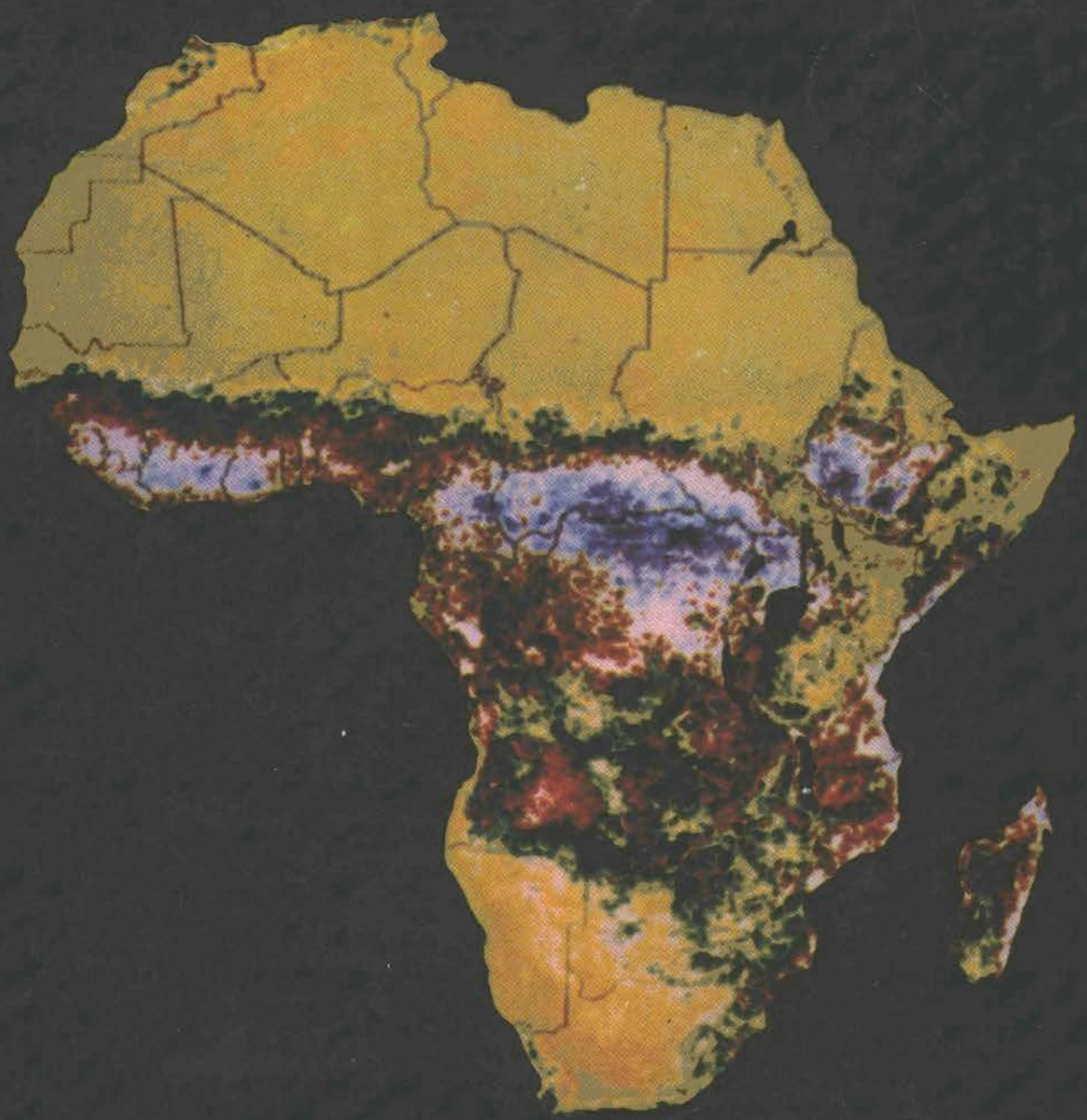
United Nations Environment Programme

ISSN 0379-2455

Desertification Control Bulletin

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

Number 13, 1986



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

- This was the first worldwide effort ever initiated to consider the global problem and responsibilities posed by the spreading deserts.

- 95 States, 50 United Nations offices and bodies, 8 intergovernmental organizations and 65 non-governmental organizations participated.

- The United Nations Conference on Desertification prepared and adopted a worldwide Plan of Action to Combat Desertification (PACD) with 28 specific recommendations.

- The Plan of Action was approved by the United Nations General Assembly at its 27th session on 19 December 1977.

- Recommendation 23 of the Plan of Action invited all relevant United Nations bodies to support, in their respective fields, international action to combat desertificaton 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 and ACC in carrying out their tasks in the implementation of the Plan of Action.

- One of the main functions required by the Plan of Action from the Desertification Unit was to prepare, compile, edit and publish at six-monthly intervals a newsletter giving information on programmes, results and problems related to the combat against desertification around the world.

Editors:

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

Stanislaw Sangweni
Desertification Control
Programme Activity Centre

Seifulaziz L. Milas
Information Service

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United Nations Environment Programme No. 13 1986

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COVER PHOTOGRAPH

AVHRR image of Africa. The tan, brown and tan-orange colours represent small amounts of green leaf activity, the gold colours represent modest amounts, the greens higher amounts, and the reds and purple the highest amounts. (Photo: NASA/Goddard Space Flight Centre)

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

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

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

A farewell note to the readers

Editor's Note: Mr. Gaafar Karrar, a member of UNEP's Desertification Unit at its inception in 1978, served first as Principal Officer and then as Acting Head of the upgraded Desertification Branch and now Desertification Control Programme Activity Centre. He retired from the United Nations in August 1985. Mr. Karrar was a dedicated, hard working professional who was much liked by his desertification control colleagues, as well as by all those who had the privilege of working with him in and outside of UNEP. The Editors of the Bulletin join the entire staff of UNEP in wishing Mr. Karrar our very best wishes for a long and fruitful retirement. We also take this opportunity to extend a warm welcome to Mr. Robert N'Daw, the new director of DES/PAC

Mr. Gaafar Karrar

On the occasion of my retirement, after having served UNEP for ten years, I think it is appropriate to make my last communication with the many people involved in the field of desertification through this Bulletin. While conveying to its readers what goes on in this field, the Bulletin also tells how we, the staff of UNEP in general and the Desertification Control Programme Activity Centre (DES/PAC) in particular, are contributing towards the battle to contain desertification.

In 1975, experts and consultants were summoned from throughout the international community to prepare for the United Nations Conference on Desertification, scheduled for 1977. Ralph Townley, the Director of the Secretariat for the Conference, is remembered advising those requesting preparatory materials that, "if they wanted to read a book on desertification, they should first write one themselves". His statement clearly assessed the dearth of available publications about the age-old phenomenon now commonly referred to as desertification. By 1982, however, a bibliographic search revealed more than 320 references to the topic.

UNEP's Assessment of the Progress in the Implementation of the Plan of Action to Combat Desertification, done in 1983/1984, found that publications were in the thousands, while institutions involved in research and/or training in the field of desertification exceeded one hundred. Scientists, economists, sociologists and others working in the field numbered into several thousands. The DES/PAC will publish these findings before the end of 1985 in the form of two directories. One is devoted to Africa, and the other is international in scope. They will list institutions, organizations and personnel working on desertification and demonstrate the exponential growth that has taken place in desertification related activities in the past decade.

This vast growth, documented in the supporting work on the problem of desertification, unfortunately has not been commensurate with desertification control efforts. Desertification control has been somewhat neglected and hampered by many constraints. After an extended period of resource mismanagement, we have worked ourselves into a state of environmental bankruptcy and now the debt has come due. We've realized that there can be no quick-fix solutions for a degraded environment and that rescheduling environmental debts with Nature is impossible.

In 1983/1984, the African Crisis was Nature's declaration of environmental bankruptcy due to unsound agricultural policies in several countries. The end of 1985, however, may turn out to be a new era offering an opportunity for rehabilitation of lost ground. But this requires far more serious consideration, and very hard work based on careful long term planning.

This Bulletin has a devoted staff behind it who have vowed to do their utmost to achieve success in the battle against desertification. It is a vehicle of information and here it is safe to say that the amount and quality of information service is, broadly speaking, directly proportional to the amount and quality of information that we can obtain from governments, institutions and others engaged in the field of desertification.

Encouragingly, the print number of the Bulletin has grown from some 900 since the No.6 issue to 4000 for this current issue (No. 13), and the mailing list has grown by more than 1000 in the last two years! It is gaining tremendous popularity. Let us all work together to reverse an exceptionally dangerous, and deteriorating situation on our planet. We will succeed.

Satellite remote sensing of desert spatial extent

Compton J. Tucker and
Christopher O. Justice
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771 USA

Two methodologies for the satellite-derived determination of continental and global estimates of desert spatial extent have evolved over the past few years. These new methodologies, based upon National Oceanic and Atmospheric Administration (NOAA) polar-orbiting meteorological satellite data and, to a lesser extent, Landsat data, and concurrent ground studies, provide the means for repeated assessment of desert extent over large areas at a reasonable cost. The methodologies are based upon the ability of satellite sensors to provide cloud-free coverage of the terrestrial surface at frequent intervals while: (1) documenting the presence of green leaf biomass in areas receiving more than 250 mm precipitation per year and (2) recording the density of dormant natural vegetation in areas receiving less than 200-250 mm precipitation per year. Whereas in the past the areal extent of deserts have been broadly determined by climatic and bioclimatic parameters, the most promising of the two satellite methodologies is based on the actual measurement of biotic activity over multi-year observation periods.

It is apparent that the use of ground-based survey for obtaining information relating to large-scale desert spatial extent is at best limited. Not only must the ground teams survey vast areas but the observations of different groups must be synthesized, which then leads to the task of reconciling disparate observations. Furthermore, the use of traditional methods for the repeated production of internally consistent maps and spatial statistics is not feasible for areas on a continental or global scale. The impracticality of traditional methods is illustrated by the widely varying estimates of the surface area of world land cover types (Ajtay et al., 1981). An alternative approach is to use satellite remote sensing data with their synoptic overview as a basis for mapping. In several studies remotely sensed data have been reported to accurately map vegetation, crops, and other land-cover types (Bauer et al., 1979). The majority of these studies have used Landsat data and have been restricted to localized areas, in part due to the resolution of the Landsat system.

The reason why Landsat studies have been localized, for example, is that it takes approximately 1,100 Landsat scenes to cover an area the size of the African continent. Not only would this be expensive ($700,000 US) for single date coverage but the logistical and data processing requirements would be sizable if the data were used in the digital mode. It is also mandatory to collect several images per year for any given point to overcome cloud problems, provide optimum discrimination between land cover classes, and monitor changes in land cover over time. Consequently, the use of Landsat data for continental and global-scale inventory is impractical and for financial and logistical reasons may be impossible.

An alternative to Landsat is the Advanced Very High Resolution Radiometer (AVHRR) sensor carried on the NOAA operational meteorological satellites. Such data have already been shown to be useful for mapping vegetation over modest areas (Gervin et al., 1985), as well as regional and continental areas (Justice et al., 1985; Tucker et al., 1985a). AVHRR data have much coarser resolution (1 and 4 km) than Landsat (80 m resolution) and hence a lower data volume and cost. More importantly, the AVHRR 4-km data are available daily on a global basis.

There are two general categories in which satellite data can be used to determine desert spatial extent. These two categories are (1) areas receiving less than 200-250 mm precipitation per year and (2) areas receiving more than 200-250 mm precipitation per year. In the first situation, albedo or reflectivity techniques are used after Otterman (1974, 1977, 1981, 1985), Otterman and Fraser (1976), Otterman and Robinove (1981, 1982), and Otterman and Tucker (1985).

Areas with less than 200-250 mm precipitation per year are characterized largely by the absence of green leaf material or green leaf cover. In this case, dormant desert vegetation produces a strong darkening of the surface or reduction in reflectivity in all spectral bands. This results from the fact that the vegetation present, and associated plant litter, commonly have lower reflectivities than the exposed soil or background material. Otterman (1985) has described this theoretically as well as with Landsat multispectral scanner data (Otterman 1974, 1981; Otterman and Fraser 1976; and Otterman and Robinove 1981, 1982) and NOAA AVHRR data (Otterman and Tucker, 1985). Reductions in bare soil reflectance of approximately 40% can result from sparce dormant vegetation cover (Otterman, 1977).

Systematic use of the albedo or reflectance techniques for desert boundary definition has been hindered by the difficulties in extrapolating between satellite images. Graetz et al. (1982) have reported that small variations in surface conditions for any one soil, for example the degree of erosion or disturbance, result in appreciable changes in absolute reflectance. Thus, not only must atmospheric conditions, time of day, and time of year be taken into account but surface soil condition(s) must also be documented.

This paper will review in more detail the use of satellite data for monitoring desert spatial extent in areas that receive more than 200-250 mm precipi-

tation per year by a technique that defines zones of green leaf biomass around their periphery. This technique of remote biomass measurement is widely used (reviewed in Tucker 1980; and Curran 1983) and has been tested in the Sahel in Senegal in collaboration with a United Nations Environment Programme/Food and Agricultural Organization project (Tucker et al., 1985b). It has been demonstrated that combinations of remote sensing measurements in the red region of the spectrum (0.6-0.7μ) and near infrared region (0.75-1.0μ) are highly and directly correlated to the intercepted fraction of the photosynthetically active radiation (0.4-0.7μ) (Asrar et al., 1984, 1985a; Daughtry et al., 1983; Hatfield et al., 1984; Kumar and Monteith, 1982; Sellers, 1985; Wiegand and Richardson, 1984). This results from the strong absorptance of incident radiation in the 0.6-0.7μ or red region of the spectrum by chlorophyll present in the leaves of green vegetation and the high reflectance in the absence of absorption in the near infrared region of 0.75-1.0μ (Gates et al., 1965; Woolley, 1971; Knipling, 1970). Various combinations of these two wavelength regions have been used to infer properties of green vegetation using ratios, differences, and other transformations of these two wavelength regions (Tucker, 1980; Curran, 1983).

The NOAA satellites provide the ability to apply this technique frequently (the approximate mean orbital period is 9.2 days) and thus record the seasonal vegetation dynamics of semi-arid zones. This is illustrated by Figure 1 which shows the ability of the NOAA AVHRR to document transient areas of green vegetation development in Mauritania in 1982. It is important to remember that temporal resolution or frequency of observation can be crucial in arid and semi-arid zones because of the often erratic precipitation events and rapid response of the vegetation.

The data used to produce Figure 1 were a combination of 1-km and 4-km AVHRR data. These data were obtained from NOAA and were processed on a Hewlett Packard 1000 computer system at the NASA/Goddard Space Flight Center. All data were mapped to a Mercator projection

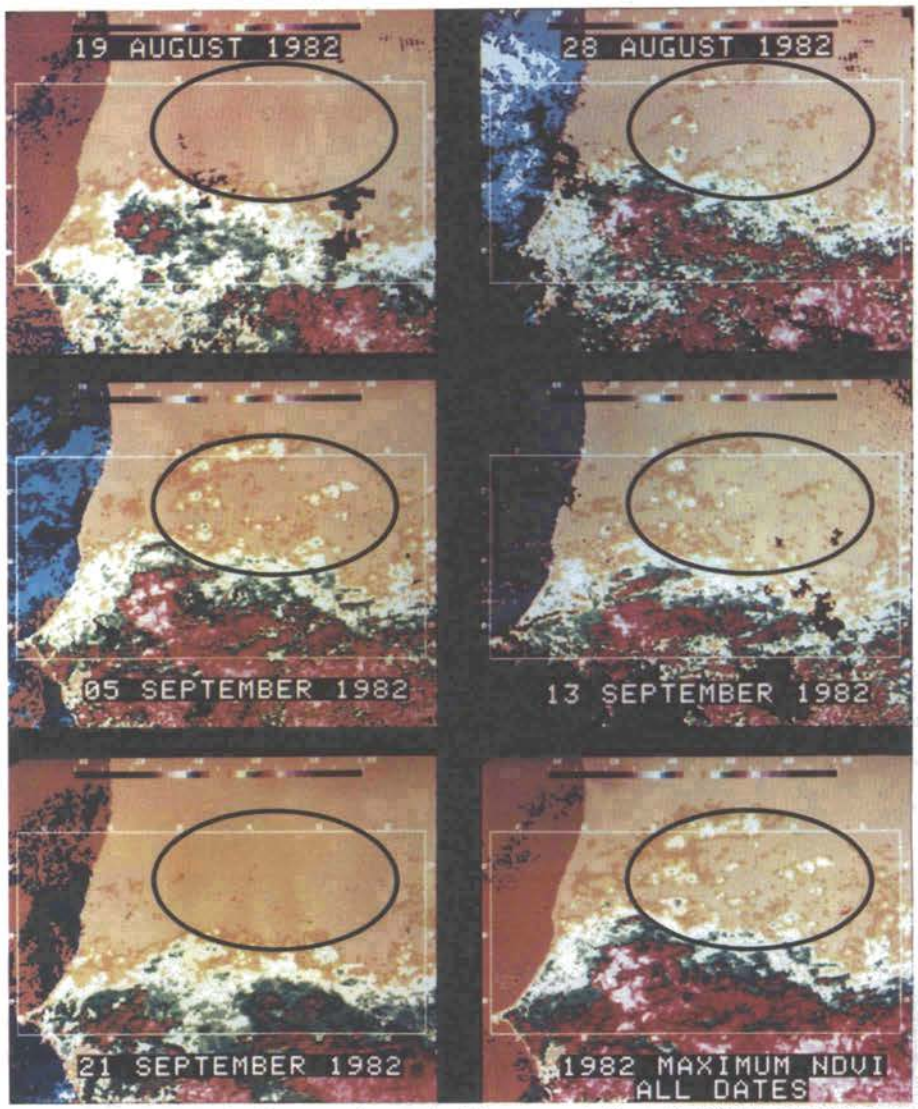

Figure 1: Time series development of green leaf biomass as indicated by NOAA-7 AVHRR data for southern Mauritania and northern Senegal in 1982. Note the complete cycle of green leaf biomass development in southern Mauritania occurred within an 18-day period. This graphically illustrates why AVHRR data are the only satellite data source capable of detecting these transient patches of green biomass development because temporal resolution is crucial while spatial resolution is not (from Tucker et. al. 1985b).

using AVHRR channels 1 (0.55-0.68 μ) and 2 (0.73-1.1 μ) to form a registered multitemporal data set of normalized difference vegetation index (NDVI) images. AVHRR channel 5 (11.5-12.5 μ) was used as a cloud mask where objects cooler than 10° C were excluded from further analysis. Data from several days were used to form cloud-free composite images. While 1- and 4-km data were used to form the data in Figure 1, 4-km data were used to produce 21-day normalized difference vegetation index composite images of the entire African continent for the time period of April 1982 through February 1985.

Figure 1 shows the ability of the NOAA AVHRR sensor to document the temporal dynamics of green vegetation biomass in a semi-arid area. Expanding this concept to the continent of Africa, inspection of the multitemporal green leaf vegetation dynamics for deserts and other land cover types is illustrated in Figure 2. The point to be drawn from Figure 2 is that a means can be developed to determine desert areas by the absence of apparent green leaf biomass. That is, we can select the decision rule that over a multiyear period "deserts" will be defined as areas where no detectable green leaf biomass developed. By selecting areas where agreement exists as to the land cover present, these "training" sites were used to label Africa into various land cover classes (Figure 3).

African normalized difference vegetation index data for a 12-month period were used to produce a preliminary classification of land cover into broad classes of desert and semi-desert; semi-arid grassland, savanna, and bushland; and more humid areas. Training sites were selected based upon agreement of existing vegetation maps and field experience of colleagues and used to label the feature space formed by the first two principal components of the 12-month data set after Tucker et al. (1985a) and Townshend et al. (1985). The labeled areas were then used to classify the entire continent of Africa into these cover classes. Several qualifications need to be made regarding this classification. First and foremost, Figure 3 is a preliminary application of a methodology for land cover assessment, including deserts. It demonstrates that the needed data can be obtained, managed, and processed to produce large-scale land cover estimates. Second, no formal accuracy assessment of Figure 3 has been carried out. It is mandatory that several representative test sites be selected at regional and national levels to determine the accuracy of assessments like those in Figure 3. If errors are found, these can then be used to refine the classification techniques. Third, it is imperative that data from several years must be used to compensate for yearly variation in climate.

