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in the Control of Deserts, Restoration of
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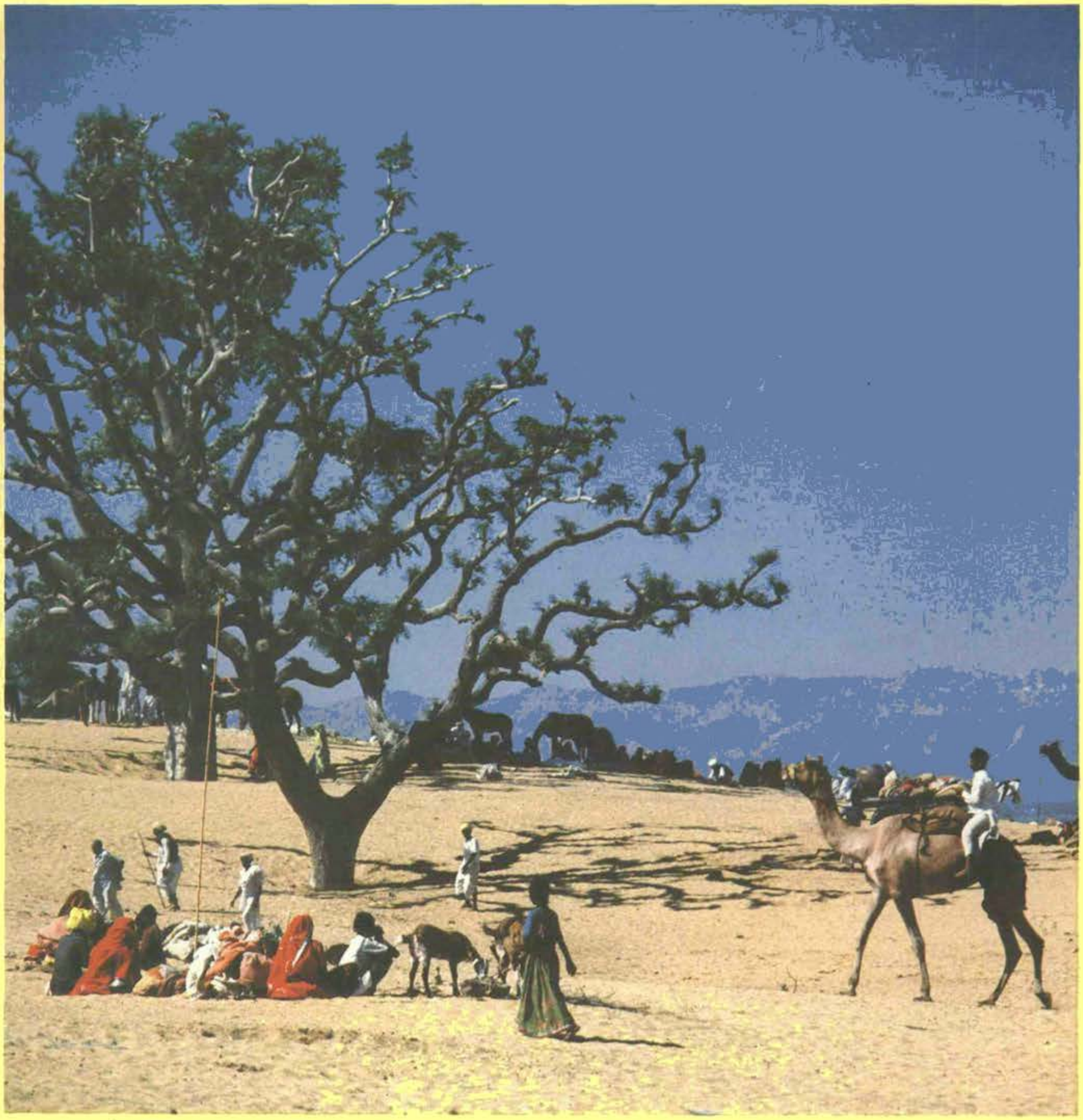

- The United Nations Conference on Desertification (UNCOD) was held in Nairobi from 29 August to 9 September 1977.

- 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 organisations and 65 non-governmental organisations 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 invitied 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 assist 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.

- In 1985 the Desertification Control Programme Activity Centre was created by UNEP's Executive Director with approval from the Governing Council. DC/PAC is a semi-autonomous office with increased flexibility to respond to the demands of following up and implementing the PACD.

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United Nations Environment Programme

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COVER PHOTOGRAPH:

*India is currently facing the worst drought of this century.
People in Rajasthan are particularly hard hit (UNEP/Daniel Stiles)*

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

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Ground Water Resources: the Key to Combating Drought in Africa

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Introduction

There is a great controversy amongst meteorologists and ecologists about the cause of the persistent Sahelian drought. According to the data gathered by Nicholson (1985), the drought appears to be nearly a century old. Based on means rainfall over a seventy-three year period, Nicholson calculated the standardized annual rainfall departure for the years 1901 to 1984 and this shows several clusters of drought years (Figure 1), the most serious of which started in 1967 and is still continuing. Weisburd and Raloff (1985) outlined some of the causes:

"Rasmusson has found a statistical link between droughts in southeast Africa and El Nino, the episode of major warming of sea surface temperatures in the central equatorial Pacific, half a world away. Peter Lamb of the Illinois State Water Survey in Champaign and Janice Lough at the University of Arizona in Tuscon believe there is a strong connection between drought conditions in western Sahel and sea surface temperatures in the tropical Atlantic."

Another cause of the reduced rainfall in Africa could be the changes in land use over vast stretches of the continent since the mid-century. Such changes include deforestation and overgrazing of farm land. The three basic drought-prolonging mechanisms have been stated by Wesburd and Raloff (1985) as the reduction in water-holding capacity of soils, changes in land surface reflectance, and removal of biogenic materials that permit ice formation in rain clouds.

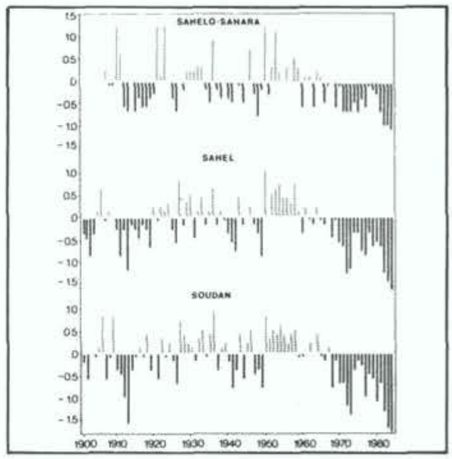


Fig. 1 Standardized annual rainfall departures for the three sub-Saharan zones (see Fig. 2) 1901-84; plotted values represent 100R and are approximately equivalent to regionally averaged "percent of standard departure".

Deforestation and overgrazing lead to reduced rainfall. (UNEP/A. Matheson)

Whatever the causes of these cycles of drought, it is clear that the Sahel cannot depend on rainfed agriculture. We should therefore attempt to combat the effects of drought by using extensive untapped groundwater resources. In this paper I shall discuss the ground water potential of Saharan Nubian basin in the Sudan and Chad Basin in Chad. Additional large unused groundwater resources are known to occur in Niger, Mali, Mauritania and Ethiopia.

Sahara Nubian Basin Water Resources in the Sudan

The Saharan Nubian Basin covers the northern part of Darfur Province; it extends northward from the Tagabo-Meidob ground water divide to the Egyptian border and covers an area of 324,656 square kilometres.

The geological formations are primarily the Nubian Sandstone, which covers most of the area, and the basement complex with tertiary volcanics that make up the Meidob and Tagabo hills.

A preliminary water level map indicates the flow direction and the area of recharge. Water flows from the areas of higher rainfall to the region of no rainfall.

The thickness of the saturated Nubian aquifer varies from 100 to 1000 m. The water level ranges from 10 to 50 m with flowing water at El Natron and Nukeila oases. Salama (unpublished data) has estimated ground water storage to be about 9740 million cubic metres with a transmissivity ranging from 500-1000 square metres per day.

Annual rainfall in this area varies from 0 to 600 mm. Sandford (1983) concluded that the Nubian sandstone aquifer receives a substantial amount of ground water from Wadi Hawa of the Erdi area. He estimated the recharge rate at 4.6 million cubic metres per day.

Two steady-state models were constructed using the water levels as shown in Fig. 2. In the model area, rainfall ranges from 200 mm to 75 mm per year. In the first model, ten per cent of the rainfall was used as recharge and the model predicted the following:

(a) Transmissivity ranged from 5,000 to 10,000 square metres per day.
(b) Out flow was 2.1 million cubic metres per day.

In the second model, twenty per cent of the rainfall was used as recharge and the model predicted the following:

(a) Transmissivity ranged from 2200 to 3300 square metres per day.
(b) Out flow was 5.4 million cubic metres per day.

It is calculated that 1 million cubic metres may be extracted daily from this basis.

Chad Basin Water Resources

The Chad Basin, with Lake Chad as its lowest level, constitutes an extensive reservoir of groundwater and is one of the largest closed river basins in the world. The waters of the lake and the surrounding territories are shared by four countries: Niger, Chad, Cameroons and Nigeria.

In the Chad Basin there are three main aquifers: water table aquifer, middle zone aquifer and deep aquifer (Fig. 3).

Water Table Aquifer

Extending over nearly 1,400,000 square kilometres, this groundwater reserve surrounding the lake varies in depth and has different hydraulic characteristics over the basin. It is currently exploited by means of shallow open wells dug by hand. Tests on boreholes penetrating the entire thickness of this aquifer produced flow rates of 370, 250, 140 and 37 cubic metres per day. The storage coefficient of 0.15 may be assigned to the entire water table aquifer.

Middle Zone Aquifer

This aquifer is composed of interbedded sand and clay, which has an area of 50,000 square kilometres in North-East Nigeria and 33,000 square kilometres in Niger. A layer of clay from 60 to 300 m thick confines the water and separates it from the upper aquifer which contains the free groundwater.

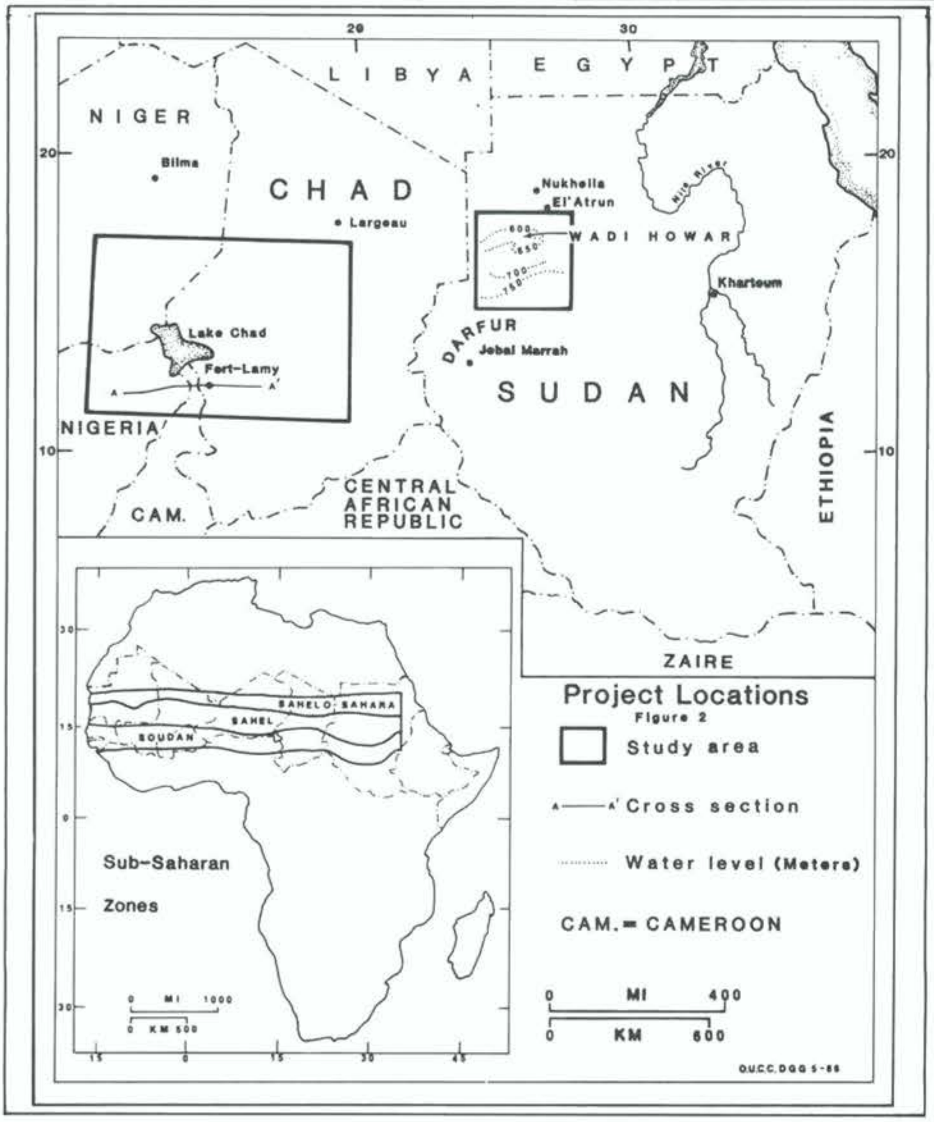


Fig. 2 Project locations

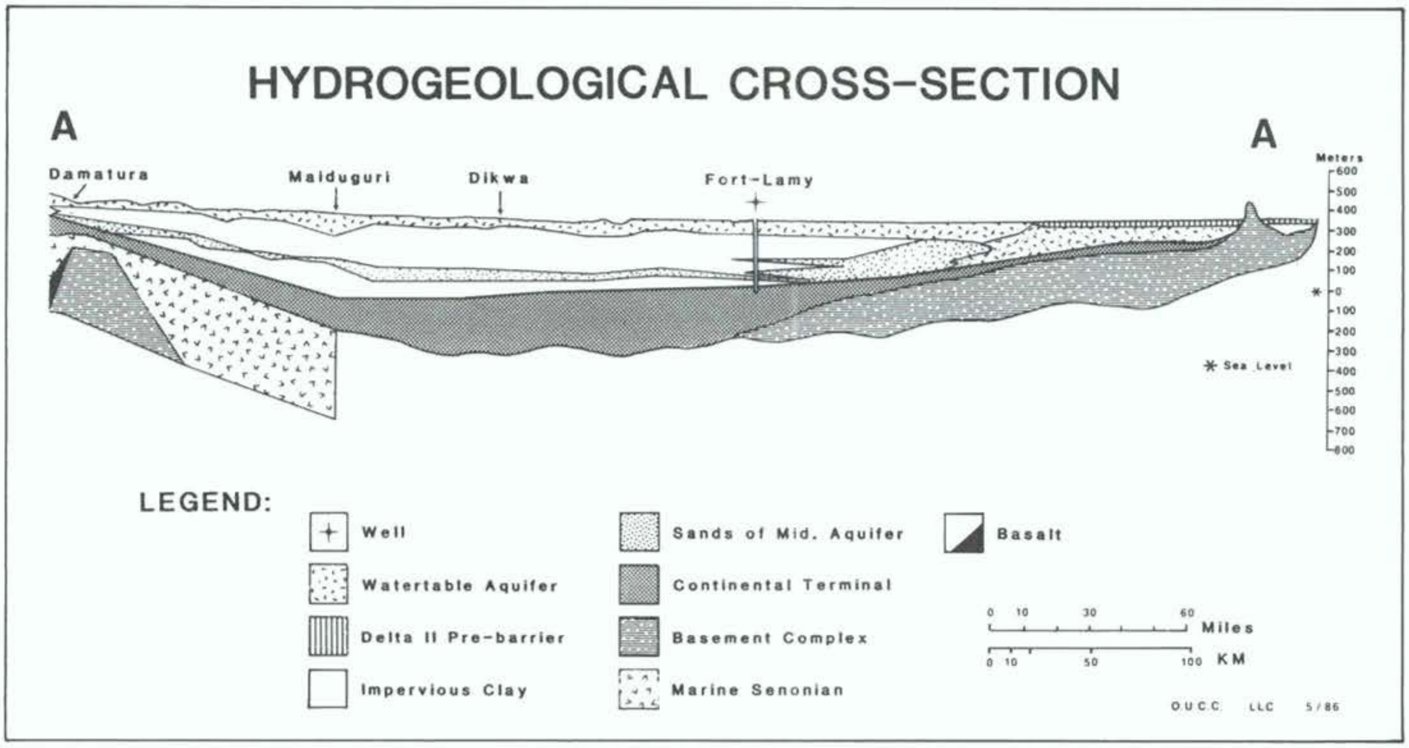


Fig. 3 Hydrogeological Cross-Section

The formation is of variable lithology, containing fine or coarse-grained water-bearing sand, cemented clayey sand; sandy clay and clay. The depth to the top of the Middle Zone in areas of artesian wells varies between 150 and 375 metres below ground level. According to Miller et al. (1968), the Middle Zone aquifer has a maximum transmissivity of 870 cubic metres per day and a reserve capacity of 1.8 cubic metres per day. It is estimated that 24.8 million cubic metres was extracted annually in Nigeria in 1965 and 6.8 million cubic metres per year in Niger.

Deep Aquifer

This aquifer is known as the Continental-Intercalaire and may be the most extensive and the one with the greatest potential. However, little information is currently available on its extent and yield.

The Steady-State Model

UNDP/UNESCO (1972) built an analogue model with the help of the U.S. Geological Survey to stimulate the behaviour of groundwater, subject to a pumping programme in the region between 11'E and 17'N (Fig. 2). The model predicted the following:

(1) From the upper zone aquifer, 1.9 million cubic metres per day may be extracted from 300,000 hectares.

(2) Middle zone aquifer may yield 2.2 million cubic metres per day with a drawdown 120 to 135 metres.

(3) The deep aquifer was not included in the model.

Plan to Assess Water Resources

It is therefore possible that at least 3 million cubic metres may be extracted daily from these two basins. The best areas for extraction can be determined by the following steps (Ahmed, 1983):

1. Interpretation of Satellite Images or Mosaic: lithology, structure and groundwater occurence based in landforms, drainage patterns, land use, soil tones and vegetation types and patterns.

2. Geological Reconnaissance: general geological mapping showing lithology, stratigraphy, and structure.

3. Hydrological reconnaissance: water-level maps, cross-sections of aquifers, aquitards and areas of recharge and discharge.

4. Drilling of exploration and production wells over a widely scattered area. These wells should be pump-tested for a 5 to 10-day duration to determine preliminary aquifer parameters and water quality.

5. Based on the data collected from the previous stages, a numerical identification model may be constructed. A three-dimensional model should be used where possible because the leakage through the aquitards eventually influences the whole system even if only one aquifer is put into production. The entire system must be represented as one model for long-term planning so that with other tools such as geological maps, air photos, remote sensing, geophysical logs etc., well-fields can be located where soil is suitable for growing crops.

6. A modern well design (Ahmad, 1985) is essential for high production performance and a network of shallow and deep observation wells should be constructed and monitored.

7. Using the data from these well fields, the original three-dimensional model should be updated every year.

Agricultural Development of the Sahel

Although traditional agriculture can be innovative, it cannot feed today's expanding population. The problem becomes more complicated if the farmer relies entirely upon rain-fed agriculture, and this is particularly true for the Sahel. Most farmers irrigate the way their ancestors did 5000 year ago.

In a few countries such as Mali or Nigeria, where water is obtained by damming rivers, water flows by gravity across a gently sloping field. This system is less than 50 per cent efficient and the water which seeps through the canals and fields causes waterlogging and a risk of salinity, as has occurred in Pakistan and Iraq. In view of the shortage of water in the Sahel, I would advocate the centre pivot system. Some 12,000 centre pivots have been installed in the desert nations over the last year. This system is 70 per cent efficient, but even more efficient sprinkler systems are now being designed (Lyle, 1982). For fruit, vegetable and orchard crops, the drip system is also a very efficient system.

Conceptual Model

It is therefore suggested that a Food Production System (F.P.S.) be established as an organizational entity to implement food production operations in the Nubian and Chad Basins. The standard project should be 2000 hectares of irrigated land and would use modern agricultural practices. The annual production target should be 20,000 tonnes of food per project (Ahmad, 1981). The water requirement of two crops per year is estimated to be about 36 million cubic metres of water a year. Therefore, the Chad Basin and Nubian Sahara Basins could produce 600,000 tonnes of food if a proper groundwater development plan would be implemented. The project might also be used to settle farmers or establish agroforestry projects.

Agroforestry

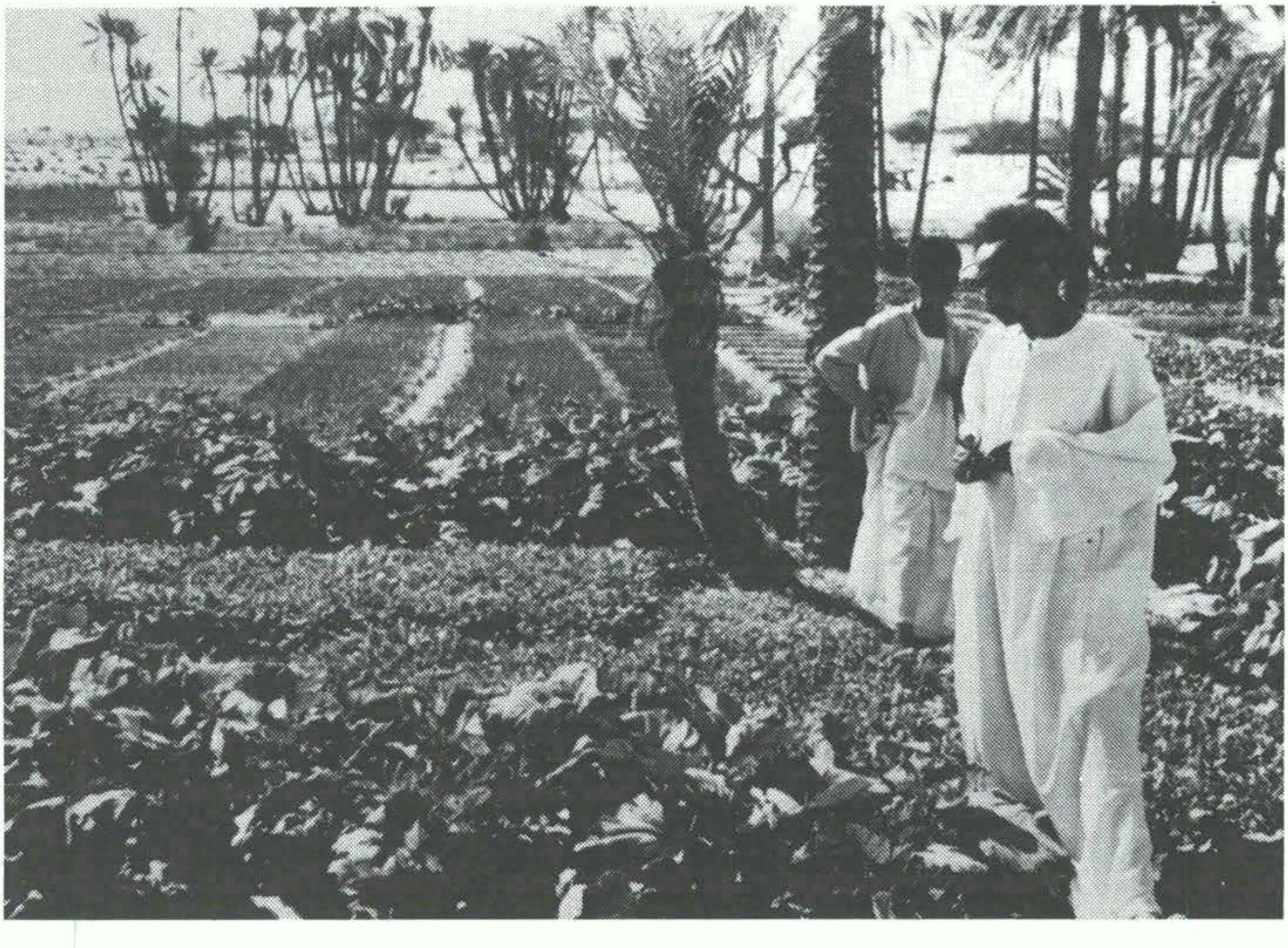
Agroforestry or, more properly, agro-silvopastoralism is a new term for the old practice of growing woody plants with an agricultural crop and/or livestock on the same land. Rural Sahelians have long practised agroforestry. Agricultural crops such as millet, sorghum, maize, cowpeas and groundnuts are often grown by Sahelian farmers under a stand of *Acacia albida*. Agroforestry could contribute to rural development in the Sahel by:

- Increasing food and fodder supplies
- Providing fuelwood
- Protecting the productive potential of a given site and improving its environment and carrying capacity.

The best sites for agroforestry are where the water table is shallow and the trees can survive on capillary water. Other sites can also be located in areas where the water table is deeper. In these areas, Von Maydell (1981) has suggested the following plan (Fig. 4):

(1) Centre of development: village with water supply from a deep well. This area would include administration buildings, residence area, market place, shops, workshops and small plots with trickle irrigation for home gardens and vegetable production.

(2) Inner land use Zone: (a) agroforestry plots of some 100 hectares each to be managed by about twenty family



With proper irrigation, desert lands can produce abundant food as demonstrated here in the central Sudan. (UNEP/S. Errington)

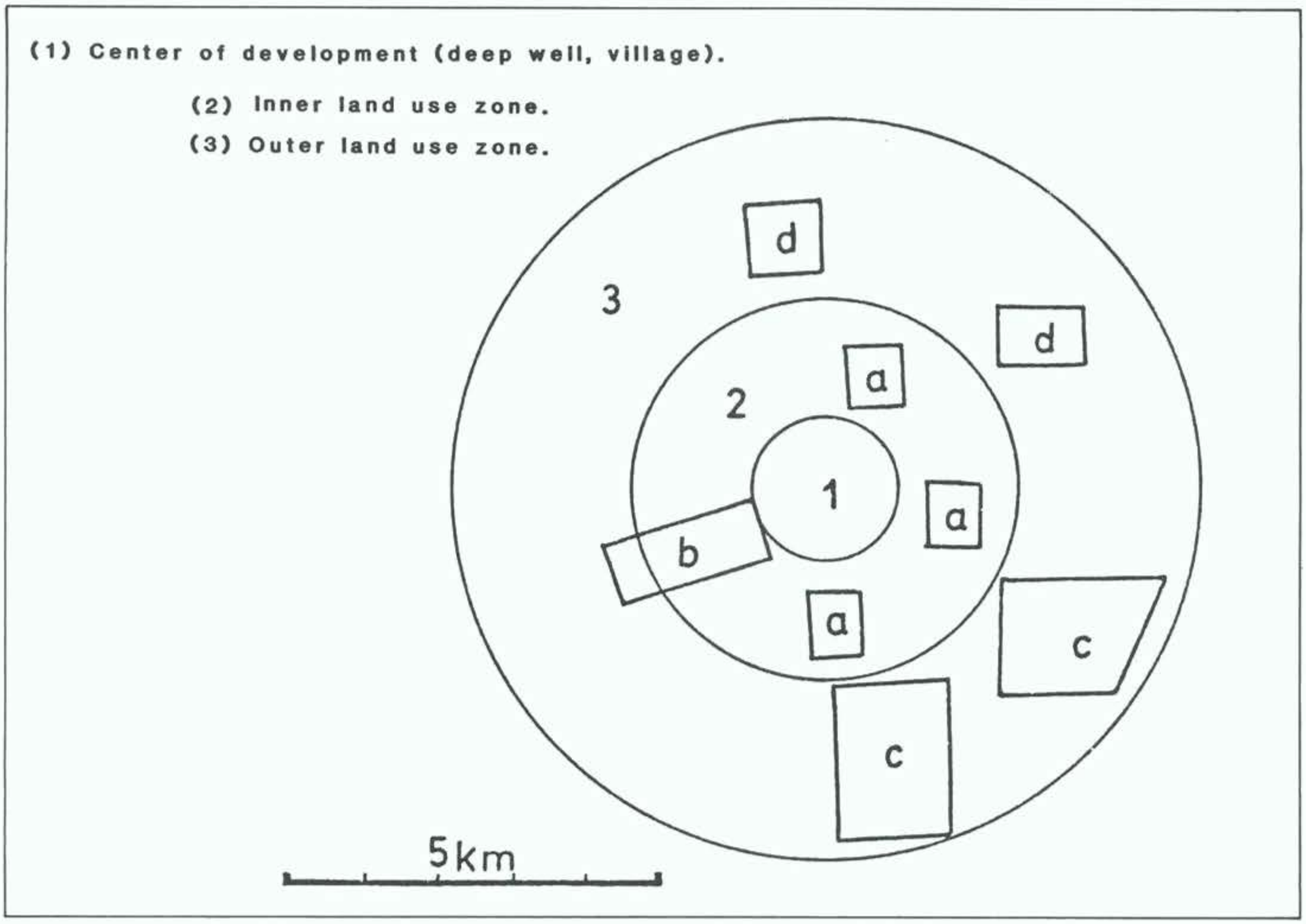


Fig. 4 Plan of land use in the area surrounding the well sites.

units, (b) intensive range management of fenced grasslands with high percentage of tree and shrub cover.

(3) Outer land use Zone: (c) forest plantation (e.g. with *Acacia senegal, Prosopis africana* and *Prosopis juleflora* for the production of gum arabic, firewood, poles, etc.) (d) protected areas for natural regeneration of local species and (e) fish farms.

Cost of Project

The standard project scale would be 2,000 hectares of irrigated land. The capital cost would be US$12-15 million and the operating costs would be US$3-4 million.

Conclusion

It is now a widely held concept that every country needs to have a developed agricultural industry before other kinds of development can be successfully undertaken. It is suggested that UNDP, FAO, USAID and others should channel their funds to establish long-term projects to eradicate the recurring famine problem in Africa. Since these famine areas are a product of surface water fluctuations, the priority is to develop the groundwater resources.

