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Desertification Control Bulletin

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

Number 12, 1985

- 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 and 65 non-governmental 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 co-ordinating 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 to serve the Executive Director 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.

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COVER PHOTOGRAPH

It is the loss of soil that is eroding this man's future, not drought. The Ethiopian highlands are in desperate need of large scale terracing and reforestation programmes to save the productive land that is left. (UNEP/Charles Stewart)

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:

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Desertification of the world's rangelands

A Keynote address given at the Second International Rangelands Congress at Adelaide, Australia, May 1984. The Congress proceedings will be published later in 1985 by the Australian Academy of Science under the title: 'Rangeland—A Resource Under Siege'.

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Nature and Impact of Desertification

In 1977 the United Nations convened a Conference on Desertification, organized by the United Nations Environment Programme in Nairobi. It was in response to world concern aroused particularly by the effects of drought in the Sahel in the early 1970's. The *United Nations Plan of Action to Combat Desertification* formulated by the Desertification Conference and later endorsed by the UN General Assembly (United Nations, 1978) asked that there should be a review of progress in the implementation of the Plan seven years after its inception. The Executive Director of UNEP, Dr. Tolba, reported to his Governing Council on the outcome of that review of progress (UNEP, 1984). I was involved with that review for two years, more particularly with assessing the present status and trend of desertification within the major dryland regions of the world, and it is on the results of that assessment that this talk is based.

First, I should make clear the terms of reference of that assessment and above all the meaning with which *desertification* was employed. In a resurvey to gain evidence of change, one cannot depart too far from the definition on which the original estimates were based, and in that respect this later review was largely constrained by usages at the 1977 Conference. On a strictly etymological basis, desertification means the creation, intensification or extension of desert-like conditions. However *desert* has no agreed scientific meaning, certainly no strict climatic definition. It carries at least three related connotations: namely 'empty of life', 'waterless' and 'unproductive'. The Plan of Action to Combat Desertification used a definition which strove to encompass some of this range of meanings:

> 'Desertification is the diminution or destruction of the biological potential of the land, and can lead ultimately to desert-like conditions'.

A World Map of Desertification produced for the 1977 Conference (FAO *et al*, 1977a) carried a slightly more revelatory definition:

> '*Desertification:* The intensification or extension of desert conditions is a process leading to reduced biological productivity, with consequent reduction in plant biomass, in the land's carrying capacity for livestock, in crop yields and human wellbeing'.

This still leaves open the geographical terms of reference of the desertification assessment. There are extreme deserts and moderate deserts in terms of aridity, cold deserts and hot deserts differentiated on the basis of temperature, and even localized deserts due to lithology or salinity. *Desertification* was originally applied by the French ecologist and forester Aubréville (1949) to the degradation of vegetation and soils in humid and subhumid tropical Africa as a result of deforestation and indiscriminate burning and cropping. Many who accept that man's intervention through land use commonly involves a displacement of ecosystems towards a more xeric phase would follow Aubréville in claiming that desertification is part of a universal trend. However a more restricted application was introduced by those who used *desertification* to mean 'desert creep' or the encroachment of the desert into formerly habitable lands. The symbol of the palm tree disappearing under an advancing sand dune is locally warranted, but as a general view of desertification it would be unduly re-

The symbol of the palm tree disappearing under the advancing sand dune is locally warranted, but as a general view of desertification it could lead to mistaken combative strategies.

strictive and could lead to mistaken combative strategies, for example in the Maginot Line of 'Green Belts' of trees planted to stop its advance. Consistent with Aubréville's insistence on desertification as a man-made phenomenon, environmental changes associated with desertification tend initially to be localized and often expressive of a combination of three factors: seasonal dryness or drought stress, excessive pressure of land use, and naturally vulnerable sites. Such loci of incipient degradation tend to intensify, enlarge and link up. Overall, therefore, the extension of desert-like conditions tends to be achieved through a process of accretion from without, rather than through expansionary forces acting from within the deserts.

Given the contemporary concern with the impact of aridity on man's livelihood systems, the Secretariat of the UN Conference on Desertification decided to limit its application of the term desertification to the world's drylands, namely the vulnerable areas of low and unreliable rainfall encompassed mainly by the arid and semi-arid climatic zones. It was considered that, irrigated lands apart, the extreme or hyperarid desert cores had little potential productivity and therefore stood to undergo little loss through further desertification. Within the drylands as defined, the relative severity of regional problems again led to an emphasis on the warm tropical and temperate deserts, to the exclusion of cold deserts in high latitudes.

The UN Conference on Desertification followed Aubréville in agreeing that man's misuse of the land was a major factor causing widespread desertification. In the mid-1970s there was considerable speculation about the possibility of secular climatic change, specifically that an expansion of the arid and semi-arid climatic zones might be in progress. There was after all good evidence of earlier expansions of desert conditions, in the Sahel particularly, and changes in world atmospheric circulation since the mid-1950s seemed to some to be consistent with a possible resurgence. Others stressed that man himself, through raising the surface albedo or increasing dust concentrations in the atmosphere, might have contributed to diminished rainfalls in the drylands, through feedback processes such that desertification could feed on itself. In 1977 these questions had to be left open, and heavier rains in the Sahel in the mid-1970s encouraged a view that the drought there had ended. Whatever the truth, it was agreed by the Conference that man was not an innocent victim of worsening climate; indeed, the degree of his causal involvement was some measure of his potential for improving things.

In practical terms, this has meant that assessment of desertification can most conveniently be made within the framework of the main forms of land use in the drylands: namely as degradation of rainfed croplands, deterioration of rangelands, and waterlogging and secondary salinization in irrigated lands. Desertification can also be indicated through overexploitation of major renewable natural resources, notably in the decrease in forest and woodland cover and in the depletion of surface and groundwater reserves.

Estimates for the 1977 Desertification Conference

No systematic world survey of the status and trend of desertification was carried out for the 1977 Conference. Such estimates as were produced were a byproduct of the mapping of desertification hazard for the *World Map of Desertification*, supplemented by FAO experience in mapping soil degradation and by a review of the literature. They were summarized in an *Overview of Desertification* presented to the Desertification Conference (Secretariat of the UN Conference on Desertification, 1977) and in a map of *Status of Desertification in the Hot Arid Regions* (FAO and UNESCO, 1977). They were largely the work of Harold Dregne, who has reproduced them in his recent book, *Desertification of Arid Lands* (Dregne, 1983).

The *Map of the Status of Desertification in Hot Arid Regions* depicted four classes of desertification, defined qualitatively on the basis of deterioration of plant cover or degree of accelerated erosion as follows (FAO *et al*, 1977):

Slight
- little or no deterioration of plant cover or soil.

Moderate
- significant increase in undesirable forbs and shrubs; or
- hummocks, small dunes or small gullies formed by accelerated wind or water erosion; or
- soil salinity causing reduction in irrigated crop yields of 10-50%.

Severe
- undesirable forbs and shrubs dominate the flora;
- sheet erosion by wind and water have largely denuded the land of vegetation, or large gullies are present; or
- salinity has reduced irrigated crop yields of more than 50%.

Very Severe
- large shifting barren sand dunes have formed; or
- large, deep and numerous gullies are present; or
- salt crusts have developed on almost impermeable irrigated soils.

'Very severe desertification' category, representing the extreme condition popularly thought of as desertification, is in most cases economically irreversible, such that the land will have been lost to production.

At the UN Conference on Desertification in 1977, no figures were presented for the extent of lands falling into the various classes of desertification. The explanatory note to the *World Map of Desertification* gives the areas subject to moderate or more severe desertification hazard, based on map evidence, as 3760 million ha, of which 3373 million ha were in the arid and semi-arid zones. Dregne (1983) however has since published estimates of areas desertified using similar criteria to those offered at the Conference. He concluded that, of a total of 4100 million ha of productive land in the arid and semi-arid zones, 3272 million ha or 80 per cent should be judged to be moderately to very severely desertified. In his continental breakdown, Dregne noted that whereas percentages of moderately desertified lands were consistently high everywhere; what identified the Third World drylands of Africa, Asia and South America was the extent of *severely desertified* lands, which amounted overall to 870 million ha or 18.5 per cent of all productive lands.

For the rangelands, desertification class was equated by Dregne (1983) with range condition class as defined by the US Soil Conservation Service. Slight desertification was equated with excellent to good range condition class, moderate desertification with fair range condition class, severe desertification with poor range condition class, whilst very severe desertification was identified with land virtually denuded of vegetation cover. On that basis, Dregne (1983) estimated that 3072 million ha or 82 per cent of the 3750 million ha of rangelands in the arid and semi-arid regions were moderately to very severely desertified (Fig. 1). This is comparable with the area of 3600 million ha stated to be subject to range deterioration through desertification in the overview presented to the desertification Conference (Secretariat of the UN Conference on Desertification, 1977).

Calculations of numbers of people affected by desertification were made for the Desertification Conference. Of a world population of approximately 700 millions in dryland areas affected by desertification, it was concluded that about 600 millions were subject to moderate desertification and slightly less than 80 millions to severe desertification. On an assumption that one third of these might be in a position to avoid the worst consequences, through high incomes or other advantages, those moderately or seriously disadvantaged come out at 400 millions and 50 millions respectively. Of these numbers, just over one fifth were identified with animal-based livelihood systems, that is mainly occupying rangelands.

Annual losses in production to be attributed to desertification were put by Dregne (1983) at US$26 billion (in 1977 figures), of which US$7.4 billion represented desertification in rangelands. Continuing annual losses of land to desertification were put at over 20 million ha, of which 17.7 million ha were in rangelands. Finally, the total cost of combatting desertification on productive drylands was set at US$141 billion, with more than half of this cost (US$ 77.5 billion) accounted for by the extensive rangelands.

Bases for the New Assessment

For the new review of progress, steps were taken to improve the data base on the status and trend of desertification, particularly with regard to the following indicators:

- encroachment and growth of dunes and sand sheets;
- deterioration of rangelands;
- deterioration of rainfed croplands;
- waterlogging and salinization of irrigated lands;
- deforestation and destruction of woody vegetation;
- declining availability and quality of groundwater and surface-water supplies

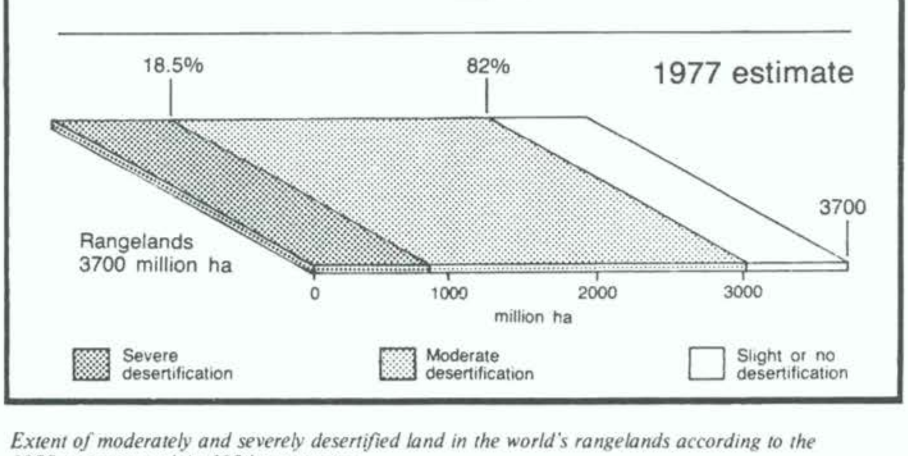
Despite the emphasis placed by the UN system on the social and economic consequences of desertification, socio-economic indicators were found not to be systematically available.

Information was sought at two levels: at the country level through responses to a *Desertification Questionnaire* addressed to 91 affected countries and to ten donor countries; and at the regional level through commissioned regional assessments, mainly within the framework of the UN Regional Commissions. With the co-operation of the United Nations Sudano-Sahelian Office, a special study was made of the critical Sudano-Sahelian zone (Berry, 1983). In addition, some of the sources used at the 1977 Conference were updated, notably the Case Studies for Chile, Niger and Tunisia, and also some country reports. An earlier study on *Climate and Desertification* was updated (Hare, 1983) and a report commissioned on demographic aspects of desertification (Caldwell, unpublished).

In terms of number of replies received, response to the *Desertification Questionnaire* was better than anticipated, but the information provided was commonly unsatisfactory and incomplete. In the event, much reliance had to be placed on regional assessments and the judgements of regional assessors. The information garnered so far, although an improvement on that available in 1977, still falls far short of an adequate baseline picture of desertification in the mid-1980s; at best it indicates the relative magnitude of the problem, the patterns and nature of its impacts, and the operation of some of the main factors. Since we have no earlier baseline for comparison, conclusions as to desertification trends must be based mainly on assessment of the present dynamics of the situation and on estimates of likely future developments in what are seen to be the main contributory causes.

Reasons for this continuing lack of satisfactory information on desertification status and trend include:

Figure 1:



Extent of moderately and severely desertified land in the world's rangelands according to the 1977 estimates and the 1984 assessment.

- lack of national organizations responsible for gathering the necessary information;
- lack of basic information corresponding to the dryland areas;
- lack of a practical method of rapidly defining desertification status for specific areas.

Concerning the first of these constraints, countries were urged under the UN Plan of Action to Combat Desertification to establish a central organization to co-ordinate the implementation of national plans This has rarely been done, and almos everywhere the concerns raised by desertification continue to fall under several branches of government, effectively reducing the priority given to desertification issues. With regard to the last-listed constraint, FAO and UNEP have been collaborating on a *Provisional Methodology for Assessment and Mapping of Desertification* (FAO, 1981) which has already had a number of tests. This should eventually serve valuable calibrative pilot studies, but is likely to prove too demanding to provide broad regional assessment of the status of desertification within a reasonable period, leaving a basic problem still to be addressed.

Two significant exceptions to this lack of data on desertification at country level were Australia and the United States. In Australia, the Department of Home Affairs and Environment has published a report on *Land Degradation in Australia* as an outcome of a Collaborative Soil Conservation Study (Woods, 1983). Its evaluations relate to 1975-77 and it does not define degradation in terms of desertification, but its statements on land condition and its recommendations on combative actions allow it to be translated into those terms. *Desertification in the United States—Status and Issues* (Sabadell *et al*, 1982) was produced for the Bureau of Land Management and refers to conditions in the late 1970s and early 1980s. Although addressed directly to the problem of desertification, it preceded the *Desertification Questionnaire* and does not directly answer the questions posed by it.

The map basis for the new assessment of desertification was the UNESCO *Map of the World Distribution of Arid Regions* published as MAB Technical Note 7 (UNESCO, 1979), replacing the map of arid and semi-arid homoclimates (Meigs, 1953) used as the basis for the 1977 Conference. The change hardly affected the limit of the drylands as earlier defined, but did draw some new internal boundaries, between arid and hyperarid and arid and semi-arid zones. More significant was its complete inclusion of the subhumid zones, against which a more extensive impact of desertification could be considered.

Summary Results of the New Assessment

Under the new assessment the area considered as being at risk of desertification has been increased over that employed for the 1977 estimates, from 4050 million ha to 4500 million ha. This has resulted from inclusion within the threatened area of the entire subhumid climatic zone as now mapped, which regional assessments indicated as undergoing significant desertification, notably in the rainfed croplands. This increase brings the area considered to be at risk to 30 per cent of the Earth's land surface, and has important implications for what is seen as the main threat of desertification for the future. On the other hand, the area now considered as productive land is diminished, to 2955 million ha compared with 4100 million ha in 1977. This mainly results from a major decrease in the area now considered as rangeland, namely 2554 million ha compared with 3700 million ha in 1977. This difference expresses an apparent change of definition. The larger area for 1977 was apparently got by assuming that all arid and semi-arid lands apart from cropland were rangeland, including lands known to be unusable for grazing because of remoteness, difficult or unwatered terrain, or various types of reservation, whereas the 1984 figures are based on country returns and FAO statistics for extensive grazing land. This decrease in the area considered as productive land is not greatly affected by a concurrent increase in the area of rainfed croplands now included, from 224 million ha in 1977 to 570 million ha in the new assessment, in the main through the inclusion of all subhumid croplands. The discrepancy between the two sets of figures is spread over all dryland regions.

The extent of productive land designated at least 'moderately desertified' under the new assessment is 2000 million ha, compared with 3270 million ha in 1977. This difference is partly explained by the larger estimate of rangelands in 1977, but also reflects higher percentages of land claimed as being moderately desertified in the 1977 estimates, both in the rainfed croplands and in the rangelands, as will be discussed below.

For the rangelands, guidelines for the classification of desertification status were provided in the *Desertification Questionnaire* as follows:

Moderate

- significant reduction in cover and deterioration in composition of pastures;
- locally severely eroded;
- would respond to management supported by improvements and conservation measures;
- loss of carrying capacity up to 25% of earlier carrying capacity.

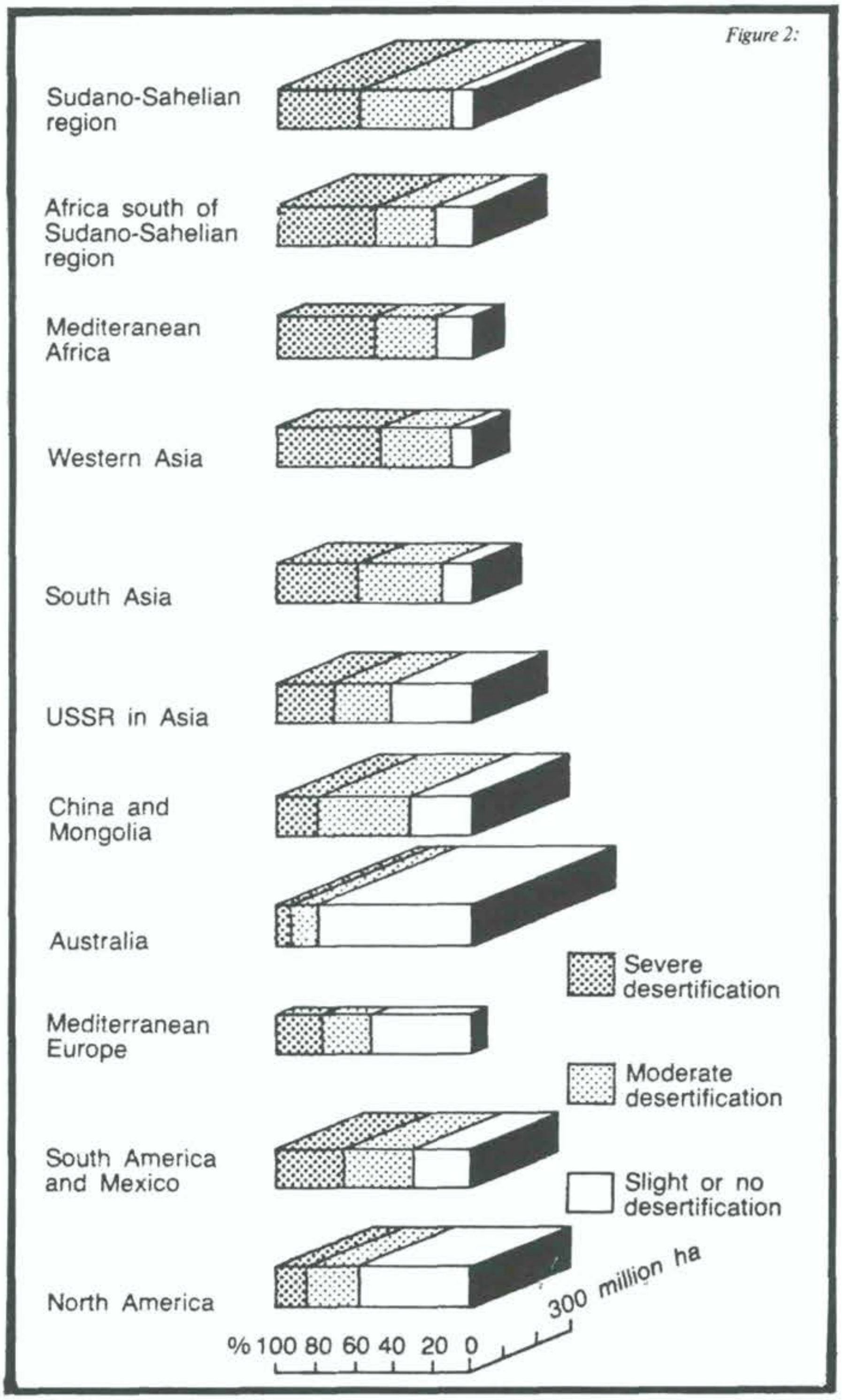
Severe

- very significant reduction in perennial vegetation cover and widespread deterioration in composition of pastures;
- widespread severe erosion;
- requiring major improvements;
- loss of carrying capacity 25-50% of earlier carrying capacity.

Very Severe

- extensively denuded of perennial shrubs and grasses and subject to widespread very severe accelerated erosion;
- large areas irreclaimable economically;
- loss of carrying capacity over 50% of earlier carrying capacity.

Losses in yield of up to 25 per cent and above 25 per cent were similarly suggested as criteria for moderate and severe desertification respectively for the rainfed croplands and irrigated lands; however desertification is not as yet significantly reflected in crop yields or stocking rates, and loss in productivity has therefore proved inapplicable as a desertification indicator. In the rangelands, as in



Extent of moderately and severely desertified land in the rangelands by major regions according to the 1984 assessment.

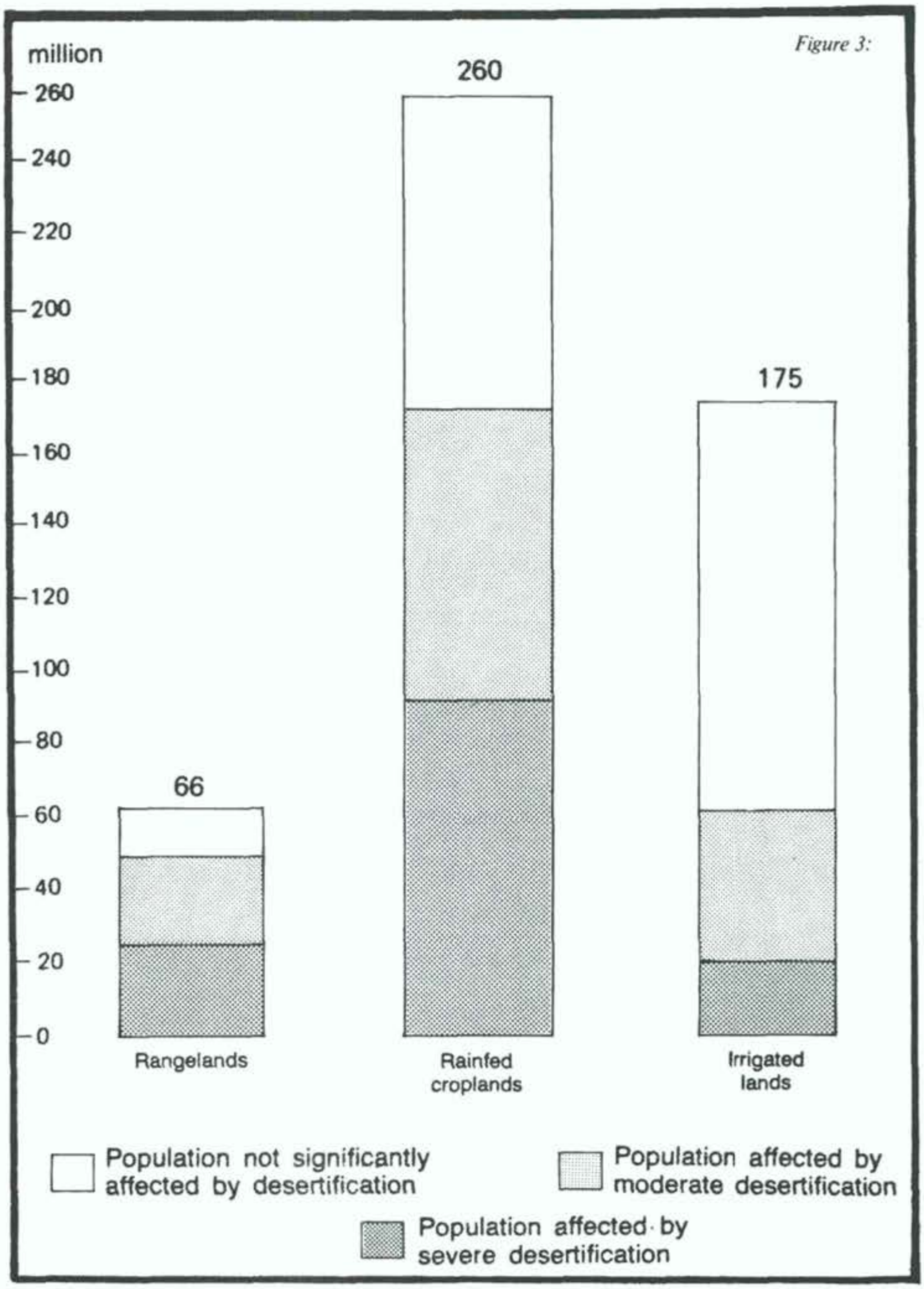
other land-use categories, estimates have had to be based on observed ecological degradation and the extent of accelerated erosion.

The extent of the world's rangelands now estimated as being at least moderately desertified is 1610 million ha or 63 per cent of the productive area, compared with the 82 per cent in the 1977 estimates. Much of this discrepancy resides in the lowered estimates now given the developed countries, and to a lesser extent in those for the centralised economies (Fig. 2); for example, the figure of 40 per cent for North American rangelands contrasts with the 80 per cent in the earlier assessment, and for USSR the estimate is now 60 per cent compared with the previous 80 per cent. On the other hand, the differences between the earlier and later estimated percentages are negligible for the African regions and small for South America. It may be significant that the reduced percentages relate to the regions with the better information, in which case the percentages of moderately desertified rangeland may continue to decline as our assessments improve. For the Australian rangelands, where I placed those areas recommended under the Collaborative Soil Conservation Study as requiring only improved management into the 'slight desertification' category, my resulting figure of 22 per cent of rangeland as being moderately desertified is probably an underestimate.

The extent of the drylands estimated as severely desertified is 945 million ha or 30 per cent of all productive land, and the overall proporton for the rangelands is similar, as shown in Fig. 1 and 2. This is significantly higher than the figure of 18.5 per cent obtained in the 1977 estimates. As with the 1977 figures, the percentages of severely desertified lands emphasize the greater severity of the impact of desertification in the Third World regions generally, including the rangelands, where the percentage of severely desertified land generally exceeds 40 per cent, compared with less than 20 per cent in the free-market systems of the developed world and around 30 per cent in the centralized economies.

The new assessment indicates a world population for the drylands of 850 million, an increase of 150 millions over the earlier figures explained largely by the inclusion of more closely settled subhumid areas, but in part also by natural increase. The rural component of about 500 millions is distributed between land-use categories as shown in Fig. 3. The new assessment gives even greater emphasis than before to the rainfed croplands as the support of the bulk of the populations affected by moderate, and particularly by severe desertification (172 millions and 92.5 millions respectively), compared with the rangelands (50 and 25 millions) and the irrigated lands (58.5 and 18.5 millions).

