met: (1) the population is predominantly rural; (2) the bulk of the food supply is normally produced by its consumers; (3) the market (or alternative systems of distribution) cannot deliver imported food in adequate quantity, or if imported food is available, impoverishment puts its price beyond the reach of some or all of the population.[13]

Desertification

The more difficult definitional question: What is desertification?[14]

A secular downward trend in the rainfall records for West Africa during the past two decades is now a strong possibility.[15] But its future direction (if a trend) or duration (if only a cycle) are unknown. Changes in the pattern of global circulation, independent of any human influence, may be responsible for the subnormal rainfall of the seventies. However, everyone is agreed that irrespective of the frequency of drought or of rainfall trends, the factors responsible for producing the symptoms of desertification include the agency of man himself. What are these symptoms? We may include: (1) soil erosion by wind; (2) dune formation or reactivation; (3) disappearance or degradation of the vegetation; (4) desiccation of the soil profile; and more controversially (5) lowering of the ground water table. The essence of desertification is "the diminution or destruction of the biological potential of the land" leading to the extension of desert-like conditions of soil and vegetation into areas outside the climatic desert, and the intensification of such conditions, over a period of time.[16] I wish to exclude certain processes of ecological degradation which are commonly, but

to my mind confusingly, included within the purview of the term. These are deforestation (which is the normal prelude to agricultural land use and is reversible), salinization of irrigated soils (which is caused by inadequate drainage), and soil erosion by water. From this restricted definition, it can be understood that the concept extends beyond the visually obvious to situations where measurements obtained over a period of time are essential.

However, there are very few data and much scope for disagreement; estimates such as those quoted already are difficult to accept at face value. How could such measurements be obtained? The most popular suggested source is satellite imagery (LANDSAT)—surely the spy in the sky can tell us where the deserts are creeping. But monitoring possibilities are limited by the lack of historical depth (not much more than a decade), by questions of interpretation, by difficulties of isolating short-term from long-term changes, and by difficulties of obtaining the relevant data. A more conventional alternative is air photography, which has greater depth (nearly four decades), but occurs at irregular dates, and incurs high interpretation costs owing to the huge numbers of photographs involved. A third possibility is to measure relevant parameters on the ground. This has scarcely begun.

Several theories seek a feedback mechanism between land use and weather conditions. The first of these (the dust theory) argues that suspended dust in the rain-bearing air modifies the temperature gradient, causing stabilization of the atmosphere and suppressing convection, thereby inhibiting rain.[17] So, the more dust, the less rain. The second (the albedo theory) argues that as deforestation proceeds, and so (it is assumed) the extent of bare ground increases, the reflectivity of the surface, or albedo, also increases, intensifying subsidence in the overlying air stream and inhibiting convection.[18] The third (the moisture theory) argues that reduced vegetation and reduced soil moisture contribute to a diminution of rainfall, since some of the moisture precipitated is believed to come from locally evaporated moisture.[19] All these theories imply that *Homo Sahel* is to blame, in part, for his own droughts. A fourth theory, however, implicates western industrial man, in suggesting that the increased carbon dioxide content of the atmosphere worldwide may be having an effect on tropical rainfall through atmospheric heating.[20] None has yet found firm acceptance; and Kidson has argued that changes in global circulation are more relevant than man's activities in producing a downward trend in rainfall that, even prior to the 1970s, was equivalent to a southward shift of the southern margin of the Sahara of five kilometres per year at lat. 15 N.[21] But Nicholson has argued that the persistence of drought after the early seventies is itself supportive of the operation of such feedback mechanisms.[22]

It is surprising that dust is involved in the matter, and this possible feedback may be discussed a little further. The dust-laden wind called the Harmattan, which covers West Africa for long periods during each dry season, has been observed for at least a century, and as far south as the Atlantic Ocean, African dust has been picked up on the coast of South America. Since the now stable sand dunes of the Sahel were formed under similar wind conditions to those of today (a conclusion which can be reached from their morphology), it is natural to see the Harmattan as an agent, or an indicator, of desertification in the catchment area, which extends into the Chad Basin.[23] It would be logical to expect the amount of dust in suspension or deposited to correlate positively with the amount of bare ground, and with ongoing desertification. But, six years' measurements of dust deposition at Kano (Fig. 2) have failed to demonstrate an upward trend, notwithstanding subnormal rainfall in 1983; rather the reverse.

The feedback mechanisms that are supposed to influence rainfall behaviour show the difficulty of separating dependent from independent variables in the process of desertification, even if it can be defined without ambiguity. In the resulting vacuum, sensational claims prosper. The empirical foundations for such claims are inadequate. Caution has been counselled by less pessimistic observers for half a century, and events have failed to bear the gloomier prophecies of an advancing Sahara.[24]

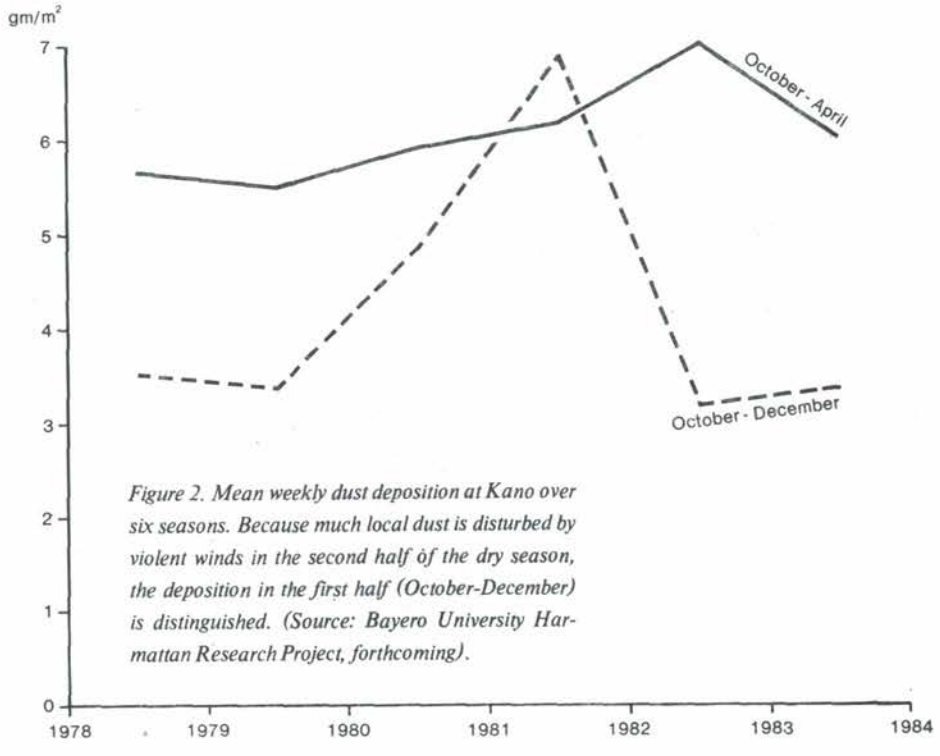


Figure 2. Mean weekly dust deposition at Kano over six seasons. Because much local dust is disturbed by violent winds in the second half of the dry season, the deposition in the first half (October-December) is distinguished. (Source: Bayero University Harmattan Research Project, forthcoming).

Adaptive response

It is clear from these extended definitions that *Homo Sahel* is not merely the victim, but also an agent, potentially or actually. However, the socie-

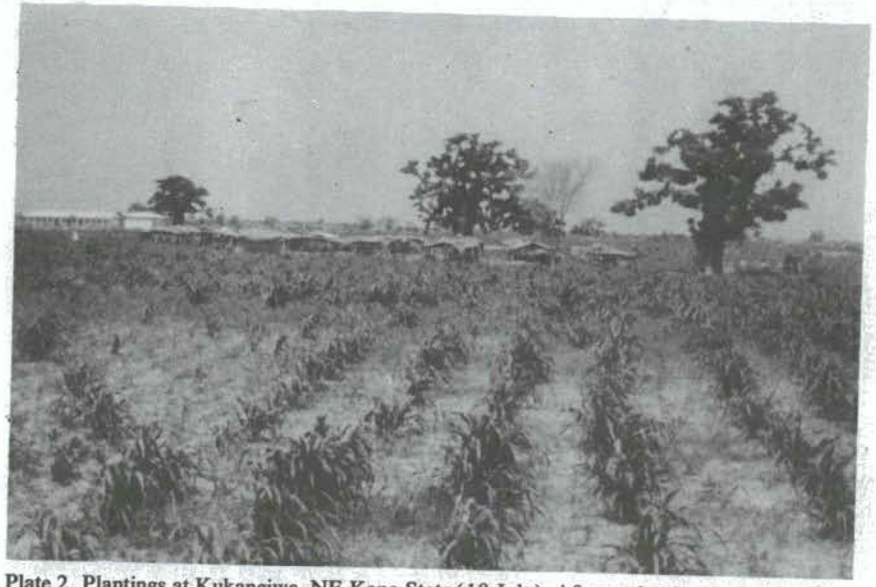


Plate 2. Plantings at Kukangiwa, NE Kano State (18 July). After replanting three times, four satisfactory falls of rain had occurred in the previous three weeks.

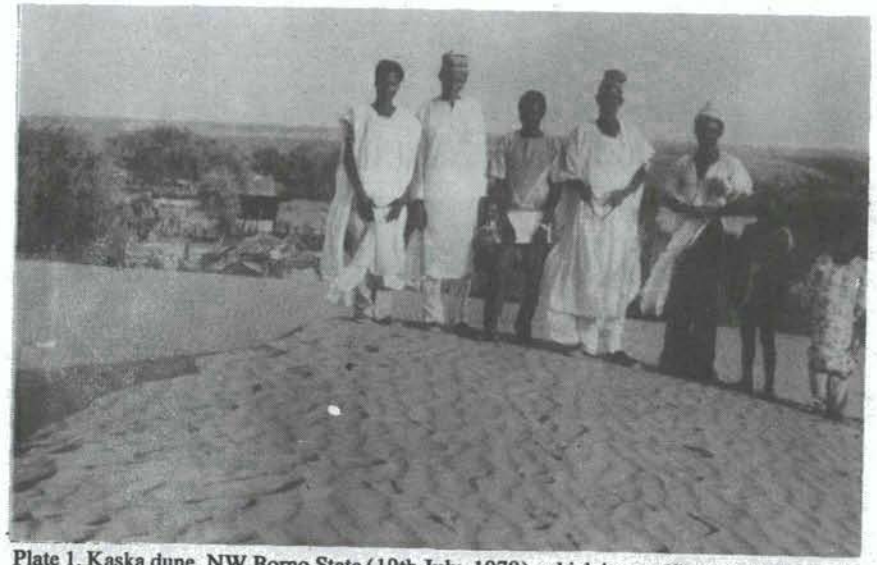


Plate 1. Kaska dune, NW Borno State (19th July, 1979), which is engulfing the village in the background.

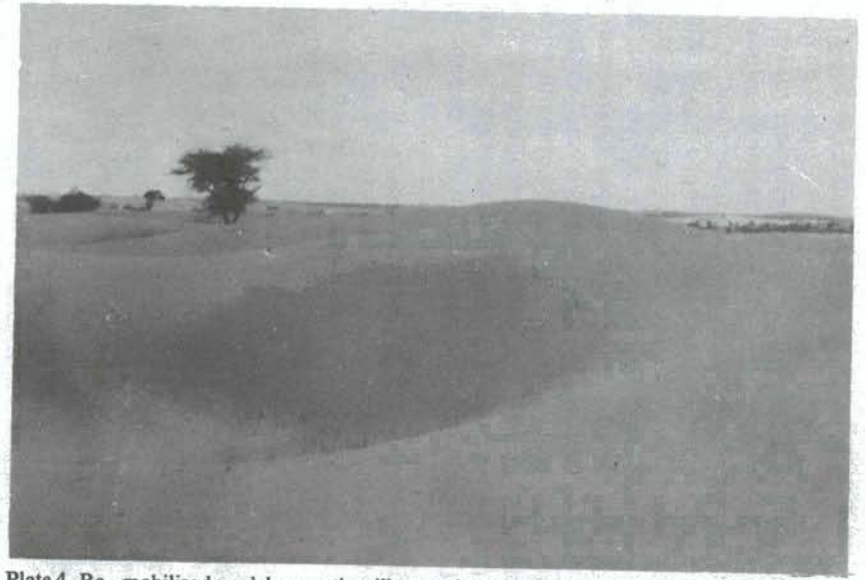


Plate 4. Re - mobilised sand dune on the village perimeter : Ligaridi, NW Borno State (20 July, 1980)

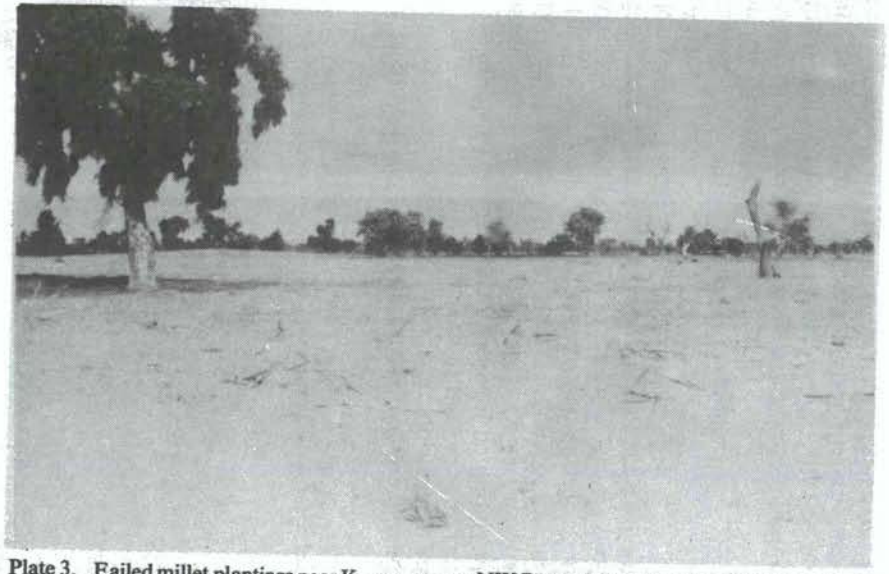


Plate 3. Failed millet plantings near Kumagunnam, NW Borno State (17 July, 1979), less than 50 miles from Plate 1. The distribution of precipitation is critical and erratic.

Plate 6. Collecting water from a hand - dug well for carrying to an outlying nomadic camp near Bulatura, NW Borno State (30 July 1981).

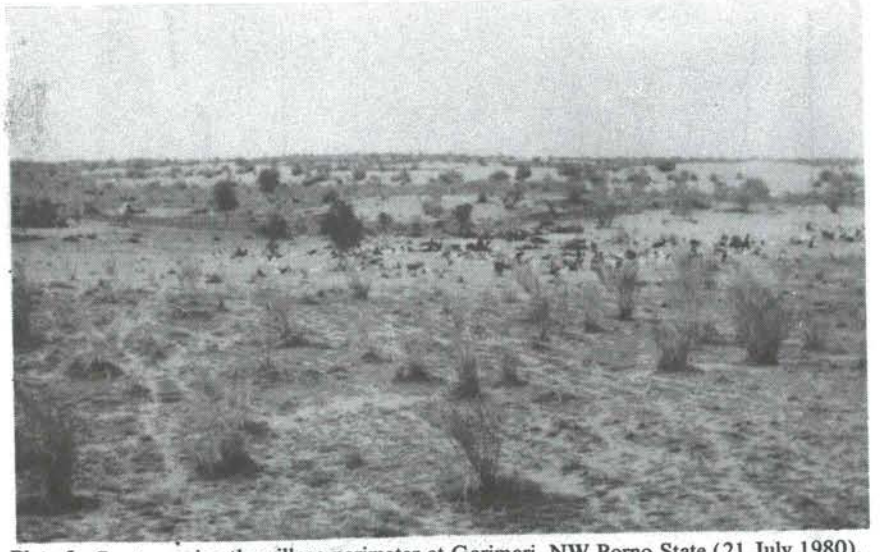


Plate 5. Goats grazing the village perimeter at Garimari, NW Borno State (21 July 1980). Hardy perennial shrubs (*Retama* spp.) are replacing annual grasses, and bare ground provides an opportunity for the reactivation of formerly stable sand dunes.

Plate 8. Well drilling rig in operation, western Kano State (February, 1984).

Plate 7. The rains and the revival of the pasture came too late : Ligaridi, NW Borno State (29 July, 1981).

ties that live and suffer in the Sahel do not easily admit the blame that science seeks to heap on their shoulders—rightly or wrongly.

Rather they see drought, famine and desertification as events or processes in whose determination village resources and technology are impotent—rationalised in a much misunderstood submission to the immutable will of God. At village level, the price of grain is as exogenous as the rainfall, and the mechanics of its variability as impossible to control. Resignation to these realities does not, however, remove initiative from the actors in the Sahelian drama. The key to survival (and to personal betterment), give the certainty that food supply will sometimes fail, to a varying extent and unpredictable occurence, is the development of a structure of alternative opportunities. It is to this structure that I now wish to direct attention by changing scale to a small part of northern Nigeria—north-eastern Kano and north-western Borno States—and adjacent Niger Republic (Fig. 3).

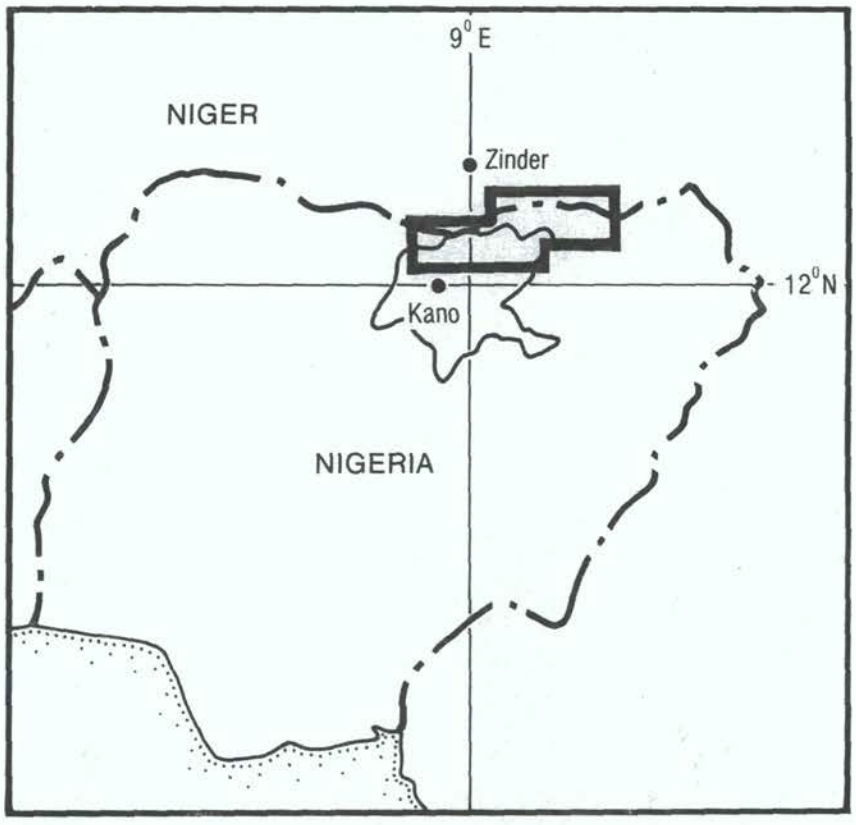


Figure 3. Study area.

The drought of the early seventies reached its climax in the seasons of 1972 and 1973, when farmers in northern Kano State reported millet mean yields of only 40 and 12 per cent. Cattle ownership was virtually eliminated in some villages, and reduced by a third in others. Sheep and goats were affected almost as badly. Families attempted to grow all their own grain; yet granaries were already empty a month or two after harvest in 1973, in two-thirds of households; by the end of the ensuing dry season, only four per cent were still eating their own grain. Between a quarter and a half were eating no grain at all; the remainder bought a little.

Adaptive response can be shown by listing the survival strategies employed to obtain money or food within the village economy, in order of frequency (Table 1).[25] The first, labouring on others' farms—or anywhere—is the most common, and a regular way of raising cash in normal years, for the poorer farmers. Second, the famine foods occur naturally in the bush and on farm trees, and may be eaten occasionally in normal times.

Table 1 Frequency of survival strategies (home) cited in one or both years

	Per cent
1. Labouring	79
2. Famine foods	75
3. Mat, rope making	55
4. Cash loans	48
5. Gifts of food	39
6. Firewood selling	35
7. Selling property	29
8. Selling manure	23
9. Cash gifts	19
10. Begging	15
11. Selling land	10
12. Selling animals	not known

They are mostly leaves (excluded here are the leaves of the baobab tree which is a normal element of the diet). Third, mats are made from the leaves of the dum palm (*Hyphaene thebaica)* in the bush, and sold to traders in the markets. Fourth, the number who admitted to indebtedness—a confidential matter—suggests the impoverishing effects of famine. Fifth, gifts of food form a part of the reciprocal networks of extended family and patron-client relations in the village. Sixth, firewood is obtained by chopping down increasingly scarce trees in the bush, or lopping farm trees, and much is sold out of the area. Seventh, the sale of personal property disperses the fruits of economic progress over the years. Eighth, selling manure imperils the fertility status of one's own farm. Ninth, obtaining gifts of money is to admit dependency, and tenth, begging (other than for koranic students) incurs shame. Eleventh, selling land is the least common and least reversible strategy. Finally, selling animals, which is one of the most frequent strategies employed, yields little income owing to the depressed prices.[26] This, then, was the structure of alternative opportunities at home.

Adult males take to the road easily in northern Nigeria, looking for work in the south or in the cities, and returning home for the growing season. In times of famine, the incidence of such circulation rises dramatically among adult males, and extends to women and children, till whole villages become nearly deserted. Destination patterns may also change. About half the households sampled in 1973 had members away; and the percentage of villages reporting migration of whole families rose from 23 before the drought to 77. The list of survival

TABLE 2

Frequency of survival strategies (away) cited in one or both years

		Per cent
1	Labouring	29
2	Begging	29
3	Mat, rope making	21
4	Visiting relatives	5
5	Selling firewood	5
6	Others	11

strategies *away from home* (Table 2) is more restricted in terms of occupation, but more extensive in terms of destinations. People will go anywhere if there is hope of earnings. It may be observed that begging grows in frequency, as the anonymity of strange places gives some protection from the shame.

Thus the response to famine is structured, a conclusion that is not all surprising. We can integrate the "home" and "away" lists (Table 3), recognizing that the resulting structure is a development of that used in normal conditions for the accumulation of wealth. However, when survival becomes the objective, a number of strategies are added. Each family or individual ranks the perceived opportunities. Progression (or regression) down the list is determined by the deletion of opportunities, which occurs when they cease to be available. For example, selling animals is deleted—obviously—when there are no more animals to be sold.

When the opportunities available at home are perceived to be less acceptable than those available elsewhere, the decision is made to move: much earlier for the adult male alone than for the whole family; and more easily for short-term circulation than for permanent migration. The end of the process of deletion is the destitute, starving family (from infants to grandparents) so vividly depicted by the media from other countries of Africa.

A number of the survival strategies lead directly to loss - "divestment" — of assets (animals, cash, personal property, manure, land) and it is not surprising that they appear near the bottom in order of frequency. Such "divestment" tends to be irreversible and leads not only to impoverishment, but to increased vulnerability. Not surprisingly, movement is preferred if at all possible.

The structure of alternative opportunities is subject to variation—in social, spatial and temporal terms.[27] Social variation occurs within the community. Obviously, wealthier members have greater resources at their disposal than the poor. Variation may also occur on grounds of ethnicity. Dagacheri village, for example, is a farming community of Kanuri-speaking Managa people. Rights of settlement and farming have been given to a community of Hausa Koranic scholars. The two divide the compact settlement and its farmlands between them. Koranic study is associated with mobility, whose incidence is much higher in the Hausa community.

Spatial variations in the structure of opportunities have been observed, for example, between the Sokoto and Kano Close-Settled Zones in Nigeria.[28] In the first, where conditions of rainfed agriculture are marginal, and urban development less advanced, the incidence of circulation is higher even in normal conditions; whereas in the vicinity of the great city of Kano, opportunities for trade, rural manufacture, urban employment and agricultural intensification are better. Mobility is invoked more reluctantly.

Short-term temporal variations occur as changing economic or political conditions alter prices, the cost of travel, the availability of urban employment, the demand for rural goods, and access to education and information. For example, shortly after taking over the country in 1984, the Federal Military Government of Nigeria embarked at state level on a repatriation exercise directed at the street economy of the urban informal sector, demolishing unauthorised retail and service premises, traders' tables and kiosks, and banning itinerant traders from pavements and intersections. Within days, 50,000 or more self-employed enterprises disappeared from the streets of Kano alone, and the traffic flowed again. "Back to the land" had remained a slogan until it was implemented by bulldozer and gun.

TABLE 3

The structure of opportunities in normal and famine conditions.

	NORMAL CONDITIONS		FAMINE CONDITIONS	
Objective:	*accumulation*		*survival*	
	home	away	home	away
	trading	trading		
	sell:	sell:	sell:	sell:
1	surplus crops			
2	surplus animals		all animals	
3	labour	labour	labour	labour
4	rural manufactures	rural manufactures	rural manufactures	rural manufacture
5	free goods	free goods	free goods	free goods
6	services	services		
			seek:	
7			famine foods	
8			cash loans	
9			food gifts	visit relative
			sell:	
10			property	
11			manure	
			seek:	
12			cash gifts	
13			beg	beg
			sell:	
14			land	
	INVESTMENT		DIVESTMENT	
	Insurance		*Vulnerability*	

Can this concept be extended from farmers to pastoralists? In pastoral land use, some mobility is intrinsic, although not all Nigeria pastoralists are nomadic. Those who are (such as the nomadic Fulani) aware that they occupy a niche that no one else desires; as one of their women said while loading water onto a donkey for the long journey back to camp: "only our people are willing to suffer". During drought years, however, nomadic or transhumant herds may be trapped between winter and summer pastures on the northward leg of their grazing circuits; and losses and weakening of animals prevent movement, even if alternative grazings are known. For semi-sedentary pastoralists, with a stake in agriculture, the alternatives are more restricted still. So animals die on their feet, remote even from markets where their residual value might be redeemed in cash.[29] At this point, pastoralists have few if any alternative opportunities at home. Further afield, divested of their herds, they enter the urban economy and seek low paid employment (Fig. 4). Nigerian cities filled, during the seventies, with Buzu families (Twareg of servile status) from Niger's Sahel zone. While doubtless demeaning their proud pastoral traditions, the existence of such opportunities saved lives and even offered hope, through savings, of rehabilitation.

TABLE 4 Preparation against drought

	Per cent	
Passive answers		
1 "God knows"; nothing	21	
2 Prayer	1	
3 Begging	1	
	23	23
Active answers		
4 Produce and store more food	58	
5 As 4 and augment off-farm production	9	
6 As 5 and cultivate a larger area	3	
7 Labouring	3	
8 Dry season circulation	4	
	77	77
		100

(Now, however, Nigeria's oil boom is over, unemployment is rife and "illegal aliens" were expelled in 1983).

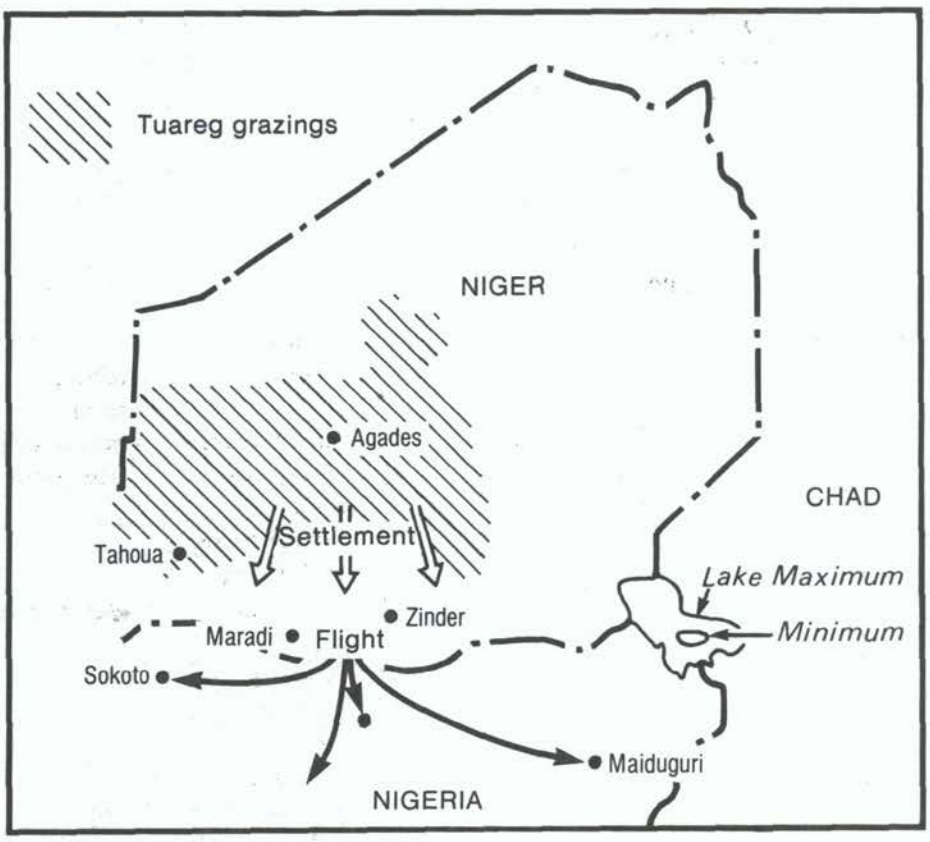


Figure 4. Southward movement of the Buzu

We can summarise the foregoing by suggesting that an individual, a family or a community may be said to possess an adaptive capability which is a function of the structure of alternative opportunities available. This capability depends on the perception of the individual or group, and on his or its position in society, in space and in time.

Indigenous insurance against drought

Prevention is better than a cure. Of the farmers sampled in the midst of the drought in 1974, 77 per cent had a clear conception of the strategies they hoped to adopt (Table 4). The first and most frequently cited was, of course, to produce and store food—the oldest insurance system in history. The second group of strategies consisted in intensified exploitation of alternative opportunities in order to generate savings: augmented off-farm production and labouring at home or away.

In addition to these two major strategies, a third—which I shall call "social insurance" can be identified. In the past, networks of reciprocity bound the community together, and additionally, relatively wealthy members had, under Islam, a moral responsibility to assist the poorer in time of hardship. (Reference has already been made to gifts of food and money amongst our sample). This network formed a part of the "moral economy" described by Watts in his recent study of food and famine in Hausaland.[30] In Kano, it was reported that such people had insufficient food for their own families, and were no longer assisting others. This was a major difference between the drought of the early seventies and those of the past. And if the community cannot help in the bad years, cohesion is likely to degenerate in the good.

A fourth category of insurance may be identified—"ecological insurance" — in relation to the community's use of its habitat. Certain features of agricultural and pastoral practice — intercropping, spatial fragmentation of holdings, diversification of livestock, and grazing mobility — give some protection against hazards which are specific to particular crops, animals or places. The protection of trees on farm

holdings provides not only browse for animals, but a range of edible materials. The retention of expert knowledge of famine foods (roots, leaves, pods, fruit) available in the bush — by women — maintains sources of emergency food for the community when they are needed.

Small scale farmers and pastoralists cannot use the financial institutions—as the victims of North American droughts for example, did and still do—to insure them against losses of crops or livestock. Yet every one of these indigenous insurance systems is threatened—if not already irreparably weakened—in modern Nigeria and other countries like it.

First, the possibility of grain storage is not only limited by land scarcity and declining yields. It has been forcibly argued by a number of scholars that the colonial introduction of taxation payable in currency, the monetization of the economy, and deteriorating terms of trade for rural commodities, drove producers from subsistence into export crop production and into a deepening dependence on a fickle market for essential foodstuffs. When the market has taken the place of the family granary in times of scarcity, it can dictate its own terms (or fail altogether). Second, as I have shown, the generation of savings from alternative opportunities is difficult, [31]and the value of savings may be destroyed by inflation if not by a sudden change in the national currency (as in May, 1984).[32] The decline of "social insurance" has been noted. Finally, as for "ecological insurance", crop (and animal) specialization is now a characteristic of nearly all major initiatives in the agricultural sector; irrigation projects and mechanised farms uproot protected farm trees; and the bush disappears rapidly as agricultural holdings expand, fuelwood cutters move out from the towns, and grazing pressure increases.

Autonomy

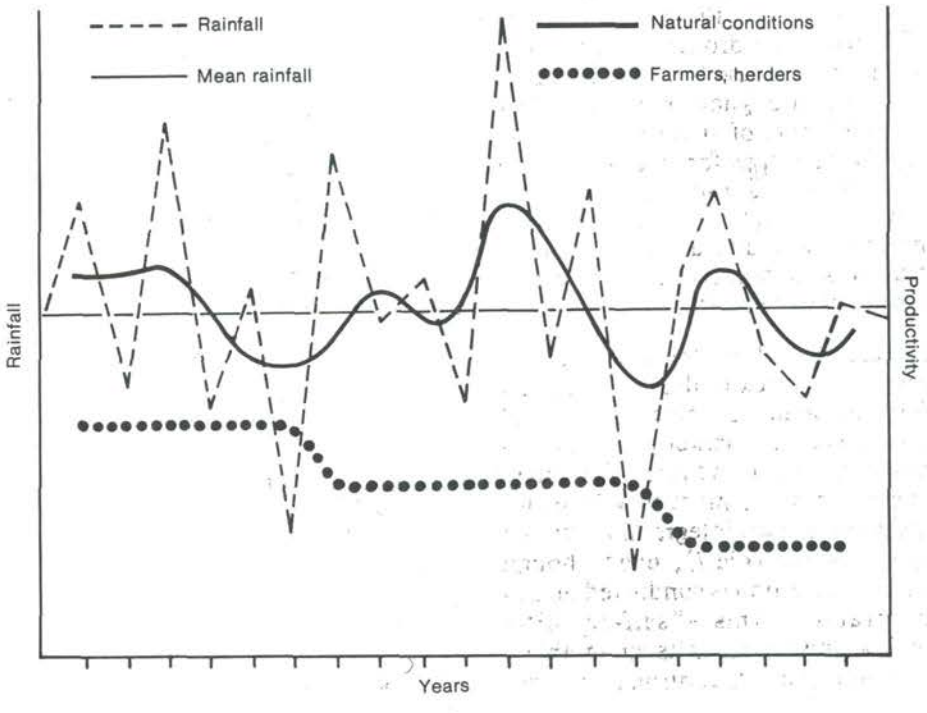
Over none of the trends just listed does the farming or pastoral community exercise any control, and this loss of autonomy lies at the heart of the crisis. Four areas can be identified:

Ecological impoverishment. First, let us examine afresh the relationship between drought and desertification, or ecological impoverishment. A drought lasts for one or more years. Desertification is a longer term process more appropriately measured in decades. The nature of their relationship can be illustrated in ecological terms by superimposing, on a plot of annual rainfall deviations from the mean, an hypothetical curve showing biological productivity (Fig. 5). Under natural conditions there appears no reason to suppose that productivity will fail to recover after a year of drought. Under the occupance of farmers and herders, things will be different. Let us suppose that Drought (1) kills half the livestock and destroys three-quarters of the crops. To survive, the population cuts and sells firewood, construction materials, mats and other products made from local raw materials, putting the surviving woodland under increased pressure. In subsequent seasons, animal manure is not available in adequate quantities to maintain soil fertility in the fields; extra land is brought into cultivation to compensate for lower yields, and to try to accumulate a grain reserve; fallow periods are shortened and the vegetation and nutrient status of fallows degenerates; a smaller amount of woodland has to supply energy requirements; grazing land diminishes and degenerates, and stock owners aim to reconstitute their herds rapidly, under the rationale, now better understood, that the more animals you have, given common access to pasture, the more are likely to survive the next drought. In Drought (2) the position worsens, and so on. Thus by a set of actions—rational in themselves—the overall productivity of the system deteriorates in a series of irreversible steps linked with the occurrence of droughts. It is only necessary for us to add population growth—as an independent variable—to complete this scenario of a structurally unstable system.

Economic impoverishment. In economic terms, people respond not to desertification as such, but to individual famines, each of which may leave their insurance systems weakened and adaptive capability impaired. It can be predicted that the sale of assets—animals, property, land—at depressed prices yields income, which is converted to food at inflated prices and unfavourable terms. From a reduced resource base an attempt has later to be made to recoup losses when the price curves have changed places.