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Sustainable Development of Arid Lands through Irrigation

A Case Study of Bhima Project, India

By Asit K. Biswas
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Much has been writen in recent years on the problem of increasing desertification of arid lands. One of the major alternatives available for increasing the productivity of arid lands — irrigation — has come under some criticism because of its potential adverse long-term impacts and poor performance in the past. While some of the criticisms are justified, others are imaginary and baseless. A major reason why irrigation development raises great hopes in certain quarters but is simultaneously a subject of despair in others results from the paucity of regular monitoring and evaluation of irrigated agriculture projects (Biswas, 1985). Without regular evaluations, it is not possible to make any definitive statements. Therefore biases tend to be perpetuated or even accentuated.

Success of any irrigation project depends on proper planning and subsequent management. Since planning and management varies significantly from one project to another, even in the same country, it is difficult to make any generalized statements on their overall performance. The situation becomes more complicated if one considers the preponderance of inadequate evaluations that are carried out by both national and donor agencies (both bilateral and multilateral), who are more concerned with the protection and enhancement of individual and institutional reputations than with determining the real costs and benefits of the projects. Furthermore, not only are there methodological problems that need to be resolved to find cost-effective and reliable evaluation techniques for specific projects, but there are often built-in institutional inertia and sensitivities which need to be overcome before a serious evaluation can be undertaken.

If these constraints could be overcome, the information available after completion of the evaluation should be disseminated. On the basis of past experiences, this could be a problem because the agencies concerned often do not wish to disseminate the information unless it is properly 'sanitized'. The bilateral and multilateral donor agencies often do not disseminate their evaluations and claim that they are forced to take such a step owing to national sensitivities. In contrast, many development experts feel that one of the main reasons for this lack of dissemination could be the poor performance of the donors, who do not wish to publicize some of their mistakes which become evident during an evaluation. They therefore prefer to hide behind the so-called national sensitivity issue. Bottral (1986) points out that the four detailed case studies he carried out for the World Bank had to be marked "Not for Quotation" and they "could not be published because of the supposed sensibilities of the governments of the countries concerned. For the same reason, the text of the final comparative study was 'sanitized' to the extent that all references were removed not only to the particular projects studied but even to the countries in which they were located." Such restrictions, which are generally unwarranted, seriously reduce the potential usefulness and impact of the evaluations carried out, and tend to defeat the purpose of the evaluation.

One of the very few irrigation projects that has been properly evaluated in recent years is the Bhima Command Area Development Project. A comprehensive evaluation of the project was carried out in late 1983, when only about 10,000 hectares of the planned total of 126,000 hectares were receiving irrigation water (Biswas, 1985). This was followed up with another evaluation three years later. Both evaluations provided information on the performance and socio-economic impacts of the project. The present paper provides a summary of these two evaluations.

Land Type	Maximum Landholding in Ha
Irrigated land	
Perennial	7.2
Seasonal: Assured	10.8
Seasonal: Unassured	14.4
Paddy land (assured rainfall)	14.4
Other rainfed land	21.6

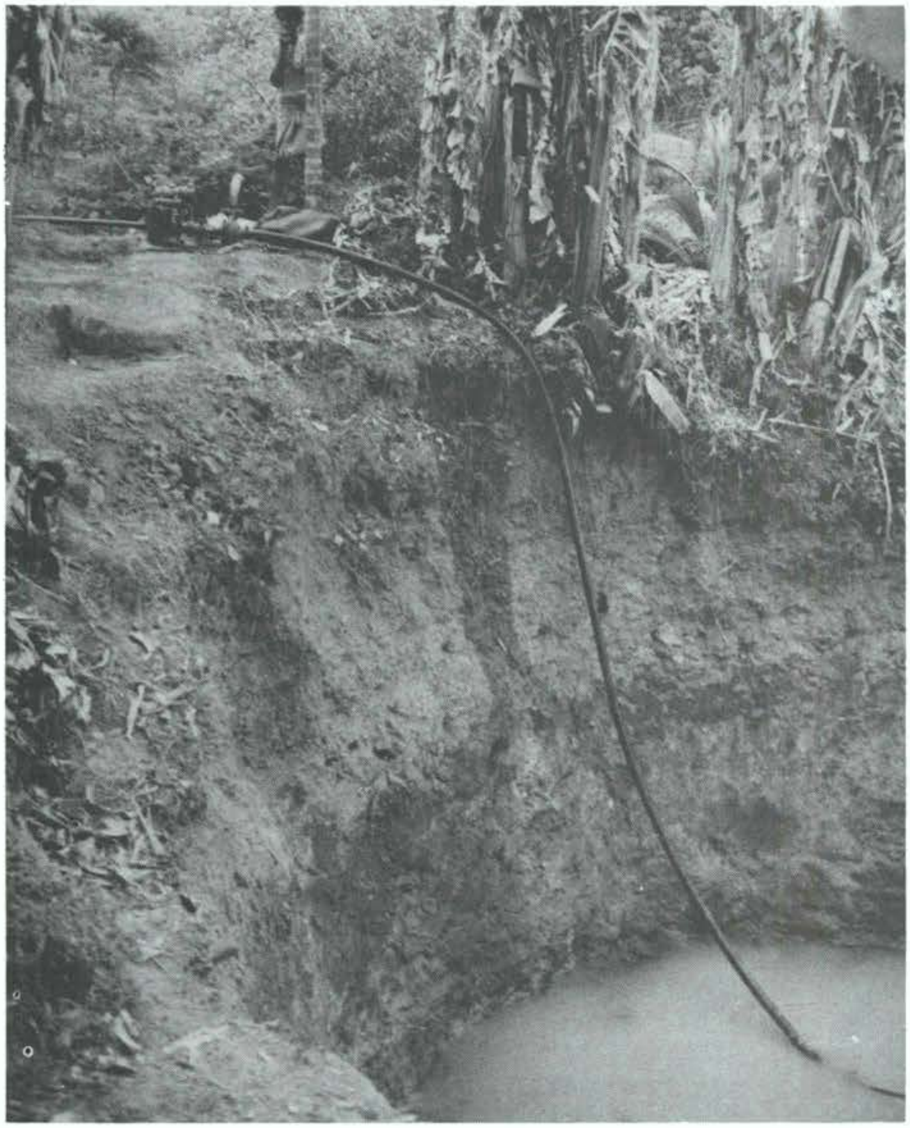
Table 1 Maximum landholding in ha per family of five in Maharastra

Bhima Project

The Bhima Command Area Development Project is located in the state of Maharastra, India. Rapid industrial growth of 4.8 per cent per annum during the past two decades has made Maharastra one of the most industrialized and urbanized provinces of India. Most of the industrial growth, however, has taken place in its two principal cities — Bombay and Pune. In contrast, agricultural growth has been low, 0.7 per cent per annum. Thus, both regional income distribution and rural-urban migration have become problems.

Currently, some 59 per cent of the provincial area is under cultivation. The area of an average farm is 5.3 hectares, but the average farm size varies significantly from one district to another. According to the 1970 census 92 per cent of the farms are owner-operated. Maximum landholdings allowed in Maharastra for a family of five (husband, wife and minor children) depend on the degree of water availability and control and are shown in Table 1.

Agriculture provides nearly two-thirds of the provincial employment but accounts for only one-third of the income. Since there is very little prospect for horizontal expansion of agriculture in Maharastra owing to lack of reliable water supply, emphasis has to be placed on better use of agricultural land and substantially increasing the cropping intensity which is among the lowest in India. As the region is generally arid, such improvements cannot occur without irrigation.



Irrigation is essential to the economy of Maharastra State. (UNEP/D. Stiles)

The government of Maharastra has been conscious of the importance of irrigation for the provincial economy and welfare. Nearly \$1.3 billion was invested in major and medium surface irrigation works during the three decades after independence to bring an additional 870,000 hectares under irrigation. Compared to the average cost of \$860 per hectare on Indian irrigation projects, irrigation investment per hectare in Maharastra has been 73 per cent higher. The high cost can be explained to a major extent by the more difficult physical and climatological conditions under which irrigation systems had to be developed.

Since water is the major constraint for agricultural development, the provincial government has embarked upon an ambitious irrigation expansion programme under Maharastra Composite Irrigation Projects (MCIP) I and II. The Bhima Command Area Development falls under MCIP II.

The Bhima Project consists of a storage dam across the Bhima River, a major tributary of the Krishna River, near the village of Ujjani. This often-called Ujjani Dam is nearly 150 km from Pune towards Solapur (Figure 1). Since the construction of the dam, a new village of Bhimanagar has developed near the dam. The project area is 166,400 hectares and has a net irrigateable area of 126,400 hectares. Since good dam sites are not available, the Bhima Reservoir has inundated an area of 29,000 hectares. This means the ratio of the land inundated to the total land to be irrigated is 1:4.35 which is somewhat on the high side. The command area extends on both banks of the Bhima and Sina Rivers (see Figure 1).

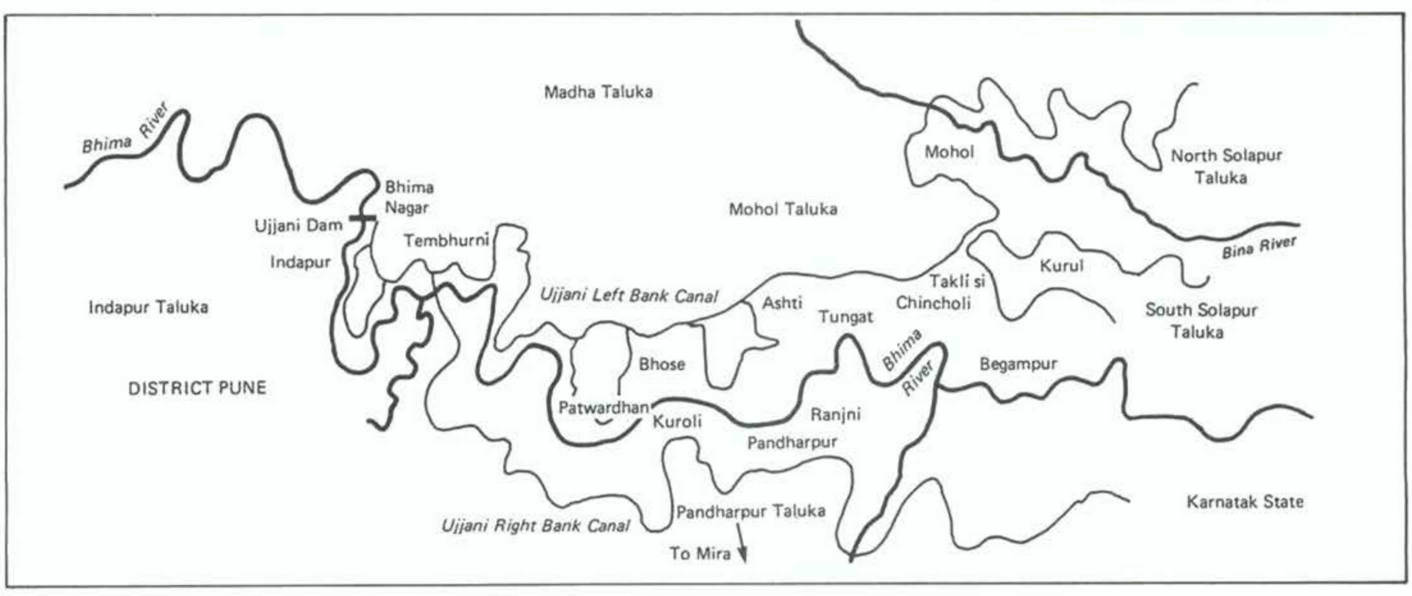


Fig. 1 Bhima Command Area

Much of the emphasis of the evaluation was placed on the villagers and their perceptions of and attitudes to the project. We wanted to know the views of farmers and landless labourers on the impact the project has had on their lives: if, and to what extent, it has changed their aspirations, and their views of the benefits and disadvantages of the project. We also specifically wanted to know the impacts of the project on women.

When the first evaluation was carried out by the author in October 1983, about 10,000 hectares were under irrigation for the *rabi* (winter) 1983-84 season. By the time of the second evaluation in 1986, rabi irrigation had extended to about 17,600 hectares, and only about 5,008 hectares (less than 5 per cent of irrigated command area) was receiving year-round irrigation.

In the absence of a reliable monitoring and evaluation system, both evaluations depended heavily on questionnaire surveys of a cross-section of individuals from different villages.

Assessment of Project Impacts

Even though only a limited part of the Bhima Command Area has been receiving irrigation water, both evaluations indicated that the impact of the project on people and the environment has been substantial. On the basis of the two evaluations, the impacts will be discussed under the following categories: income, employment generation, livestock, energy use, education, transportation, water supply, sanitation, housing, food and nutrition, health, women, public participation, and environmental impact.

(i) *Income* — There is no doubt that incomes in areas receiving year-round irrigation have increased substantially. Farmers are generally somewhat reluctant to provide correct figures (assuming they themselves are aware of these) because of fear of possible taxation, reduction in benefits and/or an increase in bureaucratic involvement. From the surveys of villagers, it is evident that the average net income of those farmers receiving year-round irrigation at present has increased from 455(1) per year before the project commenced to Rs. 4640 at present. This tenfold increase in income in only a few years of project operation is indeed remarkable. As to be expected, the net average income of farmers receiving only winter irrigation is less, Rs. 1277 at present. It is interesting to note that in the case of year-round irrigation, it is the small farmers who have realized the highest average income per hectare at Rs. 5339, compared to large farmers at Rs. 3919.

(1) US$10.00 = Rs. 12.80.

In terms of poverty alleviation, the latest evaluation indicates that some 50 per cent of all farmers with year-round irrigation are now earning more than Rs. 10,000 per annum directly from project; no farmers in the control sample are earning Rs. 10,000 per year. Indeed, 68 per cent of the control sample earned less than Rs. 1,000 in 1985-86, compared to only 2 per cent of the farmers receiving irrigation water all year. Those farmers who irrigate more than 5 hectares of land now have a net income of more than Rs. 10,000 per year, and some 34 per cent of all small farmers having less than two hectares of land now have a net income of more than Rs. 10,000 per year.

For farmers receiving only winter irrigation, the net income is considerably less. Only 5 per cent of such farmers now have a net income of more than Rs. 10,000 per year and 35 per cent earned less than Rs. 1,000.

Assuming a pre-project poverty line of Rs. 2,000 per household per year, 61 per cent of households were living in poverty before the Bhima Project was implemented. Accounting for inflation, and using a current poverty line of Rs. 5,000 per year, about 26 per cent of the households are still living in poverty, meaning that 35 per cent of the families have crossed the poverty barrier as a result of the irrigation project.

When secondary benefits like income from livestock are included, the situation improves even further. When farm and livestock incomes are combined, nearly 83 per cent of the families are now living above the poverty level. Relying on farm income alone, 51 per cent of the families having less than one hectare had an income over Rs. 5,000 per year; this figure increases to nearly 66 per cent when farm and livestock incomes are combined. This indicates that it is necessary to encourage small farmers to have subsidiary incomes from livestock and other potential sources in order to alleviate poverty.

Indirect analyses tend to confirm an increase in income of this magnitude. Standards of living are rising by improvement in houses and investment in livestock, better clothing and social functions (like marriages and festivals). Generally, people appear to have refrained from conspicuous consumption, though this may change in the future with further affluence.

(ii) *Employment generation* — employment generation has been one of the major benefits of the project. Project-related construction has already provided substantial employment for skilled and unskilled workers. For example, the first evaluation (Biswas, 1985) indicated that construction-related activities have generated 1,786 million man-days of skilled labour and 37,106 million man-days of unskilled labour up to 1983.

The work patterns of both small and large farmers have changed substantially. Prior to irrigation, family members usually worked as daily labourers after the *rabi* season. Small farmers worked as daily labourers even during parts of the *rabi* season since there was not enough work for them in the fields. Irrigated agriculture, as practised in Bhima, is a labour-intensive activity. Thus, in areas where water is available throughout the year, farmers do not now have time to work as daily labourers, with the exception of a few small farmers, who still may work for a limited number of days per month as labourers.

On the basis of the latest evaluation, 113 man-days of wage employment have been generated per hectare per year in areas receiving year-round water. In areas with winter irrigation only, the corresponding figure is 33 days per hectare per year, and in control samples only 10 days per hectare per year. If additional employment of family members is considered, an extra 90 man-days per hectare are generated so that one hectare of year-round irrigated land provides 203 man-days of employment.

It is interesting to note that 37 per cent of wage employment is accounted for by men and 63 per cent by women. To a certain extent this can be explained by the fact that the wages for women labourers are significantly lower than for men, Rs. 5.6 per day for women and around Rs. 10 for men. Furthermore, with increasing employment resulting from the intensification of agricultural activities, family wages earned by the labourers from the farms have increased from Rs. 1,671 during the pre-project period to Rs. 5,416 in 1985-86. The dependence of the labourers on non-farm sources of income has declined markedly from 38 percent of total income from the pre-project period to only about 11 per cent in 1985-86.

As employment opportunities are generated, people from outside migrate to the command area in search of work. The labour scarcity during harvest time has become serious;

many farmers are now forced to go outside the command area to bring in labourers for harvesting. So, in terms of employment generation, the project has had a positive impact both within and beyond the command area. As more and more areas come under irrigation, the labour situation is likely to become even more acute, at least in the initial years.

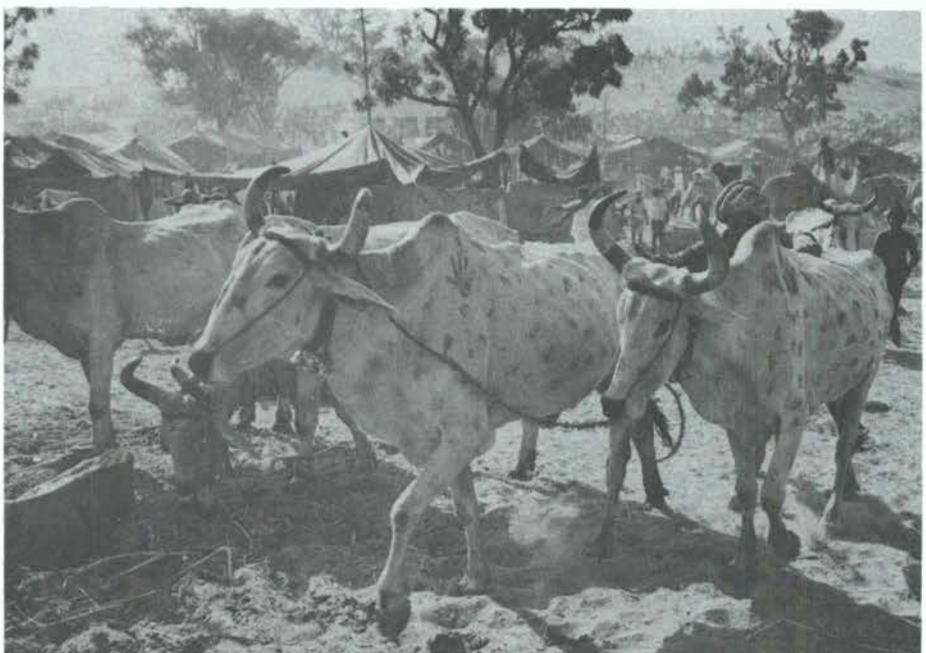
(iii) *Livestock holding* — One of the main benefits from the project is an increase in the livestock holding of the people in the area. The first evaluation indicated that farmers and landless labourers had generally increased their livestock holdings, though the latter not to the same extent. It appears that many landless labourers have invested in livestock from earnings from the construction activities of the project and they graze their livestock along the canals and/or communal areas.

The latest evaluation indicates that 65 per cent of the households surveyed had purchased 148 draft animals for a total investment of Rs. 232,000 since irrigation began. Another 87 households purchased 325 milk animals valued at Rs. 421,100. Transportation requirements meant the acquiring of 42 bullock carts by as many households during the post-irrigation period. However, a major problem that still remains is the lack of suitable veterinary services in nearly all villages.

(iv) *Energy use* — While many of the villages have received electricity under the rural electrification programme, domestic coverage is still poor. For example, during the first evaluation, it was found that in Takali village (population 3257), only one house had an electric connection. There are 30 street lights, which undoubtedly was an improvement. This sad state of affairs is a country-wide phenomenon since the main emphasis is on the number of villages electrified and not on coverages within villages. This policy needs to be changed.

In the villages, kerosene is primarily used for lighting, and firewood and agricultural residues for cooking. Women generally collect firewood and spend an average of two hours each day on firewood collection and related activities. As a result, firewood has become scarce and many rural families are forced to purchase it. An interesting observation is that the percentage of people purchasing firewood in areas where irrigation water is available all year round is much less when compared with other areas receiving water for only one season or no water at all.

There are two principal reasons for the decreased use of fuelwood. First, agricultural residues in areas receiving year-round irrigation are higher than in surrounding areas and this has tended to alleviate the problem of fuelwood scarcity. Second, people with continual irrigation have become more prosperous and have significantly increased their livestock holdings, increasing the dung available for cooking. This is a welcome development since it has reduced the pressure on deforestation in drought-prone areas like Solapur.



Livestock holdings have increased since the beginning of the Bhima Project, but veterinary services are still a problem. (UNEP/D. Stiles)

(v) *Education* — There is no doubt that the children in the project area are becoming better educated than their parents. While the new affluence has some bearing on this, it cannot be exclusively attributed to irrigation. Much of it may have occurred without the project. Irrigation does not appear to have made any noticeable change on the number and type of schools or quality of teaching (number of teachers, their experience, educational materials etc.), and in fact a few villagers haver complained about the quality of schools available. It is not possible to comment on enrolment and drop-out rates since consoldiated data are not available.

(vi) *Transportation* — Currently no plan exists for village and farm roads. It was a strategical error for an international agency like the World Bank to suggest only funding of the improvement and consolidation of the existing main road. The main road improvement would have been funded by the Public Works Department of the Maharastra Government as a matter of routine. Instead, the agency should have supported village roads and farm roads that could provide access to the main road. Because farm roads were not developed prior to the arrival of irrigation and because land-holdings are generally small, farmers are likely to be reluctant to give up land which means that the construction of farm roads will now be a very difficult process. Another problem is that lack of farm roads also means lack of cattle-crossings on the

Type of Fuel for Cooking	Percentage of Fuel Used	
	Pre-irrigation Period	1985-86
Fuelwood	66.3	53.2
Cow dung	19.2	23.8
Agricultural wastes	7.4	13.1
Others	7.1	9.9

Table 2: Changing pattern of use of cooking fuel

channels, resulting in damage to the channels, which increases operation and maintenance costs and seepage losses.

Another issue is the political agitation that has already started over the need for village roads. People in some villages have already organized *rasta rokoo* (close the road) movements in order to get authorization for the village road. Lack of village and farm roads means that access to markets will be difficult and transportation will continue to be a problem.

Some 40 per cent of the beneficiaries have now purchased bicycles and around 8 per cent now have motorcycles. This is a significant improvement over the first evaluation, and it is likely that as farmers become more prosperous, they will opt for better and more transportation facilities.

Women spend an average of two hours a day collecting firewood. (UNEP/D. Stiles)

Generally, females collect the drinking water. The breakdown of a hand pump can take six months to repair. (UNEP/D. Stiles)

(vii) *Water supply* — Sources of drinking water at present are hand pumps, tanks, wells and rivers. More and more hand pumps are being installed, but this appears to be part of a rural water supply programme and probably would have occurred with or without the project. The problem with the hand pumps now is maintenance. When breakdowns occur, it takes an average of three to six months before any repair work is carried out. All four sources of water are used at present. The primary consideration in deciding to use a specific source is its distance from the house. Generally, female members of the household fetch drinking water.

(viii) *Housing and sanitation* — There are clear indications that housing facilities in the project area are improving rapidly. Review of housing conditions indicates that out of a sample of 140 beneficiaries, 22 have constructed new houses and another 12 have renovated their houses. Nearly 83 per cent of the households have purchased new furniture, utensils, radios and other similar items.

There does not appear to have been much change in the sanitation practices during the post-project period.

(ix) *Food and nutrition* — There is no doubt that the food and nutrition situation has improved remarkably in the area receiving irrigation. Since there are two or three crops a year, both small and large farmers feel that for the first time they have food security and that their families will now not go hungry as they frequently did in the past.

Without exception, people in the project area report that the quality of food has improved. Some 71 per cent of the household samples reported that the variety and quantity of vegetables consumed have increased. similarly, an increase in livestock holdings has meant more protein consumption (milk, eggs and meat) by nearly half of the population. This consumption may be the result of the absence of a ready market for the products, so it is likely that when such a market develops, most of such products may be sold for cash. This has been the general tendency in other parts of India.

(x) *Health* — Comprehensive information on health is not available, but on the basis of limited information available it appears that women in the project area are more susceptible to malaria than men. This may be for two reasons: first, women receive less nutritious food than men. Men eat first and are given 'better' food e.g. fish, meat and more vegetables. Women eat last and eat whatever is left. Second, women spend more time in homes and animal sheds and are more exposed to mosquito bites. Increased concentrations of carbon dioxide in animal sheds are likely to attract mosquitoes. No specific trend was visible for diseases like cholera, or annual incidence of internal parasitic infections. The number of primary health centres has increased from 16 in 1980 to 58 in 1985 in the project area. There is also a significant change taking place in the attitude of people to medicine; because of affluence brought about by irrigation, people appear to be moving away from traditional medicines to visits to doctors and hospitals.

Health education appears to be one of the biggest problems in the project area. People are now living side by side with their significantly increased livestock holdings. Health hazards have increased markedly owing to the presence of flies and other disease vectors. However, since the farmers are uneducated, they are still not aware of the health dangers posed by such insects nor do they have adequate information on how to protect water stored in the home for drinking, or on family planning. This is an area that needs urgent attention.

(xi) *Women* — The irrigation project has already had much impact on women, both beneficial and adverse. The principal effects are related to work loads, attitudes to education, finance, wages, dowries, firewood collection and land levelling.

In terms of the work load, the number of hours worked per day has increased significantly since irrigation was introduced for two main reasons. First, the significant increase in livestock and the fact that women are primarily responsible for them requires extra work to be done. Second, introduction of irrigation means that two or three crops are being grown every year, instead of only one. Weeding for irrigated farming is mostly done by women, whereas very little or no weeding was done for dry land farming. Additional tasks include application of fertilizer (little used before, if any), application of water to the fields, looking after labourers and an increased managerial role. Consequently, the average number of working hours appears to have increased by around two and a half hours per day and by about four hours during harvest times.

There is now a general feeling among the wives of both small and large farmers that daughters should be educated. It appears that younger women have stronger feelings about the education of their daughters than their older counterparts. Interestingly, older women, whose older daughters were not educated, now feel the younger girls should go to school. How and why this change of attitude has occurred is difficult to say without further research.

So far as wives of landless labourers are concerned, a similar change in attitude can also be observed, but this does not appear to be as strong as the views of the farmers' wives. One point made by several landless labourers was that before irrigation, they had to move from one place to another searching for jobs. Thus, they could educate only one son, who was left with relatives or in a few cases in hostels. Daughters invariably moved with parents from place to place and were never sent to school.

With the introduction of irrigation, employment opportunities near the villages have increased significantly. Now they stay in one village and find work within the village itself or neighbouring areas. As a result of this new stability, they are sending their daughters to schools. A common wish amongst women-farmers and landless labourers is to educate their daughters as far as possible, but only within the school available at their village. There is a general reluctance to send daughters to schools outside villages. This is not the case for their sons.

The irrigation project appears to have affected dowries: with increasing prosperity, dowry requirements for marriage of daughters have increased two to five times.

(xii) *Environmental impact* — The environmental impact of the Bhima Project has been neglected right from the beginning. For example, in the 83-page Staff Appraisal Report on the project by the World Bank, environmental impact has merited only five lines. Lack of data and limited time availability for the two evaluations means that no realistic review of the environmental impacts can be made. However, on the basis of limited observation, the following comments can be made:

(1) The development of a reservoir with a large surface area, and consequent increases in vegetation due to irrigation, appears to have increased the number of birds in the area. Whether any species substitution is taken place is not possible to say without further studies.

(2) The presence of a reservoir with a surface area of 29,000 hectares in an arid region would evidently have an impact on microclimate through increased evaporation and evapotranspiration. Meteorological observations are necessary to identify changes in temperature and humidity.

(3) Within the short period in which the irrigation system has been established, aquatic weeds have already become a problem. Unless immediate steps are taken to control weeds, environmental problems are likely to increase in the future. Among these could be health (weeds would reduce velocity and hence provide good habitats for vectors of water-borne diseases); decreasing water quality (decayed weeds would reduce dissolved oxygen content of water); and increasing water requirements (since water velocity in canals could be reduced, more water needs to be released from the reservoir).

(4) The drainage system is very poor at present. Without hydrological observation, it is not possible to say definitively what is happening to the water table or to the development of waterlogging and salinity. However, circumstantial evidence indicates that the water table has started to rise, and both waterlogging and salinity have become problems in a few low-lying areas. Our interviews with farmers in these areas indicated that crop yields have started to decline.

(5) The Bhima Reservoir inundated 29,000 hectares which included 51 villages: 25 in Pune District, 23 in Solapur District and three in Ahamad Nagar District. Some 57,000 people had to be relocated due to the submergence. We met a few people who were very bitter about their experiences. Regrettably the Appraisal Report of the World Bank does not even mention these people. While the government of Maharastra does have a relocation programme, it appears that both planning and execution of plans leave much to be desired. It is a sad commentary that more than 20 years after the dam construction started, and seven years after completion, rehabilitation programmes are still incomplete.

Conclusion

Increasing the productivity of arid lands on a sustainable basis has been a major problem in many developing countries. The Bhima Command Area Development Project clearly indicates that irrigation is an important and viable option for arid land development and that the benefits of such projects can accrue to both large and small farmers as well as landless labourers. The critical requirement is that such projects must be properly planned and efficiently managed.

As the two evaluations indicate, the benefits of the Bhima Project have been substantial to all strata of society. Equally, like Bhima, any large development project anywhere is likely to have some shortcomings. For example, for Bhima three important planning problems stand out: the absence of an adequate drainage system, the lack of village and farm roads and the incomplete resettlement of the people. It is important to identify these problems in the early stages of the project's life in order that appropriate policy actions are taken to resolve them before they become more serious and affect the long-term sustainability of the project itself.