No new assessment is available of the annual losses of land and production to desertification, nor of the costs of combatting it. On the basis of costs given in the 1977 estimates, however, the effective increase in the stated area of desertified rainfed cropland, from 173 million ha in 1977 to 320 million ha in 1984, whilst at the same time decreasing the stated area of desertified rangeland from 3070 million ha to 1700 million ha, should be to increase the annual losses in production by 30 per cent whilst lowering the costs of combatting desertification by a little under five per cent in 1977 dollars.



Rural populations in areas affected by moderate and severe desertification under major land-use categories according to the 1984 assessment.

Desertification Trends

Neither the 1977 estimates nor the recent assessment is sufficiently accurate and time-related to provide a comparative basis for the determination of desertification trends in the world's rangelands, and those shown in Fig. 4 are based on an appreciation of the dynamics of the present situation drawn from the regional assessments. Generally, the outlook is poor. Accelerating desertification is typical of the rangelands of most developing regions, such as Africa south of the Sahara, tropical South America and parts of Asia. Significant improvements are confined to favourable environments in North America and Europe and to areas covered by major government projects in the centralised economies of USSR and China.

Two categories of depletion of natural resources associated with desertification in the rangelands are also shown in Fig. 4. Deforestation and destruction of woody vegetation, in part through overgrazing, fuelwood gathering and burning, as perhaps the most dynamic manifestation of desertification, is continuing and indeed accelerating in much of the drylands of the developing world, notably in Africa, Latin America and areas of South Asia. Depletion of groundwater reserves is also important, particularly in Western Asia, Mediterranean Africa and in the United States in North America.

Impacts of Desertification on the World's Rangelands

World-wide, the continuing or accelerating course of desertification in the world's rangelands shows common features, including:

- deterioration in the quantity, quality and persistence of native pastures, generally associated with a diminution of cover, but also with invasion by woody shrubs of low pastoral value;
- structural changes in the vegetation cover, notably the loss of shrubs and trees, partly through browsing but also through gathering of fuelwood and clearing and burning for agriculture, increasing the exposure of the soil surface to accelerated erosion;
- changes in soil surface-conditions, notably compaction through trampling by livestock, leading to deterioration in soil-plant-water relationships and diminished germination;
- resulting accelerated wind and water erosion of little-protected soils, removal of topsoils and the loss of nutrient and seed stores,

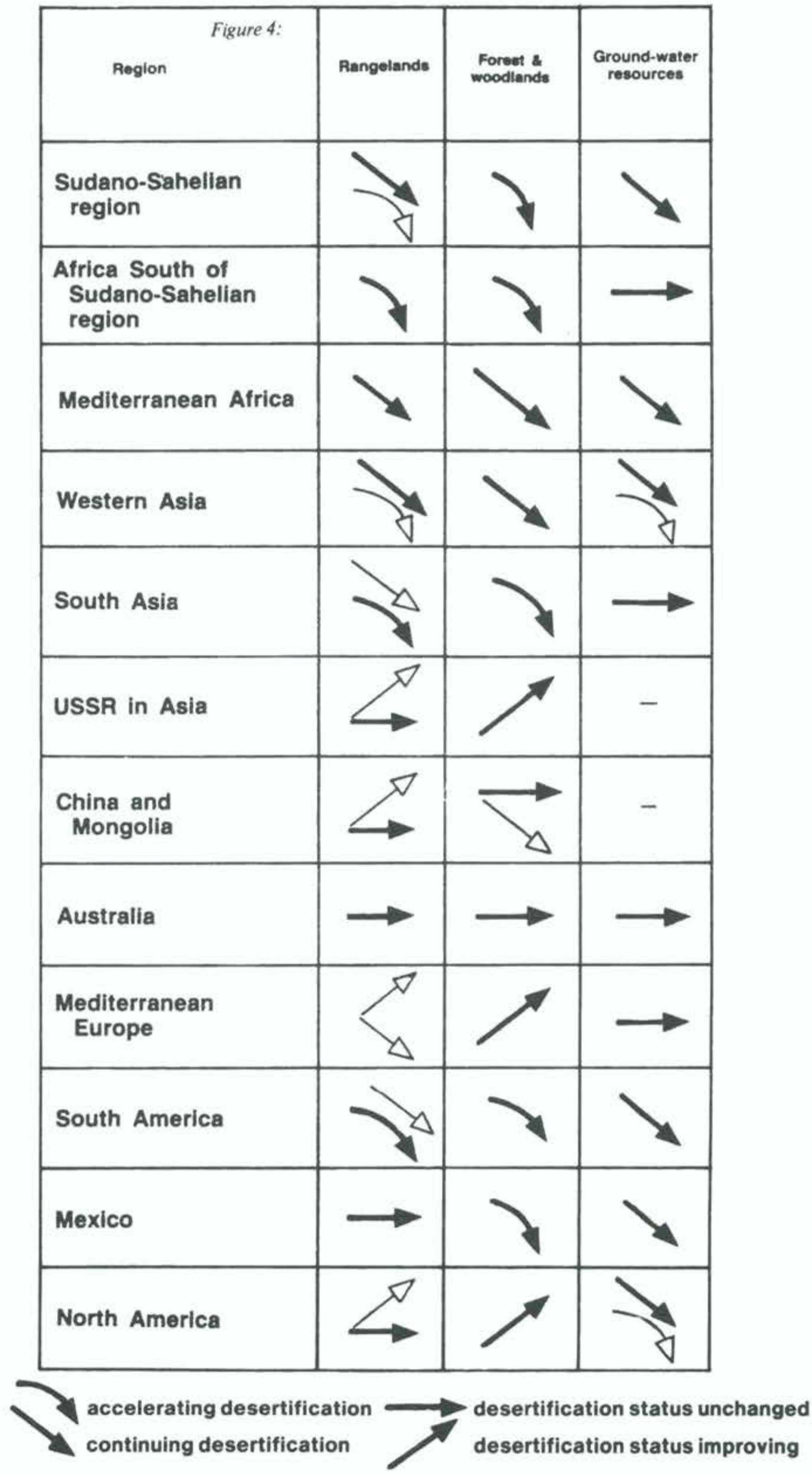
and eventually the exposure of barren, locally hard-setting subsoils which resist revegetation;

– complementary processes of sand drifting and siltation, leading to further destruction of vegetation cover and commonly to deterioration of surface and shallow groundwater supplies.

The patterns of such changes vary with the movements and concentration of grazing animals, with seasonal conditions, and with the varying vulnerability of the land itself.

Superimposed on these general trends are features specific to particular regions, in response to environmental controls and particularly also to socio-economic and related conditions. The rangelands fall into four main environmental types which are variously distributed within the regional compartments used in the recent assessment. Distinction between these environmental rangeland types is useful when considering trends of desertification, underlying causes and future desertification hazards.

Most extensive, and accounting for almost 50 per cent of the world's rangelands, are the mainly sandy plainlands typified by much of the arid zone within the Sudano-Sahelian region, by the drier western part of Africa to the south, by the arid portions of Mediterranean Africa and Western Asia, and by the arid lowlands of the western section of South Asia, western China and Asiatic USSR, the Chaco and Caribbean plains in South America, and much of arid Mexico. Environmentally equivalent areas in the United States and the sand deserts of the Australian arid zone tend to be less developed pastorally. These arid pasture lands mainly range from grass steppe to thorn scrub. Extending to the dry limits of land use, they are subject to critical variations in rainfall and to prolonged drought. Desertification in these areas has included the grazing out of valuable grasses and the destruction of woody shrubs, in part through the gathering of woody vegetation for fuelwood. The dominant processes following degradation of the pasture cover are accelerated wind erosion and sand drifting, but water erosion is also important towards the more humid margins.



Regional trends in desertification in the rangelands and in the depletion of forest and woodland cover and water reserves according to the 1984 assessment.

Much of the grazing is seasonal, traditionally through extensive nomadism or transhumance, associated with the exploitation of seasonal waters, salt licks etc. and the seasonal response of pastures to rains. Under such traditional systems, control of the rangeland may be achieved through tribal ownership of watering points, with the ownership of flocks on an extended family basis. In many such areas, grazing of these rangelands was formerly linked with control by pastoralists of migration and trade routes and oasis settlements, and sustained by important exchange relationships with farming peoples on the wetter margins.

The socio-economic bases of rangeland livelihood systems in these areas are currently undergoing important changes, to which desertification has contributed. It was the critical impact of desertification on rangelands of this type in the Sudano-Sahelian region in the early 1970s which aroused the response of the world community to the problem. At that time, there was a breakdown of the pastoral livelihood systems over large areas, migration to towns and refugee centres, and voluntary sedentarisation around permanent watering points, in many cases linked with a switch to cropping.

Grazing in hill and upland rangelands has been a major factor in deforestation. Here, near Ghazvin, Iran, if animals are allowed to strip the hillside bare of all plant life, soil erosion will follow. (FAO/H. Hull)

In these extensive sandy plainlands desertification continues and the situation remains serious over wide areas, but the drier parts of these rangelands can no longer be regarded as the most critical areas in terms of desertification hazard. In part this reflects the fact that desertification has already attained a severe status over large parts. Nevertheless, save where desertification was very severe, the sandy soils can show significant recuperative powers, as exemplified by the update of the Niger Case Study, which reported partial recovery of many shrublands with the improved rains of the middle and late 1970s. The more severe risk of very severe and virtually irreversible desertification lies towards the semi-arid margins of these plainlands, closer to agricultural and urban settlements, where there is greater human pressure on the land and where wind erosion is reinforced by accelerated water erosion, often on vulnerable tropical soils.

The second environmental type of rangeland comprises hill and upland ranges, accounting for 15-20 per cent of the whole and important in the Horn of Africa in the Sudano-Sahelian region, along the watershed of Africa to the south, in the semi-arid Mediterranean lands of Africa and Western Asia, in the western part of South Asia, in the mountains of Asiatic USSR and western China, Andean South America and in the North American Rockies. Low shrublands and upland meadows predominate among the pastures, but grazing commonly extends into and has been a major factor in the degradation of mountain forests.

In the temperate zones, use of these rangelands has traditionally been linked with a declining element of transhumant grazing; in the lower hill lands of the tropics it is commonly associated with subsistence rainfed cropping. In the Old World drylands these rangelands include the heartlands of pastoralism, and desertification here is of long standing and has resulted in extensive depauperate vegetation types. In subhumid and semi-arid central and eastern Africa south of the Sudano-Sahelian region, heavy grazing by mixed herds of cattle and small livestock in areas of close agricultural settlement, together with man's destruction of woody vegetation, has initiated severe water erosion under heavy tropical rainfalls, and the northern Andean grazing lands of South America show many comparable features. These rangelands include terrain which is naturally vulnerable to accelerated water erosion following intense summer rainfalls, often in association with the deforestation of watersheds. They are areas of potentially very severe and irreversible desertification, with consequences which can extend to adjacent lowlands through flooding and siltation. They are commonly closely associated with dense agricultural settlement and extreme land hunger, whereby grazing lands are constantly under threat by the encroachment of cropping. They include areas undergoing rapid increase in rural populations, and the situation has potential for very rapid desertification to a virtually irreversible stage.

The third major type of rangeland consists of plains or plateaux with latosolic soils, mainly under dry woodlands or tall shrublands. It occurs in shield areas of central Africa, in southern less arid parts of the Sudano-Sahelian region, over much of the Indian Deccan, in tropical Australia and in South America in the Nordeste of Brazil. Grazing in many of the Third World areas is linked with swidden systems of clearing agriculture. This rangeland type is vulnerable to severe sheet erosion by tropical rains, and despite generally low gradients can rapidly become severely desertified.

The fourth rangeland type consists of temperate short-grass steppes or low shrublands on relatively treeless semi-arid plainlands in North America, Argentina, and also in Kazakhstan in USSR and in Mongolia and adjacent northern China, where severe winters pose an additional climatic hazard. Parts of the southern Australian rangelands, albeit with a more temperate climatic regime, may be grouped here. This rangeland type includes important areas of commercial livestock production. The main form of physical degradation following overgrazing is accelerated wind erosion of fine-textured soils, but on sloping ground accelerated water erosion of duplex soils supplements and commonly interacts with wind erosion.

Fig. 4 therefore shows five critical regions of accelerating desertification: the Sudano-Sahelian region, parts of Africa to the south, Western and South Asia, and South America including the northern Andean lands as well as the Nordeste in Brazil.

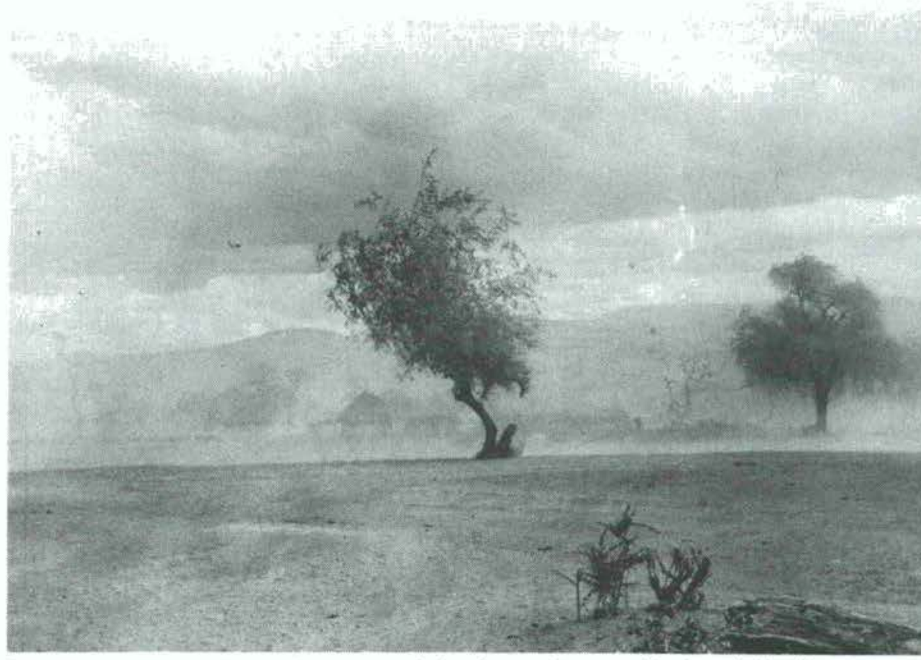
Outside these critical areas, most rangelands show a continuing steady downward trend. In general there seems to be little evidence of natural recovery of severely desertified arid rangelands, save in areas of better soils receiving run-on. Reclamation work in such rangelands, generally unfeasible on economic grounds, has not so far had impressive results, save in a few favoured and more productive areas such as the upland rangelands of the USA, and in areas subject to major government programmes, as in the USSR. Extensive planting of shrubs in areas receiving less than 350 mm rainfall, for instance in north-central Chile and Libya, has had limited success, and experience suggests that future investment of this kind should be more selective, confined to the most favourable areas, and preferably integrated with total schemes for pastoral improvement, as in co-operative rangeland projects in Syria.

Continuing Desertification Hazard in the World's Rangelands

The rangelands of the world comprise the largest areas of desertified productive land, and desertification of rangelands is seen to be accelerating in five regions: in the Sudano-Sahelian region, in Africa to the south, in Western Asia and South Asia and in South America. These are mainly tropical rangelands wherein the most critical areas are shown to be the upland and hilly rangelands of mixed farming communities, as in southern Africa, and the semi-arid margins of the drier plainlands, as in the Sahel-Sudan transition in West Africa. These are areas of close settlement and rapidly growing rural populations where increased stocking levels can be anticipated. Furthermore, grazing is here intensifying or encroaching on terrains and soils and into climatic settings under which accelerated water erosion reinforces the impact of wind action. Where nomadism or transhumant grazing has been practised in these areas, additional problems will continue to arise from continuing sedentarization, and everywhere through the encroachment of rainfed cropping. Further acceleration of desertification in these areas can be anticipated from the destruction of woody vegetation to meet the fuelwood requirements of growing settlements. Constraints such as stock diseases and land tenure make it unlikely that grazing pressures in these critical areas will be relieved through the opening up on new rangelands. In the temperate sectors of these regions, as in Western Asia, further decline in transhumance and the response to growing commercial markets for livestock will maintain pressure on the long-desertified ranges, but is anticipated that by the year 2000 the most severe desertification in the world's rangelands will have shifted markedly to the semi-arid margins of the tropical rangelands.

Underlying Causes

The causes that underlie this generally unsatisfactory and regionally critical situation cannot be discussed in detail here. However the recent regional assessments have identified a number of general factors which have contributed to the unfavourable trends. Prominent among these is continuing drought in many parts of the world's drylands, and notably in Africa. The crisis in the pastoral livelihood systems of the Sahel in the early 1970s reflected the



In areas where pastoralists are becoming settled and are taking up cultivation, the land is becoming subject to increased wind and water erosion, as here in Kenya's Baringo valley. (UNEP/Daniel Stiles)

susceptibility of arid rangelands to prolonged drought if they are under considerable grazing pressure. At the Desertification Conference in 1977, better rains in the mid-1970s lent credence to a view that the episode of drought in the Sahel had ended, but in the following years seasonal rainfalls in the region have almost without exception been below average and badly distributed, whilst severe drought has also extended southwards from the Horn of Africa through almost the entire southern African continent. Not only has the climatic factor contributing to rangeland desertification in Africa been strengthened by this sequence of dry years; equally, climatic conditions for restorative programmes have been unfavourable. The question has again been raised, and remains open, as to whether these and other marginal drylands are experiencing a long-term swing towards lower rainfalls that may call for corresponding shifts in patterns of land use and a revision of expectations of productivity from their grazing lands.

At the same time, and despite the

check of earlier droughts, there has been a general continuing growth in rural population in the rangelands of the developing countries, matched by an increase in livestock numbers in the areas worse-affected by desertification. By 1980, for example, numbers of small livestock in the Sahelian rangelands had already surpassed those of the pre-drought years of the late 1960s, and subsequent years have been a steady continuing annual increase in all livestock of up to five per cent, exceeding even the growth in rural populations. Growing markets and marketing systems, linked with rising meat consumption by urban populations, are likely to maintain this pressure of livestock numbers on the grazing lands in many of the worse-affected dryland regions.

New technological and commercial impacts on traditional pastoral systems have acted adversely to reinforce the effect of these increasing grazing pressures and to bring about desertification. The potentially harmful consequences of the introduction of technology into rangelands without the support of appropriate management controls is well-exemplified by the provision of permanent borewaters in pastures that were formerly used only seasonally, or of stock-water supplies beyond the forage capacity of the rangelands that they serve. In response to growing urban markets, new commercial forces have linked inappropriately with traditional attitudes to livestock numbers as wealth, prestige or drought-insurance, to accentuate further the recent inordinate increases in grazing pressure. Such forces have arisen just when the social structures within which traditional management systems are embedded are themselves undergoing change and breakdown through the modernization and mobilization of society. Whilst the skills of traditional pastoral management are becoming increasingly acknowledged, to a growing extent traditional pastoral societies now operate under conditions different from those under which they evolved, and under changing circumstances which are in part beyond their control.

At national levels, pastoral societies have commonly lost their relative influence within the new national states of the drylands, where political and economic powers end to reside in the urban and agricultural sectors. It is in this context for example that a marked recent encroachment of rainfed cropping into the better pasture lands can be understood, as a response to new national policies of increased food production or of increased emphasis on export cash crops as producers of foreign exchange, whereby valuable grazing lands have been lost and important traditional exchange relationships between pastoralists and farmers broken down. At the international level, Third World dryland countries have generally been unequal competitors in world trade, suffering from increasingly adverse terms of trade for their agricultural products, from the inflationary rise in oil prices in the early 1970s, and from continuing world economic recession. Many of the causes of desertification have their origins at these levels, and to that extent desertification is in part a reflection of unequal economic development and of inequality of access to resource, at national and local scales, linked with poverty and inadequate infrastructure. Desertified areas, and particularly desertified rangelands, generally show slow powers of ecological recovery and low economic returns and are unattractive to national investment policies or to international aid flows, both of which tend to be discouraged by the long period over which reclamatory measures must be sustained. The record of restorative programmes in the world's rangelands over the last decade are accordingly disappointing.

Finally, many of the worst-affected rangeland areas of the Third World have in the last decade been subjected to major social and economic disruption through political strife, warfare, attendant refugee problems and excessive out-migration, which have both exacerbated the problem of desertification and hampered actions to combat it.

Conclusion

Two priority needs which my involvement in the recent assessment of desertification by the United Nations Environment Programme have impressed upon me are particularly relevant to this Congress. The first is an urgent requirement for a means of rapid assessment of desertification status in the rangelands, even in the most general terms, harnessing the resources of satellite imagery and other forms of remote sensing to provide timely baseline estimates, supported by appropriate but simple systems of data-gathering by scientists on the ground and by governmental recording of production and other relevant information. The second is for a further continuance of the valuable and growing co-operation between social scientists and those from other relevant disciplines, carrying the understanding of desertification in rangelands beyond the scope of monitoring ecological degradation, towards that better appreciation of rapidly changing man-environment relationships and the underlying social and economic factors in which must reside the secrets of successful programmes to combat desertification and of future management systems to control its resurgence.

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Deforestation, desertification and soil loss

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DEFORESTATION

Introduction

Forests represent one of the principal natural formations (biomes) of the world, the most complex in structure and richest in species composition (genetic diversity). Forests of all types cover about 4,090 million hectares (31 per cent of the world's land area). They play two vital roles: they provide a variety of materials that mankind needs, and they have an important ecological function in the overall operation and balance of the biosphere. Forests are associated with humid climates (high rainfall), but a distinction is made between tropical forests, where nutrients are retained mainly within the biomass, leading to poor soil, and forests of the warm temperate climate, where nutrients are mostly in the soil. This means that removal of forest cover in the tropics leaves behind a habitat with soil vulnerable to further loss. In contrast, the removal of temperate forest leaves behind fertile soil capable of supporting regeneration of the forest.

Historically, forests were subject to cutting and were often menaced with fire. But today these two geographic groups of forests are threatened by different environmental hazards. The temperate-zone forests are afflicted by industrial air pollution including acid precipitation; the tropical forests are subject to depletion through excessive cutting that is not compensated by afforestation. Shifting cultivation is perhaps "the greatest single cause of deforestation" in the tropics (1).

Impact of atmospheric pollution (acid precipitation)

In recent years, die-back has affected notable areas of forest in western Europe and North America. By 1982 more than 8 per cent of forests (mostly coniferous) in the Federal Republic of Germany (560,000 hectares) were damaged; in 1983 a survey showed that damage affected 34 per cent of the forests (2 and 3). Widespread damage has also been reported from Czechoslovakia (500,000 hectares) and Poland (500,000 hectares) (4). Air pollutants—photochemical oxidants (ozone) alone or in combination with sulphur and nitrogen oxides—seem to be the trigger of this alarming process (5).

The mechanism and precise cause of damage remain to be clearly identified, but it is generally agreed that air pollution is a major factor. Acid precipitation, caused by deposition in rain of sulphuric and nitric acids which originate from sulphur and nitrogen oxides produced in fossil fuel combustion, is commonly regarded as a principal component of the causative factors. Ozone, produced through photochemical reactions involving hydrocarbons and nitrogen oxides in the presence of sunlight, is another likely factor. Other ecological stresses (climatic, historic, etc.) may also be involved. The ecological impact of acid precipitation may be much more pronounced in base-poor (mostly acidic) soils that lack the buffering potential of base-rich (mostly alkaline, e.g. calcareous) soils. The impact may have an indirect pathway through its chemical interactions with soils, particularly reactions that release certain metal ions, e.g. aluminium.

These air-borne pollutants often travel over considerable distances, hence their transboundary extent. The need for urgent action is widely recognized. The Geneva Convention on Long-range Transboundary Air Pollution was adopted by member States of the United Nations Economic Commission for Europe in 1979; an associated Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) is being implemented. The overall objective is to reduce emissions of pollutants associated with fossil fuel combustion: a 30 per cent reduction is the short-term (within the next 10 years) target.

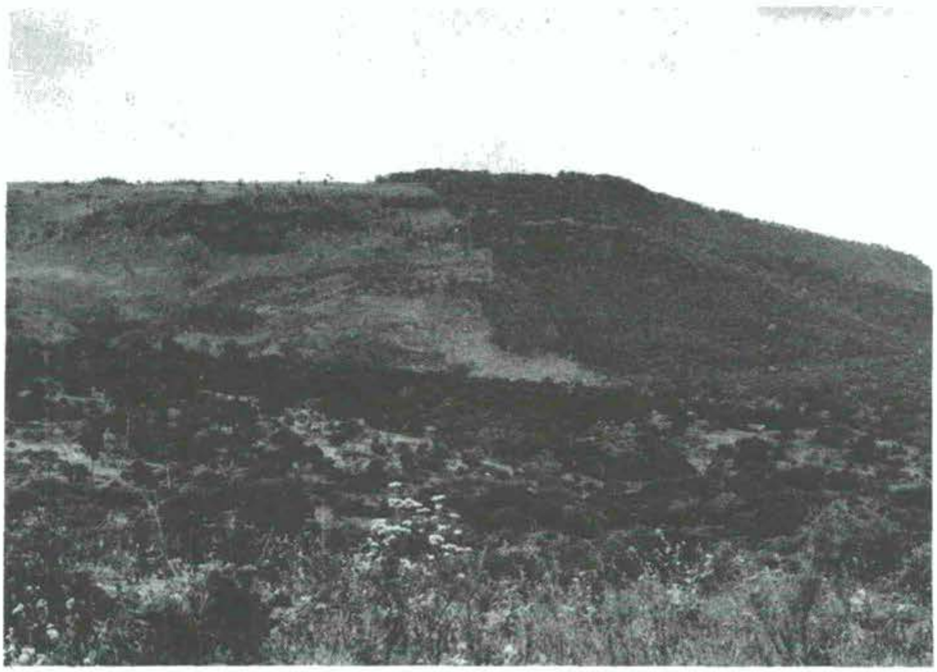
Deforestation (cutting and conversion)

Tropical forests and woodlands form a band of rich tree growth around the equator. These forests, which range from dense and evergreen rain forests to tropical woodlands of various structures, are menaced with excessive cutting and sluggish programmes of replacement. The recent FAO-UNEP *Tropical Forest Resources Assessment* (6) gives the following estimates of area and rates of change:

The rate of deforestation is 10 times the rate of planting. The depletion of tropical woodlands results from excessive population pressures and poor management of the forest-society relationship. The two principal causes of deforestation are shifting cultivation (5.1 million hectares a year) and clearing for agriculture, pasture, etc. (6.2 million hectares a year). Extraction of timber for industrial purposes is not considered a major factor in deforestation (7).