Such a prediction is borne out by the fragmentary price data available (Fig. 6). From less than 80 Naira per ton at the beginning of 1972, the price of

Figure 5. Drought and productivity



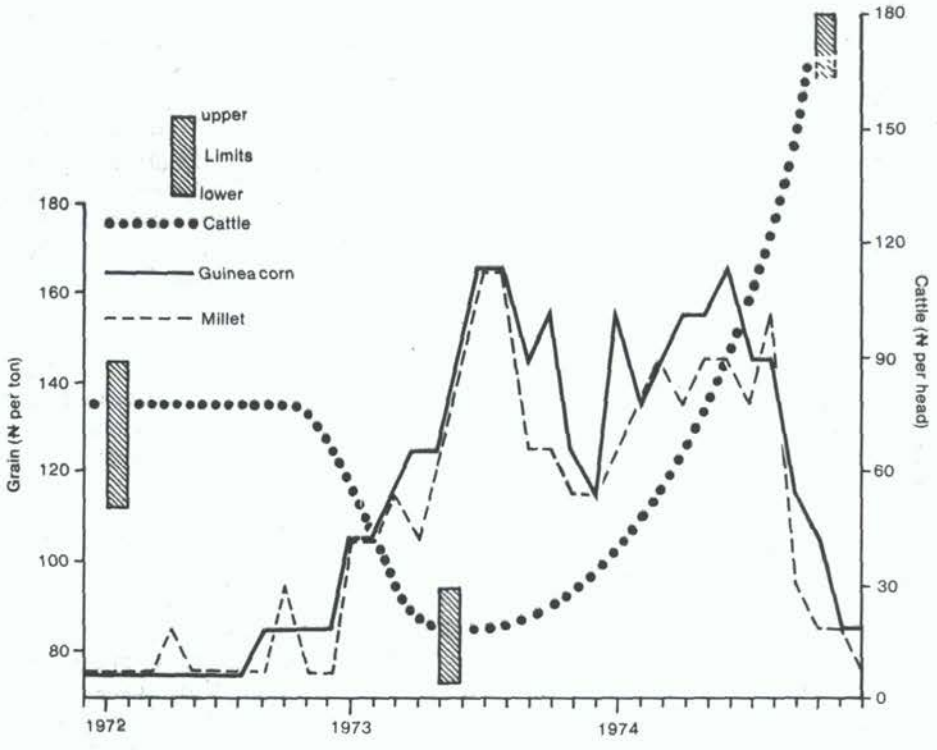


Figure 6. Prices of grain and cattle

grain climbed to over 160 Naira in June, 1973, only falling momentarily after the harvest of that year, before reaching a second peak which was held for eight months, until the good harvest of 1974 brought prices below starvation level. The prices for cattle, which are representative for livestock generally, plunged from 50 to 90 Naira (depending on condition, sex and location) before the drought to as little as 4 Naira in the early months of 1973. After the drought, they recovered to higher levels which reflected the losses throughout northern Nigeria. The terms of trade moved from roughly one cow for a ton of grain before the drought to 6 to 10 cows for a ton at its height, and afterwards to one cow for 2 and a quarter tons of grain, a detetioration in terms which turned out to be permanent.[33]

As a closed system, the village might survive the shock of drought given an adequate grain surplus in normal years. Since the market economy has breached it, however, the open system of real life must survive by intensifying its own integration with the larger system (Fig.7), even though this intensification is conducted on unfavourable terms—"self-exploitation" — and increases its vulnerability to forces beyond its control. In particular, income from secondary production, labour circulation and migration are becoming absolutely crucial to the survial of rural communities in areas prone to drought.

Government intervention. Governments are among the exogenous factors over whom rural communities rarely exercise influence. Following their colonial predecessors, the administrations tend to be remote in location, bureaucratic in organization, centrist in style and interventionist in mode, all in marked contrast to their pre-colonial forebears. Specific policies for the rural sector have attracted much criticism as capital-intensive, import-dependent, technologically vulnerable if not inappropriate, subject to uncertain direction, and unduly influenced by urban interests. For example, in a policy area highly relevant to drought, the Federal Government of Nigeria has channelled a very large proportion of its agricultural investment into the construction of costly dams for irrigation projects. None of these projects has yet been shown to be cost-effective; there are allegations of management deficiencies; capital works are behind schedule; resettlement costs are escalating. One of the dams will flood a larger area than it irrigates; one irrigation scheme is currently (1985) high and dry for lack of water. Many rural people think of Government as predatory, threatening their rights to their hand.

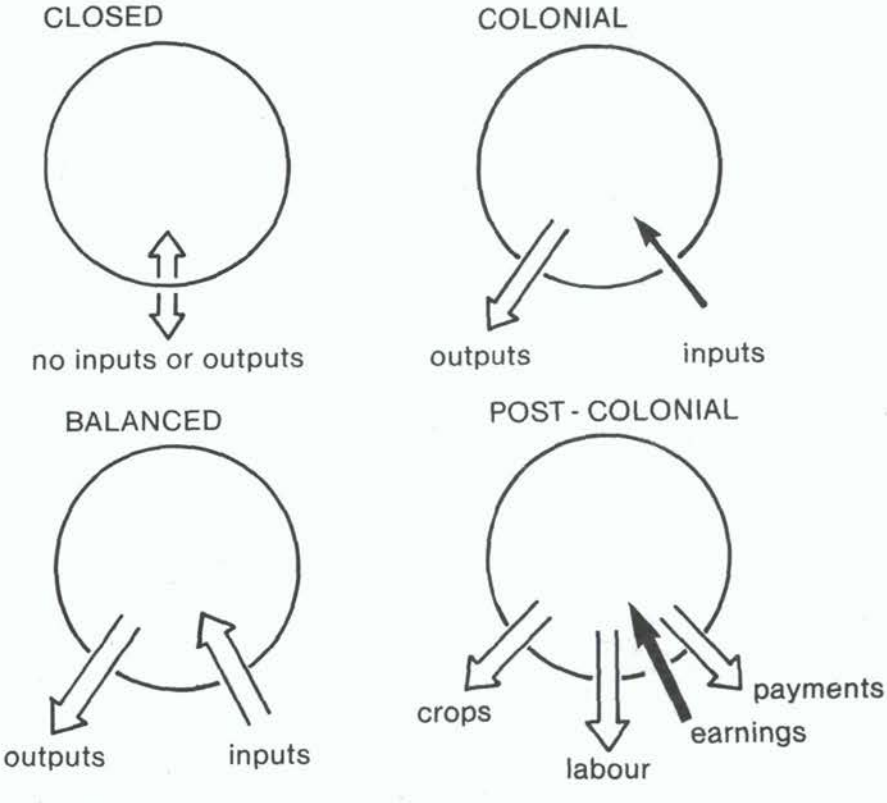


Figure 7. Rural systems and the market.

Population growth. It is often suggested (or implied) that one area over which rural populations in the Third World have ceased to exercise control is their own numbers (or those of their livestock); and that if few people (or animals) occupied those areas prone to drought and desertification, the problem would somehow go away. Population control, or evacuation, are advocated.

But a drought is still a drought, whether it threatens two hundred or two million people. Fewer people at risk would mean fewer casualties, but we should resist the tendency to measure social disasters on a Richter scale graduated in millions. The diagnosis sidesteps the intervening variables. Famine tends to follow in the wake of drought only because financial, distribution and welfare systems taken for granted in other seasonally arid environments are denied to many inhabitants of poor countries.

In fact, labour is the only factor of production which such a population has within its power to increase. The labour requirements of many production systems are growing, as diminishing yields necessitate more cultivation; as shortage of pasture necessitates the cutting of foliage from trees; as journey to water, grazings, and sources of fuelwood increase; and as more members of the family spend time away from home.[34] It must also be pointed out that under conditions of limited technology, increase labour inputs defined the intensification strategy that alone offers a path to improved agricultural productivity.

Since pastoral populations try to maintain a minimal ratio of animals to humans, the voluntary reduction of livestock numbers is also problematic. In an important paper, Sandford has shown that overstocking (in relation to the carrying capacity in the driest years) is intrinsic to what he calls "opportunistic" stocking strategies, and that the costs of understocking (i.e. wasting pasture in good years) may be considered unacceptably high.[35]

Regardless of whether human and livestock populations *should* be subject to control (which means, of course, the *loss* of control to the government) even the most draconian measures would take too long to have effect.

The evacuation of drought-affected populations to areas better endowed by nature, suggested at one time as a solution to Sahelian drought, is currently being tried by the Ethiopian Government. This programme is reported to be expensive—because migrants have to be transported, housed and fed until they become self-sufficient. In the Sahel, such a policy would involve movement across frontiers which would be unacceptable to the states concerned. Yet long-term resettlement was the solution sought in prehistory to the southward march of the Sahara, ever since the Holocene when, nine to five thousand years ago, human populations and a rich tropical fauna supported themselves in what is now the desert of northern Mali.[36] The drying out of the southern Sahara, it has been suggested, may be the backcloth to the historical development of the Hausa people,[37] and southward migration of farmers still takes place into Nigeria's relatively empty Middle Belt. The principle of autonomy, however, as well as considerations of cost, demands that resettlement should be voluntary, and unimpeded by restrictions. And it should be remembered that such migration is not undertaken by starving destitutes, but families with adequate resources to establish themselves in a new environment.

Some implications for policy

The behaviour of populations living under drought stress demonstrates the existence of innovative adaptive capability, indigenous insurance systems (in contrast to the image of hopless conservatism that is sometimes put about), and diminishing autonomy in resource management. African populations often understand their environments better than some of those who have presumed to advise them.

Starting from the perspective that in development, production is for people and not the other way around, the three concepts I have put forward—adaptive capability, indigenous insurance and autonomy — provide a framework for evaluating initiatives to "combat" drought and desertification. In particular, they lead us to question the assumptions that underlie many such initiatives: (1) that the adaptive behaviour which has facilitated human survival for centuries can now safely be ignored; (2) that the state should take over the responsibility for insuring against disaster; (3) that village or community autonomy should be replaced by directives from state agencies advised by "experts".

Drought and famine destroy domestic and productive capital. Food stocks disappear, family savings are obliterated as livestock are sold, and people sell their few consumables, their clothes, even their land in order to survive. The reconstitution of such savings is a necessary condition not only for the restoration of welfare but also for the resumption of productive activity in agriculture or animal husbandry.[38] Otherwise, rural communities will remain both impoverished and vulnerable. The injection of cash into the rural economy, for example, in cash-for-work programmes, stimulates the market and thereby enhances adaptive capability, while the work done can improve the productive infrastructure (e.g., road building or water supply).[39] On the other hand, bureaucratic food distribution programmes may create dependence and stimulate little economic activity, other than illicit trade in relief materials.

The structure of alternative opportunities that is available depends much on the intensity of rural-urban interaction, and on the operation of the macro-economy. This relationship needs to be recognised in the formulation of policies on migration, short-term circulation, the urban informal sector, and open international frontiers.

Grain storage is crucial. The Nigerian Federal Government has set about building central storage units for 250,000 tonnes of grain, which will be used for famine relief and price control (the Federal Grain Reserve Scheme), and is setting up a 4,000 hectare mechanized farm in each of the 19 states. This expensive structure has yet to prove itself. Such a system incurs high capital, administrative and transport costs and requires skilful market management; there can be no guarantee that people in remote vil-

lages will get help when they need it. It has been conceived "from the top down" and has no place for community initiatives.[40] In contrast, Burkina Faso has tried an experiment with cereal banks.[41] Village communities are provided with revolving loans, and use them to buy grain at harvest time for release in the "hungry season" at controlled prices. Such schemes may run into financial difficulties or fall foul of the incipient class structure of the village, and help to further inequality rather than assist the poor. But the restoration of an insurance capability at village level is an imperative. District grain stores were advocated in Nigeria as long ago as 1922, and village storage was practised in pre-colonial times.[42]

These points have all some bearing on the issue of autonomy in the management of resources. So does the tenure of the land. This appears particularly relevant to the operation of grazing systems which still rely heavily on the use of woodland grazings that have not yet been appropriated for agriculture or other uses. Such land is diminishing rapidly, increasing grazing pressure on what remains and threatening further ecological degradation. But pastoral land use can never be controlled by edict, whether the scale is that of the trans-national breeding and fattening zones once proposed for West Africa, or the rotational grazing schemes which failed in Nigeria, or merely rules against cutting trees for fodder.[43] While governments blame "common" rights to pasturage for overgrazing, they are reluctant to define land rights in such a way that pastoral communities can enjoy the security of tenure that is the necessary condition for improved management. The spatial mobility of pastoralists is admittedly a major handicap. But a start can be made in areas where semi-sedentary groups practise regular transhumance, and local authorities have already given administrative recognition to grazing rights.[44] For farmers, too, there is urgent need of better definition and registration of their rights to land.[45]

Emergency assistance to drought-affected communities should, so far as is possible, enhance adaptive capability; preventive action should be designed to rebuild indigenous insurance systems; and rehabilitative policies should attempt to restore autonomy in resource management—"self- reliance".[46] A decade after the Sahel drought of the seventies, we have little to celebrate in a world that has failed to conquer its oldest enemy—hunger.

"The gaunt ghost of famine stalked abroad... the stricken people tore down the ant hills in the bush to get at the small grains and chaff within these storerooms. They wandered everywhere... thousands drifted down across our borders, passing through villages en route all bare of food to offer them. They died like flies on every road... Several fell exhausted on the road...Some mature men, horribly emaciated, leant on their walking sticks; girls with eyes like trapped gazelles; women clenching their children to their shrivelled breasts".[47]

"The biggest disaster area in Africa... there have been up to 50 deaths a day from famine or disease, and Swiss Red Cross officials were stated to be in despair...Ethiopia has been like an abcess, and it is now emptying itself into the Sudan...An emaciated refugee comforts his daughter...the skin on the child's head is her only clothing..."[48]

The first was written in Nigeria in 1914, and the second in Sudan in 1985. The continued existence of such suffering is both a rebuke to governments which stand aloof and a challenge to applied social science.[49] And if starvation is prevented or reduced, shall we be any more successful in preventing impoverishment?

"So Joseph bought all the land of Egypt for Pharoah; for all the Egyptians sold their fields, because the famine was severe upon them... as for the people, he made slaves of them from one end of Egypt to the other". Genesis 47:20.

Notes

1. J.M. Kowal and A.H. Kassam, *Agricultural ecology of savanna. A study of West Africa,* 1978, 240-52.

2. Inter-State Committee for Drought Control in the Sahel, quoted in *West Africa,* 3 December, 1984, 2489; United Nations Economic Commission for Africa, quoted in *West Africa,* 14 January, 1985, 69.

3. United Nations Demographic Yearbook; food requirements estimated at 0.5 kg/person/day.

4. A.T. Grove and A. Warren "Quaternary landforms and climate on the south side of the Sahara", *The Geographical Journal,* 134, 1969, 194-209.

5. Observations on this dune have been made since July, 1979. It is believed to be representative of dunes threatening other villages in the area.

6. E.P. Stebbing, *The forests of West Africa and the Sahara,* Chambers, 1937, 16; also "The encroaching Sahara", *The Geographical Journal,* 85, 1935, 506-24; "The threat of the Sahara", Extra Supplement, *Journal of the Royal African Society,* May, 1937; "The man-made desert in Africa: erosion and drought", Supplement, *Journal of the Royal African Society,* January, 1983.

7. U.S.A.I.D., *Desert encroachment on arable lands: significance, causes and control,* Washington, 1972, 55.

8. Mostapha K. Tolba, "Harvest of dust", *Desertification Control* (United Nations Environment Programme), 10, 1984, 2.

9. For the definition of the growing period, monthly distribution and confidence limits, see J.M. Kowal and A.H. Kassam, op. cit., (Note 1), 71-79.

10. P.E. Lovejoy and S. Baier, "The desert-side economy of the central Sudan", in: Michael H. Glantz (ed.) *The politics of natural disaster. The case of the Sahel drought,* 1976, 145-75; Polly Hill, *Rural Hausa. A village and a setting,* 1972, 231-2.

11. G.J. van Apeldoorn, *Perspectives on drought and famine in Nigeria,* 1981; Michael H. Glantz, (ed.) *op. cit.* (Note 10); J.R. Pitte, "La sécheresse en Mauritanie", *Annales de Géographie,* 84, 1975, 641-64; Yveline Poncet, *La sécheresse en Afrique Sahélienne: une étude micro-régionale en République du Niger. La région des Dallols,* Centre de Développement, O.E.C.D., March 1974 (mimeo).

12. J.M. Kowal and A.H. Kassam, *op. cit* (Note 1), 37-41, 71-79; R.P. Motha, S.K. Le Duc, L.T. Steyaert, C.M. Sakamoto and N.D. Strommen, "Precipitation patterns in West Africa", *Monthly Weather Review,* 108, 1980, 1567-78.

13. As critical scholars have been at pains to point out, drought need not lead to famine, and does not do so in the western industrial

economies, for example. Michael Watts, *Silent violence, food, famine, and peasantry in northern Nigeria*, 1983.

14. The term is anglicised from the French desertification, for which there is the alternative *désechement*. In English usage, the alternatives "desiccation" and "desertization" are losing ground.

15. Nicholson has shown that in all the major rainfall zones there was a marked decrease in the last two decades (S.E. Nicholson, "Sub-Saharan rainfall in the years 1976-80: evidence of continued drought", *Monthly Weather Review*, 111, 1983, 1646-54), but earlier studies had concluded that the low rainfall of the early seventies was within statistical expectations (A.H. Bunting, M.D. Dennett, J. Elston and J.R. Milford, "Rainfall trends in the West African Sahel", *Quarterly Journal of the Royal Meteorological Society*, 102, 1976, 59-64)

16. As adopted at the United Nations Conference on Desertification in Nairobi, 1977.

17. Norman H. Macleod, "Dust in the Sahel: cause of drought" in: Michael H. Glantz (ed.) *op. cit.* (Note 10), 214-31. According to F.K. Hare ("Recent climatic experience in the arid and semi-arid lands", *Desertification Control*, United Nations Environment Programme, 10, 1984, 15-22), this theory is the least well supported. In any event, the south-westerly rain-bearing air carries little dust.

18. J.G. Charney, "Dynamics of deserts and drought in the Sahel", *Quarterly Journal of the Royal Meteorological Society*, 101, 1975, 193-202. Although dynamic modelling is understood to lend support to this theory, a practical difficulty is the explanation of how the rains get under way at a time of year when albedo reaches its maximum, even in a normal year, let alone following a major drought (as they did in 1974).

19. J. Walker and P.R. Rowntree, "The effect of soil moisture and circulation on rainfall in a tropical model", *Quarterly Journal of the Royal Meteorological Society*, 103, 1977, 29-46.

20. Discussed in F.K. Hare, op. cit. (Note 17).

21. John W. Kidson, "African rainfall and its relation to the upper air circulation", *Quarterly Journal of the Royal Meteorological Society*, 103, 1977, 441-56.

22. S.E. Nicholson, *op. cit.* (Note 15)

23. G.H. McTainsh, "Harmattan dust deposition in northern Nigeria", *Nature*, 286, 1980, 587-8; G.H. McTainsh and P.H. Walker, "Nature and distribution of Harmattan dust", *Zeitschrift für Geomorphologie*, 26, 1982, 417-35.

24. "Report of the Anglo-French Forestry Commission, December 1986—February 1937", *Sessional Paper 37 of 1937*, Government Printer, Lagos; F.S. Collier and J. Dundas, "The arid regions of Northern Nigeria and the French Niger Colony", *Empire Forestry Journal*, 16, 1937, 184-94; L. Dudley Stamp, "The southern margin of the Sahara", *The Geographical Review*, 30, 1940, 297-300; R. Mansell Prothero, "Some observations on desiccation in North-Western Nigeria", *Erkunde*, 16, 1962, 111-9.

25. The possibilities for modifying the farming system in response to drought are restricted by the shortness of the growing season (from three to five months) to: replanting, altering crop mixtures in favour of those more tolerant of drought, sowing a larger area, and withholding organic manure (which "burns" the crop).

26. Relief food had been distributed in very small quantities in 1973 and in somewhat larger quantities—but only in some areas—in June, 1974, by the Kano State Drought Relief Committee.

27. Michael Mortimore, "Framework for population mobility: the perception of opportunities in Nigeria", in John I. Clarke an Lezcek A. Kosinski (eds.), *Redistribution of population in Africa*, 1982, 50-7

28 A.D. Goddard, M.J. Mortimore and D.W. Norman, "Some social and economic implications of population growth in rural Hausaland", in: J.C. Caldwell et. al. (eds.), *Population growth and socio-economic change in West Africa*, 1975, 321-36.

29. Michael Mortimore, "Famine in Hausaland", *Savanna*, 2, 1973, 103-7.

30. Michael Watts, op. cit. (Note 13).

31. With the exception of trading, which requires working capital.

32. In the Budget of January, 1985, the Federal Government of Nigeria announced as one of its targets a rate of inflation of not more than 30 per cent (Federal Finance Minister, reported in "West Africa" 14 January, 1985, 48). When the currency is changed, there is a risk that rural savings held in cash may not be brought to the banks in time.

33. Using different grain prices, Watts (*op. cit.*, Note 13, 387) obtains a more optimistic conclusion. The grain prices in Figure 6 are for five major markets in northern Kano State, and are calculated from van Apeldoorn's simplified official data (G.J. van Apeldoorn, *Drought in Nigeria. Volume 1, Context and characteristics*, Centre for Social and Economic Research, Ahmadu Bello University, Zaria, 1978, 144-6). For cattle, the upper limits are provided by official data from Maiduguri (*ibid*, 123), and the lower by village surveys.

34. The historian of the Irish famine, Cecil Woodham-Smith (*The great hunger, 1845-9*, 1962) documented how the peasantry were obliged to marry early and have many children, not-with-standing poverty and hunger, as their only available response to the insecurity of old age.

35 Stephen Sandford, "Pastoral strategies and desertification: opportunism and conservatism in dry lands", in: Brian Spooner and H.S. Mann (eds.), *Desertification and development. Dryland ecology in social perspective*, 1982, 61-80.

36 Nicole Petit-Marie, "Le Sahara, de la steppe au désert", *La Recherche*, 15, 1984, 1372-82.

37 H.F.C. (Abdullahi) Smith, "Some considerations relating to the formation of states in Hausaland", *Journal of the Historical Society of Nigeria*, 5, 1970, 329-46. But there are alternative theories: Mahdi Adamu, "The Hausa and their neighbours in the central Sudan", in: D.T. Niane (ed.) *General history of Africa, IV. Africa from the Twelfth to the Sixteenth Century*, 1984, 266-300.

38 Herders' co-operatives use credit to reconstitute drought-shattered herds in a project in Niger (Jeremy Swift and Angelo Maliki, "A cooperative development experiment amongst nomadic herders in Niger", *Pastoral Development Network*, Overseas Development Institute, Paper 18c, September 1984).

39 A report on a cash-for-work programme in Ethiopia found that it could be more cost-effective than direct food aid (*The Guardian*, 14 January 1985).

40. G.J. van Apeldoorn, *op. cit.* (Note 11), 151-3.

41. C.J.R. Roche, "Cereal banks in Burkina Faso: a case study", *Liverpool Papers in Human Geography, Working Paper No. 18*, Department of Geography University of Liverpool, 1984.

42. Michael Watts, *op.cit* (Note 13), 302. Michael Mortimore, "Grain reserves at the village level in drought-prone areas of Nigeria", in: G.J. van Apeldoorn (ed.), *The aftermath of the 1972-74 drought in Nigeria*, Federal Department of Water Resources and Centre for Social and Economic Research, Ahmadu Bello University, Zaria, 1977, 220-6; J.G. van Apeldoorn, op.cit (Note 11), 159-62.

43. W.G. Matlock and E.L. Cockrum, "Agricultural production systems in the Sahel", in: Michael H. Glantz (ed.), *op.cit.* (Note 10), 232-55; J.G.T. van Raaji, *Rural planning in a savanna region*, Rotterdam University Press, 1975; J.T. Thomson, "Ecological deterioration: local-level rule-making and enforcement problems in Niger", in: Michael H. Glantz, (ed.), *Desertification: environmental degradation in and around arid lands*, 1977, 57-79.

44. Such areas as north-eastern Kano State and the Mambilla Plateau. The difficulties, however, are not under-estimated. In February, 1985, the former, while their transhumant herds were absent, were invaded by voracious herds from farther north fleeing the drought of 1984.

45. The Land Resources Programme at Bayero University, Kano has recently been introduced to meet the need for manpower trained in land adminsitration and development, and to mobilize research into problems of lands.

46. G.J. van Apeldoorn, *op. cit.* (note 11), 145-69.

47. A. Hastings, *Nigerian days*, Bodley Head, 1925, 111.

48. *The Guardian*, 22 January 1985.

49. Space does not permit a discussion of research priorities, but the following headings may be suggested: (1) the adaptive capabilities of populations under stress, and the impact of policies on strategies; (2) the identification, enumeration and analysis of those sections of the population having the lowest adaptive capability, with a view to devising programmes of assistance; (3) the improvement of initiating effective monitoring systems for rainfall and crop yields, land use change, ecological and other variables; (4) the physical properties and development potential of land, land tenure systems, change in these systems, registration and administration of land.

Camel vs cattle pastoralism: stopping desert spread

by

Daniel Stiles
Desertification Control PAC
United Nations Environment Programme

The Chalbi Desert of northern Kenya is one of the hottest and most arid areas in all of sub-Saharan Africa, yet even here people manage to adapt to the harsh conditions and survive from what meager resources the land has to offer. This prodigious feat is made possible by the utilization of a beast which inspires the deepest love and affection from its owners, interspersed by moments of profound loathing. Many other desert-dwelling peoples of Africa, the Middle East and Asia who could not survive but for the remarkable qualities of this animal have a similar love-hate relationship with it. This haughty and cantakerous creature is highly misunderstood by the rest of mankind, however, as they think that it has nothing to do with contemporary life and that it belongs solely to the dying world of the nomadic pastoralist. They are wrong, and it is possible that this animal could improve the lives of untold numbers of people and also save from desertification the remaining rangelands of Africa. The animal is, of course, the dromedary camel, and its future concerns us all. So does the history of its past.

Flying over northern Kenya today it is difficult to believe that the sparse *Acacia* scrub one sees was once thick woodland, and that the barren, dusty patches at one time were lakes, ponds or waving fields of lush grass. Thousands of square kilometres of bleak lava cobbles and boulders were once probably covered by at least half a metre of soil, held in place by trees, shrubs and grass. Most of the vegetation is now gone, and so is the soil. The Chalbi itself was once a lake that rivaled the present Lake Turkana (8,000 kilometres[2]) in area. Much has changed over the past few millennia in terms of climate, environment, and the culture and economy of man in the region. The dessication of northern Kenya is not an isolated case, and what happened there has parallels all over Africa and other parts of the world. Since the origin of domestic plants and animals—the so-called "Neolithic Revolution"—many parts of the world have degenerated from highly productive habitats into desert or near desert. A big question that is generating much heat and dust of its own is the cause of this land degradation, and what can we do to halt or reverse it.

Are the more recent deserts—those formed since the end of the Pleistocene some 10,000 years ago—due to desertization or rather to desertification? *Desertization* refers to a situation where rainfall decreases over time and becomes low and variable, punctuated by extended periods of drought, which leads to a steady impoverishment of wild plant and animal life[1]. It is a relatively slow process and its cause is climatic change, due to atmospheric alterations or topographic changes such as the eruption of a mountain range which blocks moist air from travelling to the leeward side. *Desertification* is caused by the misuse of the land by man and his livestock. Deforestation occurs when people chop down trees and bushes to clear land for cultivation or for fuel, fodder and construction materials faster than seedlings can sprout and grow. Animals overgraze and trample the land, leaving bare soil at the mercy of wind and water erosion. It is a much faster process than desertization, and it can happen even without climatic change.

It is difficult to disassociate these two processes in Africa because there is good evidence for climatic change at the same time that domestic animals first appeared and spread, beginning between 7,000 and 8,000 years ago in the Nile Valley and the Sahara[2,3]. Did these migrating pastoralists spreading south and east out of the Sahara create the arid wastes we see today in the Sahel and northern Kenya, or was the cause climatic change? If the pastoral activities were more at fault, then it follows that they still are today, and how can the situation best be changed to preserve the rangelands that remain? The question is an important one for Africa, as the continent is highly dependent on livestock. The value of livestock food and other products is $10 billion annually, while cereal production is only worth about $8.5 billion.[4] Africa still has to import 80,000 metric tons of domestic animal products a year because of its burgeoning population. Most livestock production comes from pastoralists, but with the steady degradation and loss of their land production will inevitably drop—unless something is done.

Northern Kenya

The story in northern Kenya can begin at about 8,000 years ago. Some 30 kilometres west of the present Chalbi "shore" line there is a carbon-14 date of 8100 ± 220 b.p. on fresh water snail shells in lake deposits which are located at a height between 30 and 40 metres above the floor of the dry lake flats.[5]The Chalbi floods today after heavy rains, but never extends anywhere near these dated lake sediments. If these deposits are the remains of an 8,000 year old Lake Chalbi, as is most likely, it would indicate that rainfall was significantly higher then than at the present time. The Chalbi is an internal basin fed exclusively by runoff waters from rain which falls on the surrounding highlands, so a high lake level is evidence of high rainfall. An expanded Chalbi

lake at this time is in accord with the results of studies conducted on lakes located to the north in the Ethiopian Rift Valley, to the south in the Kenyan central rift, and also nearer at hand around Lake Turkana.[6,7,8,9]

Archaeological research shows that man inhabited most of the Saharan region at this time, which was now a well watered savannah, and in the Sahara and East Africa fishing became an important part of the economy.[10,11] Sometime between 4,000 and 5,000 years ago Late Stone Age pastoralists began to filter into northern Kenya from the north.[12] Pollen collected from pits dug into the Chalbi show that *Podocarpus* forests on the surrounding highlands were much more extensive than today.[13] The region was probably one of wooded savannah, tall grasslands and with numerous streams feeding the permanent Lake Chalbi. These early pastoralists herded cattle, sheep and goats, possibly cultivated sorghum, made pottery with a wide variety of styles, pecked out lava and pumice cobbles to make vessels, and they buried their dead under stone cairns. The oldest cairn burial yet known from East Africa comes from near Kalacha, an oasis on the eastern margin of the Chalbi. The human skeleton under the stone mound dates to approximately 1500 B.C. These first East African pastoralists probably were Southern Cushitic language speakers who were migrating down the Great Rift Valley in search of richer pastures.[14]

Several centuries ago the Chalbi Desert Playa was a lake and the mountains were covered in Podocarpus trees as indicated by pollens dug from this pit. (UNEP/Daniel Stiles)

For the next 3,000 years a highly varied procession of pastoralists entered Kenya from the north: Eastern Cushites such as ancestors of the Rendille, Somali, and Oromo (Galla) from Ethiopia and Somalia, followed first by Southern Nilotes (Kalenjin ancestors) and then Eastern Nilotes (Maasai, Samburu, Turkana) from the Sudan and Uganda. All of these people were originally cattle pastoralists, though they also herded sheep and goats. One thousand years ago the lakes were much lower than earlier on, but the fact that Lake Chalbi still existed points out that there was still more rainfall than today. The Chalbi had greatly shrunk in size from the days when it lapped at the foot of Mt. Kulal, and charcoal in a hearth buried 90 centimetres under the surface of a sand dune near North Horr dated 1150 ± 110 b.p. indicates that dessication and land degradation had begun.[13] Pastoralists were now living on extensive sand dunes on the north end of a lake which had once covered the entire area. Geological evidence from near Kalacha suggests that the lake had almost dried up by the 9th century A.D., and that it became an ephemeral lake by approximately the 13th or 14th century, probably much as it is today.[13,15]

Coincidently, it was at about this same time that the Chalbi was invaded by people who built huge rings of lava cobbles and pebbles around the graves of their dead, some measuring up to 20 metres (65 feet) in diameter.[14] Some camel pastoralists continue the practice of putting a stone ring around a grave up to this day in the Chalbi region, but their rings are much smaller than the prehistoric ones. Could the carbon-14 dated 200 to 600 year old giant rings be remnants of the first camel pastoralists to immigrate into the Chalbi area? The drying up of the Chalbi, which signals more arid conditions than previously, fits well with a hypothesis that a camel herding people began migrating into the region between the 10th and 13th centuries.

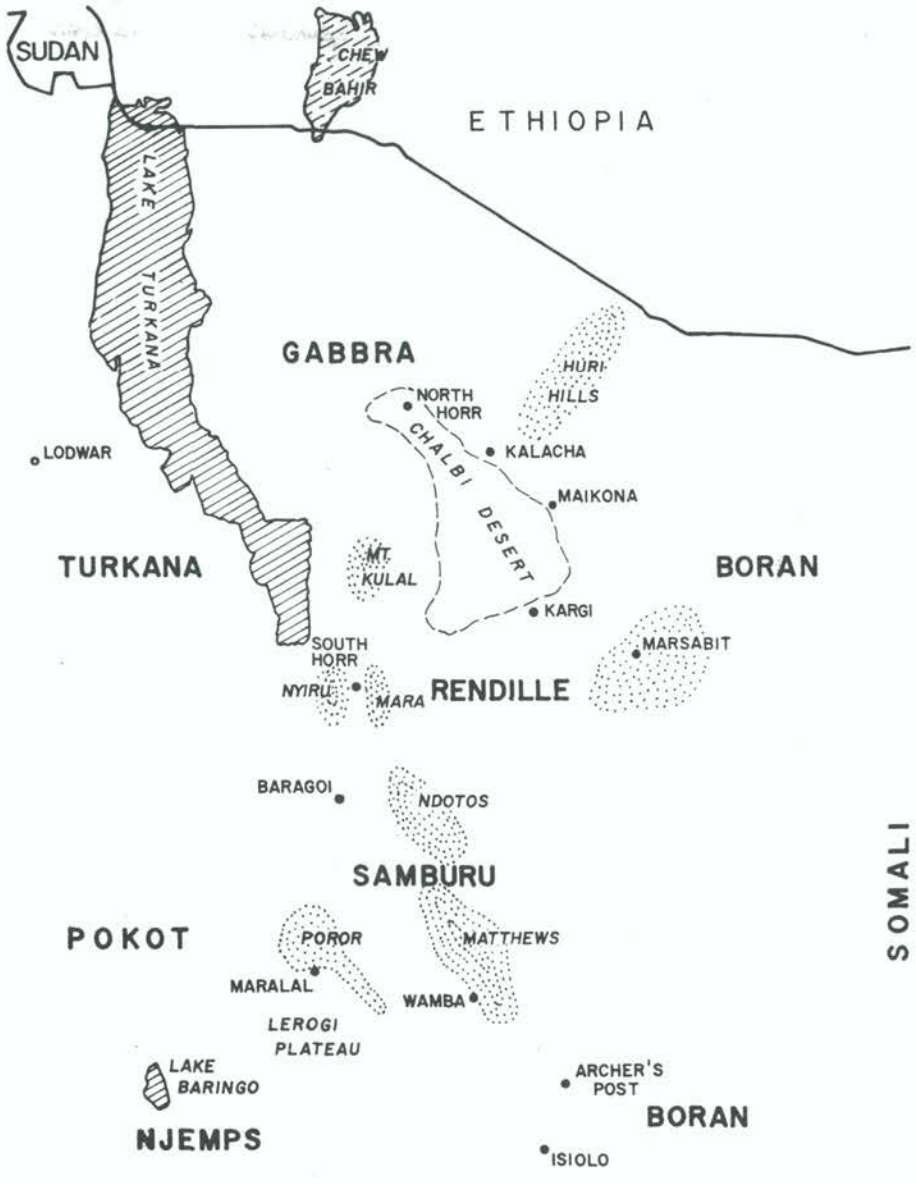
The large ring cairn burials which abound in northern Kenya could be the remains of the earliest camel pastoralists in the region. (UNEP/Daniel Stiles)

Over the centuries the camel has slowly been moving west and south from the Horn, a living indicator of a dying environment. The camel has now spread to the west of Lake Turkana, to the Nilotic people for whom the lake was named. The Turkana were originally cattle pastoralists when they arrived in Kenya in the 18th century. But they were so numerous and their herds were so large that they soon caused severe environmental degradation. Their own oral traditions recount a land rich in rain, trees and grass just three generations ago. Today there is a desert. In the 19th century the Turkana began to raid the Rendille and Gabbra, stealing camels from them. Today they have large camel herds and without them would not be able to survive in their increasingly hostile environment.

Further South

The same process is taking place further south in Kenya. The Samburu, northern cousins of the Maasai, live south of the Rendille in relatively heavy *Acacia* bush country. They are also blessed with several high rainfall mountain areas which provide good grazing for cattle—once the forests have been burned down, which is happening at an alarming rate. The Samburu have been compressed into about 60 per cent of their early 20th century range by pressure from surrounding peoples and by land alienation for a national park and private ranches south of them, and population has grown considerably over the past 80 years. The ancient response of migrating to better pastures is no longer an option for them. Increased population necessitates larger herds to feed the people, which when coupled with smaller grazing lands inevitably leads to overgrazing, deforestation and desertification. As a result of a drop in the productivity of the land, which is then expressed in lower milk, meat and blood yields from livestock, the Samburu have recently become interested in acquiring camels. The price is very high, thus camels are not increasing very quickly amongst the Samburu, though they want more of them.[16]

The Pokot, who live south of the Turkana and west of the Samburu, are also turning to camels. These fierce



Map of part of northern Kenya showing the main pastoralist groups.

pastoralists have managed to build up quite substantial camel herds from incessant raiding on the Turkana. Camels are now even spreading south of Lake Baringo to the Maasai-speaking Njemps (Il Chamus). Camels cannot move any further south by natural means as the land is owned by farmers and ranchers. This land used to be occupied by the Maasai, but the British colonial government moved the Maasai south and opened the land to European settlement. Most of this land has now been transferred to indigenous Kenyan ownership since independence in 1963, but modern agricultural techniques and a private land tenure system still prevail. If it weren't for this barrier of private land and fences it is quite possible that camels would continue their southward migration down the dry Rift Valley to the Maasai and with them into Tanzania and eventually even further south. Kenya marks the most southerly extent of camel expansion in Africa, but they would do quite well in many parts of southern Africa.