Proper identification of design problems and an analysis of the impact of the project on the socio-economic conditions of the area can only be properly carried out by having an effective monitoring and evaluation system. This must provide regular feedback to management on both the positive and adverse impacts of the project. The management can then take the necessary steps to increase the positive impact and minimize the adverse impact. Such a management system could both improve the overall sustainability of the project and maximize the benefits accruing from it.

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Some Agricultural Considerations in the Planning of Runoff Farming

Y. Orev, Beer-Sheva, Israel

Introduction

Runoff farming is a technique used in semi-arid and arid lands whereby rainfall which fails to infiltrate the ground is channelled into specific sites where it can accumulate as surface water or seep into the soil. In a dam or reservoir, runoff farming is based on a series of microcatchments in which rainfall from a small area is harvested and directed to a ditch or shallow pit, in which or near which crops or trees can be planted to take advantage of this additional moisture.

Much research has gone into the hydrological planning of runoff farming systems. Shanan and Tadmor (1976) published a series of recommendations based on the experience of the Avdat farm in the 1960's which were subsequently implemented on a larger scale at the Mishash Farm at the beginning of the 1970's, where the "Nigarin" system of micro-catchments was used and subsequently recommended elsewhere. Under this system, each tree has its own individual catchment which is designed to supply an adequate amount of runoff water for survival in very dry years and growth in years of plentiful rainfall. These authors also recognized that variations in soil type would affect runoff production potential but they did not envisage the wide fluctuations in infiltration rates within very short distances since one of their recommendations was that soil test pits should be spaced 400-600 metres apart (1 pit per 16 to 36 hectares). They concluded that test pits at a density of 1 to 10 hectares would be too expensive.

This non-uniformity can occur in much smaller areas (T.M. Boers, personal communication). At the Jacob Blaustein Institute for Arid Zone Research, differences in runoff were found during the 1982-83 rainy season, ranging from 1.5 cubic metres to 4.2 cubic metres per site on eight continuous micro-catchments of 125 square metres each.

The 1981 Annual Report of the Institute of Arid Zone Research mentioned the widespread use of the Nigarin method at the Wadi Mishash Farm and noted that the trees were not as well developed as they should have been at their age. It therefore appears that not all factors were taken into account in the development of the Nigarin method and it would be appropriate to discuss some of its drawbacks.

In the Nigarin method, the tree is planted in the lowest spot of the catchment where the water would be deepest and the dyke highest (Fig. 1). The dyke is built from the soil from the 40-cm deep pit which means that the dyke is primarily well-aerated topsoil while the tree is planted in the subsoil. This is the opposite of what is desirable for the tree. A further disadvantage is when the pit fills with water, the tree is

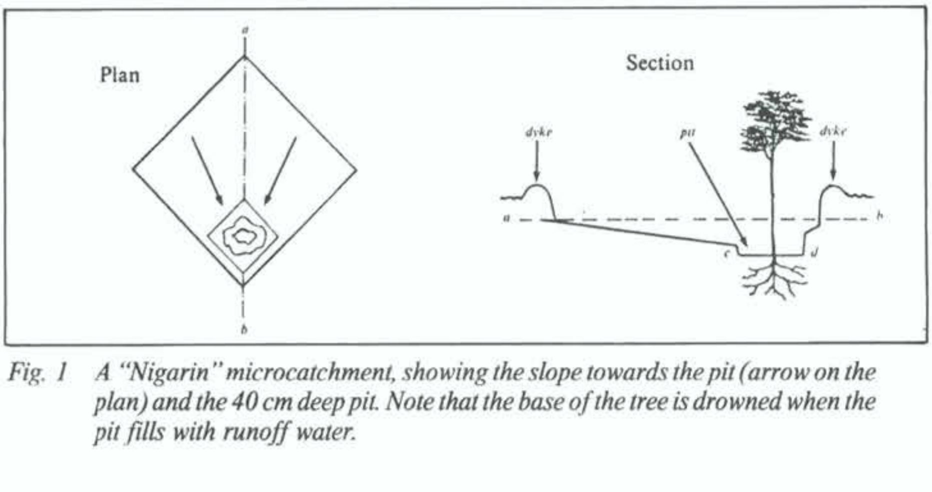

Fig. 1 A "Nigarin" microcatchment, showing the slope towards the pit (arrow on the plan) and the 40 cm deep pit. Note that the base of the tree is drowned when the pit fills with runoff water.

flooded: this may last days, or even weeks, and during that time the roots and lower stem suffer from lack of aeration and they may be more vulnerable to fungal diseases. Eventually the pit may fill with sediment and the lower part of the stem will be buried in it. Most fruit trees do not thrive when buried in silt especially when combined with prolonged flooding. Moreover, with this method it is only possible to cultivate with a hoe or a spade. Cultivation is essential for many reasons and, if possible, should be done mechanically or with animal draught. A method limited to hand cultivation is not conducive to agro-technical advance.

Site of Planting

The non-hydrological aspects of runoff farming should also be discussed beginning with the needs of the tree. First, if earth dykes are used to collect runoff water, the water stays at the bottom of the dyke and the adjacent soil is moistened by capillary rise. The best place to plant the tree is therefore immediately above the water level or on the top of the dyke where the topsoil is now found. It will still be within reach of the harvested water (Fig. 2 and Fig. 5). With conventional planting it is noticeable that both weeds and shrubs appear to thrive on this site while the places where water stays longer are usually bare of vegetation. The tree must be kept free from weeds in order to reduce evapotranspiration and competition for soil nutrients.

The cultivation is done in the intervals between floodings, as soon as the soil dries out sufficiently and the area above the high water level can be cultivated sooner than the area which has been flooded. This is a further advantage of planting on top of the dyke.

It is unlikely that runoff farming in the developing countries will be tractor cultivated but for the sake of comparison, a 50-horsepower tractor with a three-furrow plough can plough about 5 hectares daily, so this would be the minimum area of the field.

These different methods of draught will influence the length of furrow. For a farmer with a hoe, the length is immaterial because be or she must rest from time to time even in the middle of a row, or move from tree to tree. The shape of the field is unimportant and where manual cultivation is the rule, fields are often irregular in shape. A large distance between trees is not a disadvantage because the farmer can straighten his or her back and rest before reaching the next tree.

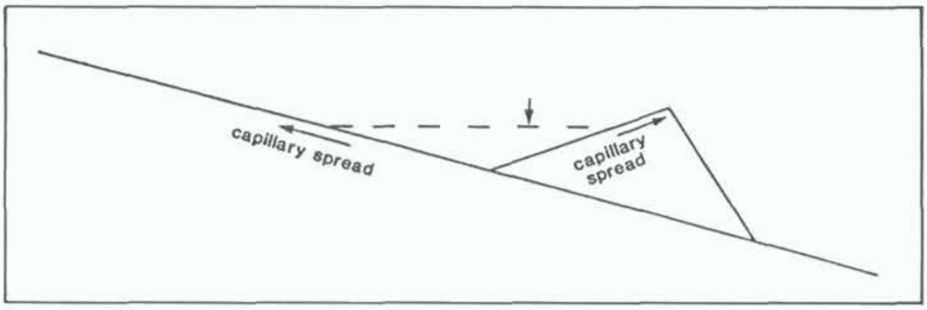

Fig. 2 A level dyke filled with runoff — the moisture spread up the dyke and upslope by capillarity.

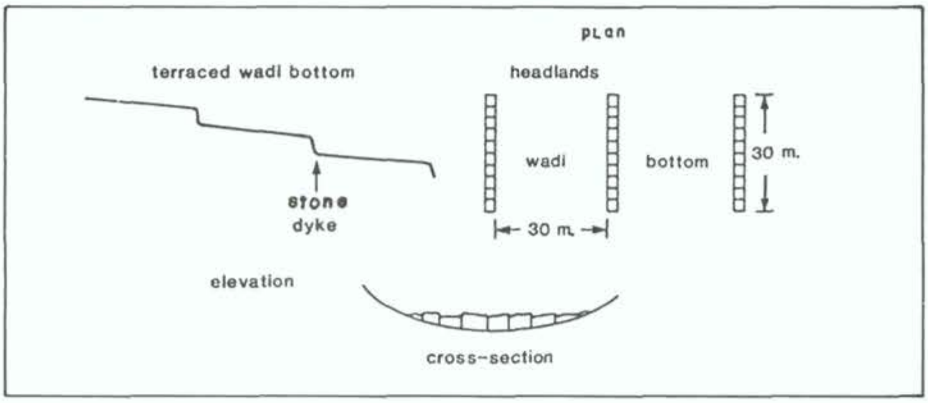

Fig. 3 Terraced wadi bottom: the top of the stone dyke must be level; the slope between the stone dykes grows less steep and levels off with sediment settling.

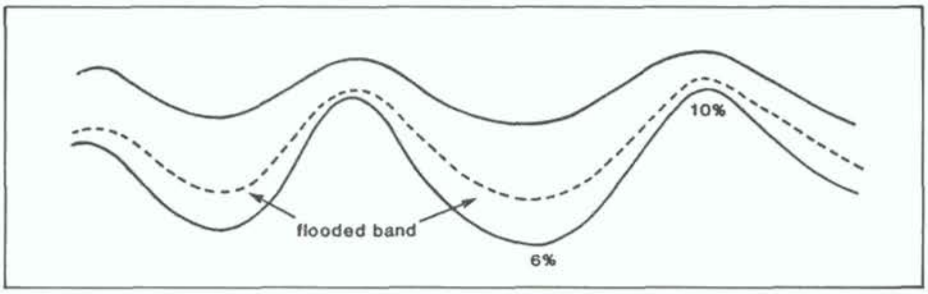

Fig. 4 The flooded band is wider with a gentle slope (6%) narrower with a steep slope (10%).

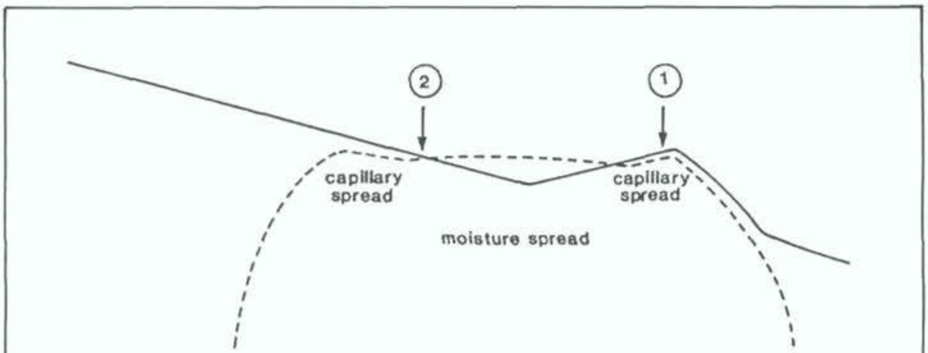

Fig. 5 The moisture spread is much wider than the flooded strip; this enables the planting of a tree in a place to suit the farmer's needs.

In contrast, the length of the furrow and the distance between trees are important when cultivation is done with animals or tractors. For animal draught, the length of furrow need not be very big as the animal must also be rested from time to time; this takes place mostly at the headlands where the plough is lifted out of the ground and turned around to cultivate the next furrow which can be as short as 30-40 metres for a donkey and up to 100 metres for a horse. There will also be some loss of cultivated area at the headlands so there will be a compromise between the furrow length and the loss of land.

Contour Dyke System

The aims of runoff farming are fourfold: first, to harvest a high percentage of rainfall; second, to be able to plant the trees close enough not to waste time and energy on travelling between widely-spaced trees; third, to be able to use animal draught, or even tractors, on orchards which are large enough for a full day's work; and lastly, to ensure that variability in runoff percentage is taken into account so that each tree will get roughly its due share of water. The contour dyke system is the nearest to fulfilling these aims.

Contour dykes will be nearly straight on flat land but where the terrain is rolling or hilly, dykes should run on the contour (Fig. 3).

The Needs of the Farmer

The fields where runoff farming is practised may be far from the homestead. Therefore, the size of the field should preferably be large enough to merit a full day's work or too much time will be wasted on walking. Every field and orchard must be cultivated several times a year. If the cultivation is done manually not more than 250-300 square metres can be accomplished daily during the season of intensive hoeing. For lighter cultivations more than 1000 square metres can be covered daily so the optimum size of an orchard or field should be not less than 0.1 hectare when cultivation is manual. When animal traction is used the optimum field size should be equivalent to what an animal can comfortably cultivate in one day, i.e. six full hours of work. A single donkey harnessed to an arid-type chisel or goosefoot plough can cultivate up to 0.25 of a hectare daily. All the cultivation and weeding can be done with this type of plough. In contrast, a single light horse with a mouldboard plough (shattering) with a 20-cm cut can plough about 0.4 hectare daily while other cultivations can be done with a chisel or goosefoot plough. This is easier on the horse, but with a narrower cut it takes as long.

Trees planted alongside a contour dyke will benefit from a higher percentage of runoff because of the short distance water will have to travel before it is intercepted by the dyke. The importance of the variability in soil infiltration rates will be lessened because the water will spread more or less uniformly alongside the dyke. There will also be a wider band of moist soil in the less steep places and trees planted at uniform spacings will be able to extend their roots to reach the moistened soil (Rivals, 1961). For example, a 40-centimetre head of water against a 50-centimetre dyke on a 6% slope will give the flooded band 6.4 metres wide, while on a 10% slope it will be 4 metres wide and the capillary extension will widen the moistened band still more. Olive roots can extend 10 metres laterally and go 3-4 metres deep. The tree spacings can be nearly the same as in higher rainfall zones where trees can grow on rainfall alone. Such a high density avoids the need to travel between widely spaced trees: only the distances between the rows will be larger but these have to be traversed only at the ends of rows. Each row (dyke) can be as long as the terrain or land ownership permits, except where animal traction is also a consideration.

Sloping and rolling areas are much more common than flat land or wadi beds and this results in larger and more efficient farming units. In semi-arid and arid regions the soil on the slopes may be stony and shallow but these sites are still suitable for trees such as grapes and olives which can send roots into cracked rocks. This widens the choice of terrain for runoff farming.

The slopes of the dyke should be made gentle enough for cultivation, for example, 1:5 or 1:6. Ploughing or other cultivations should turn the soil upwards, so that the height of the dyke will be maintained and breaches prevented. If it is impossible or inconvenient to plant on top of the dyke, then the next best place is uphill of the flooded strip (site 2 on Fig. 5), but it should be stressed that trees should never be planted in the deep point of the flooded strip.

Some workers have proposed that runoff farming systems should also be used for the production of animal fodder for storage and use during droughts. This is unnecessary because it is possible to maintain drought-resistant pastures containing perrenial shrubs and grasses where the annual winter rainfall is as low as 100 millimetres. Experience suggests that the expense and effort involved in construction and maintenance of dykes should be invested in cash crops, not fodder crops.

Studies have been conducted on runoff systems for almond production in the 250-millimetre rainfall zone (Hillel, 1974) where wheat can also be produced. However, since rainfed cropping in such a rainfall area is profitable, there would appear to be no need to resort to runoff farming (Orev, 1983).

Economics and Energetics of Runoff Farming

To ensure the best return on the labour and capital inputs of dyke construction and maintenance, the tree species selected should be those which give direct benefit to the farmer in the form of marketable produce, e.g. olive trees for oil and pickling; grapes and figs, which can be sun-dried and stored; or almonds, which yield protein-rich nuts. All these can provide insurance against recurrent droughts by yielding fruit even in dry years. For subsistence and auxiliary food production, the two most important trees are olives and figs, and both species have proved of great benefit to Negev Bedouins who have become more sedentary in the last decades.

For olive production, the yield can average 14 kg of fruit per tree when used for pickling or direct consumption, and 3 kg of oil per tree. These figures are taken from a 500-mm rainfall area but the runoff collection compensates for the difference in rainfall in the drier areas.

The energy content of the pickle crop at an oil content of 32% is 4500 grams x 9 or 40,500 cal. Twenty-five trees would therefore supply about one million cal or the energy requirements of one adult for one year. These 25 trees would require 200 metres of dykes, or 20 work-days for dyke construction, and annual cultivation would require 3-4 work-days.

Where the subsistence farmers live too far from any centre of employment, orchards using runoff farming can be an important source of supplementary food.

Some workers have tried to evaluate runoff farming systems in economic terms (Oron *et al.*, 1983) but this is not always relevant. Runoff farming is frequently a subsistence or auxiliary activity where the main income comes from livestock or grain. It is not normally the principal commercial pursuit of a settled farmer. Therefore, a more appropriate evaluation of runoff farming is in terms of labour input against the energetic value of food produced. Cash inputs are only required for the purchase of seedlings and such items as salt, pickling containers and oil pressing for olive production, the latter often being paid for by a share of the produce. Often the owners of orchards work for wages elsewhere and their labour input into their own land should not be costed.

Conclusion

A brief introduction is given to runoff farming based on the author's experiences in Israel. Two methods are advocated: where microcatchments are used, it is suggested that trees be planted on top of the dyke to avoid seasonal flooding. Where contour dykes are used, trees should be planted at either side of the water collection ditch. The size and layout of orchards where runoff farming is used is determined by the type of cultivation envisaged. In terms of economics, runoff farming is seen as a subsistence or subsidiary activity to the principal source of income but that where olives or similar fruit trees are grown, the net return in terms of food energy per hectare or per tree is substantial.

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Desert Encroachment

H.E. Dregne and C.J. Tucker

Desertification is a term that evokes visions of an expanding Sahara destroying villages, water supplies, and fields in its path while sand dunes move inexorably forward like waves on the ocean. In fact, desertification does bring destruction of people's livelihoods and land resources, but usually in a stealthy and insidious fashion which is usually less dramatic than burying a village under moving dunes. Convenors of the 1977 United Nations Conference on Desertification made it clear in the preamble to the Plan of Action to Combat Desertification that desertification was a complex process having many causes and effects. Nevertheless, it has been difficult to get the message across in both the popular press and in scientific journals. A recent paper in a respected soil and water conservation journal repeats the claim that drought is the cause of desertification (Smith, 1986). Furthermore, the article makes the unequivocable judgement that "the Sahara Desert continues to creep southward, claiming an area the size of New York State every decade". That is about 1,300,000 hectares per year and is almost certainly based on no quantitative ground studies of any kind.

The Encroaching Sahara

The originator of the "encroaching Sahara" concept apparently was a Briton, E.W. Bovill. He published a paper in 1921 in which he described some of the manifestations of desiccation south of the Sahara in West Africa, which he called the Sudan (Bovill, 1921). Bovill said that rivers in Senegal between the Gambia and Senegal rivers had dried up within the lifetime of people still living in 1920. He also noted that wells were going dry in Senegal and in the vicinity of Sokoto in Nigeria. He attributed the increasing desiccation to shifting cultivation. Bovill remarked that not all observers of the Sahara agreed with him. He said that Gautier believed that the Sudan (Sahel) was becoming wetter and that while the desert was encroaching on the steppe vegetation on the north side of the Sahara, just the opposite was occurring on the south side.

The person who brought widespread attention to the "encroaching Sahara" threat was E.P. Stebbing, a British forester. He read a paper at a 1935 meeting of the Royal Geographical Society entitled, "The encroaching Sahara: The threat to the West African colonies" (Stebbing, 1937) in which he described the degraded condition of the mixed deciduous forest and the savannas in northern Nigeria, southern Niger, and eastern Mali. His transects in the early part of 1931 went from Kano to Damaturn to Geidan, and back to Kano — all in Nigeria — then to Maradi, Birni-n-Konni, and Niamey in Niger, continuing to Gao in Mali before crossing the Sahara to Morocco. He was struck by the sand invasion from the Sahara, and by what he termed the first stage of the approaching conversion of the mixed deciduous forest to true savanna. Stebbing quoted a French political officer who had served in Niger and Mali as saying that the Sahara had advanced toward the south at a rate of 1 km per year for the past

Bovill attributed the advance of the Sahara southwards to shifting cultivation. The 'encroaching Sahara' left abandonned villages in its wake. (UNEP/T. Farkas) three hundred years. That was probably the first estimate ever made of the rate of desert encroachment, but like other estimates, it was based on anecdote. Stebbing attributed the advance to deforestation, overgrazing, and cultivation. Drought was not mentioned but increasing desiccation was said to follow land degradation. The sand front was supposed to lie on a line from Sokolo in Mali to Ansongo, Tahoua, and Zinder in Niger and from there to northern Lake Chad.

Stebbing's paper is a fascinating document. It recommends establishing two forest belts to halt the advance of the Sahara. The northern belt, a minimum of 24 km wide and extending 2200 km from Segou in Mali to Niamey in Niger and on to Lake Chad, was supposed to stop the southward movement of sand. The southern belt, about 50 to 55 km wide and somewhat shorter than the northern belt, was intended to re-establish the moist mixed deciduous forest in the Guinean vegetation zone and, by so doing, reduce the aridity of the regional climate. Stebbing's northern afforested zone is a shorter and narrower version of the Sahel Green Belt project proposed at UNCOD (1977a).

Most of Stebbing's conclusions about the advancing sand of the Sahara were derived from observations made by others. In one case, however, he saw what he thought was the encroaching sand, three miles north of the town of Maradi, in Niger, close to the Nigerian border.

A commentator at the Royal Geographical Society meeting, the director of the Royal Botanical Gardens at Kew, made a trenchant assertion about encroachment. He stated that the Sahara was not encroaching on agricultural land, it was only responding to man's stupidity in cutting down, burning, and destroying the forest. He did not think the forest belt concept was practical, however desirable it might be.

Reactions

Several of the letters written about Stebbing's paper disagreed with his conclusions. Rodd (1938) chided Stebbing for being persuaded by the dry season appearance of the landscape that lasting changes in vegetation had occurred. He noted that desert conditions along the southern fringe of the Sahara "ebb and flow over periods of a few years as well as over longer periods". Rodd also said that it was his distinct conclusion that deforestation had been arrested and reversed, at least in some regions. The dramatic difference between the desolate countryside near the end of the dry season and the lush greenness of the same area in September can easily lead to different perceptions of land degradation, depending upon when a person travels through the area.

Criticism of Stebbing's paper led him to say that he regretted using the term "encroaching Sahara" because it implied that he thought the Sahara was advancing in great waves (Stebbing, 1938). He said that he meant that forest degradation led to erosion and finally to barren land. The latter interpretation reads very much like Aubreville's description of desertification (Aubreville, 1949) and could be accommodated in the UNCOD definition (UN, 1977).

Anglo-French Commission

The most striking refutation of Stebbing's thesis about the advancing Sahara came from an Anglo-French forestry commission study conducted in northern Nigeria and southern Niger in December 1936 and January and February of 1937. Initiation of the study appeared to be a consequence of the controversy engendered by Stebbing's paper and a book he wrote later on the same subject. The commission toured the country on both sides of the Niger-Nigeria border. It concluded that there was no danger of desiccation in the region and no evidence of large-scale sand movement but there was much destruction of forests almost entirely resulting from the uncontrolled expansion of shifting cultivation. These findings are consistent with what the author of the UNCOD Niger case study concluded in 1977 (UNCOD, 1977b).

The observations of Stebbing and the Forestry Commission about desiccation are interesting. Stebbing probably connected degradation of the tree and shrub cover with increased aridity since he spoke of the mixed deciduous forest being changed to savanna, and he associated savannas with dry regions. The desiccation which he noted was very likely the same phenomenon as that called edaphic aridity (Dregne, 1983). Edaphic (soil condition) aridity is common where degradation of the surface soil leads to increased runoff, thereby reducing the quantity of soil moisture available to plants. The Forestry Commission, on the other hand, very likely was referring only to rainfall when it concluded that increased desiccation was not expected to occur. They were correct on that point, at least up to the 1960's.

Desert Advance

In 1971, the encroaching Sahara was again a concern to delegates to a United Nations Seminar on the Environment and Development held in Ethiopia (AID, 1972). The seminar recommended that desert expansion in Africa be studied so that precise measures could be devised to control desert creep. The U.S. Agency for International Development (AID) mission in Tunisia, for example, considered the "northward march of the Sahara" to be a priority environmental problem. The AID report of 1972 estimated the advance of the Sahara in some places along a 3,000 km southern front to be as much as 45 km per year, but the source of that data was not supplied. The description of desert encroachment in the AID report was similar to that of Stebbing: arable land laid waste either through the burial of land by wind-blown desert sands or through an expanding aridity induced by climatic changes, causing a loss of soil moisture.

Kassas (1970) described a type of desertification in the Sudan that was similar to Stebbing's observations on vegetation changes in the Sahel but which did not implicate climatic change. He considered desert creep to be a largely man-made process of shifting of vegetational belts both north and south of the Sahara. With proper care, reversal of the degradation process appeared for the most part to be possible.

The first and only study professing actually to measure the shift of vegetation zones resulting from desert encroachment was a survey in the Sudan (Lamprey, 1975). He concluded that the Sahara had advanced 90 to 100 km between 1958 and 1975, an average rate of about 5.5 km per year. As far as we can ascertain, all quantitative statements about the rate of worldwide desert expansion rely either on this study or use unsubstantiated assertions.

Monitoring Encroachment

Hellden (1984) cast doubt on Lamprey's conclusion based on results from his analysis of Landsat imagery, aerial photographs, and ground conditions from 1961 to 1979. He stated that there did not seem to be any evidence to substantiate the conclusion that the Sahara had advanced southward. Among other things, Hellden could not find the extensive sand dune encroachment that Lamprey had mapped. More importantly, the distribution of cultivated land in 1979 was about the same as it had been in 1962. There was no systematic change observable in the size of the degraded land areas around water sources and villages; indeed, there was a major expansion in cultivated land during the drought at the end of the 1960's and beginning of the 1970's, followed by a contraction again after the drought.

In our opinion, Hellden's findings do not prove that there has been no shift in vegetational belts during recent decades. Rather, they demonstrate the great difficulty in assessing and monitoring vegetation degradation. Interannual variations in land use, rainfall, disease and insect infestations, effectiveness of burning practices, and availability of water supplies complicate interpretation of observed changes in vegetative cover and crop yields.

The problem in interpreting observations of land degradation is illustrated by the conclusions of El Hag (1984). Whereas Hellden's study led him to believe that there was no sustained increase in degraded areas around villages, El Hag's study of approximately the same region came to the opposite conclusion. El Hag derived his information from comparison of Landsat images for 1972 and 1979, but without ground surveys.

Meteorological Satellite Studies

The very great changes in green biomass production that are possible from year to year in the dry regions are illustrated in Figure 1. The images represented the normalized difference vegetation index (NDVI) data from the Advanced Very High Resolution Radiometer (AVHRR) carried on polar-orbiting meteorological satellites of the U.S. National Oceanic and Atmospheric Administration (NOAA). Tucker and Justice (1986) described the methodology as it would apply to the measurement of the spatial extent of deserts. The great merit of using meteorological satellites is the wide view angle of the AVHRR and the twice-daily sun-synchronous coverage of the entire world. As a result of this, the cost of scenes embracing entire continents is low compared to the cost of Landsat images. The principal deficiency, for some uses, is the much lower resolution of meteorological satellites (1 or 4 km) than Landsat (30 meters) or SPOT (10 meters). For monitoring large areas, high ground resolution is less important than synoptic and frequent wide-area coverage, especially in arid and semi-arid areas. Cloud cover is also less of a problem when images are available daily.

A comparison of the integrated seasonal NDVI for the south side of the Sahara in

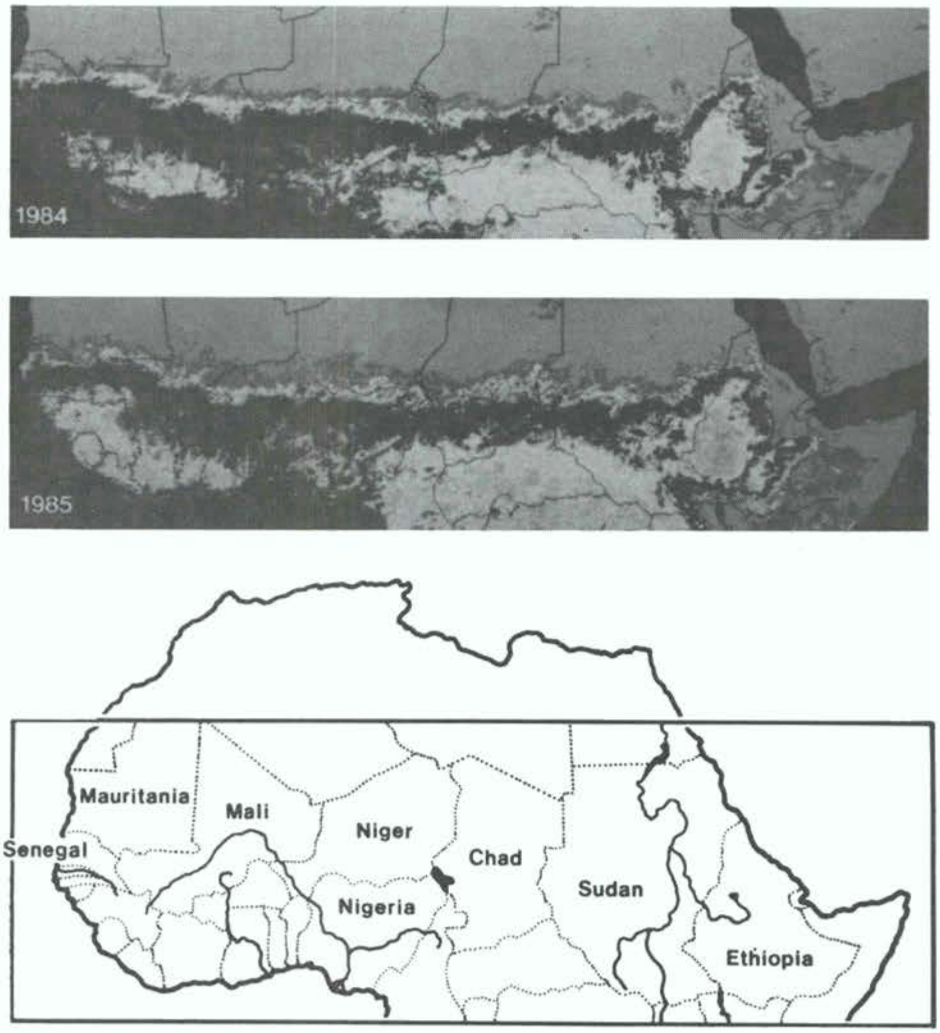

Fig. 1 Demonstration of fluctuations between wet and dry seasons.