Fuelwood is the principal source of energy for some 2,000 million people in the third world. Fuelwood scarcity is perhaps the most visible effect of deforestation in the tropics. The *Tropi-*

Region	Forest area millions of hectares	Rate of deforestation Millions of hectares per year	Rate of planting
Tropical America	896	5.6	0.535
Tropical Africa	703	3.7	0.126
Tropical Asia	336	2.0	0.438
Total	1935	11.3	1.099



The rate of deforestation is ten times the rate of tree planting. (UNEP/Daniel Stiles)

cal Forest Resources Assessment estimated that in 1980 there were some 1,291 million people (201 million in tropical Africa, 863 million in tropical Asia and 227 million in Latin America) whose fuelwood requirements could not be sustained. The number projected for the year 2000 is 2,718 million. The cost of fuelwood is escalating: the retail price of fuelwood in Bombay more than tripled between 1971 and 1980; in Cameroon a cubic metre of fuelwood cost $8 in 1976 and $44 in 1981; in Abidjan the price soared from $26 per cubic metre in 1976 to $250 in 1980 (8).

Ecological consequences of forest destruction

The destruction of forests undermines basic operations of the ecosystem and may thus cause irreversible changes. The most serious of these changes appears to be due to large-scale exposure of natural soil systems, leading to increased erosion and, in turn, having an indirect impact on water resource development (9). We may, however, note that in two extremes of forest ecological conditions (tropical closed forests with high rates of plant growth, and boreal coniferous forests) nutrients are maintained in the biomass and not in the soil. This situation subjects soil systems to irreparable damage as forest cover is removed.

Forests have a regulatory role in water flow (the hydrological cycle) and in atmospheric and climatic phenomena (biogeochemical cycling of carbon, temperature relationships—albedo) (10). They represent a considerable stock of biomass—in tropical rain forest up to 650 tonnes per hectare, the highest for all natural ecosystems (11). The ecological "services" that forests provide are difficult to assess in terms of money. But Postel (12) writes:

> "Flooding, droughts and siltation in many parts of the world are more severe because of deforestation. A half billion people in Bangladesh, India, and Pakistan are affected by water run-off from the upper Himalayan watershed ... The cost of repairing flood damages in India below the Himalayan watershed has recently averaged US $250 million per year".

Other examples from Colombia, Costa Rica, Haiti, Panama, and the Philippines, may be quoted. Rehabilitation of degraded tropical watersheds is among the priorities of global environmental management.

International trade

Apart from wood products collected and consumed at home, forest products represent an important export item for many tropical countries: the trade value of forest timber exports is about $4.7 billion a year. Other forest products (latexes, gums, essential oils, medicines, nuts and ornaments) contribute to the export trade. Asia dominates the hardwood production in the tropics: the average annual world production of sawlogs and veneer logs (in 1976-1979) was 139.1 million cubic metres (80 million from tropical Asia, 42.4 million from tropical America and 16.7 million from tropical Africa). Between 1960 and 1980 production more than doubled, from 65 to 139 million cubic metres (a year). Most of the increased production was exported to Japan, Europe, and North America.

Depletion of forests is changing the global trade pattern, and exports are dramatically subsiding, especially from tropical Africa: Ghana's 1981 wood exports totalled 7 per cent of the 1964 level, Nigeria's only 1 per cent. Thailand's log exports in 1981 were 8 per cent of their peak in the 1970s, the Philippines' 15 per cent. In addition, tropical forests are major sources of useful genetic materials for agriculture, medicine and other pharmaceutical products, a trade with potential sales values of billions of dollars.

Recommended actions

Deterioration that is manifest and widespread in warm temperate forests is apparently related to atmospheric pollution. The Multilateral Conference on Causes and Prevention of Damage to Forests and Waters by Air Pollution in Europe (Munich, Federal

Republic of Germany, 24-27 June 1984) called for the application of known technologies for the gradual reduction of emissions of air pollutants, especially sulphur and nitrogen oxides, support for regional air pollution monitoring networks, and more research on the ecology of forest damage.

Afforestation programmes, for roundwood and fuelwood, need to be stepped up as a means of meeting human requirements and taking pressure off species-rich forests and woodlands that conserve upland soil and catchment. At present the rate of planting in tropical countries is a tenth the rate of deforestation.

Agricultural development could take pressure off forest resources. Farming crops for fuel (e.g. alcohol industry in Brazil), agroforestry and community forestry (e.g. large-scale programmes in China) are options that are technically feasible and economically viable, and their social acceptability needs to be promoted.

Forest resources need to be managed for sustained productivity. Available scientific knowledge could be applied to enhance forest productivity and maintain quality. The productivity of Indian forests (0.33 tonnes per hectare per year) is low compared to the productivity potential of forests in the United States of America (3.2 tonnes per hectare per year) (13).

The fuelwood shortage in the tropics is a facet of the world energy crisis. Three approaches are recommended: improved end-use technology such as charcoal manufacture and more efficient stoves, continued research on alternative energy sources such as solar and mini-hydro, and creation of new fuelwood resources.

The disadvantages of a significant loss of tropical forests are potentially high for developed and developing countries (availability of genetic resources for agricultural improvements, for medical research and for the pharmaceutical and biotechnology industries). Joint priority action now among developing countries and between and among developed and developing countries would not only help avoid the many disadvantages but could also yield important advantages for human health and welfare in all parts of the world.

Desertification

Introduction

Extensive areas of productive lands are subject to ecological degradation that reduces their productivity, and hence undermines the life-support system of some 850 million people. Manifestations of desertification include:

- Deterioration of rangelands;
- Degradation of rain-fed croplands;
- Waterlogging and salinization of irrigated lands;
- Deforestation and destruction of woody vegetation;
- Growth and encroachment of mobile sand bodies;
- Declining availability or quality of water supplies (14).

The 1984 UNEP global assessment of desertification showed that it affects some 3.5 billion hectares of productive land: rangelands (3.1 billion hectares), rain-fed croplands (335 million hectares) and irrigated lands (40 million hectares). Each year some 21 million hectares are reduced to a state of near or complete economic uselessness. Six million hectares are lost to desertification per year. It is evident that desertification operates through land use systems, and that it results from a combination of (a) the natural fragility of the resource ecosystems in arid and semi-arid and subhumid territories, and (b) excessive pressures of land use exceeding carrying capacity. Programmes for combating desertification combine curative and preventive measures: rehabilitation of degraded lands, introduction of conservation measures, and adoption of ecologically sound systems of resource management.

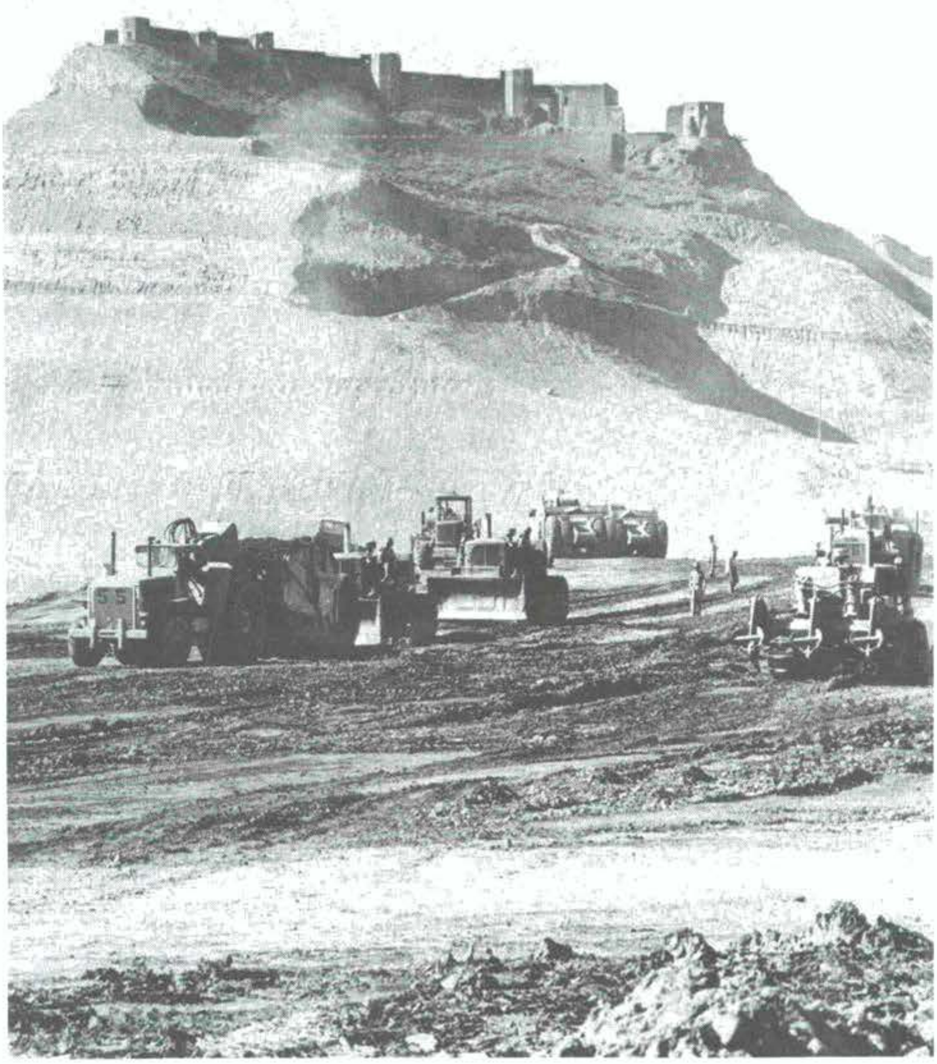
Economic issues

Actions for combating desertification are inseparable from actions of resource development and management in arid and semi-arid lands. It should be realized, however, that anti-desertification projects often entail gestation periods that are longer than those normally involved in development schemes. Schemes that aim at checking land degradation in pasturelands, rain-fed farmlands and irrigated agricultural lands, sand dune stabilization, establishing large-scale green belts, introducing soil and water conservation systems in resource management or reclaiming new territories of arid and semi-arid lands, are apt to be costly, while projects involving irrigation schemes are particularly expensive. Indeed, such projects are commonly non-competitive by prevalent market values, compared with present rates of interest. Investment in land reclamation projects commonly does not pay at all well financially in the short term.

It may be remembered that agriculture in well-established farmland (e.g. countries of western Europe) has become increasingly dependent on government subsidy. Government-subsidized ventures have social functions that relate to societal needs (in this case, satisfaction of basic needs for food). This shift towards social-service activities rather than commercially feasible ventures, has to do mainly with the costs of capital investment in land reclamation projects, and only partly with the running expenses of farming. National policies (and policies of aid institutions) should recognize this situation and develop practices of operation that accommodate it.

In a report on financing the United Nations Plan of Action to Combat Desertification (United Nations document A/35/396), various estimates are given of the cost of restoring the productivity of 100 per cent of the affected irrigated farmlands, 70 per cent of the affected rain-fed croplands and 50 per cent of the affected rangelands. The average annual cost of such a programme would be in excess of $2.4 billion, to be sustained for 20 years. External assistance to desertification control was estimated at about $600 million annually, leaving a requirement from additional sources of about $1.8 billion annually.

It is evident that (a) available aid sources fall woefully short, and (b) available domestic sources fail to assign priority to anti-desertification projects. Innovative means for financing such projects need to be explored. Such means might well combine grants with commercial loans—a combination which would soften the impact of the loans and, hopefully,



Projects involving irrigation schemes for reclaiming desertified lands, such as the Mangala dam project in Pakistan, are particularly expensive. (UNEP/P. Almasy)

make investment in anti-desertification programmes acceptable in national development plans. A 1982 United Nations study describes the feasibility of a public international corporation that would attract grants and other investment and use this combination to provide financing for anti-desertification projects with non-commercial rates of return. This concept is worthy of further elaboration, and alternative options for such combinations should be explored.

Societal issues

Methods of land reclamation and combating desertification that depend on labour may be more feasible than those depending on capital. This may require mobilization of community support, which could be achieved through effective national policies and public awareness programmes. Many measures aimed at arresting desertification failed to meet with the success which their sound technological bases promised because they lacked community participation and support. This realization underlines the special importance of formulating and implementing government policies that provide appropriate mechanisms, incentives and education programmes that are needed for the acceptance and implementation of measures at community level, their maintenance within improved and productive land use systems, and eventually the acquisition of momentum which will lead to progress towards improved living conditions.

Demographic patterns, including nomadism, that prevail in arid lands and desertification-prone territories may not be conducive to effective public participation. Settlement of nomads may not be the answer — except within the framework of transformations of land use systems, development of land resources and changes in land tenure systems. For community participation to be effective, societal instruments (legislation, institutions, means of mobilizing public support, etc.) may need to be developed. Education in its broad sense should be supportive of such enlightened development.

It is evident that active implementation of anti-desertification programmes is hindered by a complex of constraints. Government policies do not seem to accord high priority to such programmes, which indicates the meagre political weight of the communities that are directly affected by desertification, and hence their inability to have their concerns set in their rightful position of priority. As desertification further undermines the life-support systems of such communities, they are further jeopardized or "marginalized".

The Plan of Action to Combat Desertification

The United Nations Conference on Desertification (Nairobi, 29 August to 9 September 1977) adopted a Plan of Action to Combat Desertification with 26 recommendations. The Plan proceeds from three assumptions: (a) that combating desertification at field level is primarily a national operation; (b) that desertification hazards often transcend national boundaries—hence the special importance of regional collaborative action; and (c) that desertification calls for global solidarity and world-wide actions.

It is envisaged that the implementation of the Plan should be the responsibility of Governments through their national institutions. National programmes pursue three principal objectives: (a) to arrest desertification; (b) to establish ecologically sound land use practices that ensure sustained productivity; and (c) to provide for the social and economic advancement of the human communities concerned. For regional co-operative action the Plan endorses three principal approaches: transnational projects, regional research and training centres, and elaboration and implementation of regional plans for combating desertification. At the international level the Plan explores prospects of mobilizing financial and technical resources to aid the countries that face the hazards of desertification.

The UNEP evaluation of progress in the implementation of the Plan between 1977 and 1983 concluded that it had had only limited success. Dregne (15) concludes

> "Land degradation continues widely, even though in places dunes are being stabilized, trees planted, and there is some success in reducing salinization of irrigated land. Too little effort is directed towards field control of desertification. All of indirect contributions to desertification control (education, research, training, increasing awareness, assessments, etc.) will, presumably, assist in combating desertification in the field at some time in the future. It appears certain, however, that there will be no dramatic improvement by the year 2000 unless there is far more focusing of efforts on field projects than at present".

To this we may add that strained political relations between neighbouring countries have often prevented collaboration in implementing regional projects.

Recommended actions

In May 1984, the UNEP Governing Council after reviewing and debating the Executive Director's report on the assessment of world-wide actions to combat desertification since 1977, endorsed a decision including the following general guidelines for action:

(a) The Plan of Action and the institutional arrangements established by the United Nations General Assembly for follow-up remain valid;

(b) The implementation of the Plan should be more focused on:
- The most affected countries
- Field actions to arrest desertification
- Priority to areas offering the best chances for substantial rehabilitation;

(c) Governments of countries menaced by desertification should give priority to:
- Establishing National programmes to combat desertification
- Creating national machinery for implementing it
- Designing programmes in harmony with existing social, cultural and ecological systems;

(d) Regional co-operation is an effective means of increasing the efficient use of financial and technical resources;

(e) Non-governmental organizations have an important role to play in the implementation of action-oriented projects;

(f) The programmes and activities of the United Nations family of agencies need to be further co-ordinated so as to contribute to the implementation of the Plan, and UNEP has a central role to play in catalysing and co-ordinating the implementation of the Plan at the international level;

(g) There is still a need to increase resources for assisting countries menaced by desertification, by channelling more multilateral and bilateral aid to combating desertification, securing more generous contributions to the Special Account, ensuring more effective operation of the Consultative Group on Desertification Control in mobilizing additional resources, and implementing measures for securing additional and predictable financing of the anti-desertification programmes.

Non-governmental organizations have an important role to play in the implementation of action-oriented projects, as demonstrated here in India where the Millions of Trees Club is helping marginal farmers to establish nurseries. (UNEP/Daniel Stiles)

Soil loss

Introduction

Soils are natural systems that evolve as climatic factors and biota act on the parent materials that form the surface sediments of earth. The *World Soils Policy* (UNEP, 1982) provides that:

> "In recognition of the fact that soil is a finite resource, and that continuously increasing demands are being placed on this resource to feed, clothe, house and provide energy for a growing world population and to provide worldwide ecological balance, the Governments of the nations of the world agree to use their soils on the basis of sound principles of resource management, to enhance soil productivity, to prevent soil erosion and degradation, and to reduce loss of good farmland to non-farm purposes."

Soils are subject to hazards of degradation—physical, chemical or biological changes that undermine the structure and functioning of the soil system, and may eventually lead to a decline in soil quality. The various forms of soil degradation, often related to land use practices that overtax the system, include erosion, salinization and waterlogging and chemical degradation.

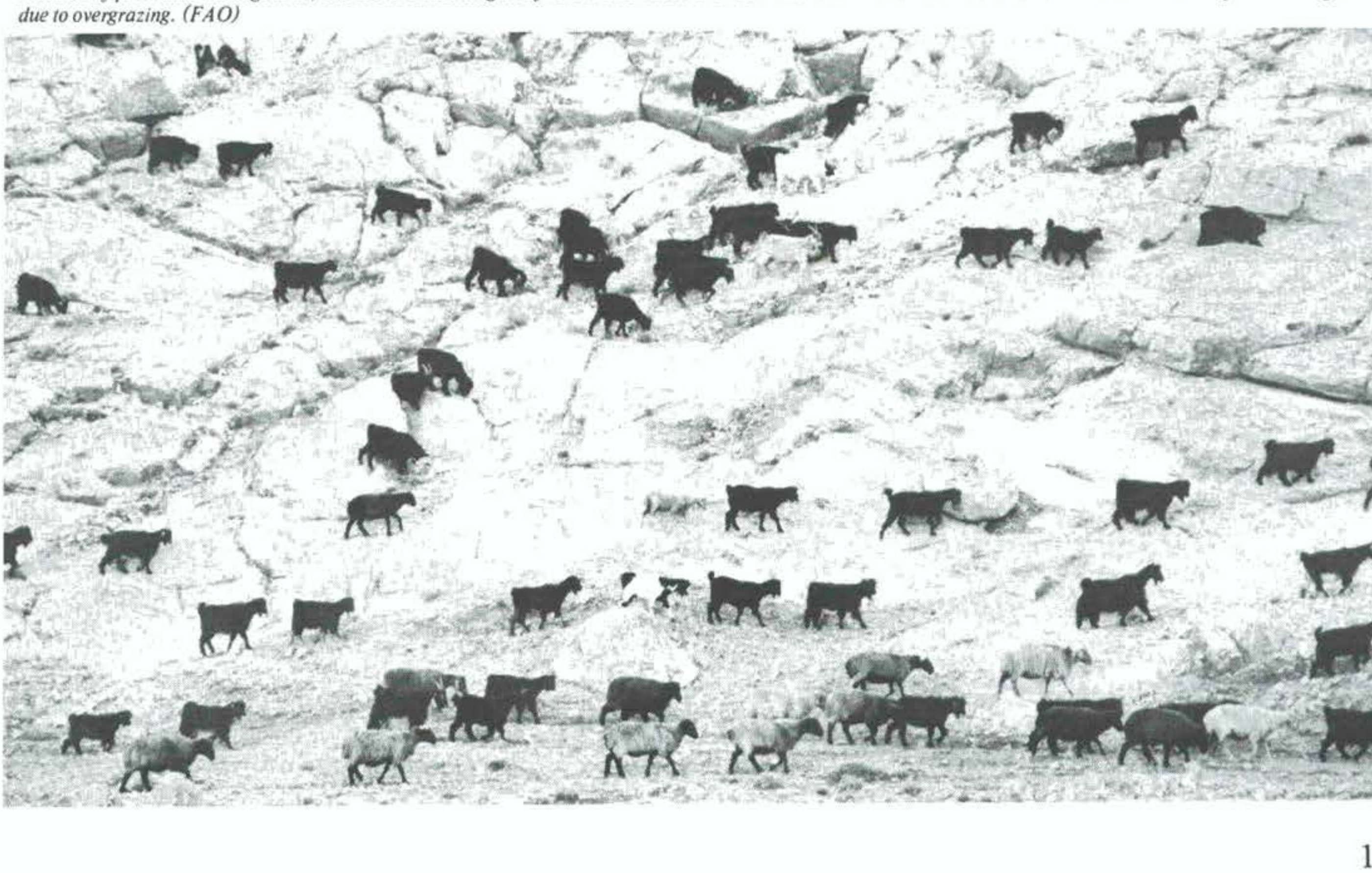
Soil erosion

Erosion is the washing or blowing away of surface soil. It is a natural process that is often greatly increased (accelerated erosion) due to land use procedures (shifting cultivation, overgrazing, overcutting, etc.) that reduce the protective cover of plant growth. It is estimated that the mass of material moved annually by all rivers to the ocean (natural erosion) is about 9.3 billion tonnes, and that the actual volume of accelerated erosion is about 24 billion tonnes (16). There are evident regional differences. Asian rivers contribute the largest share, estimated at 14.53 billion tonnes year, followed by North America (1.78), South America (1.09), Africa (0.48), Europe (0.30), and Australia (O.21) (17). Data compiled in 1980 by the Chinese Yellow River Conservancy Commission indicate that that river carries 1.6 billion tonnes of soil to the ocean each year. The Ganges of India discharges a load of 1.5 billion tonnes of deposits into the Bay of Bengal each year (18). Wind erosion moves much less material, although Saharan dust accounts for billions of tonnes per year (19).

Brown (18) reviewed information on national case-studies. Over a third of cropland areas in the United States lose more than 5 tonnes of topsoil per acre per year, with a total loss of 1.53 billion tonnes a year. Indian croplands lose some 4.7 billion tonnes a year. The USSR may be losing more topsoil than any other country. Brown concludes that the world is now losing an estimated 23 billion tonnes of soil from croplands in excess of new soil formation. To set these figures in perspective he adds:

> "At the current rate of excessive erosion, this (soil) resource is being depleted at 0.7 per cent per year (7 per cent each decade). In effect the world is mining much of its cropland ... Because of the shortsighted way one third to one half of the world's croplands are being managed, the soil on these lands have been converted from a renewable to a nonrenewable resource".

Because of poor land management, erosion is converting soil from a renewable to a non-renewable resource. This hillside in Iran has lost all of its covering soil due to overgrazing. (FAO)



Salinization and waterlogging

Excessive irrigation and inefficient drainage may convert productive farmlands into saline and alkaline waste land. The history of agriculture in Mesopotamia records massive losses of farmland resulting from salinization (20). Case-studies presented to the United Nations Conference on Desertification reported on widespread salinization and waterlogging in Australia, Iraq, Pakistan, United States of America, and USSR (21, 22). World-wide it is estimated that the area now being abandoned is about equal to the area currently being reclaimed and irrigated (23); between 30 per cent and 80 per cent of all lands under irrigation are subject to salinization, alkalinization and waterlogging. Special problems of saline intrusion are encountered in river deltas in Egypt, Greece, the Netherlands, etc.

FAO and UNESCO have prepared a world map of salt-affected soils, and in 1973 issued a source-book on salinization in relation to irrigation and drainage. FAO has also published a reference book dealing with evaluation of water quality for irrigation and means of solving problems associated with salinization (24).

Recommended actions

In 1984 the UNEP Governing Council approved a plan of action for implementing the World Soils Policy, including four major components to deal with:

(a) Land and soil inventory and assessment;
(b) Assistance to Governments of developing countries in the formulation of national soil policies;
(c) Promotion of conservation-oriented land management systems for different environments;
(d) Improved international awareness at all levels of land degradation and soil conservation.

The plan and its four components accord "highest priority" to:

(a) The need to increase the awareness of policy makers concerning land use issues, and the awareness of the public at large concerning the importance of the issues addressed by the elements of the World Soils Policy;
(b) The need to furnish assistance in the implementation of a world soil policy through the dissemination of knowledge, publications, missions, training courses and related means in individual countries;
(c) The need to assist countries in the development of policies, regulations and institutions that will enable them to implement national soils policies.

The plan highlights the:

> "Urgent need for a long-term commitment by international organizations and Governments to support research on mechanisms and effects of soil degradation, on the development of improved practices, and on farming systems for combating soil erosion ..." [and] the long-term need to educate and train specialists and to develop soil conservation programmes at universities and other institutions.

Conclusions

We have discussed three examples of environmental degradation that are often caused by excessive exploitation of resource ecosystems. In each case we note that the causative actions are local, while the consequences are much more widespread, attaining global proportions in many instances. This means that corrective actions must be implemented by national authorities, though for actions to be effective they may need to be co-ordinated at the regional and international levels. For each of the three examples we recommended some actions for consideration. In this concluding section we may outline some general recommendations that cover all issues.

National actions (Education and public opinion)

Participation enhances learning, and participation in environmental actions (planning and management) has great educational merit. A comprehensive programme of environmental education aimed at peasants, fishermen, forest workers and other rural groups was developed in Colombia. It aimed at promoting conservation of natural resources, and combating overfishing, soil erosion and over-exploitation of forests. The direct involvement of people was very effective. Participation of young people in tree planting, nature conservation and wildlife protection through wildlife clubs in Kenya, Mauritius, Uganda, the United Republic of Tanzania, and Zambia provide positive examples. The Chipko Movement in India is an example of the successful mobilization of rural people, through educative participation, for combating deforestation. The youth campaign for environmental reform in Thailand led to enactment of the National Environment Quality Act in 1975. The 4-H Clubs and Youth Conservation Crops in the United States of America, Boy Scout, Rover Touring Clubs and Youth Camps in Europe, Australia and New Zealand, the Blue and Green Patrols in USSR and many other similar youth groups all over the world help to create interest and promote action.

We have quoted examples of failure in exploiting the resources of the biosphere. Correction of such shortcomings can be enhanced through popular participation in actions and by a positive response to needs. Here education and training (formal and non-formal) have a most important role to play. National programmes, utilizing various school and out-of-school mechanisms, need to be developed with the explicit purpose of mobilizing public support for and participation in sustainable development and nature conservation.

The mass media can perform a valuable education function by communicating environmental information and popularizing the scientific basis for the management of natural resources. Media programmes are effective means of education when they explain the process and the message. Television, which can give millions sight of places and ecological situations that they cannot hope to visit, can do much to promote understanding of the problems of overtaxing natural systems.

Correction of the imbalance between society and nature can be enhanced through enlightened (and organized) public opinion that can persuade policy makers to take proper action. Legislative bodies and national parliaments have a most important role in bringing this process to fruition. Parliamentarians individually have a crucial role to play in mobilizing their constituency for effective participation in the formulation and implementation of community programmes for rational management of ecosystem resources.

International actions (Global interdependence)

Many of the issues enumerated apply to resources shared by neighbouring countries, or located in developing countries that require international aid. The *World Conservation Strategy* (IUCN-UNEP-WWF, 1980) calls for:

(a) International co-operative programmes (combining legislation, assistance and other action) to concentrate on tropical forests, drylands, preservation of genetic resources, and regional strategies for river basins;

(b) Funds provided by multilateral and bilateral development assistance agencies (about $27 billion in 1976) should give priority to addressing environmentally induced poverty and ecologically sound development of land resources (reforestation, restoration of degraded soils, efforts to combat desertification);

(c) International action to conserve tropical forests especially in West and East Africa, South and Southeast Asia, Central America and Mexico. Parallel programmes should aim at establishing fuelwood plantations and industrial plantations.