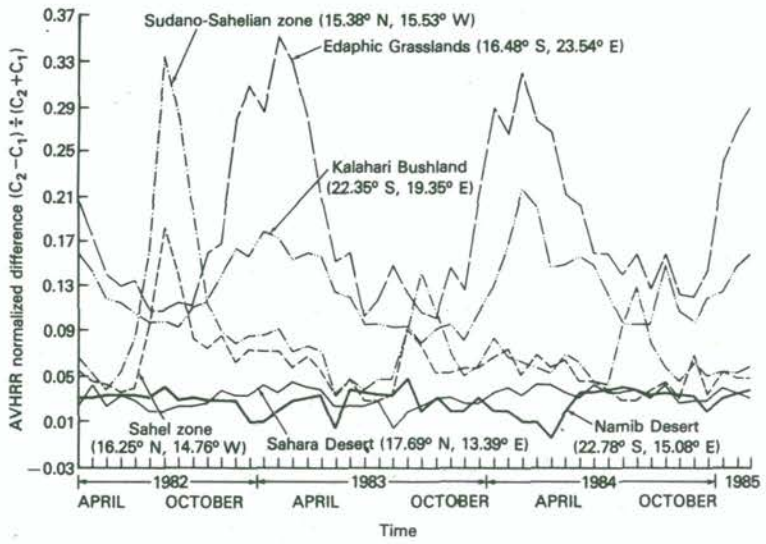

Figure 2: AVHRR normalized difference vegetation index (NDVI) plotted through time for 6 African locations. Note the low response of deserts and the low values for the Sahel area in 1984. Desert areas are defined as those locations with NDVI values of -0.02 to° 0.04.

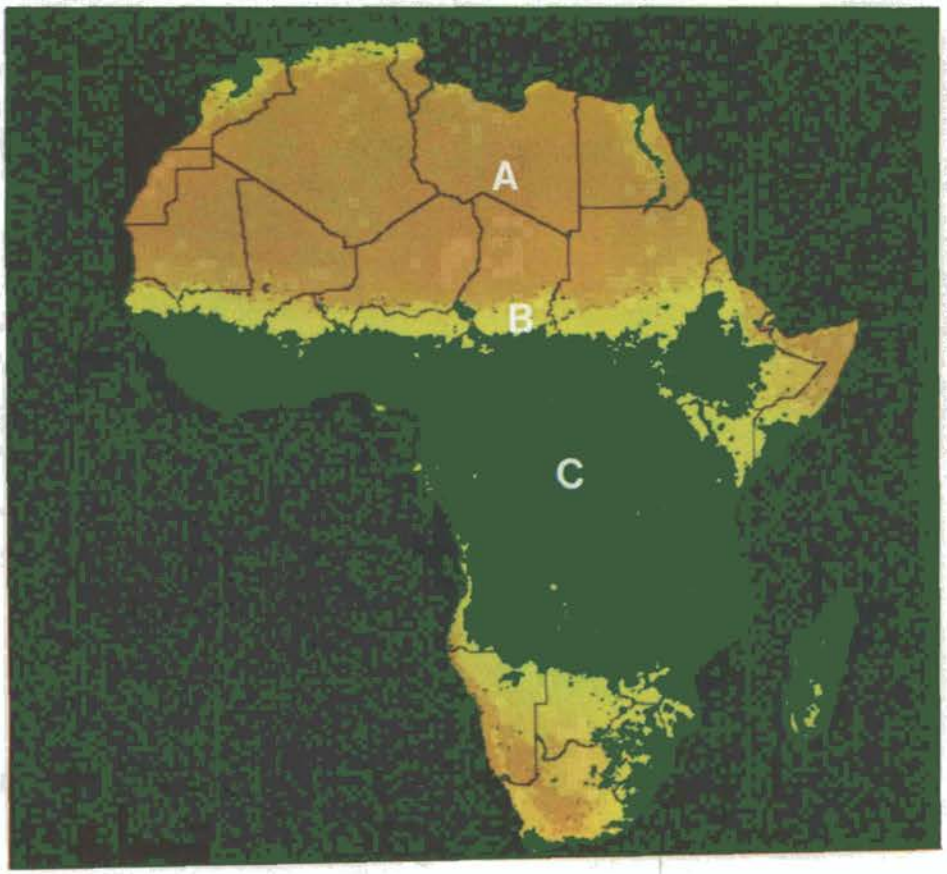

Figure 3: Classification of Africa into (A) desert and semi-desert, (B) semi-arid grassland, savanna, and bushland, and (C) more humid zone. This figure was derived from satellite data from 1982 and 1983 from the NOAA-7 satellite. This is an illustration of the possibility of satellite remote sensing for desert delineation.

Recommendations

The work we have described has immediate and continued application for inventory of desert spatial extent and how this varies with time. To be successful, study areas must be selected at the regional and national level to refine the classification process and to quantitatively evaluate classification accuracy. The methodology we propose is internally consistent and uses satellite data to delineate arid and semi-arid areas based upon green leaf biomass or its absence. Not only are the NOAA AVHRR data reasonable in cost, but they are available for the entire terrestrial surface since June 1979 and, perhaps more importantly, their operational continuity is planned through 1995. It is our opinion that use of the NOAA AVHRR for assessment and monitoring of desert extent and desertification will be a major element in any successful inventory of terrestrial deserts and how they change in time. More detailed studies are now underway and additional results should be available within the next two years.

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Desertification in Botswana: progress towards a viable monitoring system

Susan Ringrose
Department of Environmental Science, University of Botswana, P/Bag 0022, Gaborone

Wilma Matheson
Science Department, Gaborone Secondary School, P/Bag 0019, Gaborone

The significance of desertification in Botswana has only recently been given full realization. The population density, and associated livestock density, has been historically low, and while cycles of drought have occurred in the past, in large measure, pasture has returned during subsequent periods of "normal" rainfall.

Within the last 25 years, two factors have served to cause major environmental changes:

1. Larger than normal increases in human and livestock population have taken place in the agricultural "hardveld" of eastern Botswana, leading to overgrazing, soil erosion and the reduction of natural water resources (Campbell and Child, 1970; Cooke, 1983)

2. Government policy has led to the Kalahari Savanna Woodland being opened up to cattle grazing. This has been facilitated by improvements in borehole technology. Subsequent range studies have indicated a rapid expansion of overgrazing and degradation of vegetation. This, in conjunction with the present low standards of range management, has led to the risk of irreversible land degradation (Cooke, 1985).

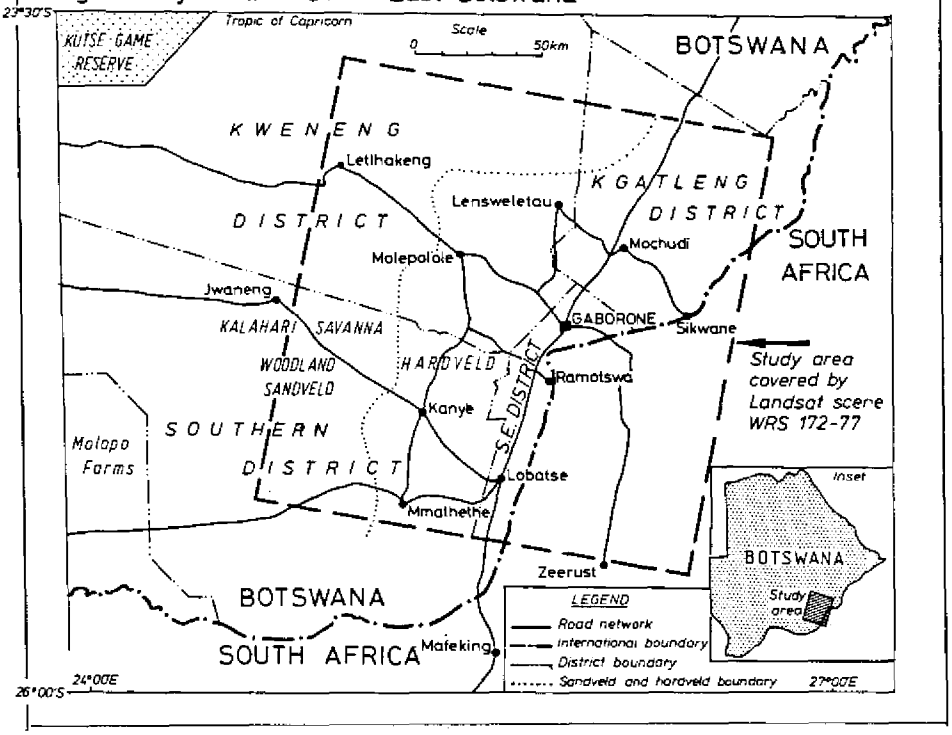
These conditions are very similar to those found in the Sahel twenty years ago and are consistant with trends in global desertification expressed in Walker and Robinove (1981). Here desertification is defined as a decrease in the productivity of arid and semi-arid lands, leading to severe decreases in food supplies and disruption of land use patterns. Given that 70% of Botswana's population is currently on drought relief (June 1985), there is no doubt that the effects of desertification are being acutely felt. These effects are also consistant with definitions appearing in the United Nations Plan of Action to Combat Desertification (Reining, 1978, p.3).

This work describes such critical factors as the diminution or destruction of the biological potential of the land, caused by overexploitation, which gives rise to the degradation of vegetation, soil and water. Desertification is expressed as a self-accelerating process, feeding on itself and, as it advances, rehabilitation costs rise exponentially.

The objectives of the present project entail the recognition of such desertification features in the field and their expression on Landsat imagery, whence changes in their extent and severity can be measured. It is hoped that, given sufficient data the authorities will be able to take steps, both on the ground and through legal channels to prevent further environmental degradation.

This project is centred on south-eastern Botswana, in an area where human and livestock population increases have been particularly acute over the last twenty years. The area consists mainly of agricultural "hardveld", in which the capital Gaborone and the contiguous eastern Kalahari "sandveld" are located (Figure 1). The total area, the Botswana portion of the Landsat 4 scene studied here, is 11,800 square kilometers and ranges in elevation from over 1300 m in the vicinity of Kanye to about 850 m in Kgatleng District.

Fig.1: Study area in South East Botswana



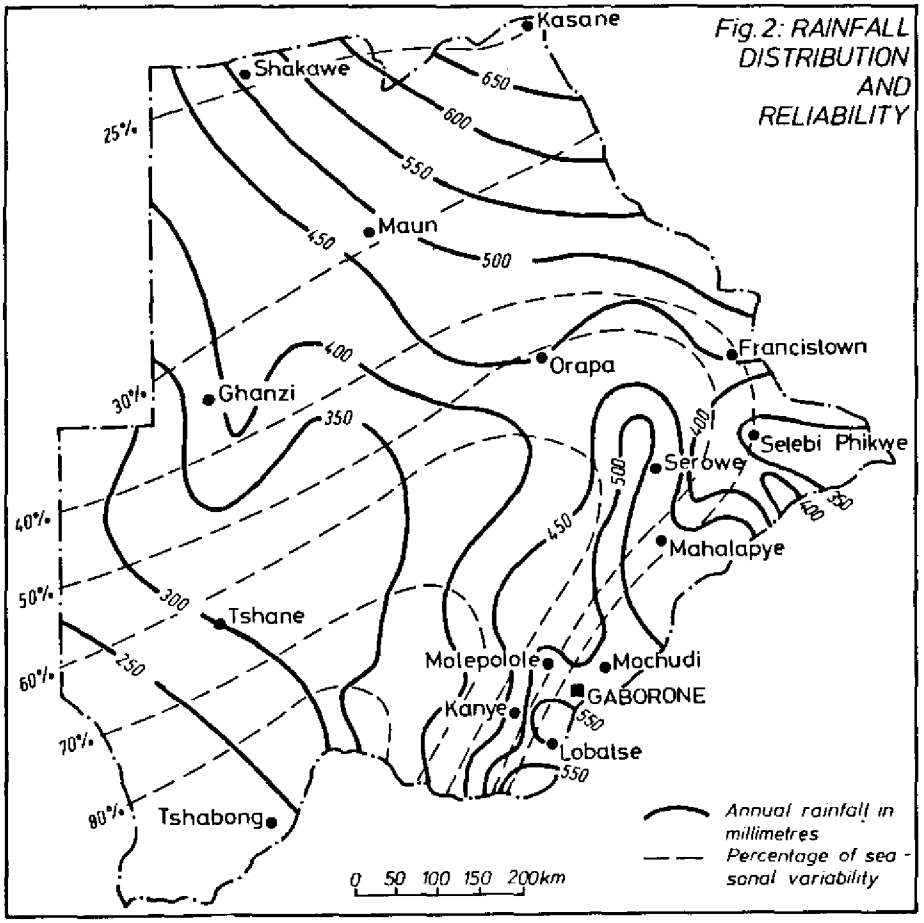


Fig. 2: RAINFALL DISTRIBUTION AND RELIABILITY

Rainfall over the country as a whole is highly variable as indicated in Figure 2. In the project area, the zone between Gaborone and Lobatse receives 550 mm rainfall annually with a 40% variability, whereas the eastern Kalahari receives between 400-450 mm annually, with a variability between 60-70%.

Landsat multispectral imagery for 1982 and 1984 has been acquired for the area shown in Figure 1, details of which are shown in Table 1. January imagery was chosen because this is the height of the rainy season, when most vegetation, agricultural and natural, is actively growing. Hence areas denuded of vegetation stand out in contrast.

Landsat computer compatible tapes, transparencies and colour composite prints were obtained. The tapes were processed at source using standard methods. Radiometric corrections included calibration, sensor balance and decompression, but excluded haze correction and sun-angle correction. Geometric corrections were applied to the pixel positions to correct for earth rotation, system geometric distortions and pixel aspect ratio. The data were also corrected to U.T.M. map projection (A.J. Caithness, personal communication).

Steps towards monitoring desertification using Landsat remote sensing techniques have been achieved by a number of workers and are adequately quoted in Walker and Robinove (1981). Work in desertification in Africa using standard and enhanced Landsat images has been undertaken by El-Shazly et. al. (1977a, 1977b, 1978) and Heilkema (1977, 1978) developed a Green Index Number (GIN) as a computer derived measure of the amount of green vegetation present in a pixel. A plot of the GIN over time gives an indication of the intensity of drought conditions.

Robinove et al. (1981, 1982) used Landsat digital data to calculate albedo changes in Utah and north-western Arizona using registered Landsat scenes. They found that phenomena tending to lower productivity of an arid land ecosystem will also tend to make the image brighter. This includes a decrease in the density of vegetation and increased erosion. Techniques have also been devised for Landsat digital data whereby distinctions can be made between vegetation and soil background (Richardson and Wiegand, 1977). This work has been extended by Colwell (1981) and Graetz et al. (1982) and applied by Graetz et al. to monitoring arid rangelands in Australia. The development of such systems has enabled the monitoring of desert environments to take place with limited ground data, for instance in Lee and Bruce's (1982) work in the Nile Valley.

In the present project, use is being made of Landsat prints and tapes, to take advantage of recently devised digital processing techniques. Initial imperatives were to establish relationships between pixel digital levels and ground conditions as of January, 1984. This provides baseline data, against which change can be measured. Three approaches were used to facilitate this:

1. The location of 82 ground control sites in the Gaborone area, where canopy cover, vegetative species, grass and litter cover, soil type and extent were measured for representative areas.
2. Readings using a hand-held Exotech 100-AX radiometer were taken on about 50 control sites to determine the spectral characteristics of significant bush species, soil types, grass cover and litter.
3. Image processing was undertaken using the University of Botswana Remote Information Processing System (RIPS).

Table 1: Imagery Used for Desertification Monitoring, Botswana

WRS	Science Identification	Date	Landsat Number	Sun Elevation (degrees)
185-77	22550-07340	82-01-15	2	48
184-77	22549-07281	82-01-14	2	48
172-77	40553-07422	84-01-20	4	51

Table 2: Ground Data and Landsat Digital Values by Ecoregion

	Bush Cover Range (%)	Bare Soil Range (%)	Print Tone Bd 7	Aver. Bd 7	Aver. Bd 5	No. of Sites
I Uplands and Rock Outcrops	31-63	36-67	DG	88	65	3
II Communal Lands and Grazing	10-74	30-92	MG	110	95	32
III South-east Kalahari	25-37	62-83	LG	101	74	7
IV Eastern Kalahari	5-47	62-90	MG	126	113	20
V Communal Grazing	20-47	51-79	DG	93	73	11
VI Riverain Area	71	27	MG	106	99	2
VII Communal Lands and Grazing with Rock Outcrops	28-47	65-85	DG	100	87	7

DG, MG, LG =Dark, Medium and Light Gray.

Initial results were stratified by ecoregions using Band 7 Landsat print imagery to provide a uniform basis for analysis. The rationale behind ecoregion mapping is discussed more fully in Ringrose and Large (1983). Seven ecoregions were identified with relatively consistant land-use/land cover types, and illustrated in Figure 3. Subdivision IIA is the Gaborone block, an area of mostly freehold land surrounding the capital.

As Table 2 indicates, the areas with the highest overall percentages of bush cover and the lowest proportion of exposed bare soil occur in Ecoregion I, Uplands and Rock Outcrops. These are areas which tend to be uninhabited. Ecoregion I is also typified by relatively low digital values on Band 5 and Band 7. Conversely, the areas with the lowest bush cover and highest proportion of exposed soil occur in Ecoregions II and IV, Communal lands and Grazing and the Eastern Kalahari. These are consistant with the higher values in Band 5 and 7.

The kinds of features which are depicted by these high digital values include abandoned fields, severely overgrazed areas, areas with a high proportion of rills and gullies, areas with extensive sheetwash and areas where trees have been removed for fuelwood in the vicinity of settlements. The variables in the system include soil moisture, soil type and tree species cover. A minor variable is the amount of herbaceous ground cover, including grass, which in January 1984 varied from 1 to 10% in the study area.

In an attempt to separate out the variables in terms of spectral discrimination, radiometer results were obtained from a number of sites.