1984 and 1985 (Figure 1) demonstrates the magnitude of green biomass fluctuations from year to year. In 1985, the arid/semi-arid boundary (the northern limit of the brown zone on the maps) was shifted northward about 200 km along the Sudan-Chad border and about 150 km along the Sudan-Ethiopia border. 1984 was one of the driest years in at least three decades, whereas 1985 was the wettest year since 1981. Crop failures were widespread in 1984. By contrast, in 1985 near-average rain fed grain production occurred in Senegal and Niger and the best yields in several years were recorded in Mauritania, Mali, Chad, and the Sudan. In the vicinity of El Obeid in the Sudan south of the area where Lamprey conducted his survey, and which has a mean rainfall of 386 mm, the 1984-1985 green biomass shift approximated 130 km. However, 200 km west of El Obeid, the northward shift in 1985 was only 50 km, so regional differences are marked and these can obscure long-term trends.

A north-south oscillation in vegetation boundaries along the south side of the Sahara amounting to 50 to 250 km inter-annually or over a period of a few years, of the kind shown in Figure 1, appears to be fairly normal. If that is correct, a permanent vegetational shift of 5 to 6 km per year would require perhaps 30 to 40 years of observation by meteorological satellites and ground studies before it would be possible to conclude that the shift was, indeed, permanent. A permanent shift of 5 km per year seems to be rather fast since it means the shift would amount to about 100 km in only 20 years. If the desertification were patchy, as it usually is, the time for determining whether changes were temporary or permanent probably would be even longer.

The absence of good quantitative data on vegetational and sand dune shifts resulting from desertification, rather than drought, calls for organized monitoring efforts to provide the information needed to assess the severity of the desertification problem. Meteorological satellites, Landsat and SPOT satellites, aerial photography, and ground studies constitute the components of a surveillance programme that can furnish data ranging from local to global scales. The detail supplied would vary directly with scale; ground studies would produce the greatest detail, meteorological satellites the least, but these provide the only practical means of observing the temporal dynamics of biomass production over entire ecological zones. Landsat and SPOT leave gaps of several days in the coverage.

The technique of ground and aerial monitoring developed through co-operation between the Global Environmental Monitoring System (GEMS) of UNEP and the Kenya Rangeland Environmental Monitoring Unit (KREMU) of the Government of Kenya is an example of the monitoring of national territories. Landsat and SPOT could be used for less detailed studies, as was done by Hellden and El Hag. Meteorological satellites would produce the regional, continental, and global data. Each level of detail complements the other. All require adequate ground measurements to establish the validity of the remotely sensed data.

Conclusions

Meteorological satellite observations have demonstrated the large interannual shifts in green biomas production levels possible on the south side of the Sahara. Those observations have thrown doubt on the validity of statements claiming that permanent shifts in vegetation zones have occurred in that part of the Sahara as the result of desertification. Attractive though the "encroaching Sahara" idea is, it is no more credible now than it was in Stebbing's day.

Permanent shifts in vegetation belts may well be occurring or may already have occurred but there are not enough data to resolve the question. Circumstantial evidence of vegetation zone movement, as noted by Kassas (1970), seems to be adequate to warrant carrying out a definitive study to settle the question.

A small-scale study covering a few hundred hectares will not suffice. What is needed is a research project designed to monitor vegetation changes by conducting ground transects across representative vegetation zones, then extrapolating results at the national or continental scale through the use of aerial photography and satellite imagery. The time required for the project will have to be decades; part of the time could include retrospective analyses of data accumulated over the past 20 to 40 years. The project could be a significant contribution to the proposed International Geosphere-Biosphere Programme.

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The Use of a Landsat-based soil and vegetation Survey and Graphic Information System to Evaluate Sites for Monitoring Desertification

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Introduction

A Landsat-based reconnaissance survey of the soil and vegetation of southwestern Mauritania on a scale of 1:500,000 was completed as part of the Renewable Resources Management (RRM) for the Government of the Islamic Republic of Mauritania (GIRM) and U.S. Agency for International Development (Dalsted *et al.*, 1982). While the survey and the accompanying resource characterizations were directed towards general planning, development and management programmes, its potential use in desertification analysis became apparent.

For the purposes of this paper, desertification is defined as the retrogressive trend of biological productivity caused by social and climatic factors, usually occurring in semi-arid and arid areas. A complete description of the physical environment is a key element in desertification analysis and while the study of social factors is also important, these will not be addressed in the paper.

The objectives of the study were threefold:

(i) to illustrate the value of Landsat-based reconnaissance resource surveys for desertification analysis in arid and semi-arid zones;

(ii) to demonstrate various applications of a geographic information analysis;

(iii) to demonstrate various applications of a geographic information system for land management and desertification monitoring.

The Resource Survey

Location and Description

Mauritania has a total land area of 1,030,700 square kilometres with a population of less than 2 million people. The RRM resource

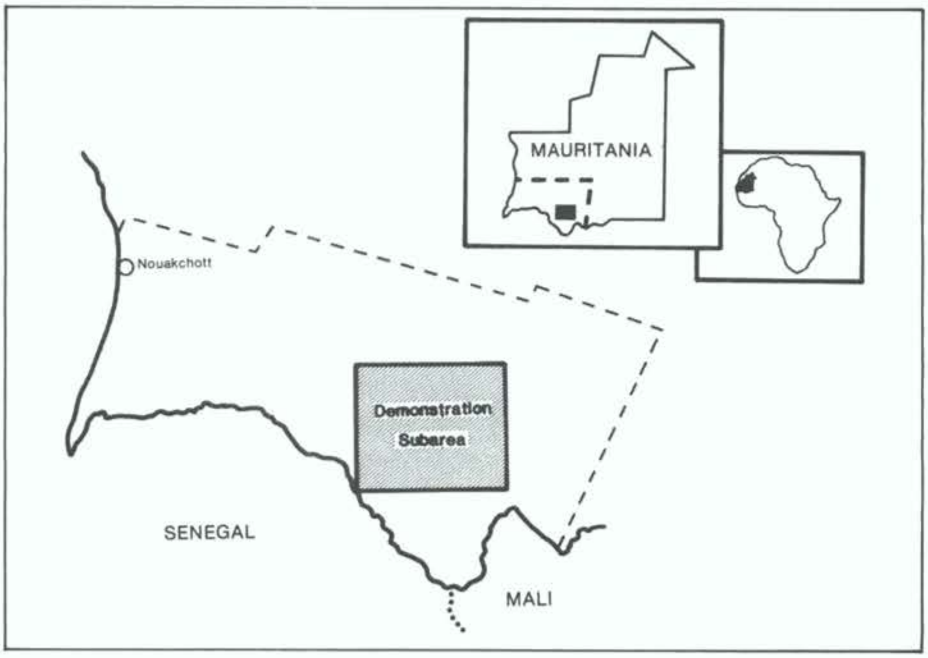

Fig. 1 Location of the RRM project and the demonstration subarea used for this study.

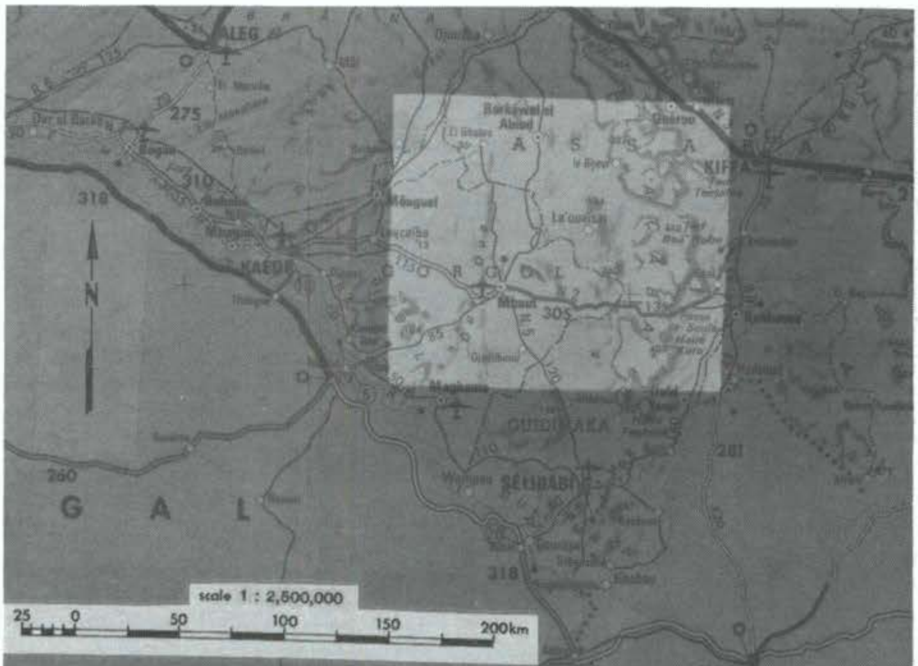

Fig. 2 Location map for the demonstration subarea (after the Mauritanie carte au 1:2 500 000, IGN, Paris, 1980).

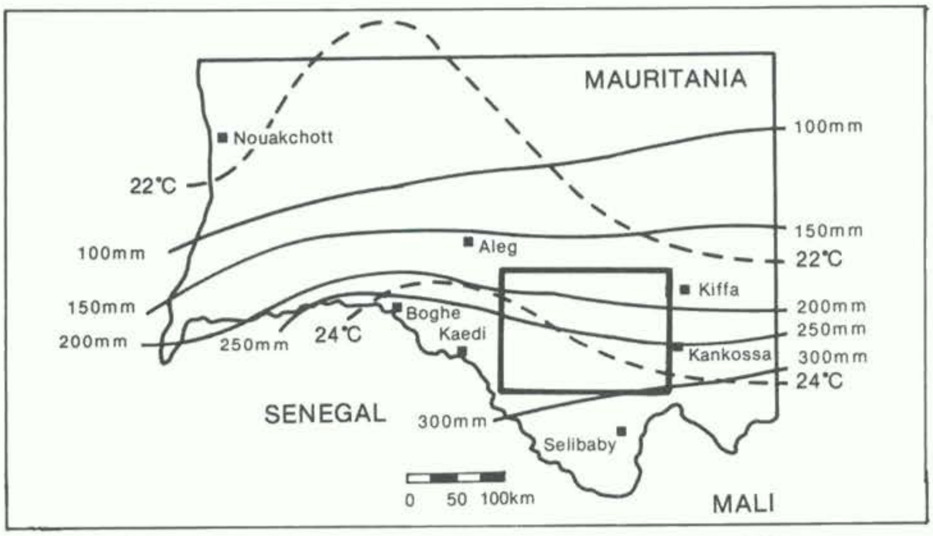

Fig. 3 Average rainfall from 1970 to 1980 over the project area and the average January temperatures (cool season).

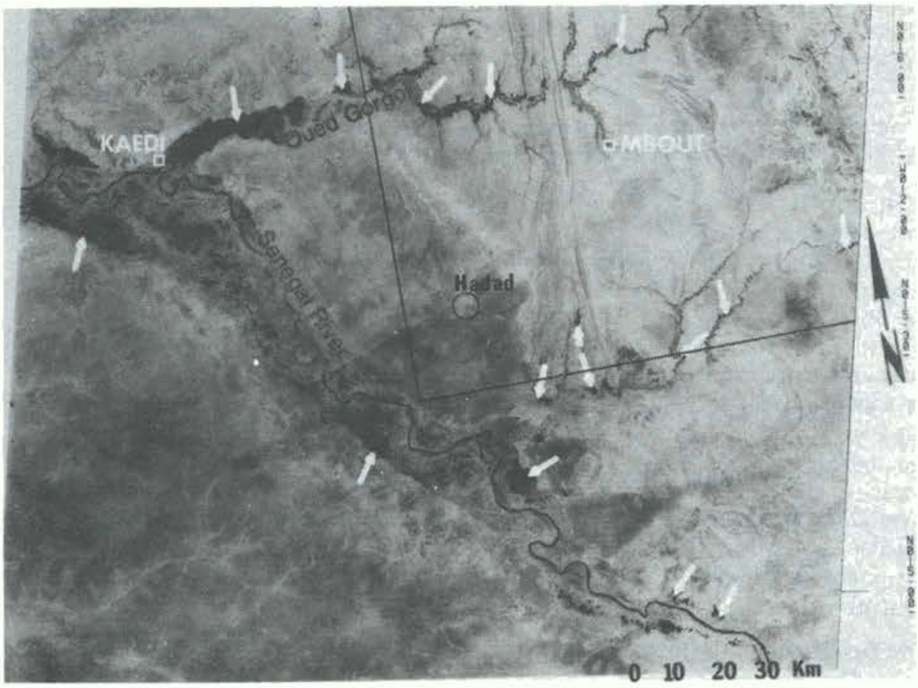

Fig. 4 Surface waters (at arrows) are shown during flooding of the Senegal River and Oued Gorgol on a 6 September 1978 Landsat near-infrared image (0.8um to 1.1um band). (The Hadad area is located for reference to Figure 5.)

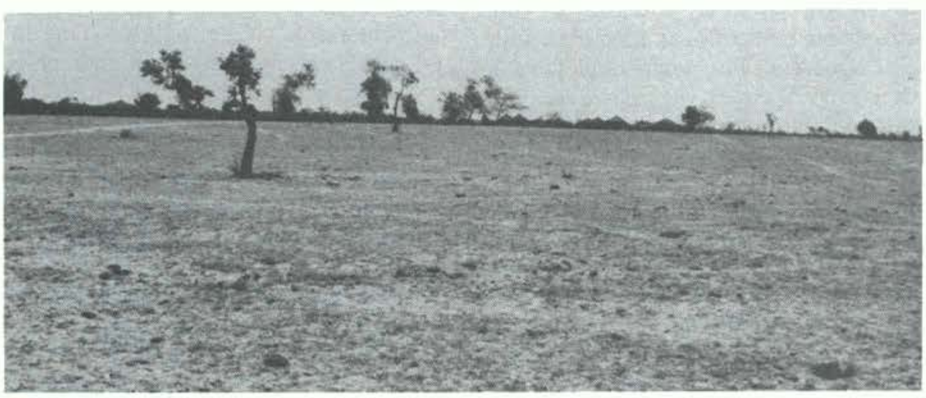

Fig. 5 Heavily grazed lands around the village of Hadad (see Fig. 4 for location). The village is seen on the horizon. (photographed in February 1981).

survey encompassed 150,400 square kilometres of south-western Mauritania; the area discussed in this paper is located in the south-eastern quadrant of this project area (Fig. 1 and Fig. 2). All or parts of 10 Landsat Multispectral Scanner (MSS) scenes were needed to cover the original project area, while approximately 75 per cent of one Landsat scene covered the subarea (26,767 sq. km).

The project area is located in the Sahelian Zone where highly erratic precipitation is the norm. Hot temperatures and dry conditions occur from March to July followed by a hot, rainy season from July to September. Increasingly cool and dry conditions occur from October to February (Figure 3). Winds are common year-round with hot, dusty north-east winds dominating during the dry season but they veer to the south and east during the rainy months.

Seasonal rainfall is important both for pasture production and for the two major types of cropland agriculture, dryland sorghum and millet and 'flood-recessional' sorghum. Effective and timely rainfall is required for dryland crop production and upland pastures In contrast, pastures and flood-recessional crop production on alluvium benefits substantially from runoff-producing rainfall that need only fall somewhere within the drainage basin (Fig. 4).

Cattle, goats and sheep are common in rangeland where grazing is the dominant activity. Seasonal use of pasture is often limited by lack of water for livestock; on the other extreme, areas with developed wells are usually overexploited and severe overgrazing is frequently noticeable near wells and around villages (Fig. 5).

Soil, Forestry, and Pasture Resource Survey

For the reconnaissance survey, the resource mapping units constituted groups or associations. Such surveys are on a small scale, ranging from 1:100,000 to 1:500,000, and are supported by field investigations. As with most other natural resource surveys, only some of the boundaries can be located in the field (Soil Survey Staff, 1952). Consequently, this scale is useful for general interpretations and is appropriate for regional surveys. Landsat MSS imagery with its large ground resolution (0.45 ha), synoptic view (34,000 square kilometres per scene), near-orthographic base, relatively low purchase price and multi-date coverage is ideal for

	SOILS	FORESTRY	PASTURE
Mapping Unit	Hierarchy by soil climate, landform, and soil association. Assocations described by slope, soil depth, surface texture, coarse fragments, estimated permeability, internal soil drainage, soil reaction, estimated available water capacity.	Associations described by dominant species and associate and/or inclusions. Map units further divided by the interpretative criteria listed below.	Associations described by dominant species, land form, and climate zone.
Mapping Unit Interpretations or Measurements	Ground cover class (ocular estimate), erosion of top soil (estimated), wind erodibility group, erosion hazard, major soil limitations for agriculture, agricultural suitability (FAO) for millet and sorghum (rainfed and flood-recession), minor soils of significant importance to agriculture	Trees/ha, average height, condition class, regeneration class (all categories based on sample data from representative sites within mapping units)	Average dry matter/ha, estimated carrying capacity (TBU/ha), carrying capacity class (FAO), seasonal carrying capacity, herbaceous and wood population histograms: height by percent cover (all categories based on sample data from representative sites within mapping units)

Table 1. Description of natural resource mapping units and interpretations completed for the RRM project.

reconnaissance-type surveys. Aerial photography and low-altitude reconnaissance can be used to provide further characterization within major map units.

The Mauritanian survey of 1981 established and defined various resource mapping units and critical baseline conditions on the basis of several interpretations (Table 1). The ground survey gathered data to support the critical interpretations within the project area using transects, plot measurements, soil profile descriptions and other field observations. These, together with multi-date Landsat imagery interpretations and limited aerial photo interpretation (1:50,000 scale) formed the basis for boundary determinations on the Landsat base map and for establishing definitions and descriptions of mapping units. Available reports and publications were also consulted, providing site-specific descriptions on a large scale. The ground observation and sampling phase of the survey was completed by three resource teams (covering soils, woody species and herbaceous species) between September 1980 and June 1981.

The various Landsat imageries, together with ground observations and samples, indicated that the severity of land and vegetation degradation across the project area is located primarily in the western and southeastern regions while the northern regions are the driest and most sparsely vegetated. On the basis of map units, a subarea in the south of the project area was chosen for map digitization and further study (refer to Fig. 1 and Fig. 2).

Water erosion and gullying are common in the subarea where steeper slopes occur and wind erosion is also common especially on coarse-textured soils where overgrazing occurs, or abandoned dryland agriculture is practised. Alluvial lands are the most productive zones in this area which normally receives between 200 and 500 mm annual rainfall.

The Geographic Information System

A geographic information system (GIS) is a data base that retains the spatial attributes of the input data. The GIS is almost always computerized allowing map analysis, data storage, interpretation and tabulation; outputs range from a line-printer or plotter to a film recorder or various video display devices. Scale and output format can be selected by the user.

The GIS can operate on a cellular (grid or raster) and/or vector (polygon) system. The GIS used for this study is called the Area Resource Analysis System or AREAS (Wehde *et al.*, 1980) which uses map input data from a digitizing table in vector format; these are then converted to a cellular format for computer manipulation. Selection of the cell size is a further option for the user.

In this study, the area covered by each cell was 10 hectares equivalent to a 0.6 by 0.6 mm square, or cell, on the input map. This cell size was two orders of magnitude smaller than the minimum map unit area (1000 ha). Selection of cell size has been quantitatively studied by matching cells to map complexity (Wehde, 1982). Further details on the GIS can be obtained by referring to Marble and Peuguet (1983) and Johannsen and Sanders (1982).

A comparison of map outputs from the plotter with the original map revealed almost no differences in boundary placement or in the shape of the map units. Since the GIS data are referenced to the same spatial coordinates, it is easy to combine or overlay several maps or important interpretations therein. Slight divergences among the input map data were not corrected in this study. In an operational approach, the map units across the various input maps would be compared with one another and adjusted for exact boundary alignments. For example, if an alluvial unit was similarly located for soils and pasture maps, the two map unit boundaries should overlay exactly.

There are numerous descriptions and interpretations attached to each of the resource mapping units (Table 1). Taking divergences into account, it is a simple exercise to produce single-theme maps (e.g. pasture productivity class) or multi-theme maps (e.g. forestry regeneration by erosion by pasture productivity class) with accompanying tabular output (e.g. area in hectares or square kilometres). The AREAS package has a menu and interactive prompting within each option allowing personnel with little or no formal computer background to use the GIS with minimal training.

Desertification Analysis

The Global Picture

The Global Environment Monitoring System (GEMS) is an activity within the United Nations Environment Programme (UNEP) and it represents the commitment of the UN to a worldwide watch on land degradation (Anonymous, 1982). GEMS has developed and tested a method of systematic monitoring of ecological change in a three-stage approach to the collection of simultaneous data: i) periodic ground sampling; ii) systematic reconnaissance flights (SRF) from light aircraft; and iii) satellite data. The SRF are used to establish initial sampling areas. GEMS method represents an economically sound combination of extensive and intensive data collection and the results are appropriate for planners, land managers and others involved in regional decision-making.

The UN approach to field assessment of desertification has been provisionally outlined and tested in selected areas around the world (FAO/UNEP, 1984). The method is based on the appearance of desertification defined as a loss of biological productivity in areas under stress. The effects of desertification may or may not be reversible. The major criteria in establishing classes of desertification lie within the processes of erosion, salinization and the ecological regression of vegetation as measured by soil properties, and human and livestock carrying capacity of the land.

Consequently, physical and social factors must be enumerated in the causative analysis of desertification. Specialists from numerous fields such as demography, range science, climatology or soils may be called upon to provide data for desertification assessment. The resultant data can be difficult to amalgamate even with a computer.

The Global Resource Information Database (GRID) has been developed at UNEP for the collation of environmental data (Fanshawe, 1985). GRID is a specialized method for multi-resource management and monitoring.

The one aspect of the UN programme that is discussed in this paper is the location of ground sites for GEMS. Extrapolation of ground data to regional areas requires that sites be chosen on the basis of representative baseline conditions. A Landsat-based reconnaissance survey with appropriate ground descriptions is an ideal means of building a resource base for use with GEMS (and GRID).

The Mauritanian Example

An ecosystem approach is an appropriate method for incorporating the RRM survey results into desertification analysis. Ecosystems are described by their components (soils, vegetation, animals) all of which are interdependent: a change in one variable leads to changes in other variables. The problem is identifying which variables are of primary importance in initiating ecosystem changes and these are called state variables (Jenny, 1980).

Measurement of certain soil and vegetation variables (the animal/human variables are not included in this study) can help produce evidence that loss of productivity over a particular area is taking or has taken place. Climatic shifts cannot be verified on a short-term basis and are not discussed although several dry years did precede the resource survey. Resources may show resistance to change, thereby requiring a larger and/or a longer period of adverse factors before the effects of desertification are observed.

In Mauritania, overgrazing on pastoral lands together with low rainfall are the main contributing factors in desertification. The status of the current environmental conditions are therefore needed to establish the reference point for assessing change. Several interpretations of the RRM survey were identified as potentially important state variables which are listed below according to what resource was mapped:

(i) *soil:* the limitations for agricultural use and the erosion factors; ground cover class; erosion of topsoil; wind erodibility group; and erosion hazard (wind and water);
(ii) *forestry:* trees/per hectare; condition class; regeneration class;
(iii) *pastures:* average dry matter per hectare; estimated seasonal and annual carrying capacity or carrying capacity class (FAO).

This list includes overlap of the variables since other soil and vegetation features may be of importance in specific areas or to different specialists. For example, the vegetation of a mapping unit indicates to the ecologist, range scientist and botanist that the resistance to change may be determined under specified conditions (Romanov and Zonn, 1982). The selected parameters are those which did not oscillate significantly under normal conditions.

Most combinations of resource conditions occurred. For example, one unit may have good pasture conditions but poor forest condition. The importance of these combinations must be assessed in the light of their potential contribution to the desertification process.

RRM Data Analysis

The forestry, soil and pasture maps were carefully cross-registered to ensure consistency of area tabulations for overlapping for composite mapping. A table digitizer (Summagraphics) linked to a PRIME minicomputer was used for this input process but other data input options of varying sophistication are available.

The number of mapping units on each subarea resource map are as follows: forestry, 60 units; soils, 32 units; and pasture, 36 units. The forestry units differed from soils and pasture in that data were defined in the legend whereas the soil and pasture map units have additional descriptions attached to the map units but which are not included in the map unit name. The additional data are reported by map unit in tables within the respective soil and pasture chapters of the final report.

Only a subset of interpretations or properties of the various resource map units were selected for analysis. Attributes are listed as follows and include the number of classes in parentheses:

forestry — condition by amount of browsing (5), regeneration (5), and density (7)

soil — erosion of topsoil (7) and erosion hazard (7)

pasture — carrying capacity (5)

The interpretation classes in the text are qualitative descriptors. The methods and procedures for quantifying the resource interpretations are standard (Dalsted *et al.*, 1982).

Data on the woody species are potentially very valuable in long-term analysis because they show a record of the longer term relationships between man, climate and degradation. When trend evaluation in this project subarea is considered, the woody species are likely to provide better temporal signs of degradation and inappropriate land use than soils or pastures. Forestry data are less affected than soil or pasture lands by certain types of land use such as clearing of herbaceous species to plant millet on sandy soils. Consequently, soils and pasture interpretations are also needed for current baseline data (i.e. 1981) and, in conjunction with forest data, for location of areas likely to experience adverse effects from land degradation such as in the vicinity of wells where both vegetation and soils suffer greatly from livestock pressure.

Single resource maps of forest density and soil erosion hazard are shown in tabular and graphic form in Figures 6 and 7 based on GIS outputs. As an example of how these data could be used, regional planning efforts in the Department of Forestry could benefit by recording current tree density within the same sample sites and comparing the results against the 1981 record to determine if proper use of resources is being made and if (and where) conservation programmes are needed. The other maps offer similar management uses. The extraction, display and area determination of single interpretations can be important to resource planners and land managers. The possibilities for this type of data are limited only by the date (in some dynamic situations the maps may become obsolete) and the number of characteristics tied to each map unit. The reliability of the boundary of any map unit is related to the map scale and can be a potential source of inappropriate use; for example, making decisions where more detailed inputs are necessary. In general, policy must be decided before using the resource data so that they can be properly integrated into short- and long-term planning, decision-making, management and development programmes (Paul, 1986).

With a single resource interpretation map, the use of the GIS is relatively straightforward. When combining two or more registered maps, other problems can occur such as mismatch among map unit boundaries, for example when the boundary between an alluvial unit and an upland unit fail to coincide on the various resource maps. This problem can be avoided if enough time is allowed for the resource surveyors to agree upon final delineation of the map unit. The RRM project did not allow enough time and consequently some minor misalignment occurred.

Similar problems arise over map detail. Using the above example, one resource map

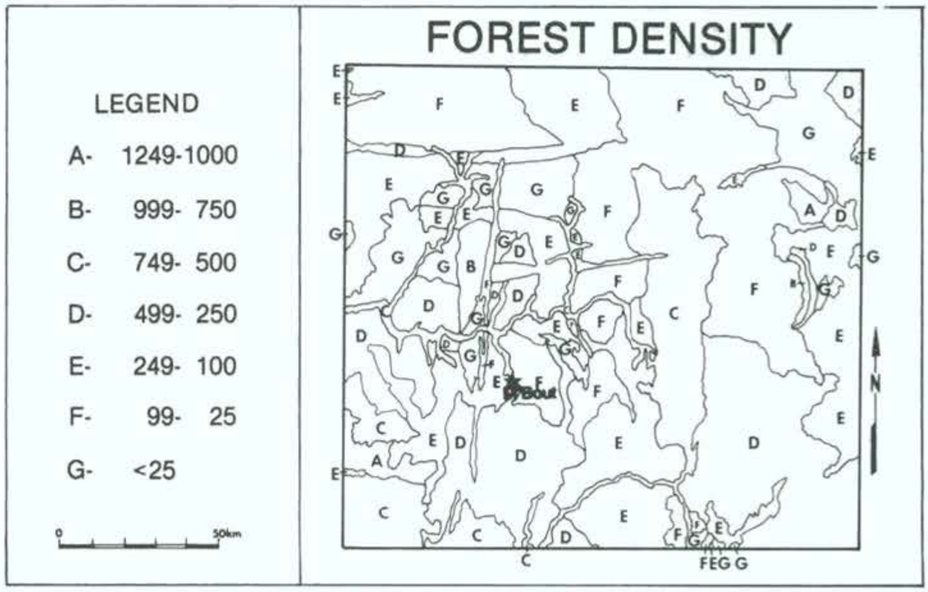

Fig. 6 GIS-generated, plotter output showing forestry density (trees per hectare) for the demonstration subarea. (This is an exact, scale-reduced map.)

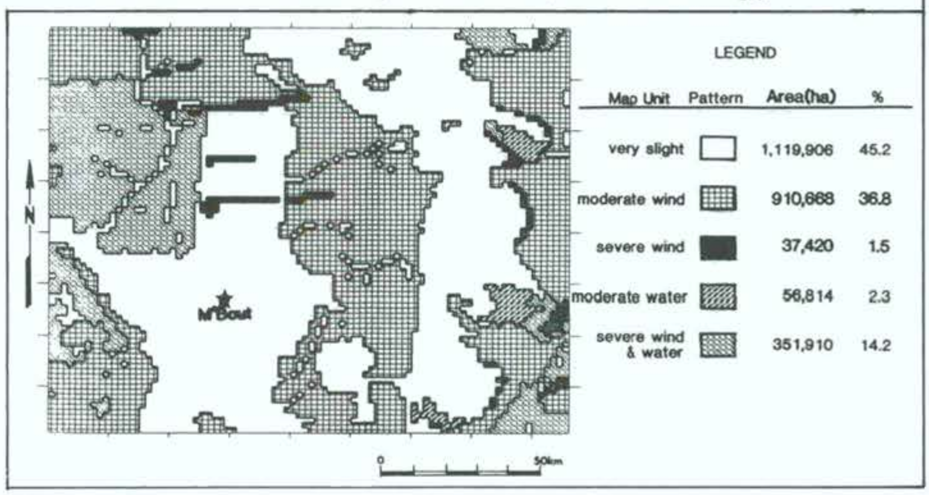

Fig. 7 GIS-generated, lineprinter output showing soil erosion hazard, an interpretation from the soil survey. Various soil and ground cover variables are integrated in the construction of this interpretation. (Note: some spatial distortion is inherent in lineprinter displays).