(d) Regional programmes to deal with international river basins:
57 in Africa
48 in Europe
40 in Asia
36 in South America.

Co-operation among riparian States will enhance the sustainable and environmentally sound development of the resources of river basins to the benefit of the partners. Failure to reconcile the interests of upstream and downstream users often creates political frictions.

Another major area of international co-operation relates to transboundary air pollution in Europe and North America. This is an environmental hazard that is causing considerable damage to plant life, including forests and crops, and is a problem that can be solved only by co-ordinated international action. The Convention on Long-range Transboundary Air Pollution, to which reference has been made above, provides an appropriate framework for such action.

Parliamentarians have a special responsibility in all these efforts, and can contribute by supporting or prompting timely action by their people and Governments.

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Soil erosion problems in the USA

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1985 marks the 50th anniversary of the soil conservation movement in the United States. This should be an occasion for rejoicing and celebration, because the American soil conservation effort has made an imaginative and valuable contribution to protecting some of the world's finest farmland.

Instead, 1985 is a time for questioning what has gone wrong, for assessing why the soil conservation movement has fallen far short of doing all that its founders and its modern-day proponents had hoped for. The answers to those questions will play a large role in determining the future health of US agricultural land and water resources and, in turn, the stability of a food production system that has a large impact on world food supplies.

Serious soil conservation work began in the United States in the mid-1930s at the time of the Dust Bowl, when years of drought led to severe wind erosion in the southern plains region of Texas, Oklahoma, and Kansas. The Dust Bowl conditions, combined with the economic depression of the time, produced one of the great social and geographical movements in US history, as impoverished farmers abandoned farming and moved to the cities or joined the migration to the west in search of better farmland in California.

It was the sight of gigantic clouds of precious topsoil billowing into the air and drifting eastward to fall on major cities of the East Coast that aroused citizens and led to the creation in 1935 of the US Soil Conservation Service. Federal soil conservation programmes were enacted to provide financial assistance to farmers who wanted to protect their land. With government help, farmers began installing soil-conserving terraces on their land, raising crops in ways that utilized the natural contours of the land to hold soil in place, and growing trees along field borders to act as windbreaks. Farmers practised crop rotation, alternating grain crops one year with hay or grasses for grazing livestock the next year.

The new soil conservation efforts proved successful, and erosion caused both by wind and water began to decline. The US also entered a long period of relatively favourable climate, which alleviated the Dust Bowl conditions and aided conservation.

Changes

However, in the early 1970s, things changed. Beginning with the first large sales of wheat to the Soviet Union, the US began emphasizing the exporting of grain—both as a means for disposing of continual surplus crops of wheat and corn and as a way to increase farmer income and improve the US balance of trade.

The direction of US agriculture changed radically. Idled cropland—some 60 million acres of it (about 24 million hectares)—was brought back into production. Earl Butz, then US secretary of agriculture, told farmers to plant all of their land, from fence-row to fence-row. They responded by converting their land to maximum grain production. Soil conservation structures were destroyed so that all land could be put into row crops. Terraces and rows of trees were removed because they kept valuable land idle and because they got in the way of the big new farm machinery that was being developed. And hilly, erosive, marginally usable land was ploughed and planted—some of it for the first time. Crop rotations were abandoned, and farmers adopted monocultural cropping of corn, wheat, or soybeans.

The result was a sharp increase in US grain production, a boom in export sales, and a rise in farmer income. Some of the increased grain production went to developing nations and helped in the fight against hunger. But the vast majority of the new grain exports were commercial sales to industrialized nations, with the principal benefit to the United States being the earning of foreign exchange to help offset the balance of payments crisis brought on by the high price of imported oil. But the new export boom was short-lived, and in the late 1970s and early 1980s US grain exports fell. Farmers now are experiencing their worst economic problems since the years of the Great Depression of the 1930s. They have gone into debt for land and machinery they purchased during the export boom, and they became tied to a high-volume production that brought them only marginal profits but which they could not afford to abandon.

Row-crop farming

That brings me to the major concern of this article—the alarming environmental impact that this intensive row-crop farming of the 1970s had upon the farmland of the United States. The new farming brought along with it great increases in soil erosion. Land no longer protected by the time-tested soil conservation methods began washing and blowing away. Topsoil by the ton began eroding from cropland, clogging roadside ditches, washing into streams, and filling lakes and reservoirs. The eroding soil carried with it chemicals and livestock wastes.

Soil scientists believe that topsoil—the most fertile, organically rich upper level of the land—can erode at rates of no more than five tons per acre per year without eventually losing its productivity. Any more than that, and the lost soil is not replaced by naturally generated new topsoil. In fact, on some fragile lands, the tolerable soil loss is much less—four, three, or two tons per acre per year.

Government studies now show that more than 40 per cent of US cropland is eroding at rates in excess of these tolerable levels. That means that more than one-third of the cropland is at risk of losing its long-term productivity (desertification). Each year, some 3 billion tons of soil washes and blows from all US cropland. When erosion from pastureland, rangeland, and forest land is added in, total erosion is more than 5 billion tons annually. Total US soil erosion now is greater than in the worst years of the Dust Bowl.

Soil erosion can bcome so severe that innovations in technology can no longer keep pace. (Photo: P. Pierscinski)

Soil erosion is not a problem in the United States alone. A recent study by the Worldwatch Institute finds that half the world's cropland is losing topsoil at a rate that undermines its productivity. The excessive loss of topsoil from world cropland is calculated by the Institute at about 25 billion tons a year—a condition that could lead eventually to reduced food production and higher food prices in nations that can ill-afford either.

In the US, the erosion rates are not uniform. Much of the severe erosion is concentrated in certain areas. That would seem to make the task of controlling erosion somewhat easier, except for the fact that some of the worst erosion is in the country's most important and intensively cultivated farm areas. In the state of Iowa, for example, the leading corn producing state, the average erosion rate on cropland is about 10 tons to the acre per year—twice the allowable limit. When Iowa was natural prairie and before it was ploughed and cultivated for crops, it has an average topsoil layer of about 16 inches. Today, because of intensive farming and erosion, the topsoil layer is only an average of 8 inches deep. Half the topsoil of Iowa has disappeared in 100 years of farming.

In the hilly regions of western Tennessee, once used primarily to graze cattle, soybeans and cotton now are grown intensively and erosion has increased on many farms to 20 tons per acre—four times the limit. Small local streams are becoming clogged with sediment, which leads to flooding, breaking away of streambanks, and further farmland erosion. These Tennessee rivers drain into the major river of the central US—the Mississippi—which has become heavily loaded with topsoil from the major farm states.

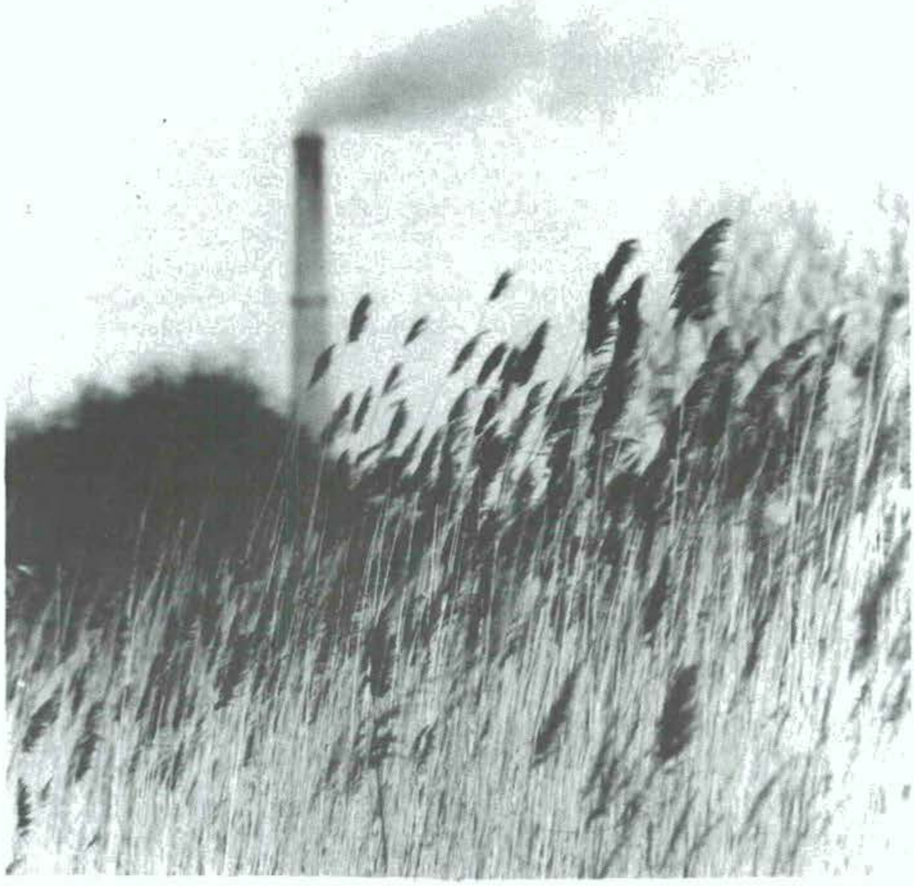
In the Pacific Northwest, in the beautiful rolling Palouse region of Washington state, erosion rates have reached 50 and even 100 tons to the acre. That is one of the few areas where the adverse productivity effects of erosion have begun to be seen. Eroded hilltops and steep slopes have lost so much of their topsoil that wheat yields have started to decline. That should be a warning for the future, to those who think agricultural innovations will allow crop yields to continue to increase despite erosion. In fact, the use of agricultural chemicals that came into common use following World War II—the insecticides, fertilizers, and herbicides—has so far masked the effects of erosion in most farm regions of the US. While erosion may be robbing the land of its inherent productivity, crop yields have risen. The combination of chemicals and better grain seed has permitted farmers to ignore the dangerous aspects of erosion and the deteriorating natural fertility. But that may change.

Disaster

The US Department of Agriculture estimated in one study that at current erosion rates, corn yields in the central Corn Belt states could fall by 30 per cent over the next 50 years. That would be a disaster, and some people think the estimate is far too high. One Agriculture Department researcher surveyed several studies of soil loss in the Corn Belt, and reported that they found on the average that the loss of one inch of topsoil reduced corn yields by about 6 per cent. The Worldwatch Institute study, cited earlier and entitled "Soil Erosion: Quiet Crisis in the World Economy", points out that as erosion increases, so do food costs. Farmers must apply more chemicals to the land in order to compensate for the fertility loss caused by erosion and must spend more money for fuel because eroded soils are more compacted and difficult to till.

Whatever the estimates, nearly everyone agrees that soil erosion reduces the natural fertility of the land. The big question is whether we may some day enter a period of relatively rapid declines in crop yields because innovations and technology no longer can keep pace with the effects of erosion.

The other major impact of soil erosion, besides its possible damage to future crop production, is that it pollutes rivers, lakes and reservoirs. The federal Clean Water Act adopted in the mid-1970s mandates that pollution of public waterways be cleaned up so that the waters are restored to fishable and swimmable quality. Deadlines for meeting that goal have not been met, however, and the primary culprit is agriculture. Water pollution caused by inadequate sewage treatment or by discharges from industrial facilities has proven much easier to treat than the kind of widely dispersed, hard-to-identify pollution caused by soil erosion from American farms. Studies show that two-thirds of all US river basins are polluted because of farming activities. The eroded soil alone would be bad enough, as it clogs small streams and fills reservoirs designed to ,conserve water supplies. But the damage is mutiplied by the presence of chemicals and animal wastes in the eroded soil, to the point that water pollution poses a threat to human health and to fish and wildlife. The financial costs of water pollution caused by soil erosion are enormous. For example, the federal government and several states have recently embarked on a long-range programme to clean up the Chesapeake Bay, one of the world's richest estuaries and the source of much of the fish, oyster, and crab catch in the United States. The Bay has become polluted with chemicals that threaten aquatic life, and it has been determined that a major cause of the pollution is erosion from farmland in the Susquehanna River watershed, which flows into the Chesapeake Bay. This long overdue clean-up effort will cost several billion dollars and involves many tricky legal and political questions in dealing with the polluters.



Pollution of soils is another serious problem in the USA (UN Photo)

Unfortunately, the adverse effects of soil erosion on US agriculture are compounded by several other environmental problems connected with moden farming. One of the most troubling is the steady depletion of water supplies—particularly in the High Plains states in the central and south-central part of the nation. These are states that depend on the large underground Ogallala Aquifer for irrigation water. During the agricultural expansion of the early 1970s this land, previously used for cattle grazing and for dryland wheat production, was converted to other types of crops that are more dependent on water. Great numbers of wells were drilled, and the Ogallala Aquifer was tapped for irrigation water. The result is that groundwater is being "mined"—that is, used at a faster rate than the water is naturally recharged by nature. Portions of the aquifer are being depleted, and already farmers in Texas and Oklahoma are being forced to return to dryland farming. The same thing is likely to happen in other states.

Semi-arid land development

Some of this semi-arid land was developed for irrigated farming by non-farm investors with no real interest in agriculture other than for what quick profits it could bring them. US tax laws and federal agricultural programmes make it financially advantageous for them to do this. When the water runs out, they have been only too happy to sell or to abandon the land, leaving it to the ravages of nature. As part of this process, millions of acres of previously uncultivated land were brought under the plough, in what is termed "sodbusting". Centre-pivot irrigators were installed, for example, in a nearly desert-like area known as the Nebraska Sandhills so that corn could be raised as cattle feed. Because the land is so fragile there, spells of dry weather and wind sometimes cause massive soil erosion on this land that prior to cultivation had been protected by grass and a thin layer of topsoil.

Another problem afflicts the Colorado River basin and the San Joaquin Valley of California, the latter being the major fruit and vegetable producing area of the US. Here, the intensive irrigation of the past few decades has started to turn water supplies salty. This is caused by evaporation from fields and by the leaching of minerals from the soil into return water flows. I have seen fields of cotton in the San Joaquin Valley where the growth of cotton plants has been stunted by the extremely saline irrigation water and where the land is caked with white salt. Some of the less salt-tolerant fruits and vegetables no longer can be grown on such land. The proposed solutions—bringing more water in, using it, piping the used water out through a complex network of drains and canals—would cost billions of dollars. And yet the alternatives—cutting back on farming there, or eventually losing major fruit and vegetable producing areas—are almost unthinkable.

Urbanization

At about the same time that the US was beginning to see a large increase in erosion and the other environmental effects of agriculture that I have described, it was learned through a federally-sponsored National Agricultural Lands Study that the US was losing very large amounts of farmland to urbanization and other development. The study found that about three million acres of agricultural land was being converted each year to other uses. Of this, about one-third—or one million acres annually-was classified as "prime" farmland. Suburban housing developments, shopping malls and freeways now cover millions of acres of land that used to grow corn, wheat, soybeans, and other crops.

The conversion of good farmland takes fertile land out of production. In addition, it puts added strain on the less desirable and less productive land to take up the slack as the size of the farmland base is reduced. As Los Angeles grows, for example, citrus orchards have been driven out and forced to relocate on the other side of the central valley on far less suitable land. The hastily replanted orchards have been subjected, during dry spells to some of the most severe wind erosion ever seen in California and, in wet spells, to damaging water erosion that removes topsoil and forms gullies.

The combination of these forces—erosion, water pollution, water depletion, farming on marginal lands, and conversion of farmland to other uses—can become very destructive. The fact that the US is the world's biggest agricultural producer, and the fact that it is a nation able to produce far more food than it can consume itself, should blind no one to the dangers that lie ahead. The condition of US soil and water resources is in decline, and American agriculture—as it began to be practised in the early 1970s—is not environmentally sustainable into the future. It seems far-fetched to think that an agriculture as bounteous as that of the United States could destroy itself, and perhaps it never will. But the nation has embarked on a type of farming that undeniably is damaging the environment. The eventual consequences still are unknown.

Recognition of the soil erosion situation in the US has come slowly, but interest in it is at last beginning to build. Until recently, farmer organizations were reluctant to admit that a problem even existed. This was due, in part, to the independent nature of the American farmer—a legacy perhaps of our frontier ethic—and to fear of government regulation of the way land is used.

Environmental organizations have been shamefully slow in sensing that soil erosion might become a major national and worldwide concern. Erosion is not as easy to detect as air pollution from cars or waste discharges from factories, nor is erosion control as attractive a public issue as creation of a national park or protection of a wilderness area. But some of the environmental organizations now are beginning to look at the farmland resource problem.

At the government level, federal conservation programmes have existed for 50 years. But they are voluntary; farmers are not forced to participate. Over the past decade or so, the conservation programmes have been very poorly funded. They have not required that a farmer permanently maintain conservation structures that the government helped to pay for. Thus, a US farmer may obtain all the benefits of price support guarantees, crop insurance, and other aid, but may ignore conservation and treat his land in a negligent manner.

The farmers themselves have been caught in an economic squeeze that makes it more profitable, at least in the short run, to "mine" the land—to extract maximum crop yields from it without regard to damage to the soil and water. Most farmers are conservationists at heart, I have found, but they are business people first. In tight economic times, they will postpone conservation work in hopes of raising that year's profits. A healthier farm economy would benefit conservation.

Some individual state governments have enacted their own conservation programmes, helping farmers with conservation work and requiring that the farmers reduce their erosion to acceptable levels. But these efforts have been scattered and inadequate. At the federal level, budget deficits and politics have combined to prevent a concerted attack on soil erosion. It is up to Congress to enact agricultural legislation, including soil conservation programmes, and it is up to the Department of Agriculture to carry them out. But the process has been very slow.

Resources Conservation Act

In 1977, Congress responded to the mounting evidence about erosion by enacting the Resources Conservation Act (RCA). This law required the Soil Conservation Service—an agency of the Department of Agriculture—to make an extensive survey of the soil and water conditions of the US. The RCA law also ordered the Department of Agriculture to submit a plan for a national soil and water conservation policy. The survey produced a great deal of valuable data. Some of the erosion figures I have cited today came from that survey. But the RCA process still has not resulted in a national soil and water conservation policy, even though it is now seven years since the law was adopted. There were many delays, including some caused by the changeover from the Carter administration to the Reagan administration in 1981.

When President Reagan finally submitted to Congress, at the end of 1982, the final RCA report and his recommendations, conservationists were deeply disappointed and angered. The report clearly stated that the present level of soil erosion was unacceptable, and said it threatens future farmland productivity and water purity. But at the same time, the President said the nation could not afford to do all that was needed.

At the same time it was sending its RCA report to Congress, the Reagan administration was asking Congress to cut the funding of current conservation programmes by 30 per cent. So far, Congress has refused to go along with the recommended funding cuts, and there now is a developing tug-of-war between Congress and the White House on conservation matters.

In 1983, Congress, at the request of the Reagan administration, adopted a "Payment in Kind" law, which gave farmers surplus government grain in exchange for their agreement to take some of their land out of production that year. The purpose was to control supplies and raise prices paid to US farmers for their grain, but it was hoped that soil conservation also would benefit if farmers would take their poorest land out of crop production and put it into soil-conserving uses. However, the conservation provisions of the Payment in Kind programme were not widely enforced, and one study showed that only 10 per cent of the idled land in the central grain states had been adequately protected from erosion. Once again, conservation potential was ignored.

Conservation tillage

The Reagan administration and Agriculture Secretary John Block have adopted as their primary conservation method a type of farming known as conservation tillage. The idea is to reduce cultivation of the land, to disturb it less with ploughing, and to leave residues of the previous year's crop on the land. This is designed to keep the land more covered and protected, and thereby reduce the chances for erosion to occur during windstorms or during heavy rains. Where a farmer used to plough his land clean before planting next year's crop, a farmer practising conservation tillage will plant the new seeds right in among the stalks and debris left from last year's harvest.

Conservation tillage has some definite advantages for farmers. It can reduce his fuel costs because he does not make nearly so many trips through the field with his tractor and ploughing equipment. It also reduces his labour requirements. The government likes to advocate conservation tillage, because it is much cheaper than giving farmers financial aid to install terraces and other conservation structures.

But there are drawbacks, too, which the advocates of conservation tillage are not eager to admit. The crop residues left on the land provide a fine habitat for insects and particularly for weeds. Conservation tillage therefore requires use of more chemicals than does conventional farming. The chemical manufacturing corporations, whose sales have been suffering in recent years as the price of fertilizer, insecticides and herbicides has risen, have embraced conservation tillage as a way to improve their own sales and are actively promoting it. Also, Maureen Hinkle of the National Audubon Society has pointed out that weeds seem to be starting to develop a resistance to the herbicides employed in conservation tillage, just as many insects have become immune to some pesticides.

Conservation tillage probably has a place to play in farming, because it can help prevent erosion. But it should not be viewed as a panacea, as a cure for the problem, as some are doing. On hilly, fragile soils, even conservation tillage will not be able to reduce erosion to acceptable rates. On such land, chemical pollution of both streams and underground water supplies may actually increase. Even where conservation tillage is appropriate, it should be combined with other time-tested conservation methods. There are no easy answers to the erosion problem, and it is foolish to think that there are.

What will the US do?

What will the US do about its erosion situation? In the last session of Congress, two pieces of legislation were proposed. One would have withheld various federal benefits from farmers who engage in "sodbusting" of native grasslands and prairies with a high potential for erosion. The other would have established a "conservation reserve", to pay farmers to retire erosive cropland from production. But neither proposal won final approval in Congress.

This year, the federal law that governs all agricultural programmes will expire, and Congress must pass a new law. The biggest hope of conservationists now is that Congress will include a strong conservation programme in the new farm law. Public pressure is building to do something about erosion, and an environmentally sound conservation effort would help win the votes of urban members of Congress that are needed to enact any farm legislation. So, hopes are high.

Many difficult problems remain to be solved, however. The US has never come to grips with the question of whether conservation programmes should continue to be voluntary on the part of the farmer. Why shouldn't a farmer be forced to practise conservation in order to protect the land and water for future generations? At least, why shouldn't he be denied the right to price support guarantees and other federal benefits, unless he practises conservation on his land? Looking at it another way, why should the government continue to subsidize farming practices that could eventually destroy the land upon which the US and many food-deficient nations depend? The answers may seem obvious, but such restrictions go against American traditions of independence and unfettered use of one's land.

The US also needs to examine its grain export policy. Grain exports are a source of income for American farmers, a source of foreign exchange, and a source of food for the world. It sounds cruel to even suggest that perhaps US grain exports should be restricted, and I am not suggesting that today. But, the US should examine its export policy, and try to determine whether there is some maximum level of exports that can be safely provided without putting undue strain on US soil. If grain is exported at such a high level that marginal lands are put into crop production, that soil erosion increases and water supplies are depleted—all imperiling the soil and water needed by those who come after us—then such an export policy would be very shortsighted. At the moment, we simply don't know what level of exports is safe. This is an issue that is painful, politically and economically, to those both in government and in the private agricultural sector.

All of these difficult questions must be dealt with, not ducked. The future health of US agriculture depends upon it, and the entire world has a stake in a sustainable American food production system. The US must develop a national policy on soil and water conservation, just as it has done for the other great environmental issues of our time. President Franklin D. Roosevelt warned Americans 50 years ago, when the soil conservation movement began in the United States, that a nation that neglects its soil endangers its own survival. That is a warning we should all heed today.

Desertification and dust monitoring in West Africa

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Introduction

In the seven years since the United Nations Conference on Desertification (UNCOD) produced the Plan of Action to Combat Desertification (PACD), progress in achieving the goals of 1977 has generally been disappointing. Recent discussion in *Desertification Control* and elsewhere has identified a number of reasons for this slow progress, including inadequate funding, reluctance of Governments to give desertification a high priority, increasing rates of population growth, and continued drought conditions within Africa.

It is proposed here that some of the problems experienced in the implimentation of PACD, (in particular, inadequate funding and reluctant Governments) could in the future be significantly reduced if UNEP and related agencies have access to hard data on the spread of desertification.

Literature on desertification (e.g. *Desertification Control)* abounds with estimates of, for example, the percentage increase in land area affected by desertification, or the millions of people whose livelihoods are directly threatened by desertification, but more accurate, tangible and quantitative data derived from actual field measurements are needed to clearly demonstrate the threat of desertification. Decision makers within developing countries must balance the costs and benefits of desertification control programmes against other important development programmes, therefore before they will commit themselves to expensive and long term desertification control programmes it is reasonable that they should require hard data to initially ascertain that the threat of desertification is real, and then once desertification programmes are in progress, to show that the programme is, or is not, effective.

The objective of the present paper is to outline a strategy for providing a semi-quantitative and long term index of desertification by measuring dust mobilisation, transport and desposition in West Africa. This dust monitoring programme (McTainsh 1985) could provide a record of desertification over the past 50 years and thus clearly demonstrate the increasing threat to Sahelian countries. In addition, the dust monitoring programme could provide an ongoing source of data from which to evaluate the success of desertification control programmes. These data could be collected for West Africa as a whole, as well as for different regions within the West African savanna.