Whereas not all the data have been analysed to date, the kinds of results anticipated are indicated in Figure 4. Here the soil values for an arenosol are consistantly high, whereas values for broad leaved vegetation (*Rhus* and *Grewia* species) are consistantly low. The best spectral band to differentiate between broad leaved vegetation and bare soil is Band 5 on the Landsat system, corresponding to channel B on the radiometer. This data tends to add credence to the view that areas with the highest reflectance in Bands 5 and 7 represent zones of exposed soil, whereas vegetated areas are more absorbant of EM energy. In general, it appears that the digital values are a function of a resolvable group of earth features VIZ:

Rill entering a broad gully in Ecoregion II, south-west corner of Metsematlhaba

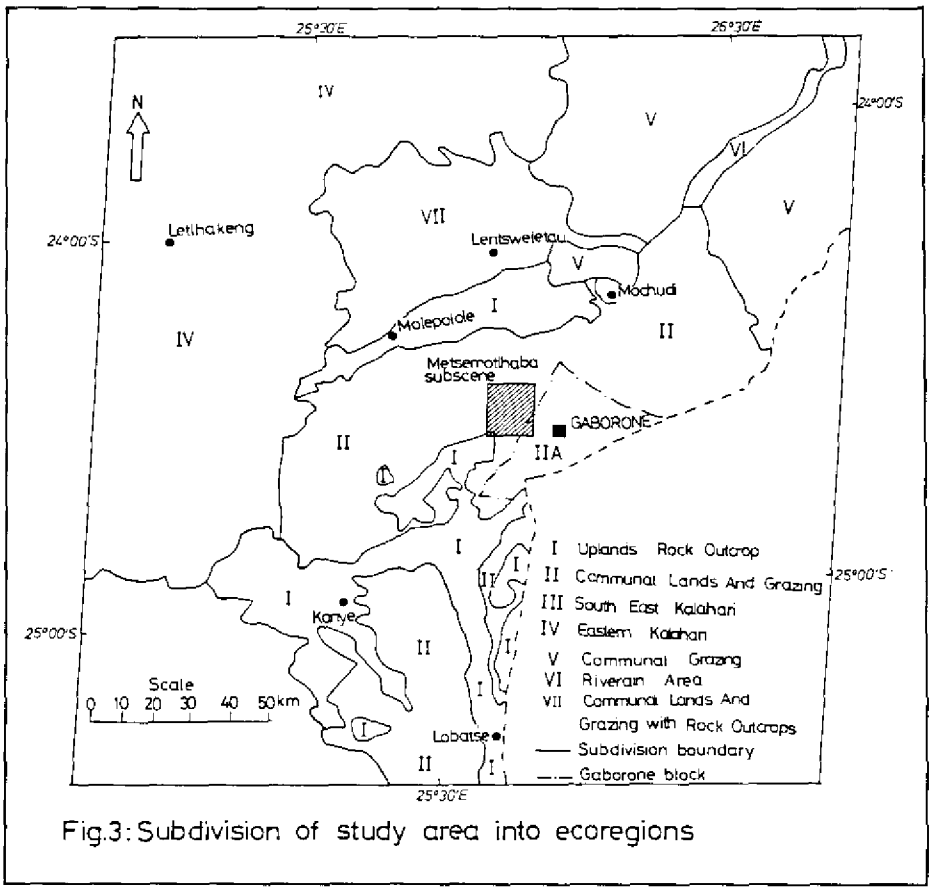


Fig.3: Subdivision of study area into ecoregions

RADIOMETER RESULTS

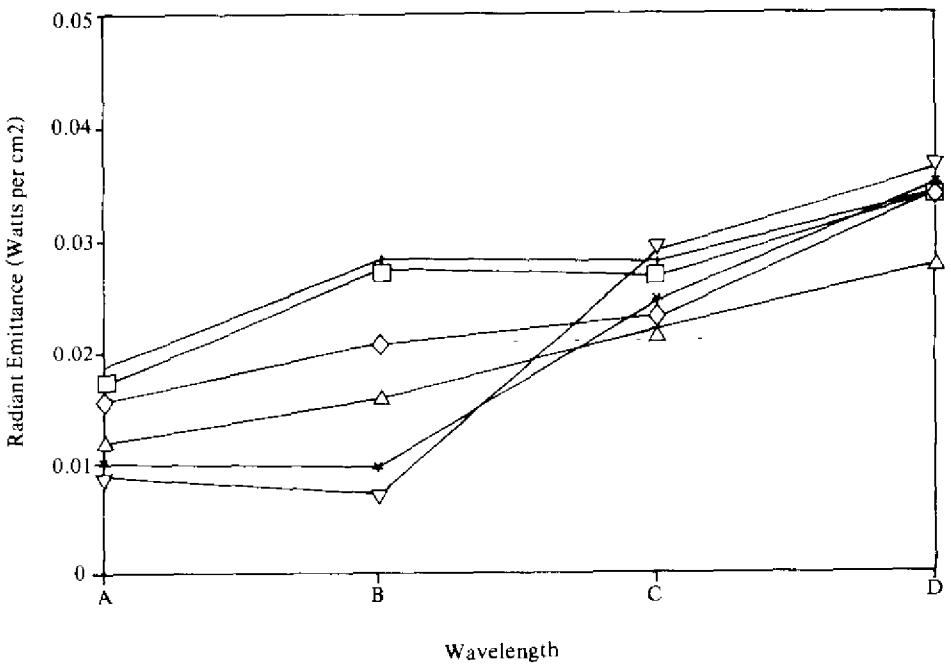


Figure 4.

Sandy Arenosol (St)

□ Silty Arenosol (St)

Litter Over Arenosol (Vd)

△ 75% Grass Cover (Vg)

▽ Rhus Spcies (Vb)

x Srewia species (Vb)

D.V. =f(St. Vb. Vg. Vd. Ef)

where St = Soil type

Vb = Bush vegetation

Vg = Grass or herbaceous vegetation

Vd = Dead vegetation

Ef = Erosion features

D.V. = Digital Value

The contribution of a given earth feature to the overall pixel value in any given band can therefore be expressed via the radiometer curves as:

$$\text{Earth feature} = \frac{(A_{1\ldots n} \times RE_{i\ldots n})}{E(A \times RE)} \times D.V$$

where A is the area covered by a specific earth feature (St, Vb etc.) per pixel;

where RE is the Radient Emittance as determined by radiometer readings for the specific earth feature;

DV is the digital value or value of the pixel within which the feature is located.

In this way, it is hoped that a range of digital values can be used to characterize specific earth features related to desertification. Ultimately these will be used to produce computer classified maps of desertification features and/or processes.

In order to determine change over time, an initial comparison has also been made between 1982 and 1984 imagery. Visual comparison of colour composite print products reveals:

1. A marked increase in the area of high digital values indicating an extension of exposed soil, particularly in the communal grazing areas close to Gaborone and in settled areas of the eastern Kalahari.
2. A decrease in the areas of high infra-red reflectance, indicating a

decrease in the amount of actively growing vegetation in the Kalahari and agricultural lands to the east.

Figures 5 and 6 indicate the changes in digital values using image processing in Bands 5 and 7. Substantial increases in 17 sites throughout the study area are shown in both Bands, but particularly in Band 5. Sites which failed to show increases in Band 5 (73, 76, Figure 2) are in a relatively moisture rich valley site (73) and an agricultural experimental area (76) where steps are being taken to combat overgrazing. In general, the digital values show a too high overall reflectance throughout the area for a country dependent on agricultural productivity, which is detrimental to the well being of its people. The Band 7 comparisons are not as extreme and complicated by the transition which occurs in plants during drought from relatively high reflectance values in the infra-red to relatively high absorption values. This, the infra-red paradox, is the subject of on-going work.

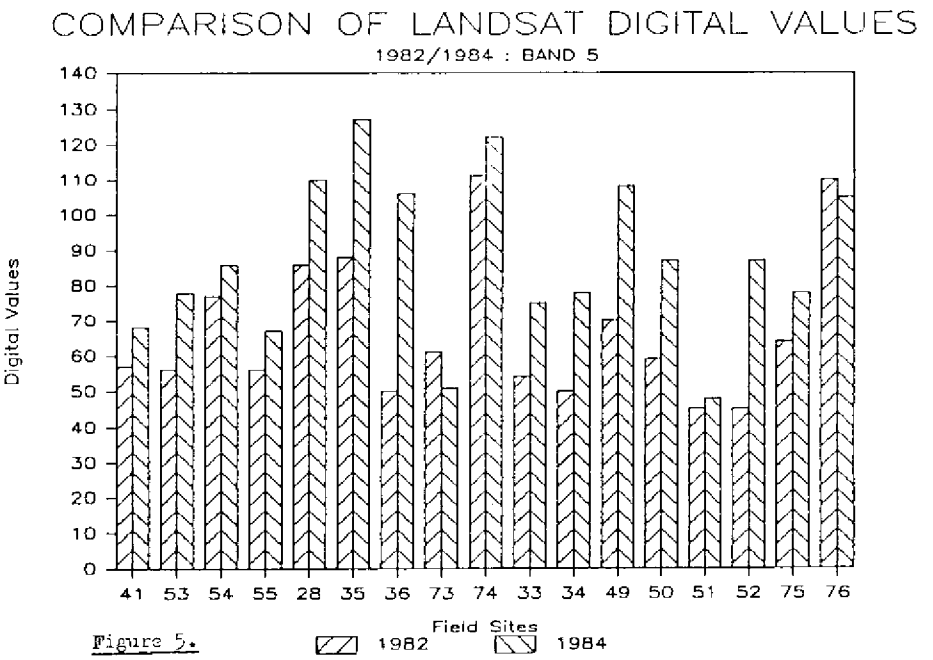


Figure 5.

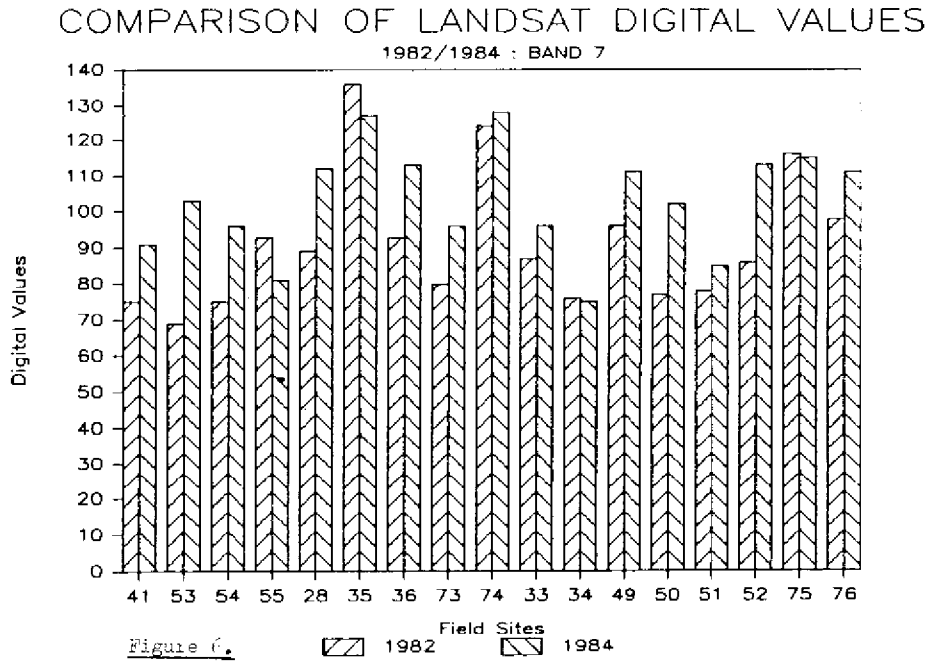


Figure 6.

In terms of what this means on the ground, an exemplary subscene area in Ecoregion II, Communal lands and Grazing, was analysed. The subscene location is shown in Figure 3, and is referred to as the Metsematlhaba area. The area was analysed using the RIPS system and EROS programmes PIXVAL and PIXCOUNT. The results are shown in Table 3. These results, which should be regarded as preliminary, suggest that the range of pixel values depicting gulleying, rill erosion, overgrazing and sheetwash for the two dates have increased significantly throughout the area in over just two years. The decrease in the area under abandoned fields is not easily accounted for.

The preliminary nature of these results notwithstanding, it appears that Landsat imagery in digital form will likely provide a useful tool in monitoring the reduction of vegetative areas and the extension of bare soil and erosion features in south-east Botswana. Further work is being undertaken to relate ground and digital data tied to specific desertification indicators. Future plans also include extending the work into a more typical Kalahari setting and determining whether relationships and trends, noted in the south-east can be used to monitor the

Table 3: Comparative Digital Analysis, 1982-84 Metsematlhaba Area

	1982 Area (%)	Area ha.	1984 area (%)	Area ha.
Gulleying and Rill Erosion	15.69	3131.4	21.01	4206.2
Overgrazing —Sheetwash	8.22	1641.7	17.28	3450.1
Abandoned Fields	29.17	5823.5	18.67	372[illegible].6

extension of desertification features throughout Botswana.

Acknowledgements

The authors wish to acknowledge financial help and encouragement from the University of Botswana and the Canadian International Development Agency. The kind assistance of Louise Crosby was invaluable in data analysis. The help of the Remote Sensing Institute, South Dakota State University, USA is also gratefully acknowledged.

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Soil at risk

Editor's note: This article is a summary of a detailed report prepared by the Standing Senate Committee on Agriculture, Fisheries and Forestry of the Government of Canada. It illustrates convincingly that soil erosion and land degradation —desertification— is not just a problem of the poor, developing nations. It is also a serious problem of the world's rich. (See also *Desertification Control* No.12 and the article on soil erosion problems in the USA and the report on the European Environment Bureau conference on soil erosion.)

Preface

This report had its beginning two years ago with a ride in a small airplane over Saskatchewan. Like many farmers, I knew that salinization was a problem, but until that time I had not realized just how much of the productive land of our breadbasket was threatened by soil degradation.

The members of the Standing Senate Committee on Agriculture, Fisheries and Forestry agreed to investigate the problems of soil degradation and decided to hold hearings throughout the country to try to find out what was being done by farmers, researchers and governments.

What the Committee discovered was genuine distress at the prospect of a continuation of the status quo. It also discovered that there is, in fact, considerable work going on to conserve Canada's agricultural soils, but that this work goes on in spite of, rather than because of, general economic conditions and government policies. Nevertheless, the Committee was heartened by the fact that governments are beginning to respond to the pleas and needs of those committed to conservation.

The Committee's major purpose in this report is to take the reader on the equivalent of an airplane ride over Canada to make clear what soil degradation is and how serious it is in all regions of the country. By increasing the awareness of this situation the Committee hopes to help make soil conservation a national issue. Our soils are at risk. Our future is eroding. It is time for action.

Hon. H.O. Sparrow, Chairman, June 1984.

SUMMARY

Soil erosion may well be the most underrated yet most damaging natural resource problem of the 80s. Must we wait for crisis conditions before action is taken to safeguard our scarce and dwindling soil resource base? — Soil Conservation Society of America, Ontario Chapter.

Canada is facing the most serious agricultural crisis in its history and unless action is taken quickly, this country will lose a major portion of its agricultural capability.

The Standing Senate Committee on Agriculture, Fisheries and Forestry has travelled extensively in Canada examining the issue of "soil degradation", a problem which is already costing Canadian farmers more than $1 billion per year in farm income. It has determined that we are clearly in danger of squandering the very soil resource on which our agricultural industry depends.

Based on the evidence presented to it, the Committee has made a number of recommendations designed to raise public awareness of the problem and to improve the dialogue between the public, farmers, governments and environmental experts.

Put simply, soil degradation is the depletion of the productive capability of Canada's precious soils and it is a costly problem.

— It is estimated that erosion of one inch of soil can reduce wheat yields by 1.5 to 3.4 bushels per acre.
— In south-western Ontario, the erosion problem has caused a loss in

Uncontrolled soil erosion in a corn field.

corn yields of some 30 to 40 per cent.
- On lands affected by salinization in the Prairies, crop yields have been reduced by 10 to 75 per cent, even though farmers have increased their use of fertilizer.
- It is estimated, at 1982 prices, that it would cost Prairie farmers $239 million in fertilizer to fully recover the present loss of grain production from wind and water erosion.
- More difficult to put a dollar figure on, but equally as serious, is the permanent loss of rich agricultural land to urban use. Between 1961 and 1976, Canada lost more than 3.5 million acres of farmland—the equivalent of the size of Prince Edward Island.

The figures do not reflect the cost of soil degradation to forest or recreational lands, or on wetlands. They also do not reflect the total cost of the problem to the Canadian economy.

Why Does Canada Have This Problem?

The dominant constraint to soil conservation is short term economic realities — British Columbia Ministry of Agriculture.

The Committee found that much of the problem lies with the great pressures being placed on our agricultural sector. Canadian farmers have been asked to demand the last ounce of productivity from our soils—largely because of economic necessity, international prices and technological progress.

As well, both old and new agricultural practices have contributed to the problem.

- Old practices and technologies such as summerfallowing and the use of mouldboard plows contribute to salinity and erosion in certain parts of the country.
- New practices and technology, such as the use of monoculture and large, heavy machinery contribute to loss of organic matter, soil compaction and erosion.

Farmers who realize the necessity of taking conservation precautions find their implementation costly in the start-up stage. They may not be able to afford the expense of a new piece of conservation tillage equipment, or the loss of income caused by replacing a cash crop with a nitrogen-fixing rotation crop.

In these days of high costs and low commodity prices, the least expensive way to operate is often the only way a farmer can survive.

Increased Production

If the farmer is selling his product at less than the cost of production, he has no energy left to go beyond that. If we can bring about profitability in our farming operations, we can then point out to the farmer a better way of carrying on his operation — Honourable Malcolm Maclead, Minister of Agriculture and Rural Development, New Brunswick.

One of the main reasons our soils are rapidly being depleted is our preoccupation with increased productivity.

- The federal and provincial department of agriculture have considered increased production a major priority, often without regard for the long-term consequences to the soil.
- Farmers are encouraged to produce in greater quantities, on the same amount of land, to meet the demands of both domestic and export markets.
- Until recently, relatively low cost fertilizer and fuels have made it possible for farmers to compensate for the resultant loss of nutrients.

Over the years this production priority has taken its toll on soil quality.

Conservation

The real progress is being made by farmers who have taken the bull by the horns, gone out and searched for information wherever they can get it ... and applied it to their own operation — David Cressnian, Ontario.

In the past several years, a growing number of individuals and associations have become concerned with the serious impact of soil degradation. Some major farm organizations have held seminars and conferences to discuss their mutual concerns and to try to find solutions to the pressing problem of soil degradation.

Farmers have formed educational and self-help groups, to provide moral support, and to exchange information. Groups such as the Warner-Dryland Salinity Control Association in Alberta, the Manitoba-North Dakota Zero Tillage Farmers' Association, the Huron Soil and Water Conservation District in Ontario, and Soil and Crop Improvement Associations are typical of local bodies being established as farmers seek the most appropriate solutions to degradation problems.

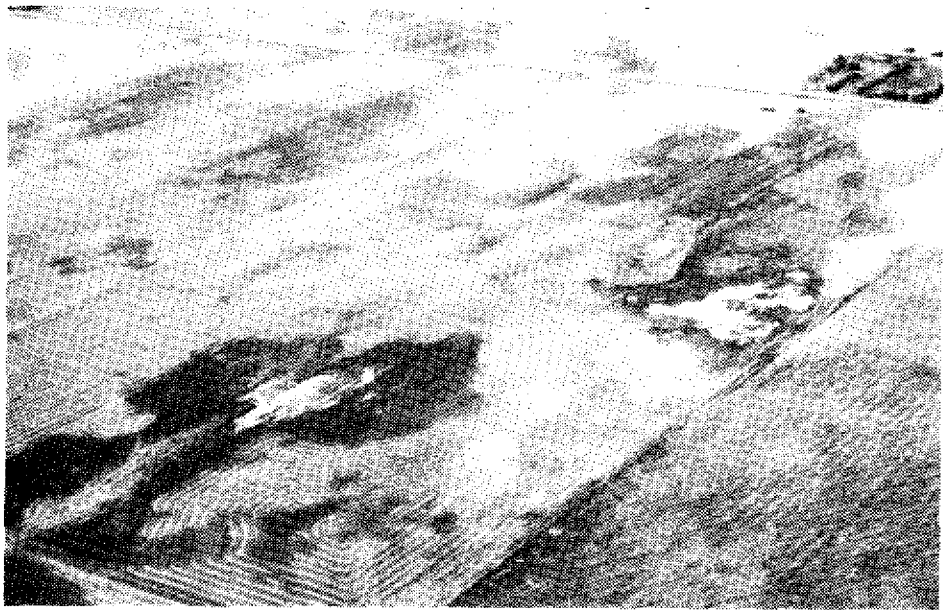
The Role of Government

Responses to-date by government and the agricultural community have been out of scale with the magnitude and severity of the problem which only threatens to worsen before it gets better. The need is urgent for a major, well-organized and adequately funded response to soil erosion and soil degradation — Ontario Soil and Crop Improvement Association.

In the past few years, Governments have begun to play a more active role in conservation—due in part to pressure placed on them by these interest groups.

Nonetheless, Government response in this area has not been great when one considers how little is spent on combating soil degradation in relation to overall agricultural expenditures. The Federal Government—which has always taken the major responsibility for agricultural research—has done little about the problem. Conservation-related research accounted for only 4.7 per cent of the federal agricultural research budget and for only 3.3 per cent of person-years in 1983.

In the latest round of Economic and Regional Development Agreement negotiations, both federal and provincial governments made some commitments to conservation, but their financial contributions were relatively small. With one-half of the ERDAs signed and the Agricultural Sub-



The white patches of salt-affected soil reduce the area of grain production on this prairie farm.

Agreements completed, the Federal Government has, so far, committed only $8 million per year to conservation for the next five years.

Ignoring the Limits

This is soil that belongs to our children and its loss guarantees they cannot be as prosperous as we are regardless of all the fancy footwork of economists, tax experts, chemists and agricultural experts — Ken Kimberly, Manitoba.