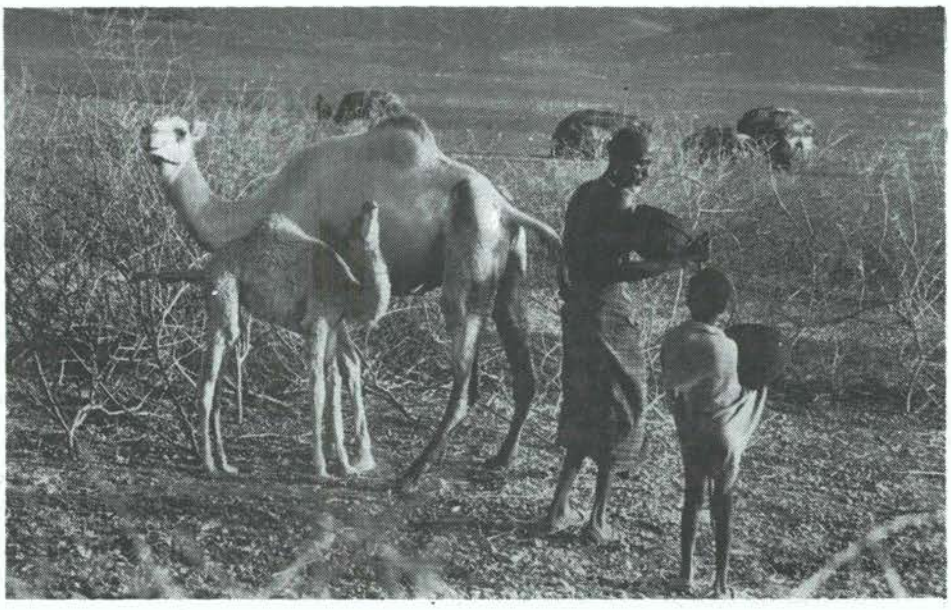
People like the Samburu, Turkana and Pokot have a deep emotional attachment to cattle built up over centuries of interrelations and mutual dependence with them. A cow or bull is not simply a piece of property or a source of food for the Kenyan cattle pastoralist; each animal is like a part of the family, it is named and cared for, and it can have an important social or

ritual significance. What then is the great attraction of the camel that will cause cattle-complexed people to desire it so strongly? And desire it they do. In a trade a good milch camel will fetch between two and five cows and up to 30 sheep and goats—if a milch camel for trade could ever be found. The pastoralists with small camel herds are also constantly complaining that available camels are so few and so expensive. They want to increase their camel herd, but are unable to do so.

There are some very good reasons why the camel is so sought after. Some the pastoralist realizes, others he consciously does not. People interested in combating desertification and conservationists should also be interested in the unique qualities of the camel, some of which are only recently becoming appreciated as a result of detailed research within the last decade. The camel is significantly superior to other livestock animals in terms of food production, what effect they have on the environment, and even in controlling human population growth. The camel should not be thought of as a specialized animal, adapted only to deserts. In fact, the camel is an extremely versatile animal, and it is the cow which is the more specialized in terms of its needs and potential uses.

Advantages of Camels

The average female camel in northern Kenya produces from five to ten times more milk per lactation period than a cow. A camel will lactate for more than a year after giving birth while the cow usually ceases giving milk within nine months or less. During the rainy season when pasturage is good the camel will give an average of about 10 litres of milk a day; a cow will produce less than five litres. In the dry season the cow will practically dry up while the camel will continue throughout to give from two to five litres a day of milk—about what a cow will give at the best of times. What all of this means is that a camel will consistently provide a substantial quantity of milk for human consumption over the course of an entire year, while the cow's milk production is relatively small and highly variable.[17]Because of the very low milk producing capacity



The camel provides significantly more milk in drylands than cattle do. (UNEP/Daniel Stiles)

of the cow during dry periods, and their poor resistance to drought, the cattle pastoralist tries to have the largest herd that he can. There is no thought of culling unproductive animals to take pressure off the pasture; that unproductive animal might survive the next drought and then be used to trade for grain or for some calves to rebuild the herd. With everyone trying to maximize his herd the limited rangeland inevitably suffers.

This difference between cattle and camel milk production extends world wide. Table 1 shows camel milk production figures from parts of Africa and Asia.[18]Table 2 shows milk production from cows in various African countries.[19]The average of 280 kilos a year milk production for cows compares unfavourably with the more than 2000 kilo average of camels. Needless to say the food security of camel pastoralists is much greater than that of cattle people during drought periods.

TABLE FOR CAMEL VS CATTLE PASTORALISM

Table 1: Milk yields of camels (kg)

Country	Daily Average	Daily Maximum	Lactation Yield	Lactation length (months)	Calculated yield per 305 day
China-Bactrian	5	15-20	1 254		
USSR-Bactrian					735
– Hybrid-Kazak					1 305
– Hybrid-Turkmen			981		
Dromedaries					
China	7.5		3 300	16-17	2 288
USSR					2 003
USSR	8.1	19	4 388		
Horn of Africa	9		1 800		
N. Kenya	4	12			
N. Kenya		50	1 897		
Ethiopia	5-13		1 872-2 592	12-18	1 525-3 965
Somalia	5		1 950	13	1 525
Libya	8.3-10		2 700-4 000	9-16	2 532-3 050
Algeria	4	10			
Tunisia	4			12	1 220
India:					
good feeding	6.9	18.2	3 105-8 190	15	2 105-5 551
bad feeding			1 360		
desert	6.8	9.1	2 430-4 914	18	1 373-2 776
Pakistan:	8.0	13.5	13 560-3 660		1 068-4 118
good feeding	9-13.6	20.5	2 727-3 636	16-18	3 150-4 148
bad feeding	4		1 364		1 220
Pakistan:	6.7-10		2 700-3 600	9-18	2 044-3 050
good feeding	15-35		5 475-12 775	12	4 574-10 675
desert	8-10		2 920-3 650	12	2 440-3 050
Egypt	3.5-4.5		1 600-2 000		1 068-1 373
Israel					
+water	6.0				
– water	6.2				

(From Yagil, Ref. 18)

Table 2: Milk Production of Cows in Sudano-Sahelian Region (Kg)

Country	Lactation Yield	Lactating Cows
Burkina Faso	80	590,000
Chad	270	360,000
Djibouti	–	–
Ethiopia	221	610,000
Gambia	175	30,000
Guinea Bissau	170	40,000
Kenya	480	2,708,000
Mali	200	540,000
Mauritania	350	250,000
Niger	200	528,000
Nigeria	290	1,230,000
Senegal	360	225,000
Somalia	350	466,000
Sudan	500	2,000,000
Total	3,646	11,732,000

X = 280 Kg

Note: The lactation period varies from 4-12 months, but under low rainfall conditions rarely more than 9 months.

(Source: FAO 1984, ref. 19)

The feeding habits of cattle and small stock are also much more destructive than those of camels. Cattle and sheep feed almost entirely on grass, as long as it is available. They also eat the green leaves of shrubs and herbs in the understory. The goat will devour

almost anything within its reach, including *Acacia* seedlings, which seriously reduces tree reproduction. All three species travel to and from grazing areas and watering points in bunched up herds with their hard and sharp hooves kicking up clouds of dust as they scuff the earth. The cumulative results are the stripping of ground cover and the very destructive trampling of that barren land. Erosion gulleys that end up carrying away tons of top soil often start out as livestock trails.

Camels, on the other hand, have a very wide diet and eat the leaves of shrubs, trees and herbs, as well as grass.[20]They do not overgraze any type of vegetation, and they can eat into the upper stories of vegetation that other animals cannot (except for tree climbing goats), thus lessening pressure on the lower vegetation levels. Camels also disperse much more and travel farther than the other livestock types while feeding, which again lessens the effects of vegetation consumption. The dispersed movement pattern of camels also reduces the effects of trampling, though with their soft, flat hoofless feet little damage is caused anyway. In short, camels on their own will not strip and kick up soil from the ground so there is no soil loss and trees have a much better chance to reproduce.[21]

The camel is also much more efficient than the cow in converting vegetation into milk. Studies in northern Kenya show that a camel can produce one litre of milk for human consumption from about two kilograms of vegetation dry matter. To produce an equivalent litre for human use, a cow must consume more than nine kilos of dry matter.[17]The camel, then, is more than four times more efficient than cattle in converting its food to human food. The implications of this finding for the future of pastoral economies in semi-arid and arid lands cannot be underestimated.

Another environmental plus for the camel is the type of settlement pattern it permits for people. The more dispersed settlements and livestock are, the less the land is affected by tree and bush cutting for firewood, stock enclosures, etc., and by livestock grazing and trampling. Camels are justly famous for their ability to go for long periods without drinking, and they can carry water long distances to settlements for human needs. Camel pastoralists can thus live in areas where there is good pasture but no water. Cattle pastoralists have no such option since their animals have to be watered at least every three days, making it necessary to live within a maximum radius of about 40 kilometres from a water source, though 15 to 20 kilometres is more common. This tends to concentrate cattle people in certain parts of the range, putting excess pressure on natural resources, while leaving other areas unused. Camel pastoralists can live up to 80 kilometres from water, allowing a more even distribution of settlements over the land.

In northern Kenya and most other semi-arid and arid areas rain falls unpredictably in patches over the landscape. It is rain that spurs plants to grow, so the pastoralists must be ready to go where the rain has fallen. Mobility is therefore essential, and it is this perpetual chase for patches of good grazing that makes the pastoralist a nomad. If a settlement stays in one area too long overgrazing results and the people create a surrounding circle of uprooted bushes and grotesque trees with lopped off limbs. Camel pastoralists like the Gabbra will move ten times in a year, but cattle people like the Samburu might stay in the same place for several years. It is a very great effort for cattle pastoralists to move, but camel people can pack everything on the backs of their beasts and be on the move with 24 hours notice.

The last environmental advantage of camel pastoralism over that of cattle pastoralism is one of the most important. Cattle pastoralists burn bush, forest and savannah to create grasslands, because cattle depend on grass. Camel pastoralists do not need to burn because camels do very well in a bush environment. Fire has undoubtedly done more to modify the earth's terrestrial habitats than any other single factor, and most fires have been and are anthropogenic. In highland areas where rainfall is high the creation of grassland plains might not be environmentally deleterious. The Serengeti, for example, is a very productive habitat for animal biomass as is well known. The long term effects of repeated burning in lowland areas can have disastrous consequences, however. Rainfall tends to be much more unreliable in areas below approximately 1200 m in East Africa,

The camel allows for greater mobility as the entire house, illustrated here by Gabbra women, can be packed onto a camel's back (UNEP/Daniel Stiles)

and once protective bush has been burned off a prolonged drought can result in severe erosion and environmental degradation.

In addition to the food and environmental advantages provided by its physiological and behavioural attributes, the camel is also the only domestic animal that has demonstrated its ability to control human population growth. If livestock are the primary source of food, and if they regulate the creation of new families by their availability, then without outside economic inputs human population cannot grow faster than the herd. Cattle herds can increase up to 15 per cent a year under ideal conditions, and this is after counting those that have been eaten. Normally, however, over the long term a herd will grow at a 3.4 per cent annual rate.[22]Small stock herds grow at rates up to 30 and 40 per cent annually, but high off-take rates keep real growth lower. A camel herd usually grows at an average rate of only 1.5 per cent a year, and a 5 per cent growth would be considered extremely good by most pastoralists. Because of the slow growth of camel herds societies dependent on them practice many different types of social controls to regulate marriage and birth.

For example, the Samburu (cattle herders) and Rendille (camel people) are neighbours and they occupy roughly similar habitats in northern Kenya, though Samburu-land receives on the average somewhat higher rainfall. Between 1969 and 1979 the Samburu tribe grew by 34.4 per cent, or at a 3.0 per cent annual rate. The Rendille increased by only 16.4 per cent, or about 1.6 per cent a year, one of the lowest growth rates in Kenya (the national average was almost 4 per cent for this period, the highest in the world).[23] These human growth rate figures are remarkably close to expected herd growth rates. Just the overall size of the two groups demonstrates that cattle people tend to be more numerous than camel people; Samburu number more than 80,000 while there are fewer than 20,000 true Rendille. The difference is probably even greater between the closely related Boran cattle and Gabbra camel peoples, but no accurate growth figures are available since these two peoples commonly cross back and forth to and from Ethiopia.

Halting Desertification

The surest—and perhaps only—way to halt desertification is to stabilize human population growth and reduce livestock herd sizes. It is very unlikely that either of these desirable objectives can be achieved as long as pastoralists depend primarily on cattle. The history of the spread of camels has shown that their southward movement was not due to climatic change alone. It is a history that chronicles what an economy based on cattle and small stock can do to the environment. The fast growth of the herds encourages and makes possible high human population growth. When the range is in good condition and rainfall is plentiful there is copious milk, meat and blood to feed a growing population. When the grazing deteriorated the people simply moved on. Woodland is destroyed by tree-felling and by burning each year to regenerate the grass that the cattle need. A forest is transformed into a savannah, and the savannah into a treeless plain. Trampling and overgrazing finish off the ground cover. Wind blows dust into the atmosphere, a devegetated land reflects the sun's rays back into the sky, heating the dust. There is little moisture to evaporate into the air from such a land, and when humid air moves into this dry region from elsewhere it is very difficult for rain clouds to form. Precipitation decreases over time, lakes and streams dry up, and a desert is created.[24,25] Man has created it, and he has actually modified the climate himself. The notion that land is merely a passive factor in climatic change, reacting helplessly to the vagaries of rain and temperature, can no longer be accepted. Conditions of land surface are inter-active with variables determining climate, and changes in the land can cause microclimatic changes, with as yet unknown affects at the macro level.

Near the end of the desertification process, when the rains become more erratic and unpredictable and cattle begin to die from drought, the camel makes his appearance. The camel can resist the drought, allowing life to continue. When the drought ends the cattle herds rebuild themselves, humans reproduce to replace those who died, and the cycle begins anew. Over centuries or millennia of these cycles a desert so desolate results that no cattle at all can survive, except in favoured spots. We are left with the shifting sands and rocky plains of the Sahara, the Sinai and the Thar Desert of India. These areas supported abundant life 10,000 years ago, and it was not global climatic change alone that degraded these lands. The process of desertification was greatly assisted by man and his beasts, and it is still happening today in northern Kenya and other parts of Africa.

It would be interesting to see what would happen if cattle, sheep and goats could be reduced in northern Kenya substantially, to be replaced by fewer numbers of camels. If managed well, there would be no loss of food production and the land and its wildlife would benefit considerably. Bringing camels into an area *before* the desert is created might just well halt the desertification process, if it is integrated with an overall programme of education and training to teach the pastoralists care and management of camels and good land use methods. Camel breeding stations, centres where cattle and small stock could be traded for camels, a marketing scheme with incentives to trade and an efficient system to supply beef and mutton to the towns could all lead to a healthier people and environment.[26]It is not realistic to expect pastoralists to give up cattle entirely, they are too important culturally, but the herds could be greatly reduced if the attitudes of the people can be changed through education and if the incentives are there.

It would be a long, slow process, as societies need time to develop new ways of organizing labour and for adapting their institutions and beliefs to a modified economy. Camels are not easy animals to live with, which is a main reason why people do not adopt them until forced to by environmental circumstances, but a desert is not easy to live with either. If camels can help to halt the spread of deserts then they may be the animal of the future rather than one of the past. The people who want camels should be given help to obtain them—that alone might be worth more to improve the life of pastoralists than many expen-

sive, socially disruptive development projects. The pastoralists, at least, would appreciate the camels more than an irrigated field of cotton. In the long term, so would the land.

REFERENCES

1. Raikes, R. 1967: *Water, Weather and Prehistory.* London: Hutchinson.
2. Wendorf, F. 1977: Late Pleistocene and recent climatic changes in the Egyptian Sahara. *Geol. J.* 143(2): 211-234.
3. Clark, J.D. 1970: *The Prehistory of Africa.* New York: Praeger.
4. McDowell, R.E. 1983: Livestock: Species, feed strategies, health, contributions. Paper presented at the 149th Annual Meeting of the AAAS, Detroit.
5. Mäckel, R. 1983: The age and geomorphological interpretation of Late Pleistocene and Holocene deposits in the Nyiru-Ndotos mountain region and adjacent plains, Northern Kenya. Unpublished ms.
6. Butzer, K.W., G.L. Isaac, J.L. Richardson and C. Washbourne-Kamau 1972: Radiocarbon dating of East African lake levels. *Science* 175: 1069-1076.
7. Street, F.A. and A.T. Grove 1979: Global maps of lake-level fluctuations since 30,000 B.P. *Quaternary Research* 12: 83-118.
8. Gasse, F. and F.A. Street 1978: Late Quaternary lake level fluctuations and environments of the northern Rift Valley and Afar region (Ethiopia and Djibouti). *Paleogeog., Paleoclimat., Paleoecol.* 24: 279-325.
9. Butzer, K.W. 1980: The Holocene lake plain of north Rudolf, East Africa. *Physical Geog.* 1: 44-58.
10. Smith, A.B. 1979: Domesticated cattle in the Sahara and their introduction into West Africa. In *The Sahara and the Nile,* (Eds) M.A.J. Williams and E. Faure. Rotterdam:Balkema.
11. Phillipson, D. 1977: *The Prehistory of Eastern and Southern Africa.* London:Heinemann.
12. Owen, R.B., J.W. Barthelme, R.W. Renaut and A. Vincens 1982: Palaeolimnology and archaeology of Holocene deposits northeast of Lake Turkana, Kenya. *Nature* 298: 523-529.
13. Stiles, D.N. 1982: Preliminary results of archaeological and paleoenvironmental research in northern Kenya. *Nyame Akuma* 20: 19-25.
14. Stiles, D.N. and S.C. Munro-Hay 1981: Stone cairn burials at Kokurmatakore, northern Kenya. *Azania* 16: 151-166.
15. Stiles, D.N. 1981: A Diachronic Study of the Demography, Human Ecology and History of Pastoral Groups of Northern Kenya. Report to the National Council of Science and Technology (Kenya) and the Ford Foundation.
16. Stiles, D.N. 1983: Vanishing grass: Samburu camel herders. *Swara* 6(1): 8-11.
17. Stiles, D.N. 1983: Desertification and pastoral development in northern Kenya. *Nomadic peoples* 13: 1-14.
18. Yagil, R. 1982. *Camels and Camel Milk.* FAO Animal Production and Health Paper; No. 26, Rome.
19. FAO, 1984. *Production Year Book,* Vol. 37. Rome.
20. Field, C. 1979: The food habits of camels in northern Kenya. *IPAL Technical Report E-1b.* Nairobi: UNESCO.
21. Personal field observations and interviews with pastoralists.
22. Dahl, G. and A. Hjort 1976: *Having Herds.* Stockholm Studies in Social Anthropology, University of Stockholm.
23. Government of Kenya 1981: *Kenya Population Census, 1979, Vol. I.* Central Bureau of Statistics, Ministry of Economic Planning and Development.
24. Sagan, C., O.B. Toon and J.B. Pollack 1979: Anthropogenic albedo changes and the earth's climate. *Science* 206: 1363-1368.
25. Hare, F.K. 1983: *Climate and Desertification: A Revised Analysis.* World Climate Programme No. 44, WMO/UNEP.
26. Stiles, D.N. 1985. Desertification et élévage dans le nord du Kenya. *Production pastorale et société,* 17: 39-53.

African drought and its impacts: revived interest in a recurrent phenomenon

Michael H. Glantz
Richard W. Katz
Environmental and Societal Impacts Group National Center for Atmospheric Research
Boulder, Colorado

Working paper prepared for the Economic Commission of Africa Multi-disciplinary Meeting on Impact of Drought on Socio-economic Activities

Introduction

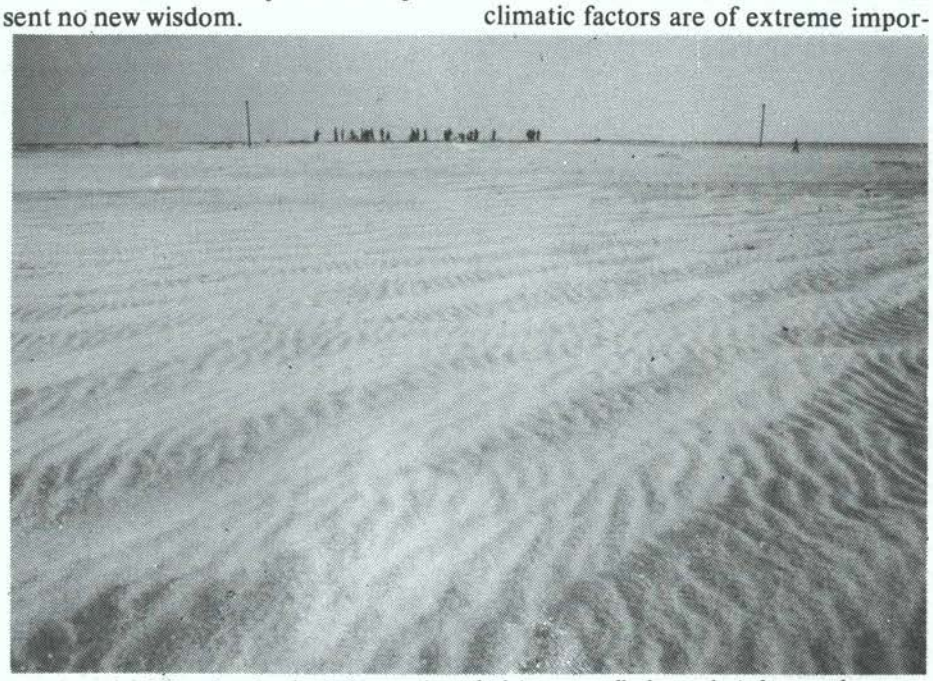
Climate anomalies represent only one of the many crises that confront national leaders. These leaders are continually plagued by a host of problems or crises which at any given time may overwhelm those relating to climate. Several years ago an author, writing about problems confronting policymakers in developed and developing countries alike, referred to them as hydra-headed crises. The list of crises included such topics as food, water, technology, environment, energy, health, nutrition, and so forth.

Many of these crises have already reached acute proportions on the African continent, where per capita food production in many countries is lower today than it was 15 years ago (Eicher and Baker, 1982). A recent World Bank report (1981) reinforced this view, noting that "... for most African countries, and for a majority of the African population, the record is given and it is no exaggeration to talk of crisis. Slow overall economic growth, sluggish agricultural performance coupled with rapid rates of population increase, and balance-of-payment and fiscal crises—these are dramatic indicators of economic trouble." (p. 2).

The hydra-headed aspect of these crises suggests that when a society addresses one particular crisis, its solutions often lead to the creation of other crises. For example, the development of an irrigation scheme may provide additional water supplies, but it may adversely affect human health by increasing the incidence of schistosomiasis of the soils. As another example, during drought periods, deep wells are often constructed in an attempt to develop new water supplies. Yet, the construction of deep wells encourages overgrazing of vegetation and trampling of soils around the water sites. New wells may also attract new herders in search of reliable water supplies. This, in turn, could lead to increased conflicts around the well sites. These and similar examples are well known to everyone and represent no new wisdom.

As suggested at the outset, to the list of crises facing the decision-makers in Third World countries should be added climate, e.g., climate variability and, perhaps, climate change.[1] Not only must decision-makers cope with a myriad of economic and social problems, but they must also cope with something over which they have no control or influence—the climate.

More often than not, climate-related crises interact with other crises. Obviously food production is heavily dependent on climatic factors, as is the water situation. Nutrition and health are also linked to climatic factors; malnutrition accompanies drought and disease accompanies malnutrition. In some circumstances climatic factors are of extreme impor-



One theory holds that denuding land of vegetation, which increases albedo, results in lower and more variable rainfall. (United Nations/ P. Frankel).

tance, while at different times, even in the same geographic location, they may be of less importance to decision-makers, who have to deal with the most pressing problem of the moment. Several countries, for example, are faced with military conflict within their borders. Influxes of refugees represent another dilemma for the countries in northeast Africa and in Ghana. Yet another problem for these leaders are the fluctuations in prices that their exports command in the international marketplace.

DROUGHT

Most reports now acknowledge that there are many types of droughts: agricultural (e.g., Palutikof et al., 1982; WMO, 1975), hydrologic (e.g., Dracup, et al., 1980), and meteorologic (e.g., Palmer, 1964) drought. Scientists have offered many definitions of drought, most of which are directly related to physical considerations, e.g., too little water at a specific stage of plant development, or rainfall being a certain percentage below "normal". Some definitions of drought have been expressed in terms of its impact on society (e.g., Sanford, 1978). For example, before a situation can be designated as a drought, a decline in precipitation that leads to a reduction in agricultural production must adversely affect the economy of a region.

Related to the climate problems that decision-makers will eventually have to address is the carbon dioxide issue. Although a recent meeting on climate in the dry margins put this issue aside as one in which Third World policy-makers have little interest at *this time* (UNEP/WMO/UCSU, 1983) it is an issue that has been linked (rightly or wrongly) to the current spate of droughts on the African continent. A recent report (WMO,1983), however, concluded that "*It is highly improbable that the increase of carbon dioxide to date has contributed significantly to the recent dry conditions.*"

Scores of reports and books, and hundreds if not thousands, of articles have been written about droughts in Africa (see, for example, the OECD bibliography on the Sahel; Michigan State University Sahel Documentation Center reports; University of Arizona Desertification abstracts, UNESCO/-MAB reports and so forth). In most instances these reports were written in the midst of, or immediately following, drought episodes in Africa and covered a wide range of topics, from the physical causes of drought to their societal and ecological impacts. Some of these reports were written as early as the turn of this century. Their findings appear to be as valid today as in the days in which they were written. In fact, new scientific findings have in many instances reinforced the findings of the earlier studies. Thus, it is time to look at the existing body of knowledge (related to drought and its impact in Africa) and to pause in the search for "new" answers to recurring problems, to reflect on the answers that may already exist.

A large number of these reports have focused on the impacts of drought in a specific region (e.g., Club du Sahel, 1980), country (e.g., Botswana Society, 1978), economic sector (e.g., Dahl and Hjort, 1976) or on a particular group in society (e.g., Monod, 1975). The 1982-83 African droughts, however, have served to foster a continent-wide perspective of drought in Africa, with suggestions that whatever may now be causing droughts in one region may be causing droughts in other regions as well. While some of the most recent droughts in Africa have affected countries that experienced lengthy droughts in the early 1970s (e.g., in the West African Sahel or in the Horn of Africa), others have taken place in countries that have been affected by drought only irregularly. The 1982-83 droughts have also affected nations that have been exporters of foodstuffs, such as the Republic of South Africa and Zimbabwe. Thus, some countries or regions in Africa have accumulated more experience in understanding and dealing with droughts than others.

The UN Food and Agriculture Organi-

Table 1. Population affected by drought, April 1986 (millions).

	Total	Affected	Displaced
Angola	8.6	0.6	0.5
Botswana	1.1	0.6	—
Burkina Faso	6.9	0.2	—
Cape Verde	0.3	0.1	—
Chad	5.0	0.4	0.2
Ethiopia	43.6	6.8	0.3
Lesotho	1.5	0.5	—
Mali	8.1	0.4	0.1
Mauritania	1.9	0.9	0.2
Mozambique	14.0	2.1	0.4
Niger	6.1	0.4	0.2
Somalia	4.7	0.2	0.2
Sudan	21.6	6.0	0.9
TOTAL	123.4	19.2	3.0

Source: Office for Emergency Operations in Africa (OEOA), Status Report on the Emergency Situation in Africa: as of 1 April 1986, United Nations, New York, 1986.

zation, among other agencies, has been monitoring food production activities in Africa, and, since June 1983, has issued several Food Situation Reports. A United Nations report published in 1986 contained the following table:

Not mentioned in the FAO reports are the Republic of South Africa and the so-called "self-governing and independent black nations." South Africa had been an exporter of maize in past years but, as a result of droughts in 1982-84, had to import about 1.5 million tons for the first time in its history. South Africa has reported that this has been its worst drought in two centuries. In the "self-governing and independent Black Nations" such as the Transkei, Ciskei, Bophuthatswana, Venda, KwaZulu, etc., the human and livestock populations have been extremely hard-hit because of the 1982-1984 drought which precipated widespread crop failures, desiccation of water resources, human disease outbreaks that accompany malnutrition, and sharp depletion of herds.

Drought as a "recurring, aperiodic" climate phenomenon

Droughts are a "recurring" climate phenomenon. In Africa they have occured throughout the available historical record of climate (Nicholson, 1978) and are certain to reoccur in the future. But the time between consecutive droughts, as well as the duration and intensity of a given drought, is uncertain. Many attemps have been made to discover statistically significant cyclical behavior in the time series of precipitation and other water resource variables related to drought. These cycles explain, at most, only a small fraction of the interannual variations in precipitation time series. More importantly, the ability to forecast accurately the occurrence of future droughts on the basis of this quasi-periodic" behaviour has not been demonstrated. Many researchers still question whether such cycles even exist (Yevjevich, 1974; Palutikof, et al., 1982). For all practical purposes, including planning for the impacts of future droughts, we might as well view drought as an "aperiodic" phenomenon.

Other scientists have focused their research on linking these drought episodes to climate anomalies elsewhere on the globe. For example, it has been hypothesized that many of these droughts may have been linked to an atmospheric-oceanic phenomenon known as El Niño, a warming of ocean surface water in the eastern equatorial Pacific off the coasts of Peru and Ecuador (e.g., Flohn and Fleer, 1975). Much of the talk in the scientific and popular literature about such linkages with El Niño, however, remains quite speculative at this time.

Forecasting Droughts

While there have been many fruitful research activities undertaken on the topic of drought forecasting, little success has been achieved in the operational forecasting of its onset, duration, or geographic extent. Precipitation amount generally is regarded as the most difficult meteorological variable to predict. For example, in the United States no skill has been demonstrated in forecasting precipitation amount for a specific location beyond a few days (i.e., 3-5 days). Weak positive correlations have been established between precipitation totals for consecutive months, especially when averaged over a region, suggesting some potential for long-range forecasting of drought on a regional scale. However, even in the United States skill in forecasting precipitation totals has only been verified for time periods of up to three months, and this skill is only slightly better than chance.

Any real periodicities in annual precipitation time series would allow the forecasting of drought with some accuracy at least several years in advance. But, as argued earlier, drought is at best quasi-periodic and extrapolation of cycles for forecasting has not been successful. New research approaches currently being undertaken could, perhaps, lead to some skill at predicting droughts a year or more in advance. As just mentioned, teleconnections (that is, correlations between meteorological and/or oceanographic events at distant locations and at possibly different times) recently have been claimed between droughts and other phenomena such as El Niño. Specifically, Hastenrath and Wu (1983) have proposed a means of forecasting drought in Northeast Brazil several months in advance, largely on the basis of what would be considered teleconnections. We must conclude, however, that at the present time the capability to forecast droughts on the African continent eludes the scientific community.

Most studies of drought in Africa refer to the paucity of meteorological data. The African time series is generally considered to be relatively short and this paucity of information forces the author of each scientific report to recommend the expansion or improvement of the meteorological network. The lack of reliable meteorological information fuels the controversies over what is happening to Africa's climate. Nevertheless, efforts have been made in recent years to set up reliable agrometeorological networks (e.g., Rijks, 1980) and to test the feasibility of using data obtained from such networks to assess crop conditions on an operational basis (CEAS, 1979).

However, we do know many things about rainfall in arid and semi-arid areas. Because several reports have adequately summarized what we do know (e.g., WMO, 1976; FAO, 1981), only a few general characteristics of rainfall will be mentioned here. The probability distribution of rainfall is typically positively skewed; in particular, more than half of the rainfall values fall below the mean. This positive skewness decreases as the time over which precipitation amounts are totaled is increased and as the spatial extent over which the data is averaged is increased. The practical implications of rainfall skewness for assessing the impacts of climate on society are that such impact assessments should be based on the entire probability distribution rather than simply a mean rainfall value (Katz and Glantz, 1977). A second characteristic of rainfall is its variability. In comparison with other meteorological variables such as temperature, rainfall is highly variable both spatially and temporally. In a relative sense, this variability increases, the drier (i.e., in terms of mean or median) the location or the smaller the region under consideration. Rainfall variability complicates impact as-

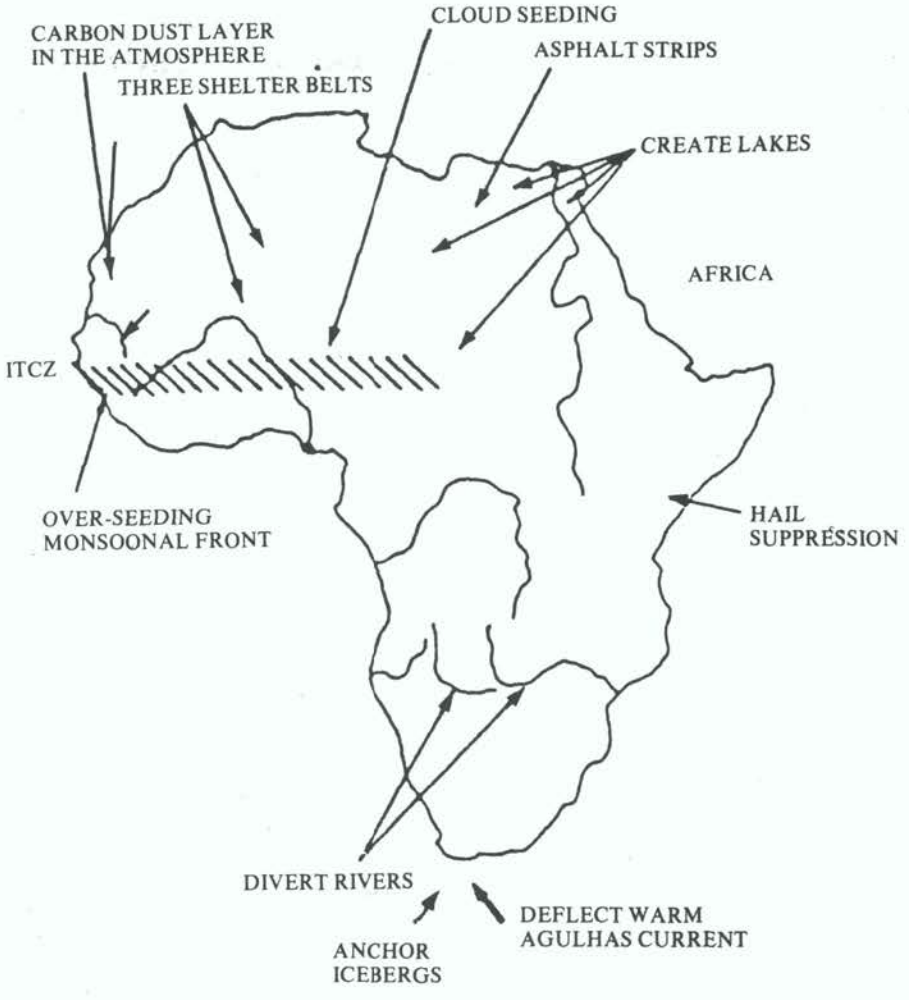
sessments because the temporal and spatial dimensions of drought need to be considered in detail to prepare for the possible impacts of drought on society, economy, and ecology. Reinforcing the need for policymakers in various affected African countries to understand as well as to accept the climate characteristics of their region, is the view constantly expressed in many reports that drought is a normal component of climate in parts of the tropics and sub-tropics.

There are people who believe that although drought conditions cannot be forecast now or at least in the near future, they could be alleviated by undertaking projects that have been designed to modify atmospheric processes for the purpose of creating precipitation. In theory, it is quite logical to see drought as simply a problem of water shortage. Two ways, among others, have been suggested to do that: weather modification and climate modification.

Weather and climate modification

Whenever there has been a drought in Africa in recent times, there has usually been a call for rainmaking. Such calls for weather modification during drought are not unique to Africa but take place also in industrialized countries such as the United States, Canada, and the USSR. Cloud-seeding activities, however, are often no more than short-term, ad hoc approaches to drought-induced water crises.

Attempts at operational weather modification have been carried out in Senegal and Niger, for example. During the Sahelian drought of 1972-73, Niger embarked on an operational cloud-seeding programme at a cost of several hundred thousand dollars. These programmes, however, seldom include evaluation activities to ascertain the effect, if any, of the seeding activities. Several questions must be raised and answered about cloud-seeding before decision-makers are asked to spend scarce national resources on such controversial activities. What are the findings of the scientific community (not just the claims of the seeders) about this activity? Has such an activity been proven to work elsewhere? If so, under what conditions? If cloud-seeding works, would it not be best to cloud seed during wet periods, when there are more clouds to seed, and to store the water (if it works) for its more efficient and regulated use?



Climate modification schemes, too, have been suggested during and immediately after major drought episodes in Africa. These are attempts to modify the atmospheric circulation on a more permanent basis and are often grandiose and expensive, not to mention being scientifically in the stage of "wishful thinking." Climate modification schemes for Africa have been discussed elsewhere (e.g., Glantz, 1977a) and can be summarized in the following map.