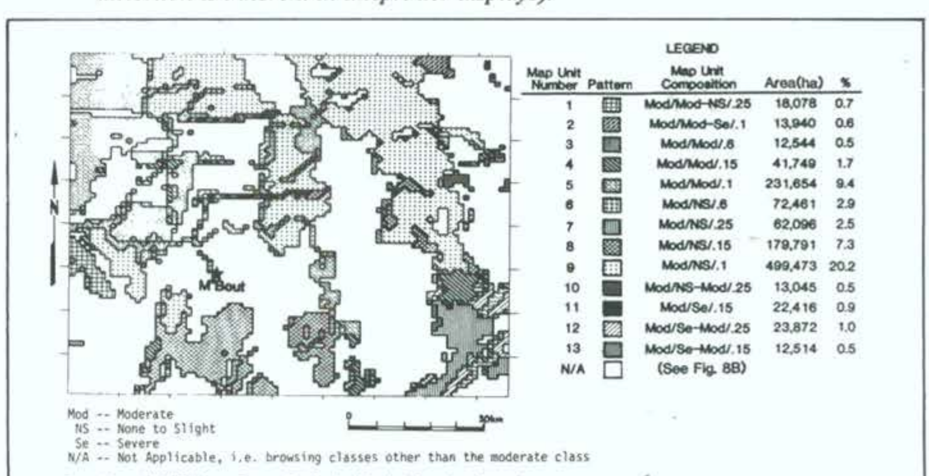

Fig. 8A Composite of moderate forest condition calss (i.e., brownsing class) with exiting erosion class and pasture carry capacity class.

may show a rock-outcrop unit that meets minimum mapping area criteria (i.e. 1000 hectares) while the other maps include the rock outcrop as a defined component in a larger composite unit such as sloping sands and rock outcrops. Both maps are correct according to mapping unit description but preparation of composite of maps introduces unnecessary complexity. Again, standardization during the final delineation of map units (or before entry into a GIS) would solve this problem.

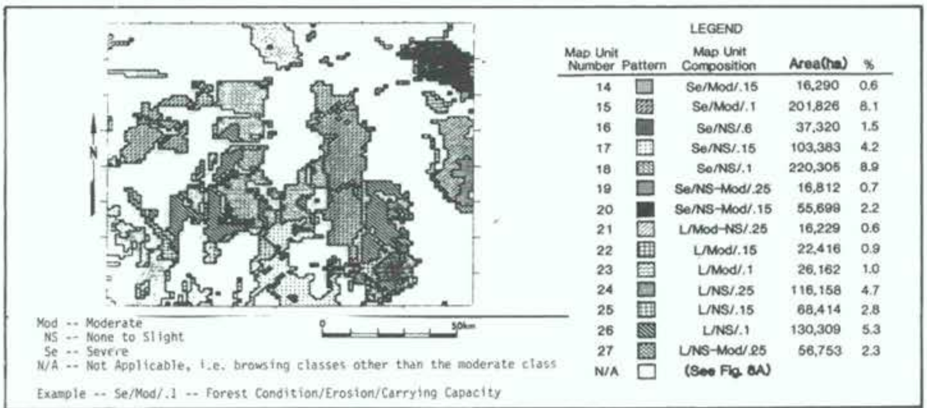

Fig. 9A Composite of light woody regeneration class with erosion hazard class and pasture carrying class.

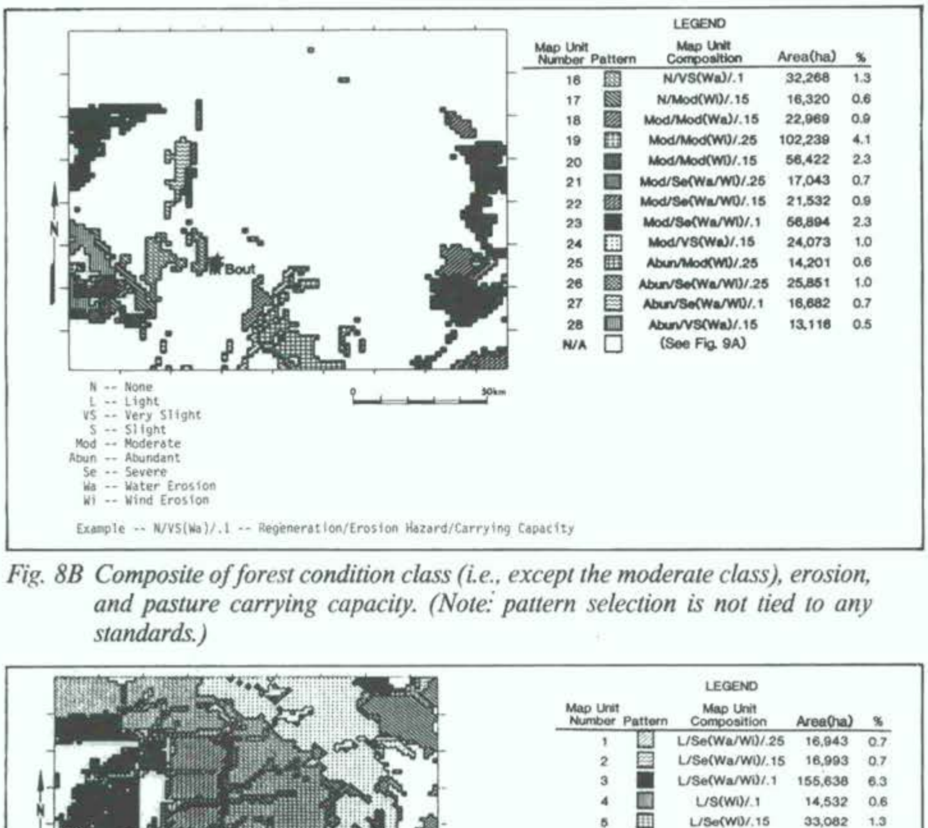

Fig. 8B Composite of forest condition class (i.e., except the moderate class), erosion, and pasture carrying capacity. (Note: pattern selection is not tied to any standards.)

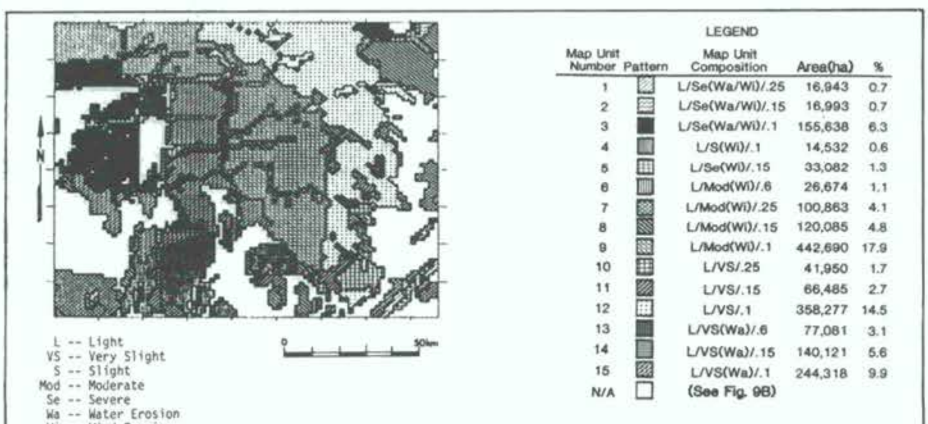

Fig. 9B Composite of woody regenration class (all but light class), erosion hazard class, and pasture carrying capacity.

The characterization of vegetation and soil resources covered the most important parameters in the superficial analysis of desertification. Additional data on social and cultural factors, or on infrastructure or hydrology, such as the location of wells or the availability of groundwater were not always available. Baseline resource units can narrow the focus of site location for desertification analysis in any region.

Two composite maps are discussed for desertification monitoring and analysis. The first is the current (1981) situation on forest condition, erosion and carrying capacity; the second is a map of the areas having a significant likelihood of deterioration under unchanging conditions using regeneration of woody species, erosion hazard and carrying capacity. Both maps include a large number of composite map units. To reduce this number to a manageable size, only units whose area was greater than 123 square kilometres (0.5%) were saved. Two line-printer displays were generated per composite because of the excessive number of map-unit patterns needed.

The forest condition/erosion/carrying capacity composite and its area data (hectares) present a complex picture (Figure 8A and Figure 8B) and two options are available for the data analysis: the first is a different organization of variables. For example, erosion could be used as the first sorted variable in place of forest condition. Second, examination of each composite unit can be done separately to determine its situation. For example, map unit no. 16 is severely browsed, has had little erosion, and has a high TBU value. The interpretation would be a high production unit, probably alluvial soils (see soil map), and overuse of woody species. Proper management schemes should be investigated as continued deterioration of woody cover may lead to gullying.

On the basis of such composites, a stratified, random-sampling scheme could be implemented to establish *representative* and *baseline* ground monitoring sites. The units selected could be overlaid on a map showing villages, towns, trails, latitude and longitude, in order to assist actual site selection and establishment. The sample assignment procedure is straightforward and the details could be refined to meet GEMS objectives. Extrapolation of this approach to larger areas would require a uniformly-derived base of resource maps. A case can be made for satellite resource assessment programmes which record environmental variables. These can be related to desertification monitoring and other uses. International boundaries

UNIT NO.	BROWSING CONDITION	REGENERATION	PERCENT OF SUBAREA
(1)	severe	moderate	4.7
(2)	severe	light	23.6
(3)	moderate	abandant	2.1
(4)	moderate	moderate	5.8
(5)	moderate	light	42.5
(6)	light	abandant	1-8
(7)	light	moderate	3.9
(8)	light	light	10.7
(9)	light	none	3.1

Table 2 Composite of browsing condition and woody regeneration.

should not be a barrier to regional resource evaluations.

The final illustration (Figure 9A and Figure 9B) presents a composite of resource evaluations that relate to the future situation of the land: forest regeneration/soil erosion hazard/carrying capacity. The first overlay, forest regeneration, refers to seedlings per unit area. Since regeneration may be affected by browsing pressure or naturally poor soil conditions (or a combination of these two), a GIS composite of regeneration and browsing condition was created. Areas of naturally low regeneration were identified (Table 2). With browsing condition as an indicator of use, 14.8 per cent (units 8 + 9) of the subarea is naturally low in productivity for tree and shrub growth. At the other extreme, 23.6 per cent of the area (unit 2) is severely browsed and regeneration is light. Abundant regeneration occurs only in the moderately and lightly browsed condition class, while moderate regeneration occurs across all the condition classes.

The second overlay, soil erosion hazard, integrates the following soil characteristics or land observations: ground cover, slope, surface soil texture, soil structure and its perceived stability, and existing erosion. Rainfall can have both a positive and negative effect on soil erosion: while it is needed for vegetative growth, rainstorms can lead to water erosion when infiltration rates are exceeded and vegetative interception is minimal. A slightly different set of variables is important when considering wind erosion, for example, ground cover, wind breaks and surface soil texture.

The third overlay, carrying capacity, accounts for annual and perennial herbaceous production. Since this figure is the summation of seasonal figures, it represents only an annual approximation. The implication of a land unit with a relatively high carrying capacity is that although annual production can sustain a relatively high number of livestock, erosion may be low because of the additional ground cover produced. Conversely, excessive use leads to trampling, soil compaction and erosion.

The significance of this three-layer composite is that light woody regeneration, severe erosion hazards, and relatively low carrying capacity are shown to be prevalent in this subarea. Furthermore, the highest carrying capacities (0.6 TBU) occur excusively in areas with light regeneration. Even in the abundant regeneration sites only 0.5% (Unit 28 of Fig. 9B) of the 2.8% total have less than a moderate erosion hazard. Consequently, the prognosis is worsening unless livestock management improves and the rainfall regime is adequate.

Conclusion

A regional assessment of the physical resources of any area is a logical first step to land management and planning. Satellite-based surveys provide an economical and rapid means of accomplishing regional, or reconnaissance, natural resource assessments, albeit on a relatively small scale. New generation satellite imagery (Landsat 5 and SPOT) permits larger scale mapping.

Full use of a reconnaissance survey of resources can be made with geographic information systems which can be directed toward regional planning, management or development. This paper discussed desertification analysis from the view of establishment of baseline characterization. A stratified, random ground-sampling scheme based on representative resource conditions is recommended for elucidating environmental trends in relation to land degradation.

The mechanism for world-wide desertification analysis and characterization exists in UNEP's and GRID programmes. The results from this study suggest that many more considerations are needed for a comprehensive analysis but a base of various resource-derived interpretations provide an excellent means of establishing representative ground monitoring sites for use in GEMS or similar programmes.

Acknowledgements

We are grateful to USAID and the Government of the Islamic Republic of Mauritania for funding the original survey project. Likewise, Dr. Mr. WaNsanga, Mr. John Falconi, and the late Mr. Christopher Stewart were contributors to the original mapping and enchanced the team effort. Mr. V. Myers and Dr. D. Moore, Project Administrators, are acknowledged for their valuable and positive contributions to RRM Project.

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Dynamics of Range Plants and Desertification Monitoring in the Sudan.

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Introduction

Most of the Sudan is located in the arid and semi-arid zones and it is considered among the countries most seriously affected by desertification. It has been estimated that 650,000 square kilometres of the Sudan had been desertified over the last 50 years and that the front-line has been advancing at a rate of 90 to 100 kilometres annually during the last 19 years (DECARP, 1976). Pastoralism is the principal form of land use in these areas but since grazing resources are overused owing to the high stocking rate, desertification has resulted. The problem attained tragic dimensions during the prolonged droughts in the years 1968-73 and 1980-84 when agricultural productivity, particularly the availability of grazing, declined and more than 8 million people were affected.

Desertification of rangeland not only affects livestock production, but also precipitates a series of events that affect the whole ecosystem. For example, a reduction in plant cover exposes the soil and increases the risk of erosion, often leading to an irreversible decline in primary productivity. Desertification monitoring may therefore be feasible by analysing rangeland trends and vegetation dynamics. This science is still in its infancy since there are few objective methods for assessing trend. However, subjective measurements of soil and plant parameters, such as trampling, plant vigour, reproduction of plant species and the presence of litter, can be used in assessing trends in range conditions (Stoddart *et al.* 1974).

This paper uses long-term records from transects located in open rangelands and livestock exclosures in Kordofan Region in the Sudan. These transects were chosen to study the dynamics and changes of range plant in relation to grazing. The main objectives were to study the changes of range communities in the semi-arid zone where very high rates of desertification have been reported. The specific goal is to show how these changes can be used in a systematic approach to the monitoring of desertification.

The Study Area

The study area was in the northern Kordofan Region, between 10°N and 16°N, and 27°E and 32°E (Figure 1). Kordofan Region has been classified into five major ecological zones: semi-desert; low rainfall woodland savannah; high rainfall woodland savannah; flood region; and mountain vegetation. (Harrison and Jackson, 1985). The soil has also been classified into five groups: desert soil; stablized sand-dune soil; dark cracking clay; laterine soil; and various hill soils.

The climate of the region is dominated by the annual movement of the boundary between the dry northerlies and the moist southerlies (Ireland, 1948). The rainy season is shortest in the north and longest in the south and annual rainfall varies between 280 and 400 mm per year in Kordofan. The effective rainfall is concentrated in the period between May and October.

Three sites in the low rainfall Woodland Savannah were included in this study, En Nahud, El Khuwie and El Mazrub sites (Figure 1). The dominant soil type in the three sites is stablized sand-dune soil (Qoz), with some minor variations.

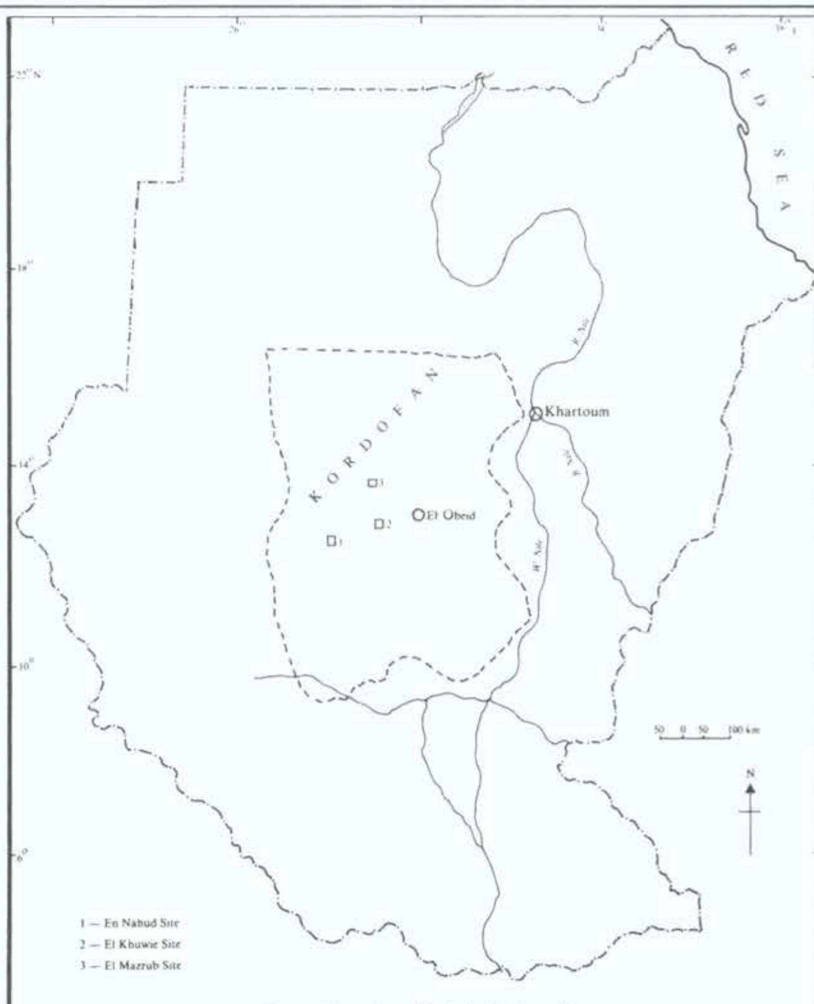


Figure 1. Location of Kordofan Region and location of the three specific sites

Fig. 1 Location of Kordotan Region and location of the three specific sites.

El Nahud site is situated on a sandy pediplain consisting of Abuzabad soil groups. The site is included in the grazing orbit of the sheep-raising Hamar tribe and the cattle-raising Messeriya tribes and receives an annual average of 400 mm rainfall.

El Khuwie site is also located on the sandy pediplain. The site has adequate water and attracts large numbers of nomadic, village-based and trading livestock. Annual precipitation averages 375 mm.

El Mazrub site is the driest (280mm) and most northerly site. It is characterized by deep sandy soils in the Qoz soil grouping.

Materials and Methods

Data were collected from a series of livestock exclosures of one hectare each which were established in 1963 under the UN special Fund project in northern Kordofan Region. They were all grassland sites in different ecological zones.

Measurements on percentage ground cover by plants and litter were taken annually on fixed transects both inside these exclosures and on the open range. The method used in the measurements of the transects was the Parker Loop Transect Method (Parker and Harris, 1959) which is widely used in the U.S. Forest Service for determination of range condition and trend.

Records from the three sites were available from 1963 to 1977 in the Range and Pasture Administration, Khartoum, but subsequent data were unreliable. However records from some transects were anyalysed and published by Skerman (1966). In the present analysis Skerman's records were used as baseline data. The data were chronologically divided into three groups for 1963-65 (Skerman data), 1966-70 and 1971-77.

Skerman's data on species diversity suggested that there was no difference in the number of different plant species found in the three sites at the beginning of the investigations in 1963-65. For example, there were between 17 and 19 different plant species in the open range during the period 1963-65 at the three sites. Inside the exclosures there was little variation in species diversity at the beginning of the investigations in the 1960's with up to 24 species found in the El Khuwie exclosure most of which were annual forbs (Table 1). Occurrence of a high number of annual forbs is often an indicator of site disturbance (Clements, 1920). In the early 1960's this site was a focal point for livestock watering (Skerman, 1966).

(a) En Nahud

	1963-1965*		1966-1970		1971-1977	
	OR	EX	OR	EX	OR	EX
Perennial grasses	3	2	—	1	—	—
Annual grasses	3	3	2	4	1	3
Perennial forbs	1	1	3	3	2	—
Annual forbs	10	10	3	4	1	1
Total	17	16	8	12	4	4

(b) El Khwuie

	OR	EX	OR	EX	OR	EX
Perennial grasses	2	2	2	2	—	—
Annual grasses	4	8	2	5	2	3
Perennial forbs	—	3	1	1	1	2
Annual forbs	11	12	2	3	2	1
Total	17	24	7	11	5	6

(c) El Mazrub

	OR	EX	OR	EX	OR	EX
Perennial grasses	2	2	1	2	1	2
Annual grasses	5	4	4	4	4	4
Perennial forbs	6	4	1	1	—	1
Annual forbs	6	8	2	3	2	2
Total	19	18	8	10	7	9

* Skerman data
OR: Open Range
EX: Exclosure

Table 1:- Species diversity during the periods 1963-65, 1966-70 and 1971 -77 for En Nahud, El Khuwie and El Mazrub.

% of Total Botanical Composition

	1963-1965*		1966-1970		1971-1977	
	OR	EX	OR	EX	OR	EX
(a) En Nahud Site						
Perennial grasses	19.3	11.3	0.0	2.1	0.0	0.0
Annual grasses	18.4	27.1	57.5	63.8	46.8	83.0
Perennial forbs	0.1	2.0	12.5	10.7	34.8	—
Annual forbs	62.2	39.9	30.0	23.4	18.4	17.0
(b) El Khuwie Site						
Perennial grasses	3.6	4.4	3.3	7.2	0.0	0.0
Annual grasses	11.7	24.0	39.4	46.8	16.9	26.4
Perennial forbs	0.0	1.6	6.2	2.5	20.0	12.0
Annual forbs	85.1	72.2	51.1	43.5	63.1	61.6
(a) El Mazrub Site						
Annual grasses	44.8	46.6	54.4	48.0	53.9	49.9
Perennial forbs	12.5	15.3	4.8	1.8	0.0	1.9
Annual forbs	29.6	27.7	18.6	34.3	44.7	46.2

* Skerman data
OR: Open Range
EX: Exclosure

Table 2: Botanical composition for the periods 1963-1965, 1966-1970 and 1971-1977 at En Nahud, El Khwuie and El Mazrub sites.

Results and Discussion

Changes in plant species diversity since Skerman's papers are shown in Table 1.

Botanical Composition

Over the study period, there was a marked change in the botanical composition in the three sites. The trend was from species of high successional status such as perennial grasses to pioneering species such as annual forbs (Table 2).

Perennial Grasses

In 1963-65, perennial grass species constituted 19.3 and 11.3 per cent of range and enclosure respectively at En Nahud site while in 1971-77 these grasses had disappeared (Table 2). Similar changes in the botanical composition were found at El Khuwie site.

Although there was a substantial decrease in the contribution of perennial grass species to the total composition of the area at El Mazrub site, the distribution of perennial grasses in this particular site indicated less desertification than at the other sites studied.

Annual Grass

Annual grasses increased substantially between 1963 and 1977. In the open range, the contribution of annual grass species to the total botanical composition at En Nahud and El Khuwie sites, was 18.4 and 11.7 per cent respectively during the period from 1963 to 1965. While it was 46.8 and 16.9 per cent for the two sites during the period from 1971 to 1977.

At El Mazrub site there was no difference in the contribution of annual grass species to the total composition during the periods included in the comparison (Table 2).

Perennial Forbs

There was a relative increase in perennial forbs as a proportion of the total botanical composition at En Nahud and El Khuwie sites between 1963 and 1977 (Table 2). Between 1963 and 1965, Skerman reported only 0.1 and 2.0 per cent in the open range and exclosure respectively at En Nahud site. In the period 1966-77, perennial forbs disappeared from En Nahud exclosure but made up over 34 per cent of the total composition in the open range (Table 2).

Plant Cover

Since 1963 plant cover has decreased in all three sites. At En Nahud, plant cover over the 14-year period fell from 20 to 14 per cent and from 25 to 15 per cent in 1971-77 at El Khuwie. Average plant cover at the open range site at El Mazrub has changed less than the other two sites (Table 3).

Litter

This refers to dead plant material on the soil surface and is useful since it protects soil from erosion and increases water infiltration rate. Litter values decreased substantially between 1963 and 1977 both in the open range and livestock exclosures (Table 3) but these values were higher at El Mazrub than at En Nahud or El Khuwie in the period 1971-77.

Bare Soil

The percentage of bare soil increased substantially between 1963 and 1977 at all three sites (Table 3). Values from Skerman's work were 69, 54 and 56 per cent at En Nahud, El Khuwie and El Mazrub. These values had increased to 85, 84 and 79 per cent over the three sites in the last period.

(a) En Nahud

	1963-1965*		1966-1970		1971-1977	
	OR	EX	OR	EX	OR	EX
Av. Plant Cover	20	14	77	90	14	38
Av. Litter	11	19	1	7	1	18
Av. Bare Soil	69	57	22	3	85	44
(b) El Khuwie						
Av. Plant Cover	25	31	58	82	15	30
Av. Litter	21	22	2	8	1	12
Av. Bare Soil	54	47	40	10	84	58
(c) El Mazrub						
Av. Plant Cover	19	30	66	77	18	29
Av. Litter	25	36	3	6	3	1
Av. Bare Soil	56	34	31	17	79	70

* Skerman data
OR: Open Range
EX: Exclosure

Table 3: Percentages of plant cover, litter, and bare soil for three periods in three sites.

Conclusion

There was a substantial and steady decrease in the number of plant species at all three sites between 1963 and 1977. For example, there were a total of 17 different plant species in the open range at En Nahud during the period 1963-65 falling to four species during the period 1971-77. Of added interest was the absence of perennial grass species from En Nahud and El Khuwie sites in both exclosures and open range period 1971-77. This may be the result of selective grazing or drought. However, selective grazing was considered to be the cause of the increase in unpalatable perennial forbs at En Nahud and El Khuwie.

It appears that the rate of man-iduced desertification and general environmental degradation were higher at En Nahud and El Khuwie than at El Mazrub. The former two sites adjoined the cities of En Mahud and El Khuwie so that high stocking rates and high rates of fuelwood collection are expected. Moreover, El Mazrub site was drier than the other sites and therefore the area was less attractive to nomadic tribes than En Nahud and El Khuwie, possibly explaining the comparatively slow rate of land degradation. However, the increase in average bare soil was slightly less at El Mazrub site than at En Nahud and El Khuwie sites.

From changes in plant composition, plant cover, litter and bare soil at the three sites, some conclusions can be drawn. As indicated by species diversity, the reduction of plant cover, and the increase in bare soil at the three sites, the most northerly site at El Mazrub was least affected by desertification. This suggests that aridity was not the major cause of desertification at the three sites during the study period and that the degradation was largely anthropogenic. High stocking rates and subsequent overgrazing as a result of the abundant livestock water at En Nahud and El Khuwie sites may be the major cause.

Herbaceous range plants might therefore be used as indicators of desertification, provided the change is studied on fixed transects. This approach is simple and cheap and it involves the most important components of the semi-desert ecosystem, namely, range plants. However, for greater accuracy in the monitoring of desertification, the following techniques can be used:

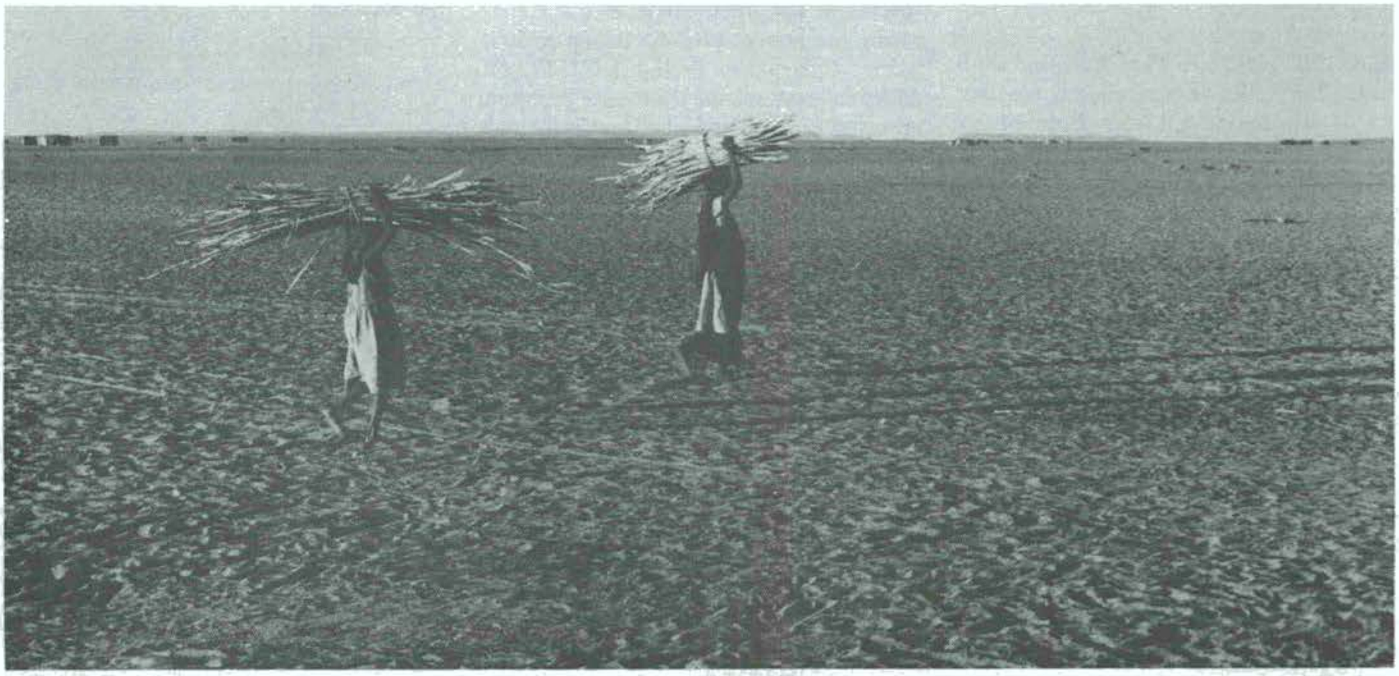
(a) Use of longer, or wider, permanent transects in areas prone to desertification. Parameters such as plant composition, relative abundance, plant cover and the percentage of bare soil must be measured annually. Livestock exclosures need not be used as they are of limited benefit and controversy exists over the results obtained from them.