Why should we be concerned about this apparent lack of commitment to soil conservation at the official level? The reason is fairly straightforward.

Although Canada is the second largest country in the world, very little of our land is suitable for agriculture.

- Almost half of our land area is totally unsuited for agricultural production because of our cold climate.
- A further 28 per cent of Canada has low temperatures and is so rocky or dry that there is virtually no potential for agriculture.
- Less than 9 per cent of Canada's land area is capable of being cultivated and of that, only about one-half is actually cropped. This 4.5 per cent, quite literally, is spread from coast to coast.
- The other 4.5 per cent is used for pasture, forests, recreational lands, transportation corridors and urban or industrial land.

There is no substitute for the agricultural land which Canada possesses, and indeed, the margin for error in trying to save the soil becomes smaller and smaller every year. We cannot ignore the limits of this vital resource.

A Canadian Perspective

There is a major difference between soil and forest and fisheries. Forests can be replanted and managed. Fisheries can be restocked. But once our soil is gone, that is the end of economic agricultural production. Our children's grand-children will not see a rejuvenation of our soils — New Brunswick Institute of Agrologists.

It is clear that soil degradation is costly not only to agricultural industries, but to the Canadian economy and our rich, full lifestyle. The facts speak for themselves.

- Agriculture is the foundation of the economies of many provinces and accounts for between 0.4 and 14 per cent of provincial incomes.
- While only 4 per cent of the population actually earn a living as "primary producers", fully one job in ten in Canada depends on agriculture or agriculture-related industries.
- Approximately 40 per cent of the nation's Gross Domestic Product is generated by the agribusiness sector.
- Agriculture is also important to Canada's balance of trade, making up a consistent 10 per cent of export earnings.

The facts and figures in this report are presented to call all Canadians to action—to show that soil degradation has become a *national* problem requiring *national* attention.

Soil degradation is more than a spectacular dust storm on the Prairies or a land use battle over the Niagara Escarpment or the Fraser Valley. It is a serious, ongoing problem in all regions of Canada. It is a multi-faceted problem which cannot be dealt with inexpensively or easily.

To actively conserve the soil requires a major commitment by all Governments, farmers and scientists. It also requires a commitment to action from all Canadians—coast to coast.

CONCLUSIONS AND RECOMMENDATIONS

We cannot afford the luxury of waiting for a crisis to make the effects of the loss of agricultural land apparent to everyone, for by then it will be too late — Manitoba Conservation Districts Association.

Conclusions

Having heard and carefully considered the testimony of the witnesses who appeared before it, the Committee concludes that:

1. Soil degradation is a serious problem in *all* regions of Canada.
2. There is insufficient awareness of the existence and the severity of the problem within all sectors of society.
3. Because there is insufficient awareness of soil degradation, the solution of the problem has not been a priority.
4. Canada risks permanently losing a large portion of its agricultural capability if a major commitment to conserving the soil is not made immediately by all levels of government and by all Canadians.

Therefore, the Committee further concludes that:

5. Soil conservation cannot be dealt with in isolation from related issues such as water quality, land use, wildlife management, fisheries and forestry.
6. Because of the complexity of the issue and the ramifications that policies set at all levels of government have on soil conservation, a valid conservation effort demands policy and programme coordination.
7. Existing policies, not necessarily directed at soils, can have the effect of discouraging good soil management.
8. There is a need for further basic research on the causes and effects of soil degradation.
9. There is also an overwhelming need for practical, on-the-ground research to determine (a) the costs of degradation to the farmer and (b) the costs and the benefits of the use of conservation practices on the farm.
10. While there is a great deal of information available about soil conservation, the transfer of this information and the accompanying technology to the farmer is the key to a successful conservation effort.
11. The practical technical information and expertise necessary to adapt conservation practices to individual farms is often unavailable to farmers because existing agricultural extension officers are overburdened, and soil management technicians are few and far between.
12. Farmers are often not able to underwrite the initial costs of some conservation practices without financial incentives or tax concessions.
13. Canadians must become aware that soil degradation has a major environmental impact, a potentially serious impact on consumers and an equally serious impact on the national economy.

Recommendations

Having reached the above conclusions, the Committee has determined that it is time for action. Therefore:

Wind erosion on unprotected soil in Ontario

To establish a national commitment the Committee recommends:

1. That, because of its serious economic implications, the matter of soil degradation be added to the agenda of the next meeting of First Ministers, including Territorial government leaders, to demonstrate to the Canadian public the gravity with which all governments view the situation, to consider the recommendations of this report and to take action to implement them.
2. That a comprehensive federal soil and water conservation policy for Canada be developed and adopted immediately. It must (a) clearly state the Federal Government's intension to make soil conservation a priority in the development of all of its policies, programmes or projects; and (b) require all departments to co-ordinate their efforts to make the most efficient use of resources and information.
3. That provincial governments also develop comprehensive soil and water conservation policies.

To begin to resolve policy conflicts, the Committee recommends:

4. That the Canadian Wheat Board modify the quota system to extend (a) full quota entitlement, at the "bonused" level of seeded acreage, to those remnant farmlands considered of marginal value for agriculture; and (b) partial quota entitlement, equivalent to current quota levels for summerfallow, to extensive tracts of unimproved pastureland which form integral parts of farm units.
5. That provincial governments strengthen and more conscientiously enforce their land use legislation to preserve agricultural lands.

To intensify conservation research the Committee recommends:

6. That the Federal Government establish Soil and Water Conservation Institutes in Western, Central and Eastern Canada for the purpose of carrying out applied research.
7. That the Federal Government provide greater funding for soil conservation research through the Natural Sciences and Engineering Research Council's Strategic Grants Program for Agriculture.
8. That the Federal Government use the Special Fund for Centres of Specialization Programme in the Secretary of State as a model for a ten year programme to develop regional centres of specialization in soil and water conservation at universities across the country.

To facilitate the transfer of technology the Committee recommends:

9. That the Prairie Farm Rehabilitation Administration (PFRA) extend its activity into British Columbia, particularly the Peace River District.
10. That all Federal lands, especially Agriculture Canada Experimental Farms and Research Stations, be developed and managed according to good conservation practices and become conservation showcases for the nation.
11. That agricultural and technical colleges increase their training of agricultural technologists to work in the field providing assistance to the individual farmer, thus providing an important link in the transfer of conservation technology.
12. That the Skills Growth Fund of the Department of Employment and Immigration be modified to include agricultural land-based occupations, specifically the training of soil conservation technicians.
13. That all provincial governments adopt legislation encouraging the establishment of conservation districts or authorities such as those which exist in Manitoba and Ontario.

To provide a more favourable fiscal climate the Committee recommends:

14. That financial incentives be provided to farmers through federal-provincial agreements, appropriate to local needs, to help defray the costs of conservation practices.
15. That accelerated capital cost allowances be permitted on capital expenditures relating to soil conservation, such as conservation tillage equipment, grass waterways, terraces, etc.
16. That land tax assessment notices in all provinces clearly show the basis on which the land is being taxed so that the owner is aware of the worth of the productive capability of various portions of the land.

To increase awareness and to sustain a national conservation effort, the Committee recommends:

17. That the Federal Government declare a National Soil Conservation Week to ensure that soil conservation becomes, and remains, an important national issue.
18 That Provincial Governments commit themselves to the introduction of soil degradation and conservation studies at the primary and secondary school levels through the addition of environmental courses.
19. That the Federal Government sponsor a National Conference on Soil Conservation to promote awareness of soil degradation as a *national* issue and to foster co-ordination and co-operation amongst all of those involved.
20. That a Council on Soil and Water Conservation be established: (a) to provide a neutral forum within which the participants can discuss the issues and the actions necessary to conserve Canada's natural resources; (b) to encourage improved co-ordination and co-operation between the participants; (c) to review methods of dealing with the needs and demands of particular sectors; (d) to aid in the priorization of research and programme demands; and (e) to gather and disseminate information concerning conservation.

The Committee believes that if these recommendations are acted upon quickly, the risk to our soils and to our future can be reduced—the time for action is now!

Combating desertification in Zimbabwe

Michael B.K. Darkoh
Department of Geography
Kenyatta University College, Nairobi

Introduction

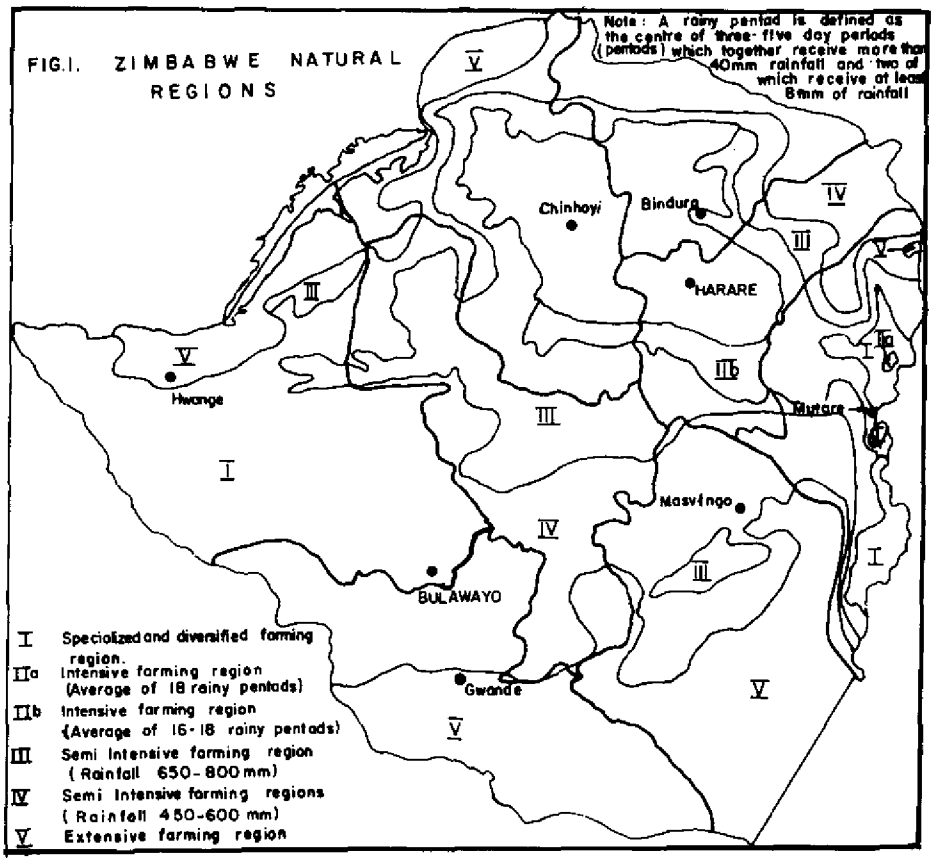
From March to May 1983, this author, under the auspices of UNEP, undertook a consultancy mission to Zimbabwe and five other countries in the eastern and southern African sub-region. The purpose of the mission was to conduct a survey of past and current anti-desertification programmes and prepare a directory of national, regional and international institutions involved in the implementation of desertification control projects, and research and training in subjects relevant to desertification. This paper, which describes the problem of desertification and Zimbabwe's efforts to combat it, is based on data collected during the author's personal visit to the country from 14-21 May, 1983. Based upon documented sources, field observation and interviews held with institutions and organizations involved in environmental matters, the paper briefly sketches the general features of Zimbabwe and outlines the dimensions of the desertification problem, paying particular attention to the problems of soil- and wood-loss and drought. It next probes the historical record and attempts being made from the First World War to the present in combating desertification, and the current major anti-desertification and related projects and activities constitute the remaining principal themes described in the rest of the paper.

General Features

The land-locked state of Zimbabwe occupies a land area of approximately 39 million hectares and has a population of about 8 million people growing at an average rate of 3.6% per annum. There are four main topographic divisions: (a) highveld, a plateau at an altitude of about 1300 m running through the centre of the country from south-west to north-east; (b) the middleveld, about 900 m extending on either side of the highveld; (c) the lowveld, about 500 m located in the south-east and north-west corners of the country; and, (d) a high altitude ridge running along the eastern border with Mozambique. Superimposed on this physical pattern is a rainfall pattern which is not entirely related to altitude and which falls off from north to south, from about 1,000 mm. in the north to about 300 mm. in the south. Rainfall is monomodal, from about October to March, sometimes with a mid-season dryspell about January.

The agricultural potential of the country has been surveyed by the Ministry of Agriculture and categorized into five agro-ecological regions, sometimes referred to as Natural Regions (Fig. I). Approximately 17% is suited for intensive crop production, 18% for cropping on a semi-intensive basis, and the remainder for limited drought resistant crop production and ranching. In fact, about half of the land has poor crop production potentials.

The agricultural sector has historically been divided into three sub-sectors. Although the pattern is now changing slowly, it is geographically organized as follows: (a) Communal Areas (former Tribal Trust Land Areas) totalling 16.3 million hectares inhabited by the indigenous African population. Land is held under customary or traditional communal tenure with individual usufructual rights assigned by hereditary chiefs; (b) Commercial Areas covering 15 million hectares under freehold title cultivated by 5,800 farm families almost wholly of European origin; and (c) African Purchase Areas cover-



ing 1.5 million ha. with about 8,500 farm families of African origin, land is held under tenancy of freehold titles.

The Dimensions of the Desertification Problem

The primary symptoms of the problem of desertification or land degradation in Zimbabwe and possible causes are related to increasing population pressure on land resources. The result has been soil-loss and extensive deforestation, brought about mainly through clearance of the land for cultivation, pushing cultivation too close to river beds, growing crops in areas which cannot support them, over-cropping, badly constructed and maintained conservation works, overgrazing and periodic incidence of drought.

A pioneering soil survey of the European and African farms conducted by the Department of Conservation and Extension in 1974 revealed the following startling results (table 1):

Table 1: Condition of Arable Land in the Farming Areas of Zimbabwe Condition of the land

	% of Total Arable Area Opened Up for Cultivation	*Range*
Seriously damaged by sheet, rill and/ or gully erosion (has been or is in danger of being put out of cultivation)	2.5	0-20
Moderately damaged so that crop yields have been affected and farming operations made more expensive	9.5	0-30
Slightly damaged with visible sheet and rill erosion but not yet seriously enough to have caused a fall in crop production or to have increased the cost of farming	41.0	10-100
Land in good condition with no visible signs of erosion	47.0	0-100

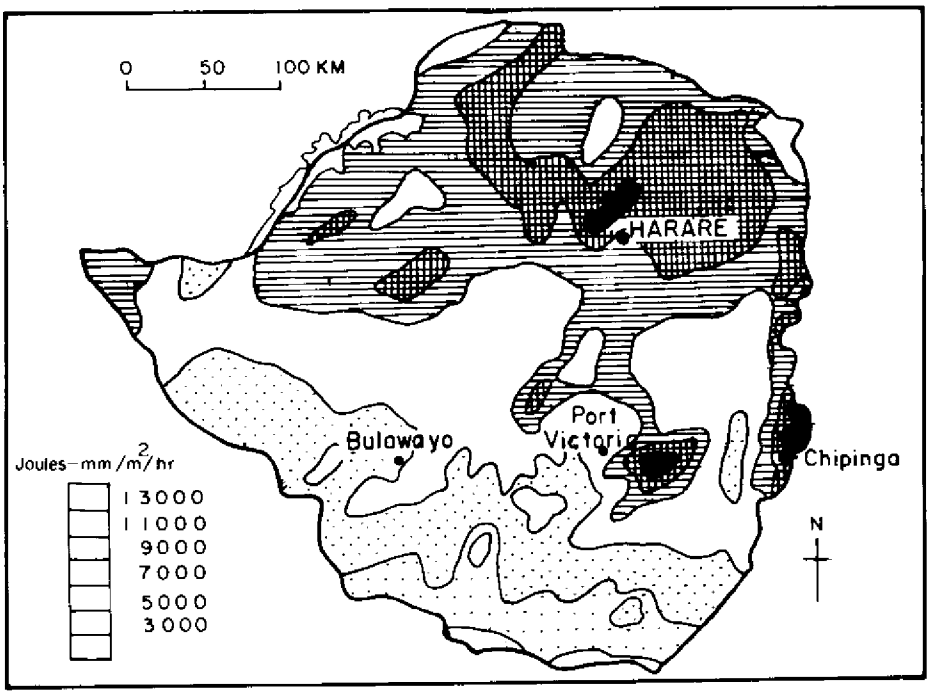
Source: H.A. Elwell (1974), "Soil Erosion Survey", Department of Conservation and Extension, p.2.

The above figures are clear pointers that Zimbabwe's soil resources are deteriorating at an alarming rate.

After only a very short period of cultivation—the major development has taken place within the last 50 years—the productivity of 12% of the land has been moderately to seriously affected; 41% is in imminent danger of declining productivity and less than one half (47%) is in good condition. For a nation so heavily dependent on agriculture as its major export industry and foreign currency earner, this is a very serious state of affairs.

Elwell notes that seriously damaged land predominates in the Eastern Highlands where steep slopes and high rainfall combine to give highly erosive conditions (Fig. 2). Midlands Intensive Conservation Areas are a close second followed by Mashonaland North. Mashonaland South and Victoria Province have little land in this catergory.

Moderately damaged land follows a similar overall provincial pattern, but with two adjacent areas of Mashonaland North (Banket or Mazoe Groups) showing up as serious problem spots. In these two areas overcropping and badly constructed and maintained irrigation works are the major causes of the trouble.



FIG·2: MEAN ANNUAL EROSIVITY OVER ZIMBABWE·

Soure: Stocking and Elwell, 1976·

Elwell finds that in Mashonaland North Groups, a very high percentage of the land is "teetering on the brink of deterioration in crop production". The major problem in these areas is badly constructed and maintained conservation works, over-cropping and steep crop row grades on moderate to steep slopes. The land is in good condition in the flatter and more fertile

areas of the country, particularly in Mashonaland South and the Lowveld regions.

The Problem of Soil Loss in the Communal Areas

The survey data described above relate only to the state of arable lands in the commercial farming sector, where management is generally high. It excludes the Communal Areas (the so-called Tribal Trust Lands) and grazing areas. The picture in the latter is nothing short of grim. During the exercise to evaluate the general situation in the Communal Areas, Elwell (1979) estimated that soil losses from communal farms were averaging 50 tons per hectare per year. At this rate of loss, it was anticipated that the communal arable soils currently in good condition would not be able to sustain yields in 35 to 50 years time. In the Sabi Valley, where soils are already degraded by soil erosion, "the soil life span drops to between 10—20 years under a current soil loss rate of 60 tonnes per hectare per year" (Elwell 1983; Meikle, 1982).

This author had the opportunity of going on a day's field trip by road to the Sabi catchment—from Harare through Sengezi, Dsa Dsa, Nyahoni and Sachipiri Irrigation Works back to Harare. The area covered parts of Mashonaland East and the Midlands. Big patches of denuded and overgrazed land, bare surfaces of sheet-eroded land intersected by inselberg landscapes of kopjes, bare rocky outcrops and dongas as well as sand and silt-choked streams and dry river beds were the commonest features that caught the eye in most of the places visited. The widespread destruction of the vegetation, stream-bank cultivation and subsequent siltation and drying up streams so common in the communal areas of this catchment, stood in sharp contrast to the lush green landscape of the adjoining Purchase Areas and Commmercial Areas through which the author passed on his way back to Harare. It would appear that the root causes of land degradation in the Sabi catchment area lie in population pressure, stock numbers and quality of the management practiced. The same could probably be said of the problem in the other parts of the Communal Areas.

The Communal Areas make up 42% of Zimbabwe's total land area of 389,000 km^2.

According to Stubbs (1977), 3.7 million people occupy and subsist on the 16.2 million ha. of land available there; a poignant contrast to the situation in the 40% of the land classed as Commercial Area, where only a settler population of 200,000 occupy almost the same hectarage of land. The position can be more fully appreciated when it is realized that, of the total area of 16.2 million ha. in the Communal Area, only 2.2 million ha. are cultivated land, much of which, according to Stubbs, should not be cultivated at all because of steep slopes and low potential fertility. The remaining 14 million ha. is grazing land supporting some 3.4 million cattle at a stocking rate of 4.1 ha. per head—not counting goats (the recommended stocking rates vary from one Tropical Livestock Unit (TLU) per 4 hectares in NR II to one TLU per 10 ha. in NR IV, but are lower for degraded land).