When compared with climate modification schemes, weather modification activities appear to be quick fixes. Both types of modification, however, are technological fixes to problems that have geophysical as well as societal components. Flooding depressions in the Sahara, tree belts across the width of the African continent, changing the direction of river flow, besides being complex, yet unproven, technological solutions, all require a degree of international co-operation and funding that are not easy to establish.

Inadvertent modification

Not only does climate affect society, but there are a growing number of hypotheses about how society can and does affect climate. These have been termed inadvertent modifications because the human activities that may modify the atmospheric processes are not designed to do so. Inadvertent modifications are the result of human activities that have been undertaken for other reasons.

An example of hypothesized inadvertent modification relevant to the dry margin areas is related to overgrazing, an activity which tends to increase the reflectivity of the earth's surface

(changes in albedo) and to reduce the availability of biogenic nuclei. Such nuclei are viewed as instrumental in the formation of precipitation processes. Tree belts, designed primarily to check wind erosion, have also been linked to the inadvertent modification of the atmosphere on the mesoscale. Similarly, irrigation of large expanses of territory has been cited as a modifier of regional climate. There has been much scientific research, as well as scientific and popular speculation, about these modification processes, but most of them require more research.

Desertification

Closely tied to drought and its impacts on the physical and social environments has been the phenomenon known as desertification. The ECA draft report of the Scientific Roundtable on the Climate Situation and Drought in Africa commented on the Secretariat's perception that there is a linear relationship between drought and desertification. This assumption requires further comment. Studies of desertification became popular in the mid-1970s, following the drought in West Africa in the early 1970s and the UNEP Conference on Desertification in Nairobi. Drought and desertification are two processes that sometimes overlap, with drought frequently leading to or at least abetting desertification. Desertification, however, can take place in the absence of drought.

There has been an apparent shift in interest between these two topics; in the early 1970s and again in the early 1980s, drought questions received the lion's share of attention from governments, non-governmental organizations, and UN agencies. In the mid and late 1970s, however, interest focused on desertification. Some observers think these two processes are so entwined that one cannot occur without the other. This view, however, does not have general scientific support. An assessment of the scores of definitions of desertification shows that not all researchers consider climate to be the primary contributor to desertification (Glantz and Orlovsky, 1983).

One of the main issues that arose during the UN Conference on Desertification was the role of human activities in that process. With a lack of precipitation, land use practices such as overgrazing, or the growing of high-water-use crops in drought-prone areas tend to lead to wind and water erosion, acknowledged sub-processes of desertification. Some scientists argue that the processes that appear to be relatively harmless during wetter periods become exacerbated during drought. Those potentially harmful processes, however, were only masked by wetter conditions. Drought episodes sometimes prompt defensive reactions by society that in the long run may exacerbate the desertification process. For example, deep boreholes in drought times attract herders and their herds. Because the water supply at boreholes can be relatively permanent, the herds overgraze the areas for tens of kilometers around the well site. This process has been well documented (Glantz, 1977b). The particular example of boreholes highlights a dilemma facing African leaders from local to national levels. Short-term responses, e.g., a quick-fix water supply, may in the long term lead to adverse impacts on the environment. Decision-makers are under pressure to supply water during droughts; but they are often unable to control its use.

Possible drought scenarios appropriate for impact studies

It has become increasingly accepted by many groups that drought must be viewed as recurring, aperiodic climate phenomenon. We can illustrate these characteristics by means of future scenarios of drought for a particular region of Africa. At a theoretical or a statistical level, this is easy to show, but what is the practical value of this knowledge? Can statistical assessments of climate in various parts of Africa be converted into meaningful planning tools for decision-makers? It can be argued that such scenarios based on the climate characteristics of a given region are predicated on assumptions particularly appropriate for impact studies.

The main value of these simulations is to demonstrate that there can be lengthy runs of dry as well as wet years, given the climate characteristics of the region. This does not mean that any one of these sequences of wet-dry years that is generated in a simulation will in fact take place. While it is true that these are just simulations of reality and not reality itself, they do show that a variety of quite different possible futures can be suggested. These futures were developed (using a random number generator) based on the known climate characteristics of the particular region being investigated. Thus, as the reader will readily see, many different futures are possible even in the absence of a change in the key climate statistics such as the mean, the mode, or the variability of rainfall.

From a statistical perspective, one of the most striking features of climate is its variability. Precipitation, a key climatic factor and the central factor in most definitions of drought, exhibits a relatively large degree of variability from one year to the next. These interannual fluctuations make the questions of whether the climate is changing and, if so, what its impact on society would be, difficult to answer. In engineering terms, the inherent variability of climate can be viewed as "noise." Because of the presence of this noise, any climatic "signal" (such as a gradual change in the likelihood of drought) is masked. It appears that, with respect to undertaking impact assessments, we may be asking the wrong question; that is, whether droughts are becoming more likely. Uncertainty about the exact time of occurrence and intensity of future droughts will be present whether or not the likelihood of drought is changing. Thus, there is less urgency at this time to focus on the impacts of hypothetical long-term climate change when we can focus on the impacts of interannual variability of climate.

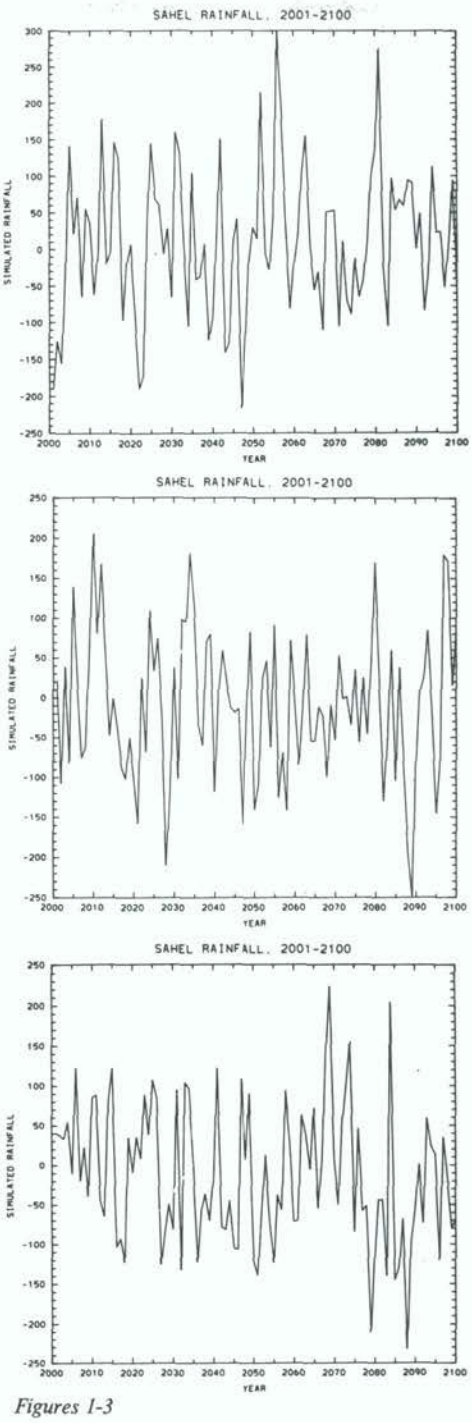
An example of the statistical characteristics of precipitation time series is presented, based on data used to construct an index of annual Sub-Saharan rainfall (Lamb, 1982). Using parameters estimated from the historical precipitation record for the region, simulated time series of annual precipitation were generated. These simulations (also referred to as synthetic data) can be viewed as "scenarios" of future climate, derived with the assumption that no real climatic change has occurred. That is, the likelihood of drought is assumed to be constant over the time period of concern and

no real cycles are assumed to be present.

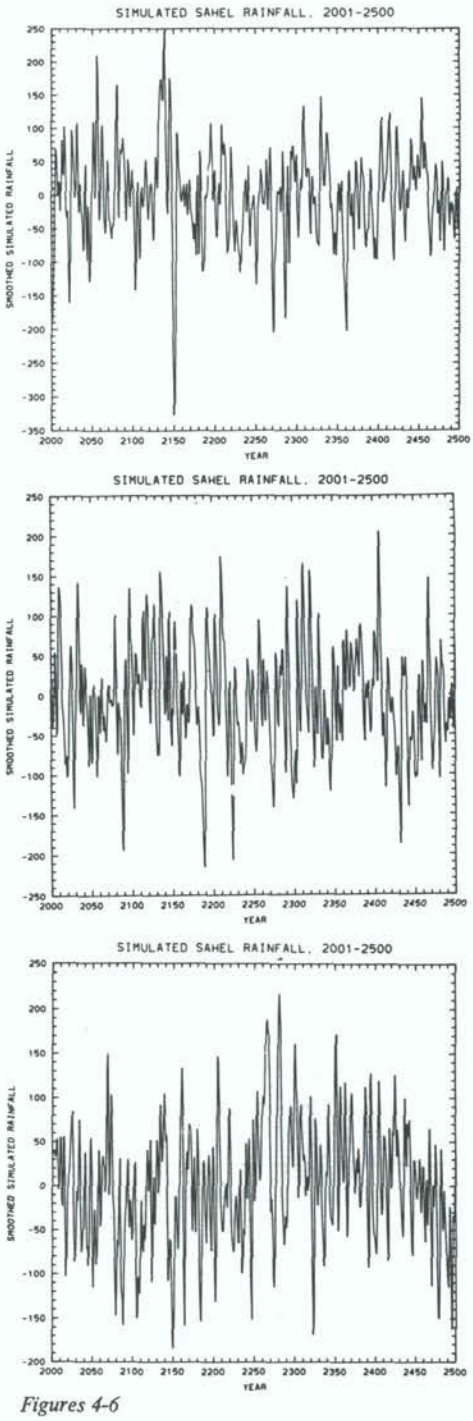
There have been several attempts to construct rainfall indices for regions within Africa. Indices attempt to characterize the rainfall over a region in terms of a single number. Although such a characterization ignores important spatial variations, indices may reveal general patterns in rainfall time series that are hidden by the noise when individual locations are considered separately. Lamb constructed a time series of standardized annual Sub-Saharan rainfall, based on an index previously employed by Kraus (1977) and Nicholson (1979). Other indices of African rainfall have been proposed, for example, by Snijders (1983). By averaging deviations from the mean April-October rainfall for the same 20 West African stations (located between 11°N and 18°N and west of 9°E) used by Lamb, we constructed an index somewhat simpler than Lamb's.

Our index represents the average deviation from the mean rainfall over the region. An index value of zero corresponds to average rainfall over the region, whereas an index value greater (less) than zero corresponds to above (below) average rainfall.

Three 500-year simulated rainfall index time series were generated by this method. These time series can be viewed as possible scenarios for the time period 2001 to 2500. Figures 1 to 3 show the first 100 years (2001 to 2100) of these three time series. Figures 4 to 6 show the smoothed rainfall index time series for the entire 500-year period.[3]



Figures 1-3



Figures 4-6

The results of this simulation experiment are quite sobering. Many "apparent" trends and cycles of relatively long duration are evident (of course, none of these are real in a probabilistic sense). Tables 2 to 4 show the runs for the first 50 years, the first 100 years, and the entire 500-year time period, respectively, for each of the three scenarios. In particular, the longest runs of consecutive years with below mean rainfall (i.e., index value below zero) in the three simulated records range from four to eight years for the first 50 years, five to eight years for the first 100 years, and 11 to 14 years for all 500 years. Despite the common perception that a year of below average rainfall is likely to be followed by a year of above average rainfall, it is evident from Tables 1 to 3 that dry spells a single year in length occur only about 40 per cent of the time. In other words, given that a single year of below average rainfall has occurred, the chance that the dry spell will continue is about 60 per cent (as compared to the long-run probably of a dry year which is 50% for this spatial rainfall index). This increase, from 50% to 60%, in the likelihood of below average rainfall is due to the fact, mentioned earlier, that dry weather has a slight tendency to persist from year to year.

These three scenarios are presented primarily for illustrative purposes.

[3] To fit 500 numbers on a single graph, a smoothing technique called hanning (equivalent to applying a two-year running mean twice) was used.

Table 2. Frequency of runs of dry years for period 2001-2050

Run length (yrs.)	Scenario 1	2	3
1	4	5	5
2	6	2	1
3	2	1	1
4	1	0	1
5	0	1	2
6	0	0	0
7	0	0	0
8	0	1	0
8	0	0	0

Table 3. Frequency of runs dry years for period 2001-2100

Run length (yrs.)	Scenario 1	2	3
1	7	11	10
2	10	4	2
3	3	4	3
4	1	1	2
5	1	1	2
6	0	0	1
7	0	1	1
8	0	1	0
8	0	0	0

Table 4. Frequency of runs of dry years for period 2001-2500

Run length (yrs.)	Scenario 1	2	3
1	39	34	39
2	23	22	21
3	18	18	20
4	8	7	5
5	7	5	7
6	2	0	3
7	2	1	3
8	0	3	0
9	0	1	0
10	0	1	0
11	0	1	1
12	1	0	0
13	0	1	0
14	0	1	0
14	0	0	0

One could, of course, generate many more scenarios to conduct a more thorough study. By doing so, probabilities of runs of specified length could be estimated. On the basis of similar simulation studies and other methods of analyzing historical African rainfall data, much is known about the probabilities of relevant climatic events. For instance, Stern and Coe (1984) have reviewed research on obtaining the probabilities of the start of the rains, of runs of wet and of dry weather, of levels of soil moisture, and of many other events related to rainfall-dependent agricultural activities.

An assessment of these simulations suggests that they may be of some value to policy-makers. A definable frequency of runs of two or more years that is greater than the frequency of one-year events suggests that the fact that a year of drought has occurred can be used to adjust the likelihood that a second year of drought could follow. While it is not possible for forecasters to tell us when a drought is about to occur, what its severity might be, or even whether a country is in the midst of, or near the end of, drought, the fact that one year of drought did occur may be of some use to planners in anticipating a second year of drought. With this information, planners, for example, could pursue more definitive measures to protect their citizens, livestock, environment, and economy. If these measures of conservation (with respect to water resources, seed stock, livestock culling, and so forth) prove not to have been needed, little would have been lost. The adage that comes to mind is that "an ounce of prevention is worth a po.nd of cure."

Concluding comments

One could assert, on the one hand, that we already know a lot about the physical aspects of drought and about how different societies (or even the same society under different conditions) respond to them. We also know that to date the ability to forecast such climate anomalies has been extremely limited. Furthermore, we know that attempts to augment precipitation through weather modification practices in different areas remains unproven and highly controversial. We are also aware that governments exhibit a strong interest and much concern about droughts but that once a drought episode passes, other pending crises move to the forefront demanding the scarce time and attention of national decision-makers.

On the other hand, one could argue that we cannot forecast the onset of a drought, its magnitude, or its duration. It is even difficult to identify, other than retrospectively, when a region is in the midst of a drought situation. Many crop seasons, for example, have been "saved" by a timely rainfall. We can also show that in selected cases the problem with the inadequate response to the impact of a particular drought episode was not a lack of information about the physical or societal aspects of drought but was the lack of resolve on the part of the government to deal with them. One example of such a situation occured in the early 1970s in Ethiopia during the rule of Haile Selassie (e.g., Shepard, 1975).

The need now is to encourage governments to use existing information to develop strategies to minimize the impacts of drought on their populations, their environments, and their economies. Such strategies can analytically be divided into three groups: prevention, mitigation and adaptation.[2] Each report on drought in Africa has commented implicity, if not explicitly, on one or more of these strategies in the context of a particular drought in a specific region. What we mean by them can be summarized briefly in the following paragraph.

Paraphrasing an earlier paper on an analysis of strategic responses to long-term environmental problems (Glantz and Ausubel, 1983), *prevention* refers to strategies that attack the problem at its origin, which in the case of drought could mean developing reservoirs and irrigation systems that can be brought into play in the event of drought-induced water shortages. Prevention might also include matching the human activities (in drought prone-areas) to the climate of the areas. Thus, planners would avoid creating a regional economic dependence on high-water-use crops that cannot be supported in water-short years. *Mitigation* strategies suggests an anticipation of drought and its impacts. Thus, if drought is projected, a

tactic might be to grow only in the more favourable rainfall areas, or to replace high-water-use crops with those with lower water demands and so forth. *Adaptation* suggests that societies do little or nothing to prepare for drought but, when it occurs, accept its impacts and respond as best as they can under such adverse conditions. This point of view is based on the belief that there is little that can be done to prevent the drought or mitigate its impacts (which vary greatly from one episode to the next).

The three terms are not mutually exclusive but reflect the predominant character of broad stretches on a continuum which ranges from responding primarily to causes of environmental change

How feasible is it to expect the African countries (or donor countries) to drought-proof scores of human climate-dependent activities from the effects of drought and ensuing water shortages? Such "drought-proofing" projects have been developed for arid and semi-arid areas in developed countries but not without scepticism about whether such a goal could be achieved (e.g., Canadian Prairies Projects). Drought-proofing efforts, whether totally successful or not, do have side benefits such as raising awareness about the recurrence of drought. However, adverse effects may arise as inhabitants of a "drought-proofed" region begin to believe their area has, in fact, been immunized against the vagaries of climate. Assuming African decision-makers become convinced of the need for instituting drought-proofing strategies, can such strategies in fact protect their people from the impacts of drought? From where will the funds to support such efforts come? Will those efforts work? What will these societies have to give up in order to operationalize such drought-coping strategies?

Mitigating the effects of drought may perhaps be the most favoured, if not the most realistic strategy. Yet, it, too, bears a high cost. Which activities in society should be protected; cash crop or subsistence crop production? Which economic sectors or geographic sections of the country will be adversely affected? As suggested earlier, in the midst of drought those affected are willing to pursue most of the suggested mitigation strategies, without regard to cost. Once the drought's impact wanes, however, interest in continued pursuance of those mitigation strategies quickly evaporates.

Societies know that droughts recur but they do not know when. For example, the Vice President of Botswana noted (Botswana Society, 1978, p.1), that

> Drought is a recurrent hazard which has sorely afflicted us in the past, and which, as a future threat, we ignore at our peril... It is easy to forget such harsh times when we have enjoyed such bountiful rains for the past few years.... Common sense tells us that such good times cannot last indefinitely and that another drought must come, sooner or later.

While these events are too infrequent and their onsets too uncertain to plan on, their societal impacts are often too great to ignore. Thus, drought phenomena are difficult to deal with in terms of the development of economic planning strategies. It becomes a major challenge for agrometeorologists, climatologists, or climate impact researchers to convince government decision-makers, including development planners, to pay attention not only to a specific drought, but to drought as a recurring, aperiodic phenomenon, i.e., to the realities of their climate. With respect to drought, decision-makers should realize that there are two separate issues: how to combat drought, and how to combat droughts in general.

Drought, like desertification, can have long-term effects (even if they are relatively subtle) on society, the economy, and ecology. Thus, it is important for decison-makers to take the long-term implications of any particular drought situation more seriously. Finally, it is also imperative to convince leaders of new governments to maintain the drought strategies devised by their predecessors.

Footnotes

1 Related to the climate problems that decision-makers will eventually have to address is the carbon dioxide issue. Although a recent meeting on climate in the dry margins put this issue aside as one in which Third World policy-makers have little interest at *this time* (UNEP/WMO/UCSU, 1983), it is an issue that has been linked (rightly or wrongly) to the current spate of droughts on the African Continent. A recent report (WMO, 1983), however, concluded that "*It is highly improbable ... that the increase of carbon dioxide to date has contributed significantly to the recent dry conditions.*"

2 The three terms are not mutually exclusive but reflect the predominant character of broad stretches on a continuum which ranges from responding primarily to causes of environmental change to responding primarily to consequences or impacts of environmental change.

REFERENCES

Botswana Society, 1978. *Proceedings of the Symposium on Drought in Botswana.* University Press of New England, Hanover, New Hampshire.

CEAS, 1979. Weather-crop yield relationships in drought-prone countries of Sub-Saharan Africa. Final Report to US/AID, NOAA, Columbia, Missouri.

Club du Sahel/CILSS, 1980. Strategy of drought control and development in the Sahel. Sahel D(80) 102, OECD, Paris (draft).

Dahl, G., and A. Hjort, 1976. *Having Herds: Pastoral Herd Growth and Household Economy.* Department of Social Anthropology, University of Stockholm.

Dracup, J.A., K.S. Lee, and E.G. Paulson, 1980. On the definition of droughts. *Water Resources Research,* 16, 297-302.

Eicher, C.K., and D.C. Baker, 1982. Research on agricultural development in Sub-Saharan Africa: A critical survey. MSU International Development Paper No. 1, East Lansing, Michigan.

FAO, 1981. *Arid zone hydrology for agricultural development.* FAO Irrigation and Drainage Paper 37, Rome.

Flohn, H., and H. Fleer, 1975. Climatic teleconnections with the equatorial Pacific and the role of ocean/atmosphere coupling. *Atmosphere, 13,* 96-109.

Glantz, M.H., 1977a. Climate and weather modification in and around arid lands in Africa, in *Desertification: Environmental Depradation in and Around Arid Lands,* M.H. Glantz (ed.), Westview Press, Boulder, Colorado, pp. 81-102.

Glantz, M.H., 1977b. Water and inappropriate technology: Deep wells in the Sahel, in *Water Needs for the Future,* V.P. Nanda (ed.), Westview Press, Boulder, Colorado, pp. 305-308.

Glantz, M.H., and J.H. Ausubel, 1983. CO_2 and the Ogallala: Comparison and convergence. Unpublished manuscript, NCAR, Boulder, Colorado.

Glantz, M.H., and N. Orlovsky, 1983. Desertification: A review of the concept. *Desertification Control Bulletin* 9: 15-22.

Hastenrath, S., and M.-C. Wu, 1984. Towards the monitoring and prediction of Northeast Brazil droughts. *Quarterly Journal of the Royal Meteorological Society* (in press).

Katz, R.W., and M.H. Glantz, 1977. Rainfall statistics, droughts and desertification in the Sahel, in *Desertification: Environmental Degradation in and Around Arid Lands,* M.H. Glantz (ed.), Westview Press, Boulder, Colorado, pp. 81-102.

Kraus, E.B., 1977. Subtropical droughts and cross-equatorial energy transports. *Monthly Weather Review, 105,* 1009-1018.

Lamb, P.J., 1982. Persistence of Subsaharan drought. *Nature, 299,* 46-48.

Michigan State University, 1977-. *Sahel Bibliographic Bulletin.* Sahel Documentation Center, East Lansing, Michigan.

Monod, T. (ed.), 1975. *Pastoralism in Tropical Africa.* Oxford University Press, London.

Nicholson, S.E., 1978. Climate variations in the Sahel and other African regions during the past five centuries. *Journal of Arid Environments 1,* 3-24.

Nicholson, S.E., 1979. Revised rainfall series for the West African Subtropics. *Monthly Weather Review, 107,* 602-623.

OECD, 1977-. Elements for a bibliography of the Sahel drought. Development Centre, Paris.

Palutikof, J.P., G. Farmer, and T.M.L. Wigley, 1982. Strategies for the amelioration of agricultural drought in Africa. *Proceedings of the Technical Conference on Climate—Africa.* WMO, Geneva, pp. 228-248.

Palmer, W.C. 1964. *Meteorologial Drought.* U.S. Weather Bureau, Department of Commerce Research Paper 45. Washington, D.C.

Rijks, D., 1980. Agrometeorological network over Africa: Collection, documentation, and analysis of data. *Proceedings of the International Workshop on the Agroclimatological Research Needs of the Semi-Arid Tropics,* International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India, pp. 17-22.

Sanford, S., 1978. Towards a definition of drought. *Proceedings of the Symposium on Drought in Botswana.* Botswana Society, University Press of New England, Hanover, New Hampshire, pp.33-40.

Shepard, J., 1975. *The Politics of Starvation.* Carnegie Endowment for International Peace, New York.

Snijders, T.A.B., 1983. A study of the variability in space and time of Upper Volta rainfall. *Preprints, Second International Meeting on Statistical Climatology,* Lisbon, pp. 3.5.1—3.5.7.

SOAS, 1973. Drought in Africa. Report of the 1973 Symposium. Centre for Africa Studies, University of London.

Stern, R.D., and R. Coe, 1984. A model fitting analysis of daily rainfall data. *Journal of the Royal Statistical Society, Series A* (in press).

UNEP/WMO/ICSU, 1983. Draft of the Working Group on the Study of Climatic Fluctuations in the Dry Margins. Study Conference on the Sensitivity of Ecosystems and Society to Climate Change, 19-23 September, Villach, Austria.

UNESCO, 1971-. Man and Biosphere Reports. Paris.

University of Arizona, 1976-. Desertification: World bibliography update. Office of Arid Lands Studies, Tucson, Arizona.

WMO, 1975. *Drought.* Special Environmental Report No. 5 (WMO No. 403). Geneva.

WMO, 1976. *An evaluation of the climate and water resources for development of agriculture in the Sudano-Sahelian zone of West Africa.* Special Environmental Report No. 9, (WMO No. 459), Geneva.

WMO, 1983. Report of the ECA Scientific Roundtable on the Climate Situation and Drought in Africa. 6-7 October, Geneva.

World Bank, 1981. Accelerated development in Sub-Saharan Africa: An agenda for action. Report, International Bank for Reconstruction and Development, Washington, D.C.

Yevjevich, V., 1974. Determinism an stochasticity in hydrology. *Journal of hydrology, 22,* 225-238.

Rethinking forestry strategy in Africa: experience drawn from USAID activities

by

T.M. Catterson, F.A. Gulick and T. Resch[1]
United States Agency for International Development
Washington, D.C., U.S.A.

Paper prepared for FAO Expert Consultation on the Role of Forestry in Combating Desertification, Saltillo, Mexico — 24-28 June 1985

Introduction

The problems of drought and desertification have achieved world-wide notoriety since the late 1960's/early 1970's when ecological disaster and famine gripped the arid and semi-arid areas of Sahelian Africa. This catastrophe was addressed first with humanitarian assistance and later with development programmes aimed at alleviating the causes of the problem. Despite concerted efforts over the last decade to turn the tide, another period of extreme drought is spreading havoc across the African landscape. *The world is once again confronted with the tragic reality of the frailty and fragility of human existence in the arid and semi-arid regions of Africa.*

It is therefore not surprising that the concern felt by African governments and their development assistance partners is prompting intense introspection. Past efforts are being reviewed and a better understanding of the problems and their solutions are actively being discussed.

Forestry sector activities, often viewed as the spearhead in the fight against desertification, have expanded enormously in dought-prone Africa. In 1983, Weber[2]estimated that approximately 200 million U.S. dollars had been earmarked for forestry efforts in the eight countries of the CILSS alone[3]. He was far less sanguine about the qualitative results of these endeavours.

Despite the evident setbacks, not the least of which is the continued staggering loss of vital vegetative cover, important lessons have been learned about the role forestry can and should play in the development scenario of this region. These results must be shepherded, nurtured and carefully used in the design of future programmes. The purpose of this paper, therefore, is to describe the evolving role of forestry activities in light of this experience and its implications for the fight against drought and desertification.

Drought and Desertification

Before proceeding further it is useful to review the difference between drought and desertification. The phenomena are, in the authors' opinion, frequently confused with evident impact on the effectiveness of the measures employed to counter them.

Drought is, in the main, a climatic event. While it is beyond the scope of this paper to examine in detail this complex subject, a few important notions are worth mentioning. The weather systems which underlie the extreme variability of the rainfall of arid and semi-arid Africa are thought to be the result of displacement of wind and precipitation patterns induced by other climatic circumstances which take place well beyond the affected areas [4]. As yet there is little empirical data to link the occurrence of drought to human activities. Some authors have suggested, however, that to a certain extent drought through its effect on the vegetation and surface conditions in the affected areas feeds upon itself. Nicholson points out that this relationship has important meaning for land use in these areas as human activitiy itself in clearing the land may have the same effect.[5] African and donor policy-makers must recognize the enormous potential for damage inherent in the systematic and well-intentioned conversion of natural vegetation to areas of marginally sustainable agriculture. It thus seems eminently sensible to adopt a "probable-case scenario" in designing interventions involving land-use practices in the region[6]. Average rainfall is a deceptive indicator in assessing production potential for these areas, given the now well documented extreme variability of precipitation. Once cleared, it is an extremely costly and long-term endeavour to rehabilitate these lands. This should not be interpreted as a pessimistic call to simply control the expansion of the agricultural frontier. What is required are new methods of using these lands which sustain environmental stability. Much of what follows constitutes information on these new methods.

When taking drought into consideration, special care must be taken in choosing alternative actions in the stricken areas. Confronted with the impact of drought, governments and donors alike have sometimes chosen large-scale, administratively unwieldy projectized responses. These projects composed essentially of government "inputs" attempt to implant shallowly conceived technocratic solutions to

poorly understood problems. Besides the fact that they do not work, they also often degenerate into ineffective social welfare programmes which further undermine the community fabric on which solutions can and must be built. There is also a need for a sense of perspective which recognizes the long-term nature of the problem. Equally importantly, this perspective should focus on the "doable" and achievable rather than the most challenging issues. It may mean, given the present drought, emphasis on maintaining viable farming systems and lifeways of the people on the vulnerable sedentary edge of the limits to cultivation whose land must often absorb the brunt of nomadic and refugee influxes.

Drought is unpredictable and recurring, as is the famine that frequently accompanies it. As such, it is a particular challenge to the preparedness of governments and donors alike to deliver humanitarian assistance in a timely and adequate fashion. Fortunately climatic impact assessment technology growing out of the increasingly sophisticated and extensive applications of satellite-based remote sensing holds promise for the future. Through the use of these tools and techniques, early warning of potential drought-induced food shortages, with lead times of 60-90 days, are now possible. This will enable more careful review of actual field conditions and preemptive mobilization for drought relief efforts. Obviously, as this technology develops, it is likely to greatly expand the available information so necessary for pertinent land use planning in the arid and semi-arid areas of Africa.

Desertification is an even more serious problem than drought in that it represents a long-term, pervasive loss of productivity in a world whose escalating populations can scarce afford to lose it. Drought often exacerbates the impact of desertification, but it is principally a result of man's inadequate stewardship of the land, driven by exponential demographic pressures. *Desertification is the major environmental problem afflicting Africa today.* It is also an important constraint, if not the major one, impeding food self-sufficiency over vast areas of the continent.

Desertification refers to the loss of the land's productive capacity—a change to desert-like conditions.[7] More specifically this may involve the following negative results:

- Soil degradation due to decreased organic matter content which diminishes the cation exchange capacity, lessening water retention and accelerating soil nutrient leaching and loss;
- Persistent decline of crop yields and recurring crop failures;
- Crop damage from blowing sands scouring young plants or uncovering their root systems;
- Breakdown of traditional socially and economically accepted farming systems;
- Loss of vital topsoil from wind erosion;
- Increased rainfall runoff and associated soil erosion, gully formation and downstream flooding;
- Decrease of available sustainable surface water and lowering of the water table from reduced infiltration and watershed degradation;
- Lack of sufficient forage and browse resources or conversion to less palatable plant species;
- Soil destabilisation and moving sand dunes;
- Impaired natural regeneration/rehabilitation capacity;
- Localized deficits of the products of the forests, woodlands and trees including fuelwood and charcoal, food, building materials, game meat and raw material for income generation, artisanal and domestic needs;
- Loss of biological diversity.

In the final analysis, the most important result of desertification is the misery and poverty of the people in the affected areas. These people often exist even in the better years with a tenuous hold on economic stability. Drought and its consequences can be remedied with short-term palliatives such as food aid and medical relief. Desertification may mean reconstructing a way of life.

In order to place forestry activities in proper perspective in combating desertification, it is necessary to review its causes. It is no doubt well understood that the principal cause of desertification is population pressure which induces increasingly intensified use of fragile resources leading to their degradation and destruction. Under such circumstances desertification can occur in better rainfall years as well as drought years.

Loss of vegetative cover—the trees, shrubs and herbaceous plant life removed from the land in converting it to other uses exposes the surface to the unrelenting extremes of climate and breaks down the thin mantle of productive topsoil. Expansion and intensification of agriculture are the primary reasons for conversion. Much of the modest gains in agricultural productivity achieved in the Sahelian countries of West Africa has come from expansion of the agricultural frontier, often onto soils too marginal to sustain production for more than a few years without fairly intense soil conservation measures and fertilization[8]. This expansion is particularly problematic when it takes place on sloping lands whose rapid degradation then cancels the important watershed effect they exercised in recharging groundwater. Even on better soils, intensification of use includes increased crop monocultures, choice of soil exhausting crops, inappropriate mechanization, disregard for soil conservation needs and shortened fallow periods. Uncontrolled burning, common in the semi-arid areas, also adds immeasureably to the problem. Over-grazing has long been associated with desertification resulting in elimination of palatable annual forage species, destruction of cover and soil compaction. Fuelwood and charcoal harvesting to supply domestic energy needs (often for more than 85 per cent of the population) has also contributed substantially to long-term resource degradation.

These causes, seemingly irrational behaviour for the subsistance farmer, must also be viewed in the context of the social, economic and institutional factors which mitigate against sustainable use and resource conservation. These include: land and tree tenure issues; lack of access to agricultural production inputs and credit; limited rural development initiatives; conflict within the communities and with local authorities (eg. with the forest service); changing political systems; restricted market outlets; lack of off-farm income opportunities; risk

Messrs. Daby Diallo and Roger Jones of USAID/Senegal inspecting young seedlings of Prosopis juliflora planted on the Bandia Forest Project site in Senegal. The seedlings grew vigorously despite the 1984/85 drought. (Photo by T.M. Catterson)

perception by rural people (e.g., keeping large herds); and, lack of social guarantees, to mention but a few.

Past Forestry Activities

Laudable efforts to contain the pace of deforestation and desertification have been launched throughout Africa since the great Sahelian drought. These endeavours represented increasing understanding of the importance of trees for environmental stability in arid and semi-arid Africa. Unfortunately, cause and effect vis-a-vis desertification has been too closely ascribed in the past to the "fuelwood problem". With escalating fuelwood demand, driven by population increases and readily quantified in astronomical terms, it is not surprising that the first programmes set ambitious production targets for reforestation.

Likewise, reforestation was seen as the task of the foresters and they were encouraged to take up the challenge with large influxes of donor support. Their early plans focussed on block plantations, their traditional forte, and occasionally on village woodlots aimed at involving the rural people. In the absence of sector models capable of analyzing priorities in the context of overall development issues, these first initiatives were readily accepted and their highly visible impact (plantations) judged appropriate. It was not until the late 1970's/early 1980's, as projects came under scrutiny as part of routine evaluation, that the lessons started to emerge. Reviewing ongoing projects in light of their efficiency and effectiveness led both Africans and donors to begin to question the strategy options which had been chosen.[9] Capital intensive block plantations for fuelwood production in arid and semi-arid areas have been crippled by the stifling combination of high costs, slow growth and low market prices. For the time-being, such plantations are regarded as not being feasible in areas with less than 800 millimetres annual rainfall. Village woodlots relying on shared work for shared benefits on common land have proved an elusive goal for many reasons. In areas where trees are needed, by definition there is usually not enough real common land to achieve adequate impact.

The reality, as seen above in the discussion on causes, is that the fuelwood model accounts imperfectly for the disappearance of trees in the desertification equation. In areas undergoing desertification, many components of the rural production system are in stress. Even the limited experience to-date has shown that rural people have seldom been enthusiastic about planting trees specifically and uniquely to produce fuelwood. This narrowly defined objective has tended to be rather self-limiting and has understated the real value of trees to rural people.[10] An exclusively "fuelwood approach" actually exacerbates the dichotomy between agriculture and forestry by reinforcing the ill-conceived notion that somehow the foresters alone are going to resolve the fuelwood/environment problem.[11]

Trees and Agriculture in Subsaharan Africa

Renewed interest in forestry activities on a large scale by international donors grew out of the concerns for fuelwood supply ("poor man's energy crisis") and the environment. The early emphasis was useful essentially because it prompted action, although in part this rather narrow view of the problem contributed to the approach featuring block plantations. The needs for and the role of forestry in Subsaharan Africa, however, now appear quite different.

The major development issue in Subsaharan Africa today is the declining capability to produce the food necessary to feed the burgeoning population. An important dimension of this situation is the continued soil degradation resulting from intensified cultivation, continued clearing of marginal lands and the overall diminuation of environmental stability leading to desertification. Forestry sector development specialists and others are coming to understand that rarely can projects and activities whose sole purpose is fuelwood production be sustained—particularly in the arid and semi-arid areas of the region. Rather these activities must be dual in nature, both production and protection oriented, exploiting on a large-scale the ameliorating soil and water conservation effects of vegetative cover in sustaining and promoting environmental stability.

Simply translated, that means working with farmers to promote tree planting at least cost and with greatest scale and spread namely on the farms and farming lands of Africa. In the harsh climatic extremes of arid Africa, agricultural development efforts must do more than simply strive to increase area yields of basic food crops through the introduction of modern technology. Attention must also be devoted to building on peasant subsistance farming systems in order to increase their resilience during poor rainfall years. Similarly it seems evident that good fertile soils will be necessary to exploit the full potential of the increased supply of genetically enhanced varieties of food crops. It will likely require more than improved seeds to start the green revolution where it is most needed in Africa.