(a) En Nahud

LIFE FORMS AND SPECIES	Average Composition (%)					
	1963-1965*		1966-1970		1971-1977	
	OR	EX	OR	EX	OR	EX
Perennial grasses						
Andropogon gayanus	0.3					
Aristida pallida	7.4	8.7		2.1		
Sporobolus festivus	11.6	2.6				
Sub-Total	19.3	11.3	0.0	2.1	0.0	0.0
Annual Grasses						
Dactyloctenium aegytium	0.1	0.1		2.2		
Digitria sp.	0.8					
Erogrostis Tremula	17.5	26.6	18.1	41.2		46.5
Schoenefeldia gracilis						
Brachiaria sp.		0.4				
Cenchrus biflorus			39.4	18.1	46.8	31.2
Setaria pallida				2.3		5.3
Sub-Total	18.4	27.1	57.5	63.8	46.8	83.0
Perennial Forbs						
Abutilon fruticosum			5.3		14.3	
Cassia italica			4.4		20.5	
Indigofera diphylla	0.1	2.0	2.8	3.2		
Sida cordifolia				2.2		
Stylosanthes fruticosa				5.3		
Sub-Total	0.1	2.0	12.5	10.7	34.8	—
Annual Forbs						
Ocimum dichotomum		0.3				
Cyperus sp.	3.7	1.3	2.4	2.3		
Dicoma tomentosa	6.9	3.7				
Fimbristylis sp.	1.0	1.8				
Hibscus sp.	21.7	13.4				
Indigofera echinata	18.1	11.2				
Mitracarpus scaber	1.3	2.0				
Monechma ciliatum	0.9	0.1				
Polycarpaea corymbosa	0.9	2.9				
Triumfetta Pentandra	1.6	3.2				
Zornia glochidiata	6.1		26.5	4.1		
Ipomea sp.			1.1	2.3		
Fimbristylis sp.				14.7	18.4	17.0
Sub-Total	62.2	39.9	30.0	23.4	18.4	17.0
Total	100	100	100	100	100	100

* Skerman data
OR: Open Range
EX: Exclosure

Table 4:- Average botanical Composition (%) for the periods 1963 — 1965, 1966 — 1970, and 1971 — 1977 at *En Nahud Site*



The absence of the herbaceous layer is a good indication of desertification. Monitoring of this using transects is a good method of tracking change. (UNEP/D. Stiles)

(b) Use of permanent quadrats located at various sites in the range which can be charted annually using pantograph methods to obtain an accurate estimate of the area covered by plants.

These techniques can substitute or supplement systems analysis, computers and satellite imagery which are often unavailable or too expensive for routine monitoring in many parts of the developing world.

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Life forms and species	Average Composition (%)					
	1963-1965		1966-1970		1971-1977	
	OR	EX	OR	EX	OR	EX
Perennial Grasses						
Aristida pallida	2.3	0.4	1.0	0.9	—	—
Sporobolus festivus	1.3	4.0	2.3	6.3	—	—
Sub. Total	3.6	4.4	3.3	7.2	0.0	0.0
Annual Grasses						
Aristida mutabilis		2.4	10.2	10.2		16.1
Brachiaria spp.	0.8	1.8		1.0		
Cenchrus bifflorus	0.3	0.4	31.2	19.2	12.2	8.2
Ctenium elegans		0.4				
Digitaria spp.	0.3	0.8				
Eragrostis aspera			8.2	6.4	4.7	2.1
Eragrostis tremula	10.2	16.2				
Setaria pallida-fusca		0.8		10.0		
Dactyloctenium aegyptium		1.2				
Sub. Total	11.7	24.0	39.4	46.8	16.9	26.4
Perennial Forbs						
Stylsanthes fruticosa		0.8				
Indigofera diphylla		0.8				
Cassia sp.			6.2	2.5	20.0	
Cassia italica						12.0
Sub. Total	0.0	1.6	6.2	2.5	20.0	12.0
Annual Forbs						
Achryanthes aspera						
Blepharis linariifrlia	18.0	10.1				
Commelina imberbis	1.3	3.4				
Cyperus spp.	8.0	6.3		7.0		
Fimbristylis spp.	3.1	6.3	2.1	3.3	20.1	19.3
Cisekia pharnacisides	0.3					
Indigofera echinata	0.8	1.4				
Mitracarpus scaber	16.0	11.0				
Monechma spp.	0.8	1.0				
Monechma ciliatum	15.2	8.0				
Pandiaka elegantissima						
Polycarpae corymbosa	2.6	1.2				
Zornia glochidiata	19.0	22.5	49.0	33.3	43.2	42.2
Amaranthus spp.		0.6				
Indigofera spp.						
Pcimum dichotomum						
Phyllanthus maderaspatensis		0.4				
Sub. Total	85.1	72.2	51.1	43.5	63.1	61.6
Total	100	100	100	100	100	100

* Skerman data
OR: Open Range
EX: Exclosure

Table 5: Average botanical composition (%) for the periods 1963 — 1965, 1966 — 1970 and 1971— 1977 at El Khuwie Site

Life forms and species	Average Composition (%) 1963-1965		1966-1970		1971-1977	
	OR	EX	OR	EX	OR	EX
Perennial grasses						
Aristida ciliata	0.5	2.9	—	1.3	—	1.0
* Aristida pallida	12.6	7.4	6.0	4.1	1.4	1.3
Sub. Total	13.1	10.3	6.0	5.4	1.4	2.0
Annual Grasses						
Aristida mutabilis			14.7	20.2	2.3	6.7
Cenchrus biflorus	28.1	19.2	35.6	11.1	42.4	25.2
Ctenium elegans	6.6	11.9				
Dactylocenium aegyptium	1.2	0.7	4.2	12.6	6.1	9.8
Eragrostis aspera						
Eragrostis tremula	8.1	14.8				
Schoenefeldia gracilos	0.8		1.9	14.6	3.1	8.2
Digtaria spp.						
Sub. Total	44.8	46.6	54.4	48.0	53.9	49.9
Perennial Forbs						
Aerva javanica						
Cassia italica	0.6					
Chascanum marrubiifolium	0.5					
Chrozophora bracchiana	1.1	3.1				
Chrozophora pblongifolia	8.6	10.6				
Euphorbia sp.	1.1	4.8	1.8			
Indigofera diphylla						
Stylosanthes fruticosa	0.6	0.3				1.9
Chascanum marrubiifslium		1.3				
Sub. Total	12.5	15.3	4.8	1.8	0.0	1.9
Annual Forbs						
Alyslcarpus manilifer	0.1	0.6				
Cyperus spp.	4.4	9.5				
Fibristylis spp.	20.4	11.8	12.6	20.2	20.5	29.2
Ipomosea spp.	2.0					
Mitracarpus scalper	2.6	4.7				
Monechma ciliatum	0.1	0.1				
Blepharis linariifolia		0.1		2.1		
Cisekia pharnacioides		0.6				
Heliotropium spp.		0.3				
Zornia gloctidiata			20.2	12.0	24.2	17.0
Sub. Total	29.6	27.7	18.6	34.3	44.7	46.2
Total	100	100	100	100	100	100

Table 6:- Average botanical composition (%) for the periods 1963 – 1965, 1966 – 1970 and 1971 – 1977 at *El Mazrub Site*

* Skerman data
OR: Open Range
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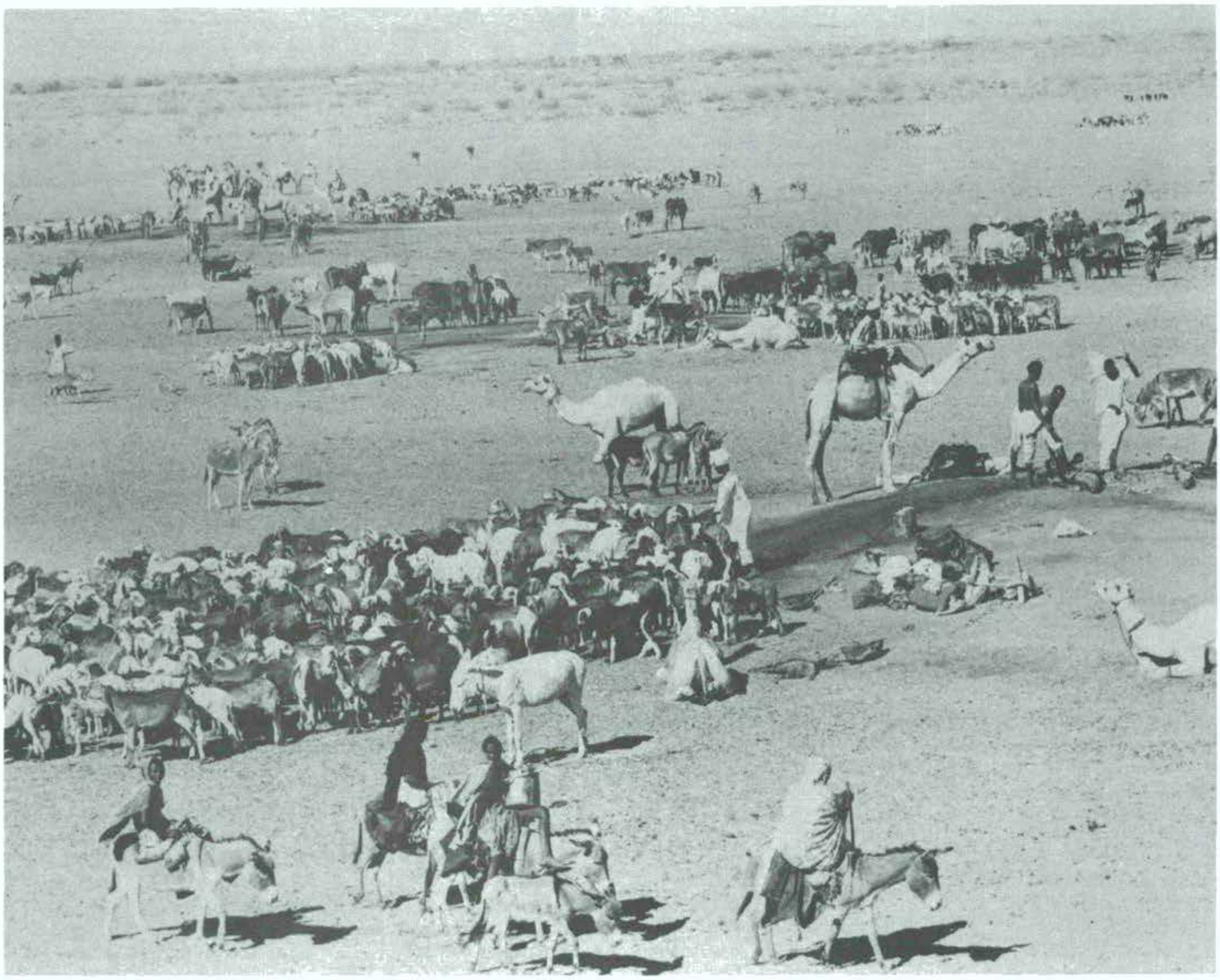


Cattle, goats, sheep, camels, donkeys at nomad watering holes at El Beshiri oasis. Note bare ground near to waterholes, sparse grass in distance. (Earthscan/Mark Edwards)

NEWS FROM UNEP

Asia-Pacific NGO Network Formed

UNEP co-sponsored a conference along with Threshold of the U.S.A. and the Indian National Trust for Arts and Cultural Heritage in New Delhi, 23-25 Octover 1987. The purpose of the conference was to launch a DC/PAC-supported Deforestation and Desertification Control NGO Network in the Asia-Pacific region. In addition to more than 30 NGOs from the region, participants included represenatives of the World Bank, the United Nations Non-Governmental Liaison Service, the International Union for the Conservation of Nature and Natural Resources (IUCN), the International Institute for Environment and Development, World Resources Institute, Environmental Defense Fund (U.S.A.), the Environmental Policy Institute (U.S.A.) and the Environmental Liaison Centre.

The main issues discussed at the conference were the crisis of tropical forest destruction and land degradation — desertification — and economic development policy and planning at the national and international levels. Fróm these discussions, and drawing from the results of previous NGO conferences and workshops over the past year dealing with the issues, a strategy and list of initial actions to take were recommended. These recommendations have been incorporated in a DC/PAC project which will be implemented initially by the U.N. Non-Governmental Liaison Service (UNN-GLS), based in New York. UNN-GLS will co-ordinate the launching of network activities.

This DC/PAC activity responds to UNEP Gorverning Council decision 12/10 which calls on UNEP to establish regional NGO networks to assist implementation of the Plan of Action to Combat Desertification. It is the second regional NGO network to be formed, following the creation of the African NGO Environmental Network (ANEN).

The Asia-Pacific network members will work to increase the quality and quantity of information and data on forest and other land resources at their disposal. They will also compile databases of development organizations and activities relevant to the conservation and environmentally sound management of terrestrial resources. This information will be used to put together publications and reports to submit to governments, donor agencies, multilateral development banks, research institutions, the press and other NGOs to influence development policy and planning. Strengthening NGO institutions will help foster the goals of both the NGO's and UNEP: development without destruction.

Environmental Song Contest

Ully Sigar, the Indonesian environmental folk singer, is helping UNEP to promote environmental song contests in various Asia-Pacific countries in connection with World Environment Day 1988. (UNEP/Daniel Stiles).

One of the points of interest to emerge from the NGO conference in New Delhi was a decision to organize an environmental song contest in the Asia and Pacific region in 1988. The idea was first suggested in June 1987 by Ully Sigar, an Indonesian environmental singer, when she was at UNEP headquarters in Nairobi to accept her Global 500 award. UNEP is giving recognition to individuals and groups working for the environment from around the world. Ms. Sigar received an award for her imaginative use of music to spread the message of conservation of nature. She organized a song contest with the theme of tropical forests in Indonesia in 1987. The contest attracted 250 entries from all over the archipelago and resulted in broad media coverage and concerts for the environment. She proposed that UNEP sponsor similar events in other countries, which UNEP is pleased to do.

The NGOs at the conference enthusiastically adopted the idea and are now busy organizing song contests in their own countries in the Asia-Pacific region. UNEP is providing seed money, promotional support and advice. The success of the venture depends, however, on support mobilized locally in each country. UNEP appeals to all those concerned about the environment to help make the song contests a success.

As part of World Environment Day ceremonies, 5 June 1988, UNEP hopes to organize an international music festival to be held in Bangkok. Some of the best entries from each country will be selected to come to Bangkok to stage a televised concert in support of the environment.

Project Evaluation Mission in Southern India

From 17-22 October 1987 a UNEP project evaluation mission of the *Pilot Demonstration Project of Community Afforestation and Training in Southern India* was carried out. This project, started in October 1985, was implemented by the G.G. Soans Memorial Farmers' and Rural Afforestation Training Centre under the leadership of Mr. Ben Soans. Descriptions of the project are contained in Bulletin Nos. 13 and 14, but, to summarize, the project aimed to strengthen five Van Vigyan Kendras, which are afforestation training centres for farmers and school children. In addition, the project was to assist in the establishment of tree and shrub nurseries (Peoples' Nurseries), encourage tree planting and raise the standard of living of farmers participating in the project.

In 1985, at the start of the project, there were eleven Peoples' Nurseries with one million seedlings at Muloor and four Peoples' Nurseries with 400,000 seedlings at Tumkur in Karnataka State. There were three Peoples' Nurseries with 100,000 seedlings at Kodaikanal and two Peoples's Nurseries with 100,000 seedlings at Rajapodukodi in Tamil Nadu. In spite of a severe drought, by 1987 there were 30 nurseries with 2,500,000 seedlings at Muloor, seven nurseries with 600,000 seedlings at Tumkur, three nurseries with 200,000 seedlings at Kodaikanal and five nurseries with 400,000 seedlings at Rajapodukodi. From these nurseries, over two million trees and shrubs have been planted in southern India during the two-year course of the project. In addition to the obvious environmental benefits of the newly planted seedlings, which had a survival rate of 75-95%, the people establishing nurseries gained economic benefits from the sale of the seedlings. The Indian Government and other donors such as NORAD and OXFAM are now providing substantial support to this project, which has become, in Ben Soans' words, a "peoples' movement".

UNEP, having provided its mandated catalytic support, will now turn this successfully launched project over to other donors and direct its limited resources to other pilot demonstration projects.

Ben Soans, pictured in the centre, has helped people from Karnataka and Tamil Nadu states of India to plant millions of trees.

CAZRI Visit

In November 1987 a DC/PAC staff member visited the Central Arid Zone Research Institute (CAZRI) in Jodhpur, Rajasthan, India's driest state currently experiencing its worst drought this century. Ploughed fields lay barren, awaiting monsoon rains which never came, and the roads bustled with overloaded lorries from Punjab and Harayana states transporting livestock fodder to the distressed pastoralist communities in the desert. So far, the Indian Government is dealing well with the effects of the drought, but the months ahead will put an increasing burden on the Government's coffers and infrastructure.

The purpose of the visit was to explore areas of CAZRI-UNEP collaboration. CAZRI, the subcontinent's foremost drylands research institute, has accumulated a wealth of information and experience from its more than twenty years of concerted research on making drylands productive and stopping desertification. CAZRI can help UNEP in its goal of training government and NGO workers from different regions in techniques to combat spreading deserts, and in return UNEP has offered CAZRI assistance in developing its planned desertification monitoring and information systems.

Fourteenth Meeting of the Inter-Agency Working Group on Desertification, 21-23 September 1987

The Inter-Agency Working Group on Desertification (IAWGD) held its Fourteenth Meeting from 21-23 September 1987 at UNESCO head-quarters in Paris. There were representatives from ESCWA, FAO, ILO, IFAD, UNDRO, UNEP, UNESCO, UNIDO, UNSO/UNDP, WFP and WMO in attendance from within the UN system, as well as participants from the Arab Centre for Studies of Arid Zones and Drylands (ACSAD), International Union for the Conservation of Nature and Natural Resources (IUCN) and Southern African Development Co-ordination Conference (SADCC). The meeting was chaired by Mr. G. Golubev, Assitant Executive Director of UNEP/Programme.

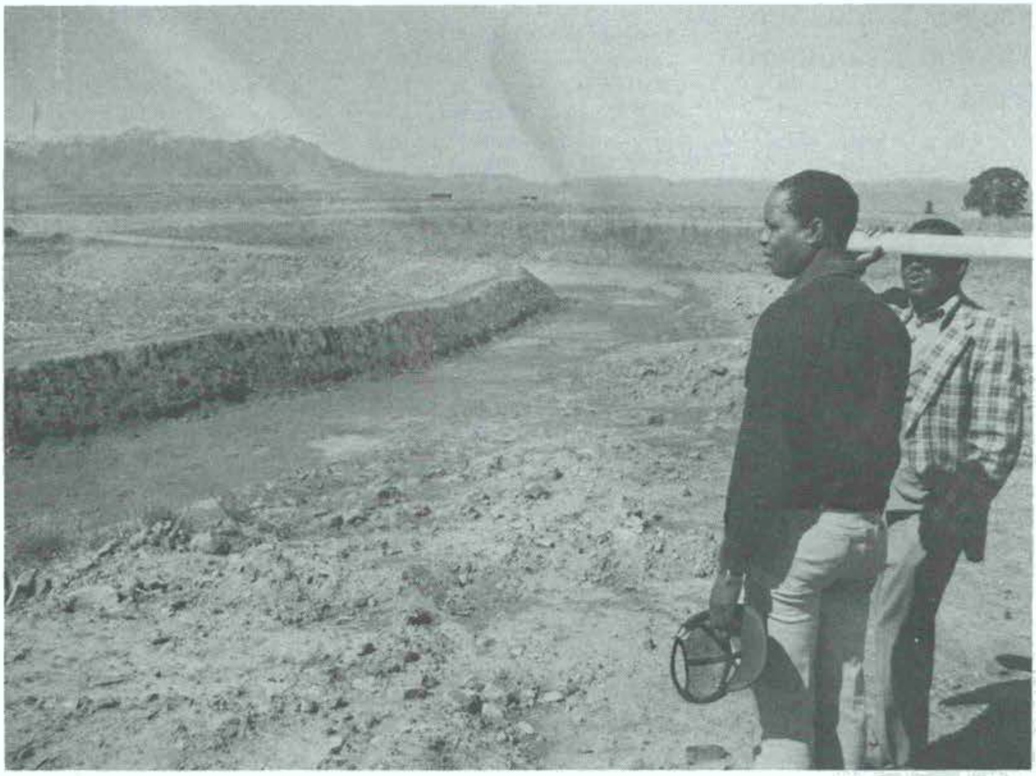
The "Report of the World Commission on Environment and Development" and the "Environmental Perspective to the Year 2000 and Beyond" has been completed and reviewed by the UNEP Governing Council, and the latter forwarded to the General Assembly for consideration at its forty-second session. The second session of the African Ministerial Conference on the Environment (AMCEN-II) was held in Nairobi in June 1987, following the first meeting in Cairo in 1985.

Within the World Bank a new Environment Department had been created with combatting desertification as one of its priorities. UNDP will also be exerting more effort toward solving environmental problems. Mr. S. Dumitrescu, Deputy Assistant Director General for Science, representing the Director General of UNESCO, stated that his organization would continue to place embasis on desertification problems in its programmes, particularly under the Man and the Biosphere (MAB) Programme and the International Hydrological Programme (IHP).

The Secretariat reported on networking and training activities spearheaded by FAO and UNESCO in various regions. FAO has reported activities in establishing sand dune fixation and afforestation networks in the Middle East and North Africa, the Sahelian and north Sudanean Zones, and in Latin America. A Network of Research and Training Centres for Desertification Control in the ESCAP region has been established in which ESCAP will coordinate the networking activities. The UNESCO/MAB Programme has set up networking related to arid zones research and training aimed at combating desertification. The networks are based on MAB National Committees, international network of Biosphere Reserves, national or regional pilot projects and case studies on specific topics. There is a training course on Principles of Remote Sensing Control of Droughts and Desertification organized annually by UNDRO/FAO/WMO/ECA.

Thus far, however, it was felt by members of the Working Group that there was a lack of information regarding past and planned training activities, meetings and seminars which would otherwise enable members to coordinate their own activities, thus taking advantage of the network and avoiding duplication. The Secretariat, which had made some provision in its 88/89 programme budget for networking activities, suggested discussing ways in which the Working Group could strengthen these networks, and it was agreed that this be done at an *ad hoc* meeting of the Working Group in April 1988.

Further conclusions were that the Secretariat explore the possibility of issuing a newsletter to be circulated among members of the IAWGD, as well as other organizations, to exchange information regarding activities of networks, training seminars and meetings by Agencies in general. Development of networks concerning sand dune fixation and afforestation for Asia and the Pacific region and those of research and training centres in Latin America should be discussed by the Secretariat and by FAO and UNESCO respectively.



UNEP has begun formulating project proposals under AMCEN as here in Lesotho. This soil conservation project is being carried out with Swedish assistance. (UNEP/T. Maukonen)

UNEP has the responsibility of setting up a secretariat for the Cairo Programme which was recommended by African governments of AMCEN. In all, 75 villages and 22 stock-raising zones have been nominated by 25 African governments under the Cairo Programme. The Working Group was asked to respond positively to requests for assistance by governments to implement the Programme, and pilot projects for villages and stock-raising zones have already begun in Egypt, Lesotho, Senegal, Sudan, Uganda, Zaire, Zambia and Zimbabwe in keeping with the national focal points of the African Deserts and Arid Lands Committee (ADALCO). This work is to be carried out in close collaboration with the already existing sub-regional governmental bodies such as IGADD, SADCC and COMIDES and the UN system. FAO, UNESCO and ILO reported having been approached in connection with development of village pilot projects for Senegal and Zaire and were prepared to respond favourably if budgetary constraints allowed. However, it was pointed out by UNESCO that Zaire does not fall within the context of desertification control as it is located within the humid tropics.

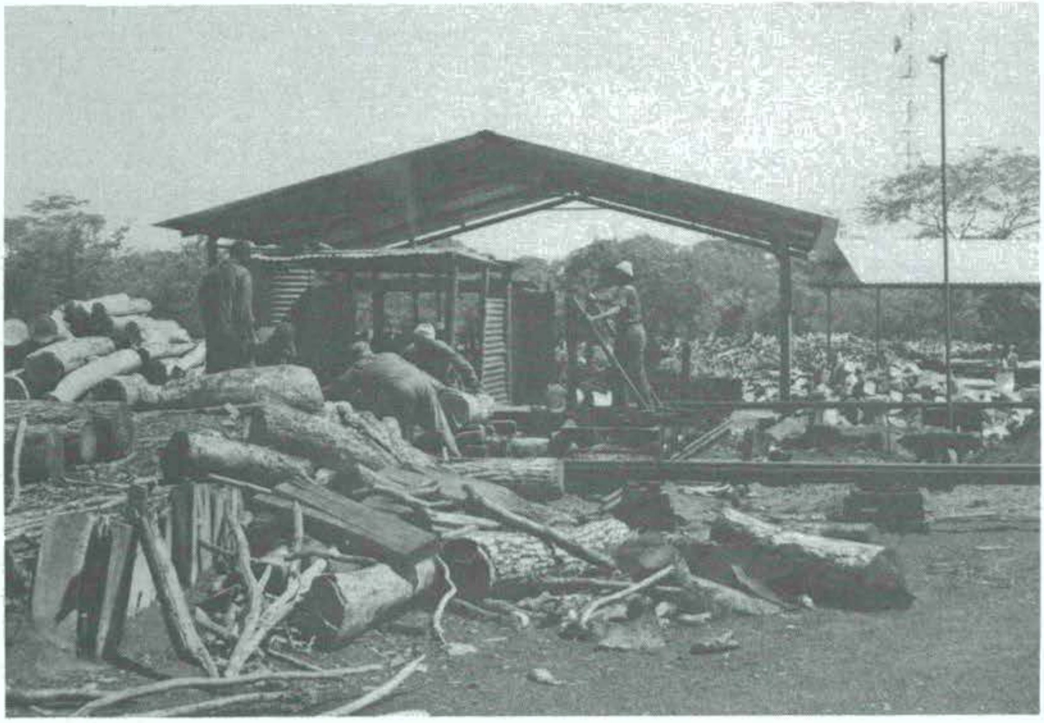
The representative from IUCN informed the meeting that they would be implementing the Cairo Programme in collaboration with African NGO's in line with government policies. SADCC has arranged a training programme with UNEPCOM. The SADCC representative expressed concern that IAWGD was focussing its activities in the northern regions of Africa at the expense of areas in the SADCC region, such as the Kalahari-Namib desert and degraded areas.

The Cairo Action Plan

As reported in Bulletin No. 14 *(pp.48-49)*, UNEP, in association with the OAU and the U.N. Economic Commission for Africa, sponsored an African Ministerial Conference on the Environment in December 1985 in Cairo. A comprehensive plan for Africa's environmental recovery emerged from this conference.

The Second African Ministerial Conference on the Environment was held in June 1987 immediately preceding UNEP's fourteenth session of its Governing Council in Nairobi. The second conference reviewed progress since the Cairo Action Plan was adopted.

DC/PAC, working in collaboration with other sections of UNEP and the Regional Office for Africa, has begun action to formulate projects under two broad headings of recommendations made at Cairo. The first



The Cairo Action Plan, formulated under AMCEN, has as one goal to make pilot villages in Africa self-sufficient in energy. Saw mills producing timber for pulp and construction, as here in Zimbabwe, compete with the home energy needs of the people. A solution has to found for sustainable management. (UNEP/T. Maukonen)

involves the recommendation to assist three villages in each of fifty countries in Africa to become self-sufficient in food and energy in five years. The approach is to work with local community groups at the grass roots level, building on indigenous technologies and social organization. These pilot villages can then act as demonstration models which can catalyze replications throughout each country. The second heading involves pilot livestock zones in which smallscale irrigated fodder production would be encouraged to take pressure off the usual pasture during the dry season. DC/PAC has designed an animal-driven water pump to use in this smallscale irrigation. The pump is to be tested in Mali in 1988.

Project proposals are in the advanced stage of development in Uganda, Senegal, Ethiopia, Sudan, Zaire, Zambia, Zimbabwe, Mali and Lesotho. Activities have already begun to initiate project formulation in Egypt and Kenya, and plans are being prepared to start work in other countries.

Consultative Group for Desertification Control, Sixth session, Geneva,

24 to 27 March 1987

The sixth session of the Consultative Group for Desertification Control (DESCON) was opened in Geneva by Mr. W. Mansfield, Deputy Executive Director of UNEP. The meeting was attended by five sponsors, ten core members, seventeen invited countries, and UN and other organizations. In his opening address, Mr. Mansfield presented an overview of the worsening problem of desertification and told delegates that despite progress on methodologies, plans of action and know-how, DESCON had once again made little progress in raising funds. He attributed this to a number of factors including the donors' preference for bi-lateral aid, the failure of the countries at risk to accord a high priority to desertification control, and the lack of co-ordinated international programmes, follow-up, or information exchange. The question was asked whether the continued existence of DESCON was justified in view of its poor performance. Mr. Mansfield replied that DESCON should not be allowed to fail because the long-term economic, ecological and social cost of continuing to allow desertification would be too great. He suggested a number of steps to improve DESCON's support of the PACD. First, UNEP should institute a vetting procedure of proposals prior to their submission to DESCON. Second, there should be an improvement in the quality of projects submitted by developing contries. Third, there should be a clear and regular reporting procedure for DESCON projects. Lastly, as well as bilateral aid, donors should also provide money directly to DESCON.