Is is quite clear from these figures that there are too many cultivators with too few resources working in inhospitable conditions, and that the grazing lands are overstocked by several times the recommended rates.

In his paper, Stubbs further points out that there is an alarming rate of increase in the pressure being put on the land. In the fifteen years from 1961/62 to 1976/77, the number of cultivators in communal areas increased by 88%, the gross area under cultivation by 91% and the number of cattle by 70%.

By the year 2000, Zimbabwe's total population is expected to double. In the past, the Communal Areas have absorbed 64% of the population growth and provided social security for 90% of the people. If this added pressure is imposed on the Communal Areas, argues Elwell (1983), the rate of deterioration will increase over the intolerable level outlined by Stubbs.

An additional feature of Communal agriculture which hinders efficient application of technical solutions is that arable lands tend to form a patchwork of small blocks scattered throughout the grazing areas. Under such circumstances, grazing management schemes are difficult to implement and the most effective systems of protecting arable lands cannot be applied (Elwell, 1983)

The impact of these higher rates of soil loss on the national water resources is quite evident. Catchment protection reports submitted to the Natural Resources Board frequently suggest the necessity to divert valuable resources towards building silt traps to protect the major dams.

This concern for the country's important structures is not misplaced. In fact, at a meeting of the Natural Resources Board which this author was privileged to attend in the course of his mission, one of the key issues on the agenda was the siltation of dams. In the case of only one province, Masvingo Province, as many as 120 dams showed varying degrees of siltation, ranging from 7% to 100%, with 79 of these having siltation rates of 50% or more.

Masvingo is only one of the numerous reports that are received almost daily by the Natural Resources Board from all over the country recording alarming rates of siltation of vital water storage facilities. Recent estimates of the damage done by siltation to some other dams in Matebeleland and Nanda Provinces have been provided by Elwell (1983) and are detailed in Table 2.

One of the primary causes of the high rates of siltation in dams and weirs, as this author observed in the Sabi catchment area, is the practice of cultivating too close to the river beds. Although there are by-laws governing the cultivation of high flood-level (one of which stipulates that farmers should not cultivate within 300 m. of the high flood-level), the farmers and peasants are not obeying these laws. In many of the stream valleys crossed during the author's field trip, it was observed that several cultivated lands extended from the valley slopes right to the stream bottoms.

Another facet of arable farming which is contributing to the problem of desertification in the Communal Areas of Zimbabwe is the growing of

Table 2: Recent Estimates of Siltation of Dams and Weirs
(Siltation estimates from N.R.B. reports and other statistics provided by the Ministry of Water Development)

Dam/Weir Name	Capacity $10^3 m^3$	River built	Year	Locality	Estimated % silted
Austral	Small hydro weir	Tokwe	1972	Nyanda	46
Chepiri	59	Duvure trib	1956	Gutu	0.5
Chidoda	84	Pembedzi trib	1955	Gutu	30
Gudi	*	Nyarushange	*	Mashaba	100
	64	Nyazwidzi trib	1956	Gutu	10
Mahope	173	Nyamachore trib	1955	Gutu	15
Marab	*	Mungezi trib	*	Gutu	10
Mtshelele	1911	Mtshelele	*	Matopos	100
Nyatari	Small weir	Nyatari	*	Ndanga	100
Nyazvivi	141	Nyazwidzi trib	1955	Gutu	15
Ghumbyawanda	*		*	Nyanda	100
Siteze	*	Tuli	*	Wenlock	66
Giya	109000	Turgwe	1976	Bikita	Heavy
Gizwe	228	Tuli	1970	Wenlock	66
Tselele	241	Shapi trib	*	Maribohe	100
Zuwa	61	Pembedzi trib	1955	Gutu	2

* Information not readily available from Provincial Office records.

Source: H.A. Elwell (1983).

crops in areas which cannot support them. Maize is being pushed to drier areas fit only for grazing.

The other factor accounting for the increased soil-loss and endemic siltation taking place in the country's vital storage facilities is deforestation. This also has been brought about mainly through clearance of land for cultivation under conditions of increasing population pressure in the Tribal Areas.

As a result of growing concern about the widespread deforestation in Zimbabwe, a national survey was undertaken in the latter part of 1978 by J.R. Whitlow of the University of Zimbabwe, at the request of the Natural Resources Board of Zimbabwe to assess the extent and rate of woodland destruction.

By a systematic comparison of aerial photographs, Whitlow (1980) was able to determine the general changes in woody vegetation and the pressures on miombo woodlands. The main decreases in woody vegetation were recorded in areas of high to moderate population densities, particularly in the Communal Areas where extensions of croplands combined with the collection of woodfuel and building materials had resulted in a diminution of woody plant cover. It was also discovered that considerable denudation had taken place in some of the wildlife areas in the north-western and north-

Table 3: Woodland Shortages in the Communal Areas

Degree of pressure	% of Total Tribal Areas	% of Critical Areas of Timber Shortage
Balanced or no pressure	32.7	5.6
Some pressure	29.8	20.7
Great to exteme pressure	37.5	73.7
Totals	100.0	100.0

Source: J.R. Whitlow (1980) "Deforestation in Zimbabwe: Some problems and Prospects", NRB p.10.

ern parts of the country. In the case of open woody vegetation, which is the common type of vegetation occuring throughout the country, it was found that in some regions rates of 8 to 10% decreases per year had occured.

Whitlow also assessed the extent of shortages of firewood and building materials in the Communal Areas. The results are shown in Table 3.

According to Banks (1980), annual fuelwood consumption in Zimbabwe is in excess of five million cubic metres and this represents over 80% of the total wood usage in the country. The indigenous woodland no longer sustains this rate of production in the face of increasing demands for agricultural land and is a diminishing source of energy.

The principal users and uses of woodfuel are:

(a) farming communities: wood is consumed in the curing of tobacco and for the domestic requirements of the labour force. An estimate of consumption in 1978/79 was 238,000m^3 for tobacco curing and 555,000m^3 for domestic fuel-wood. This timber is derived from commercial farmland.
(b) Communal Land Population: In the same year 1978/79 it was estimated that fuelwood consumption in the communal lands was 3,500,000m^3. The timber is taken almost exclusively from communal land and is used for cooking, heating, beer-brewing and brick-making.
(c) Mining Sector: Fuelwood consumption by the mining industry was estimated to be 131,000m^3 in 1978/79. The wood is used by the labour force on the mines for cooking and heating. In the early years of the industry in Zimbabwe, vast quantities of fuelwood were cut mainly from private land in the rural districts, to provide energy in the form of producer gas which operated the various mine machinery. Recently, widespread electrification of mines has eliminated this use.
(d) Urban Areas: The 1978/79 estimate of fuelwood consumed is 281,000m^3 a year. The timber is obtained from nearby communal land.

Finally, Zimbabwe, like most of the other countries of the Kalahari region, is a drought-prone country. During the author's mission, the country was under severe drought. The most affected areas were Matabeleland South, Victoria and the Midlands. These areas are normally low rainfall areas (average annual precipitation being between 200 and 400 mm). During drought years, as in the case of 1980-84, the rainfall situation in these areas becomes even worse. During his fieldtrip to Mashonaland East and the Midlands, the author saw several truckloads of animals being driven from drought-stricken areas to better regions for grazing and water and possibly to markets for sale.

The London Missionary Society first took Zimbabwean rainfall records at Hope Fountain in 1888. Since then the worst droughts remembered are the consecutive dry-spells from 1911 to 1914, the 1946/47 drought and finally the 1972/73 rainy season which was the driest on record. The average rainfall for that season for the whole country was 388.6 mm—57% of normal rainfall.

The following agricultural statistics (commercial agricultural sector only) casts some light on the effect of the 1972/73 drought: an average yield of 1.5 million tons of maize was slashed to 80,000 tons; sorghum yields were reduced to 60% of the normal despite a threefold increase in planted acreage; and tea yields fell from 1,400 kg per ha. to 1,100 kg (Ngara, 1982).

The Historical Record

Historical records show that at the turn of the last century, Zimbabwe was a country of rich natural vegetation teeming with a variety of wildlife. The soil nourished the vegetation and the vegetation protected the soil in a natural balance. The inhabitants of the country at that time had over the years evolved a system of landuse which was in consonance with the prevailing climatic conditions. The nomadic and shifting systems of landuse were in complete accord with the ecological demands of a fragile environment. Lower numbers of both human and animal populations ensured the stability of the equilibrium between man and natural resources. This stability was augmented by the seasonal cyclic movement of man and beast which enforced some sort of rotational cultivation and grazing, thereby reducing cultivation and grazing pressure and affording intermittent rest and regeneration to the land and its vegetation.

With the advent of the European and the introduction of agricultural, medical and veterinary sciences, there was a rapid increase in both human and animal populations. Crude implements soon gave way to the plough. The cattle economy became mone-

tized and markets were opened. At the same time, comparable changes were taking place in other sectors of the economy. General development in the country accelerated with the construction of roads and railway lines, rapid development of the mining industry, the building of towns and cities and large scale expansion of agriculture.

All these activities created tremendous pressures not previously felt by the earlier inhabitants; nor by Europeans who were used to life in a more temperate zone and had not adapted their farming methods to the harsh climatic variations in this country. As a result, the stable equilibrium which had originally existed between man and natural resources was completely upset. The outcome was the deterioration of pastures and arable lands.

The situation was aggravated by the alienation of land for European settlement and the division of the land into Crown land, Reserve land and Trust land which seriously restricted the operations of the traditional responses and increased the pressure on the land. The Land Appointment Act (1931) barred Africans from purchasing land outside the designated areas at a time when they might have done so. Confinement of the majority of the African population into reserves and Tribal Trust Lands, which occupied less than half of the total acreage of the country, created localized areas of high population densities with attendant overcropping and overgrazing, giving rise to serious soil erosion. During the period 1931-41, 50,000 African families moved to the reserves, while an equal or greater number moved there between 1941 and 1945.

Other actions taken by the colonial government and the European settlers to create a low-paid proletarian labour force to serve the needs of the capitalist sector of the economy exacerbated the environmental situation in the reserves and tribal areas. The list of actions includes the division of African land into permanent arable and permanent grazing, the introduction of forced labour, taxes and land rents, expulsions of Africans from alienated lands and an introduction of marketing controls, including a discriminatory dual pricing system (Arrighi, 1970).

By 1926, overcrowding on the reserves was being noted. In 1943, the Department of Native Agriculture estimated that 62 out of 98 reserves were overpopulated, and of those remaining, 19 were in, or dangerously close to, tse tse fly zones and not suitable for cattle keeping.

Progress in Combating Desertification

Concern over the soil erosion problem in Zimbabwe was evinced as early as 1913 by J.M. Mowbray of Chipoli Farm, Shamva. Mowbray realized the widespread havoc caused by soil erosion and advocated the technique of contour ploughing which, up to today, is the basis of mechanical conservation practices in the country.

Between 1913 and 1934 several ordinances were enacted aimed at preventing the growing threat of soil erosion. Similar legislation was also passed to control the indiscriminate burning of vegetation which was recognized as the immediate cause of soil erosion.

During the period 1921 to 1934, a series of bulletins and advisory notes were published by the then Department of Agriculture and much technical assistance was given to farmers in pegging contours. In spite of all these efforts, wanton destruction of the country's natural resources continued. In 1938, the Natural Resources Commission was appointed to inquire into the extent to which the natural resources of the country were deteriorating or being wasted. In 1939, the Commission submitted to the government a grim 76-page document illustrated with alarming photographs which was an indictment to the nation for having opened the door to destruction of the soil and other natural resources.

The outcome of the Commission's recommendations was the promulgation of the Natural Resources Act which made provisions for "the conservation and improvement of the natural resources and other matters incidental thereto". In November 1941, The Natural Resources Board was established.

It was a statutory non-government, independent body, and the trustee of the natural resources of the country. Its functions were to exercise general supervision over the natural resources; to stimulate through the mass media and other means the conservation and improvement of natural resources; and to recommend to the government the nature of legislation or measure deemed necessary for the proper conservation, use and improvement of natural resources. The Board did not directly undertake land reclamation or conservation projects for agricultural or rangeland development. It worked through several sub-committees who maintained close liaison with other agencies interested in the conservation and wise use of the country's resources. Its major task was to monitor the land in use, send out early warnings of possible problems and encourage people to take action.

The executive agents of the Board in the European and African areas were respectively: the Intensive Conservation Area Committees (ICAs) and the District Conservation Committees (DCCs). Their functions were to undertake the construction of works and measures for soil and water conservation, the preservation and protection of natural resources in their areas and to make recommendations to the Board on matters related thereto.

Communal Areas

Concern for the environmental status of communally occupied land (CA) is nothing new. As early as 1918, it was noted in Native Commissions Annual Reports that in some districts there was inadequate pasturage due to the large number of cattle, followed by reports of widespread shortages of water and grazing during a 1922 drought, and in 1926 the death of an estimated 25,000 cattle from starvation. This was at a time when there was a move by central government to divide African land into permanent arable and permanent grazing land, a system unsuited to African techniques of farming and which consequently hastened soil erosion.

In 1929, Alvord introduced a system of scientific landuse planning which

became known as "centralization", of which one prime objective was to "set free larger areas for grazing", and of which he stated "our policy is one of conservation" (Geza and Reid, 1982). By 1930, he had identified 1 million acres which he described as "worn out", and of the CAs generally he said that "there is little virgin soil left, and most of the land is badly worn out and overstocked with cattle" (Geza and Reid, 1982).

This theme continued throughout the years up to the present time; it led to a programme of enforced destocking during the 1940s and to an introduction of the Land Husbandry Act (LHA) during the 1950s.

The 1951 LHA was aimed at good farming methods. When it was first passed, it was hoped that it would promote a beneficial revolution in economic and social conditions in Communal Lands and lead to a widespread betterment of living conditions (Hill, n.d).

Essentially, the Act was based on improved farming methods on a consolidated block of arable land, with an allocated stock holding pastured on ecologically stable communal grazing area. In this manner a settled community of some 2.6 million Africans could become established in a peasant agriculture with sustained production, but with the potential to enter a cash economy in approximately 41% of the land area of Zimbabwe.

Unfortunately, one of the factors recognized then, and now, was the fundamental requirement of an optimum stocking rate to ensure stable primary plant production ground cover. When the implementation of the LHA was commenced, the communal grazing areas were moderately overstocked, some areas considerably more so than others, but a general figure of 12% overstocking was commonly accepted. As a result, the implementation of the Act was often accompanied by a destocking exercise. This, plus the influence of political and other opposition to the Act, first led to the decision to amend the Act in 1961, to allow further allocations of arable land in grazing areas. However, destocking and enforced land reorganization caused resistance to the point where both had to be abandoned in 1964.

Following the LHA, emphasis in environmental matters became more educational. Voluntary, co-operative action was encouraged, with the result that by the early seventies most arable land had a framework at least of mechanical conservation and emphasis was directed towards biological conservation and management in grazing areas. According to Geza and Reid (1982), over a thousand grazing schemes had been established before they were interfered with. These schemes ranged from sophisticated multi-paddock, well-fenced and watered schemes to very simple schemes with simple rotations in camps which were demarcated by beacons and cut lines and in which stock were rotated by herding. Some schemes were well controlled by active and efficient committees, while others were run in a rather slipshod manner.

The Natural Resource Board assisted the extension service, which ran district, provincial and national competitions that were keenly contested, and in which prices of fencing material and stock management equipment were awarded. This programme was going on well, and veld and water supplies improved vastly in many schemes, cattle health and calving rates improved and participating farmers were proud and enthusiastic.

One area in which all schemes fell down was in a reluctance to keep stock numbers at a correct level, and, despite good fencing and rotational management, grass was heavily overused, sponges and vleis dried up and with the increased numbers of cattle and small stock, severe degradation once again took place.

The Present Position in the CA

The CA at present totals over 16 million ha. Just over 2 million ha are cropped, of which one million is well protected by mechanical conservation works and about one half million is partially protected. There are 1,647 dams and weirs and 3,598 boreholes known (it is probable the number is greater). Using a crude average, this is one dam or weir to 10,000 ha and one borehole to 4,500 ha. For the rest, surface water in rivers, vleis and shallow wells provide the CA water supply. There are some pipe schemes in Matebeleland and Midlands, but not of a great scale.

Current Major Anti-desertification Programmes

Several projects are currently being undertaken in Zimbabwe to arrest or reduce desertification. While in most other countries of the Kalahari region, anti-desertification and conservation projects are mainly the responsibility of the government and its implementing ministries and departments. In Zimbabwe on the other hand, despite Government participation, most land reclamation and conservation projects are undertaken by the communities themselves, often under the direction of extension staff and the DDCs or the ICAs. Several other private and non-profit organizations commonly known as NGOs are either actively involved in raising funds to assist in combating desertification or are engaged in action projects, public information campaigns and promoting awareness and activities in the varied fields related to desertification.

It is impossible to describe all the on-going and planned anti-desertification projects in Zimbabwe. In what follows, therefore, only the main projects initiated or planned since 1977 and particularly since independence in 1980 are described.

Resettlement Scheme

The most ambitious project launched since independence in 1980 in Zimbabwe is the resettlement scheme. This is an exercise to relieve the pressure on the Communal Lands by resettling thousands of peasant family farmers on formerly white-owned farmlands which the state has bought at current market values. Some 160,000 families are affected, but estimates indicate that up to 300,000 families need to be resettled if the pressure on the Communal Lands is to be eased and land degradation there brought under control.

The programme is on-going and it is too early to assess its results. However, intractable problems being encountered include a high population

increase on the Communal Lands (estimated annual increase is about 3.7%) and the high cost of land purchase. The estimated cost of procurement of land for resettlement is Z$250 million and that for the development of infrastructure about Z$300 million.

Reclamation Teams

One other ambitious land reclamation and conservation project planned for agricultural and rangeland development in Zimbabwe since independence is Reclamation Teams. The project comprises the establishment of 4 reclamation teams to carry out major reclamation and soil conservation works in Communal Areas where soil erosion has become a major problem and its control is beyond the ability of local communities and field extension staff.

The project aims at combating the major soil erosion problems that are occurring in the rural areas of Zimbabwe. The primary objective of the teams is to carry out such major conservation works as filling in and sloping of gully sides, diversion of storm water, ripping of compacted soil, pasture furrows, storm drains, bolsters, silt traps in the form of dams and weirs, flooding of gully heads, diversion dams and other necessary conservation works. Secondary work such as fencing, re-seeding, re-routing stock corridors and increasing water supplies are to be carried out. An extensive extension programme constitutes an integral part of the mechanical work to ensure local involvement and participation. Teams are to work in close liaison with Provincial and District staff and other Government Departments. Mechanical equipment is to be owned by CMED and hired in the normal way by Rural Development. The total capital cost of the project is estimated at Z$1,050,540, and the estimated total running cost is Z$886,132. Implementation of the project started in 1983.

Rehabilitation of South Matebeleland Based on Irrigation, Cattle and Wildlife

In Zimbabwe, game ranching is a significant component of landuse management and the Department of National Parks and Wildlife Management (1982) has proposed an interesting rehabilitation project for South Matebeleland which advocates the development of integrated game, cattle ranching and irrigation schemes in the region. The project area comprises a set of communal areas together with the Tuli Purchase area and the recently acquired ranches of Doddieburn, Shobie Block and Jopembe covering an area of some 54,000 ha. Most of the project area is suited only to extensive livestock production and wildlife utilization. Past arrangements for grazing and grazing rights have led to persistent overgrazing and serious declining productivity.

Because of the depressed state of the region and its inherently fragile ecosystem, the Department of National Parks and Wildlife Management feels that there is a need to examine regional development in terms of rehabilitation rather than resettlement. It also feels that there are good ecological as well as economic reasons for the integration of certain large herbivore species with extensive cattle grazing schemes. Single species cultures use less of the available plant production than multi-species communities. The production of protein can be further enhanced by using species which show more rapid growth, higher reproductive rates and better dressing out percentages than do cattle. Suitable species are considered to be impala, warthog, kudu, zebra and eland.