African agriculture is hostage to four major constraints which trees can help to ameliorate. These circumstances are part of the desertification problem but also come into play on lands that for the moment are more or less intact. Rainfall is highly variable and growing seasons can be as short as two months. Frequently large portions, as much as 40 to 60 per cent of what rainfall does occur, are lost to runoff because of inadequate infiltration.[12] Topsoils are unstable and subject to erosion from rain and wind. Several studies report losses from runoff of 20 to 170 tons of soil per hectare per year.[13] In the summer of 1969 alone, 60 million tons of fine soil was blown from the Sahara and the Sahel to the Atlantic, carried by seasonal easterly winds.[14] Nutrients are scarce, especially nitrogen, phosphorus and potassium, the major ones. When nutrients are lost to harvesting, leaching and runoff, soil fertility rapidly declines as do food crop yields. If not replenished, all available nitrogen in a field can be depleted by annual harvests in four years. Natural restoration of fertility through fallow may take up to twenty years.[15] Annual crops can take up half the readily available nitrogen in a single harvest.[16] Organic matter is easily lost under high soil temperatures thereby undermining the cation exchange capacity and accelerating nutrient leaching. Finally, growing populations compete for static amounts of food, fodder, fibre and fuel. The area of land available to produce these commodities remains essentially the same, although populations in Africa at current rates may double every twenty years.

In contrast to these substantial constraints, and somewhat overshadowed by the fuelwood/forestry approach, are the positive effects of trees and shrubs in supporting agriculture. Where trees and shrubs are present, either bordering, sheltering or scattered within fields and grazing lands, these effects can have substantial impact. These are documented below:

- Rainfall runoff can be considerably reduced, conserving water and soils.

  Trees and their roots can have a bunding effect and enhance soil porocity which increases infiltration of rain.

- Windspeed and temperatures can be diminished at ground level.

  This improves the microclimate within fields. Wind erosion is slowed. Neem tree windbreaks in Niger slowed wind velocities within the cropped area between the trees by 45 to 80 per cent.[17]

- Soil nutrients are converted and recycled, particularly by leguminous trees.

  Nitrogen is captured from the air, fixed in the soil, retrieved through roots, redeposited as leaf litter and twigs.

  Enrichment of surface soil layers attributed to the presence of *Acacia albida* trees has been documented in several studies.[18] Increases in total organic carbon (C) and total nitrogen (N) in the soil under the trees, as compared with field soil beyond the tree canopy, were:

Niger	(1960)	N: 231%	C: 269%
Senegal	(1969)	N: 33%	C: 40%
	(1965)	N: 194%	C: 192%
	(1966)	N: 110%	C: 91%
Sudan	(1969)	N: 600%	C: 200%

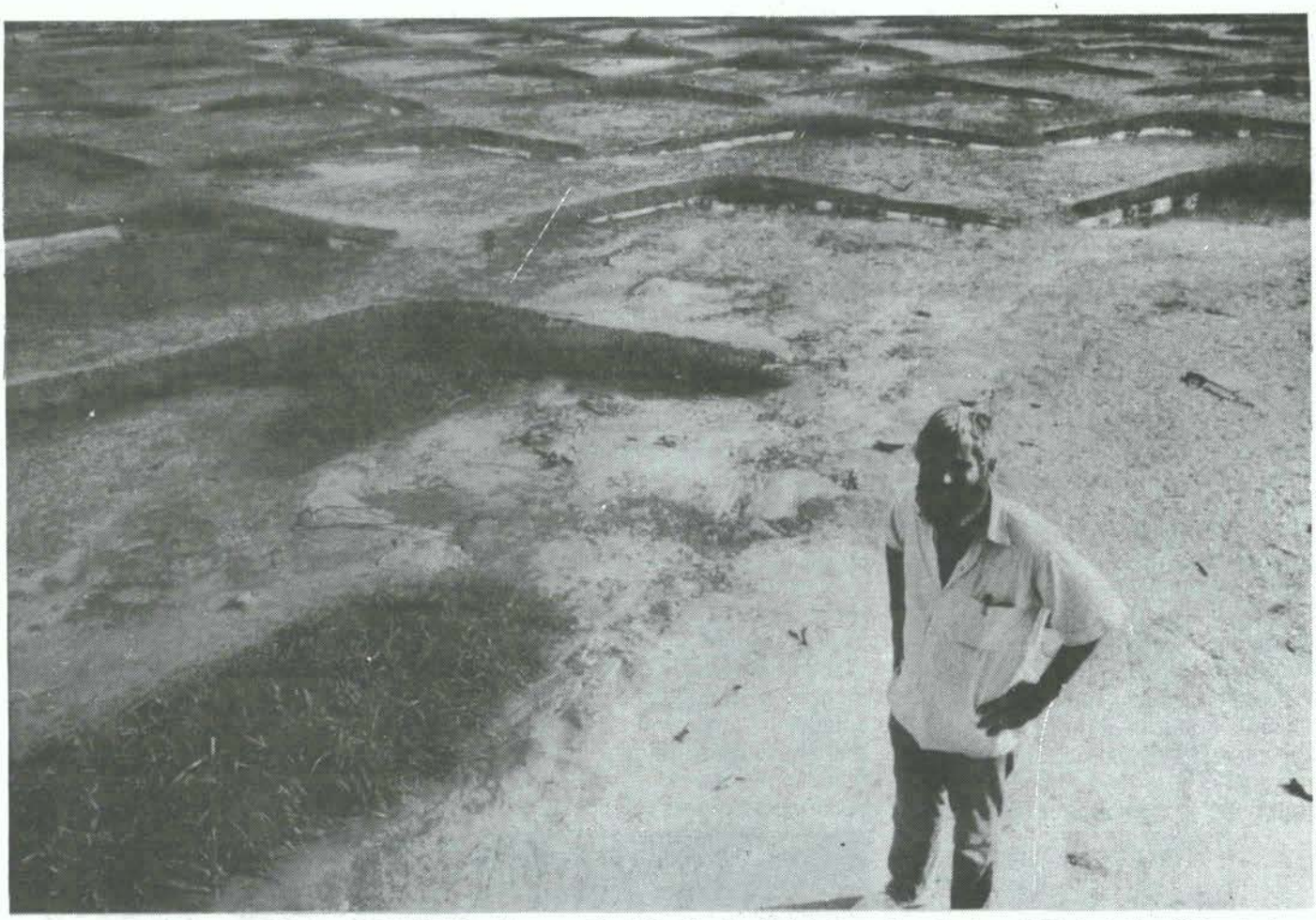
  Several of these studies also documented increased soil water holding capacity and cation exchange capacity. Increases in mineral constituents (Ca, Mg, K and P) ranged from 20 to 100.[19]

  In Nigeria, *Leucaena* hedgerows, cropped with maize, were still producing, after six years, about 160 kg N/hectare/year from five tons/ha/year of leaf prunings applied as green mulch.[20]

- Crop yields can be stabilized, and in some cases increased. A few research studies have reported the following:

  Niger (1979): Yields of millet between seven-year old neem tree windbreaks were 1099 kilos per hectare, compared with 854 kilos per hectare in the control plot, a net increase of 23 per cent after subtracting the area under the trees where no millet grows.[21]

  Nigeria (1984): Maize yields stabilized at about two tons per hectare per year after continuous cultivation for six years, using green mulching with leucaena leaves at rate of five tons per hectare per year. Yields in the control plot declined to 500 kilos per hectare during this period.[22]



Mr. John Heermans, Forestry Advisor on the USAID/Niger Forest and Land-Use Planning Project. As an alternative to costly block planting efforts, simply constructed, low cost micro-catchments have helped to revegetate a previously barren area. (Photo by USAID)

Senegal (1965): Yields of millet under *Acacia albida* canopy were reported as equivalent to 1,688 kilos per hectare, compared with 660 kilos per hectare on land outside the canopy, an increase of 152 per cent.[23]

Senegal (1968) Yields of sorghum under *Acacia albida* canopy were reported as equivalent to 934 kilos per hectare, compared with 457 kilos per hectare on plots outside the canopy, an increase of 104 per cent.[24]

Burkina Faso (1963): Yields of millet under *Acacia albida* canopy were reported as equivalent to 125 kilos per hectare, compared with 820 kilos per hectare in control plots outside the canopy, an increase of 50 per cent.[25]

— Food and fodder reserves are available between harvests and during drought. Trees usually survive periods of no rainfall, drawing on ground water stored beneath the soil. Taproots of many trees are 20 meters long or more.

In the Sahel, tree leaves, seeds and pods account for about five per cent of livestock fodder needs during the rainy season and up to 45 per cent toward the end of the dry season, averaging about a third of year round forage supply.

In Malawi, leucaena is produced on small holdings, undersown with maize, the foliage used as fresh forage, or sun-air dried for winter supplement, or sold as a cash crop. In some areas leucaena provides about one-fifth of fodder needs.

In addition to fruit, the seeds, pods and leaves of many trees are regularly used as food supplements. In times of drought, they provide marginal supplies.

— Farm trees can be a significant source of fuelwood.

As few as 50 trees, on a two-hectare farm, occupying less than five per cent of the arable land can supply half or more of a farm family's fuelwood needs, by regular pruning and selective cutting.[28]

Implementing Greater Integration of Agriculture and Forestry

The use of trees and forests, at the macro-level for overall environmental stability and at the field level for their effect on field moisture, soil nutrient status and crop yield, is probably the most tried and accessible technology available in Africa today to combat desertification.

Planting trees in farmers' fields in agroforestry configurations or as small

woodlots or fence-rows around the homestead or wherever they may fit, as well as maintaining and managing forests and woodlands for sustained multiple-use, can be the key to environmental stability in Africa. This, however, means more than having foresters espouse and promote agroforestry. It means in effect, a policy and programmes that recognize the importance of tree and forest cover for agricultural productivity and which translate into a meaningful administrative, legislative and institutional framework capable of promoting and delivering this approach to the farmers. It will necessarily be a long-term proposition; neither the foresters nor the agronomists are as yet ready for this marriage and many vested interests and institutional problems will have to be overcome along the way. The time to start, however, is now; the outcome should be a multidisciplinary extension approach which seeks to service the opportunities and needs of the peasants rather than three separate extension services (agriculture, livestock and forestry) which compete for the attention and resources of the farmers.

Farm forestry will also mean change that must start with the foresters themselves, their attitudes and the way they do things. The traditional emphasis on safeguarding the reserve forests has led to policies and actions geared to conservation and control. In order appropriately and effectively to service and nation's largest client group—its peasants—these policies and actions must evolve to a development and service orientation. It will be, in some cases, difficult to overcome the antagonism between peasants and foresters; the former are unlikely to believe that the latter have suddenly and miraculously become their benefactors. More work on basic studies and research to assemble and amplify the effect of what is already known about the benefits of tree planting on crop production from a farming systems viewpoint will be necessary. More important, however, will be continuing the policy review already underway in some African governments about the integration of agriculture and forestry, and extending it and accelerating it where possible. A dynamic, practical process of policy dialogue among government ministries concerned, and between African governments and their donor partners, is necessary to address the issues of policy reform and institutional changes required to proceed with a practical integration exercise.

An important policy benchmark along the way to greater integration of agriculture and forestry will be a resolution of problematic land and tree tenure issues. Too often farmers are dissuaded from planting trees on their land because of doubts, real or imagined, about their future rights to those trees.

Putting such farm forestry systems in place will require, eventually, a massive and effective agricultural/forestry extension services programme, able to demonstrate to the farmer that the production tradeoffs associated with tree planting, protection and maintainance will yield tangible positive benefits to his family. The key to the success of the farm forestry fuelwood development strategy will be the nature of this extension programme. In the past there have been a series of misconceptions about extension which have undermined their effect. Extension needs to be understood for what it is—the outreach function of a programme or project which permits dialogue between the client and the service. The outreach approach which is necessary is based on the notion that the most important element of a people-oriented development strategy is the people themselves, their needs, aspirations and opportunities. The forestry extension message strategy must shift the control on policing to a service and development orientation. Such changes must be initiated by the government services themselves but must be guided by patiently acquired information about the people, their attitudes towards trees and forests, their present uses (demand) and future needs, and their farm production practices as well as social management arrangements. Such information will guide the necessary reorientation of policy, codes, rules, forestry programmes, projects, and management practices. It will also assist the extension staff in helping the people themselves devise local participatory management schemes necessary to control the management, production

The improved charcoal stove of Kenya "the jiko" on sale by local artisans in the Nairobi market place. The private sector is now producing and marketing these stoves developed with USAID assistance at the rate of 6,500 per month. (photo by T. M. Catterson)

and protection of agreed natural resources development schemes.

Farm forestry in Africa combined with the economic opportunity of a cash market place for fuelwood holds bright promise for meaningful impact on both productive and protective initiatives required to contain desertification.

A Final Word

It should be emphasized that these actions are recommended as part of, rather than substitutions for, the wide range of essential soil and water conservation and crop improvement measures urgently needed to help increase food production in Africa. Expanded national efforts in soil conservation engineering (terracing, bunding and contour ploughing, etc.), water runoff control (micro- catchments and water harvesting), no-tillage techniques and research to shorten crop cycles will all be needed if we are to build in greater resilience against drought in African farming systems. These measures cannot overcome the consequence of excessive drought or high population pressure. However, if systemically pursued they can increase the area of sustainable agriculture and buy time for the full spectrum of longer-term economic development efforts needed for individual and national growth.

FOOTNOTES

1. T.M. Catterson is Senior Forestry Advisor, and F.A. Gulick is Forestry Planning Consultant, Africa Bureau, Agency for International Development, Washington, D.C.; T. Resch is Africa Coordinator, Forestry Support Programme, USDA—Forest Service, Washington, D.C.
2. Weber, F. *Review of the CILSS Forestry Sector Programme Analysis Papers,* CILSS Forestry/Ecology Technical Meeting, Banjul, The Gambia, Oct. 1982, pp. 94
3. CILSS: Permanent Interstate Committee for Drought Control in the Sahel: includes Chad, Cape Verde, Gambia, Burkina Faso, Senegal, Mali, Mauritania and Niger.
4. For an excellent discussion of the climatology and arid and semi-arid Africa, see: "The Climatology of Sub-Saharan Africa", by Sharon Nicholson—Appendix B in *Environmental Changes in the West Africa Sahel,* National Academy Press, Washington, D.C., 1983, pp. 71-92.
5. Ibid.
6. A detailed discussion of the subject may be found in: *Desertification in the Sahelian and Sudanian Zones of West Africa,* West Africa Projects Dept., World Bank, Washington, D.C., Report No. 5210, 2nd draft, Feb., 1985, pp.—60.
7. *United Nations Conference on Desertification, Round-up, Plan of Action and Resolutions,* United Nations, New York, 1978.
8. *Food Problems and Prospects in Sub-Saharan Africa— The Decade of the 1980's* by C. Christensen et al., Foreign Agricultural Research Report No. 166, USDA—Economic Research Service, Washington, D.C. 1981, pp.—293.
9. A detailed analysis of past strategy is beyond the purpose of this paper. A similar exercice was undertaken in the paper: *AID Experience in the Forestry Sector in the Sahel— Opportunities for the Future,* by T.M. Catterson prepared for the meeting sponsored by the CILSS/Club du Sahel—"Concerted Action in Developing the Ecology/Forestry Sector in the Sahel Countries", Paris, June 1984. pp.—29.
10. *Tree Growing by Rural People* (Review Draft) FAO Forestry Dept., Rome, Feb. 1985, pp.—133
11. Op Cit. Catterson.
12. Charreau, Claude, *Soils of Tropical Dry and Dry-wet Climatic Areas of West Africa and their Use and Management,* lectures at Dept. of Agronomy, Cornell University, 1974, Agronomy mimeo No. 74-26, pp. 200-203. See Table on p.202., and *Productivity of Sahelian Rangelands, Course Book, Volume I,* Wageningen Agricultural University, The Netherlands, 1982, pp. 145.
13. Ibid.
14. Jensen, A.M., *Shelter-belt Effects in Tropical and Temperate Zones,* July 1983, IDRC-MR80e, Canada, 61 pp., 34.
15. Op. Cit., *Productivity of Sahelian Rangelands.*
16. Op. Cit. *Productivity of Sahelian Rangelands,* p. 115.
17. Els Bognetteau-Verlinden, *Study of Impact of Windbreaks in Majjia Valley, Niger,* February 1980, Agricultural University, Wageningen, The Netherlands, 77 pp. plus annexes. Hereafter cited as Majjia Valley.
18. Felker, Peter, *State of the Art: Acacia Albida,* U. of California, Riverside, Calif., April 1978, (AID Grant Afr-C-1361) pp. 87, summarizing original research prepared by Dugain (Niger, 1960); Charreau and Vidal (Senegal 1965); Dancette and Poulain (Senegal 1969); Jung (Senegal 1966); Radwinski and Wickens (Sudan 1969).
19. Op. Cit., Charreau, Op. Cit., p. 214
20. Kang, B.T. and B. Duguma, Nitrogen Management in Alley Cropping Systems, paper presented at the International Symposium on Nitrogen Management in Farming Systems in the Tropics, IITA, Nigeria. 23-26 October 1984, p.7
21. Op. Cit. Els Bognetteau-Verlinder, pp. 66-69 and Appendix VI.
22. Op. Cit., Kang, B.T., p. 12
23. C. Charreau and P. Vidal, *Influence de l'Acacia albida del. sur le sol, nutrition minerale et rendements des mils pennisetum au Senegal,* in L'Agronomie Tropicale, 1965, pp. 601-626. Yieldings reported p. 616.
24. Dancette, C. and J.F. Poulain, *Influence of Acacia albida on pedoclimatic factors and crop yields, in African Soils,* (XIV, N. 1-2) 1969, pp. 143-183.
25. Direction des Eaux et Forêts, Republic of Upper Volta, Secteur de Restauration de Sols de Ouahigouya, 1965,pp. 36.
26. *Agroforestry in the West African Sahel,* Advisory Committee on the Sahel, BOSTID, National Research Council, 1983, citing H.N. LeHouerou, "The Range Lands of the Sahel, "*Jnl of Range Management,* (33 (1): pp. 41-46, 1980.
27. Savory R, J.A. Breen and C.I.A. Beale, "Leucaena as a Forage Crop on Small Farms in Malawi", in *Browse in Africa,* H.N. LeHouerou, ed., International Livestock Center, Addis Ababa, Ethiopia, 1980., pp. 411—415.
28. Spears, J.S., *Review of World Bank Financed Forestry Activity,* FY 1983, IBDR, mimeo, pp 37.

Grassland revegetation by land imprinting a new option in desertification control

by Ray Anderson
Tuscon, Arizona

The Need For Revegetation

The readers of this unique bulletin are fully and painfully aware of the widespread fact of desertification (or devegetation), how it has happened, and its spread from the dry grasslands where it began to such unlikely places as mountain slopes in the humid tropics. The loss of life-giving vegetation is serious enough but to this we must add the erosion of irreplaceable topsoil by unimpeded runoff, and finally the downstream accumulation of damaging floodwater and siltation of rivers and expensive reservoirs. And then, we must not overlook the loss of this rainfall to the site where it originally fell. What is an asset in one locale becomes a problem in another. Desertified soil has developed a crusted surface and extremely efficient drainage patterns. Instead of becoming soil moisture where it falls, rainwater immediately turns into erosive runoff.

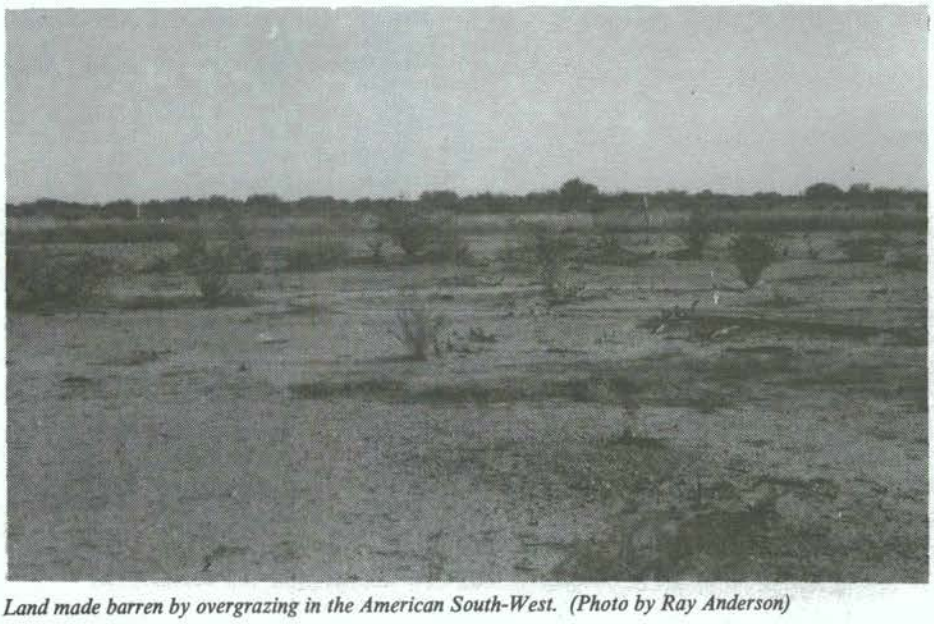
Even agriculturally sophisticated nations are experiencing unacceptable soil loss from excessive and unsafe tillage, while conditions are approaching catastrophic proportions in some other nations. Man is destroying basic resources far faster than their capacity of self renewal. The Great Landlord in the sky is concerned about the way his earthly tenants are looking after his real estate.

Man has been aware of devegetation for centuries but in earlier times the resources seemed limitless and when his locale became untenable he simply migrated to an undamaged area. Since trees are more evident than grass or even grain, reforestation became man's first effort in revegetation. Deforestation is also more obvious than the disappearance of grass by overgrazing. Much more interest and technology have been devoted to tree culture than to grassland revegetation. Furthermore, most trees require higher rainfall and thus grow on more productive land. However, this is not to imply that reforestation is keeping pace with deforestation. The concern of this paper is limited to grassland but as will be seen further on, shrubs and trees are becoming involved under certain climatic conditions.

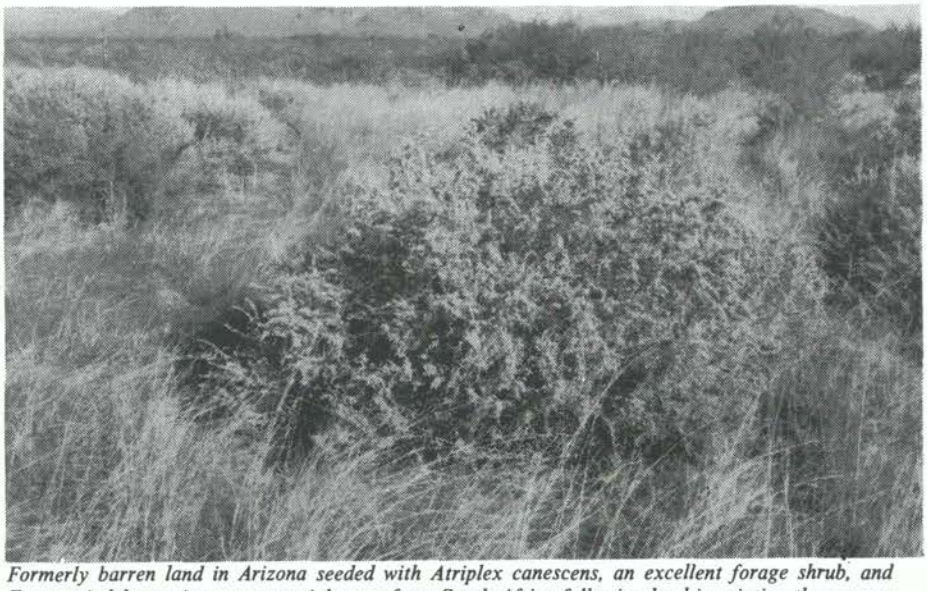
When we consider that grains are grasses, that grasses provide both forage and grain to sustain our livestock, and that perhaps the greater part of man's food consumption consists of grain and meat, we soon reach the conclusion that the overall significance of grass is not sufficiently appreciated.

The primary objective of revegetation is to stabilize and protect the soil; the utility value of the renewed vegetation is simply a fringe benefit. It is obvious that if the topsoil is gone, the *option* to revegetate, or to properly manage it, has gone with it. The opportunity is already lost in some cases and this calamity is being magnified annually. A single intense rainstorm on exposed soil can erode away a century of Mother Nature's soil building efforts. Revegetation is a drastic and last-chance measure, yet it is no more drastic than the man-caused activities that make it necessary. In many situations of vegetative regression, but where the soil remains intact, revegetation can be economically feasible on the basis of increased forage production alone. At the other extreme it may be necessary to plant anything that will grow there—even what we may regard as weeds— to maintain the remaining topsoil. Any kind of vegetation is an improvement over none at all.

The revegetation of dry grassland has



Land made barren by overgrazing in the American South-West. (Photo by Ray Anderson)



Formerly barren land in Arizona seeded with Atriplex canescens, an excellent forage shrub, and Eragrostis lehmanniana, a perennial grass from South Africa following land imprinting three years previously. (Photo by Ray Anderson)

never been generally regarded as an option because it has not offered either technological nor economic feasibility. The feasibility has now assumed a positive position by virtue of an unconventional technological breakthrough and it would thus appear that grassland revegetation will rapidly become a major rehabilitation/development activity.

Drought

Drought is endemic to grassland. It is inevitable; a known and fixed characteristic of the climatic setting. It should not be regarded as a surprise nor as a primary cause of desertification. Its effect is temporary while overgrazing brings its own drought and with long term damage that will not be healed by the certain return of the rains. Healthy grassland recovers rapidly from drought. Drought serves the useful purpose of emphasizing the symptoms of prolonged ecological stress. Each new drought appears to be more severe than its predecessor, but in fact it is a simple case of reduced capacity of the land to survive and recover. Each recovery from drought is more doubtful.

In addition to low rainfall in general, grassland climate is also characterized by highly variable rainfall. Its extremes can vary from flood to drought. The climate is further noted for scattered yet intense rainstorms in the wet season and equally intense wind in the dry season. Both can be lethal to desertified and unprotected soil. Nature never intended that the thin soil should stand naked to the onslaught of her erosive forces.

Drought is Mother Nature's ruthless way of bringing resource production and consumption back into equilibrium. She practiced her rigid population control on the original herds of wild game. This is to say, that if man does not voluntarily undertake proper management of his livestock and forage resources, she will ultimately do so for him with far more painful consequences.

Drought is predictable in the sense that we know that it will come sooner or later. The longer the time element since the last drought the greater the likelihood of reappearance this year or next. Yet people gamble that it will not come, and trust that rain will follow the hoof. It is prudent to assume that drought can come at any time and to undertake advance precautions against it. Therefore, while drought is always a grave problem to cope with, it need not necessarily become the repeated and worsening calamity of starvation proportions it has become in Africa. Land that has been damaged by the activities of man cannot be expected to be productive in time of drought.

Drought has also been the mortal enemy of conventional revegetation programmes.

Revegetation Equipment Development

Serious overgrazing occured on the western grasslands of the United States during the period from 1880 to 1920. About eighty per cent of the land was then and continues to be public land. The bison had been eliminated and replaced by twice as many cattle. The public land was used communally without restriction or cost. Fierce competition for use of what was known as the "free range" quickly developed, to be followed by devastation of the more palatable and nutritious perennial grasses. The absence of these vital species was soon followed by the disappearance of their seed as well. The damage had been done long before the time the American government finally assumed control and management of its land, beginning in the 1930s. The free and uncontrolled use of public land has had the same disastrous effects the world over. It is significant that it was the American ranchers themselves who finally petitioned for government management.

At this time the U.S. Department of Agriculture began a world-wide search for suitable grass species to "reseed" the ranges; and also initiated research on the formidable task of how to accomplish this on dry grassland without irrigation or undue expense. The harsh confines of grassland economics dictate a rigid limit on rehabilitation costs. Futhermore, the equipment had to be able to function dependably on irregular terrain distant from repair facilities and thus mechanical simplicity and freedom from breakdown became a necessity. In time it also became evident that the search for suitable species was much more successful than the development of equally suitable equipment. Although a wide variety of machines was designed and tested, the mechanical solution proved to be elusive until the late 1970s; It is for this reason that grassland revegetation has not been viewed as a viable option.

One of the various favourable outgrowths of these government activities was the birth of the modern art and science of range management.

Conventional Soil Tillage

We learned long ago that simply scattering seed on dry grassland will not result in a worthwhile response. Nature dispenses seed in prodigious amounts, while perhaps something like one per cent germinates and survives to reproduce. Man's revegetation efforts must offer a much higher rate of success. A suitable seed-bed must be prepared if revegetation is to be successful.

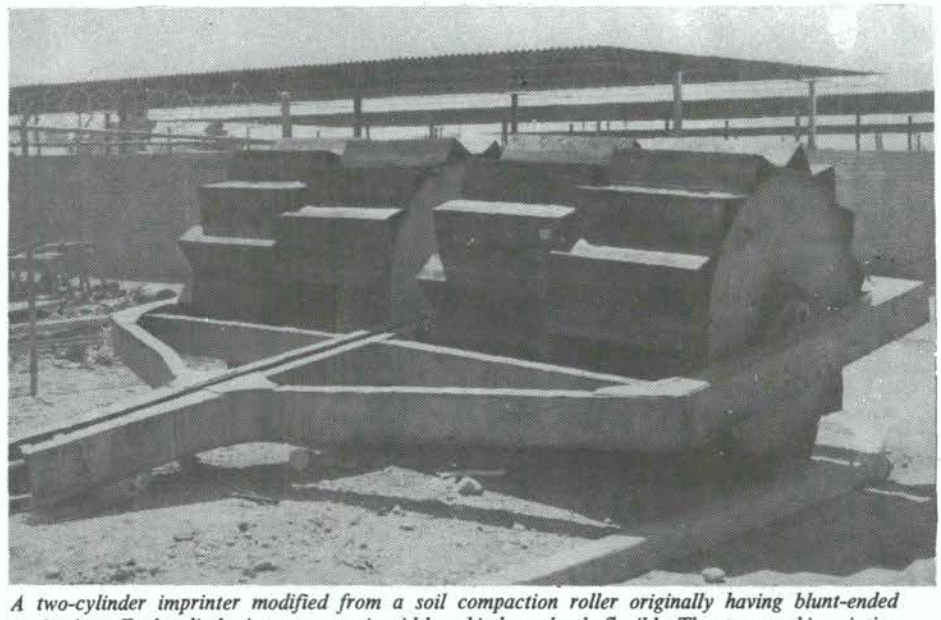
Traditional seed-bed preparation involves cutting into the soil and loosely turning it over. The conventional tools for this are the plough and the disc. Only in recent years have a few innovative thinkers dared to question and examine standard tillage and to suggest "no till" and other potential techniques for preparing soils for planting. One of these concepts involves only "shaping" and management of the soil surface, together with soil "firming", in direct contrast to soil loosening. Destabilized soil is highly vulnerable to the erosive forces of wind, water and gravity.

In Niger, the writer has personally witnessed the darkening of the sun on cloudless days by fine soil particles suspended in the air. The particles are topsoil and the origin is exposed soil from excessive grazing and unsafe tillage practices. It was related that this enormous dust-cloud occasionally reaches as far as southern Europe, adding an environmental hazard to the loss of soil. Atmospheric scientists in Hawaii are aware of when the planting season begins in China. At the moment of this writing a vast dust-cloud from North Africa is arriving over the Caribbean. There is some evidence that this man-caused atmospheric dust actually reduces rainfall, again adding one problem to another. Reappraisal of historical soil tillage is indicated, especially within grassland climatic conditions.

Land Imprinting

A recent technological development has firmly brought grassland revegetation into the realm of both biological and economic feasibility. The research was done by the U.S. Department of Agriculture in the hot and dry south-western state of Arizona. This new and unorthodox concept is known as "land imprinting" because it establishes impressions in the soil surface.

The imprinting machine consists of a simple rolling cylinder attached to the towing frame by an axle bearing at each end, with the cylinder being the only moving part. Angle irons are welded to the surface of the cylinder to force imprints in the soil. A broadcast seeder (electrically powered by the tractor) is mounted on the towing frame so that the seed will be pressed into firm contact with the soil by the following machine. Brush damage (if present) is performed by the crushing action of the imprinting teeth as the machine passes over it. The interior is filled with water for additional weight on heavier soils.



A two-cylinder imprinter modified from a soil compaction roller originally having blunt-ended projections. Each cylinder is two metres in width and independently flexible. The staggered imprinting teeth are the normally recommended configuration. (Photo by Ray Anderson)

The machine is almost indestructible and the only regular maintenance required is daily lubrication of the two bearings. Given proper design and dimensions for the site conditions where it will be used, it can be fabricated in any sophisticated welding shop anywhere in the world, which is the reason why none of the farm implement companies have decided to manufacture it. Most of the machines in use in the United States have been fabricated locally, while others are modifications of other rolling-cylinder machines originally intended for different purposes.

Although not originally understood or appreciated, the development of the imprinting concept had its origin in easily observed but generally ignored functions of nature. This is in reference to the hoofprints of grazing and browsing ungulates, wild or domesticated. These hoofprint impressions in the soil attract some of the rainfall and hold it for soil infiltration, resulting (if seed is still present) in "nature-irrigated" germination and plant growth. We have here the classic example of man's inadequate but developing comprehension of the co-evolution/co-habitation and mutually beneficial relationship between the forage resource and the foraging beast. In addition to the quite obvious return of nutrients to the soil by animal faeces, as well as physical seed dissemination, the animal plays the critical role of seed-bed preparation. This phenomenon is only recently receiving scientific attention. Now we begin to understand why more than just seed scattering is necessary in revegetation programmes. A popular new grazing management system recognizes the contribution of this natural seed-bed preparation in "Holistic Resource Management".

Land imprinting brings refinement to and expands upon the hoofprinting example of nature. Hoofprints tend to be quite unequally distributed. They are too concentrated from excessive trampling along trails and around watering and resting areas (frequently resulting in soil compaction), too

sparse where forage is sparse, and too shallow when the soil is dry and hard. Mechanical hoofprinting, or imprinting, is done in an evenly spaced and organized pattern, and is specifically designed to penetrate dry soil at the proper time of year for planting. (The seed-bed preparation and the seeding must be done before the seasonal rains begin). Unlike hoofprints, imprinting is not repeated. What we have here is a rainfed and runoff irrigation system, based on catchments or resevoirs on a micro scale. Thus, the next result is maximum capture of rainwater where it falls, maximum soil infiltration, and the halting of runoff and topsoil erosion.

In effect it amounts to a multiplication of the benefits of natural hoofprints; a reversal of man's normally damaging role to one of co-operation with nature for improvement. We can learn far more about the environment from observing nature than from the activities of fellow mankind. Imprinting gives temporary control of infiltration, runoff, erosion, flash-flooding and downstream siltation. Subsequent vegetative cover gives permanent control.

In revegetation projects on dry land, moisture is the critically limiting element and drought occuring in the same year is the major risk. However, land imprinting offers maximum utilization of whatever rain does fall and the stabilizing effect on the soil insures that the imprints will persist for a year or two in the event of severe drought. Thereby, current drought can be overcome by a second or even third opportunity to receive more favourable rainfall. Imprinting is not a rain-maker, but it is a rain-stretcher. Moisture is concentrated in the imprints. Again, we cannot avoid or control drought but we can minimize its harmful effects.

Additional benefits of imprinting are the crushing effect on any existing undesirable vegetation and the mulching of this plant litter into the soil surface. The normal values of mulching, such as protection against soil moisture evaporation, seedling shading from a harsh sun, and the provision of plant nutrients from decay, are all present. The concentration of these resources in the imprints enhances germination and growth.

Imprinting is flexible to site differences in soil, rainfall and existing vegetation by changes in the number and configuration of the teeth and by increasing or decreasing the weight of the unit. However these modifications require specialized knowledge.

A crawler tractor equipped with a bulldozer blade is preferred. This allows disconnection from the imprinter to prepare roads across gullies and other difficult terrain, and travel from one project site to another without the expense of truck transport with its problems of loading and unloading.

There is no environmental damage in land imprinting; only ecological and economic benefits. Given conservative grazing management, there is no need to repeat the process, and a new and unprecedented opportunity in land management is presented.

Land Management Opportunity

It would be foolish to undertake the effort and expense of revegetation without assurance that the same desertification process will not befall the land again. Lush grass has an irresistible appeal to pastoralists and therefore a legitimate objection to revegetation is the question of how to protect and maintain the renewed resource. The same population and resource consumption pressures are still present. In the case of public land the offer of resource restoration presents the government with a singular opportunity to negotiate for specified grazing management control of the treated land. This would involve an exchange agreement between the pastoralists and the government: the gift of reestablished forage to the pastoralist in exchange for surrender of certain basic management rights to the government. Where desertified land is concerned it would seem that neither side would have much to gain in debating this arrangement.

The arrangement would obviously require collective and *authoritative* restraint in resource management, for there is no point in conservative forage use if a neighbour is free to preempt whatever is unconsumed. With an unused annual reserve the resource can be maintained indefinitely, drought can be survived without outside assistance, and it becomes possible for a robust grassland economy to replace a subsistance pastoralism prone to repeated disaster.