Delegates were told that the record of DESCON was not good: the group had considered 74 projects of which only 28 had received support for implementation. Of the $122.4 million required, only $45.5 million had been secured over the last seven years. The secretariat had carried out its work in line with the recommendations of DESCON-5 stressing a limited number of elements of the PACD. As a result the thirteen proposals submitted to the sixth session dealt with three areas, namely monitoring, the formulation and co-ordination of national policies, and the use of water resources. But it was clear that such an approach was inadequate. In the general discussion, the delegates addressed working documents submitted to them, a consolidated report on information exchange (which had been called for after the fifth session), a working paper on additional measures for financing PACD, and the extracts from both the 1985 and draft 1986 Annual Report concerning the implementation of PACD.

Among the specific points raised on the consolidated report, it was agreed that the questionnaire method for information exchange amongst members was inadequate and restrictve, and that the purpose of such a consolidated report should be to give the Group a comprehensive picture of what was being or needed to be done in a few selected desertification projects and what lessons had been learned. Following an address by Professor Mohammed Kassas on financing, it was decided that more time should be given to the consideration and recommendations of this important topic.

Specific project proposals submitted to DESCON-6 were

- the establishment of three pilot demonstration areas for desertification control in Chile
- a large-scale project on food and energy production through sound environmental management in Zambia
- a soil assessment and mapping project in Swaziland
- a watershed and resources conservation scheme for the Yemen Arab Republic

— an assessment of water resources for anti-desertification work in Bangladesh

— construction of small dams for livestock in Northern Benin

— rehabilitation of reservoirs in Togo

— a small-scale irrigation project in Cape Verde

— collaborative research on the dromedary camel in Africa

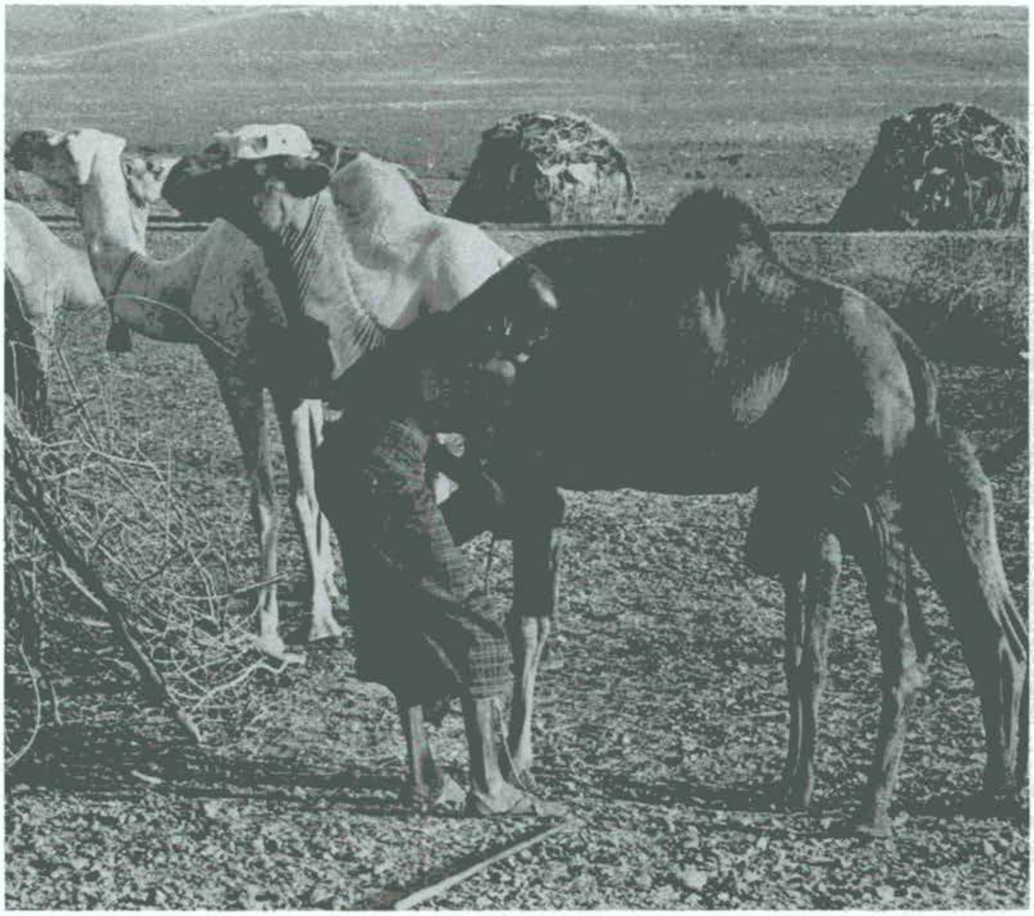
— development and introduction of improved cooking stoves for Somalia

— a master plan for water use in Rwanda

— development of gum trees in the Sahelian zone of Burkina Faso.

After these projects had been discussed individually, the secretariat stated that so far efforts to combat desertification had followed a sectoral approach lacking coherence and clarity. To counter this problem, UNEP had decided to encourage some willing Governments such as Sudan, Botswana and Tunisia to implement an integrated approach to the problem and it was agreed that this approach would help DESCON establish a sound basis for its future activities. It was decided that DESCON should assist with the setting up of national strategies as part of development plans, and that where such strategies were not present, more information should be given linking the project with overall national environmental objectives. A working group was set up to review DESCON's progress, to outline the lessons learnt and to make recommendations that would define its role more clearly and improve its operational methods. The group would also propose criteria for the selection of countries for concentration.

Several of the project proposals received expressions of support which are being followed up by DC/PAC.



A project proposal for research on the camel in Africa was one of the proposals submitted to DESCON-6. (UNEP/Daniel Stiles).

UNEP Support to NGOs Combating Desertification

DC/PAC is providing support to the African NGOs Environmental Network (ANEN) to strengthen its ability to co-ordinate and catlyze desertification control activities at the grass roots level. ANEN is based in Nairobi and co-ordinated by Mr. Jimoh Omo-Fadaka, assisted by a number of appointed regional representatives.

A number of activities are being initiated by the network:

— compilation of a directory of NGOs working in the field of desertification in Africa

— publication of six issues a year of the *Eco-Africa* newsletter

— one "how-to" technical booklet for use in the field

— a training seminar held in Nairobi for about 35 NGOs from around Africa in September 1987

— support to NGO field projects

The four NGO field projects approved so far are

— Environmental rehabilitation of four villages in Nakuru, Kenya

— Environmental rehabilitation of four villages in Kweneng District, Botswana

— Environmental rehabilitation of four villages in Senegal

— Environmental rehabilitation of one village in Burkina Faso

Similar projects with the aim to assist NGOs to network is under development for the Asia-Pacific and Latin American regions. More details will be presented on these efforts in the next issue of the Bulletin.

UNEP Evaluation of Village Project in Burkina Faso

DC/PAC representatives visited a UNEP-supported village and family afforestation project in Burkina Faso from June 29 to July 4 1987. Since 1982, when the project began, nearly 316,000 seedlings (using ten exotic species and nine indigenous species) were reported to have been raised in the four nurseries, and 151 hectares of trees have been planted with the participation of 125 villages. However, there were discrepancies between figures submitted by the project and field observations: drought and lack of monitoring has resulted in poor seedling survival rates and a smaller area appeared to be under trees than that reported.

A large number of people have been trained locally including 30 forestry workers, 120 people in nursery management and planting, and 259 people in the construction of wood stoves. Inhabitants from 72 villages have been educated in the project activities. Research has also been undertaken in both forestry-related activities and in the fields of climatology, hydrology, soils and socio-economics.

Among the problems that need addressing are the shortage of local technical staff and a lack of co-ordination. The UNEP mission recommended greater integration and co-ordination of forestry activities with agricultural development, an improvement in record-keeping and monitoring, and a concentration on increasing the awareness and participation of the local inhabitants in project activities. The mission also recommended the hiring of a short-term consultant to prepare an agro-forestry management plan. UNEP's involvement in the project ceased in June 1987, but UNSO will be extending the project until at least September 1988.

Mission to Botswana

A representative from DC/PAC spent a week in March 1987 in Botswana visiting the Ministry of Local Government and Land, the University of Botswana, Botswana Agricultural College, the National Institute for Development Research and Documentation, the District Council of Tsabong and field areas. The purpose of the mission was to assess the severity of land degradation in the country and, for this, it was necessary to visit the problem areas. Between Gabarone and Kwaneng, both gullying and crusting were in evidence on the hardveld, and the extent of run-off and water erosion was confirmed by aerial survey and satellite imagery. Wind erosion also occurs there but is worse on the 'sandveld'. A visit to one of the driest areas of Botswana showed some reactivation of linear dunes in the vicinity of Bokspits and surrounding boreholes owing to excessive overgrazing, while in most other areas, the dunes were fairly well vegetated although there is some risk of wind erosion. The overuse and overdrilling of boreholes was observed, and this is considered to presage total desertification in the area within 20 years. DC/PAC recommended that an immediate check be made on the digging of new boreholes to prevent a major ecological disaster. In addition, DC/PAC noted that the use of Eucalyptus for reforestation is inappropriate in such dry zones as the species is very demanding of water.

Three seminars were planned in the Bokspits area to bring together Government officials, farmers and local land users at which there will also be a UNEP resource specialist. In addition, the Botswana Government agreed that the second part of a UNEP training course on Rangeland and Soil Conservation in the SADCC Region would be held in the country in September-October 1987. The three-week course would include both field work and formal teaching of remote sensing techniques and will follow the first part of the course to be held in the USSR.

National Workshop on Sand Dunes

A well-attended national workshop was held in Somalia from 23-26 March 1987 at which a number of recommendations were made for sand dune fixation. The Somali Government also requested UNEP's help, and at their request a field mission was carried out following the workshop. All sandy areas in the country are affected by serious wind erosion and four locations where desertification control activities are being carried out were visited, namely Brava, Shalambot Merka, Gelib Merka and Gendershe. The findings at Brava were that despite wind barriers and an artificial dune having been built, the work was not systematic enough to stop wind erosion and the necessary expertise was lacking. The artificial dune could be improved by the siting of wind barriers in a "herring-bone" pattern perpendicular to the wind direction. More wind breaks of live vegetation are also required as well as better organization of the nurseries. At Shalambot Merka, attempts to arrest the gully erosion are being carried out well. There is a good nursery and successful reforestation and dune fixation using *Opuntia indica* and *Euphorbia conifera* as living fences. At Gelib Merka, reforestation has also been successful with *Casuarina, Prosopis* spp. and Neem trees all showing promise. Seven check dams have been constructed cheaply and are halting the spread of gully erosion. At Gendershe, *Casuarina* trees are growing well and their planting is to be encouraged. DC/PAC made several recommendations on how sand dune fixation activities in Somalia could be improved and wind erosion reduced.

In Botswana, severe desertification is taking place around boreholes and watering points. This water hole is drying up. (UNEP/T. Maukonen).

Workshop on Sand Dune Mapping, Stabilization and Afforestation

This workshop was held in Rabat, Morocco in April 1987 in which eleven Arab countries, FAO, UNESCO, UNDP, WMO, and UNEP were represented. The need for the following was stressed: information about sand dune stabilization; mapping of the problem using remote sensing and field verification; training at both technical and managerial level; research into improved techniques; and sensitization of the affected population. UNEP's possible involvement could take the form of a DC/PAC or Clearing House project on wind erosion control. The DC/PAC representative offered the services of its wind erosion database to those seeking information on sand dune fixation technology and methods.

National Soil Conservation and Agroforestry Programme in Zambia

A specialist from DC/PAC visited the Southern Province of Zambia in June — July 1987 as a member of a team comprising soil and agricultural specialists from Zambia and the Swedish International Development Authority (SIDA). Areas badly affected by soil erosion were visited and discussions held with farmers and regional authorities. This was followed by talks in Lusaka with different departments and ministries concerning project proposals to redress the situation of environmental degradation. It was decided that a National Soil Conservation Unit should be set up with SIDA financing which would co-ordinate donor inputs. It was agreed that the Unit would concentrate initially on Eastern and Central Provinces and that within this programme there would be three pilot village schemes, one of which was allocated to UNEP by the Government.

The most striking feature of the village areas was the livestock-induced erosion and this, together with fodder tree development, was seen as the link between the Dutch-financed Cattled Development Area and erosion control within the soil conservation programme.

UNEP has prepared a project proposal for a pilot village scheme under the Cairo Action Plan.

Combating Desertification through Integrated Agricultural Development in Lodar, PDR Yemen.

DC/PAC and the Environment Fund paid a four-day visit to the People's Democratic Republic of Yemen to assess progress at Al Ghoz farm which was set up as one of Yemen's national anti-desertification measures. Despite delays resulting from machinery breakdown and spare part procurement, some progress has been made. Since the field work started in 1984, 88 hectares have been levelled, demonstration plots for a new type of surface irrigation have been established, a reservoir with a capacity of 1100 cubic metres has been built, and pipe irrigation installed for 5 hectares of citrus orchard. In addition, 35,000 seedlings, including some new Australian species, which are destined for wind breaks and fuelwood, have been distributed for planting from the nursery. Seven kilometres of wind breaks have now been established on the farm perimeter, 100 hectares has been fenced for rangeland development, and a soil and topographic map completed.

A three-month training course was held in the USSR for a forester, an irrigation specialist and four other trainees, while a further 26 technicians took part in local training courses in afforestation, agriculture and water management. However, in general the various problems and the absence of a range management plan has meant that development targets have not been met. As a result of the UNEP mission, a more realistic timetable has been prepared, a work plan for 1987/88 has been drawn up, and better management routines have been discussed with the Project Manager and the irrigation specialist. A further UNEP review is expected to take place in 1988.

UNEP to support Meeting of the Committee on Deserts and Arid Lands (CODAL)

CODAL was set up as a result of the 1985 Cairo Plan and will co-ordinate implementation of regional projects on appropriate land use for the semi-arid zones. It will also collaborate with the African Network for surveying and monitoring the environment to collate information on desertification from the Kalahari Namib, Chalbi Somali, and Sahara deserts. The Committee will also assist in the implementation of anti-desertification programmes operated by the UN and OAU.

Amongst CODAL's priority activities will be an agreement to call upon national experts to ensure rapid implementation of decisions and the contribution of member groups of the Committee to specific activities of regional concern, e.g. Southern Africa Development Co-ordination Council (SADCC) for the Kalahari. Each African country is expected to bear the cost of its participation.

The recommendations of CODAL will be used by governments to implement their programmes for the control of

Contour ridges are being ploughed in Zambia as part of a SIDA financed programme. (UNEP/T. Maukonen).

desertification. UNEP will provide logistical and administrative support in collaboration with UNSO and the Senegalese government.

A GIS for the Sudan

DC/PAC is assisting the Sudanese Government to set up a Geographic Information System for all natural resource and environmental data available in the country. The World Bank, USAID and Norway are also interested in assisting Sudan to improve its natural resource planning and management capabilities and they might work in co-operation with UNEP in this GIS activity. The project is still under discussion, but is planned to get underway in 1988.

Successful Shelterbelts in Kazakhstan

A member of DC/PAC attended a UNEP/UNEPCOM training session on dry land agriculture for 18 participants from 15 countries held in the USSR in 1986. The first week was taken up with lectures in Moscow followed by a week of practical teaching in Kazakhstan. Of particular interest was a visit to a state farm, Kaskelensky Sovkhose, where more than 16,000 hectares are protected against wind erosion by tree shelterbelts, the establishment of which has resulted in the doubling of crop yields in sheltered fields. At the Kazakhstan Management Research Institute, trainees were taught the principles of anti-erosive methods for arid land agriculture, and relevant techniques for rainfed, irrigated and mountain agriculture in the state, which is prone to both drought and desertification.

DC/PAC Steps up Research and Training Activities

Six new projects started in 1987 that involve research and training activities. They are described below.

Training Course in Desertification Assessment and Control for Latin America and the Caribbean

A one-month training course was held in November 1987 at the Instituto Argentino De Investigaciones de Las Zonas Aridas (IADIZA) for twenty-three technicians from the Latin American and Caribbean region. The training course consisted of two weeks of lectures followed by two weeks of field work. The course focused on methods of assessing desertification and measures for planning control. A report on the training course will be prepared by IADIZA in co-operation with UNEP's Regional Office for Latin America and the Caribbean.

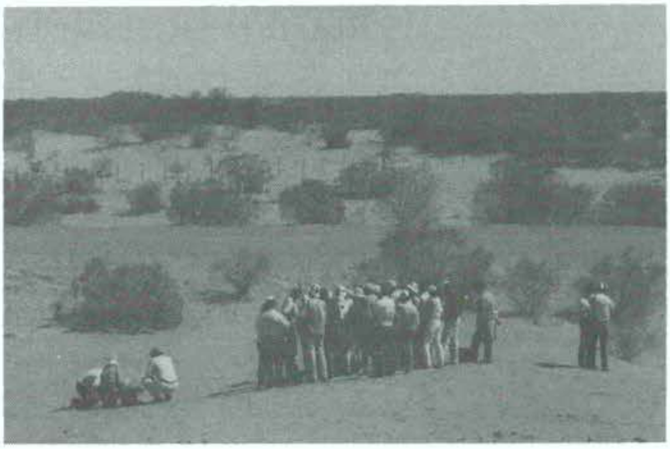
Desertification Control Training Courses for SADCC Countries

Two training courses were organized for participants from the Southern Africa Development Co-ordination Council (SADCC) countries (Angola, Botswana, Lesotho, Mozambique, Malawi, Swaziland, Tanzania, Zambia and Zimbabwe) in collaboration with the USSR Commission for UNEP (UNEPCOM) and the Government of Botswana.

The first training course, held in September-October 1987 at the Desert Institute in the Turkmen SSR, was on the topic of Rangeland Ecology, Management and Productivity. The main aim of the course was to train personnel from the SADCC region in the methodologies and techniques of rehabilitating degraded rangelands and to ensure their sound management, with emphasis on increasing productivity on a sustainable basis. The course lasted three weeks and had twenty-three trainees.

The second training course, held at the Botswana Agricultural College in Gabarone, covered the topic Rangeland and Soil Conservation in the SADCC Countries. It lasted three weeks and twenty participants took part.

Reports on both of these training courses are under preparation.



A field trip as part of the IADIZA/UNEP training course in Argentina showed the trainees sand dunes planted with indigenous species of shrubs. (UNEP/L. Kroumkatchev).

Desertification Control Training in West Asia

In co-operation with UNEPCOM and the Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD), DC/PAC is supporting two training courses for participants from West Asia and North Africa. The first training course covered the Reclamation of Saline Irrigated Soils and was held for three weeks in the USSR. The second course was on Soil Laboratory Technology and was held for three weeks at ACSAD in Damascus, Syria. Twenty trainees attended each of the training courses. A report tentatively entitled "Reclamation of Saline Soils and Laboratory Technology" will be prepared by UNEPCOM and ACSAD.

Research and Training in Desertification Control in West Africa

Three training courses are planned for 1988-89, each with twenty participants and to last three weeks, for technicians and research officers from both English and French-speaking West African countries. The titles of the three courses are "Techniques of Combating Erosion and Sand Dune Fixation Methods," "Assessment, Mapping and Monitoring of Desertification" and "Rangeland Development and Desertification Control in the West African Countries." The first training course will be organized by UNEP in co-operation with UNEPCOM and the National Institute for Research in Animal Husbandry, Forestry and Hydrology, Mali, and will be held in Bamako. The two other courses will be held at the Desert Institute in Turkmen SSR.

In addition to the training courses, this project will also conduct research into methodologies for assessing and mapping desertification following the FAO/UNEP Provisional Methodology for the Assessment and Mapping of Desertification. This project will be closely co-ordinated with the Kenya project described below.

Training in Desertification Control

UNEP's training policy is designed to promote sustainable development. The aim of specialized training is to create awareness about the threat of desertification and to enhance the capabilities of the developing countries to deal with it: general training for policy and decision-makers, and specialized training for those whose activities have an important bearing on desertification control.

The Desertification Control Programme Activity Centre continued training programmes in co-operation with China, India, Tunisia, the UN members of the Inter-Agency Working Group on Desertification (IAWGD), UNEPCOM and

Report of DC/PAC Training Activities in 1987

Title of Training Course	Date	Duration	Number of Participants	Hosting Country
Assessment and Desertification Control in the Latin America Region	1-25 October 1987	4 weeks	23	Mendoza, Argentina
Rangeland Ecology Management and Productivity	23 September — 10 October 1987	3 weeks	21	USSR
Rangeland and Soil Conservation in the SADCC Region	23 November — 11 December 1987	3 weeks	20	Botswana
Soil Laboratory Technology	28 November — 10 December 1987	2 weeks	20	Damascus, Syria ACSAD
Assessment and Desertification Control in Brazil and African South Atlantic Countries	December 1987	4 weeks	30	Recife, Brazil
Rangeland Improvement in the Arid and Semi-arid Zones and its Environmental and Socio-economic Aspects	17 May — 4 June 1987	3 weeks	14	USSR, Moscow Samarkand

regional training institutions. As a result of the initiative and financial support of DC/PAC in 1985-86, 2050 trainees have been trained at the project and field level. A further 2968 people have been trained in areas related to desertification control under the auspices of the IAWGD.

Training activities undertaken by DC/PAC covered a number of dryland management topics including the following:

- desertification assessment and control through integrated regional development and public awareness
- planning for development in drought-prone drylands
- rangeland ecology, management and productivity
- soil conservation, fixing of shifting sands and the reclamation of saline irrigated soils
- rainfed agriculture, including soil and water management.

To increase cost-effectiveness, more emphasis will be put on training courses at the regional level, bringing overseas experts to participate in courses in developing countries. Evaluation of training programmes has now become an integral part of the training activity.

Kenya Desertification Assessment and Mapping

In 1980 a project started up with UNEP and FAO working together to devise a methodology for assessing and mapping the status, rate, risk and hazard of desertification. Even though the methodology was tested in nine countries, the provisional methodology produced in 1983 proved to be complicated and difficult to apply. It was decided later in 1985 that a further testing period was needed to refine the methodology to make it more practical and cost-effective. It was recommended to conduct the testing in Kenya, as the country had good available data sets, the necessary institutional support and trained manpower, and UNEP would be able to work directly with the project. The Kenya Department of Resource Survey and Remote Sensing (formerly KREMU) will work with DC/PAC and UNEP's Global Environment Monitoring System (GEMS) in refining the set of desertification indicators and modelling rules contained in the FAO/UNEP Provisional Methodology. Data on indicators of vegetation degradation, water erosion, wind erosion, salinization and soil crusting and compaction will be collected by satellite imagery, aerial photographs and ground-truth checks. Both Landsat Thematic Mapper and SPOT imagery will be used to investigate three study areas in Kenya: part of Marsabit District in northern Kenya, the Baringo basin, and an area containing the Kora National Reserve and surrounding marginal farmlands.

Maps of the various indicators will be prepared, digitized, and stored in a computerized Geographical Information System (GIS) which is being established in KREMU with assistance from the World Bank. Once the assessment and mapping methodology has been finalized, KREMU will extend coverage from the three study areas to other parts of the country and eventually will have a national desertification GIS. UNEP will also extend use of the methodology to other countries in need of such a standardized tool. The maps can be used for planning desertification control activities and natural resource management.

Transnational Project on the Major Aquifer in Northeast Africa

The objective of this project, which started in 1982, is to promote ecologically sound agriculture through the effective use of groundwater from the Nubian sandstone aquifer which underlies much of Egypt, Libya, Chad and the Sudan, with each country soliciting funding through bilateral aid. The Italian government has provided a grant for both Egypt and the Sudan for the implementation of the project. In addition, UN/DTCD and UNDP have provided financial assistance which includes the funding of a regional co-ordinator. Funds were also made available for fellowships and for short-term consultancies to develop a management scheme for the aquifer, for cereal-growing, and for the control of desertification. DC/PAC's contribution is to provide a co-ordinating office located in Khartoum to ensure transnational co-operation, standardization of methodology and the monitoring of the project activities.

Progress to date has included the survey of the aquifer and identification of its extent, boundaries and the most promising areas for groundwater extraction. Canadian, Danish, West German and Egyptian assistance has established data on sustainable water yield, the likely effects of shelterbelts on wind erosion and on the arrest of desertification, and a substantial quantity of maps has been prepared. The project is proceeding as scheduled with considerable co-operation between the Sudanese and Egyptian Governments which have established well-qualified teams of national staff who have benefitted from the fellowships and the expertise of the consultants. Two pilot farms making use of the aquifer waters were planned in Egypt and the Sudan during 1987.

NEWS OF INTEREST

The Negev Desert: Where the grass is browner

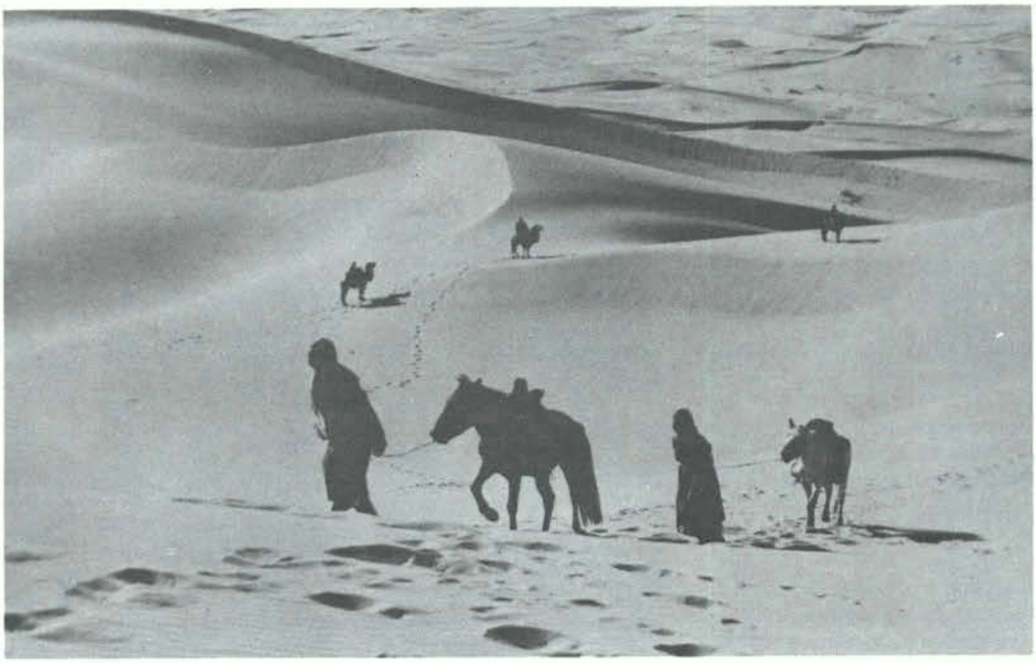
(Extracted from the Financial Times, June 1st 1987)

Ben-Gurion's dream of transforming the Negev desert into a flourishing part of Israel is turning into a nightmare. Despite making up two-thirds of Israel (as it was before the 1967 war), the Negev still has only 10 per cent of the population, and it is today an area of net emigration.

In 1948, when Israel was founded, the Negev was sparsely inhabited by Bedouins. Successive waves of immigrants from North Africa, and later Eastern Europe, were forcibly settled into towns including the regional capital Beer-Sheba (population 110,000) and industries were created.

When the Likud came to power in 1977, Government policy changed and it was the new Jewish settlements of Gaza, the West Bank and Jerusalem where immigration was encouraged. In recent years there has been a slump in the petrochemical and textile industries in the Negev resulting in high unemployment and the creation of ghost towns from former industrial centres.

The area is reverting to desert once again. There are those who suggest that the Negev's real asset is its natural beauty and its flora and fauna; they have suggested that tourism should be promoted on the scale that it has been in the coastal town of Eilat on the Gulf of Aqaba which has become a flourishing international resort. If a consortium of companies currently prospecting in the area is proved right, even that will be unnecessary: they believe that oil may be present in substantial quantities and the Government is hoping that their optimism is well-founded.



Dunes such as these are widespread in northern China and Inner Mongolia.

Fighting Desertification in China

(Extracted from 'China reconstructs' Vol. 36(2), Feb. 1987)

There are nearly 1.5 million square kilometres of desert in China including the Gobi desert. Since 1959, the Chinese Academy of Sciences has been conducting research in the Taklamakan desert and in eleven other sites. It is estimated that 1000 square kilometres are lost to desertification in China each year and that 85 per cent of the desert area of the country was caused in the first place by overgrazing, deforestation and excessive cultivation. Research has shown that it only takes five to ten years for desert reclamation, and recent progress has been substantial. In the north, a Green Belt has been established in a line 7000 kilometres long, from the Kashi oasis in Xinjiang Uygur, across the Gobi desert and the Loess plateau, to the Hinggan mountain range. Since 1978 when aerial seeding was begun, 6.05 million hectares have been replanted with forest while a further 6.37 million hectares of moving sand have been stabilized with vegetation. This should lead to an increase in forest cover from 5.9 per cent to 7.7 per cent in the coming decade.

A remarkable achievement has taken place in the Tengger desert of Inner Mongolia where plant cover has increased from 0.2 per cent to 47.3 per cent following a massive programme of aerial reseeding; this includes 30,000 hectares of grassland on rolling sand dunes. UNEP has held three training courses in the Ningxia Hui region and it is hoped that by disseminating current techniques, 20,000 square kilometres of desert will be reclaimed by the end of the century.