Rural Afforestation Project

When it became apparent in the late 1970s that Zimbabwe was heading for a fuelwood 'crisis' such as already experienced in other developing African countries, the Whitsun Foundation, a private non-profit development agency initiated discussions with the Forestry Commission and what is now the Department of Agricultural Technical and Extension Services (Agritex), which led to the implementation of a feasibility study for a project suitable for submission to government and aid agencies for inclusion in an integrated rural development programme.

The project is being financed by the World Bank. It aims at ameliorating the fuelwood deficit in 30% of the rural districts over the eight provinces in the country by the planting of fast-growing exotics (World Bank, 1982). The districts concerned have an estimated deficit of over 6 cubic metres of wood per family per annum. Components of the project include the development of an infrastructure for the production and distribution of seedlings and the planting of woodlots; the provision of education, information and extension services necessary to promote tree planting and management by communal land farmers as an integrated part of their farm management; and the undertaking of research into many aspects of rural afforestation and wood as an energy resource. It also involves the establishment of 66 nurseries near rural service centres in the 16 districts involving 44 communal lands.

The project was started in July 1982. The first year's (1982/83) target was to establish 12 nurseries in four provinces. To date 11 nurseries have been set up and are producing plants. Four of the nurseries have been established in Mashonaland East Province, five in Victoria Province and one each in Manicaland and Midlands Provinces. A second nursery site has been provisionally selected in Manicaland. A minimum production of 80,000 seedlings per nursery was envisaged during 1983.

Sites had been cleared for block plantations on two forest areas and by 1983 there were 40 ha of plantations established at two urban centres, with a further 40 being prepared for planting during the following season. The total estimated cost of the project is US$93,237,000. Although it is too early to assess the impact of this rural afforestation, on the whole, progress has been satisfactory. Major questions facing the scheme in the Communal Areas are the availability of land for planting and access to such land, protection of trees on grazing land and the willingness of inhabitants to plant.

Agro-forestry Project — Mafungabusi

This is a project aimed at the integration of forestry and agriculture and the creation of additional employment and income in the drylands of Zimbabwe. The project is located in

Gokwe District and it covers an area of 1,200 ha. It is supposed to benefit 140 families. Its components include inter-planting of crops and trees on Kalahari sand which has been denuded. The estimated cost is Z$300,000. It is being funded by the government and executed by the Forestry Commission. It is scheduled to last five years and the projected annual income to be generated from it is Z$50,000. The projected number of jobs created is 140. The project has just started and it is too early to assess its impact.

Development and Improvement of Irrigation and Water Resources

The Ministry of Water Resources and Development is in charge of investigation and construction of water storage works for urban, industrial and agricultural purposes. It is also involved in the drilling of boreholes for primary and village water supplies. It has undertaken a large number of projects in the past and was in 1983 undertaking 10 major water works involving the commissioning of water pumps,. the drilling of boreholes, the construction of reservoirs and storage dams and the excavation of reservoirs. The Ministry had also undertaken several water works projects in the resettlement areas.

One of the strategies suggested for the reclamation and conservation of the Sabi River Catchment which has provoked a great deal of controversy is dam construction. The Chairman of the Natural Resources Board, Mr. L. Smith, with whom the author discussed the problems of the Sabi River Catchment, quite correctly thinks that the main cause of soil erosion in the catchment is the inordinate pressure on the natural protective cover caused by poor landuse which in turn has been precipitated by population pressure. He believes that the first task is to reduce the population pressure and notes that resettlement programmes are attempting this but with inadequate alternatives. He thinks that other alternatives are available in the form of water conservation, i.e. dam construction, and that efforts should first concentrate on the building of three major dams: The Condor, the Maguadzi and the Umfuli.

The Condor would control and conserve the water of Zimbabwe's biggest river with the most highly populated rural catchment area. It would be able to supply water for irrigation to areas, at present underpopulated, with capacity to absorb some 50,000 families. These would be drawn off the densely populated parts of the Sabi Catchment and the Masvingo Province allowing a replanning of land holdings of those remaining behind with the introduction of a more suitable landuse pattern.

As regards the two other large scale irrigation dams, the Maguadzi and the Umfuli, the chairman believes that the associated problems of the Sabi Catchment and the Masvingo Province make it essential that these two dams be considered as complementary and be put under construction as soon as possible. The Maguadzi would maintain the productive capacity of the high rainfall area of Northern Mashonaland both for supplementary irrigation and the winter production of wheat. The Umfuli, with a dam at the Seignury site, would provide for tremendous development opportunities for resettlement or irrigated projects in communal land and on a larger scale on commercial land.

Development of New or Alternative Energy Resources

About ten institutions and organizations were identified by the author and included in his Draft Directory (Darkoh, 1983) as involved in the development of new or alternative energy technologies in Zimbabwe. Many of these were non-governmental and non-profit organizations (NGOs). Their activities ranged from the designing of efficient wood stoves to the construction and installation of solar cookers, biogas digestors and windmills.

The newly established Ministry of Industry and Energy development was also involved in similar projects and experiments in the rural areas of Zimbabwe. The government was at the time of the author's mission negotiating with the EEC for funds to install two units of biogas plants and two units of woodstoves in each District Council in the country. The objective of this programme was to ensure efficient utilization and conservation of woodfuel, to lessen dependence on petroleum imports and to supplement the costly electricity supply where feasible. The project involved mobilization of the people via their district councils to select plant locations, provide labour and local building materials. It also involved training local builders for each district council. The estimated cost of the project was US $150,000 for the biogas installation and US $100,000 for the wood stoves. As of 1983, 15 units of biogas plants had been completed and two test stoves approved and recommended.

Educational, Public Information and Research Projects and Activities

In the field of training and research in alternative energy technologies, the Department of Energy Development in collaboration with the EEC in 1982 launched a project involving the use of biogas for cooking and lighting. During this author's mission, it was installing Chinese and Indian biogas units in all districts of Zimbabwe for demonstration purposes. The results of experiments in the development of fuel efficient woodstoves by the Department of Energy Development indicated that use of such stoves saved 50% of available wood compared to an open fire.

The Department, again in collaboration with the EEC, was establishing eight provincial field training centres. These centres would train people in the building and maintenance of biogas plants and efficient woodstoves. The training system in woodstoves and biogas initiated by the Ministry of Industry and Energy Development was not intended to be carried out at established institutions. It was aimed at taking appropriate energy technology to the people at the grass-root level.

The Forestry Commission and the Government have instituted a College of Forestry at Mutare. The college offers certificate and diploma courses for forest rangers and foresters. The Diploma Course takes two years and produces an average of 20 graduates a year. The Forest Ranger Certificate Course lasts one year and produces 15 graduates a year.

The University of Zimbabwe has a permanent Technology Forum in the Department of Land Management, Faculty of Agriculture, Harare. The Technology Forum operates an appropriate technology extension service for approximately 90,000 people, men, women and children in the north-east of Zimbabwe, north of Inyanga, through their own elected Inyanga Development Committee.

The Ministry of Education and Culture has introduced Environmental Science and Agriculture syllabi in all primary schools, that is, from Grade I to Grade VII. In secondary schools Environmental Science is being taught in Forms I and II. Agriculture is taught in Forms I to IV. In Teachers' College and in Zintec, agricultural programmes are being taught to enable the teachers to teach in both primary and secondary schools. There are radio programmes for schools on Environmental Science.

Furthermore, as a part of its educational, mass mobilization and people's participation programme for afforestation, the Government has declared the first Saturday in December each year as a National Tree Planting Day. On that day, everybody in the country is expected to plant a tree.

Information dissemination to the public on soil conservation is undertaken not only by the National Resources Board but also by several other non-governmental and non-profit organizations referred to already. It is also carried out by extension services of the Ministry of Agriculture, the Ministry of Natural Resources and Tourism and the Forestry Commission.

Technical Research and Experimental Projects

A number of interesting technical research and experimental projects have been initiated or proposed which are directly relevant to desertification control and resource planning and development in arid areas. The rest of this section will concentrate on these research and experimental projects.

In semi-arid regions, one of the main hydrological characteristics is the unreliability of the dry season river flow

On National Tree Day everyone in the country is expected to plant a tree. (UNEP/M.B.K. Darkoh)

in the months before the onset of the rains. The provision of water for irrigation and urban purposes etc. throughout the year usually entails the construction of impoundments to store the flood flow during the rains and to release this water during the dry season. There is considerable variation in rainfall from year to year so that the reservoirs also need to be of sufficient size to store water during years of above average rainfall to make up the deficiencies during years of low rainfall. The Ministry of Natural Resources and Water Development has pioneered and improved a method which can be used to analyse quickly and efficiently this type of seasonal annual store-and-release procedure. It is called the *Transitional Probability Matrix (T P M)* method of yield analysis (Mitchell, 1982). Through this method curves can be presented for estimating the potential yield of a system. The method that has been proposed is reliable and simple. It is also economical in that it uses only those hydrological variables that have a direct bearing on the problem. It can therefore overcome such problems as a lack of a high density of recording stations so common in Africa.

The Institute of Agricultural Engineering of the Department of Research and Speciality Services is undertaking a number of projects concerned with collection of data for a *soil loss estimation system (SLEMSA)*. The system is now in use by Agritex to design safe rotational systems for arable lands.

SLEMSA is made up of two types of data: "fundamental" data from which the predictive equations are built up and user data tables to enable the designer to select the site values of the variables to put into the predictive equations (Elwell, 1978). The user data comprises routine compilation of the energy content of rainfall from autographic rain gauge charts, routine weekly measurements of crop cover and soil erodibility. The fundamental data comprise measurements of soil loss and runoff (soil erodibility) and simulation studies of rainfall energy, soil moisture and the components of vegetation.

Another research project being undertaken by the Institute of Agricultural Engineering is an investigation into the economic aspects of alternative energy sources related to tillage practice. It is comparing the cost of energy involved in four different tillage systems (conventional tillage, reduced tillage, zero tillage, zero tillage and strip tillage) in practice in Zimbabwe and three stover (crop residue) treatments (burn, graze, leave) with the expected economic returns for maize in Zimbabwe. A third research project is looking into two basic ways

of utilizing solar energy: photovoltaic panels and generating electricity.

The Division of Livestock and Pastures of the Department of Research and Specialist Services is carrying out veld and pasture research. One of its projects aims at developing a simulation model of grass growth on 'red soil' thornveld, using commonly recorded meteorological data so that variations in veld production can be quantified over as long a period as records permit. This model is to be used in conjunction with a model of animal production to evaluate grazing management strategies aimed at stabilizing animal production and preventing damage to the veld in critical drought years. Another veld research project is being conducted at the Matopos Research Station and is making a comparison of continuous and rotational grazing on open granite sandveld. Two rotational procedures (a four-paddock system with a ten-day period of stay and an eight-paddock system with a five-day period of stay) are being compared with continuous grazing.

The Department of Research and Specialist Services of the Ministry of Agriculture is undertaking various research projects into: agronomic and crop-breeding in the low rainfall areas of Zimbabwe; tillage and erosion research, including soil loss estimation and reclamation of degraded areas; range management and effects of stocking rates on grazing land; and dryland irrigation research.

The Henderson Agricultural Research Station is investigating dryland fertilized pasture and legume pastures. It has planned as part of its future programme to undertake integrated farming systems research in association with ILCA.

The Department of Geography of the University of Zimbabwe has a project proposal on land degradation in Zimbabwe with particular reference to the peasant farming area. It intends to carry out a thorough survey of land degradation as it exists at the present time. The proposed survey involving the use of aerial photos and national census would be directed initially at mapping the occurrence and lengths of gullies, the extent and severity of sheetwash, the area of rock outcrop and relevant aspects of landuse including areas under dryland cropping and areas under wetland cropping. The second stage of the project would be an analysis of spatial patterns and inter-field sampling to examine degradation problems at a local level and to check on the occurrence of the aerial photo-interpretation.

Improved Wildlife Management Project

The Department of National Parks and Wildlife Management has drawn up a drought relief programme to conserve the indigenous flora and fauna of the drylands and improve wildlife management in Zimbabwe. Because of two years of drought, the vegetation in some of the National Parks is beginning to be affected. To relieve pressures on the land, the Department has proposed to undertake the following measures:

a) the Department embarked on a heavy culling programme in Wankie, Gonarezhou and Zambezi Valley;
b) the hunting quota for the 1983 hunting year was increased in order to remove excess animals;
c) some of the animals are being captured and translocated to areas with no grazing pressure;
d) the possibility is being considered of allowing the farmers to
   (i) graze their cattle in some of the park areas which still possess a reasonable quantity of edible grass; and
   (ii) water their cattle in National Parks which still have permanent supplies of water.

The Department is also installing water pumps in Hwange National Park as a drought relief measure.

Drought Relief Committees

The Ministry of Labour and Social Welfare has instituted Drought Relief Committees in each province. These Committees are provided with funds by the Government to extend relief in the form of water and food to drought-stricken areas.

Conclusion

The government and people of Zimbabwe have for some time now taken various measures at local and national levels to combat desertification. These have included land reclamation and resettlement projects for agricultural and rangeland development, rural afforestation and agroforestry programmes, development and improvement of irrigation and water resources, and development and promotion of new and alternative energy technologies. Some emphasis has also been given to educational, public information and research projects and activities and an improved wildlife management project and Drought Relief Committees have been set up to cope with the consequences of drought. While a great deal has been achieved, probably making Zimbabwe the leading conservation-oriented country in sub-Saharan Africa, a lot still remains to be done, especially in the Communal Areas where severe degradation is still rife. Current emphasis particularly on resettlement as a long term solution to the problem should be coupled with a programme of transforming farming methods to improve conditions in the Communal Areas. It is of primary importance that the resettlement programme currently being implemented in the country does not become merely a transfer of the agro-ecological problems from the Communal Lands to the Commercial Lands. It is necessary from the outset to ensure that in the lands being resettled, proper conservation practices are maintained and that stocking rates do not exceed the carrying capacity of the land. It is also important to ensure sustained crop yields and maintenance of the optimal condition of such natural resources as soil, water, wildlife and flora. These conditions are absolutely essential if Zimbabwe is to continue to feed itself, as well as produce surplus food which is much needed by its neighbours.

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Desertification in India: trends and countertrends

Vandana Shiva and Jayanta Bandyopadhyay
Research Foundation for Science, Technology and Natural Resource Policy, 105 Rajpur Road, Dehra Dun 248001

Desertification is not yet viewed as a serious ecological problem in development planning in India, although 14% of the world's land threatened by desertification lies in India. Also all ecology movements in the country are, in one way or another, a response to increasing trends of desertification in humid as well as arid zones and in uplands as well as in lowlands. Desertification is not merely a threat under extremely low rainfall conditions. It becomes a threat wherever the soil-vegetation system becomes incapable of conserving moisture. Under conditions of seasonal rainfall this can happen even under conditions of high rainfall, as in the Himalayas.

Policy response to desertification in India has been much slower than the peoples' response. This paper presents three case-studies where people have sensed an early threat of desertification and have taken the initiative to arrest the trend and reverse it. One case is from the high rainfall zones of the Garhwal Himalaya, the home of the Ganges river, and two are from the semi-arid region of the Deccan plateau which lies in the rainshadow of the Western Ghats. The cases thus cut across different land use in diverse ecozones and are presented here to establish the general pattern that desertification arises from inappropriate land use which destabilizes the soil-water-vegetation system.

Women volunteers of the Chipko movement in Tehri Garwal district demonstrating against an acute shortage of drinking water. (Photo: Vadana Shiva)

Desertification in Humid Regions

Chipko Against Desertification of the Himalayas

The Garhwal Himalaya is the home of Ganges river. It is the source of water for the entire North Indian plains. Except for the fraction of water flow from glacial sources, the recharge of the springs and streams which feed the rivers depends on the monsoon rainfall. In spite of the heavy precipitation received by the Garhwal region, water resources are rapidly disappearing. Springs are drying up. In the monsoons, much of the water is lost as flood water run-off. The flood prone region in the basin has multiplied four-fold over a decade. During the remaining year there is no water to support plant life. Women are walking longer distances to collect water. In some regions no water source exists now within walking distance, and water is being supplied on mules.

The Chipko (Hug-The-Tree) movement, a grassroots movement of the Garhwal region, is a response to this desertification of the Himalayas. The women of these hill villages got organized to stop deforestation. They stopped commercial fellings by hugging the trees. The women wanted an end to commercial exploitation of their forests, because they recognized their central ecological role. The central Chipko slogan became: "What do the forests bear? Soil, Water and Pure Air."

Since different vegetative cover has hydrologically different properties, the demand for water became a demand for a protection and expansion of oak forests and an arrest of the expansion of pine forests which were preferred by forest industry and the forest bureaucracy. Mimicing these conflicting priorities, the women sang: "What do the forests bear? Resin, timber and profits."

On Environment Day in 1979, women from villages around Tehri demonstrated with empty pots, reminding the district administration that schemes for drinking water were failing because the spring sources were drying up. Out of 2,700 drinking water supply schemes in these hill regions, 2,300 projects had become defunct as a result of the drying up of sources of water. The women pointed out that providing water was an ecological problem, not an engineering one.

The women's priority for water as expressed in Chipko through forest protection, through species selection, through anti-liquor campaigns, has recently expressed itself as a resistance to limestone mining. Limestone mining in Doon Valley had been resisted by the urban populations of Dehra Dun and Mussoorie. Studies had established that fissured limestone in this mountainous region is an important hydrogeological unit for conserving and storing water. The citizens had therefore taken the case to the Supreme Court in 1983. With protests against mining in Doon Valley, the contractors moved to the rural areas of neighbouring Henwal Valley which has a long history of the Chipko movement. The Chipko women quickly organized themselves in April and May 1984 and this time, instead of clinging to trees, they clung to limestone boulders singing: "The Valley's fertile land is being turned into sand, stop tampering with these soil, rocks, water, trees. If you break the backbone of the hills, throughout the country floods will spill."

The contractors had to run away in spite of initially assaulting the Chipko activists. On 12th March, 1985, the Supreme Court closed most of the Doon Valley mines on conservation grounds. The contractors are again looking towards the interior in Tehri Garhwal. The Chipko women are once again preparing to resist the rape of their streams and fields and homes.

The Government is stepping up its investments in engineering works, while the Chipko movement focuses on ecological responses to desertification. The village Pujargaon is a good example of what can be achieved ecologically in desertification control. Here, Chipko activist Vishweshar Datt Saklani has led the community to afforest bare slopes with oak. Saklani has eighty to ninety per cent success in trees reaching maturity, compared to the government plantation survival rates of thirty per cent. The secret lies in the care and protection. For Saklani each tree is a child. Springs in Pujargaon are perennial again with the soil always moist. The plantations of pine that the government plants are arid and do not reactivate streams. As the villagers like Saklani know, oak will reverse desertification, pine will not. What the Chipko movement has shown is that desertification control cannot arise from fragmented knowledge. It arises from ecological knowledge, from being a participant in nature's processes of healing.

Desertification in Arid Regions

In arid regions where rainfall is low and erratic, desertification control is equivalent to conserving moisture as efficiently as possible. The Deccan region of India gets low rainfall—between 60-100 cm annually. This water has to be used throughout the year to supply drinking water and irrigation needs. Increasingly larger areas of the Deccan are losing their potential for biological productivity. The two cases discussed here show how subtle changes in land use can destroy water and soil resources and contribute to desertification trends.

Eucalyptus and Desertification in India

The various aspects of the ecology crisis to which people are responding can be summarized in one word—desertification. Tragically, tree planting which was to have been the cure has itself become an added cause for desertification because of inappropriate selection of species. Eucalyptus, which has spread throughout India and other countries of the South, is threatening to deplete already scarce water resources.

The singlemost important criticism against the reckless expansion of Eucalyptus has been its impact on water resources. Throughout the country reports are available about the rapid destruction of water resources as a consequence of large-scale planting of Eucalyptus. Sunderlal Bahuguna recorded the following statement of an elderly forest ranger in the Nainital Tarai of Uttar Pradesh: "We felled mixed natural forests of this area and planted Eucalyptus. Our handpumps have gone dry as the watertable has gone down. We have committed a sin." Mahashweta Devi described the impact of Eucalyptus on the water resources in the tribal areas of Bihar and West Bengal in the following words: "I am concerned with the India I know. My India is of the poor, starving and helpless people. Most of them are landless and the few who have land are happy to be able to make most of the given resources. To cover Purulia, Bankura, Midnapur, Singbhum, Palamau with Eucalyptus will be to rob my India of drinking and irrigation water."