The Harmattan wind and its dust

The Harmattan wind and its dust is a distinctive feature of the climate of West Africa. During the Harmattan Season (October to May) dust-laden winds pass over West Africa in periodic pulses or plumes reducing visibility, air temperatures and relative humidity (Plate 1). The dust plumes appear to originate from the Bodele Depression area near Faya Largeau in the Chad Basin (Fig. 1), although the Tenere Desert may also be a source area (Bertrand *et al* 1979). Once entrained, the dust passes out over West Africa and the Atlantic Ocean (Fig. 1). Measurements in northern Nigeria (McTainsh and Walker 1982) indicate

Plate 1: A dusty day in Kano City, Northern Nigeria (location Fig. 1)

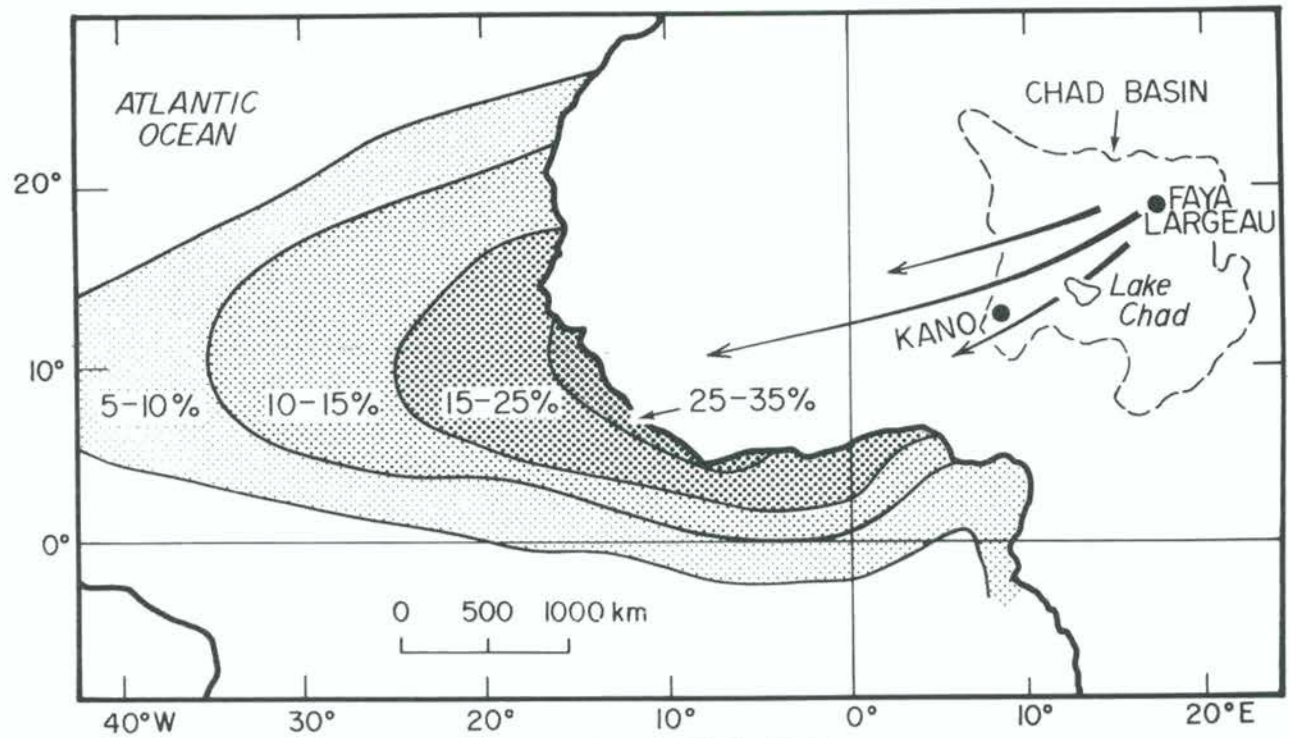

Fig. 1: The Harmattan Wind and its dust.

that both the rate of dust deposition and the particle-size of the deposited dust, decrease with distance downwind. Also, once deposited, the dust is then vulnerable to remobilisation by wind, particularly in poorly vegetated areas.

Studies of the dust component within Atlantic Ocean sediments off the West African coast (e.g. Bowles, 1975) suggest that dust processes have been operating at varying rates at least over the last 600,000 years. Furthermore, recent results from studies in northern Nigeria (McTainsh 1984) suggest that some savanna soils are largely the product of Harmattan dust deposition during the Quaternary past. There is evidence to suggest that during past arid phases the Sahara Desert extended hundreds of kilometres south of its present borders producing both dune sand and dust mobilisation in the Sahel areas, a situation perhaps not unlike that which existed during the Sahelian Drought and persists at least sporadically, to the present.

Dust as an index of desertification

A basic premise of the present desertification monitoring programme is that desertification, whether by man and/or natural influence, almost invariably involves the depletion or removal of the protective vegetation cover, leaving soils vulnerable to wind and water erosion resulting in soil degradation with a consequent decrease in soil productivity.

In the semi-arid West African savanna aeolian (or wind) processes are particularly effective in soil degradation and there are generally two kinds of aeolian processes: firstly, dune sand mobilisation, a process which can be dramatically illustrated using photographs of encroaching sand dunes (Plate 2), and secondly, dust mobilisation which involves the entrainment by wind of the finer fractions of soils (silts and clays) in dust storms (Plate 3). Dust mobilisation also occurs during dune sand mobilisation but it is less easily demonstrated and has received much less attention.

Examination of a dune sand profile within the Sahel savanna area of northern Nigeria (Fig. 2) demonstrates that dust mobilisation is perhaps the most important degrading effect of soil erosion by wind. The soil profile has a 5 cm deep top layer which is pale coloured and low in organic humus which contrasts with the underlying red soil. This top soil layer results from wind erosion during the Sahelian drought, however, during the wet season a lush grass cover conceals any appearance of soil degradation. The most significant effect of this remobilisation appears to be the removal of the finer silts and clays from within this soil layer, which is apparent from a comparison of the particle-size curve of the remobilised top layer with that of the underlying soil (Fig. 2). The principal difference between the two soil layers is that absence of the minor silt mode (15-40 mm) in the remobilised soil layer. Furthermore, comparison with a typical Harmattan dust particle-size curve suggests that the silt mode is dust-derived. Therefore, it appears that an important effect of dune sand mobilisation is the entrainment and loss of the dust component.

While this dust component is a relatively minor part of the total dune soil, its presence significantly increases the structural stability, soil moisture storage capacity and the chemical fertility of these dune sand soils and consequently its removal during drought is an important degradational process.

The dust monitoring programme proposed here can provide a measure of the rates of dust mobilisation, transport and deposition at locations

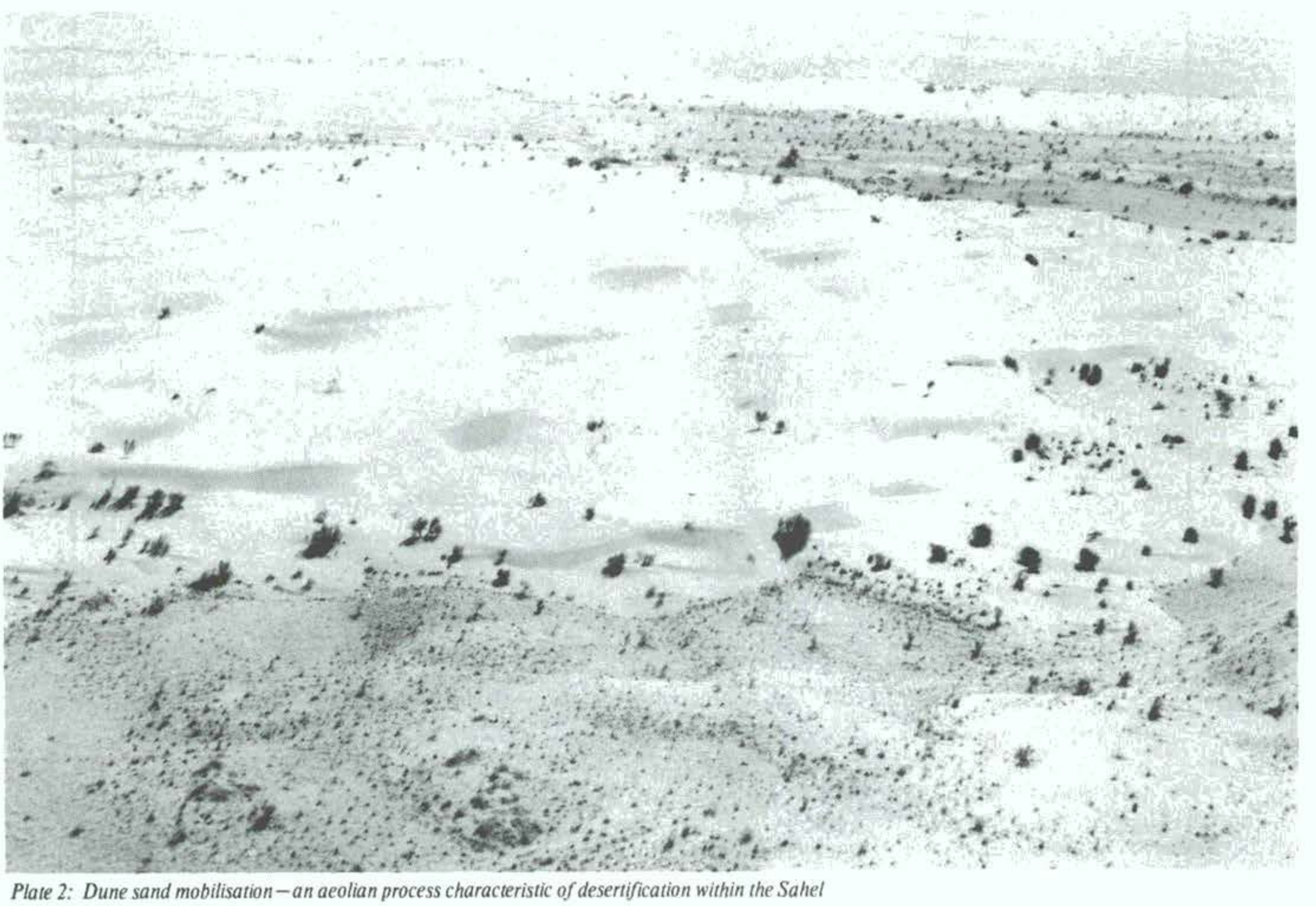

Plate 2: Dune sand mobilisation—an aeolian process characteristic of desertification within the Sahel

throughout West Africa and over the Atlantic Ocean. These rates can then be used as an index of the stability of soils, controlled largely by vegetation cover, both of which are critical manifestations of desertification.

Since the Sahelian Drought (1968-1973) several research proposals have been put forward to monitor desertification by using dust emission from Africa as an index (Rapp 1974, Rapp 1976, Rapp & Hellden 1979; Morales 1979). A Workshop on Saharan Dust was also held in 1977 "to review the present state of the art and make recommendations for future research and monitoring" (Morales 1977, p.5), but despite these important recent developments, the principal constraint upon the establishment of a dust monitoring programme is the limited knowledge of dust entrainment transport and deposition processes in Africa. A case in point is the recent study by Prospero and Nees (1977) who found a marked increase in dust emission from Africa during 1972-1974, the last years of the Sahelian Drought and this increase in dust emission, which was measured at Barbados, was tentatively attributed to the accelerated wind erosion of soils within the West African savanna regions during the Sahelian Drought (i.e. desertification). However, the dust plumes monitored by Prospero and Nees at Barbados displayed a marked seasonality, with maximum dust concentrations during June to August (summer) of each year, whereas Harmattan dust has an equally marked seasonal occurrence during the months of October to May (winter). It is difficult to see, therefore, a relationship between this summer dust monitored over the Atlantic and desertification within the Sahel. In fact, there is a considerable body of evidence that the summer dust comes from regions to the north of the Sahara.

This example demonstrates the need for a holistic approach to dust monitoring for desertifiation purposes and a convenient model for such an approach is the model of the Harmattan aeolian system proposed by McTainsh and Walker (1982).

The Harmattan aeolian system—a model for desertification monitoring

In order that dust measurements can be related directly to desertification at a particular location the Harmattan wind is viewed as an aeolian system comprising three dust process zones, each of which may have inputs, outputs and throughputs of dust. In Figure 3 the symbols of Forrester (1970) are used to show the main types of dust processes which may be operating in, for example, Zone II.

Zone I—the Central Chad Basin Entrainment Zone (Fig. 4)

It is within this zone that most of the dust entrainment occurs. The sediments of the Bodele Depression may be entrained into aeolian suspension by the migration of dune sands across these dry lake beds under the influence of strong winds during the Harmattan Season. This process is referred to here as *primary entrainment* (Ep in Fig. 3).

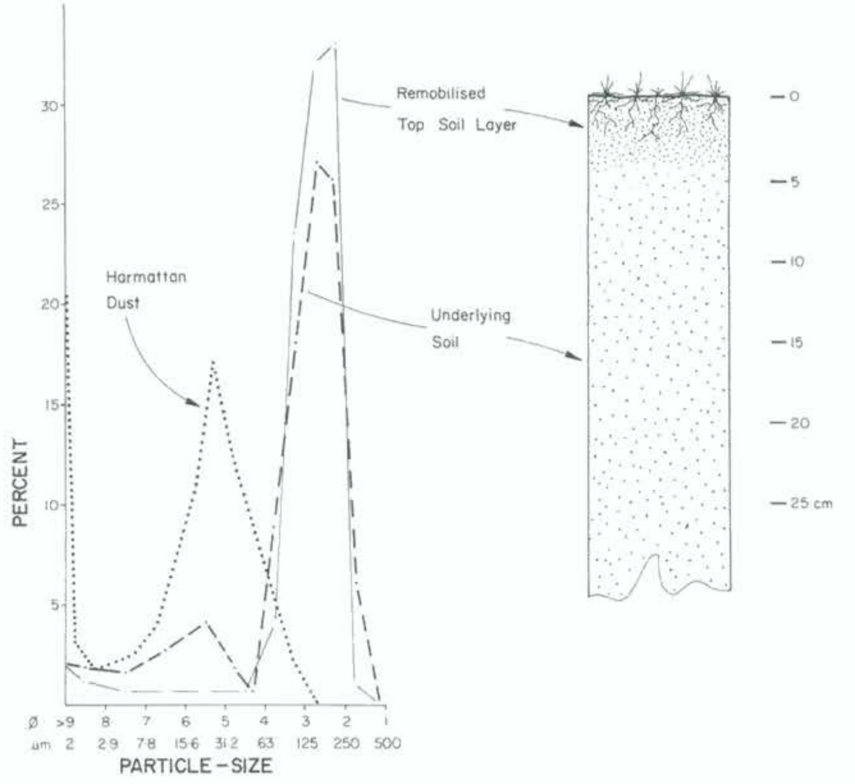

Fig. 2: Effects of wind erosion upon the particle-size characteristics of a dune soil in northern Nigeria.

Zone II—the West African Deposition Zone (Fig. 4)

As the dust plumes pass over this zone, deposition of dust is the dominant process, (referred to as *primary deposition,* Dp in Fig. 3), however once deposited, dust remobilisation (or *secondary entrainment,* Es) can occur, depending upon vegetation cover, soil moisture levels, and wind speeds. Some of this dust may be redeposited locally *(secondary deposition,* Ds) while the rest remains in the plume (Tp). The rate of dust stabilisation at any location with Zone II is therefore a product of the balance between dust outputs from the plume (primary and secondary deposition) and dust inputs (secondary entrainment).

Zone III—Atlantic Ocean Deposition Zone (Fig. 4)

Once over the Atlantic Ocean, deposition and transport are the dominant processes.

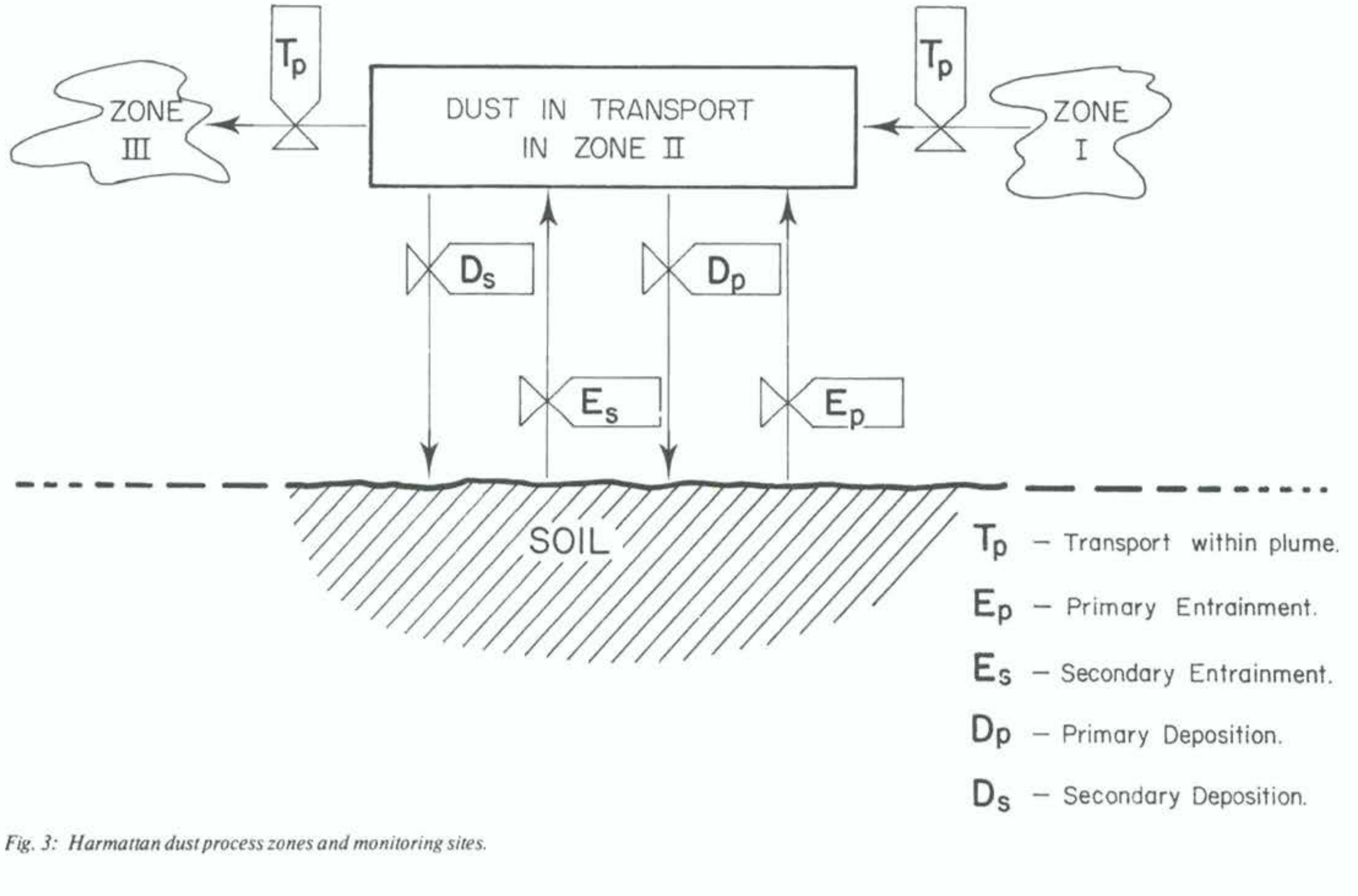

Fig. 3: Harmattan dust process zones and monitoring sites.

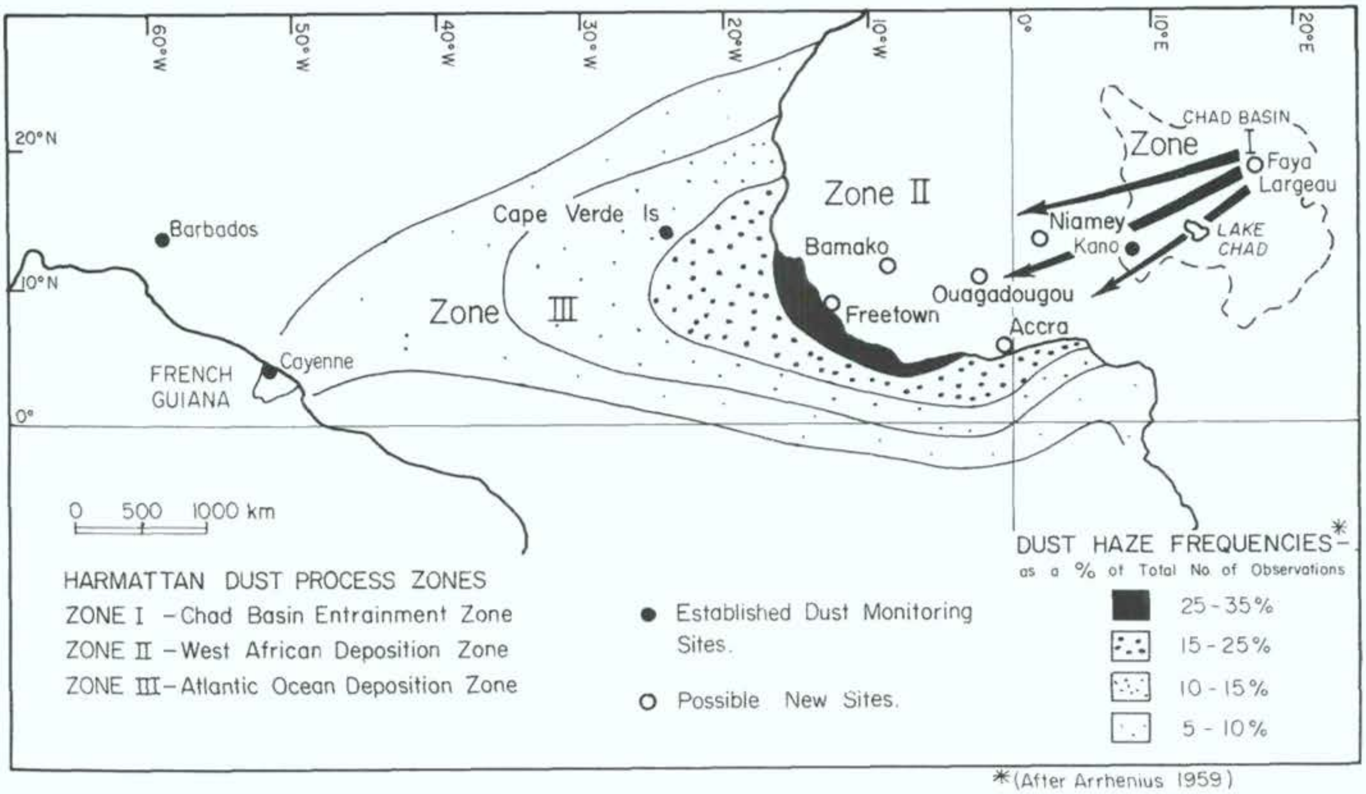

Fig. 4: Types of dust processes operating in the Sahel Savanna.

In summary, within each dust process zone a mixture of three dust processes may occur: dust entrainment, transport and deposition. The entrainment processes represent an input into the aeolian system, the deposition processes are an output from the system and transport represents a throughput within the system (Fig. 3).

Expressed in desertification terms; if the quantity of dust carried by each of the three processes can be measured through time within the savanna areas of Zone II, this would provide an index of environmental degradation or desertification. For example, removal of vegetation in Zones I and II will increase both primary and secondary entrainment processes, but it is likely to increase secondary entrainment within Zone II to a greater extent than primary entrainment in Zone I, because the dust source areas in Zone I already lie within the Sahara Desert which seldom has substantial vegetation cover. Therefore, removal of vegetation associated with desertification is likely to increase the quantity of dust emanating from West Africa which could be monitored, but more importantly the devegetated areas of Zone II could become a major dust source area.

The relationship between dust processes and desertification described here is made more complex by the independent influence of changing windspeed upon dust processes. It is possible, for example, for an increase wind speed over a few seasons to produce an increase in the dust throughput from Zones I and II in the same manner as an increase in desertification, however, if windspeed measurements are made in Zone I and Zone II it should be feasible to isolate its effects from those of desertification.

Outlined below is a strategy for monitoring the dust processes illustrated in Fig. 3 at a network of sites throughout the West African savanna.

Dust monitoring techniques

A number of dust sites could be set up within each of the dust process zones (Fig. 4). Some of these sites are already in operation including Barbados (Prospero 1968), Cayenne (Prospero *et al,* 1981), and Kano (McTainsh 1982) while in the past other sites have operated in the Cape Verde Islands (Jaenicke and Schutz 1978) and elsewhere in North and West Africa (d'Almeida and Jaenicke 1985). It should, however, be feasible to integrate the measurements at the established sites with those at the new sites.

At each location, measurements could be made of dust deposition (primary and secondary), dust entrainment (primary and secondary) and dust transport. These dust measurements could then be related to measurements or observations of the two main environmental factors controlling dust processes, namely vegetation cover, a product of desertification; and windspeed. Windspeed data should be available from local meteorological sites or airports, whereas vegetation cover measurements or observations could be related to dust processes at a site. Additional meteorological parameters such as solar radiation and visibility can also provide independent measures of the intensity of dust plumes.

Finally, and most importantly, all of the above measurements can be related to data on dust plume intensities, directions and speeds obtained from satellite imagery, as proposed by Rapp (1974) and Rapp and Hellden (1979).

Dust collection and measurement techniques

In selecting the most appropriate collection and measurement techniques for the new sites emphasis is upon measurement accuracy, equipment cost, ease of maintenance, suitability to local conditions and compatibility with methods at established sites.

Two general measurement techniques are proposed to measure dust entrainment and transport: dust aerosol sampling and indirect measures of atmospheric turbidity.

1. Dust aerosol sampling techniques

Dust aerosol sampling can be carried out using an air pump with replaceable cloth or paper filter cartridge. The filter pump method measures dust aerosol concentration in terms of mass of dust collected per volume of air pumped. The main practical constraint upon its use is the availability of an electric power supply, but this should not be a problem at the sites proposed. The filter pump method is already widely used at the Atlantic Ocean sites of Barbados, Cape Verde Islands (Glaccum and Prospero, 1980) and at Cayenne, French Guiana (Prospero, Glaccum and Nees, 1981).

The positioning of the filter pump samplers in Zone II is critical for determining which of the two processes, dust entrainment and transport, are being measured. For example, one filter pump sampler, set up at around 10m above ground level, will collect a composite sample (C_1) comprising dust in suspended transport (T_p), plus dust being deposited (D_p). A second filter pump 1m above ground level, will also collect a composite sample (C_2) including dust being entrained (E_s), plus dust being deposited ($D_p + D_s$) (Fig. 3). To measure the quantity of dust being transported or entrained it is necessary to separate these measurements from the deposition measurements (to be described later) in the following manner. The quantity of dust in transport in Zone II is calculated as follows:

$$T_p = C_1 - D_p$$

While the quantity of dust being entrained in Zone II is:

$$E_s = C_2 - (D_p + D_s)$$

2. Atmospheric Turbidity Measurements

In Zone II the onset of dusty conditions is manifest by reduced visibility and increased dispersion of solar radiation. Measurements of both these meteorological parameters can provide an indirect measure of dust aerosol concentration. In northern Nigeria, McTainsh (1980) demonstrated a relationship between dust deposition, solar radiation and visibility. Therefore, it should be relatively easy to define a relationship between dust aerosol concentration, solar radiation, and visibility.

Atmospheric turbidity measurements have the disadvantage that they do not collect a dust sample, which can be later analysed, but they do have three important advantages: firstly, turbidity data are already available from meteorological stations in the form of standard visibility and solar radiation measurements. Therefore, once a relationship is defined between dust aerosol concentration and both solar radiation and visibility, past meteorological records of solar radiation and visibility can provide a much longer term record of dust entrainment and transport for virtually no extra cost; secondly, atmospheric turbidity measurements using Campbell-Stokes sunshine recorders can be used to expand a network of sites into remote locations where standard meteorological data are not available. This technique is both inexpensive and does not require an electricity supply.

Feasibility experiments carried out at Kano (McTainsh, 1982) where cloud cover is low during the Harmattan Season demonstrate that the burn-trace on the sunshine recorder card provides a measure of the intensity of solar radiation as well as length of the day. Therefore, if the sunshine recorder card is weighed before and after exposure, the weight loss of the card provides a quantitative expression of the dispersion of solar radiation by dust. The sunshine recorder method of measuring dust-induced solar radiation dispersion has been further refined by Jaenicke and Schutz 1978, Jaenicke and Kasten 1978 and Helmes and Jaenicke 1985.