Given success in management of the restored resource and some visible evidence of the potential for social and economic benefits of a productive and self-sustaining livestock economy, the government would encounter fewer difficulties in eventually gaining management control of the entire national public land resource. Along the way, this in turn would lead to the regulation of animal numbers, direction of migration and seasonal land use, the collection of land use fees and taxes, and the general development of an equitable and economically viable pastoral system. Witness *dry* Australia and its prosperity from meat and animal by-product exports. At least some of the people who have fled to the city slums can return to the land. All this appears to be impossible without beginning with resource restoration.

Revegetation Restrictions

The availability of seed of specifically site-adapted species is a short term restriction in some cases. There has been no demand for the seed and so it is not available. Local hand harvesting is the only means of obtaining a supply of indigenous species seed now unavailable for a pilot project. However, a rapidly expanding demand for seed would stimulate production and this poses no technology problems. A wide range of species are already in hand for the various climatic regions of the entire western United States and much of Australia. It is true that some specific regions might require species not yet identified but this can be resolved in a relatively short time. Given the suitable species, seed multiplication is the smallest of our problems.

The climate of our Sonoran Desert here in southern Arizona is quite similar to that of other world grasslands and it is possible that some of our species used for revegetation would be equally suitable elsewhere. It is interesting to note that our most successful local species is an exotic from South Africa. There is great adaptation versatility in many species and some that we automatically judge as not likely to be adapted may prove to be remarka-

bly well adapted. It has been observed that some species actually thrive more in a new environment than in their original habitat. (Absence of strongly competitive species?). In any event it is possible that southern Arizona could become a major initial seed source for certain other world regions. This merits early investigation.

There is no reason that seed multiplication and production cannot be done in the host country, along with the revegetation programme itself, and thereby some employment and economic activity would be generated. In a short time, and with the exception of the tractors and the fuel, all the elements necessary for revegetation activities can be provided in the host country.

Revegetation Benefits

Aside from soil protection and the opportunity to assume management control, revegetation offers highly visible and early benefits in the form of additional forage. The volume of this forage is in direct proportion to the remaining depth and fertility of the soil, the adaptability of the species seeded, the proper application of the imprinting, the extent of the area treated—and the current mood of the Rain Gods. A specific case of scientific measurement of forage increase reveals a leap from 40 to 750 kilos per hectare (air dried). This great difference should not be surprising; the land had been desertified. Depending on the amount of pre-existing forage, if any, the volume of increase can vary from a small amount in an unfavourable rainfall year on up to a thousand per cent or more. How do you express the percentage increase if there was no pre-existing forage?

This new forage requires close management until it is firmly established. During the first two years it should not be grazed until seed has been made. Livestock will then prepare another seedbed in the ways of nature. Thus an early forage benefit becomes available, and later any of several appropriate and authoritative grazing management programmes would be adequate to maintain productivity.

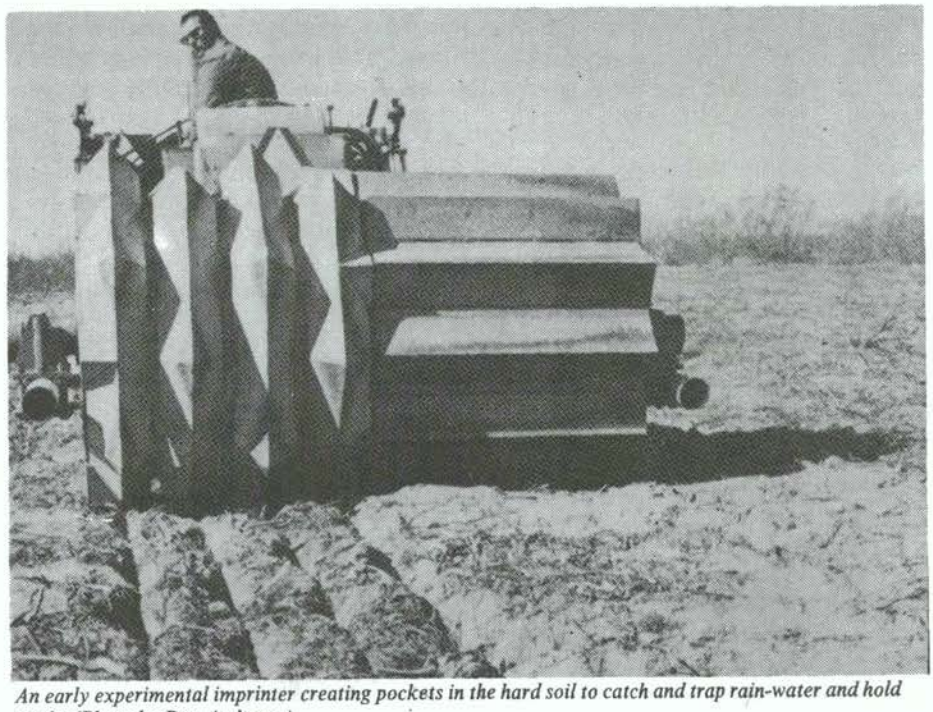
Given the financial assistance and the seed, large scale revegetation programmes can be initiated rather quickly. As many as three imprinting machines can be pulled by one large tractor, at 6 kilometres per hour. Annual treatment work can begin as early as four months before the rains, allowing enough time to treat large tracts of land each year.

Agroforestry

Agroforestry is the term for still another recent and intriguing development. As the term implies, it refers to agriculture in conjunction with forestry. By extension it also includes forage grass production together with either or both cropping and forestry. Shrubs useful for forage or other needs can be added. Many areas in Africa and elsewhere in the world have, or at least originally had, a savanna type multi-ecosystem presenting a bountiful mixture of grass with scattered shrubs and trees. As in the case of reforestation, there is considerable activity now occuring in agroforestry.

Many shrubs and trees offer supplementary and, or, emergency livestock forage during the annual dry season or drought. Fuelwood for cooking has been disappearing along with the grass and the construction sized wood. There is not much point in producing more food if there is no fuel with which to cook it. The shrubs and trees also offer a wide variety of fruits, nuts, gums, resins, etc. useful for direct human consumption or cottage industry. Like the forage and the foraging beast, these diverse forms of vegetation are interdependent upon one another while competing only minimally for soil moisture and nutrients. The sum variety of benefits amounts to an almost completely self-contained habitat for man.

Agroforestry challenges us to an opportunity for co-operative revegetation activity between the agriculture, forestry and grazing interests. Agroforestry, however, is limited to the higher rainfall grasslands. Forage shrubs have been tested and respond as well to imprinting as the grasses. Since both imprinting and agroforestry are of recent origin, trees have not yet been tested but there is no apparent reason why they would not respond equally positively. An imprint should be an ideal cradle for tree seed germination and continued growth. A minor problem does arise in the fact that seeding equipment is not adjustable to wide variations in seed size and shape. Different seeders are required for the larger and odd-shaped seed. "Dribbler" seeders (yet another recent development) are quite adjustable and one can be mounted on either side of a crawler tractor engine.



An early experimental imprinter creating pockets in the hard soil to catch and trap rain-water and hold seeds. (Photo by Ray Anderson)

They are powered by the movement of the tracks, and dispense a low volume of seed. They were originally developed to permit a crawler tractor doing bulldozer work to also seed the disturbed soil in one operation, but in this case they would permit dissemination of several seed sizes and shapes. The impressions left by the tractor tracks are an inadvertent yet effective variation of imprinting. There is a pressing need for pilot projects involving grass, crops, shrubs and trees.

Revegetation Costs

While imprinting is too new to offer much cost background, we do have one documented case of the costs of revegetation by imprinting in 1981. At that time, the U.S. government agency charged with management of public grazing lands stated that $75 per hectare should be the economic limit of revegetation expense. In this documented case provided by a private rancher the seed cost was $20 per hectare. The tractor and driver were rented, including fuel and tractor maintenance, at $ 17 per hectare. Not included was the rancher's management time nor the amortization of the large (3 metre width) imprinter at a $7,000 initial fabricating cost. The total cost was estimated at $45 per hectare, well within the limit. This purely economic limit does not take social or soil protection values into account. What is the current market value of topsoil or human life?

Seed is the most variable cost. Again, not much volume of grassland seed is produced since revegetation has not been a general practice. Given the market demand, rapidly expanding the availability of seed poses no technical problems. Large scale production in the manner of other crops would greatly reduce what is now a high price. The price should fall by more than fifty percent.

Strip Treatment

Several ranchers in Arizona have been imprinting continuously for four years. (There is an unknown extent of imprinting activity in Texas and other states as well as Australia and Israel). These ranchers have learned to reduce costs even further by "strip" treatment. This permits eventual revegetation of an area much larger than that actually treated. With controlled grazing pressure, the aggressive grasses spread into the untreated strips and in time the cost per unit of land becomes attractively low. It must be understood that the primary objective is to re-introduce a seed source of desirable species over a large area rather than intensive seeding on a small area. Mother Nature and rational grazing management are then quite capable of assuming the remainder of the revegetation responsibilities. The cost/benefit ratio becomes an offer that can't be refused. Strip treatment offers obvious advantages in the mounting of enormous projects, which in turn still further reduce the cost per unit of land.

Technical Summary

Three basic elements are essential to successful revegetation by the land imprinting concept: (1) a satisfactory imprint must be achieved within the specific site conditions, (2) the species seed-bed must be carefully selected and site adapted, (3) there must be at least a minimum amount of rainfall.

The first two essentials are controllable by available knowledge. However the mechanical simplicity of the machine itself disguises a complex concept. Highly variable site conditions require modifications in both machine and seeder. To insure proper design, dimension, and imprinting-tooth configuration with respect to existing vegetation, rainfall, soil type and topography, the first unit to be used in a given site or region should be fabricated in the United States where the necessary specialized knowledge and experience is available and only after a specialist has visited and carefully examined the specific site conditions. This unit would then serve as a model for making additional machines locally by a fabricator who should be experienced with agricultural equipment. Most third world countries would have to import all the necessary parts and materials. Aside from the machine, grassland revegetation is a unique and highly specialized field.

Conclusions

We have an increasingly stressed relationship between man and the dry lands. The environmental balance is disturbed and the capacity of the ecosystem to meet human needs is crippled. Many grasslands have become untenable for man or beast. Past and present grassland development efforts have been attempting to impose various and sundry grazing management schemes without back-up authority and on a vestige of forages too sparse to support a livestock industry at the subsistence level. Hence the increasingly devastating effect of drought.

Momentary drought disaster assistance is of course necessary but it is enormously expensive and fails to address the core of the problem. Feeding the starving offers no lasting benefits to either the recipient or the donor. Moreover, conditions are rapidly worsening instead of improving and the future bodes an eventual culminating catastrophy which world resources may not be able to cope with. A number of countries largely dependent on grassland resources are already threatened by ecological and economic collapse. Africa, the continent originally richest in animal production resources is also the lowest in per capita protein consumption. The reason is the deterioration of resources rather than the absence of them. The tide of refugees can only be slowed by rural ecological regeneration. We have become enmeshed in a strange paradox wherein "rock" music stars are generating funds for momentary disaster relief when responsible governments and international aid should be arranging permanent relief by means of land rehabilitation. The goal should be sustainable grassland economy and society.

Mankind has experienced two major eras in the past several hundred years. The first era began with global exploration, to be quickly followed by land appropriation and then harsh land exploitation. At that time, man did not understand that dry and fragile grassland requires sophisticated management if it is to maintian productivity, or that uncontrolled private individual use of "common" land would eventually lead to over-use. The damage to the land occured over time rather than immediately and was further obscured by alternating wet and dry periods. The current generation only knew that their elders talked of the plentiful

grass and great herds of livestock of earlier times. There was no more land to conquer. The system together with expanding population pressures discouraged judicious land use. This was the beginning of the second era: that of a struggle to survive on depleted or devastated land. The drought disasters of recent years have made it clear that increasing numbers of people are failing to survive.

It is becoming evident that a third and final era must be forthcoming. The first phase of this era should be one of land healing; a time of dedicated rehabilitation to something akin to original productivity. It will employ modern vegetation technology. The second phase follow-up will employ equally modern grassland management toward permanent self-renewing productivity and stability. This era will permit grassland to become an asset instead of a burden and to assume its proper role in the overall global economy. Without revegetation therapy, the third era will never materialize.

We specialists can discover or recognize and evaluate new technological knowledge, but only those who allocate funding can determine if available knowledge will be utilized.

NEWS FROM UNEP

AGFUND-UNEP Desertification Control Projects

The Arab Gulf Programme for United Nations Development Organizations (AGFUND) has been providing generous financial support to five UNEP desertification control projects since 1982. One of the projects is the Lodar, P.D.R. Yemen project reported elsewhere in this issue of the Bulletin.

AGFUND was started up in 1981 by the efforts of Prince Talal Bin Abdul Aziz al Saud of Saudi Arabia who, after visiting many poor Third World countries as a Special Envoy of UNICEF, decided that a special fund was needed to speed up UN assistance to people who needed help. The seven Arab nations of the Gulf - Bahrain, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates joined together to found AGFUND. In its first biennium of operations it reached out to seventy-seven countries with grants totalling more than US$ 81 million. To-date, AGFUND has contributed some $ 3.16 million through UNEP projects.

One of the projects, involving the development and improvement of water resources in Mauritania, was completed in 1984. The project, implemented by the Ministry of Rural Development and the Office of Project Execution of UNDP, resulted in the construction and rehabilitation of several dams in the Gorgol and Assaba regions. The water in the reservoirs is being managed to provide small-scale irrigation and livestock with water to increase food production. AGFUND contributed almost $ 500,000 to the project.

Two other projects in the Sudano-Sahelian region involve tree planting and the provision of fuelwood, timber and fodder to village communities. These activities are taking place in Benin and Burkina Faso and involve the establishment of nurseries to furnish villagers with a variety of tree seedlings to set up family and village plantations.

The last project aims to improve natural resource management and agricultural production in the coastal plain of Djibouti. Following a survey of the available natural resources, an experimental station and a training farm are being used to develop appropriate agricultural techniques and provide training for settled nomads. With a growing population and increasing desertification, Djibouti is seeking to develop more intensive land-use technologies.

The assistance of AGFUND to UNEP desertification control activities is greatly appreciated and UNEP looks forward to continuing co-operation between the two organizations in their joint efforts to create a better future for the world's poor and needy.

UNEP progressing on Lodar project

In 1984 the United Nations Environment Programme embarked upon a desertification control project in the Lodar area of the People's Democratic Republic of Yemen. Now in Phase I, the Integrated Agricultural Development Project has three long-term objectives:

Men constructing internal steel reinforcement for a small dam in Mauritania. (UNSO/UNEP)

A project nursery in Benin. (UNEP/Hussein Abaza)

- To set a pattern for farm planning, layout and levelling;
- To provide modern irrigation systems for production of high-value horticultural crops; and
- To introduce improved methods of crop husbandry.

The first year of the project saw the construction of site facilities, the training of professional staff, and the commencement of afforestation and agricultural activities.

Infrastructure. During Phase I (October 1984-September 1985), housing facilities for professional and local staff were completed, as were a machinery shed and an 8000-seedling nursery. All necessary vehicles arrived during this time. One hundred hectares of rangeland was fenced. Experts in irrigation and afforestation were trained in the USSR. Local staff included specialists in irrigation, forestry, and crop production.

Afforestation. Thus far some 11000 seedlings have been produced at the project

Putting in the 'long-strip, long-furrow' irrigation works in Lodar, P.D.R. Yemen. (UNEP)

nursery, including experimental varieties from Australia. Many have been used for shelterbelts and windbreaks along roads, the irrigated perimeter, and farms of interested local farmers. Others are targeted for a 30-hectare afforestation plot that will produce fuel and industrial wood.

Agricultural Land Development. Thirty-six hectares of land have been levelled and now contain plots demonstrating the "long strip, long furrow" method of surface irrigation. This method permits increased efficiency of soil and water use, control of soil salinity, and introduction of mechanization.

Two new tube wells are producing saline but usable water at a rate of 40 litres per second, and an irrigation network has been designed that allows mixing of low- and high-salinity water. A 10-hectare drip irrigation unit is under construction.

Despite the successes the project has realized so far, many constraints remain. Machinery and spare parts are difficult to obtain, and both the training and availability of the labour force are considered inadequate. Poor management and scheduling have been blamed for confusion and inefficiency.

UNEP has extended Phase I until September 1986, in order to complete the project's short-term objectives and assess its environmental impact.

Camel Forum Workshop

A three day workshop 9-11 May 1986 was held in Wamba, northern Kenya, sponsored by UNEP and the Food Security Programme of the West Germany aid agency GTZ. The purpose of the workshop was to bring together representatives of pastoral communities which live in the arid and semi-arid lands of northern Kenya and scientists and development oriented people who work in the area to create a dialogue between the pastoralists and scientists and between the pastoralists themselves, who often spend more time stealing livestock from one another than talking and sharing their knowledge and experiences of how to survive in a difficult land. What was the subject of the dialogue? Camels.

Why talk about camels? Camels in dryland pasture and bush lands have much to do with how people can better adapt to their harsh environment, how they can better survive drought, and how the problem of conserving and rehabilitating degraded land can be solved. The pastoralists themselves — five representatives each from the Somali, Rendille, Turkana and Samburu groups — gave eloquent testimony to their appreciation of the great value that camels have for food production, transport and maintenance of a productive environment (see the article on camels in this issue of DCB for a detailed discussion).

The workshop was a historic occasion, as for the first time pastoralists from groups which often are hostile to one another were brought together to exchange views on a subject of common interest. To add to this, scientists and developers joined in the discussions on an equal basis to that of the pastoralists. Communication was facilitated by interpreters provided by the workshop organizers. The entire exercise worked much better than anyone anticipated and a great deal of useful information was exchanged between all parties.

In an initial session, the pastoralists identified three general areas which were of most interest to them in discussing camels: (1) disease and veterinary care, (2) management and production and (3) marketing. The plenary group, consisting of about 50 people, divided themselves into three sub-groups to deal with each of the subjects. There were alternating sessions of the three workshops and a plenary to report on progress in each of the working groups to keep everyone informed. The workshop resulted in a number of recommendations for concrete follow-up action in the area to improve camel production and development.

A film crew from Channel Four in Great Britain was there to make a film on camels. They recorded the extraordinary degree of communication achieved and the feelings of friendship which grew between the participants as the days went by. The District Officer of Wamba opened the workshop and it was closed by the Member of Parliament for the area. As a note of interest, UNEP's representative to the workshop arrived after a six-day, 150-kilometre trek — how else? — with camels.

Postscript

As a follow up to the Wamba workshop, a larger camel conference was held in Marsabit, northern Kenya, 25 to 30 September 1986, hosted by the Kenya Arid Lands Research Station. Representatives of six of Kenya's pastoralist communities attended, along with Government and donor agency representatives.

Several specific project ideas received expressions of support from donors in the areas of improved veterinary care, upgrading of camel breeds and marketing. Funding has also been secured for purchasing and transporting high milk-yielding camels from Pakistan to Kenya where production and breeding research will be conducted on a private ranch.

Film on Camels and Desertification

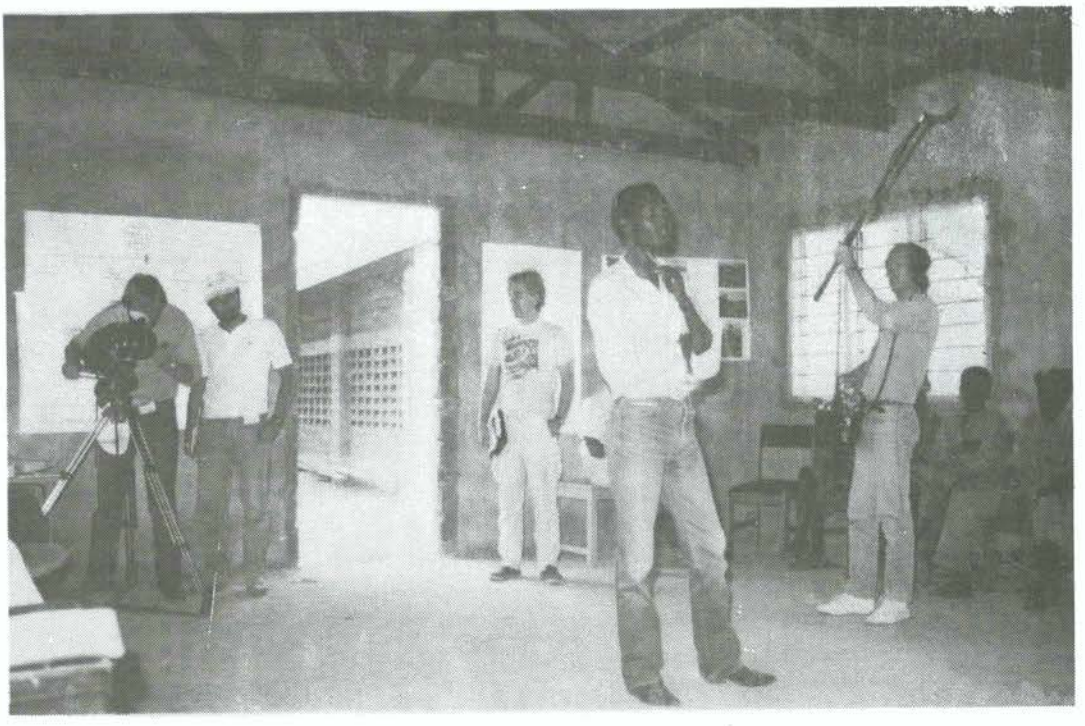
The Desertification Control PAC sponsored a television documentary which was shown on Worldwide Television News (WTN) programme "Roving Report" in September 1986. The film showed how the Samburu people of northern Kenya, who traditionally are cattle pastoralists, are now adopting camels in the face of increasing land degradation and drought. The Samburu realized from their contacts with camel pastoralists further north that camels enabled them to survive droughts more effectively and, during the good years, camels provide much more milk than an equivalent number of cows.

The film also visited a private ranch in Kenya where camel production research is being carried out. Milk yields from camels on a daily basis are being measured and experiments are being carried out on making camel cheese and condensed milk, which could be used both as a way to preserve milk products for future use by pastoralists during the dry season, and for marketing in urban centres. Camels are also being used for ploughing and cart-pulling, thus the camel could become a useful farm and dairy animal much like the cow, particularly in the drylands, to which they are better adapted.

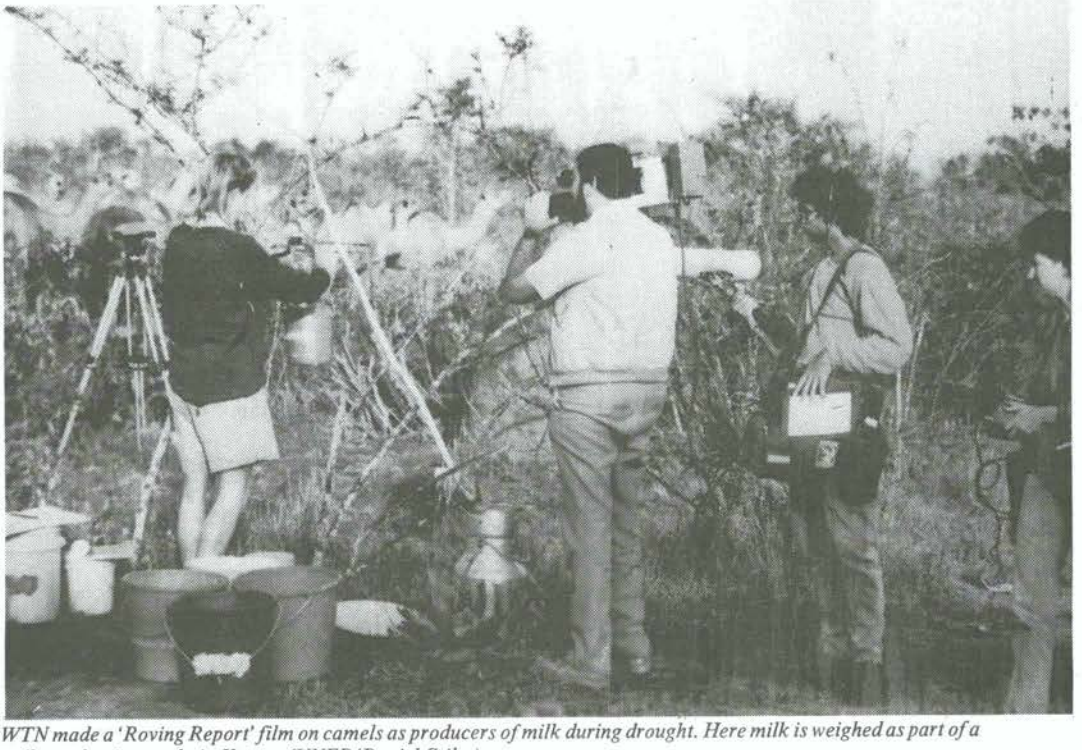
Tommorow's Famine

The Desertification Control Programme Activity Centre recently finished a film linking famine to increasing rates of land degradation. The film, produced by the award-winning film-maker Mohammed Amin of Camerapix, Kenya, is entitled *Tomorrow's Famine.*

The main theme of the film is that chronic food shortages such as those experienced in may parts of Africa are due more to land degradation — desertification — than to drought. Drought is temporary, aperiodic, while desertification has become a permanent feature of life in many parts of the world, not only in Africa. To prevent famine desertification will therefore have to be stopped and degraded lands rehabilitated, so that they can provide the space necessary and produce the ever increasing quantities of food



A UNEP supported camel forum workshop in northern Kenya was filmed for a U.K. Channel 4 film which was televised in November. (UNEP/Daniel Stiles)



WTN made a 'Roving Report' film on camels as producers of milk during drought. Here milk is weighed as part of a milk production study in Kenya. (UNEP/Daniel Stiles)

The film crew shooting a sequence of 'Tomorrow's Famine' in the Sudan. (UNEP/Daniel Stiles)

needed to feed a burgeoning population.

The film shows how misconceived development policies and programmes, often encouraged and financed by industrialized countries, cause more harm than good and actually increase the pressures on already overburdened land, leading to faster rates of desertification. If economic development and natural resource management are not reoriented to conserve and rehabilitate Africa's land, tomorrow's famine will be unavoidable and more disastrous than those which preceeded it.

NGO network in the Asia-Pacific Region

An international conference on "Forest Resources Crisis in the Third World" was held in Penang, Malaysia, sponsored by Sahabat Alam Malaysia (Friends of the Earth), 6 to 8 September 1986. The disappearance of tropical forest, both humid and dry, is progressing at an alarming rate according to a World Resources Institute report financed by the World Bank and UNDP. Cutting down trees and destroying forest is the first step down the road to desertification.

It was thus urgent that this tropical forest crisis be brought to the world's attention. The conference brought together representatives from 23 countries, including active NGOs from the Third World and industrialized countries, concerned planners in regional agencies, and researchers from universities as well as the news media. The conference identified South-East Asian insular countries as the region where tropical deforestation is the highest in the world today.

NGOs around the world are becoming increasingly effective and active in combating forest depletion and desertification. UNEP recognises their valuable efforts and, in an attempt to assist NGOs to work more effectively together, the Desertification Control PAC attended the conference in Penang and offered to provide financial support for the creation of a network specifically dedicated to tropical forest conservation and desertification control. The response was positive and the details of forming the network are now being worked out.

UNEP and the African crisis

Africa's nearly two decades of intermittent drought may be coming to an end. That is the ray of hope engendered by 1985's rains in the Sahel, Ethiopia, and eastern Africa. But even the return of normal rains is far from enough to resolve the African crisis.

Africa is the only major region increasingly unable to grow or buy its own food and facing a long-term decline in per capita food production. Some 150 million Africans suffer from chronic malnutrition and in 1984 to 1985 about 30 million were facing famine.

After two decades of large infusions of foreign economic aid and advice — much of it directed to dealing with symptoms — Africa is now preparing to deal with the basic cause of its problems: environmental degradation. The continent's Environment Ministers met in Cairo on 16 to 18 December 1985 under the auspices of UNEP, the U.N. Economic Commission for Africa (ECA), and the Organization of African Unity (OAU) to work out a programme to halt environmental deterioration and achieve self-sufficiency in food and energy.

In a report presented to the Conference, UNEP Executive Director, Dr. M.K. Tolba, said that "Africa is a continent in crisis. It is suffering from a continual drain on, and degradation of its natural resources — plant cover, soils, water, animal resources and climate". This general degradation has led to the poverty of the African.

Africa's increasing food shortages and poverty are products of the deeper problems of soil erosion, land degradation and rapid population growth, exacerbated by adverse climatic conditions, the lack of indigenous technology and domestic financial resources and by a world economic order balanced against the third world. The balance between population, resources, development and environment has deteriorated. The harsh reality in many states is that the average quality of life has worsened and environmental and economic deterioration have become widespread. Most African economies are in decline, some 40 per cent of the rural population is under-employed, and environmental pressures are growing.

Africa is rapidly losing its croplands to soil degradation increasing almost in direct proportion to growing population pressure. Some 80 per cent of the cultivated land is used for food crops and many African farmers are forced to overexploit the land to survive. Most agriculture still follows traditional methods of shifting cultivation. This worked when land could be left fallow for long periods to recover its fertility. But, with increased population density, these fallow periods have often had to be diminished or eliminated.

An estimated 117 million hectares of land are under crops. The area increased by 17 per cent between 1965 and 1976, but per capita food production declined during

the same period — partly because of land deterioration and declining soil fertility.

A Programme for Action

Three villages in each of Africa's 50 countries and 30 pasture areas, one in each of the 30 African countries with rangeland, will become home to pilot projects to assist villagers in managing their resources and sustaining their own environments.

After two years preparation by UNEP, in co-operation with the OAU and ECA, and after consideration by environment experts from 48 African countries and relevant members of the U.N. family, the proposal to develop food and energy self-sufficient villages as show cases for others, was endorsed at the African Ministerial Conference on the Environment.

The US$ 50 million needed for the five-year experiment will be provided by voluntary contributions from African countries from monies they receive from the U.N. Development Programme. The villagers will be shown the dangers of deforestation and overgrazing and helped to restore their land through the application of African knowledge and experience, combined with relevant scientific and technological know-how.

The ministers also endorsed the upgrading of African institutions and the pooling of their talent, experience and know-how in networks specializing in environmental monitoring, soils and fertilizers, energy, climate, water resources and other aspects of African food and energy production.

The report designates a number of specific areas in which joint action could promote development. For instance, climatic studies aimed at better weather prediction could help farmers to better withstand the vagaries of fluctuating rainfall. Another such area is co-operation to make better use of the continent's water resources.

The development of hydroelectric power resources, production of low-cost fertilizers, protection and development of forest resources, range management, livestock and agriculture development, and development of innovative technologies for production of renewable energy and efficient use of fuelwood and animal energy, are all areas for fruitful regional co-operation.

To guarantee its decisions are implemented, the Conference of Ministers has been insititutionalized and will meet every two years to review and plan future actions. Technical committees will also be established to oversee implementation and help the Conference Bureau in the follow-up on Conference decisions. A Conference Secretariat will be provided by UNEP's Regional Office for Africa, in co-operation with OAU and ECA.

The message is clear: Africa can do much towards solving its own problems. But intra-African co-operation is essential. The African Environmental Conference was the first step towards building that co-operation.

Special Session

A second step for Africa's survival, adopted by the world community at a Special Session of the UN General Assembly in May 1986, focuses on the conservation of natural resources as a crucial area for urgent action. It took an ecological tragedy — the recent drought whose victims appeared on television screens worldwide bringing home the horror of mass starvation — to propel Africa into the arena of international concern and with it the sorely neglected African environment.

The drought is now seen in its broader context as the manifestation of the fragile nature of Africa's socio-economic structures. If the horror is not to recur, a massive long-term development effort has to be made, spearheaded by African leaders but aided by the donor community. And in such an effort environmental measures hold centre stage.

The programme of action — Africa's Priority Programme for Economic Recovery, 1986 to 1990 (APPER), first approved in 1985 by the OAU — to which African leaders recommitted themselves involves national, sub-regional and regional measures. The total cost of implementing the Plan is estimated at US$ 128.1 billion — 64.4 per cent of which, some US$ 82.5 billion, is to be financed by African countries themselves. The balance, hopefully, will be met by the donor community which has committed itself to provide sufficient resources to support and supplement the African development effort.

At the national level, APPER singles out agricultural development, with the aim of increasing food production, as first priority. This is expected to absorb some US$ 57.4 billion, almost 45 per cent of the total cost of implementing the Plan. Arable land is to be restored, protected and developed. Animal diseases are to be controlled and rangelands better managed so that livestock and livestock products can be developed. More fertilizers, improved seeds and pesticides are to be used and such inputs, as well as tools, made accessible to small farmers. Better storage facilities are to be developed, and a network of agronomical research stations will be set up through which the use of appropriate agricultural technologies is to be spread.

Water resources are to be better managed and low cost irrigation schemes established. Reafforestation and afforestation programmes are to be set up as well as assistance programmes for small farmers, with accent on women and young people. To support agricultural development, agro-related industries are to be rehabilitated and developed to which end Africa's capacity to use renewable sources of energy, such as the sun and bio-mass, are to be increased. Significantly, the Plan stresses training in such fields and the development of local capacity for project design and preparation.

Drought and desertification control is expected to absorb US$ 3.41 billion. Measures are clearly spelt out and largely follow the recommendations made by UNEP officials in their technical paper presented to the Preparatory Committee whose job it was to prepare the documentation for the Special Session. The UNEP paper was based on the recommendations adopted at the African Environmental Conference. Measures include reafforestation and afforestation, management of water resources including river basins and irrigation, protecting common eco-systems, developing alternate sources of energy to replace woodfuel, stabilizing sand dunes, stopping soil erosion, preventing salinization, and improving drainage in irrigated areas.

The Plan proposes the integration of measures for the protection of the environment into national development programmes and according them high priority as well as the full implementation of the 1977 UN Plan of Action to Combat Desertification. In addition, population policies are to address, among other issues, environmental protection and appropriate land use and settlement patterns, with sights on attaining as soon as possible an agro-food production growth rate at least equal to population growth rate*.

The Plan recognizes the special needs of specific African regions. Drought- and desertification-prone

areas, such as the Sahel and the areas covered by the Intergovernmental Authority on Drought and Development for East African Countries and the Southern African Development Co-ordination Conference, are increasingly incapable of raising the cash needed to implement APPER. International aid will therefore be needed for tree-planting, water conservation, and the development of alternate sources of energy to wood and charcoal, low-energy-consumption cooking stoves and drought resistant crop varieties.

The implementation of the Programme of Action for African Recovery 1986 to 1990 — which the General Assembly finally adopted by consensus — will be up for review and appraisal at the General Assembly's 43rd Session in 1988. Meanwhile, progress will be monitored by the Secretary-General who will report to both the 42nd and 43rd sessions.

In addition, the mechanisms adopted in Cairo at the UNEP/ECA/OAU — sponsored First African Ministerial Conference on the Environment will be a useful tool through which to implement APPER.

* See UNEP's 1985 *State of Environment report: Environmental aspects of emerging agricultural technologies, population and the environment*, available in UN languages from UNEP's Nairobi headquarters on request.

New Desertification Control Projects

Three new projects have recently been approved for implementation under the Desertification Control PAC programme. They are:

ESCAP Regional Network of Research and Training Institutions

With assistance from UNEPCOM of the U.S.S.R., six to eight institutions which specialize in desertification control research and training will be linked in a network in the Asia-Pacific region. This project funds the preparatory stages in establishing the network, including an Inter-Governmental Meeting on Research and Training Institutions in the ESCAP Region held in Bangkok 9 to 15 September 1986, and two seminars to be held in 1987. A directory of institutions in the region will be compiled, a study made of environmental training priorities, and finally a co-ordinated programme of desertification control research and training will be prepared.

African NGO Network to Combat Desertification

NGOs involved in anti-desertification activities in Eastern, Southern and West Africa will be joined together into a network under the umbrella of the African NGO Environmental Network (ANEN), based in Nairobi, Kenya.

The network will involve information exchange through ANEN's newsletter *ECO-AFRICA*, a workshop planned for 1987 will bring some 35 of the major NGOs together in Nairobi, a technical "how-to" manual on desertification control techniques will be prepared in English and French, a complete NGO compendium will be compiled on those NGOs in Africa which are active in desertification control related activities, and from four to six field level NGO projects will be funded through the project.

This project should serve to co-ordinate NGOs in Africa in their combat against desertification and catalyze increasingly effective action, improve an exchange of information on activities and experiences between NGOs, and promote public and governmental awareness of the problems associated with desertification and ways in which commmunity grass roots efforts can help combat desertification.