On August 10, 1983 the farmers of villages Barka and Holahalli in the district of Tumkur in the state of Karnataka, marched en masse to the forest nursery and pulled out millions of Eucalyptus seedlings, inserting tamarind and mango seeds in their place. According to them, the Eucalyptus plantation in the catchment of the streams feeding their agricultural land had led to their drying up. Describing the state of the main stream feeding the village Guttalagolahalli, a local farmer complained: "Earlier we would take our cattle to this stream in the summer. But now, as the stream is dry, we have to fetch water from a well."

The hydrological impact of Eucalyptus on water resources has been systematically studied by the hydrological division of the CSIRO in Australia. A long term experiment established that during years with precipitation less than 1000 mms, deficits in soil moisture and groundwater were created by Eucalyptus. A permanent water deficit was avoided by significantly high rainfall of 1,477 mms in one of the five years of the study. Table 1 summarizes the results of the long term hydrological study showing that when rainfall is of the order of 1,000 mms or less, Eucalyptus plantations create deficits both in the soil moisture and groundwater.

Table 1: Changes in Soil Moisture and Ground Water in Eucalyptus Catchments (mms)

Year	Precipitation	Soil Moisture	Ground water	ETR
1974	1477	+29	+27	1255
1975	914	−87	−14	932
1976	883	−49	−33	947
1977	983	+49	−12	811
1978	900	+30	−19	813

ETR = Evapotranspiration rate

Quite clearly in the semi-arid regions of India, where the rainfall is about 700 mms, the soil moisture and groundwater deficits created by Eucalyptus plantation will act cumulatively, resulting in groundwater depletion, soil aridization and desertification. Such regions never enjoy years of rainfall of the order to 1,500 mms which, in the Australian habitat, provide surplus precipitation to make up for the deficit created in the lower rainfall years. Eucalyptus, which is ecologically adapted to its native habitat in Australia, thus threatens to become a serious ecological hazard in the water deficient regions of India.

The people of India are resisting the threat of desertification created by Eucalyptus cultivation. In Karnataka they have started an anti-Eucalyptus movement called "Save the Soil Movement". Parallel to government afforestation drives supported by international aid which propagate Eucalyptus, people are setting up their own nurseries of indigenous species which are soil builders, not soil depleters, and which contribute to water conservation both in the soil and in underground aquifers.

Sugarcane and Desertification in Maharashtra

In 1972, Maharashtra had a severe drought. To tide over the crisis borewells were dug and energized pumps were used for withdrawal. Yet in no time, the project was transformed from a drinking water scheme to an irrigation scheme for cultivating water-intensive crops like sugarcane whose water requirement is far in excess of renewability. This has led to over-exploitation of groundwater. The Groundwater Survey and Development Agency of Maharashtra has found that out of 1,481 watersheds in the state, there is over-exploitation of 77 watersheds spread over 14 districts. The problem is extremely acute in the five districts of Ahamadnagar, Sangli, Jalgaon, Dhule and Nasik. Abuse of water for water-intensive cultivation has created a severe drinking water crisis and severe food crisis. As the Chief Minister of Maharashtra stated at the 1984 meeting of the National Development Council in the Sixth Plan, 17,112 villages were identified as facing drinking water problems of which 15,302 villages are likely to be covered by the end of this year, leaving 1,810 villages to be covered in the ensuing Seventh Five Year Plan. The rapid depletion of groundwater resources has, however, increased the problem of villages with no source of drinking water to a staggering 23,000 villages in the meantime.

The replacement of natural mixed forests by commercial monocultures, such as Chir Pine and Eucalyptus, has led to widespread shortages of fodder and the destabilization of delicate hydrological balances, as here on a degraded hillslope in the Himalayas. (Photo: Vadana Shiva)

Sugarcane is among the cash crops which has an extremely high water

demand. In the area around one sugar factory alone, sugarcane cultivation with groundwater irrigation has increased dramatically over two decades (Table 2).

Table 2: Growth of Irrigated Sugarcane in a Region of Maharashtra

Period	Area Under Sugarcane (well irrigated) (Hectares)
1961-62	3,248
1971-72	6,990
1981-82	17,612

Incomes have risen as a result of shifting from rainfed coarse grain production to an irrigated cash crop But the costs, especially for women, have been heavy. The Manerajree village of Tasgaon Taluk is among those that have benefitted financially but lost materially by the expansion of energized groundwater withdrawal for sugarcane cultivation. A new water scheme with a potential supply of 50,000 liters was commissioned in November 1981 at a cost of Rs.6.93 lakhs. The source well output lasted for one year and it went dry by November 1982. To increase the yield three bores were put in near the well to a depth of 60 meters. The yield from all the three with power pumps was 50,000 liter/day for 1982 and all bores had gone dry by November 1983.

There has been continuous tanker service for water supply since 1983. In 1984, one bore well of 60 meters depth was drilled in the villages, and this was found dry. Another bore of 200 meters was made which provided some water, but also went dry. At present, water is being brought by tanker from a distance of 15 kms. More than 2,000 privately owned wells in this sugarcane country have also gone dry.

There is a tendency to associate rainfall failure with the water famine and to see the lack of rain as the cause for the disappearance of water. Yet rainfall failure cannot lead to a disappearance of groundwater by itself because ground water storages are the cumulative effect of long periods of percolation and recharge. For instance, the deep aquifers under the Sahara are recharged at the rate of 4 km^3/year. This means that it would take nearly 4,000 years at the present rate of recharge to fill these formations. Quite clearly, groundwater will not get exhausted merely because rains fail during one year. On the other hand, even with regular rainfall, groundwater depletion can take place if withdrawal exceeds annual recharge. Traditional cropping patterns in arid zones have been based on effective use of soil moisture recharged by rainfall, with irrigation used as a protective measure. High yielding varieties of crops have high water demand, and this is not always matched with water availability. At the national level, current patterns of agricultural development will outstrip water availability before the turn of the century. 1980-1990 is a Drinking Water Decade and one thing that must be ensured during this Decade is that water is not abused in such a manner that the vital needs for drinking water are denied to the poorer, less privileged groups.

Groundwater depletion depends more on rates of withdrawal in relation to long-term recharge than it does on one or two years' rainfall. A balance must be maintained for groundwater use to be sustainable. (UNEP/Daniel Stiles)

There are two solutions to the water famine in Maharashtra—one that is proposed by the 'sugar barons' (the rich sugarcane farmers) is to bring water over large distances at high capital investment of scarce government finances, with no guarantee of sustainability. The other solution has been practised by a village called Ralegaon Shindi which has totally reversed the desertification threat. Under the leadership of Gandhian Anna Sahib Hazare, the village community has adopted two simultaneous measures for desertification control. Firstly, they have planted soil building species of trees on every possible inch of common land. These trees provide fruit and fodder. The improved fodder base has increased the livestock wealth of the village, which has built up organic matter availability to conserve soil moisture in the fields. Tree cover has also improved local groundwater recharge increasing the yields of wells.

The second measure for

desertification control is a change in cropping pattern. No villager is allowed to cultivate sugarcane or other water intensive crops. Water is equitably distributed between all for protective irrigation of high water-efficient crops such as coarse grains, which are the local staple. Protective irrigation is a sustainable option because it uses water within limits of renewability. While the surrounding villages wait precariously for water to be delivered by tankers for drinking and their fields lie dry and withered, Ralegaon has overcome its problem of water-scarcity and desertification.

Ralegaon is, of course, an exceptional village. And it has been possible to have local measures for desertification control because of the peculiar geohydrological conditions of the Deccan trap in which groundwater recharge is a very localized phenomenon. However, the principle of arresting desertification through appropriate land use which conserves soil and water is applicable at all levels. Desertification results from changes in the soil-vegetation system that reduces the water conservation capacity of an ecosystem and adversely affects plant and animal life, undermining the biological productivity of the ecosystem. In the final analysis, desertification can be arrested only with appropriate farming and forestry practices which enhance the conservation potential of the ecosystem.

Stabilizing the destabilized hydrological and nutrient cycles has to be a central concern in desertification control. Grassroots initiatives have showed the way. It is now time for policy makers to learn from these invisible, unknown scientists. Forestry science needed the Chipko activists to remind it that catchment forests were not mines of timber but a source of water. Agriculture needed Anna Sahib Hazare to point out the hazards of sugarcane cultivation in zones where water was already scarce. Scientists, technologists, and decision-makers need to develop a new respect for these other sciences and scientists. In this recognition of their insights and experiences lies the only hope against desertification.

Climatic change and variability in eastern Africa

Thomas E. Downing
Climate and Society Research Group
Center for Environment, Technology and Development
Clark University
Worcester MA 01610, U.S.A.

There is no doubt that drought is a recurring phenomenon in eastern Africa. Drought in the 1970s has been followed by severe drought in Ethiopia, Sudan, Somalia and Kenya in 1983 and 1984, and mild to moderate drought in other countries and other years. The frequency of drought episodes in the region, and its social impacts, has led to renewed interest in the question of drought prediction. Many, whether scientists, planners or affected residents, have wondered whether the climate of eastern Africa has undergone some fundamental change, such that the historical records and our recollection of the historical climate will be inadequate to describe the climate of the next few decades, or the next century. The issue is whether or not the parameters by which climate is characterized are changing, and if that change will be significant to agricultural production and human society.

By its very nature, the question can only be adequately answered as an historical event. That is, it will require ten to twenty years of data after the point of change to determine whether or not there was a significant change. This is unfortunate as planners looking toward the 1990s and beyond need some assessment of the current trends. At this stage, the best that can be done is to document the historical trends in climatic parameters, and project them into the future.

Twenty six rainfall stations in eastern Africa were analysed for trends in average rainfall by means of polynomial regressions. Figure 1 presents results for six of the stations, which represent the general trends documented in the other stations. About half of

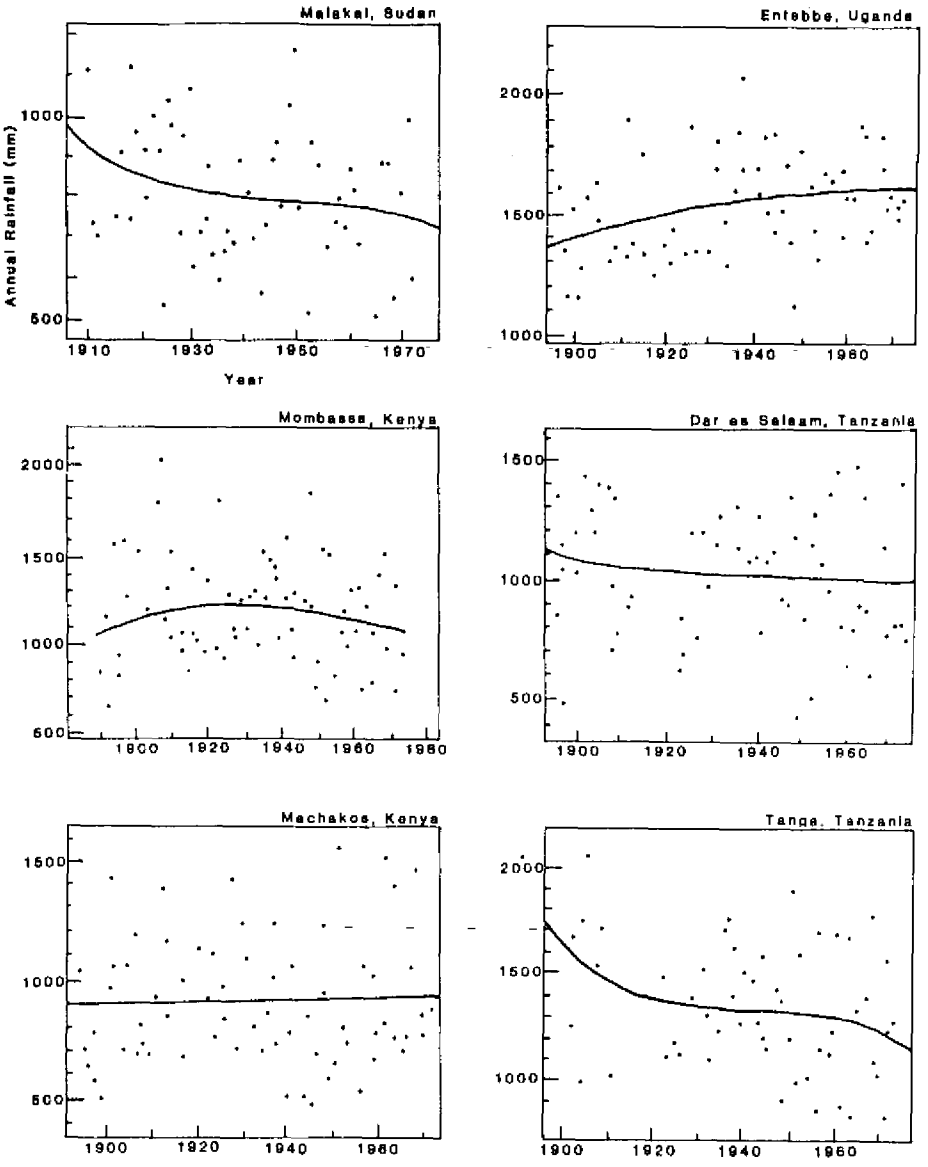


Figure 1. Trends in Rainfall at Selected Stations in Eastern Africa.

the stations show a decrease in annual rainfall since the 1940s (e.g. Malakal and Tanga) and a number have distinct plateaus in the 1920s to 1950s (e.g. Dar es Salaam and Mombasa). The strongest negative trends were found in stations in the Sudan and along the coast of East Africa. However, there is no general spatial pattern to the trends that can be explained by changes in the general atmospheric circulation. In addition, even for stations with strong negative trends, changes in average rainfall projected to the year 2000 are within the current estimate of the standard deviation. Thus, the climatic changes in the next few decades due to continuations of the current trends in average rainfall must be considered as rather small compared to the expected variability of rainfall.

Drought is not a function of average rainfall, but of the departure of rainfall from normal, or its variability. One measure of rainfall variability is the coefficient of variation—the standard deviation divided by the mean, times 100. To assess climatic variability over time, coefficients of variation for 11-year running periods were computed for the same 26 stations (Figure 2) As with the trends in average rainfall, no clear pattern was evident throughout eastern Africa, although drier stations predictably showed large changes in the CVs, the effect of single unusually wet years. A number of stations, particularly along the East African coast, had large variabilities in the 1890s to early 1900s and again in the 1960s to 1970s (e.g. Zanzibar). Only three of the 26 stations analyzed had a decrease in variability in the 1960s to 1970s; twelve evidenced recent increased climatic variability. These data indicate there is some likelihood that the climate of the next few decades will be more variable than in the recent past, but not unprecedented in the historical record.

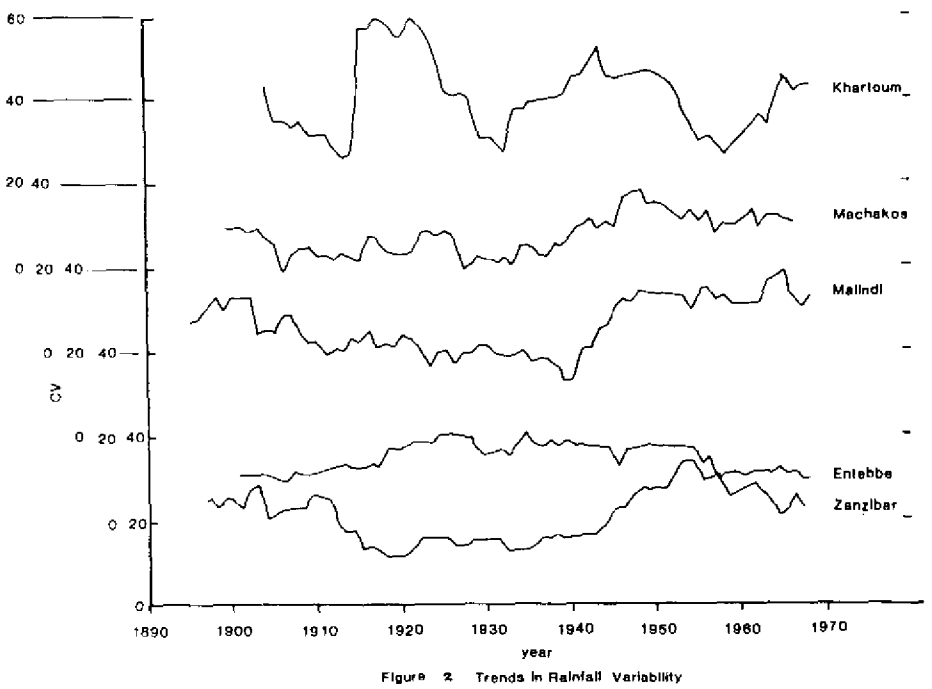


Figure 2 Trends in Rainfall Variability

Given that the trends in average rainfall are not large, that climatic variability in the 1970s is not unusual in the historical record, and that there is, at present, no adequate explanation of the causes of the potential climatic changes, it is wiser to assume that climatic variability and drought are normal characteristics of the natural resources of eastern Africa. Policies can then focus on the social, technological and economic factors which can mitigate the effects of meteorological drought.

News from UNEP

Meeting of the Consultative Group for Desertification Control (DESCON V) Fifth Session: Geneva, 18-24 July, 1985

The meeting was opened under the chairmanship of Dr. Mostafa K. Tolba, Executive Director of UNEP, on 18 July, 1985. Dr. Tolba noted that the session was of special significance because it takes place at a time when the world is besieged by the horror of famine in Africa, with the major cause being desertification. It was also one year since his report to the 12th session of the UNEP Governing Council on the General Assessment of Progress on the implementation of the PACD over the previous seven years (1978-1984).

Dr. Tolba relayed his distress at the unhampered spread of desert-like conditions, and the myriad related problems. He noted that if the worldwide, generous spirit that characterized the international response to the African food crisis could be channeled into desertification control activities, these disasters would not happen. He went on to say that the present state of desertification control is grim, with response to DESCON's initiatives being minimal, at best. Only 12 of the 48 project proposals submitted to DESCON since its inception in 1978 have been fully financed, and seven partially financed, and out of the $102 million additional funds sought for these projects costing a total of $528 million, only $26 million has been secured.

He sent a plea to donor and recipient countries to help DESCON in carrying out its responsibilities to assist in the implementation of the Plan of Action. He encouraged DESCON to rise to the awesome challenge posed by desertification and to live up to its important responsibilities entrusted to it by the community of nations.

The meeting was attended by seven United Nations agencies, co-sponsors of DESCON, 14 core members and 21 invited countries, and other international and regional organizations.

The Group reviewed the status of projects considered at the second, third and fourth sessions of the Consultative Group on the basis of a progress report prepared by the secretariat. It was suggested that, in addition to the summarized report on progress, the secretariat should prepare a one-page evaluation brief for each DESCON project. They would highlight experience gained during implementation of DESCON projects and provide lessons on the basis of which future actions and strategies could be recommended to the UNEP Governing Council by the Group.

The Consultative Group decided that its sixth session (DESCON-6) should be held in March, 1987 before the fourteenth session of the UNEP Governing Council.

In the general discussion, Dr. Tolba introduced the topic on *Exchange of Information*, by recalling the General Assembly resolution 38/165 by which the original mandate of the Group had been expanded to included exchange of information on the anti-desertification policies and programmes of its participants. The Group discussed the problems involved in securing reports from members on their national experiences in combatting desertification (recomended to be submitted to each DESCON by its fourth session).

The Group recommended that a simple questionnaire be designed by the secretariat and sent to governments for completion focusing on three areas chosen by the Group to be discussed at its next session. The three areas of focus include: i) monitoring ii) policy formulation and co-ordination and iii) management, under which afforestation, rangeland or water resources should be chosen. Such focusing on a limited number of components of the PACD in every session of the Consultative Group will make it possible ultimately to have an in-depth analysis of the whole plan.

The whole exercise should be aimed at identifying gaps that need to be filled and proposing elements of strategies to fill them with specific activities.