Jaenicke and co-workers also conducted a series of atmospheric turbidity measurements at Cape Verde Islands and over the Atlantic Ocean using a Volz II type sun photometer (Jaenicke and Schutz 1978, Jaenicke, 1979). This approach allows much greater measurement accuracy and sensitivity than the methods of McTainsh (1982) in Nigeria, and as such is appropriate to the much lower dust aerosol concentrations experience over the Atlantic. With better communication, however, the data arising from these different measurements can be compatible.

Historical turbidity data from meteorological sites will provide only a total estimate of dust in transport, being deposited and entrained. However, more detailed data could be produced by positioning one solar radiation recorder at ground level and a second at 10m above ground level, as with the Filter Pump Samplers.

3. Dust Deposition Measurements

Techniques for collecting dust and measuring dust deposition were discussed at the Gothenburg Workshop on Saharan Dust, but most of these were developed for air pollution monitoring in temperate environments and are not very useful for measuring larger-sized mineral particles in tropical environments.

The dust deposition trap used by McTainsh (1982) in northern Nigeria consists of a painted metal basin containing distilled water and exposing a water surface area of $0.27m^2$ for the trapping of deposited dust. Wet traps are not common in humid climates, perhaps because rainfall can cause them to overflow, but this is not a problem in northern Nigeria as no rain falls during the Harmattan season.

The use of an appropriate regular measurement period is critical if deposition results are to be correlated between different sites. A weekly deposition measurement period was found to be most appropriate for northern Nigeria as it allowed time for sufficient dust to accumulate to reduce collection errors and to allow enough dust for laboratory analysis.

At least two deposition traps should be set up at a site, the first at around 10m above ground level to measure primary deposition (D^p), the second

Dust mobilisation by a convection storm in northern Nigeria.

Plate 3-A: During the dust storm

but small dust sample sizes can pose practical analytical problems. The use of a Coulter Counter (Walker *et al*, 1974; McTainsh and Walker, 1982) capable of analysing samples down to 0.01g has significantly increased the utility of particle-size as an environmental indicator. Other sedimentological characteristics which can be measured using standard techniques include mineralogy (light and heavy), quartz roundness and surface characteristics, geochemical composition, plus the presence and types of diatoms and phytoliths.

Administration

The desertification monitoring programme outlined here has several distinctive features which combine to make it a viable proposition whether viewed from a practical or a research viewpoint. A critical feature which sets this programme apart from most other desertification programmes, is that it would be a low cost operation because equipment required is both cheap to purchase and simple to use and maintain. Personnel costs could be minimal as the intention is to attract

at ground level to measure primary plus secondary deposition (D_s).

The choice of an appropriate dust monitoring site is critical to avoid dust contributions from unwanted sources, such as, dust remobilised within urban areas by traffic movement on unsealed roads. Monitoring sites should be located in a rural setting, as remote as possible from man-induced dust sources.

Laboratory Analysis of Dust

A principal requirement of the direct collection methods proposed here is that they collect a representative sample of dust associated with a particular process (e.g. entrainment, transport and deposition) over a particular measurement period. The objectives of the laboratory analysis of these samples are two-fold. Firstly, the character of the dust provides additional independent evidence of the kind of aeolian (and desertification) processes operating and/or secondly it reflects the source areas of the dust.

Dust particle-size is a particularly sensitive indicator of aeolian processes

Plate 3-B: The same location on a clear day

interest within universities, with only limited numbers of technical personnel required. If the three dust monitoring sites already operational were willing to joint the programme and if former sites were reestablished, costs could be further reduced. Placed within the context of the difficulties experienced by UNEP in raising money over the past seven years, the low-cost feature of this programme is critical.

A second important feature of this programme is that administration of the programme could be quite low key, as the approach taken here is not to establish a large new programme, rather to channel existing personnel and resources in a new direction, by drawing the attention of established dust researchers to the possible broader implications (i.e. desertification) of their research. Within the context of recent statements in *Desertification Control* in which a significant proportion of expenditure on desertification programmes in past years has been of an "infrastructural" nature, then the light administration feature of the proposed programme may have considerable merit.

In conclusion, the proposed dust monitoring programme could provide a much needed and low cost source of valuable hard data on past, present and future trends of desertification within West Africa.

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Eastern Africa's spreading wastelands

Seifulaziz Milas and
Mesobework Asrat

The wastelands are spreading in eastern Africa, with millions of the region's people facing starvation in the worst drought of this century. Eight million of them are in Ethiopia, and millions others in Mozambique. In several other countries of the region, food reserves are rapidly diminishing or are already depleted — and there is no end in sight. Not only the people are affected, but the land as well, with implications for the future of diminishing productivity.

The food crisis has been triggered by prolonged drought, but the drought is only part of a much bigger problem in which drought has exacerbated the results of expanding population pressures and accelerating soil degradation that in combination with inappropriate food pricing policies, rural neglect and external economic pressures, caused per-capita food production to drop by over 11 percent between 1970 and 1980 — before the full impact of the present drought was felt.

The United Nations Environment Programme (UNEP) says that much of the problem is due to a growing imbalance between population, resources, development and environment. Rapid population growth is exacerbating the existing problems of imbalance between human numbers and available arable land, deforestation, poor land-use systems and inappropriate farming methods — all among the major problems leading to food crises and desertification in eastern Africa.

The basic problems are similar throughout the region, whether in Ethiopia, Kenya, Tanzania or Mozambique: technical crisis, development crisis, and economic crisis, all superimposed on each other. The prevalent farming methods are inadequate for the region's fragile, easily eroded soils, erratic rainfall patterns and almost non-existent irrigation. The situation is made worse by other interacting factors; the world's highest rates of population growth, rapid urbanization, fuelwood shortages and continuing desertification. Their effects are intensified by the region's economic crisis and rapidly deteriorating market terms: In 1982 Africa's agricultural exports could buy only half the volume of manufactured goods and petroleum products that they could pay for in 1978.

Drought, Demography and Famine

Drought is only part of the problem, and a temporary one, but it threatens to have a permanent effect through accelerating other problems of soil erosion and desertification. While drought is largely a natural phenomenon, social responses and poor land use practices greatly amplify its impacts (ECA, 1983). When severe drought is combined with land misuse the result is often permanent land deterioration and loss of productivity. That is, desertification. Desertification, in turn, intensifies the effects of drought. There are many examples in Ethiopia, northern and eastern Kenya, central Tanzania, Lesotho and Zimbabwe.

Droughts are a "recurring" climatic phenomenon. In Africa they have occured throughout the available historical record of climate (Nicholson, 1978) and are certain to recur in the future. The ability to forecast accurately the occurance of future drought on the basis of periodic or quasi-periodic behaviour has not been demonstrated — drought is at best quasi-periodic and extrapolation of cycles for forecasting has not been successful.

High variability of rainfall is a fact of life in the semi-arid zones of eastern Africa, from Ethiopia to Lesotho, and severe prolonged drought is a quasi-periodic phenomenon. Northern Ethiopia, for instance, has had several disastrous droughts over the past century and the Akamba of eastern Kenya recall the drought years of the 1890's which may have halved their population. They survived another such drought in the 1930's by labour migration and food aid.

While a great deal is known about the physical aspects of drought we cannot forecast the onset of a drought, its magnitude or its duration. Nevertheless there are practical measures which could be taken to mitigate the worst effects of drought. For instance, improved national meteorological services and application of meteorological knowledge which can lead to better use of water available from rainfall and irrigation (WMO, 1983). Drought control planning and appropriate land-use planning are also important. If under normal climatic conditions ecosystems are used at or near their long-term capacity, they and the societies they sustain will suffer severely in times of sub-normal rainfall (Berry, 1984).

The real cause of famine and economic collapse is increasingly evident—soil erosion—loss of the thin layer of top-soil that is the basis of agricultural production. Throughout the region this is a major and rapidly growing problem. Northern Ethiopia with its ravaged hillsides may be a worst case scenario, but similar scenes are appearing in Kenya and Tanzania, in Mozambique and Zimbabwe.

When drought occurs, particularly in croplands or rangelands which are already overcultivated or overgrazed, it leads to further reduction or elimination of the land's essential vegetative cover, leaving it bare and vulnerable to wind and water erosion. Erosion strips away the thin layer of top-soil, destroying the land's fertility and its

Several Low and Middle Income Countries Affected by Desertification

Population Projection by Countries Affected by Desertification

	Population (millions)			TFR[a]	GNP/capita	Percentage of women child-bearing age using contraceptive methods
	1980	2000	2025	1982	1982	
Burundi	4	7	14	6.5	280	—
Ethiopia+	31	57	110	6.5	140	—
Kenya	17	40	83	8.0	390	7
Lesotho	1	2	4	5.8	510	5
Malawi	6	12	23	7.8	210	—
Mozambique	12	24	45	6.5	—	—
Rwanda	5	11	22	8.3	260	—
Somalia	4	7	12	6.5	290	—
Tanzania	19	36	67	6.5	280	—
Uganda	13	25	47	7.0	230	—
Zimbabwe	7	16	34	8.0	850	15

[a] TFR-total fertility rate based on 1984 World Bank estimates and projections.

+ Ethiopia's recent census indicates a 1984 population of 42 million with par capita ENP of $114.

In most of sub-Saharan Africa significantly less than 5 per cent of eligibile women use contraceptive methods.

potential to support its human and animal populations.

When the rains return, particularly the torrential rains common to much of tropical Africa, soil erosion is accelerated. Most of the water runs off, tearing away the topsoil at an ever faster rate. Drought, land degradation, soil erosion and flooding, are all part of a vicious circle and one that is turning farmland into desert at rapidly increasing rates.

In eastern Africa the main causes of soil degradation and desertification are well-known: overcultivation, overgrazing and deforestation. But while the reasons are known they are not so easily corrected. Efforts to do so must contend with severe demographic, economic and social constraints.

One key reason is that there are many more people to feed. In most of eastern Africa, populations are growing at rates of 3.1 to over 4.0 per cent a year. But farming methods and land use have not improved. The population of the region has more than doubled in the past three decades and in many areas pressures on arable land have already reached disaster levels.

Agriculture is the economic backbone of eastern Africa, and subsistence agriculture provides the livelihood of most of its people. But food production is often constrained by limited arable land. Some estimates say as much as 80 per cent has serious fertility limitations.

Demographic factors—population growth and distribution—play a key role in land degradation in the region. Many areas are subject to intensive population pressures, while others are only sparsely settled. But low population densities are usually found in the arid zones, high mountain areas and moist tropical forests—areas with low potential for agricultural production—particularly in view of the low technological level and limited financial means of the subsistence farmer. The existence of disease vectors such as the tse-tse fly and malaria mosquito also effectively constrain human habitation of large areas even where other conditions are good.

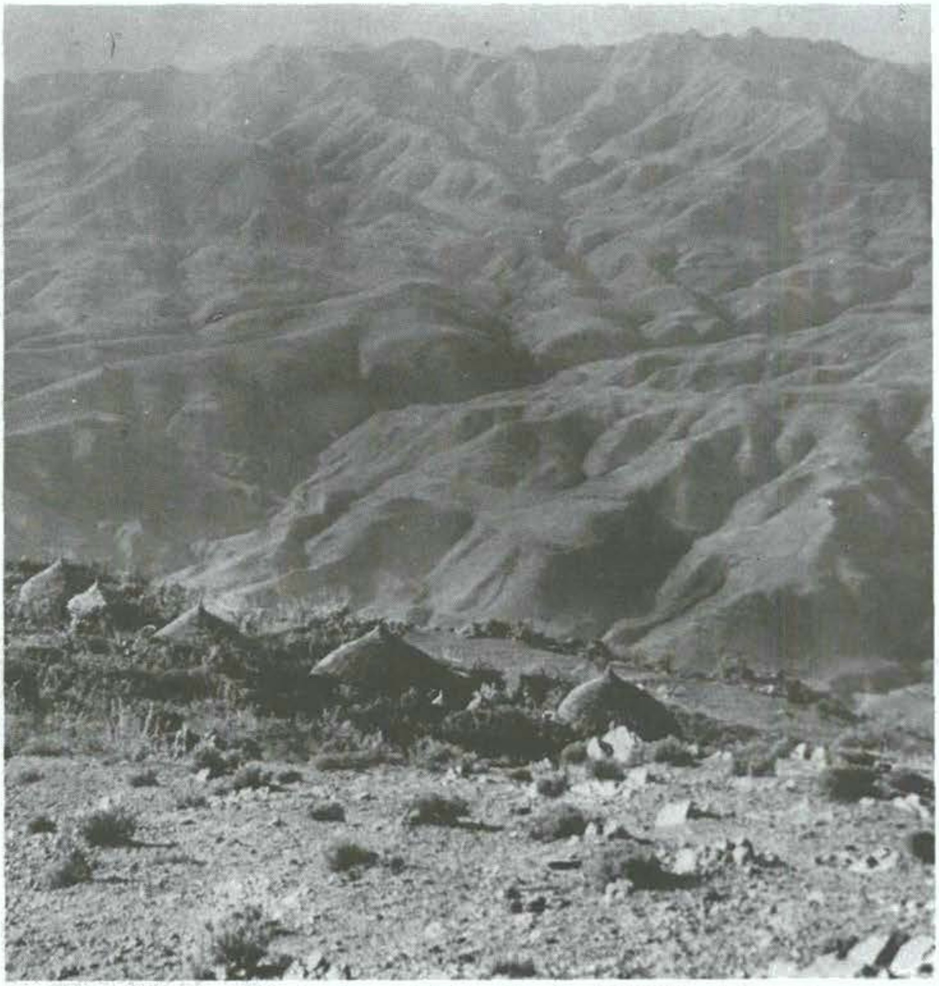
The result is often concentration of a large part of the population in the limited proportion of the land suitable for crop production. When population size is small and stable this arrangement may work reasonably well. But in recent decades, unprecented increases in population size have led to excessive pressures on arable land and to spill-over into increasingly marginal areas—pasture and forest lands, and steep slopes, applying excessive human pressures to fragile ecosystems and leading to accelerated land degradation.

There are other problems such as aridity which limit the area of usuable land, intensifying the pressures on available farm and grazing lands. Large areas of eastern Africa are too arid and the soils too poor for sustainable cultivation.

Mining the cropland

The situation is deteriorating. The population of eastern Africa has doubled in the past 25 years. At the present rate of increase it will double again shortly after the end of the century. These high rates of population growth have led to "mining" croplands through overcultivation without adequate inputs or crop rotation and expanding the cultivated areas, diminishing available rangelands and forest cover.

With rapid population growth and the use of increasing amounts of land for cash cropping rather than subsistence agriculture, the subsistence farmers are putting more pressure on the remaining land. In traditional shifting agriculture exhausted land was left idle for years to regain its productivity. This is often no longer possible. Now there are too many people and not



In northern Ethiopia the hillsides have been ravished by soil erosion. (UNEP/Charles Stewart)

enough land to afford these long fallows which are being progressively diminished or eliminated with often disastrous results for land productivity.

In effect, over 80 per cent of Africa's available farmland has already lost a significant part of its fertility to these pressures and the process is still going on. There is good reason to believe that the proportion is particularly high in eastern Africa. The situation is especially serious with respect to rainfed croplands which provide the livelihood of most of the people and tend to be the most vulnerable to population and other pressures.

The results of all this are seen throughout the region: in northern Ethiopia, subsistence farmers trying to cultivate land that cannot support them adequately even when there is enough rain; cultivation of submarginal lands along Kenya's eastern escarpments, and the semi-arid plains surrounding the fertile, well-watered, but increasingly overpopulated highland areas of central Tanzania.

In northern Ethiopia the population has more than doubled over the past three decades. In the meantime some 40,000 km^2 of farmland has been almost irreversibly degraded into what could be described as stone deserts. Agricultural production has suffered near-collapse and efforts to keep up producation by bringing new land under cultivation — 60 degree slopes and the like — have led to ecological disaster.

Kenya has a population of over 19 million, increasing at some four per cent a year. Over the years 1948-1977 the population grew by an estimated 170 per cent. In 1978 it was estimated at 14.86 million and there was an acute shortage of arable land. In 1984 it passed the 19 million mark, and by the year 2000 it will be over 34 million.

Only 17 per cent of Kenya's land area is suitable for rainfed cultivation and most of that is already being used. According to the FAO/UNFPA survey of food producing potential, the population is already above the land's carrying capacity — that is, the number of people or animals that a given unit of land can support on a sustained basis at a given level of inputs and technology.

Carrying capacity can be increased by raising the level of technology and inputs applied by using fertilizers, pesticides, improved crop mixe's and conservation measures — and many commercial farmers in Kenya's highlands have done so. But that requires capital and for the average subsistence farmer it is often not available.

Land for subsistence farming is also in short supply. According to 1981 projections, the Nyanza region, the country's largest high-potential farming area is expected to run out of additional land for subsistence farming by 1995 (Kisumu District, 1983; South Nyanza, 1987; Siaya, 1995). In most of the province it has already happened as it has in Central Province, one of the other two main high-potential farming areas.

Now Kenya's severe shortage of arable land is forcing farmers to move into marginal lands unsuitable for rainfed cultivation, the eastern escarpment's steep slopes and the arid drought-prone rangelands of the east and north. The results are familiar - severe soil erosion and rapid loss of productivity. When drought comes, as it eventually does, the process is accelerated. It is the same process as in central Tanzania and the semi-arid regions of southern and central Mozambique, and the results have been similar. Where drought has intervened it has brought social and ecological disaster.

UNEP's General Assessment of Progress in the implementation of the Plan of Action to Combat Desertification predicts that deterioration of rainfed croplands will worsen over the next 15 years (UNEP/G.C.12/9, 1984). This problem is already particularly serious in eastern Africa and existing high rates of population growth are rapidly increasing the pressures on rainfed croplands throughout the region.

According to the FAO/UNFPA study of Land Resources for Future Populations, most of the countries of eastern Africa will be unable to grow enough food for their populations by

Only 17 per cent of Kenya's land area is suitable for rainfed cultivation and most of that is already being used. (UNEP/Daniel Stiles)

the year 2000 at their present low levels of farm inputs. In fact, by 1975 much of the region was already incapable of feeding its population on a sustained basis at the existing low levels of farming.

By the year 2000 Kenya, for instance, will be able to feed only 17 percent of its population from its own land using low inputs and unable to produce adequate food for its entire population even at an intermediate level of inputs. At low input levels Ethiopia would be able to produce 36 percent of its food; Somalia, 34 percent; Uganda, 45 percent; Malawi, 61 percent; Swaziland, 89 percent; Zimbabwe, 95 percent. At the other end of the scale, the figures for Burundi and Rwanda are respectively 10 percent and eight percent. Burundi would be unable to feed its population in the year 2000 at an intermediate level of inputs and Rwanda at even a high level of inputs.

These figures imply drastic increases in pressure on the land with destructive results. Crop production can be increased in the short term by expanding the cultivated areas, overcultivating arable lands, diminishing or eliminating fallow periods, and cultivating 'marginal' land unsuitable for tilling. In the medium and long term, however, the result is often less of productivity, and more of land degradation and accelerating desertification.

Solutions

The solutions are clear: if deterioration of arable land is to be halted or slowed the pressures leading to its deterioration must be reduced. As rapid population growth will continue up to the year 2000 and beyond, these pressures can only be reduced by increasing and maintaining the productivity of the available cropland. This can be done through increased inputs in the form of improved technology, better land-use systems, more appropriate crop mixes, increased use of fertilizer and basic chemicals, and appropriate conservation measures.

These solutions indicate a way to cope with the pressures on croplands over the next two decades. For the longer term up to 2025 and beyond a great deal will depend on efforts to address the problem of rapid population growth within the context of available resources, development and environment. If eastern Africa is to be able to support its population as projected for 2025 (50-200 percent increases in population size) it will have to achieve substantially higher levels of farming and slow the current rapid loss of land productivity.

The vanishing rangelands

Eastern Africa from Ethiopia to Lesotho is suffering from a generalized deterioration of its rangelands. There is moderate to severe deterioration of rangelands in Ethiopia, Kenya, Somalia and Uganda, while in Djibouti the problem is particularly severe (Berry, 1984). There is also moderate to severe rangeland deterioration in the semi-arid regions of Tanzania and Mozambique.

In Kenya and Uganda there is evidence to show that this is caused primarily by increased population pressures, increases in livestock populations and consequent overgrazing (Berry, 1984). The same is true in central Tanzania where in the Gogo country around Dodoma (the proposed new capital) livestock density is reported to be about 1.9 hectares/stock unit, while a UNDP/SF livestock project in Dodoma estimates the minimum safe density at 2.5 ha./stock unit. Similar problems are to be found in rangeland areas of Ethiopia, Mozambique and elsewhere in the region.

Population pressures on rainfed croplands and increasing encroachment of cultivators on adjacent rangelands are diminishing the areas of available grazing lands and intensifying overstocking and overgrazing in various areas (Berry, 1984). It is a widespread problem in semi-arid areas of Ethiopia, Kenya, Lesotho and Tanzania among others.

The pastoral populations are also increasing — in some areas such as northern Kenya they are increasing at unprecedented rates — along with the numbers of their livestock, as they require more animals to support their growing numbers (UNESCO 1983). As a result, overgrazing is intensifying and desertification is reaching critical dimensions in parts of Kenya's northern and eastern rangelands, and in the semi-arid regions of Ethiopia, Mozambique, Tanzania, Uganda and Zimbabwe.

The onset of the current prolonged drought found livestock populations in much of the region at higher levels than the rangelands could carry on a sustainable basis. This has led to the loss of large numbers of livestock and to accelerated desertification of large areas of rangeland, as the cattle destroy the land's vegetative cover before finally starving to death.

Deforestation

Deforestation is an important factor in desertification in eastern Africa. Forest cover is decreasing rapidly due mainly to clearing for settlement and crops, extraction of timber for commercial and domestic use, and removal for fuel and charcoal production particularly around settlements and urban areas.

In much of the region actual population density already exceeds sustainable density in terms of fuelwood supply. Fuelwood is being cut much faster than it is being replaced and the supply — and forest cover — are rapidly diminishing. This is reflected in the fact that in Tanzania firewood has become so scarce that the average household spends 250-300 working days per year gathering its fuelwood supply (McNamara, 1984). Similar or worse situations are found in Ethiopia, Kenya, Lesotho and Somalia, among others. In some areas of Lesotho, Northern Ethiopia and central Tanzania, fuelwood supplies have already run out, and people are forced to use animal dung and crop residue for cooking fuel.

In addition to domestic fuel requirements, cash cropping and the pressure to earn foreign exchange play an important role in deforestation and desertification in eastern Africa. In Mozambique, forests are being overexploited to provide much needed foreign exchange. In several areas of the region extensive deforestation is taking place to supply the necessary fuel for tobacco and tea production. In Mozambique, Tanzania and Zimbabwe large areas have been cleared for planting tobacco and even larger areas for fuel with which to cure the tobacco crop. In Zimbabwe, for instance, about 70,000 hectares of new land are cleared annually for cultivation, with an additional 75,000 to 100,000 hectares being cleared for fuelwood needs.

Tobacco growing in particular has led to widespread destruction of forests and to situations where farmers now have to travel as far as 30-35 kms to collect enough wood for fuel to cure their tobacco crops. The critical need to earn foreign exchange ensures that this deforestation will continue But it cannot continue indefinitely unless effective steps are taken to ensure that these forests are replaced.

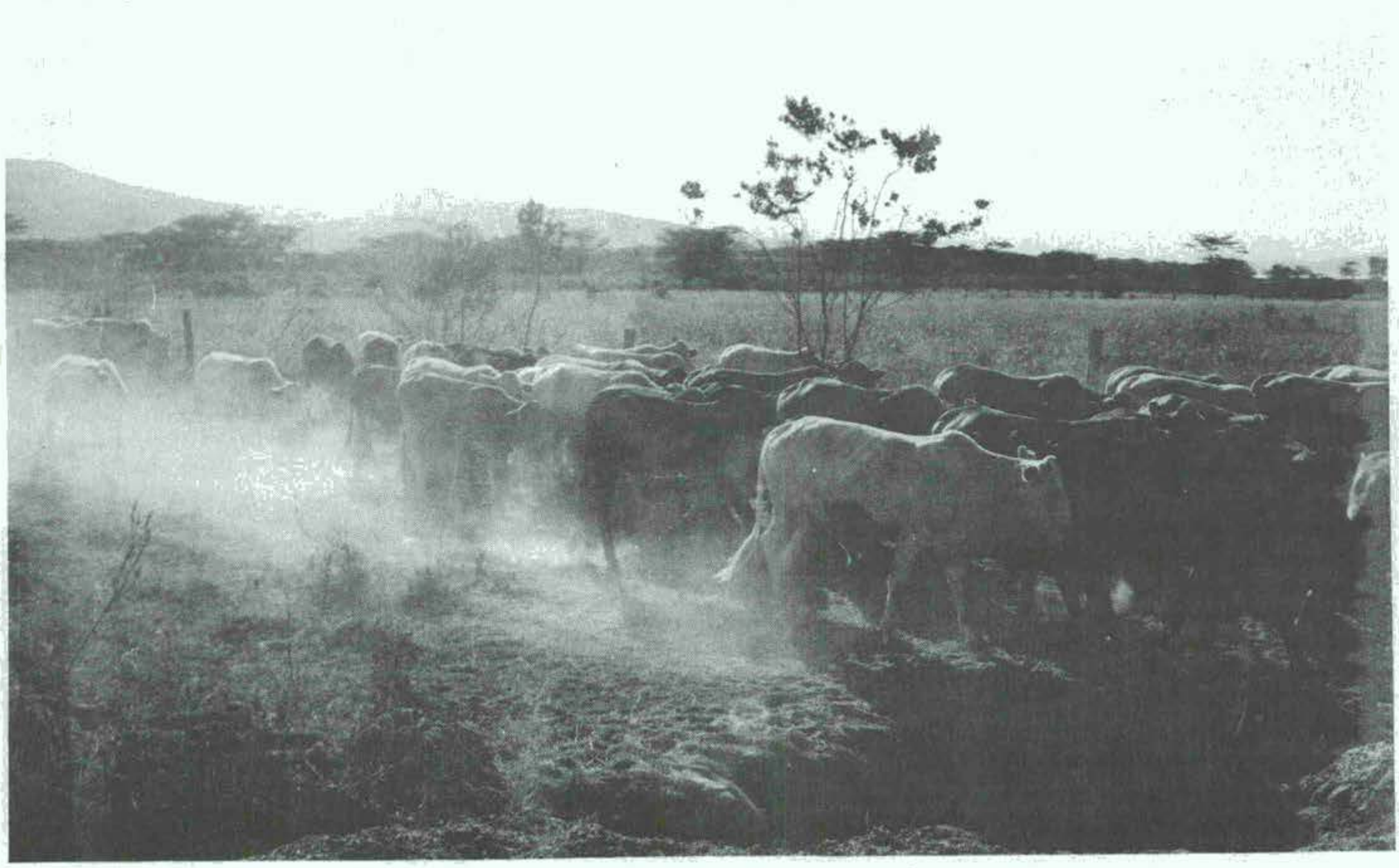
The incidence of deforestation resulting from fuelwood requirements and in association with subsistence and commercial farming is growing throughout eastern Africa. The impact of drought, together with steadily increasing population pressure on arable land has led to subsistence farmers extending cultivation into forested areas or fragile mountain zones (UNEP/UNESCO/ECA, 1984). The encroachment of cultivation on these vulnerable lands has led to accelerated soil erosion making the people and the land even more vulnerable to future droughts.