Creation of a Seed Bank and Promotion of Revegetation Activities in Southern Tunisia

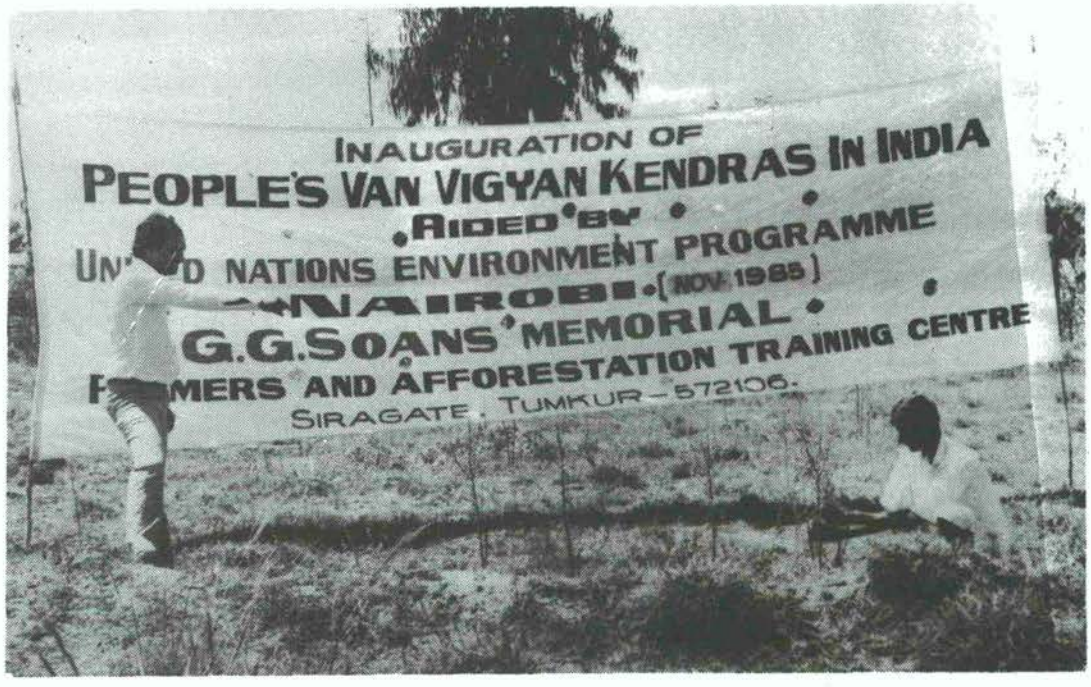
In co-operation with UNDP, UNEP is assisting the Tunisian Government begin implementation of the Tunisian National Plan of Action to Combat Desertification by supporting the first priority project proposal contained in the Plan of Action. The project will create a seed bank at the Institute of Arid Regions, near Medenine, in southern Tunisia.

Seeds will be obtained through collections from plants in the wild and from irrigated seed production plots. They will be treated and stored in the seed bank. In addition, a registry will be compiled of the best plant species for specific purposes (e.g. sand dune fixation, fodder production, hedge rows, etc.) and methods of collection and propagation, based on years of research supported by UNEP and UNESCO through the Tunisia Integrated Project on Arid Lands. A revegetation plan for southern Tunisia will be formulated by the Institute to be carried out in collaboration with the Department of Forestry.

This project will be one of the first large-scale field level actions based on years of research in the area, which will demonstrate the practical usefulness of the studies carried out.

UNEP is supporting a revegetation programme and creation of a seed bank in southern Tunisia in co-operation with UNESCO, UNDP and the Institute of Arid Regions in Medenine. (UNEP/Daniel Stiles)

India's "people's forestry programme" — a decentralized approach to reafforestation



The inauguration of one of the Van Vigyan Kendras in southern India. (Photo by Ben Soans)

As is true in many developing countries, deforestation in India is a major problem. In this country of 736 million people, firewood meets 36 per cent of total energy needs and is the exclusive source of heating and cooking fuel throughout most rural areas. Not surprisingly, the loss of this resource has seriously affected India's peasantry, who must spend inordinate amounts of labour and income to secure fuel. In many cases, desperation has led to poaching and to further degradation of marginal lands.

In the past, many of India's reafforestation efforts have failed due to centralized or top-heavy management, poor incentives for peasant involvement, and suspicions that such programmes have benefitted the wealthier at the expense of the poor. This provided the impetus for the People's Forestry Movement, a reafforestation programme that is decentralized, self-sufficient, peasant-operated and now burgeoning along the west coast of India.

The Movement traces its roots to the work of G.G. Soans, the "Father of Horticulture on the West Coast," who set up India's first known People's Nursery and spent the years 1910 to 1952 in a solitary effort to reafforest the West. His lifelong dream, "to make the west coast of India the California of India," inspired his son Ben Soans to extend such efforts nationwide.

Under the auspices of the Youth Hostels Association of India, Soans in 1974 pioneered the People's Forestry Programme. The programme had three goals: self-sustainability, self-propagation, and autonomy. Two years later, he began an experimental reafforestation programme in a denuded area near Herekala in southwestern India. Over the ensuing decade, Soans, the Millions of Trees Club, and Herekala's landless poor perfected mass planting techniques that have led to the propagation of 400,000 trees in the Herekala area.

During this time Soans evolved what he calls a "dynamic partnership" between the country's educated youth and the marginal farmers and landless labourers of the rural areas. Other People's Nurseries sprang up throughout the West, and Soans declared his goal to be peasant-run nurseries located every 16 kilometres along the coast:

"We believe that provided there is a will, a methodology, and an organization, every human settlement can become a man-made forest.....The aim is to raise enough fuelwood and pulpwood in every village to meet local, urban and industrial consumption without touching existing forests."

Each nursery is run by a marginal farmer who typically owns two hectares of degraded, unproductive land. Supplied with seeds, capital, and expertise, each nursery raises hundreds of thousands of seedlings for distribution to neighbouring communities. In the process, the farmer becomes a local expert on arborization, sharing his knowledge with the 20 to 30 manual labourers who plant the seeds and protect the seedlings.

In 1980, the Millions of Trees Club inaugurated the first of several Van Vigyan Kendras or afforestation training centres. These centres, located amid clusters of People's Nurseries, co-ordinate nursery activities and serve as clearing houses and training centres for local farmers and youths. Run by the nursery farmers themselves, the Van Vigyan Kendras are intended to evolve into independent and self-sufficient societies. By 1984, India had 15 People's Nurseries as well as Van Vigyan Kendras in the villages of Muloor, Harekala, Tumkur, Kodaikanal, and Rajapudukodi.

In October 1985, the United Nations Environment Programme provided $35,000 for a two-year "Pilot Demonstration Project of Community Afforestation and Training in Southern India." The project was intended to further the objectives of the People's Afforestation Movement; to promote awareness of the causes of and solutions to environmental degradation; to organize reafforestation activities at the national level; and to make people self-sufficient in timber, fuelwood, fodder and cash crops.

The project included the following:

- Stengthening of afforestation training centres at Herekala, Muloor, Tumkur, Kodaikanal and Rajapudukodi;
- Training courses for farmers and school children in propagation and planting techniques;
- Demonstration planting of various tree types by labour brigades;

- Extension work 1) with farmers to set up People's Nurseries and 2) with schoolchildren to establish seed-beds;
- Establishment of model Womens' Nurseries, with the assistance of extension agents and the project co-ordinator;
- Production of a 20-minute television film on training and planting activities;
- Development of commercial outlets for seedlings;
- Stimulation of public awareness through written and audio-visual materials; and
- Visits by journalists in order to stimulate the interest of government officials and potential donors.

In the past year, seeds and saplings have been distributed to the five Van Vigyan Kendras. Several factors have increased publicity for the programme. UNEP released its television film on reafforestation activities; the Prime Minister declared his support for the People's Afforestation Movement; and the Millions of Trees Club was awarded the prestigious K.P. Goeke Award for Environment.

In March of 1986, Soans announced a "nationwide crusade" to reafforest every one of India's 500,000 villages. In addition, the Millions of Trees Club is developing the first of several Nature Education Schools in Kodaikanal. For these and other activities, Soans has solicited support from donor agencies and interested individuals.

Potential donors and interested parties may contact the G.G. Soans Memorial Farmers' and Rural Afforestation Training Centres, Sira Gate, Tumkur 572 106, Karnataka State, India.

Sudan national seminar on desertification control

Twenty-seven representatives of ministries, technical departments, universities and UNEP/DECARP attended a National Seminar on Desertification Control in Khartoum, 1 to 2 March 1986, to analyse desertification in Sudan and to make recommendations on how to address this complex issue.

The meeting reviewed the progress of the Desertification Control and Rehabilitation Programme (DECARP) since 1976, and agreed that the issue of desertification in Sudan called for a coherent inter-sectorial approach within the framework of a national plan of action which will catalyze and co-ordinate desertification combat activities in Sudan.

Under scrutiny was the draft of such a plan - The Sudan National Plan of Action for Desertification Control - drawn up by the Sudanese authorities and UNEP which, after some debate and several amendments, was adopted by the Seminar. The Action Plan will provide the Sudanese Government with a national framework for the co-ordination of on-going projects and the integration of all new desertification projects.

Also under discussion was the national mechanism for co-ordinating the implementation of the Plan and ways and means of strengthening co-ordination between the different ministries and technical offices at the decision making and technical levels. To assure a better co-ordination, it was decided to strengthen the mandate of existing institutions within the draft plan, in line with recent Government resolutions.

The establishment of a national computer-based Geographic Information System (GIS) was also discussed, and the seminar recommended that the development of technical resources should be undertaken by the Sudanese Government, with assistance from UNEP, using the National Council for Research (NCR) as a focal point for activities. As a result, UNEP is considering a project to assist Sudan and, once all approvals are obtained, expects to be working with a co-ordinating group from the Sudanese ministries, in order to centralise and integrate sectorial data bases on natural resources as well as develop analysis tools for natural resource planning.

The Seminar also proposed that the following new project ideas should be considered within the Action Plan:

- Using the excess water from irrigation canals to flood adjacent areas in order to improve fodder production and tree cover;
- Careful development of the link between land-use planning and desertification control; and
- Increasing the number of farmers chosen to try out the improved mechanized rain-fed package, and increasing the sites of these trials to include the Umajaja area.

To conclude, the Seminar recommended that three priority actions should be undertaken immediately by the Sudanese Government with the help of UNEP. They are:

1) Adoption and implementation of the National Plan of Action;
2) Strengthening of the national mechanism for the co-ordination of activities under the Plan; and
3) Establishment of a national computer-based Geographic Information System.

Chinese training course examines desertification control in Ethiopia

- Ethiopia, once almost half covered by trees, is now forested over only three per cent of its land area.
- The country's highlands, home to 88 per cent of its population, 90 per cent of its economic activity, and 95 per cent of its cultivated land, lose 3.5 billion tons of topsoil per year due to drought and poor land management practices.
- The burning of animal manure as fuel has lowered the amount of available fertilizer and hence the productivity of agriculture. This is aggravated by irregular rainfall and continued reliance upon marginal farmland.

These are some of the issues that confronted participants in a UNEP-sponsored three-week trajning course on desertification control held in Addis Ababa between January 8 and 19, 1986. Run by Chinese agricultural experts from the Institute of Desert Research, Lanzhou, the course comprised three weeks of meetings, field trips and lectures on the desertification and reversible degradation of Ethiopia's farmlands.

The first week was spent in meetings with representatives from the Ministry of Agriculture. Here participants discussed the state of Ethiopian agriculture and various steps being taken toward re-afforestation, conservation training, and the development of rangelands and irrigation.

The second week consisted of field trips to regions affected by land degradation. In the highlands, where rainfall is abundant, the group noted that management practices including terracing, water storage, and agroforestry could improve yields and protect against landslides and

water erosion. Pressure on the highlands, it was observed, could also be eased by improved water management and agricultural development of low-lying areas. In the Debrasina-Epheson region, hard-hit by drought, the group recommended that cropland uses be replaced by rangeland and pastoralism, and that the area strive for self-sufficiency in food, water and forage. Although these field trips exposed participants to varied examples of human pressure on agricultural lands, they unfortunately bypassed areas of desertification per se.

The third week of the course comprised lectures and video presentations. Topics covered included the causes, detection and combat of desertification, particularly as caused by wind erosion.

Course participants concluded that, in Ethiopia, reversible degradation is more of a problem than actual desertification. It was felt that improvements in land use and water management could restore vegetation after as little as one rainy season.

UNEP Contributes to US Policy Development

In March 1986 Mr. Dan Greenway of the Geographer's Office of the US State Department visited Kenya as part of a fact-finding tour. Mr. Greenway was gathering first hand information on desertification in Africa to assist the United States in formulating its policy on how to deal with the problem.

After being briefed in the offices of the Desertification Control PAC, a staff member accompanied Mr. Greenway and Mr. Edward Bittner, the United States Permanent Representative to UNEP, to northern Kenya for a tour by light plane of areas undergoing desertification. Dr. Walter Lusigi, a UNESCO expert and Technical Advisor to the West German funded Kenya Arid Lands Research Station (KALRES), accompanied the group and provided information on the more than ten years experience he has had in the area as former co-ordinator of the Integrated Project on Arid Lands in Marsabit District. IPAL was part of the Man and Bioshere programme of UNESCO and the first four years of the project was funded by UNEP (1976-1980).

After detailed discussions with UNEP and UNESCO officials, Mr. Greenway said that he had learned a great deal about land degradation problems and that this new knowledge would assist him greatly in preparing his report and recommendations to the State Department on policy in Africa directed towards combating desertification.

In a related development, Mr. Robert N'Daw, DESPAC's director, also visited the KALRES area and UNEP is now formulating a project proposal to assist KALRES in implementing the Management Plan which was an output of the IPAL project.

Fouta-Djallon development project under review

The Fouta-Djallon Massif in Guinea is currently the focus of an OAU-sponsored development project, "Integrated Development of the Fouta-Djallon Massif." According to Dr. Ousmane Sylla, Guinea's Minister of Natural Resources, Energy and Environment, the project has three aims:

1. Improvement of the living conditions of the inhabitants of the Fouta-Djallon region;

2. Use of soil and water conservation measures to permit more efficient natural resource utilization, and thereby contribute to drought and desertification control; and

3. Encouragement of co-operation and joint programming between the countries in the region.

On March 25 and 26, 1986, the Government of Guinea and the International Coordinator of the OAU convened two meetings in Conakry, Guinea to discuss the project. Participants included representatives from the OAU, the Government of Guinea, and other institutions including UNEP, the FAO, and the World Bank.

The first meeting was a technical evaluation of Phase I of the project, an investigation of the potential for water resources development in the Massif. Despite delays in the establishment of hydrological and climatological stations, the meeting noted that 80% of this phase's objectives had been met. Participants stressed the regional nature of the project, recommending that 1) the project acknowledge other such activities in the region, to avoid duplication and to benefit from acquired experience; and that 2) neighbouring governments commit themselves further to its development and implementation.

The second meeting was a "sensitization" effort intended to mobilize international support for the second phase of the project. Most representatives expressed a willingness to participate further, either on a regional or bilateral level, but were uncertain about the extent of their commitments at this time.

Inter-Agency Working Group Holds Second Ad-Hoc Meeting

On 18 to 20 March 1986, the Inter-Agency Working Group on Desertification (IAWGD) held its Second Ad-Hoc Meeting at UNIDO headquarters in Vienna. Attending were representatives from the following IAWGD member agencies and organs: Economic Commission for Africa (ECA); Economic and Social Commission for West Africa (ESCWA); Food and Agriculture Organization (FAO); International Labour organization (ILO); UN Environment Programme (UNEP); UN Educational, Scientific and Cultural Organization (UNESCO); UN Sudano-Sahelian Office (UNSO); UN Industrial Development Organization (UNIDO); World Meteorological Organization (WMO); and the World Bank.

The meeting's agenda included the following items: reporting on follow-up actions on the programmes agreed to at the First Ad-Hoc Meeting on Training and proposed Networks; preparation of a world atlas of thematic maps on desertification; and discussion of UNEP's new concentration policy in implementing the Plan of Action to Combat Desertification (PACD).

Training and Network Programmes

The secretariat of ESCAP (Economic and Social Commission for Asia and the Pacific) announced plans for an expert intergovernmental meeting, to be held in Bangkok in August 1986, to establish a regional network of research and training centres for Asia. It was proposed that UNEP prepare a project document on a component of a planned research, communication and training network for ECSWA countries.

With regard to training activities, the representative from UNESCO stressed the importance of focal point institutions and reported on UNESCO's training activities which include a training programme on integrated pastoral management of the Sahelian countries. UNIDO representatives informed the meeting of their organization's training

programmes in energy management, including alternative technologies to avoid desertification. The ILO representative stressed his organization's emphasis upon practical, grass roots training support rather than high-level seminars and training programmes.

The World Bank then announced a workshop on rural participation in natural resource management, planned for 8 to 14 June 1986, in Oslo, Norway. UNSO, which co-sponsored an international symposium on drought and desertification held in Washington, D.C. in October 1985, reiterated its support for the "sensitization" of a wide spectrum of policy-makers, educators, technicians and land-users. The FAO representative submitted a report concerning programmes on sand dune stabilization and afforestation. The Arab Center for Semi-Arid and Dry Lands (ACSAD) announced a training course on rangeland rehabilitation and management to be held in November 1986 with the co-operation of ALECSO (Arab League Educational, Cultural and Scientific Organization).

Desertification Atlas

The meeting next discussed UNEP's report on Proposed Indices to be Used in Preparation of the Atlas of Thematic Maps on Desertification and the report of the Expert Meeting on Desertification Assessment, Mapping and Database held in Nairobi, 11 to 14 March 1985. The following concerns were raised regarding the Atlas:

- That it incorporate mapping methods within the reach of developing countries;
- that the selection of indices be an outcome of pilot case studies rather than theoretical desk studies;
- that the atlas reflect socio-economic data related to desertification;
- that maps be prepared on a variety of scales and themes; and
- that the Advisory Committee investigate further the likely audience for the atlas and the availability of relevant data.

Concentration Policy

The meeting then examined UNEP's concentration policy of desertification control activities, in which the PACD focuses on selected countries or areas to achieve maximum demonstrable impact. It was felt that such a policy made it difficult for member agencies to co-ordinate their resources effectively given differences in mandates and donor preferences. The meeting suggested that a "pilot country" approach should be adopted, involving only countries selected through vigorous criteria. It was also recommended that such a policy adopt a longer time frame and work through a specific focal point, such as the Planning Ministry in each country.

To conclude, it was agreed that the Third Ad-Hoc Meeting of the Inter-Agency Working Group on Desertification should be held in March 1987.

NEWS OF INTEREST

Indian NGOs fight an uphill battle: drought, desertification, famine

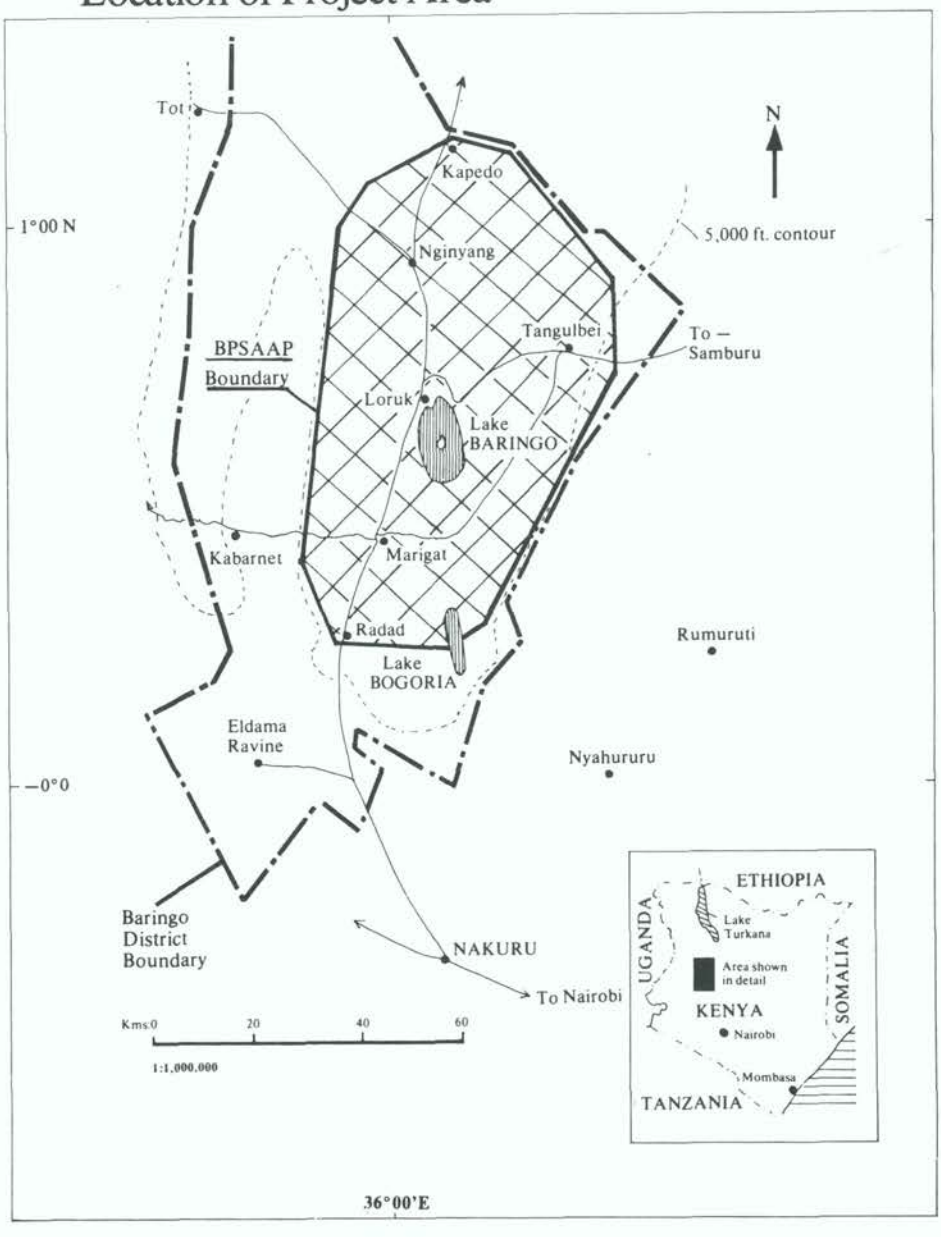
In an impressive show of unity, Indian NGOs joined forces at a seminar to thresh out solutions to alleviate worsening problems of prolonged drought, widespread desertification and famine. During 1986, some US$ 895 million have been allocated by the Government of India for projects in afforestation and soil conservation. However the problems are far from resolved.

Among the recommendations advanced by the seminar are massive afforestation activities, the nationwide introduction of agricultural practices which will make the best use of limited water and land resources, and the formulation of legislation to control groundwater pollution. Inter-disciplinary research on natural resource systems in desertifying areas was high on the agenda.

The seminar, held from 17 to 18 May in New Delhi, was organized by the Indian National Trust for Art and Cultural Heritage and the Research Foundation for Science, Technology and Natural Resource Policy in Dehra Dun. Dr.Daniel Stiles, a staff member of UNEP's Desertification Control Activity Centre, joined 70 other participants at the seminar, which was described as "the first step in mobilizing public awareness and catalyzing action by NGOs and the Government".

Dr.Stiles also presented a public lecture sponsored by the India International Centre on "Drought and Desertification in Africa and its Relevance to India".

Location of Project Area



Rehabilitating Kenya's North — the Baringo pilot semi-arid area project

Background.

Lake Baringo is located in a sparsely populated, semi-arid part of Kenya's Rift Valley. Throughout this century, the Baringo Basin has experienced severe soil erosion from a combination of natural and human factors. Steep land forms, heavy rains, erodable soils and poor land management practices have all contributed to a rate of soil loss presently estimated at 200 tonnes per year.

The area's vegetation consists of Acacias and grasses that have adapted well to harsh surroundings. Both the productivity and palatability of forage have fallen in recent years, and the number of trees has declined due to charcoal production and the grazing of seedlings. The area supports a dwindling number of cattle and small stock, the "average" number of animals owned having declined from 15.4 to 5.6 per family in the last 25 years. Rates of stock growth and reproduction are low, and trypanosomiasis and tick-borne diseases are endemic.

Reliance upon crop production remains low, although this may change as livestock raising becomes less viable. Although poorly suited to local growing conditions, maize and beans are the primary crops due to dietary preferance. Primary constraints to agriculture are

the limited supply and distribution of rainfall, poor infiltration rates, and the use of inappropriate crops.

The area's 55,000 residents are scattered unevenly, their settlements corresponding not to transportation or water supplies but to grazing patterns. Twenty-two percent of the children in the area are malnourished, particularly those whose families do not farm.

Project Development.

The Baringo Pilot Semi-Arid Area Project has its roots in Kenya's 1979-83 National Development Plan, which emphasized development in the dry parts of the country. The project's central objective was "to establish a field-tested basis for the rehabilitation and development of the semi-arid areas of Baringo District." Highly experimental in nature, the BPSAAP project was intended to be both empirical—assuring replicability in other areas—and integrative of all aspects of the area's society and economy. It was to be as decentralized, and as reliant upon local talent, as possible.

The project involved eight Ministries of the Kenya Government. Its major components were soil conservation, crop development, runoff harvesting, livestock and range management, and water development.

Project Components.

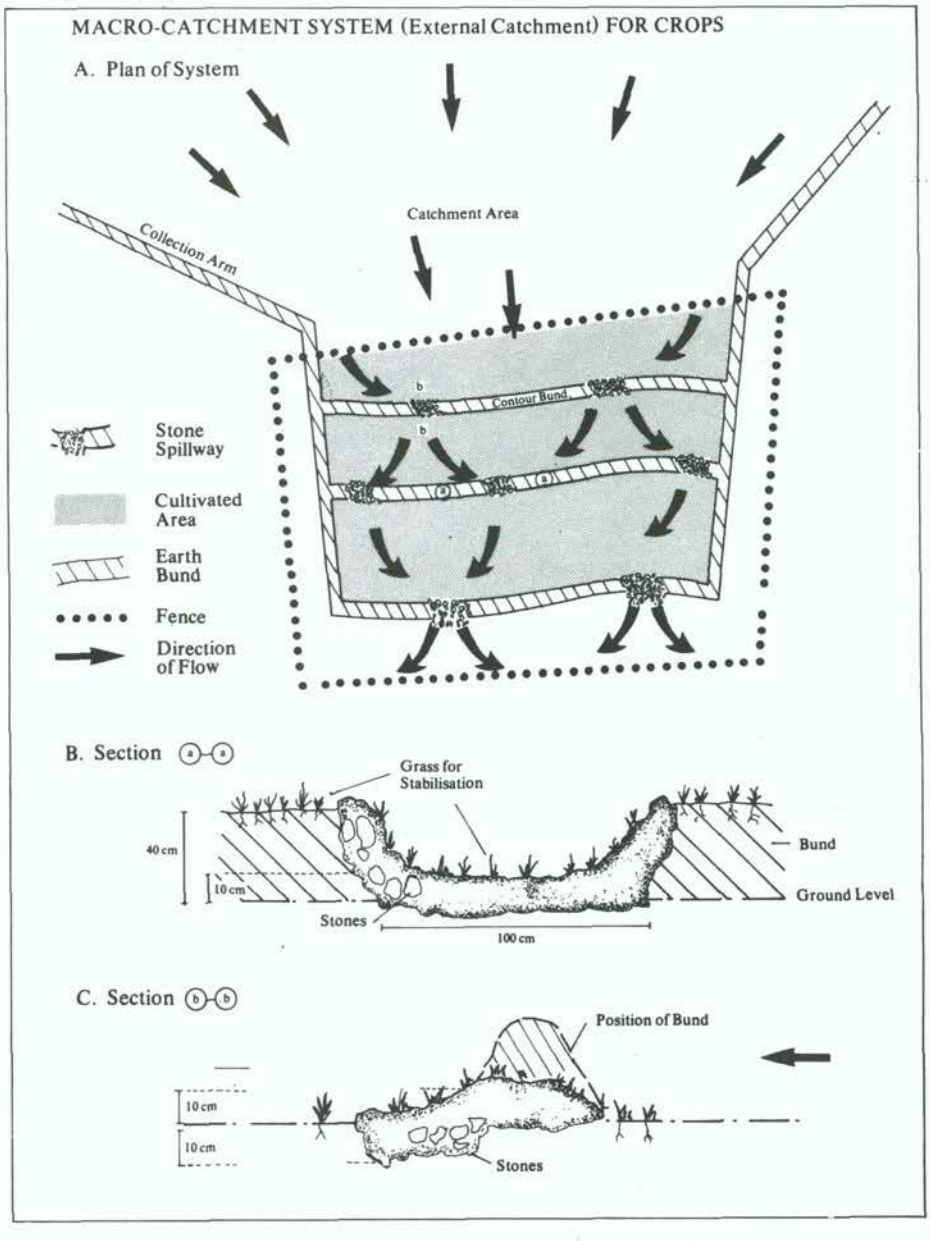
1. SOIL CONSERVATION. According to the project report, the policy of this component has been "to concentrate on simple, cheap, labour-intensive methods that require the minimum of training and supervision to implement." This means heavy concentration upon cropland terracing and the stabilization of gullies though check dams and gabion weirs. These activities as well as preventative measures have relied heavily upon volunteer "Harambee" labour, necessitating rapid completion time and the appearance of tangible benefits.

2. CROP DEVELOPMENT. This component was designed to improve food security by introducing low-input, highly-stable cropping and soil protection techniques. Farmers were encouraged to increase production of food, rather than cash crops, and to introduce fruit trees and drought-resistant sorghum, cow peas, and tepary beans. BPSAAP staff estimates that simple low-cost techniques such as donkey ploughing, live windbreaks, and using handmade, local equipment could double crop production. Unfortunately, local farmers have rejected many of these as "inferior technology."

3. RUNOFF HARVESTING. Also called "water harvesting," this is an ancient system that is nevertheless new to Kenya. It increases the water available for plant growth while preventing soil erosion, and is particularly useful in areas such as Baringo that experience high-intensity storms and poor water infiltration. There are two kinds of runoff harvesting: macro-catchments and micro-catchments.

Macro-catchments trap runoff from outside a cultivated area and direct it to the cultivated area. These involve a series of *collection* and *contour* bunds for trapping and impounding runoff, respectively. Bunds are dirt ridges that are constructed by hand and contain stone spillways for removing excess water. *Micro*-catchments, alternately, are much smaller and are designed to trap only water within the cultivated field. They are cheaper and

Runoff Harvesting



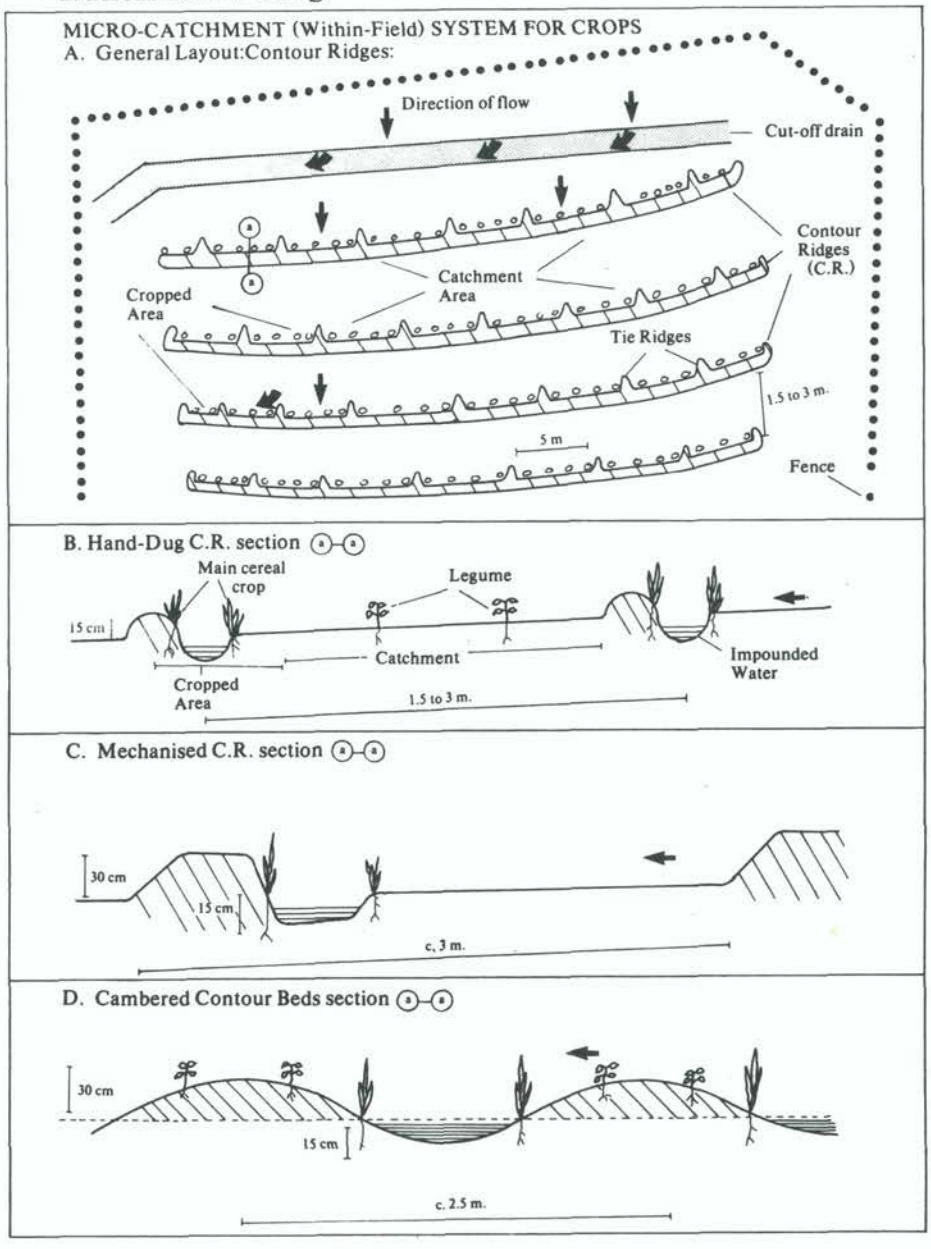
easier to build, but do not utilize heavy rainfall as efficiently.

Demonstration trials of runoff harvesting systems have increased sorghum yields 2.3 to 3.4 times, and cowpea yields 3.5 to 7.7 times. Despite the obvious benefits of this technology, farmers have been reluctant to adopt it, due to the increased land and labour requirements involved. More work is needed to improve the acceptability of these systems and to train farmers in their use.

4. RANGE MANAGEMENT. Rangelands cover 95 per cent of the Baringo project area and experience the greatest erosion. The seeding and rehabilitation of these areas requires effective fencing and cooperation between local herders to limit grazing. This, in turn, requires incentives: demonstration of the feasibility and effectiveness of the techniques, in terms that everyone can understand; the maintenance of attractive prices and reliable markets; and an equitable legal framework for the system.

One encouraging development in this area is the increase in private control over ranch lands and livestock marketing—evidence of the greater responsibility being shown by individuals and local committees for this sector.

Runoff Harvesting



5. WATER DEVELOPMENT. This component has not yet had a significant impact on the area's water supplies, two constraints being inadequate funding and inadequate volunteer participation. The BPSAAP project report recommends a mixture of pans, subsurface dams, and piped water schemes to meet water demand, two-thirds of which is for livestock and one-third for human consumption. By September 1984, over 3278 check dams and 27 gabion weirs had been built, protecting an estimated 60 kilometres of gullies.

Work is also underway on catchment protection and rainwater harvesting schemes.

6. OTHER SECTORS. Tree planting is vital for soil conservation as well as to assure a reliable supply of timber, fuelwood, and fodder. Other important issues for the Baringo area include land tenure (a necessary incentive to ensure durable land improvements) and basic agricultural education.

Evaluation.

A BPSAAP quarterly report somewhat simplistically noted that "nothing that was planned was achieved and nothing that was achieved was planned." In fact, although it has fallen short of its goal of establishing a complete field-tested basis for the semi-arid areas of Baringo, the project has met most of its objectives — particularly in the areas of livestock and range management.

The resistance of the local people has been attributed to several factors. These include reluctance to invest time and land in activities with dubious payoffs, dietary preferances for ecologically-unsuitable crops such as maize and beans, and misperceptions regarding the role of "high technology" in development. Most such resistance can be overcome through additional training. The idealism of Kenya's Harambee ("Pulling Together") programme is seldom sufficient motivation for long-term projects, for participants also require appeals to their self-interest and the assurance of their physical and financial security.

Finally, the decentralized nature of the BPSAAP project and the use of a cautious empirical approach have provided valuable insights into its application in other areas. Although BPSAAP's efficiency and speed have suffered, the Baringo Project has succeeded as a "Pilot" experiment. It now remains to translate the lessons learned at Baringo into successful management programmes in other semi-arid regions.

To restore rangelands

Harold T. Wiedemann, PE
Texas Agricultural Experiment Station
Vernon, TX 76384

While aerial seeding of depleted rangeland to improve grasses can substantially increase forage production, this requires an improved aerial seeding method, a positive metering system to use in the aircraft, possible aerodynamic seed modification, plus a practical method of preparaing the ground to receive the seed.

Timing of the aerial seeding in relation to rainfall is critical. Stands may be reduced by 80 per cent, for example, on seed-beds crusted by rainfall compared to seeding on freshly prepared seed-beds.

Thus the first challenge becomes: How to achieve practical seed-bed preparation, particularly when the rangeland is too littered with debris to allow disking with ordinary disk ploughs? A problem in restoring grasslands in many arid and semi-arid regions is that the shallow soils, often of minimum fertility, cover hilly lands dominated by weeds, underbrush, and other scrub vegetation.

Various colleagues at Texas Agricultural Experiment Station — and particularly B.T. Cross — plus colleagues at Texas A & M University, USDA-ARS at Woodward, OK, and with the USDA Forest Service have joined me in seeking to develop a practical system of ground preparation prior to aerial seeding.