China: Creating Farmland from the Desert

(Extracted from China reconstructs, Vol. 36(2), Feb. 1987)

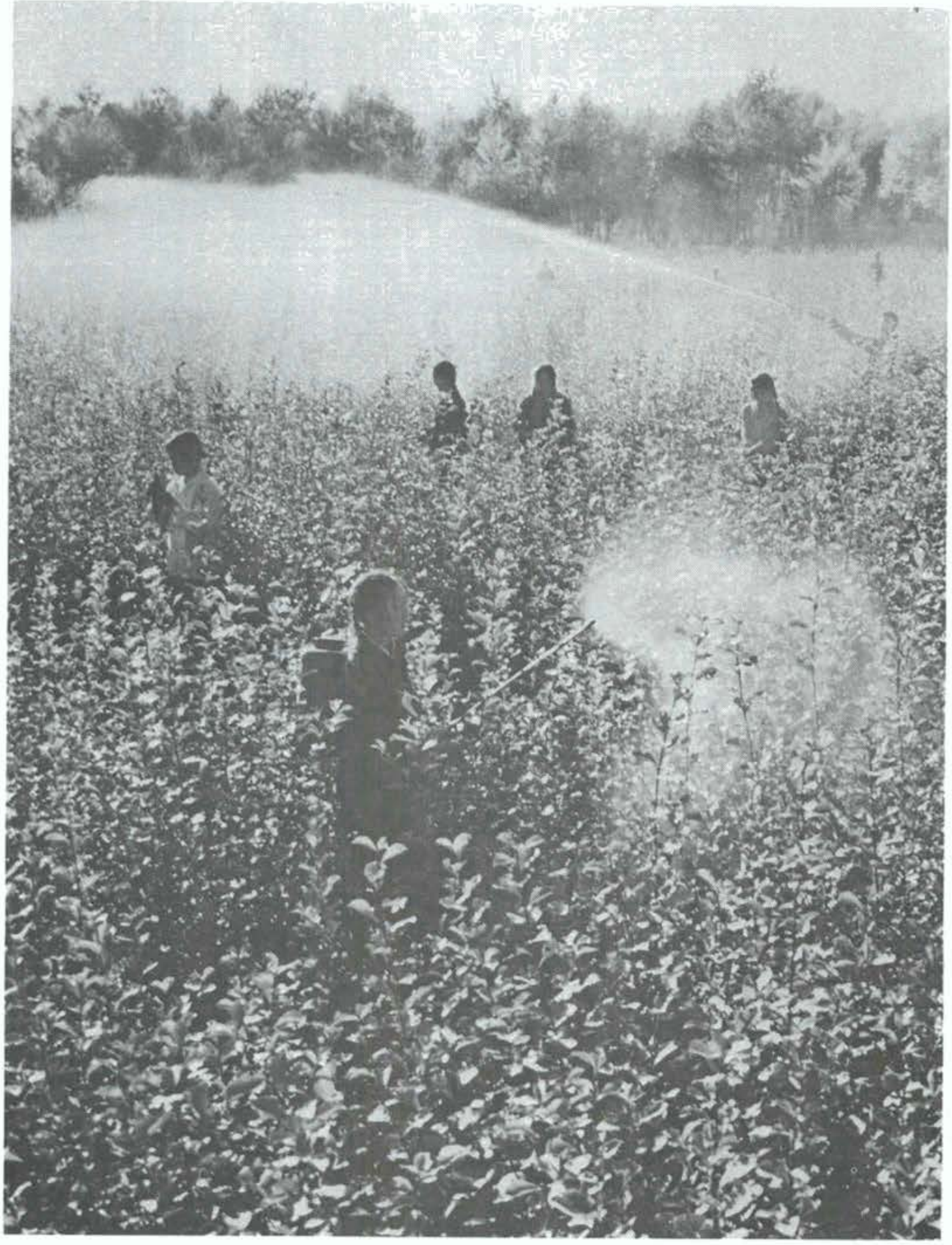
For countless years, the fierce desert winds drove the sand off the Badain Jaran desert of Inner Mongolia onto the habitations, canals, temples and even portions of the Great Wall to the south. In recent times, some local farmers have had to move four times as their houses and their land were buried. But in 1980, they were able to move for a fifth time, back whence they came, as desert reclamation schemes successfully established wind breaks and dune fixation. One village of 8000 people has returned to its original site to find that 65 per cent of the land is covered with vegetation where ten years ago the plant cover was only 3 per cent. The whole area is now an oasis of fertile crop growing with grain production per hectare having been doubled in ten years.

A similar story comes from the northern boundary of the Gobi desert. Poplar trees have been established as wind breaks in a region where a decade ago not a blade of grass or a person was to be seen. Today a community of 600 thrives among fields of grain, watermelons, onions and grass. The ten-year reclamation programme was started in 1975 and since then 6660 hectares of sand dunes have been immobilized and two canals built to transport water to the area. Olives, tamarisks and other fast-growing trees were planted round the farmland while on the dunes themselves, squares of woven straw and clay matting were placed to stop the sand blowing with shrubs planted between them. Areas of natural vegetation were also encouraged round the village, and control over overgrazing and tree cutting was rigorous. The scheme has become a showcase in desertification control and a joint seminar on it was held by China and UNESCO in 1984. However, the problems are not over: the abundance of water has now led to waterlogging and alkalinity, and researchers are working hard to devise an appropriate irrigation system for these desert soils.

China's ancient deserts

Northwestern China contains the hyper-arid 330,000 square kilometre sand sea known as the Taklamakan desert (from the Uygur word for 'labyrinth'). The Tarim Basin, located in this desert, is important historically as the great Silk Route which linked China with the empires of the West bifurcated to pass along its northern and southern edges. This area is of great interest to prehistorians and palaeo-climatologists as there are remains of ancient civilizations and richer environments in the past buried under its sands.

A joint Chinese Academy of Sciences and University of Arizona (U.S.A.) research project has started up to study the long-term processes of desertification in the Tarim Basin. The objectives of the project are to characterize past desertification trends, identify the causes, and use this knowledge to formulate water management plans. A system for monitoring desertification will also be established.



Workers tend tree saplings at the Yichinholo Forestry Farm, Inner Mongolia.

The multidisciplinary project will make use of palynology, geomorphology, sedimentology and dendrochronology (tree-ring dating) to reconstruct past climate and environment; archaeology to study past land use and settlement patterns; and remote sensing to investigate recent land use and water management. Remote sensing will also be used to look at more recent environmental change and the technology will be applied to the desertification monitoring methodology.

This project is based on a growing realization amongst development planners that a good knowledge of the past is essential to understanding how best to plan for the future.

Spotlight on India

Desertification in Rajasthan

Mr. Indra Kumar Sharma has written to us about anti-desertification measures in Rajasthan. He points out that the unreliability of the rains has increased as a direct result of deforestation since the dry air currents rising off the hot ground dispel weak monsoonal fronts whereas in contrast the warm moist air rising from vegetated areas promotes the build-up of local thunderstorms so that areas of dense vegetation receive 40 per cent more rain than neighbouring deforested areas. A number of water collection methods are suggested including diverting run-off from roofs into underground tanks and the construction of ponds which should be lined with mud or lime to reduce infiltration. The banks around these ponds should be tree-lined to act as wind-breaks thereby reducing evaporation from the surface of the water. Desilting of the ponds is essential, the silt being a useful addition to arable soil. Deeper wells, or *pukka,* should also be excavated nearby to supply water during droughts.

Mr. Sharma recommends the addition of animal and household waste to soil in order to raise the water retention properties of the soil while the construction of 20-centimetre high bunds *(Khadin)* is a common practice in the state to increase the infiltration of rain water for winter cropping. Shallow cultivation is also practised as this reduces run-off. The extra moisture in the soil is used to advantage for early sowing of crops having a low water requirement such as millets, sorghum, cluster bean and *Phaseolus aconitifolis.* Field observation shows the substantial benefits of agroforestry, since the trees not only provide fruit, fuelwood and fodder but also serve as wind-breaks. They also reduce the parching of topsoil and reduce the erosive intensity of heavy rainfall.

The author advocates the provision of subsidised grain during famines and possibly food-for-work schemes so that labour can be used during famines to construct these permanent anti-desertification measures, particularly lined water reservoirs which should be covered to avoid contamination and evaporation. During normal periods, Green Belt schemes and large-scale reforestation programmes should be initiated.

Greening the Arid Wastes

A success story from India

In the state of Kerala in south-western India, desertification control is proving a success with one NGO project in the Attapady Tribal Development Block. This is an area of 765 square kilometres which has suffered extensive deforestation and land degradation, particularly in the last ten years when population has increased from 51 people per square kilometre in 1976 to 92 persons today, while forest cover has been reduced from 80 per cent to 10 per cent over the same period. This hilly region receives annual rainfall of 800-1000 mm and is also susceptible to erosion from strong winds.

The project is sponsored by the Council for the Advancement of Rural Technology, and reclamation work has included soil conservation measures and reforestation. Gullies have been repaired using pits, bunds and filter dams in order to reduce runoff and soil loss, and to increase water infiltration. Indigenous pioneer trees such as *Ciris* and *Acacia* spp. have been successfully re-established with 70 per cent of seedlings alive and healthy.

The success is due to a number of factors such as local participation, the provision of employment during the season of low agricultural work, the simplicity of the measures and the guarantee that the local people will be able to reap the rewards of their labours by sharing the produce. In addition, the mistake of providing smokeless stoves has been recognised and new fuel-efficient stoves have been introduced.

The project's success owes much to improvisation, innovation and adaptation of the locals and it is hoped that the achievement will be emulated elsewhere. Readers who may wish to know more about the project should contact Mr. C.J. Punnathara, Press Trust of India, 4, Parliament St., New Delhi 110 001, India.

Desertification Control: the Bishnoi Approach

An unusual socio-religious approach to the prevention of desertification is reported from India where a sect of the Hindus forbids the felling of trees or the killing of wildlife. The Bishnoi sect was founded in 1451 and today it is thriving as an agricultural community on the edge of the Thar desert in western Rajasthan and southern Haryana states. Its founder recognised the connection between famine and man's over-exploitation of his environment and the result to this day is visible in the form of an oasis of greenery amid the wastes of Rajasthan. A unique institution in Bishnoi villages is the 'Ouran' which is a combination of mini-forest and wildlife sanctuary. An important feature of the cultivable land is the protection of *Prosopis cineraria* trees whose long tap-roots not only ensure that they have access to deep sources of moisture making them independent of irrigation but also make cultivation around them easy. The tree acts as a windbreak and its canopy reduces the erosivity of the rainfall while its light shade has a cooling effect on the soil. The leaves provide fodder for livestock during droughts and the pods are a source of protein.

The Bishnoi's conservation of their environment has protected them from the ravages of famines suffered by their non-Bishnoi neighbours and the sect would like to promulgate the use of *Prosopis* to other arid areas at risk from desertification. For this to be successful, education, incentives and the establishment of nurseries for the dessemination of seedlings are all required. Those interested are asked to write to Mr. R.S. Bishnoi, Defence Colony, Dehradun 248005, Uttar Pradesh, India.

Social Forestry or Commercial Monoculture in India?

A controversy from Karnataka

(Extracted from a report 'Social Forestry in Karnataka: an Impact Analysis' by D.M. Chandrashekhar, B.V. Krishna Murti and S.R. Ramaswamy, 1987.)

Large areas of India have been denuded of their natural forest in the 20th Century as a result of land clearance for agriculture, timber production, resettlement schemes and hydro-electric projects. These losses have been exacerbated by land degradation, overgrazing and forest fires.

In the state of Karnataka, many of the bamboo stands have been destroyed for the paper industry while timber has been taken for the manufacture of rayon and building materials, or charcoal for the blast furnaces.

A jointly-sponsored World Bank/ODA project on Social Forestry (1983-88) promoted the planting of mixed forest stands for the provision of fuelwood, fodder, food and mulch for the rural people. In reality, what has been created is a monoculture of *Eucalyptus tereticornis* for the rayon and paper industries. Not only is the species not appropriate to several parts of the state (40,000 hectares were destroyed by the fungal "Pink disease"

Large areas of the Western Ghats in Karnataka have changed from thick forests to bare laterite in the 20th century. This barren hillside nevertheless received 5000 mm of rain a year. (UNEP/Daniel Stiles).

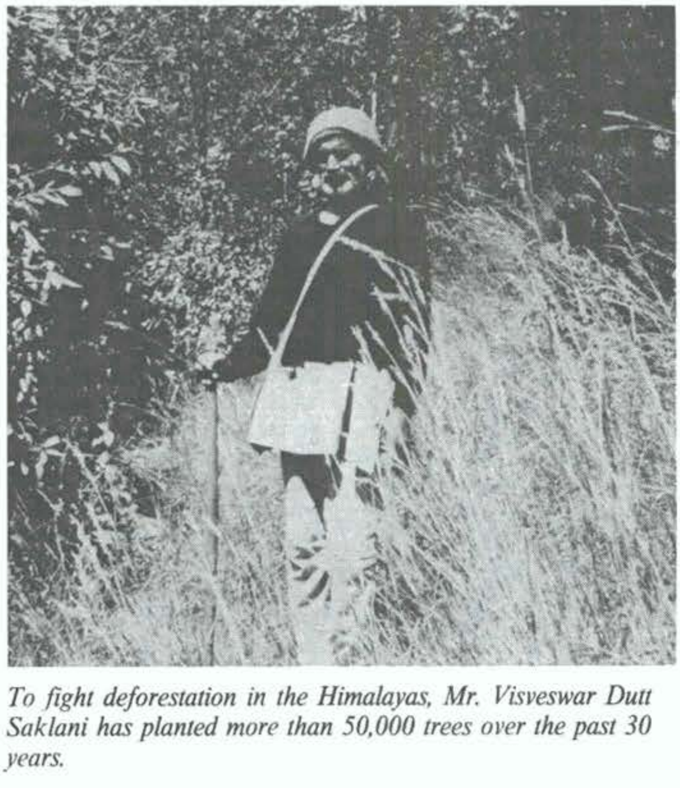
owing to the planting of trees in a high rainfall area), but the tree cannot be used as fodder or as a source of food or mulch. Although the residue from the trees (leaves and twigs etc.) are used for fuel, and this can account for thirty per cent of the biomass per tree, less than three per cent of the total number of logs are sold as firewood.

At the end of 1986, 0.5 million hectares of Eucalyptus and "Fuel and Mixed" stands have been planted, but the latter category is still 87-92% Eucalyptus.

The source of contention is twofold. First, the National Commission on Agriculture in the 5th Five Year Plan stressed the importance of social forestry whereas what has developed is a monoculture of Eucalyptus, mainly on private land and almost wholly in the interests of the commercial forestry sector. Second, Eucalyptus has been planted on previously arable land since large landowners, faced with surrendering their tenanted lands to the tenants, or their uncultivated lands to the State Government, suddenly saw a lucrative method of retaining their land for minimal inputs. Until recently, the larger the land-holding, the greater was the proportion planted with Eucalyptus. But now smallholders are planting the trees in order to supplement their meagre incomes. However, they tend to plant the trees on shallow soil around their fields where "ragi", the staple cereal, is grown. The Eucalyptus roots spread horizontally taking both moisture and nutrients from the soil, resulting in reduced crop yields leaving an area of "desert" up to a radius of 15-30 metres from the trees.

The ODA review stressed that the social forestry project was designed to meet the forestry needs of the poor by providing fodder for animals and fruit, food and mulch for the people. Instead, the project is serving short-term industrial interests and is not based on sound ecological management. By 1988, a further 220,000 hectares of Eucalyptus will be planted on overgrazed land in a Wasteland Development project and this is seen as an exacerbation of the shortage of livestock feed. Protests are increasing against such Government schemes and many sectors of the community are calling for a lessening of Eucalyptus planting in favour of more socially acceptable or native tree species that will provide livestock fodder and other benefits.

Further information can be provided by writing to Mr. S.R. Ramaswamy, 'Keshava Shilpa', Kempegowda Nagar, Bangalore 560019, India.



To fight deforestation in the Himalayas, Mr. Visveswar Dutt Saklani has planted more than 50,000 trees over the past 30 years.

Energy and Environment Group

Himalayan Ecosystem Development Programme

The Himalayas is one of the most endangered ecosystems on earth and every effort is needed to preserve this vast resource, on which more than one-third of the total population of the subcontinent is dependent. Government cannot do this alone. It needs the support and participation of local populations which is often achieved through voluntary agencies or Non-Governmental Organizations (NGOs). The NGOs are losing sight of their priorities and are diverting their energies to activities other than soil conservation and tree planting, suggesting that they are short of resources and ideas. The Energy and Environment Group's Himalayan programme aims to bring together these NGOs with the purpose of identifying their ideas and their need for resources. A resource centre for technical and funding information and technology is being planned at Delhi.

Anyone who can help develop this programme is welcome to participate. Please contact:

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BOOK REVIEWS

Drylands Dilemma: a solution to the Problem

The Economics of Policy and Planning

Government of Australia, Conberra, 1987.
24 pp.

A superbly illustrated brochure on desertification has been produced by the International Project on the Economics of Dryland Degradation and Rehabilitation, which is chiefly sponsored by the Australian Government, UNEP and the East-West Center. The report is a general overview of the economic importance of drylands and an extensive discussion of the perils of land degradation and its effect on the rural poverty trap. It also attempts to show the wider impact of desertification at both the national and international level and then presents a synopsis of the collaborative programme on the economics of dryland degradation. The aims of the initiative are to increase awareness of the magnitude of this global problem by publishing an Executive Report for senior Government, NGO and Aid officials; a technical guide for project analysts, economists and planners; and a Case Study Reader in which successful projects will be analysed to provide solutions to various dryland management problems. This document is particularly useful in that it illustrates the role, methods and design of economic analysis as an important corollary to the ecological dimension of dryland degradation.

Desertification: Financial support for the Biosphere

edited by Y.J. Ahmad and M. Kassas

Hodder and Stoughton, London, 1987
187 pp.

This book, sponsored by UNEP and prefaced by UNEP's Executive Director, deals with ideas for raising the huge sums required to arrest desertification estimated at $4.5 billion per year for the 20 years following the UN Plan of Action to Combat Desertification (PACD) drawn up in 1977. The book is an edited version of three reports prepared by specialists in international financing, and each report deals with measures for financing the implementation of the PACD. Ideas for raising the funds vary from taxes on trade surpluses, satellites, military sales and polluters, to income from the use of the international commons to the sale of IMF gold reserves. The authors and editors recognise that the problems are not practical or technical but rather to be found in the lack of the necessary political will which finally determines the level of financing. The report also stresses the need for 'automaticity' of financing, or in other words the need for sustained, predictable and assured financial resources for the global problem of desertification. The reports will be a useful source of ideas to other specialists concerned with the problem of raising the ever-increasing funds needed for the reversal of environmental degradation.

The Greening of Africa: Breaking through in the Battle for Land and Food

by Paul Harrison.

Paladin Grafton books, London, 1987.
380 pp.

This eminently readable book was written in the wake of the most serious famine yet seen in Africa. The book is divided into three sections. In the first section, the Challenge, an attempt is made to explain the causes of the disaster: the high rate of population increase which led to the food crisis; the extreme poverty; the debt crisis; and finally, the man-made environmental crisis which is exacerbated by the burgeoning population. The author goes on to explain why the record of Aid schemes in Africa has been so dismal and suggests that not enough has been spent, wrong policies pursued and the smallholder ignored. He then starts to highlight the success stories in the second section, the Response, particularly in the field of anti-desertification, water conservation and forestry. In some interesting case studies, Zimbabwe's success with both population control and food production provides ample evidence that changes for the better can appear rapidly once the political will is there. Other countries leading the way include Kenya's success with tree planting and Burkina Faso's Naam movement for self-help. In the final section, entitled The Lessons, Mr. Harrison suggests that African farmers are both adaptable and inventive but stresses that it is imperative for them to intensify food production before the spectre of population density compels them to. For this, economic incentives and effective extension are seen as the key to success to achieve a Green Revolution for Africa. He points out that on present trends, disaster will carry the day: at present, the rate of deforestation is thirty times greater than reforestation while food production *per capita* falls steadily each year. To reverse this trend, new techniques such as alley cropping and agroforestry, fuel-efficient stoves and alternative energy sources must be disseminated. The keys to success are seen as participation, empiricism and flexibility which must go hand in hand with population control, conservation of natural resources, effective extension and the development of low-risk enterprises.

The book contains a useful source of statistics and some informative maps on rainfall amount and variability, soils and vegetation, desertification and erosion, disease and tsetse distribution, and population and fuelwood availability. The Greening of Africa is both a refreshing and an optimistic book but at the same time it should not mislead the reader in thinking that the appalling prognosis for Africa is unwarranted.

Weather and Climate
World-wide Weather
Edited by K. Takahashi

A.A. Balkema, Rotterdam, 1986. 252 pp.

This book, originally written in Japanese, contains chapters written by separate authors on various aspects of meteorology. It is divided up into three sections: the first part concentrates on global aspects of the subject such as long-range forecasting, long-term trends and fluctuations in climate, and the next Ice Age. It also deals with the effects of water and solar activity on weather patterns. The second part of the book describes meteorological phenomena such as cyclones, tornadoes, blizzards and drought that are peculiar to specific man and weather patterns and climate changes. It discusses such diverse topics as air pollution, the effects of jet streams and clear air turbulence on aviation, urban micro-climates and the effect of agriculture on the climate. Some useful statistics on rainfall and temperatures are given at the end of the book.

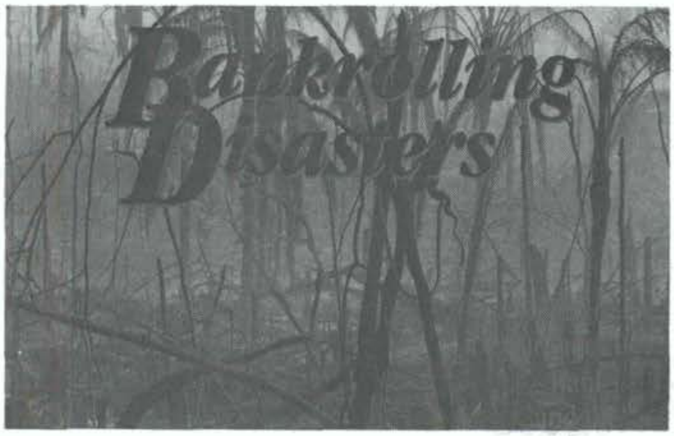
This is a well-translated, informative and enjoyable introduction to the subject of meteorology and climatology designed for the general reader with no previous knowledge of the subject, and it is recommended easy reading for anyone who wishes to acquaint himself with weather and the relationship between weather and man's environment.

Weather and Climate. Changes in Global Climate
A study of the Effect of Radiation and other Factors during the present Century. by K.Y. Kondtat'eve

A.A. Balkema, Rotterdam. 1986. 280 pp.

This is a more technical book than World-wide weather above and it is designed for the specialist climatologist but still of interest to the general reader. The book is divided into three chapters. Chapter I deals with recent trends in climate changes and discusses at length both variation in the solar constant and the radiation budget of the earth. Chapter II links these climate changes to changes in the gaseous composition and radiant heat influx of the atmosphere, with particular emphasis on the 'greenhouse' effect and to variations in the ozone content of the atmosphere. The parameterization of radiation processes in the circulation model of the atmosphere, theories on the climatic effect of a thermo-nuclear war and the sun-stratosphere relationship are also topics examined in detail.

The final chapter deals with the effect of natural (e.g. volcanic ash or dust) and man-made aerosols on radiative heat transfer and climate. The author makes it clear that the precise effects of aerosols remains controversial and little-understood. For example, although the emission of industrial aerosols has increase by 20-30% in the USA during the 1970's, no change in the transpareney of the atmosphere has taken place in the last fifty years, once sporadic variations have been excluded, despite an increase in haziness in urban areas as detected by satellite pictures. Stratospheric aerosol is given special attention owing to its long residual effect and its possible role in alterations in the climate. The increasing concentrations of sulphur and chlorofluorocarbons in the atmosphere is a topic of special concern and is covered at length. An appraisal is also made of the changing surface and atmospheric albedo and its possible affect on global temperature. The author sees the main barrier to a complete understanding of the role of radiation factors in climate as the inadequate data on global aerosol, particularly with regard to its distribution, dynamics and physical-chemical properties, and he urges experimentation under both natural and laboratory conditions.



The book, translated from Russian, is a detailed examination of the external factors, principally variations in solar constant, in gaseous composition and in aerosol content that may be contributing to climatic change. In view of the recent UNEP conference on the ozone layer, and the concern over the expanding uses of halocarbons, the monograph is relevant to all environmentalists and makes useful reference material.

Land Use in Africa: Land Use Policy
Volume 3(4). pp. 246-372

Butterworths, London 1986.

A whole volume of this journal is devoted to land use in Africa. The first three papers deal with land use, desertification and irrigation while the next three papers discuss land use and rural development issues in three selected regions of the continent, namely East Africa, the West African Middle Belt and the Zambezi Valley. A large number of useful statistics are to be found, particularly in the general papers, and in addition the journal has sections on conference and book reviews and shorter papers which are in the form of essays on aspects of land use planning and related topics.

Bankrolling Disasters
International Development Banks and the Global Environment

Sierra Club, Washington D.C., 1986

The Sierra Club is an American-based non-profit organization which promotes sound environmental policies throughout the world. This publication takes a hard look at the role of the multi-lateral development banks (MDB) and suggests that, far from improving the standard of living of the poor, many of their projects have the opposite effect by failing to foresee the side-effects of the schemes and by ignoring the need for sustainable development. Four case studies are taken to illustrate some of the failures of MDB projects. These include the Polonoroeste project in Brazil in which landless peasants were given primary forest to cut down and cultivate only to find that the soil was unsuited for sustained cropping. Not only did this increase the rate of deforestation and ecological degradation, but the farmers were forced to sell their land to cattle ranchers and enslave themselves at subsistence wages.

The workings of the MDB's are explained clearly and logically: the source of funds, project

financing, loan repayments and project appraisal are all described. The Sierra Club is an environmental pressure group which is clearly concerned about the harmful social and environmental effects of some of the MDB-financed projects and it sets out objectively and dispassionately to bring these failures to the attention of the ordinary citizen of both donor and recipient countries and explain how the individual can influence the World Bank in its policies.

Arid Zone Research: Scientific reviews Vol. 3

edited by H.S. Mann.

Scientific Publishers, Jodphur, India, 1985
250 pp.

This is the third volume of a series based on interdisciplinary research into the practical problems and solutions of the management and use of arid lands.

The papers cover many aspects relating to the drier regions of the earth, varying from geology and pedology to anthropology, zoology and animal nutrition.

Two reviews are made of the soils of arid lands. The first is an overview of their classification based on their chemical and pedological properties. The failure of soil scientists to agree on a standardized system of classification is seen as a hindrance both to technology transfer and to the correct management of these soils. A brief introduction is given to the genesis of the soils and to their agricultural potential. The second review focuses specifically on the Sahara, describing the four major land use regions, which varies from the nomadism of the Sahel to the intensive irrigation of the Nile Valley, and offers suggestions for the exploitation of this desert zone based on climate and soil type.

A further set of three papers deals with desertification. The first discusses the role of geomorphological studies in desertification control and gives examples of the value of applied geomorphological research in the study of ecosystems, with reference to the formation of arid landforms and dunes, and the effects of erosion and sedimentation on land use. The second review examines the definition of desertification with reference to its causes, its preconditions and its effects, while a third paper looks more specifically at the relationships between desert and man. A fourth paper, written in French, discusses land degradation in the Sahel and ascribes it to overpopulation, overgrazing and reduced rainfall.

Three papers deal with animal-related topics. There is a review of nutrition and reproduction of sheep in Queensland, a paper on the effect of high temperature on poultry production and a technical paper on helminthology in birds of arid zones. Two other papers relate to the establishment of crested wheatgrass in the rangelands of North America and to sociological aspects of agnation in the Middle East.

This book contains a wide-ranging choice of papers for those interested or involved in the problem of desertification and the related, but more specialized, topics dealing with the biological or physical environment in arid lands.

Combating Desertification in Developing Countries Arid Zone Research.

Vol. 4

edited by J.K. Jain.

Scientific Publishers, Jodphur, India, 1986
315 pp.

This is a compilation of the twenty country reports prepared and presented to the United Nations Conference on Desertification (UNCOD) in 1977. The countries range across the complete spectrum of climate and stage of development, from Kuwait to Ghana, and from Australia to Bangladesh. Each report discusses the causes and extent of, and the measures to halt desertification. The scale and rate of increase in desertification is now well-known but a decade after the conference, the situation is yet more serious and the human tragedy that resulted from it in 1983-5 was of an unprecedented scale. In addition to the vicious circle of poverty and land degradation, desertification is also blamed on administrators, economists and politicians who give low priority to the problem and who fail to see the fight against desertification as an integral part of social and economic development. Moreover, the international banks are criticized for encouraging short-term projects which are expected to yield rapid returns in areas needing long-term development. The successes in desertification control are highlighted, while the positive correlation between under-development and desertification is a recurring theme.

The book has much useful information on the natural resource base of these twenty countries which are discussed by continent. It will be an invaluable reference for planners and specialisits in the field of desertification.

Troubled Waters: New Policies for Managing Water in the American West

by M.T. El-Ashry and D.C. Gibbons

World Resources Institute Study 6, 1986

This is the first product of WRI's Arid Land Project and discusses the use of water resources in the western states of the USA, particularly in California where irrigation and the high indigenous growth rates and immigration have resulted in increasing demand for water. There is increased likelihood of serious water shortages in the area since many of the supplies come from groundwater whose rate of extraction has far exceeded replenishment. The authors explore the nature of the water demand and suggest that western water should be made to work harder. Policies for water management and the anachronistic water laws of the West are discussed at length. The authors emphasise the need for reducing the cost of water supply by increasing the efficiency of water use and by sensible reallocation of existing supplies. They also describe the widespread problem of salinity in the region.

The book has many cautionary tales that are of relevance to other countries where over-exploitation of water resources is leading to a shortage of Nature's most precious resource. Many of the recommendations in Troubled Waters, when adapted to prevailing social, cultural and economic conditions, could contribute to increasing the productivity in other countries and it will prove an invaluable study for anyone involved in water resource management in semi-arid and arid-zones.

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 hand corner.

Metric system

All measurements should be in the metric system.

Tables

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

Illustrations

Line drawings of any kind should each be on a separate page, drawn in black china ink and double or larger that 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 that 4,500 words are not accepted.

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

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