Deforestation is one aspect of a more complex picture of overexploitation and destruction of natural resources. In much of Africa it is closely linked with such other aspects as overgrazing and overcultivation. For instance, increased pressures on arable lands tend to be reflected in encroachment of cultivation on forests and rangelands. This in turn leads to intensified overgrazing and deforestation as grazing areas are diminished, forests are cleared and soil erosion increases. As a result of these factors, vast tracts of land are being transformed into "dust bowls", losing their productivity and impoverishing their population.

Soil erosion

Of the four main causes of

Overstocking leads to overgrazing and serious trampling of the earth by sharp hooves, both of which result in soil erosion. (UNEP/Daniel Stiles)



desertification, three of them — deforestation, overcultivation and overgrazing — pose the principal threat to the livelihood of the peoples of eastern Africa. All of them lead to soil erosion and the rates of soil erosion in this region are among the highest in the world, and soil is a non-renewable resource. For nature to form a layer of top-soil thick enough to support plant life takes thousands of years, but through human misuse it can be destroyed in a few decades — or a few years — and once eroded its loss is permanent. That is desertification.

The key problem is soil erosion. The continent's precious top-soil is being lost at almost incredible rates. Some experts say that any erosion rate above 50 tons per km^2 is "unusual". Others say that 10 tons per hectare is barely "acceptable", but in much of Africa soil erosion rates are very much higher. Ethiopia, for instance, has an overall average annual rate of soil loss of 830 metric tons per km^2 but the cultivated areas of the highlands feature rates of 2000 tons per km^2 and up, and in some parts of the Sudano-Sahelian region — the band of countries across Africa below the Sahara from Senegal to Kenya — local soil erosion figures as high as 4500 tons per km^2 per year are not unknown.

In Ethiopia where an estimated 1000 million tons of top soil are lost each year, as compared to some 1500 million in the United States (Brown, L. *et. al.* 1984), which has several times Ethiopia's area of cropland, observers describe hillside fields that have been eroded down to bedrock in less than two decades. This has led to high levels of soil degradation and desertification over large areas of Ethiopia's northern highlands. It has destroyed the productivity of the land, brought famine to the people and resulted in plans to resettle 1.5 million people in the lowlands hundreds of kilometres away.

There are many other examples throughout the arid, semi-arid and subhumid regions of eastern Africa. In Kenya, for instance, a study of soil erosion shows that the value of annual top-soil loss exceeds the country's gross national product. At a conservative estimate the world is losing some 25,000 million tons of topsoil a year. But 1000 million tons of that lost top soil come from Ethiopia alone. There are indications that Ethiopia, Kenya and Tanzania alone may be losing as much topsoil per year as the whole of North America.

In most of these cases there is a common thread — the factor of deforestation. Once the forest cover is gone, these often fragile soils become vulnerable to rapid destruction by wind and water erosion.

Combating desertification in eastern Africa

Several Governments in eastern Africa are manifesting an increasing awareness of the problem of desertification and its implications for the future of their countries. Ethiopia, Kenya, and Tanzania,for instance, are placing great emphasis on strengthening public participation in afforestation and soil and water conservation projects. More thought is also being given to problems of rapid population growth and population distribution, both of which are important factors directly or indirectly affecting the spread of desertification.

In several countries projects aimed at controlling deforestation are planned or being implemented. In Ethiopia, for instance, current projects include the establishment of nearly 9,000 hectares of fuelwood plantations near the towns of Debre Berhan and Nazareth. UNSO, which channels assistance from UNEP and UNDP to the Sudan-Sahelian region, is particularly interested in agro-forestry and several schemes based on complementary forestry and agricultural activities have been set up in the region.

In Lesotho, the Government with outside assistance has implemented woodlot projects leading to the planting of nearly 3,000 hectares of woodlots in the densely populated western lowlands where the demand for fuelwood is most acute. In Mozambique, where annual fuelwood consumption is estimated at 12 million m^3, the Government has supported establishment of "green belts" near the major urban centres to provide fuelwood and timber. To date, nearly 70,000 hectares of woodlots have been planted near Maputo, Beira and Nampula. The Government of Zimbabwe has embarked on a rural afforestation programme to produce fuelwood poles in the communal lands. Some 24 million seedlings will be raised annually for sale to rural dwellers who want to establish their own woodlots.

In Ethiopia most of the country's rural population is organized into 28,000 Peasants' Associations which have been given responsibility for reclaiming eroded land and for efforts to halt soil erosion. In the badly eroded highlands, over the past several years, the Peasants' Associations with support from the UN World Food Programme, have built some 700,000 kms of elaborate terraces to halt soil erosion and planted an estimated 500 million tree seedlings. Hillside farmers are being moved to new land and hillsides are being closed to grazing.

The Ethiopian Government, with support from the World Food Programme (Food for Work) and the Federal Republic of Germany, is implementing 19 catchment rehabilitation projects, afforesting key water catchment areas in six regions of northern and eastern Ethiopia. In the long term this is expected to revitalize hydrological cycles and diminish soil erosion.

A particularly promising effort, the Sirinka Catchment Rehabilitation Pilot Project, an integrated land-use project in northern Wollo region, aims at restoring land productivity without resettling the population. This highly successful project with an area of 533 km^2 was scheduled to be extended to an additional 4500 km^2 if funding could be found.

In its Four Year Plan for 1979-1983 (Kenya, Government of, 1979) the Kenya Government acknowledged that there was "inadequate environmental control and land misuse resulting in desertification, soil erosion and associated economic problems". Subsequently, Kenya has made a sustained effort to reduce the rate of deforestation and to enlist public participation at the local level in afforestation and soil and water conservation activities. Restrictions have been placed on tree clearing and charcoal making and support given to the "Green Belt" tree planting campaign organized by local NGOs.

Kenya, in particular among the countries of the region, has shown a growing awareness of the implications of population pressure on its natural resources, a key factor in desertification, and has demonstrated a strong interest in slowing its rate of population growth. Activities towards this end are carried out through family planning services offered through the public health services and through an NGO, the Family Planning Association of Kenya. The level of success in this area, however, has been limited.

On 14-16 September 1984 the Tanzanian Government organized a National Seminar on Tree Planting at Shinyanga in central Tanzania, a region with severe desertification problems. The seminar, opened by President Nyerere and attended by over 400 national leaders from the top levels of the country's political and government structures, aimed at formulation of a national afforestation programme at the national, regional, district, village and household levels. The seminar was seen as a clear indication of the Tanzanian Government's concern with the country's desertification problems and its resolve to tackle them.

Conclusions

The combination of unprecedented population growth and accelerating loss of land productivity to soil erosion and desertification is increasingly a threat to the long-term survival of several countries of eastern Africa. It is a threat that can be contained, but to achieve this much more must be done to raise the level of farming, to increase and maintain the productivity of croplands, to improve rangeland management and to rehabilitate forests and vital watersheds. Halting the spread of the wastelands in eastern Africa will require, above all, better management of natural resources taking into account the certainty that drought will come again.

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News of interest

Forestry and Nomadic Pastoralism Project

This project is being implemented by Green Deserts Ltd. of the United Kingdom under the supervision of Project Manager Steven Bristow. The project is based at Ed Damer on the Nile River some 300 km ENE of Khartoum, in Nile Province, Sudan. Most project activities are undertaken in the Bayuda Desert to the west of Ed Damer, in an area of less than 150 mm annual rainfall, although there has been total rain failure for three to five years in most parts.

The aims of the project are to promote community forestry in Nile Province, and Jebel Hasaniya in particular, as a means of changing established patterns of land use in an attempt to slow down or even reverse the expansion of desert areas and the movement of nomadic pastoralists from the desert to a more or less permanent life on the fringes of the agricultural reverine communities where pressure on resources is already at an unprecedented level. The project also works to foster an awareness of the reasons for, and problems associated with, desertification, and the possibility of improving the situation through education in schools, through research, and through discussion and practical work with all interested parties. Particular emphasis is placed on the problems associated with overstocking and overgrazing.

Methods:

Community woodlots have been established in a number of areas in the Hasaniya Mountains, at sites selected both for socio-economic as well as silvicultural reasons. All sites are located in wadis where water will flow when rain eventually falls (although in some areas none has been recorded for several years), and micro-catchments have been constructed to trap water after rain. The tree species used is predominantly mesquite (*Prosopis chilensis*), although now native species are being raised from locally collected seed for trial plantings. In all cases emphasis is placed on community involvement and participation in decision making. Local people are employed to plant, protect and irrigate trees with water drawn from wells, and in some areas fencing made from branches cut from the mesquite shelterbelts by the river are used to protect the trees.

Apart from the sites with paid labour, there are many individuals, families, and communities now growing trees by their homes. These trees are provided by the project for those who request them, and the people concerned are thereafter visited periodically to discuss any problems that have arisen. Some families have now started to raise vegetables and sorghum next to the trees.

Some research into the growth of native trees is being carried out, and advice and practical demonstrations given to schools who wish to set up tree nurseries. A more efficient charcoal stove has been introduced to the river community, and ways of improving general awareness of the problems and results of tree cutting and overgrazing are continually being sought.

Five project sites have been established to create woodlot plantations, principally of mesquite *(Prosopis chilensis)*, but indigenous species are also being tested (*Balanites aegyptica*, *Acacia albida* and *A. Tortillis* ssp. *raddiana*). Most of the woodlots are being fenced using mesquite, described below, and watering is done using paid labour. Survival rate of the trees planted up to the end of 1984 ranges from 100% to 71%, a remarkable achievement when one considers that the area receives little or no rain and is heavily grazed by livestock. There is a high degree of involvement and support by the local population, the key to success.

Mesquite Fencing Units

A simple, replicable technique for providing protective fencing and shelterbelts has been underway in Nile Province of northern Sudan for the last 10 years. The system is based on the thinning of mesquite shelterbelts to provide a sustained yield of small diameter poles and brushwood without prejudicing their function as shelterbelts. This project has used such thinnings to construct fencing units that are cheap and easily transportable, are made entirely from locally grown materials and are produced by local unskilled labour. So far, after 6 months use, they have proved to be durable and effective at excluding livestock providing the fences are inspected regularly. The units are also more acceptable than barbed wire to the local population, and are generally more acceptable in the landscape.

They are constructed as follows: 12–16 stems are cut 200 cm long and 2–3.5 cm in diameter. They need not be particularly straight, and seldom are, and should retain plenty of side shoots. These stems are then laid out in a 2m square lattice, with half of the stems vertical and half horizontal. The stems are interwoven and tied together with rope made from leaves of the Dom Palm (*Hyphaene thebaica*). When the framework is complete any large holes are filled by weaving small thorny branches into the lattice. The more thorns the better, although this can cause problems for the fence makers. The finished units can be stacked ready for transport. Each unit has little structural strength on its own, but when tied to a supporting stake in the ground it becomes a formidable barrier to animals and people alike. If animals are seen to browse on the fencing, used sump oil can be painted on as a deterrent.

Cost:

Total cost per unit plus stake: £S 3.64 (US$ 1.46). Cost to fence 1 feddan (1 acre): £S 473 (US$ 189.20) excluding transport and erection costs.

This is less than a quarter of the cost of a barbed wire fence for materials alone. The concept of "Grow your own fences" is both ecologically sound and cost effective.

An integrated approach to desert development

In September 1978, an International Workshop on "Applications of Science and Technology for Desert Development" supported by the United States National Science Foundation convened in Cairo under the auspices of the American University in Cairo (AUC).

During the workshop, a consulting group composed of some of the major speakers, and coordinated by Dr. Adli Bishay, Director of the Workshop, met to consider a proposal for the establishment of a "Desert Development Demonstration and Training" programme at the American University in Cairo.

In its final session, the members of the Workshop, unanimously supporting the recommended programme for environmentally and sociologically acceptable desert development, requested that the American University in Cairo continue to provide leadership in the development of this programme, and urged the support of the government of Egypt, the government of the United States and national and international institutions.

Following the recommendations of the Cairo Workshop, a "Desert Development Demonstration and Training" (DDDT) programme was officially initiated in January 1979 by the President of the AUC. Dr. Bishay was given responsibility for the development of the programme.

Goals and objectives

The major goal of the programme is to undertake applied research into alternative, integrated approaches to arid land agricultural and community development. It also seeks to develop and demonstrate economically viable systems that can be used by governement and private enterprise in creating new desert communities that offer an improved "quality of life" and therefore attract families from cities and villages.

In order to achieve these goals, the objectives of the project are to:

- search for technologies appropriate for desert agriculture where water and nutrients are scarce and energy is expensive:
- harness renewable energy resources that are abundant in the desert and develop technologies useful in desert environments;
- identify and demonstrate desert community development strategies that are feasible with local resources, are socially acceptable, protect the natural environment, and enhance human life; and
- disseminate the results through demonstration sites, consulting, training and actual experience for farmers, students, technicians, scientists, businessmen and policy makers.

The AUC Desert Development Programme proceeds through four major activities:

- Data collection and facility development
- Multidisciplinary applied research on alternative integrated approaches i.e: appropriate agriculture, appropriate technology and appropriate communities
- Diffusion of information and knowledge through demonstration, training, documentation and technical communications
- Adoption, modification and development in cooperation with relevant institutions and ministries.

Measurable progress can be achieved if the concept of the integrated blend and balance of indigenous methods with modern technology is consistently a part of all related activities. Although these concepts are now internationally recognized as being essential to successful development projects, they have never been systematically and collectively applied in desert cases.

Implementation of the programme

To help implement the DDDT Programme, the government of Egypt, through the Ministry of Land Reclamation, in November 1979 allocated 500 acres in the "Intelaq" area of South Tahrir at a distance of about 140 kilometers northwest of Cairo and about 40 kilometers west of Behira, in the Nile Delta. The site was serviced by a semiportable sprinkler irrigation system also donated by the Ministry.

Furthermore, the Ministry of Development and New Communities has provided DDDT with 200 acres in Sadat City, a new city being built on the desert road, halfway between Cairo and Alexandria.

In addition to initial set-up costs and continuous support provided by the University, the programme is funded by a substantial number of national and international agencies and wealthy individuals.

Following is a short review of some of the present activities based on the AUC Integrated Approach to Desert Development:

Data collection and facility development: Since its initiation, data collection, testing and monitoring have been conducted at the two sites of the AUC Desert Development Programme. This included soil, water, solar and wind characteristics and testing of potential crops under such conditions. It also included monitoring of four types of solar cells (10 KWp photovoltaic), three types of solars pumps (3KWp) and solar passive architecture (AUC headquarters building).

Facilities added during 1982-1983 included a cattle shed, expansion of sheep shed, addition of a deep well with diesel pump, and introduction of side-roll sprinkler, drip and biwall irrigation systems at the S. Tahir site. Facilities under construction at the Sadat City site include a soil testing laboratory, a plant tissue culture laboratory and a desert library.

Applied research in desert development systems: The following "Alternative Integrated Approaches" encompassing biological, technological and community aspects of desert development have been adopted:

- A "Desert Farming Systems" approach for improving productivity of sandy soils, now in its second phase (1983-1985). A major addition in this applied research is the use of zero or minimum tillage in the second phase as an alternative to ploughing under green manure in the first phase. Both phases, however, include sheep (fattening and animal manure utilization), crop rotations under desert environment, and windbreaks and multipurpose trees as part of the Desert Farming System.
- A desert development approach based on appropriate horticulture, irrigation and management now in its second phase (1983-1986) (after the termination of the first phase (1980-1983). Various citrus species including grapefruit, orange, tangerine, lemon and lime, have been grafted in the S. Tahrir Nursery with different citrus rootstocks resistant or tolerant to the "Quick Decline" disease. The successful combinations (seven rootstocks and 20 species or variety) were transplanted in a new orchard in 1984 and are irrigated by a newly installed drip irrigation system. Some traditional vegetable crops such as peas, have proven to be particularly adaptable for desert cultivation. Onion sets were produced successfully last season and are currently being used for cultivating an onion crop. Furthermore, certain high value vegetable crops suitable for export, such as asparagus, broccoli and sweet corn, have been tested and proved to be successful under the desert environment.
- An alternative approach, based on fodder/cattle/biogas, which was initiated in 1983 and has become a major activity. This programme will utilize renewable energy and hybrid systems (solar, wind and biogas) for the different desert agricultural and household activities (pumping, irrigation, heating, desalination, and passive solar architecture).

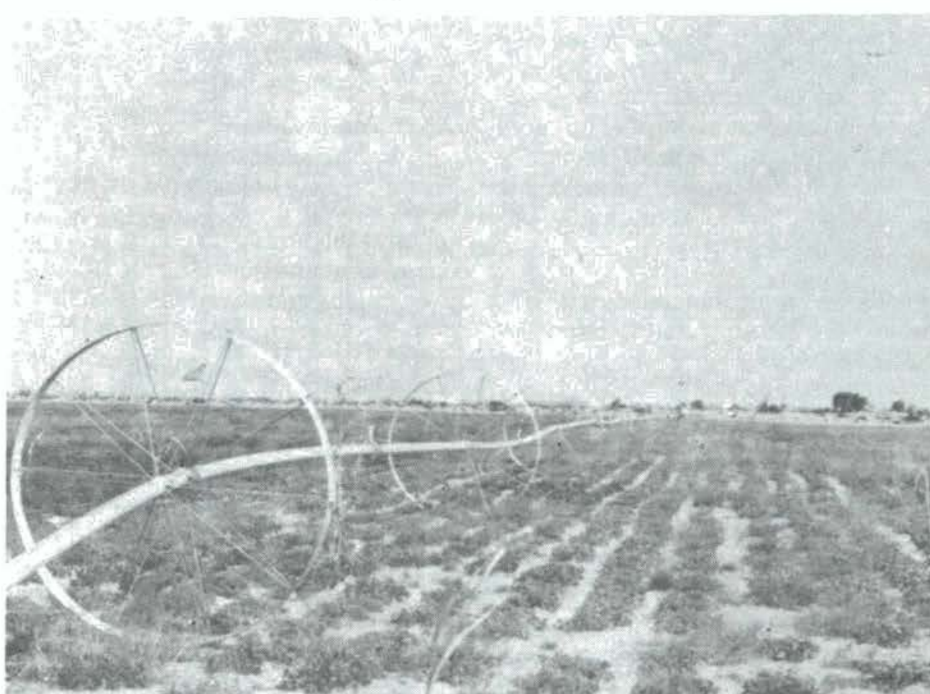
The socioeconomic aspects of the above three alternative approaches is given special attention with the socioeconomic research programme for desert development (1983-1985).

Diffusion

The component of diffusion is made up of the following three procedures:

- Demonstration: During the past five years, appropriate irrigation techniques such as drop, biwall, side-roll sprinkler, and bubbler irrigation, were tested and demonstrated. The latter system was manufactured in Egypt using Egyptian materials and under the supervision of the AUC scientists. The Ministry of Land Reclamation is planning to replicate this technique on a 500 feddan area (a feddan is 4,200 square meters).

The use of solar pumping has been demonstrated successfully in Sadat City using alternating current (AC) and direct current (DC) as well as sub-



One of the irrigation techniques being used by the DDDT of the American University in Cairo to reclaim the desert.

mersible and deep well pumps. The AUC building at Sadat City proved to be a very successful demonstration in the use of old technologies (Coptic and Islamic styles of domes, vaults and courtyards using adobe bricks) in conjunction with modern technologies (solar protovoltaic and solar thermal). This unique combination is frequently visited by groups organized by ministries of new communities and electricity as well as a number of international agencies.

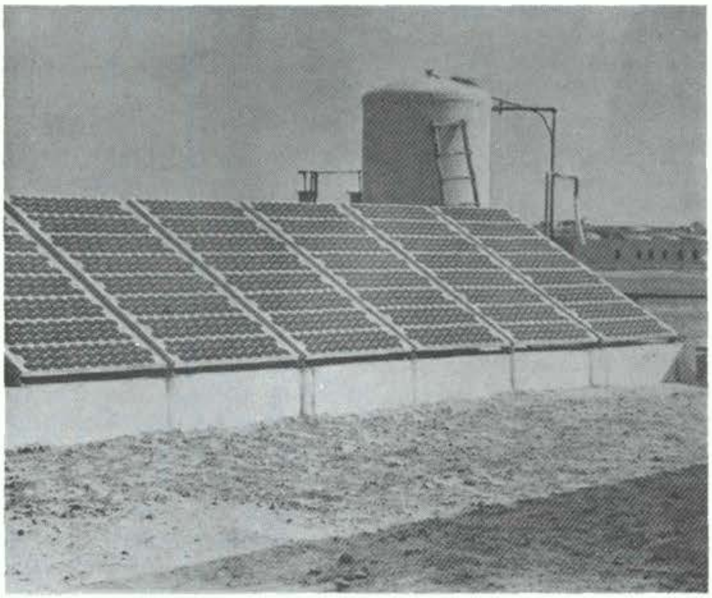
Preliminary studies are currently being made to design demonstration housing units for single and multiple families as well as a dairy and meat pilot project (using solar, wind and biogas hybrids) for the possible replication by farmers and agrobusiness in remote desert areas.

The possibility of propagation of corn, sorghum and alfalfa for seed production is currently being investigated. It is anticipated that, when successful, business companies may adopt the appropriate techniques and replicate them on a large scale using neighbouring farms for production and possibly renting some of the AUC facilities and know-how for seed preparation and treatment operations.

- Documentation and technical communication: The "Desert Library" at Sadat City is now being developed. This library is collecting the latest audio-visual equipment and international references in the areas of "Desert Technology and Development," "Renewable Energy," and "Community Aspects" of desert lands.

In addition to the interactions with different Egyptian universities and relevant ministries, more contacts and agreements are taking place with American and European universities such as the University of Arizona, the University of North Carolina, the University of London (Wye College), etc.

- Training: On-site training of students from the AUC (Science and Engineering) and Alexandria University (Agriculture) has taken place during the summer and in some cases continued during the whole academic year. Furthermore, training is considered to be initiated in 1984-1985 as an important and integral part of a newly approved project. A number of meetings are being held to consider different courses in the areas of Desert Technology and Development, Renewable Energy Technology and Socioeconomic Aspects of desert development which can be offered to students from different ministries and companies with activities in these areas. The experience from these training courses should make it possible for the University to initiate a degree programme in the area of Desert Technology and Development.



Solar energy for pumping water is being used at Sadat City.

Desert communities

A major, long range goal of the Desert Development Programme is to develop and demonstrate economically viable systems that can be used by government and private enterprise in creating desert communities in Egypt. These communities must offer attractive, quality living conditions to encourage migration from overcrowded cities and villages to desert areas. The DDDT "Desert Community unit" will seek to identify desert community development strategies that are compatible with local resources, are socially acceptable, protect the natural environment and enhance human life. It will disseminate its findings through demonstration sites, consulting, training and actual on-farm experience where the farmers will take a major role.

With this long range goal in mind, members of the "Desert Community Unit" will analyze past and present experiences from the social, economic and architectural points of view and use the results of the analysis to establish socioeconomic research frameworks for current as well as planned biological and technological projects within the programme.

The design and construction of appropriate desert housing is another important objective. Such an effort requires a multidisciplinary team approach to design and construction involving engineers, architects, sociologists, planners and potential inhabitants. Here, the themes of attractiveness and "self-sufficiency" dominate; climatic conditions, culture, and local traditions are also important inputs. An attempt must be made to draw as much as possible upon traditional Islamic and Coptic styles and adapt them to such modern applications as solar energy, as well as to revive and improve upon techniques that will enable the inhabitants themselves to do their own building construction.

The true measure of success of the AUC integrated approach to desert development is to reach the optimum combination of technical, agricultural and socioeconomic practices which would attract Egyptians who are currently living in overpopulated areas to participate in the formation of new desert communities where they would enjoy a substantially better quality of life.

INTERNATIONAL WORKSHOP ON SAND TRANSPORT AND DESERTIFICATION IN ARID LANDS Khartoum—Sudan 18—29 November 1985

The International Centre for Theoretical Physics (Trieste, Italy) and the School of Mathematical Sciences (University of Khartoum, Sudan) will organize an International Research Workshop on "Sand Transport and Desertification in Arid Lands", to be held in Khartoum, Sudan during the period 18-29 November 1985. It will be directed by F. El-Baz (International Development ITEK Optical Systems, Lexington, Massachusetts, USA) and M.H.A. Hassan (School of Mathematical Sciences, Univerity of Khartoum, Sudan). The Workshop is co-sponsored by the Canadian International Development Agency (CIDA), UNESCO, The United Nations University (UNU), the OPEC Fund for International Development and the National Council for Research of Sudan. The Desertification Control Programme Activity Centre (formerly Desertification Branch) of UNEP is providing five travel grants to participants from developing countries.

Purpose and nature

In many countries throughout the world, and especially in the African Sahelian countries, the physical process involving the transportation and deposition of sand by wind is a serious hazard to human settlements, agricultural lands, communications and water resources. In North and Central Africa, for example, several villages, oases, roads and railway lines are invaded by mobile sand. Near the banks of the Nile in Egypt and Northern Sudan, vast quantities of wind-blown sand are deposited annually into farming areas and also into the river.

The Workshop will deal with several case studies of "Sand transportation and deposition by wind", selected from certain regions in Sudan and in other countries where drifting sand is seriously affecting fertile soil. Based on these case studies, the general purpose of the Workshop will be to identify common factors contributing to the flow of sand and to determine, through the applications of field and laboratory studies, remote sensing techniques and mathematical models, the rate of sand movement around human settlements, water resources and productive areas. The Workshop will also investigate critically and constructively the effectiveness of existing approaches to sand fixation and will endeavour to explore new and realistic methods to curb sand encroachment.

Participation

The Workshop is open to research workers from all countries of the world that are members of the United Nations, IAEA or UNESCO. Participants should preferably have completed several years of research after a first degree and must have a working knowledge of the English language.

As a rule, all expenses of participants are borne by the home institutions. However, a limited number of financial grants are available for people from *developing countries*. Preference will be given, however, to those contributing to the poster sessions and who obtain at least partial travel support from local sources.

Participants can obtain further information from:

International Centre for Theoretical PhysicsInternational Workshop on Sand Transport and Desertification P.O. Box 58I-34100 Trieste, Italy.

(Telephones: 224281-6; Cable: CENTRATOM; Telex: 460392 ICTP I)

Wind blown sand from the Nubian Desert is advancing across valuable agricultural land near Korti, northern Sudan. (UNESCO/Hugh Lamprey)

Fertilizing the desert: a revolutionary technique from Belgium

To fertilize a desert, the very first thing of course is to have enough water available. But irrigation alone, without any other method of fertilization, will never produce the desired results. For any water that is added to desert soil will either seep down immediately, well below the roots of plants, and will not give them the humidity they need, or else will evaporate on the surface as a result of heat and often violent winds.

A technique had to be found therefore to prevent water seeping down or evaporating.