The Disk Chain Design

In the 1960s the huge King Ranch here in Texas had developed a device for reclaiming rough lands. Disk blades were welded to alternate links of an anchor chain: swivels attached to either end of the chain allowed that chain to be pulled diagonally between two crawler tractors over rough ground and debris. This concept had proved itself — but we hoped to simplify it for use where the possibility of providing two crawler tractors and operators would be impractical. Cross has worked with me in developing this triangular anchor chain and disk blade implement.

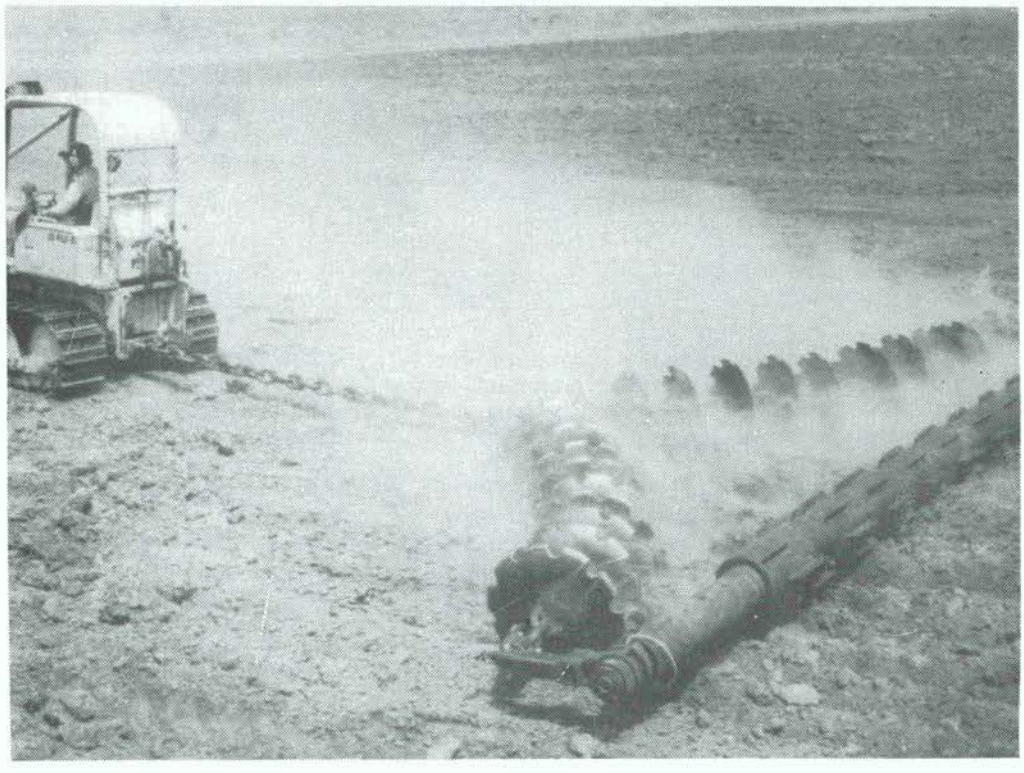
The 60-deg pulling angle we settled on for the disk chain requires less pulling force than other configurations we tested and results in greater operating width. A disk chain with 610-millimetre disk blades and 33.6 kg/blade gave adequate operating mass and required significantly less draft than heavier units we have tested. This disk chain pulled in the triangular configuration resulted in a draft of 667 N/blade at 4.4 kilometres per hour. The triangular pulling configuration reduced the pulling force by 36 per cent and increased operating width by 23 per cent compared to diagonally pulled disk chain configurations we had tested.

Considerable work lies ahead in developing specifics on blade and chain size; specifics of pulling the disk chain through various types of soils and vegetations to achieve maximum results; and on practical low-cost fabrication of the disk chain. However, the potentials this system can offer in reclaiming poor lands around the world hopefully mandates this additional research. Fig. 1 shows our experimental implement and the soil pattern it creates. Note how the diagonally pulled anchor chain has disk blades welded to alternate chain links to provide the disking action at costs closer to that of chaining.

Seeding by Air

With the specifics on how to achieve practical seed-bed preparation firming up, the challenge became that of how to deliver the seed accurately. A few aerial seed metering devices already on the market are successful for seeding certain types of grasses. Our challenge, however, was to develop a system that would permit accurate aircraft seeding of high quality grasses.

While hard, slick seed flows well through the hopper gate opening to make aerial seeding practical at high seeding rates, seeding small slick seed such as kleingrass or lovegrass becomes erratic because of the small opening at the hopper gate. Grass seed



The triangular disk chain is dragged through a test plot to ready it for aerial seeding. (Photo by H. Widemann)

chaffier than sideoats grama such as bluestems and buffelgrass (a hardy forage used extensively in Texas and in Mexico, South America, Africa and Australia) have not metered successfully from aircraft because their seeds bridge the hopper gate opening to hault the seed flow. Thus the challenge becomes how to accurately meter those chaffy seeds of high quality grasses from the air.

The aerial grass seed metering system described here appears promising. It is being tested in co-operation with Chet Dewald of the USDA-ARS Southern Plains Range Research Station. Other researchers are exploring various devices for specific types of aerial seed metering.

The Air Seed Shucker

To handle that bridging problem with bluestem seed and other chaffy seed, Oklahoma rancher/inventor Aaron Beisel, working with USDA-ARS, has developed a seed shucker that strips apendages from chaffy bluestem seed to permit accurate and apparently trouble free metering. A commercial unit developed from that first seed shucker concept is now available — it can handle about 4.5 kilograms per hour.

The seed shucker includes a power unit (nozzle, mixing chamber and venturi muzzle), recycling tube, cyclone air separator, and classification cylinder. Compressed air at 275 to 620 kPa enters the power unit nozzle and travels through the mixing chamber to exit via the venturi muzzle.

Air-entrained chaffy seeds entering the mixing chamber are stripped of their chaff through the air blast and through the force of acceleration. Because the clean grain (caryopses) is more dense than the chaffy seed, the cleaned grain falls from the classification cylinder. Seed not shucked on the first cycle passes through the system to re-enter the venturi muzzle again and again — until shucking is complete.

In laboratory tests a 10 gramme sample has been cleaned in less than a minute with no damage to the seeds — a problem with hammermill cleaning. Cleaning times of course vary with different grass species. The shucking technique reduced the bulk seed volume by 97 per cent.

Through these and other tests our goal of allowing the agricultural aircraft to carry a load of hulled seed suitable for reseeding 160 hectares becomes closer. Flying time then becomes the limiting factor rather than hopper load. Laboratory and field tests have established a relationship between flow rate and rotor speed up to 125 rpm for various grasses. These test results are helping greatly in field calibration of the system.

Three sites have been selected for aerial seeding studies using two rates of WW Spar bluestem hulled by the air-impinging device. Those aerially seeded plots are 305 metres by either 61 or 122 metres. Swath width is 15 metres. Each study site is about 16 hectares. The two application rates have been tested with four methods of seed-bed preparation at each site.

In these aerial tests seed lots are weighed before and after each flight to determine the amount of seed dispensed. Applications have been made with a Cessna AG-Truck aircraft equipped with a positive metering system and a Transland Slimline spreader. Air speed has been maintained at about 160 kilometres per hour. In these tests cotton seed meal was mixed with julled bluestem seed at a 1:1 w/w ratio to lower the seed flow rate from the metering rotor. With this mix the rotor speed has been great enough to maintain uniform output and still provide a low seeding rate. The seeding rate accuracy in these experiments has been exceptionally good, an average coefficient of variation of four per cent for the 27 test plots.

One study in which kleingrass was seeded on 27.4 hectares gave a good indication of commercial potential. It appears from this test that the minimum speed of the motor driving the vane rotor should be 500 rpm; uniform seed output cannot be maintained at a lower rpm. System operation could be further improved if the rotor is modified so that motor speeds of 1000 to 2000 rpm are normal and bulk carriers are not necessary.

The Potential

The aerial dispensing of aerodynamically modified chaffy seed through positive metering systems is one of the most promising advancements in the grass seeding industry. This optimism is based on the assumption that caryopses obtained by modifying chaffy grass seed may be used without seriously affecting seed germination, emergence, and stand establishment.

Because of the nature of grass seed, every seed lot differs slightly and meters differently. Being able to calibrate an airplane on the ground in a few minutes and then to dispense load after load with little variation will be a welcome achievement in aerial grass seed application.

Reprinted from *Agricultural Engineering,* November 1985, with permission from the author.

The Australian Revegetation Corporation: an Integrated approach to agricultural rehabilitation

The Australian Revegetation Corporation (ARC), a group of companies based in Perth, Western Australia, is playing a broad international role in the rehabilitation of arid and semi-arid lands. Founded in 1970 by Stephen Hill, a graduate in Agricultural Economics from the University of New England, the A.R.C. has expanded its operations to the Middle East, North Africa, and Southeast Asia. The Corporation's three component companies provide seeds, rehabilitation technology, and consulting services in "turn-key packages" designed to maximize recipient involvement and complement existing aid programmes:

- Kimberley Seeds is a major producer, supplier, and trader of seeds worldwide. Aided by a computerized data base, Kimberley distributes species suitable for fodder, soil stabilization, afforestation, and fuelwood.

- Australian Revegetation Machinery provides specialized seeding equipment designed to improve germination and establishment while minimizing seedbed erosion. The company also supplies tree-planting and seed-processing equipment.

- Australian Revegetation and Environmental Consultants (AREC) supplies the expert technical advice necessary for effective use of seeds and machinery. Providing an integrated approach to agricultural production and land-use management, AREC's consulting activity focuses on: 1) rehabilitation and reafforestation through low-cost technology; 2) land-use management to minimize post-treatmentregression; and 3) training in environmental and agricultural management techniques.

According to the company, such aid provides three things: 1) *technology transfer* through training of local staff in seed production and propagation, rangeland management, and livestock husbandry; 2) *heritage protection* for future generations; and 3) *improved social stability* and increased living standards brought about by increased animal production and seed sales.

The ARC's experience includes coastal sand dune stabilization and reclamation of salt-affected farms in Australia; World Bank-sponsored development work in Thailand; irrigation research in Sudan; and missions throughout Asia and the Middle East. The company has supplied seeds to over 32 countries and numerous international organizations, and is presently the largest manufacturer of revegetation machinery in Australia.

Those interested are invited to contact the Australian Revegetation Corporation at 51, King Edward Road, Osbourne Park 6017, Western Australia, or telephone 169-446-4377.

Bhutan and Nepal acting to reverse deforestation

Bhutan. The Himalayan foothills of Bhutan stretch 550 kilometres along the Indian border. Subtropical and tropical vegetation cover 61 per cent of this region, one of the most important wildlife sanctuaries in the country.

Until recently, the foothills were threatened by population growth, industrial development, and the uncontrolled harvesting of teak and sal forests. The Government of Bhutan is acting, however, to stop this degradation. The United Nations Economic and Social Commission for Asia and the Pacific reports that:

A low cost vacuum seed harvester used for collecting seeds for replanting. (Photo by John de Sallis)

- Bhutan is implementing a comprehensive afforestation programme with a fund of US$ 6.8 million;
- A strict ban is being enforced against the commercial planting of teak—which has devastating effects on undergrowth and topsoil—and the commercial felling of trees;
- Encroachment of settlements and cultivation is forbidden, and;
- Schools and communities are running extensive campaigns to promote social awareness of the problem.

Nepal. Nepal's forests, meanwhile, provide 87 per cent of the country's energy needs, 20-25 per cent of its livestock fodder, and all of its domestic timber. Because of the intense demand upon forest resources, it is possible that all accessible woodland in Nepal will disappear within 20 years—unless massive forestry management programmes are undertaken.

According to ESCAP, the Nepal Government has integrated the following environmental policies into its Sixth Five-Year Plan:

- Control over afforestation, fertility, and soil erosion in the country's watersheds;
- Studies and surveys of endangered wildlife, and the establishment of wildlife conservation centres and national parks;
- Environmental impact assessment of large-scale engineering projects;
- Limitations on land uses within irrigated areas;
- Environmental education programmes on natural resource protection and balanced land use; and
- Establishment of a National Council for the Conservation of Renewable Natural Resources.

By bringing land use into balance with the environment, the Plan intends to remedy most of the forest management problems facing the country.

China's "Green Wall" against desertification

Millions of Chinese are participating in a drive to plant a 7,000-kilometre long stretch of trees to halt desertification in northern China. This region, which stretches from Heilongjiang Province in the northeast to Xinjiang in the northwest, encompasses one quarter of China's land mass.

The UN Economic and Social Commission for Asia and the Pacific (ESCAP) reports encouraging results in this once-threatened area. Thus far, six million hectares of farmland belt, sand dune-fixing forests, and soil and water conservation forests have been planted. This has resulted in the protection of 6.7 million hectares of farmland and 3.4 million hectares of pasture. Crop yields in this area have increased by 20 per cent.

The second phase of the "Green Wall" project (1986 to 1990) will green another 6 million hectares. This will increase vegetative cover in

the Heilongjiang-Xinjiang belt to 7.5 per cent.

Between 1949 and 1981, China established some 28 million hectares of timber-producing forests, economic forests, and shelterbelts at an average rate of 869,000 hectares per year. ESCAP reports that the country's forest cover increased from 8.6 to 12 per cent during this time.

Which Tree

Which tree? Where?

Finding the most suitable species and provenance for a particular site is a puzzle for many foresters. The problem is especially serious in the many countries which are experiencing fuelwood shortages.

In some places native trees can be utilized, but in many locations introduced species offer greater productivity. Selecting appropriate trees for fuelwood trials is complex, as many promising species have not been widely tested.

New methods of climatic analysis being developed in Australia can assist in identifying species for testing. The techniques use recently developed mathematical methods, which can provide accurate estimates of long-term monthly mean temperature and rainfall at both natural and trial sites. This information can be used to develop detailed descriptions of species' climatic requirements.

Foresters have, of course, used climatic matching methods for many years, but the new methods can take much of the guesswork out of the procedure. Other factors, such as socio-economic needs, soil conditions and pest/disease hazards, must still be considered, but the climatic analysis can greatly simplify the problem.

More information on the methods can be obtained from Dr. Trevor H. Booth, CSIRO Division of Water and Land Resources, P.O. Box 1666, Canberra, ACT 2601, Australia

Dambo preservation through "contour spreader seepage furrows"

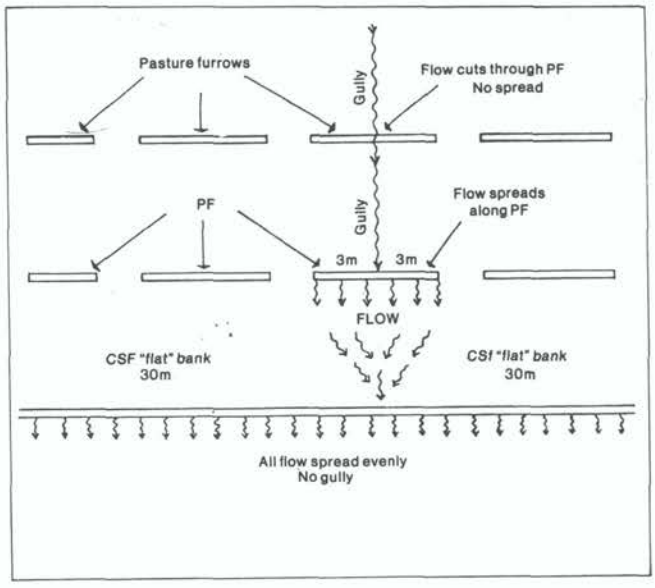
Dambos are treeless wetland areas bordering watercourses. These areas are vital to maintaining both the flow and the ecological balance of a stream; acting like giant sponges, they absorb moisture during rainy periods and during the dry season release it slowly to the stream below.

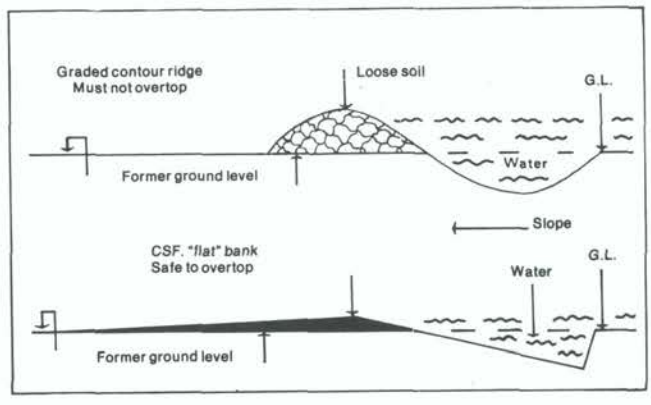
Dambos are valuable lands for cultivation and grazing, particularly in countries such as Zambia where they constitute 30-40% of the total land area. Unfortunately, human use of these areas has led to serious soil erosion in many cases.

Jack Hindson, a former Zambian Conservation Officer, proposes an unorthodox yet efficient means of protecting and restoring these wetlands. His "contour spreader seepage furrow" (CSF) method is based upon a series of miniature furrows constructed along the contours of a dambo and running from one end to the other.

Unlike conventional drainage furrows, which are designed to remove runoff and discharge it elsewhere, CSF's are intended to dissipate and absorb these flows. As the figure illustrates, a CSF bank functions as a grass spillway: water collecting in each furrow will spread sideways 100 to 200 metres before overflowing and trickling down the grassed slope. This process dissipates the erosive strength of the water and encourages greater seepage into the subsoil.

Hindson emphasizes that with occasional maintenance, CSF-treated dambos may be cultivated and grazed easily.





The trapping of silt on the dambo banks not only restores soil fertility but reduces siltation of dams downstream.

A major advantage to this technique is its ease of implementation. The C.S.F. method is simple for villagers to understand, and it relies heavily on neither money nor machinery. The margin of error for the method is so great, Hindson claims, that "even if a big mistake has been made, no harm can possibly come to the CSF in question."

Despite his success in Zambia, Hindson remarks that no one else has yet tried his method or attempted a full-scale hydraulic analysis of its design. His advice: "Try it out for yourself. Choose a small gully which flows gently when it rains, and make one or more CSF's across it, 20 metres to either side of the gully. Firm the loose soil and allow the bank to grass over. It is easy to extend the furrow dead level by eye if a little water is standing in the furrow."

Combating drift sands in the Ukraine

By Nikolai Nesvitenko, Novosti correspondent

The use of the new Soviet technique of consolidating drift sands has made it possible to cultivate vast tracts of sandy lands in the lower reaches of the Dnieper in the Ukraine. Today cereals, grapes and fruits are grown here. Those lands have become the venue of international courses of specialists from Afro-Asian and Latin American countries on the problems

"Afforestation and Consolidation of Drift Sands" and "Assistance to Training in Combating Desertification through Integrated Development", sponsored by UNEP's Desertification Control Programme.

Tracts of sands in the lower reaches of the Dnieper were once called a local Sahara. Dunes and dust storms gradually turned adjacent fertile lands into a desert.

In the 18th and 19th centuries, attempts were made to combat sands in the lower reaches of the Dnieper through setting up protective pine belts. But there was no experience in afforestation of sandy soils and insignificant funds were earmarked for such purposes. Therefore, all these attempts produced no appreciable results.

Soviet scientists have solved the problem of consolidating and cultivating sands in the lower reaches of the Dnieper. This has become possible thanks to forests grown here by man. Over 20,000 hectares of sands are now covered with fields, orchards and vineyards.

The gist of the new technique of afforestation on sands is deep loosening of soil with the simultaneous application of fertilizers, said Vitaly Koptev, Deputy Director of the Ukrainian Research Institute of Forestry and Agronomical Forest Amelioration.

A tractor moving on the tract of sand carries out the mouldboardless belt preparation of soil to a depth of 50 to 60 centimetres for planting pine seedlings. At the same time, hexachlorane, an agent for combating cockfather larvae, is put into the soil. The upper sand layer can also be disked, and herbicides and fertilizers can be applied. Pine seedlings are planted in spring when sand is rich in moisture after the snow melts. Then the soil is systematically loosened in space between rows. This improves its porosity, as well as the water, nutritive and temperature regime, and stimulates development of the roots of seedlings, which makes for their better acclimatization.

Some 100,000 pines have been planted on sands in the lower reaches of the Dnieper. The forest has stopped the sands, has barred the way to sand storms and dry winds, has minimized the danger of new sites of erosion appearing, and improved the wind, temperature and water regimes. Water bodies have been created in the sands, which makes the microclimate milder and contributes to the shapping of new zoophytocenoses. Animals, birds, insects and plants are appearing here, something which was out of the question in the past.

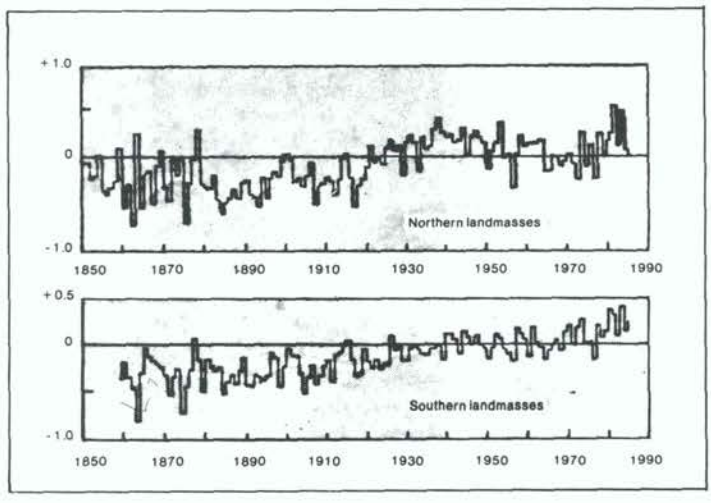
There is another important aspect. Due to sanitary cuttings 50,000 cubic metres of timber is produced here annually. Every year the processing of timber waste yields over 2,000 tonnes of coniferous-vitamin flour for livestock farming, 35 to 40 tonnes of medicinal coniferous extract and more than 700 kilograms of ethereal oil.

New pine species have been bred in the USSR for planting in sands which develop more intensively. For example, at the age of two years they are 14 per cent taller than ordinary pines and the diameter of their trunk is larger by 20 per cent. Techniques of afforestation are improving.

Global warming is linked to Sahel drought

The World is warming up as fast in the southern hemisphere as in the northern hemisphere, according to recent data on world temperatures collected by British scientists. The warming has been linked to retreating glaciers and African drought. It may be a consequence of the "greenhouse effect" due to increased amounts of carbon dioxide in the atmosphere.

Temperature measurements from around the world are collected and collated by a team at the Climatic Research Unit of the University of East Anglia, as part of a project funded by the US Department of Energy. The group has also been gathering and interpreting the best available historical records of temperatures both north and south of the equator. They believe that their latest figures, which suggest that the warming has been going on for most of this century, are the best yet — especially for the southern hemisphere.



The apparently large variability from year to year in the graphs for the early years reflects poor coverage at that time, but the long-term trends are reliable. The graphs show both hemispheres warming by about 0.5°C in two stages; from 1920 to 1940, and in the past few years.

The early 1980s were the warmest years in both hemispheres. A cooling in 1984 and 1985 in the northern hemispheres fits in with computer predictions of the effect of the eruption of the volcano El Chichon in Mexico in 1982. Volcanoes send huge amounts of dust into the upper atmosphere and so reduce the heat reaching the Earth's surface. This does not prove that the computer models are right, but it is encouraging for the modellers.

Independent confirmation of the warming trend comes from a new analysis of the retreat of mountain glaciers over the past 150 years. Climatologists have been puzzled that glaciers around the world should have shown such a marked retreat. However, J. Oerlemans, of the University of Utrecht, has been investigating the behaviour of glacier tongues in mountain valleys, and finds that they are particularly sensitive to the carbon dioxide greenhouse effect.

Oerlemans says that even a small "surplus" of infrared radiation in a valley partially filled by glacier ice can have a profound effect on the glacier. This is because the increased temperature of the unglaciated part of the valley causes a strong transfer of energy horizontally, which encourages the ice to retreat.

This effect disappears when the valley is completely glaciated, but it could explain why glaciers might be very good indicators of climatic changes induced by small shifts in the radiation balance of the Earth. These are exactly the kinds of shifts that result from the trapping of infrared radiation in the Earth's atmosphere because of the build-up of carbon dioxide and other trace gases, derived from human activity.

Recent concern that the continuing droughts in the Sahel region of Africa may

represent a long-term climatic shift also receives support. This evidence again seems to tie in with global warming.

Scientists from Britain's Meteorological Office have compared recent changes in ocean temperatures with the occurrence of wet and dry years in the Sahel, the part of West Africa on the edge of the Sahara. They find that there is a clear link between drought years in this part of Africa and relative warmth in the oceans of the southern hemisphere and in the North Indian Ocean, taken together.

Sahel droughts happen in years when these oceans are warmer than the northern oceans. The link may be changes in the flow of westerly winds in the upper troposphere which are similar to changes in atmospheric circulation associated with the El Nio phenomenon.

This discovery places a premium on investigations into changes in ocean temperatures. The work at the Climatic Research Unit has so far concentrated on data from land masses around the globe. But the present aim of the East Anglia team is to incorporate measurements of temperatures taken at sea by ships into the expanding archive of data on temperatures.

New Intergovernmental desertification authority named

On January 15 and 16, 1986, the Governments of Djibouti, Ethiopia, Somalia, Sudan, Kenya and Uganda inaugurated the Intergovernmental Authority on Drought and Desertification (IGADD). IGADD's Programme of Action includes emergency measures and long-term plans for combating drought and desertification in the six countries, and provides an excellent example of sub-regional co-operation in this area. During the Assembly, a budget and scale of assessment were drawn up, based upon each country's GDP/capita, export earnings, population and size.

The Assembly was considered highly successful, and was attended by relevant UN agencies as well as representatives of all major donor countries. The UN is likely to play a significant role in IGADD's activities, and UNEP plans to provide the necessary input to ensure environmentally-sound policies and actions.

IFAD agrees to $500 million replenishment

After two and one-half years of uncertainty, the International Fund for Agricultural Development (IFAD) has authorized US$ 500 million in replenishment funds for the 1985-1987 triennium. Countries belonging to the Organization for Economic Co-operation and Development (OECD) have pledged US$ 300 million, and US$ 200 million has been committed by members of the Organization of Petroleum Exporting Countries (OPEC). More than one-third of these funds are destined for Africa.

In addition, IFAD's Governing Council has approved an additional US$ 300 million Special Programme for Sub-Saharan Africa. The three-year Special Programme will assist small farmers and is intended to alleviate agricultural and environmental stress in the region. Funds for the Special Programme will come from voluntary contributions and bilateral donations.

Post-graduate hydrology programme at free University of Brussels

The Interuniversity Postgraduate Programme in Hydrology at the Free University of Brussels is now in its seventh year of postgraduate instruction. Supported by the Universities of Antwerp, Ghent, and Leuven, the I.U.P.H.Y. offers one, two, and four-year programmes of study, leading respectively to a Diploma, Master's Degree, and Ph.D. in hydrology.

In 1985 the Programme enrolled some 47 students from 26 countries. I.U.P.H.Y. research activities reflect this international mix, and in their thesis work students are encouraged to address issues relating to their own countries. The recent proliferation of microcomputers at the Laboratory has permitted more data-intensive coursework, and is providing students with career skills that will be of considerable value in their home countries.

Students holding a Bachelor's degree or equivalent will be considered for admission. Classes begin on September 1, and English is the language of instruction. For further information and application materials, contact Professor Dr. A. Van der Beken, Director of the Programme, Laboratory of Hydrology, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium.

DESERTIFICATION CONTROL BULLETIN

CONTENTS OF PAST ISSUES

Desertification Control Bulletin		Article title	Author
No.1 (June '78)	i)	United Nations Conference on Desertification	Editorial
	ii)	Recommendations of the Plan of Action to Combat Desertification	-do-
	iii)	Action taken by the General Assembly on the Report of the Conference	-do-
	iv)	Action taken by UNEP towards the implementation of General Assembly resolutions concerning the Conference	-do-
	v)	Summary account of recent and current global activities related to combating desertification	-do-
	vi)	Activities proposed by organisations within the UN System concerning the implementation of the Plan of Action	-do-
No 2 (Dec. '78)	i)	Can Desertification Be Stopped?	Dr. M.K. Tolba
	ii)	Developing the Desert: the Soviet Example: A visitors view	Enid Burke
	iii)	Training Seminar in China: A participants' report	Carlos Zamora
	iv)	Follow-up to the UN Conference on Desertification. A review of activities	Editorial
	v)	Policy Statement by the Consultative Group on Desertification Control	-do-
No.3 (June '79)	i)	Desertification — The Greatest Single Environmental Threat	P.S. Thacher
	ii)	Soils Policy	
	iii)	Australia Controls Desertification	Editorial
	iv)	Pushing Back the Desert	Nina Darnton
	v)	"What the Ants Are Saying"	Don Marquis
No.4 (June '79)	i)	Sudan: An Apalling Southward March of the Sahara	James Walls
	ii)	A Search for Solutions in Chile	S. Milas
	iii)	The Negev: The Biblical Wilderness Made Productive	J. Schechter

	iv)	Malta: An Ancient Problem — Soil Erosion	S. Busuttil
	v)	Women of the Desert	Enid Burke
No.5 (Dec. '81)	i)	Combating Desertification in the Sudano-Sahelian Region	Ruben Mendez
	ii)	Are Solutions to Desertification in the West African Sahel known but not applied	M. H. Glantz M.E. Krenz
	iii)	Desertification and Desertification Control in Northern China	Zhu Zhanda and Lio Shu
No.6 (April '82)	i)	Revegetation of the Indian Desert	H.S. Mann
	ii)	Combating Desertification Around Iran's Salt Desert	Ellen Tavakoli
	iii)	Desertification Monitoring and Assessment Within GEMS	Editorial
	iv)	Additional Measures To Finance the Plan of Action to Combat Desertification	Editorial
	v)	Population Expansion and Desertification in Tanzania	M.B.K. Darkoh
	vi)	Review of the Implementation of the Plan of Action to Combat Desertification	Editorial
No.7 (Dec. '82)	i)	Environmental Degradation and Development of Arid Lands	Mark Speece and M.J. Wilkinson
	ii)	Combating Desertification in Sahelian Conditions	Yakov Orev
	iii)	The Definition, Diagnosis and Assessment of Desertification in Relation to Experience in the USSR	B.G. Rozanov and S. Zonn
	iv)	Management Issues in Controlling Negative Impacts of Irrigation in the Latin American Arid Region	Susan H. Lees
	v)	"For Every Child a Tree": Update on International Activities	Editorial
	vi)	Gobi Desert: Preserving a Unique Area.	Editorial
No.8 (June '83)	i)	Camel Pastoralism and Desertification in Northern Kenya	Daniel Stiles
	ii)	The Struggle Against Environmental Degradation — Botswana's Experience	H.J. Cooke
	iii)	Planning for Integrated Agricultural Resource Management and Development in the ECWA Region	K.M. Azam

	iv)	Stone Deserts on Africa's Roof	
No.9 (Dec. '83)	i)	Ecology and Environment: What do We Know About Desertification?	Editorial
	ii)	The Years of Drought	S.L. Milas
	iii)	Desertification: A Review and Concept	M. Glantz and N. Orbusky
	iv)	The 1982 Drought in Australia	Brian Martin
	v)	A Spatial Analogue of Potential Desertification in Swaziland	C.S. Bootsman and G.F. Schmidt
	vi)	Urbanization and Deforestation in Zambia	E.N. Chidumayo
No.10 (May '84)	i)	Harvest of Dust	Dr. M.K. Tolba
	ii)	Summons to Action	James Walls
	iii)	Recent Climatic Experience in the Arid and Semi-arid Lands	F. Kenneth Hare
	iv)	Desertification in the Sudano-Sahelian Region 1977-1984	Leonard Berry
	v)	Combating Desertification and Rehabilitating Degraded Production Systems in Northern Kenya: the IPAL Project	Walter J. Lusigi and Gisbert Glaser
	vi)	Poverty, Population Growth and Desertification	Erik Eckholm
No.10 (Oct.'84) (Supplement)	i)	Back to the War	James Walls
	ii)	Summary of the Activities and Output of the General Assessment of Progress in the Implementation of the Plant of Action to Combat Desertification	D. N. Stiles and S. S. Sangweni
	iii)	The Man Who Planted Trees	Jean Giono
	iv)	Desertification Control Training Course in China and its Relevance to Anti-Desertification Activities in Kenya	G. E. O. Ondeng'e
	v)	The UNEP/USSR Desertification Control Training Course and Application in Morocco	A. Hafdaoui
No.11 (Dec. '84)	i)	Desertification: A Question of Linkage	Daniel Stiles
	ii)	Desert Spread and Population Boom	S. Milas
	iii)	Ecological Villains Or Economic Victims: The Case of the Rendille of Northern Kenya	Michael O'Leary

	iv)	Controlling Sand Dune Encroachment in Iraq	Ferenc Gati
No.12 (Dec. 1985)	i)	Desertification of the World's Rangelands	J.A. Mabbutt
	ii)	Deforestation, Desertification and Soil Loss	Prof. M. Kassas
	iii)	Soil Erosion Problems in the U.S.A.	James Risser
	iv)	Desertification and Dust Monitoring in West Africa	Grant McTainsh
	v)	Eastern Africa's Spreading Wastelands	S. Milas and Misobework Asrat
No.13 (May 1986)	i)	Satellite Remote Sensing of Desert Spatial Extent	C.J. Tucker and C.O. Justice
	ii)	Desertification in Botswana	Susan Ringrose and Wilma Matheson
	iii)	Soil at Risk	Hon. H.O. Sparrow
	iv)	Combating Desertification in Zimbabwe	Michael B.K. Darkoh
	v)	Desertification in India: Trends and Counter-trends	Vandana Shiva and J. Bandyopadhyay
	vi)	Climatic Change and Variability in Eastern Africa	Thomas E. Downing

Photographs for
Desertification Control Bulletin
Covers

The Editor of *Desertification Control Bulletin*is seeking photographs for consideration as bulletin covers. All submissions should be addressed to:

The Editor
Desertification Control Bulletin
UNEP
P.O. Box 30552
Nairobi, Kenya

Technical requirements

Photographs must be colour transparencies of subjects related directly to desertification, land, animals, human beings, structures affected by desertification, control of desertification, reclamation of desertified lands, etc. Submissions must be of high quality to be enlarged to accommodate a square.

Captions

A brief caption must accompany each photograph giving a description of the subject, place and country, date of photograph and name and address of photographer.

Copyright

It is assumed that all submissions are the original of the photographer and all the rights are owned by the photographer. *Desertification Control Bulletin*gives full credit to photographers for the covers selected, but does not provide remuneration.

Desertification Control Bulletin invites articles from the world's scientists and specialists interested in the problems arising from or associated with the spread of desertification.

Desertification Control Bulletin is an international bulletin published at six-monthly intervals by the United Nations Environment Programme (UNEP) to disseminate information and knowledge on desertification problems and to present news on the programmes, activities and achievements in the implementation of the Plan of Action to Combat Desertification.

Audience

The bulletin addresses a large audience which includes decision makers, planners, administrators, specialists and technicians of countries facing desertification problems, as well as all others interested in arresting the spread of desertification.

Language

The bulletin is published in English. All manuscripts for publication must be in English.

Manuscript preparation

Manuscripts should be clearly typewritten with double spacing and wide margins, on one side of the page only. The title of the manuscript, with the author's name and address, should be given in the upper half of the first page, and the number of words in the main text should appear in the upper-right corner. Subsequent pages should have only the author's name in the upper-right corner.

Metric system

All measurements should be in the metric system.

Tables

Each table should be typed on a separate page, should have a title and should be numbered to correspond to its point in the text. Only essential tables should be included and all should be identified as to source.

Illustrations

Line drawings of any kind should each be on a separate page, drawn in black china ink and double or larger than the size to appear in the bulletin. They should never be pasted in the text. They should be as clear and as simple as possible.

Photographs in the bulletin are printed black-and-white. For satisfactory results, high quality black-and-white prints 18 x 24 cm (8 x 10 in) on glossy paper are essential. Dia-positive slides of high quality may be accepted; however, their quality when printed black-and-white in the bulletin cannot be guaranteed.

All line drawings and photographs should be numbered in one sequence to correspond to their point of reference in the text, and their descriptions should be listed on a separate page.

Footnotes and references

Footnotes and references should be listed on separate pages at the end of the manuscript. Footnotes should be kept to an absolute minimum. References should be strictly relevant to the article and should also be kept to a minimum. The style of references should follow the format common for scientific and technical publications: the last name (s) of the author (s) (each) followed by his initials, year of publication, title, publisher (or journal), serial number and number of pages.

Other requirements

Desertification Control Bulletin publishes original articles which have not appeared in other publications. However, reprints providing the possibility of exchange of views and developments of basic importance in desertification control among the developing regions of the world or translations from languages of limited audiences are not ruled out. Short reviews introducing recently published books in the subjects relevant to desertification and of interest to the readers of the bulletin are also accepted. Medium-length articles of about 3,000 words are preferred, while articles longer than 4,500 words are not accepted.

A reasonable fee is paid for articles accepted for publication, and 25 reprints are provided to the authors.

Printed by Printpak P.O Box 78354 Nairobi Kenya

Desertification
Control Bulletin

United Nations Environment Programmme