A new technology

At the Faculty of Agronomics of Ghent University, new technology has been developed based on the use of elements which condition the soil. They are polymers which, if applied on the surface in very small quantities (+or−0.2 %), give the soil the requisite properties. The effect is obtained by a system of pulverization which protects the water in the soil. This pulverization increases the water-retention capacity of sandy soil and substantially diminishes the rate of evaporation on the surface. As a result far less water is needed and plants are able to develop. Aggregation of sand particles, through their fine, porous structures, results in improved water-retention.

To achieve a substantial reduction in water evaporation, various formulas may be used, depending on requirements. Their composition depends on the hydrophile or hydrophobic properties of the soil.

There is scope also for formulas which are partly hydrophile and soil-oriented, and partly hydrophobic and air-oriented.

Testing of the new technology has been going on since 1981, within the framework of an EEC project involving the Department of Soil Physics of Ghent University, directed by Professor De Boodt, as well as the Academy of Sciences of Egypt. The tests proved successful and, after an initial experimental period of three years, the project has been extended until 1987.

In addition to this successful experiment in Egypt, the same positive results were recorded in China, where only Labofina products were used. The same products proved equally successful in Malaysia and in Indonesia.

The fundamental research aspect of the project was sponsored by the National Fund for Scientific Research (FNRS-NFWO) and the applied research aspect by the Institute for the Promotion of Research for Industry and Agriculture (IRSIA-IWONL).

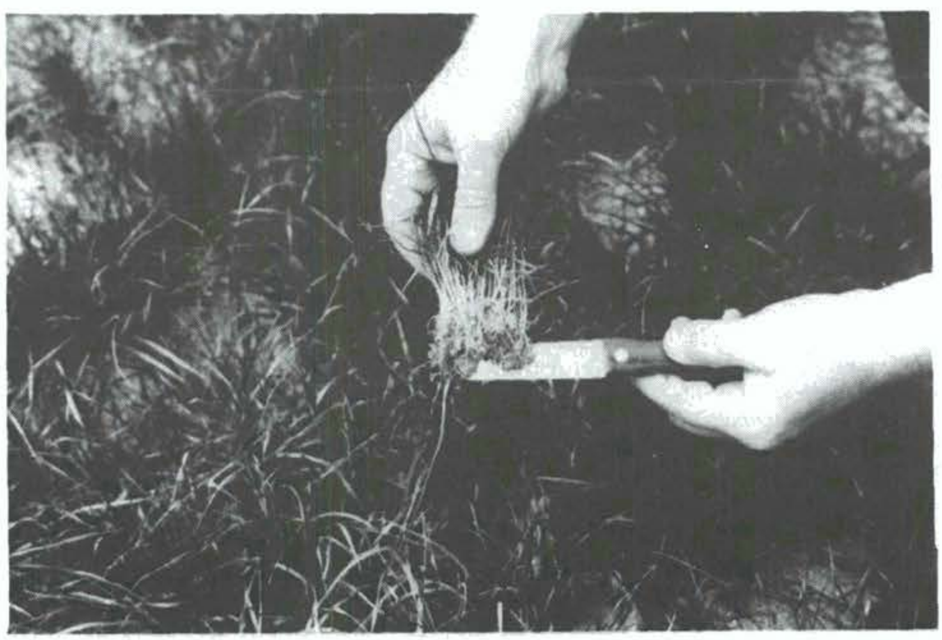
Industrial groups which participated in the project, by developing their own soil conditioning formulas, are : Labofina (the Petrofina research group), S.B.A. (Carbochimique and Recticef (P.R.B.).

Another application

The process developed in the Soil Physics laboratory in Ghent has been used for another purpose too, i.e. fixing and fertilizing coal residue—whole mountains of dust—left over from the combustion of coal in electric stations.

This dust has the same characteristics as desert sand: grains of sand or grains

The dry, sandy soil before treatment.



The soil and vegetation after treatment.

of coal-dust do not hold the roots of plants and are easily shifted by wind. Vast amounts of coal-dust, of which only part could be recycled to be made into cement, were causing a serious environmental problem. An interesting solution is to apply the same planting technique that have been developed for desert soil.

The polymers, which are large synthetic molecules, "stick" the dust particles together just as they do grains of sand, while allowing water and light to penetrate the soil, in which vegetable life can then develop.

Today already, in the industrial area of Ghent, large amounts of coal residue—25 % of the tonnage used—are covered with greenery, especially poplars, which are growing normally.

That surely is confirmation of the fact that the amazing process discovered by Professor De Boodt is bound to prove valuable in many different fields.

Israel's Ben-Gurion University assists world hunger problems with new Blaustein International Center for Desert Studies

The Institute was established in 1976 to cultivate the Negev and to apply scientific techniques to halting the worldwide spread of desert, one-third of the Earth's land surface. The Blaustein Institute's successes to date include growing crops in special desert greenhouses which protect the plants

"Closed system" greenhouse agriculture at Israel's Ben-Gurion University of the Negev.

Ben-Gurion University of the Negev, Israel's only university in the desert, will be sharing its expertise in arid lands thanks to a major grant from the Jacob and Hilda Blaustein Foundation in Baltimore, Maryland. The grant establishes the Blaustein International Center for Desert Studies at Ben-Gurion University's Jacob Blaustein Institute for Desert Research at Sde Boker in the heart of the Negev desert.

According to BGU President Shlomo Gazit, "The International Centre will be devoted to helping the Jacob Blaustein Institute for Desert Research, already in existence, cultivate international scientific programmes in desert development. The Centre will concentrate on outreach through exchange programmes, international conferences and seminars at Sde Boker."

Work will begin shortly on the Blaustein International Centre's classrooms, dorms, workshops and offices. Construction will apply the principles of desert architecture developed at the Blaustein Institute.

from both the desert's harsh heat and cold; using the desert sun and brackish water to grow protein-rich algae for food in drought-stricken regions; and reviving ancient methods of desert agriculture using runoff water from winter flash floods.

International programmes already in place include instructing Arizona's Navajo Indians in the techniques of runoff water agriculture.

Of special interest in a fuel-conscious world is the Blaustein Institute's adobe house. Using innovative methods of passive and solar heating, the house is cool in summer, warm in winter, with an annual fuel bill of $20.

EEB Resolution on Soil Protection Policy in the European Community

Because of relatively high rainfall over most of Europe, this region is not noted for significant areas affected by desertification. Desertification, nevertheless, is becoming a serious problem in many parts of Europe through other causes: pollution of soils, destructive land uses and soil erosion. All of these lower the biological productivity of soils, which is, in part, how the United Nations Conference on Desertification defined desertification. The ultimate end product of these processes, particular to industrialized countries, if allowed to continue, would be barren lands every bit as devoid of life as the central Sahara Desert. Recognizing this threat, the European Environmental Bureau organized a meeting on soil protection policy in the European Communities, held 12-14 November 1984 in Brussels. The following is the main body of the resolution which emerged from that meeting:

CONCERNED ABOUT THE INCREASING DETERIORATION OF THE SOIL IN ALL MEMBER-STATES OF THE COMMUNITY AND ELSEWHERE

Considering that soil is a highly complex and sensitive part of the environment composed of mineral and organic elements, water, air and organisms and showing great diversity in composition geographically;

Aware that biological, physical and chemical processes in the soil influence vegetation and the water cycle and thus are at the basis of the main food resources for man and animals. Further aware that these natural functions, and other functions of the soil as genetic resource, carrier of human activities, source of raw materials and water are of vital importance for the social and economic well being of today's and tomorrow's society;

Considering however that past and existing use of soil functions and other human activities poses a serious threat to the quality of the soil and in the long run is counterproductive and threatens its ability to perform its functions adequately;

Considering that the deterioration of the soil can be characterized as follows:

- Pollution of soil by toxic substances from energy production, industrial activities, agriculture, waste disposal and other human activities;
- Destruction of soil as a living system and soil structure by agriculture, mining, use of land for housing and transport and other human activities;
- Erosion of soil from the rapid change in farming systems, disappearance of good forestry practices and inadequate management of abandoned land causing insufficient vegetation cover.

Further considering that consequences of this deterioration are:

- Serious loss of soil for food production and forestry;
- Severe Landslides in mountainous areas;
- Loss of groundwater for drinking water supply;
- Increased accumulation of harmful substances in the food chains;
- Increasing loss of plant and animal species on which the eco-systems depend.

Believing that deterioration of the soil is amongst other things due to lack of detailed knowledge of the complex soil properties and functions with as a consequence the lack of recognition of the importance of the soil especially in the long term;

Considering that most of the Member-States and the European Commission have not yet developed a comprehensive and integrated soil protection policy; considering further that those Member-States who do have some legal instruments to protect the soil have made only limited use of these instruments, so far;

Considering the 3rd action programme on the environment of the European Communities which explicitly stipulates an integration of environmental concerns into other Community policies such as agriculture, industry and transport.

Considering that there exist several EC directives, aimed at amongst other things soil protection, which are inadequately implemented by some of the Member-States;

Considering furthermore that the European Commission—as Guardian of the Treaty—is not sufficiently active in controlling their implementation;

Considering finally that some human activities and some policies of the Member-States and the European Community degrade the quality of soil in many developing countries and thus the agriculture and the very survival of large parts of the population in these countries.

Recalling several existing international efforts calling for urgent and energetic action to safeguard the world's soils, most essential resources for the survival of mankind: the European Soil Charter (1972), the United Nations Conference on Desertification (1977) and its subsequent Plan of Action, the World Conservation Strategy (1980), the UN World Charter for Nature (1980), the World Soils Charter (1982), the World Soils Policy (1982) and the proposed Plan of Action (1984) for its implementation at national, regional and international level.

Calls upon the governments of the Members-States and the European Community.

(1) to develop and adopt a comprehensive and integral soil protection policy, aimed at the prevention of further deterioration of the soil and at recovery of deteriorated soil, as far as possible,

(2) to develop adequate instruments to implement this policy;

In doing so the following premises must be taken as the guiding principles:

- The soil must retain its ability to perform a wide variety of functions adequately;
- The effects of human activities

which influence soil quality must be investigated and taken into consideration before decisions on those activities are made;

- Clean air and water policies must not lead to pollution of the soil;
- Soil quality standards have to be developed primarily from an ecological point of view, bearing in mind the need for sustainable productivity;

Summarized in the annex to this resolution are specific demands for soil protection policies from the Member-States and the European Community.

Miss W. Campbell-Purdie

Miss Wendy Campbell-Purdie, who died in Athens on January 20 at the age of 59, had been working on reafforestation projects in North Africa and round the Mediterranean for the last 25 years.

Born in New Zealand of pioneer stock, Miss Campbell-Purdie found her vocation in her late twenties, literally breaking new ground in tree-planting schemes aimed at halting and then pushing back the advance of desert land in North Africa, setting up what she hoped would become a "Green Front". She wanted to create a belt of trees round the Sahara, within the shelter of which food crops could be grown, and the overall effect of which could perhaps be to create a microclimate which would stimulate local rainfall and "make the desert bloom".

At first she worked virtually alone, devoting her own small income to experimental plantations in the pre-Sahara, first in Morocco, then in Algeria. As the success of these schemes became apparent, governments, international agencies, and charities such as War on Want showed an interest in backing further work, and thus the Bou Saada project was born.

Just outside Bou Saada, a small town in Algeria wedged between the Atlas foothills and the Sahara desert, Miss Campbell-Purdie and a fluctuating team of local workers—a subsidiary aim of her scheme was to provide sorely needed employment in the area—planted nearly a hundred thousand trees.

Two years ago, after several years spent in attending conferences, lecturing, showing films of her schemes, and setting up charities to further the work, Miss Campbell-Purdie settled in Greece. She was in discussion with the Greek government about tree-planting schemes in the Peloponnese when she became fatally ill.

At a time when drought and famine in the Horn of Africa has given a dreadful urgency to the need for long-term, stable food-growing programmes in the area, the pioneering projects of Miss Campbell-Purdie and those like her have an added value and relevance.

The Times, 2 February 1985.

News from UNEP

Desertification Control Programme Activity Centre (DESPAC)

In response to decision 12/10 of UNEP's 12th Governing Council on desertification, May 1984, the Desertification Branch has been re-organized into a Programme Activity Centre. The new organization will confer more autonomy on the desertification unit and allow it more flexibility and responsiveness in its actions to mobilize the combat against desertification.

Desertification Assessment, Mapping and Database

Two experts' meetings were held, one 3-6 December 1984 at FAO headquarters in Rome and the other 11-14 March 1985 at UNEP headquarters in Nairobi, to review the status of the development of the FAO/UNEP methodology for the assessment and mapping of desertification. In addition, the topic of the establishment of a desertification database within UNEP was discussed.

The two meetings resulted in the following recommendations for action:

1. The methodology contained in the FAO/UNEP publication *Provisional Methodology for Assessment and Mapping of Desertification* (1984) should be tested and evaluated in detail in one country pilot case study. The methodology should be refined in the light of practical field and data analysis experience.

2. An international symposium should be held following the conclusion of the national pilot case study to review and evaluate the results of the refinement of the methodology. UN system, Government representatives and representatives of other organizations and institutions involved in land resources monitoring and assessment will be invited to attend.

3. After the methodology has been refined and evaluated at the international symposium it should be applied in a number of selected countries affected by desertification.

4. The methodology should be applied within the context of the establishment of national Geographic Information System (GIS) in the countries which participate in the programme. The national GIS will contain a great range of environmental and socio-economic data in the country geo-referenced by grid or polygon structures. This data will be stored in the Global Resources Inventory Database (GRID) of UNEP's Global Environment Monitoring System (GEMS) and will be available for use in training of and analysis by nationals of the participating countries.

5. DESPAC will make use of the national GIS databases and data gathered by the ecological monitoring methodology[1] to create national desertification databases, initially stored with UNEP. These databases will be available for use by Governments and other concerned bodies in formulating policy and national plans of action for combating desertification. When national capabilities allow, the data can be transferred to databases within the respective countries.

6. A World Atlas of Thematic Maps on Desertification Control Prgramme Activity Centre (DESPAC) and GEMS of UNEP hope to develop national capabilities in building up natural resource and desertification databases within the context of the Geographic Information System methodology. These databases will be used by national planners and decision-makers in formulating the policy and plans for rational and sustainable development. Sustainable development can only be achieved if land degradation is prevented.

Desertification Information System

The Desertification Control PAC is dedicated to improving its information, documentation and data collecting, organizing and dissemination capabilities. In March 1985 the manager of the Arid Lands Information Centre of the Office of Arid Lands Studies, University of Arizona, visited UNEP for two weeks to advise DESPAC on steps that need to be taken to establish an efficient information system.

DESPAC's documents library currently contains approximately 4000 items, part of which are reference materials and the rest are available for distribution on request. DESPAC hopes to obtain more items of interest relating to desertification and on a continuous basis update an annotated bibliographic database which it plans to create this year. In addition, databases relating to directories of institutions and organizations, sources of expertise and funding, compendia of activities by the UN system, NGOs and countries, and compilations of various antidesertification methods and technologies will be created and stored for easy retrieval in a computerized databank. This information will be disseminated in the form of published directories, listings, printed bibliographies and through the *Desertification Control Bulletin*. Some materials will also be available on request.

DESPAC plans to become a centre for information which can be used by Governments, international organizations, NGOs, UN agencies, and individuals in the combat against desertification.

Annotated Directory of Institutions and Organizations Concerned with Desertification

The Plan of Action to Combat Desertification recommended that an annotated directory be compiled of institutions and organizations concerned with desertification activities. DESPAC is currently compiling such an annotated directory. Previously published directories have been collected and studied

[1] Ecological monitoring methodology makes use of satellite remote sensing imagery, systematic aerial survey and ground truth checks to collect environmental data.

and some 900 questionnaires have been sent out in English, French and Spanish around the world to identified institutions requesting further information concerning their organization and activities. DESPAC hopes to have a provisional version of the directory ready for distribution by early next year. This document will then be disseminated to the respondants of the questionnaire and to other relevant bodies and individuals for review and comment in the hope of soliciting additional information. The directory will then be revised and prepared for final publication and dissemination. The directory will be stored in a computer database (see item on the Desertification Information Service for updating and retrieval).

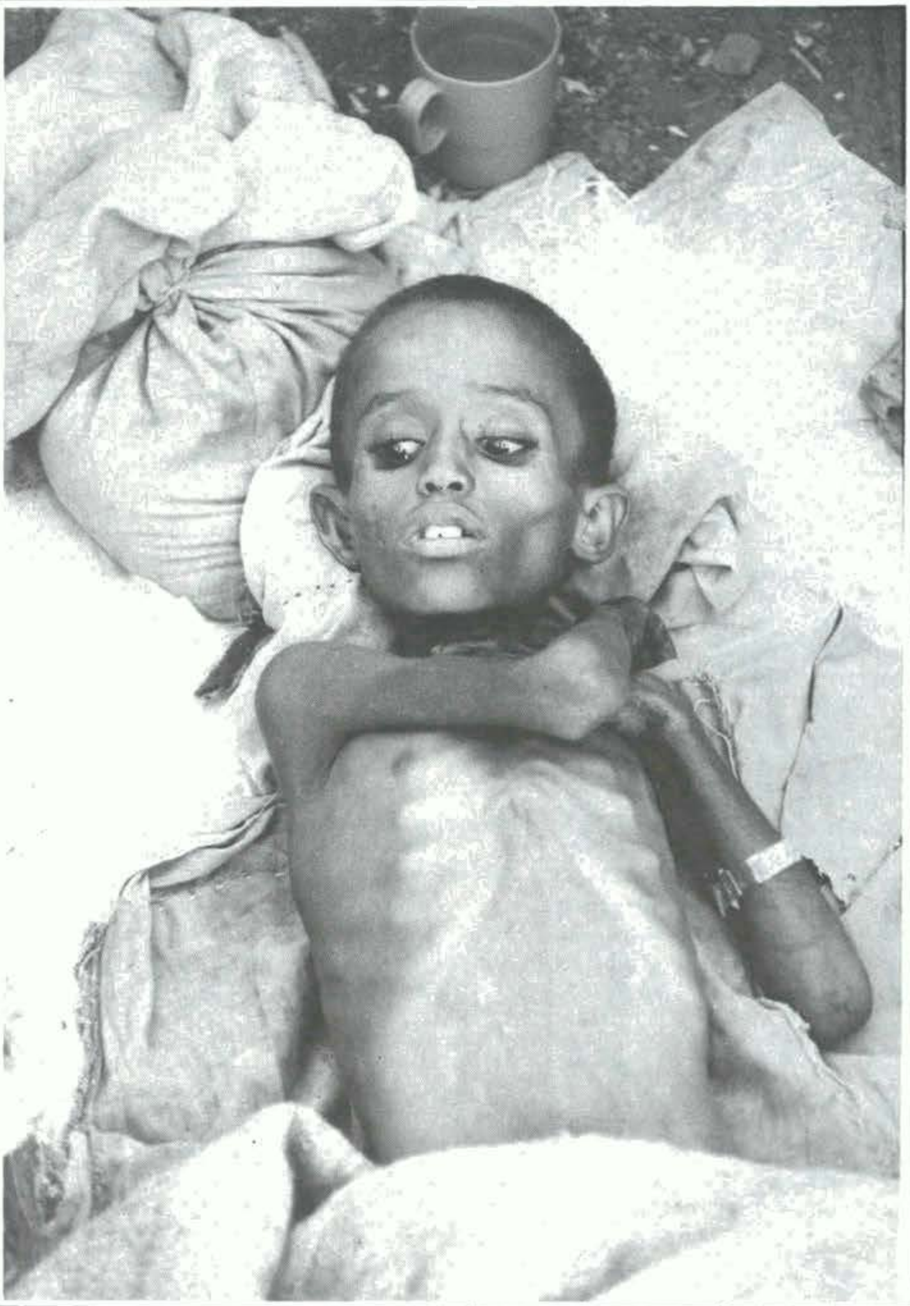
Seeds of Despair

On 4 March 1985 Central Independent Television (CITV) presented a cheque for £25,000 to the Disasters Emergency Committee Fund to help the victims of famine in Ethiopia. This money was raised by the film "Seeds of Despair", which first alterted the world to the famine in Ethiopia when it was transmitted on the ITV network in Great Britain on 17 July of last year. The Disasters Emergency Committee took the opportunity of the film's showing to announce the opening of their Ethiopia Famine Fund, which has since then raised several million pounds for assistance in Ethiopia.

CITV offered "Seeds of Despair" to countries overseas as soon as it was available and it has been sold to seventeen countries, including the U.S.A., France, Switzerland and New Zealand. It has been given to other developing countries free of charge—including Ethiopia itself—so that people can see what is happening. The profits of the film were earmarked for the Ethiopia Famine Fund.

CITV film-maker Charles Stewart, who made the film, was in Ethiopia in July 1984 because he was working on another film for UNEP on desertification. He has been working on this film since mid-1983. A question that can be asked is, "Why did television ignore the disaster for so long?" Once the CITV film was seen, BBC sent a team immediately which was soon followed by an influx of other television crews, journalists and various fact-finding missions.

Part of the answer is that up until that time the main news from the famine affected areas carried a strongly political slant. A creeping drought and famine are not headline news, nor is the sight of people suffering from malnutrition. To make the story "news", journalists tied the problem into the chronic anti-governement war going on in the Wollo, Tigre and Asmara regions. Stories said that there was a drought going on, yes, but that starvation was caused by the rebels preventing government relief operations. The entire situation was turned into an East-West conflict, which seems to be more news-worthy than human suffering and land degradation.



A victim of drought and desertification in northern Ethiopia. (UN/John Isaac)

The real story in Ethiopia, however, is desertification. With or without the drought, many parts of Ethiopia are in trouble because the land is no longer capable of supporting its population. Overpopulation and bad land-use practices have gone on for so long in the regions affected that much of the former rich soil has been washed or blown away, exposing jagged rocks or unfertile sub-soils to the surface. Seeds planted in this type of ground are not likely to produce bumper crops, with or without rain.

The long term answer to the problem lies not with famine relief, but with effective desertification control measures.

First Ad Hoc Meeting of the IAWGD

In conformance with a recommendation made as a result of last year's Governing Council, the Inter-Agency Working Group on Desertification will hold ad hoc meetings on specific topics as and when the need arises. The regularly scheduled meetings will be reduced from two to one a year.

The first ad hoc meeting was held 11-15 March 1985 in Paris at UNESCO headquarters and was attended by representives of ECA, FAO, UNSO, WMO and UNESCO and was chaired by UNEP. The purpose of the meeting was to discuss training programmes in desertification control and the establishment of regional networks of sand dune stabilization, afforestation and research and training as called for in UNEP Governing Council decision 12/10 of May 1984.

Each agency prepared and presented a background paper concerning their ongoing training programmes related to desertification control and current activities related to sand dune fixation and research and training regional networks. Based on these contributions the meeting examined the training programmes, defined some of the key areas of training, identified gaps in training on desertification and agreed on appropriate measures to be taken by members of the groups to fulfill objectives for desertification control training. A work programme was also agreed to concerning the establishment of regional networks of sand dune stabilization in Africa and for research and training in Asia.

The meeting did not have sufficient information to be able to propose a clear programme of work for the establishment of an afforestation network in Latin America. More information and discussions will result from the Expert Consultations on the Role of Forestry in Combating Desertification to be held in Mexico in June 1985.

Testing the FAO/UNEP Provisional Methodology

In a doctoral dissertation from the university of Ghent entitled "Study of Desertification Based upon LANDSAT Imagery (North Kordofan-Sudan)", Dr. Mustafa El Hag applied the FAO/UNEP Provisional Methodology for Assessment and Mapping of Desertification.

The data used in applying the Methodology were obtained from reports of previous fieldwork and from LANDSAT satellite imagery. These data were used to evaluate the status and rate of desertification while the estimates of risk and hazard were obtained using the parametric methods recommended in the Methodology.

From the quantified class scales of the desertification indicators (aspects of vegetation cover, wind erosion, water erosion, salinization, soil crusting and compaction and reduction in soil organic matter) the status of desertification for the study area was mapped for 1972 and 1979. Comparing the changes over seven years a rate of desertification was calculated for each of the defined morphodynamic units. Desertification hazard is arrived at by adding human and livestock population pressures to the combined effects of all of the aspects of desertification which determine status.

The dissertation presents maps of the status of desertification (1979), rate of desertification (1972-1979) and hazard of desertification (1979) for each of the morphodynamic units in the study area, with indicators of which desertification processes (and degrees of severity) are most responsible for change.

Dr. El Hag's work is a pioneering effort in desertification assessment and mapping and it will be of great use to FAO and UNEP in evaluating and testing the validity of the provisional methodology.

Press Visit to the BPSAAP

As part of the information dissemination function of DESPAC, a staff member accompanied New York Times journalist Sheila Rule to visit the World Bank/Government of Kenya funded Baringo Pilot Semi-Arid Area Project (BPSAAP) in the dry Baringo District of Kenya. The purpose of the trip was to explain and present concrete examples of desertification, and at the same time demonstrate activities that can be undertaken to prevent and control desertification. These observations would then form the basis for an article to be published in the New York Times.

Dr. Jeffrey Lewis, World Bank project officer, and Kenyan staff explained the various land degradation problems and activities being carried out to ameliorate the situation in on-site visits. The project started in 1980 and the first phase was completed at the time of the visit in early 1985.

The BPSAAP project area covers 4600 km^2 in the Rift Valley Province, centred on Lake Baringo. Soil erosion has been a major problem in this area for many years, and the 200 tons of silt washed into the lake every year keeps the lake perpetually brown in colour. Overgrazing by sheep, goats and cattle is the major cause of the erosion, and huge, ugly rills and gullys are common on hill slopes and around the permanent settlements. If soil erosion and deforestation continue at current rates the area will be largely a desert by the end of the century. There is still considerable tree and bush cover and, with proper land-use management, the area has the potential for the sustained food production needs of the population. Without good land-use the hills will end up looking like those in Tigre and Wollo provinces of Ethiopia—barren.

The main objective of the project was "to establish the field tested basis for the rehabilitation and development of the semi-arid areas of Baringo". It was intended that this should involve the "evolution and development of effective and replicable systems for project planning and implementation in arid and semi-arid areas". Several different kinds of activities, each working with the relevant Kenyan ministry, were devised in an integrated approach to rural development.

The project components involved soil and water conservation, crop development using water harvesting techniques, livestock and range development, tree nurseries, water development, land adjudication, resource surveys, education and the onstruction of access tracks. Working through a steering committee made up of local community leaders, chaired by the District Commissioner, the project worked closely with the local population in the planning and implementation of the various activities.

The project developed slowly and it had its problems, said Dr. Lewis, but because it functioned through Government ministries and was integrated with district development plans, and because the local people are involved in it, the chances of it continuing on its own in the future are much greater than if the project was directed and funded from the outside. A second phase of the project is envisaged.

Sheila Rule of the New York Times interviewing Dr. Jeffrey Lewis of the World Bank in the Baringo Valley. (UNEP/Daniel Stiles)

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.

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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.

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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.