The second part of the general discussion was devoted to *the Role and Function of the Consultative Group for Desertification Control.* The E.D. called attention to the new mandate given to the Group under GA resolution 39/168. The new mandate reconfirms the original mandate of DESCON by which the General Assembly "*calls upon* the Consultative Group for Desertification Control to intensify further its efforts for the implementation of the Plan of Action", and further extended the role of the Group by explicitly adding to the mandate responsibility for advising the E.D. on:

a. The progress and effectiveness of activities implemented under the Plan of Action, identification of constraints and possible solutions to problems taking into account relevant evaluations and case studies;

b. Programmed priorities of the United Nations Environment Programme related to problems of desertification;

c. Measures required to improve implementation of the Plan of Action on a regional and world-wide basis.

The meeting noted that available resources mobilized through various assistance programmes, including bilateral mechanisms, had not so far been utilized as effectively as desirable to combat desertification. It was also recognized that in order that recipient countries benefit more from limited available resources, they should establish national policies and strategies for combatting desertification. UNEP, in its catalytic role, should help ensure such co-ordination at both national and regional levels.

In the latter part of this discussion, the E.D. informed the Group that UNEP was contemplating selecting a few countries on which desertifcation control efforts could be concentrated for five to six years to see what results could be achieved and used as success stories. The Group discussed the idea

extensively, and agreed that UNEP should pursue this idea further and carefully elaborate sound criteria for the selection of countries, and that the matter should be brought to the attention of the forthcoming Conference of African Ministers for the Environment.

The Group then reviewed the fourteen project proposals submitted to it for consideration and support. Six received expressions of possible interest for support from donors.

In their General Comments the Group expressed appreciation to the retiring Chief of Desertification Branch, Mr. Karrar and welcomed the new Director of DES/PAC, Mr. Robert N'Daw and pledged co-operation with him.

The Group stressed that DES/PAC should get involved in the preparation of the analysis of information and experience on desertification issues, e.g. fuel-wood plantations and sand-dune fixation, to become the centre of excellence in the field which could answer queries and give advice as necessary.

They also issued guidelines which projects presented to the Group in the future should adhere to.

The Group considered a draft report which was adopted with some amendments and additions, and the E.D. gave his closing remarks.

Report of the 12th Meeting of the Inter-Agency Working Group on Desertification Control (IAWGD)

The 12th Meeting of the IAWGD was held from 9-11 September, 1985 at the FAO Headquarters in Rome, Italy. The meeting was attended by representatives from 14 UN organizations and bodies. The objective of the meeting was to review progress in implementation of recommendations of the 11th Meeting and the outcome of the First ad hoc Meeting of the Working Group, receive reports from members, discuss updating of the compendium of UN projects in desertification, and prepare a draft ACC report for consideration by the Meeting of the Designated Officials on Environmental Matters (DOEM).

The meeting reviewed reports presented by the Secretariat on actions taken to implement recommendations of the 11th meeting of the IAWGD, including preparation of teaching and management manuals envisaged in the Plan of Action to Combat Desertificaton. They then discussed a report on the outcome of the First ad hoc Meeting of the Working Group which dealt with: the establishment of regional networks for research and training, afforestation and sand dune stabilization.

In presenting the report dealing with activities of UNEP under its mandate of implementation of the Plan of Action to Combat Desertification, the Secretariat introduced a methodology which UNEP proposed to adopt in addressing the problems more effectively, by concentrating all desertification control activities of the UN-system and bilateral programmes on selected pilot countries which would serve as an example for other countries and for the international community. This had also been discussed at DESCON V. The Secretariat felt there was need for an integrated multi-disciplinary approach in combating desertification and a concerted effort to incorporate environmentally sound development policies and practices into national development plans.

After extensive discussion and comment, the IAWGD welcomed, in principle, the pilot country approach in combating desertification and agreed on the following actions to be taken:

a) UNEP will prepare and send to the IAWGD members a working paper on the criteria for selection of pilot countries and steps for the implementation of the proposed pilot country approach;
b) The IAWGD members will provide UNEP with comments and views, taking into account their respective evaluation of the proposed criteria;
c) The 2nd *ad-hoc* meeting of the IAWGD (March 1986) will consider this subject further on the basis of information the Secretariat will make available derived from preliminary country profiles to be prepared in the intervening period.

The member agencies belonging to IAWGD also presented reports on desertification control activities by their respective organizations, and recommendations were made by the meeting on how reports for future meetings should be prepared.

Assisting NGOs to initiate good land-use practices

The twelfth session of UNEP's Governing Council called on the Desertification Control PAC to step up its support to non-Governmental organizations (NGOs), since they had proved to be highly effective as field oriented desertification control agents. The Governing Council also recommended that UNEP assist in carrying out pilot demonstration projects in good land use practice.

On 1 October 1985 the first project to put these recommendations into effect began implementation in Karnataka and Tamil Nadu states of southern India. The project, entitled 'Pilot Demonstration Project of Community Afforestation and Training in Southern India', is being carried out by the G.G. Soans Memorial Farmers' and Rural Afforestation Training Centre, which is based in Tumkur, Karnataka State. The training centre, which also has branches in Muloor, Karnataka, and in Kodaikanal and Rajapodukodi in Tamil Nadu, is the implementing arm of the Millions of Trees Club.

Deforestation is a critical problem in India, a country of 730 million people. Wood, where available, is a primary source of fuel for cooking and heating. The poorest all over India are now short of fuelwood because of unplanned deforestation in the past. Another problem is the large number of marginal farmers who have small land holdings barely sufficient to support their families. They are forced to overexploit their land in order to try and stay alive, causing desertification. These environmental and economic problems are interrelated. Environmental projects often do not have a sufficient economic incentive to interest people in their implementation, a constraint recognized in the Executive Director's report concerning implementation of the PACD (UNEP/GC.12/9). This project incorporates both economic incentives and good land-use practices, which have as a result an improved environment and economic situation for the project participants. This integration of environment and development can serve as a demonstration model of the application of good land-use policy, which was a major discussion topic at UNEP's 1985 Governing Council.

The Millions of Trees Club has developed a methodology and an organization in which the poor can play an important role in reforestating India, through "self-sustaining, self-propagating and autonomous peoples' organizations at rural levels". In 1976 the Club began an experiment with the landless poor on 300 acres of national

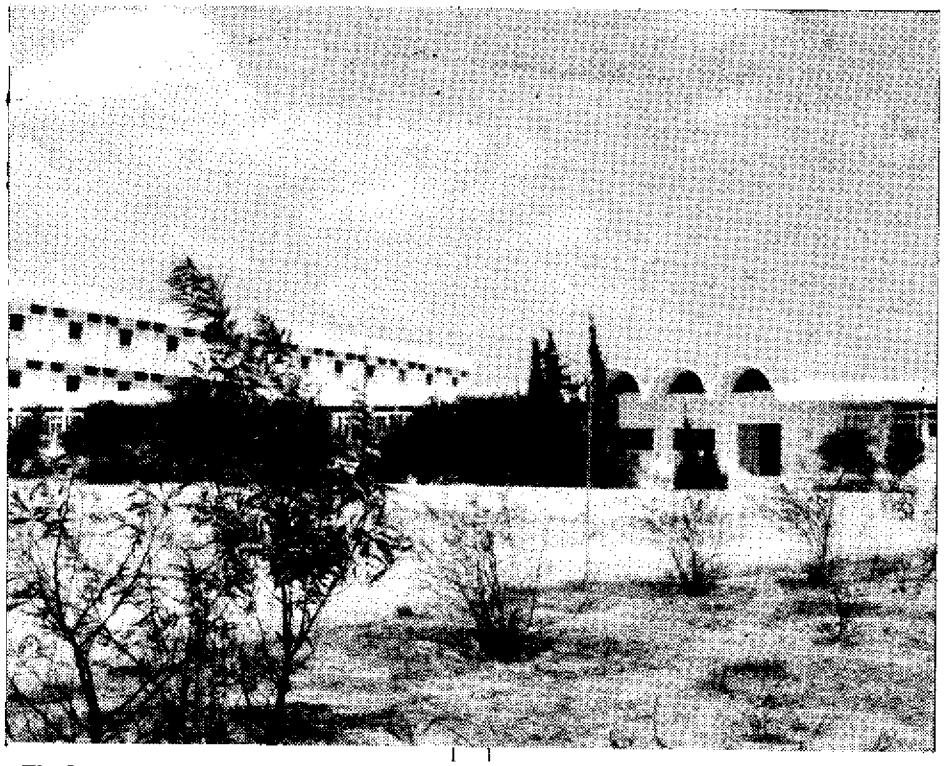
Mr. Herekala Moideen, the leader of the Herekala Landless Poor and Marginal Farmers Development Society, stands next to his successful "Peoples' Nursery", which contains a rich mix of indigenous and exotic tree species which can be applied for a variety of uses such as fuelwood, fodder, small timber, food, etc. (UNEP/Daniel Stiles)

"forest" land, actually a soil eroded wasteland in the hills around Herekala village near Mangalore, Karanataka State on the west coast of southern India. Over the past ten years many simple but universally applicable ideas on massive tree planting have been perfected, and tests and experiments on appropriate tree species (indigenous and exotics) and their propagation have been carried out. The Club is now trying to pass on their knowledge and experience by the creation of Van Vigyan Kendras (literally "Forest Knowledge Centres"), or afforestation training centres, to other rural Indian villages. The goal is to create a vast network of such centres which will ensure a large and sustainable tree population for human and environmental conservation needs. Nearly 400,000 new trees and seedlings are now growing around Herekala. Through the G.G. Soans Memorial Farmers' and Rural Afforestation Training Centre, similar grass roots activities have started up in Muloor and Tumkur in Karnataka State and in very incipient form in Kodaikanal and Rajapodukodi in Tamil Nadu. The objective is for these communities eventually to form their own independent societies, as the farmers of Herekala have done, and to become self-sufficient.

The Government of India is involved in a large scale reforestation effort through its Department of Forestry. This includes the creation of large plantations of eucalyptus and other tree species, and strip planting along roads. Part of its programme involves the distribution of tree seedlings to individuals, but this practice has not resulted in large scale planting because of the labour involved, and the lack of knowledge of how to plant and maintain the seedlings properly. The Government strongly encourages actions by NGOs of the kind proposed in this project. Almost twenty "Peoples' Nurseries" are fully functional in Herekela, contributing significantly to the economic well-being of previously destitute people and resulting in tree seedlings being made available for afforestation activities, which are in evidence to the observer when visiting the area. The Desertification Control programme of UNEP has received criticism in Governing Council for not providing leadership. This project can serve as an indication of the type of project UNEP would like to see supported by other Governments and agencies in co-operation with NGOs.

The activities of the project will be:

- The strengthening of existing afforestation training centres at Herekela and Muloor and the establishment of new centres at Tumkur, Kodaikanal and Rajapudakodi by the construction of simple meeting places and the creation of centralized work areas;
- Four short training courses for farmers and school children in techniques in propagation and planting of trees at the five centres;
- Following the training courses, demonstration planting of the various types of trees by Labour Brigades in critical areas;
- Follow up extension work with farmers to set up Peoples' Nurseries and with school children at the schools and at home to establish seed beds by two project extension agents;
- Nurserymen to work with selected women to establish model Women's Nurseries, assisted by extension agents and the project co-ordinator;
- Work to develop outlets for the commercially viable types of tree and shrub seedlings;
- Stimulation of public awareness concerning environmental rehabilitation through pamphlets, posters, banners, a-v materials, etc. and the preparation of educational materials on tree planting and environmental awareness;
- The production of an approximately 20 minute film of the training and planting activities for Indian and other Asian countries television.



The Institute of Arid Regions near Medenine, Tunisia, which has received considerable support from UNEP since 1978 under several desertification control projects. The Institute will now become the centre for dryland seed collection, treatment, storage and distribution in a revegetation programme to regenerate land productivity in southern Tunisia. (UNEP/Daniel Stiles)

Tunisia National Plan of Action

In March of 1985 the first draft of a national strategy to combat desertification was completed in Tunisia. The strategy was devised by the Tunisian Government with expert assistance provided by UNEP's Desertification Control PAC, following an official visit to Tunisia by Dr. Mostafa Tolba in September 1984.

The Plan concentrates on the southern part of the country, which ranges from semi-arid to arid land which is under serious threat from desertification due to expanding population pressure and the consequent increase in land exploitation by pastoralists and marginal farmers.

Twenty-two priority project proposals were formulated and included in the National Plan. As follow-up to UNEP's involvement in development of the National Plan, a Desertification Control PAC staff member went to Tunisia in September 1985 to negotiate with Ministry of Agriculture officials the detailed formulation of the top priority project proposal contained in the Plan. The project concerns the creation of a seed bank at the Institute of Arid Regions near Medenine, in southern Tunisia. The Plan stresses rehabilitation of land productivity through programmes of plant cover regeneration in the dry lands of southern Tunisia, thus a seed bank is a necessary requisite to revegetation activities.

UNDP-Tunisia volunteered its cooperation with UNEP in support of the seed bank project, and of the National Plan in general. In a cost-sharing venture, UNEP and UNDP will assist the Tunisian Government in financing the creation of the seed bank at the Institute of Arid Regions and in providing technical assistance and staff training to ensure effective operation of the seed bank from the very beginning. The Institute, for its part, will continue its experimental work and research with arid zones grasses, shrubs and trees, amongst other activities, under the UNEP-UNESCO Pilot Project on Desertification Control in Southern Tunisia, which began implementation in September 1985. The pilot project is follow-up to the UNEP-UNESCO Integrated Project on Arid Lands, which lasted from 1978 to 1984, within the context of the Man and Biosphere Programme of UNESCO.

Journalist Attachment Programme

UNEP's Information Service sponsored a programme to disseminate information on environmental issues during its last thirteenth session of the Governing Council, held in May 1985. Ten press and radio journalists from different countries worldwide—from Africa, Asia, the Americas and Europe- spent three weeks at UNEP headquarters. Before the opening of the Governing Council, the journalists were briefed on major environmental problems from desertification, soil erosion, and deforestation to water management and water pollution and the damage caused to the environment and people's health by toxic chemicals.

A field trip to northern Kenya was held in which a Desertification Control PAC staff member accompanied the group to help explain the causes and consequences of desertification. UNESCO staff of the Kenya Arid Lands Research Station in Marsabit (formerly Integrated Project on Arid Lands) greatly assisted the group by accompanying it to their field research stations in various parts of the district. The entire trip was carried out in small aircraft, which allowed the group to cover thousands of square kilometres of land in only three days.

IUCN Workshop on Rehabilitation in the Sahel

The International Union for Conservation of Nature and Natural Resources (IUCN) sponsored a Workshop held at the Elsamere Conservation Centre located on scenic Lake Naivasha in Kenya from 25-31 August 1985. The objectives of the workshop were:

- to review the IUCN report on the Sahel — "The Sahel — Environmental Degradation and Rehabilitation — Diagnosis and Proposals for IUCN's Response";
- to review and assess the processes leading to desertification—actions which have already been taken—their successes and failures and suggestions on possible solutions;

Participants of the IUCN Workshop on Rehabilitation in the Sahel. (UNEP/Daniel Stiles)

— to develop proposals and recommendations leading to a strategy for the conservation of natural resources and environmental rehabilitation of the region and an appropriate Plan of Action for IUCN.

IUCN called together a Task Force on the Sahel to assist them in their endeavours. The members who attended the Workshop were:

The Task Force decided early on in the Workshop to consider all of Africa affected by drought and desertification, not just the Sahel region. The Task Force broke into discussion groups on topical areas and reviewed the IUCN document in great detail. The analysis of desertification in Africa and IUCN's response to it was rewritten by the Task Force. The draft was edited in Geneva by IUCN and the text will be published with funds provided by the Desertification Control PAC of UNEP.

Name	Address
Ag-Youssouf, Ibrahim	Consultant P.O. Box 96 BAMAKO, Mali
Aidoo, Agnes	Director Africa Training and Research Centre for Women Economic Commission for Africa ADDIS ABABA, Ethiopia
Ayyad, Mohammed	Professor University of Cairo Remdene Project P.O. Box 589 ALEXANDRIA, Egypt
Backstrand, Goran	Director International Department Swedish Red Cross P.O. Box 27316 102 54 STOCKHOLM, Sweden
Child, Graham	c/o Dept. of National Parks and Wildlife Management P.O. Box 8365 Causeway HARARE, Zimbabwe
Dalfelt, Arne	Forest and Environmental Adviser NORAD P.O. Box 46263 NAIROBI, Kenya

Name	Address
Fell, Arthur	Club du Sahel c/o USAID U.S. Embassy Haile Selassie Avenue NAIROBI, Kenya
Gritzner, Jeffrey	Senior Scientist National Academy of Sciences 2101 Constitution Avenue Washington D.C. 20418 U.S.A.
Hamidil, Alio	Reforestation Specialist Direction des Eaux et Forets B.P. 579 NIAMEY, Niger
Kante, Bakary	Directeur de l'Environnement Ministère de la Protection de la Nature DAKAR, République du Sénégal
Lusigi, Walter	Director UNESCO's Integrated Arid-Lands Project P.O. Box 147 MARSABIT, Kenya
Naguib, Ahmed	Academy of Scientific Research and Technology 101 Kasrel-Aini Street CAIRO, Egypt
N'Daw, Robert	Director Desertification Control Programme Activity Centre UNEP P.O. Box 30552 NAIROBI, Kenya
Odidi Okidi, Charles	Professor of Law, Institute for Development Studies University of Nairobi P.O. Box 30197 NAIROBI, Kenya
Omo-Fadaka, Jimoh	African NGOs Environment Network (ANEN) P.O. Box 53488, Nairobi, Kenya
Spitz, Pierre	Independent Commission on International Humanitarian Issues (ICIHI) 47 bis Avenue Blanc 1200 GENEVA, Switzerland
Tatu, Kabede	Head of Forestry and Soil Conservation Division Ministry of Agriculture ADDIS ABABA, Ethiopia
Stiles, Daniel	Desertification Control Programme Activity Centre UNEP P.O. Box 30552 NAIROBI, Kenya
Western, David	Animal Research and Conservation Centre Embassy House, Harambee Avenue P.O. Box 48177 NAIROBI, Kenya

The Plan of Action of IUCN to work for environmental conservation and rehabilitation in Africa will be oriented towards small-scale, low cost ecodevelopment projects which will be carried out by local people in the areas affected by desertification. The projects will be formulated with inputs made by local people, and traditional systems of production will be incorporated where appropriate. An overriding concern of IUCN is to avoid the 'top down' and 'from the outside' approaches which are commonly used by the large international and United Nations assistance agencies. Their philosophy is that sustainable conservation and rehabilitation activities can only be achieved through long-term actions by the people who live in the areas affected by drought and desertification.

News of interest

The Rajasthan Canal

India is cutting one of the longest man-made waterways in the world through one of the most inhospitable areas on earth—and no one is sure what the environmental and economic effects will be.

The 649-kilometre Rajasthan canal project was taken up in 1958 and is unlikely to be completed before 1986. Work on associated irrigation schemes and water networks may carry on until the end of the decade.

Well over $300 million has been spent so far, and the bill is still rising. Work ground to a halt after the fall of the Shah of Iran, who had promised financial support, but was resumed when the World Bank picked up the tab. The project was recently renamed the Indira canal, after former Prime Minister Indira Gandhi.

Parts of the barren Thar desert are being transformed, and the vast man-made water system which is causing the change is a testament to Indian engineering skills. It was described as "showpiece of the World Bank" by the institution's former president, Robert McNamara.

Starting from the Harike barrage, constructed below the confluence of the rivers Sutlej and Beas in Punjab, the aim of the canal is to irrigate 10.9 million hectares of land by gravitational water flow and a further 50,000 hectares through lift irrigation.

The Agriculture Ministry says that the area already irrigated by the canal is yielding returns worth $200 million a year.

The net annual benefit from the completed project is estimated at 3.4 million tonnes of grain, 3 million tonnes of cash crops and 6 million tonnes of fodder.

Engineers associated with the canal claim that the average cost of turning an acre of dryland into irrigated land here works out at $800 compared with $ 2,000 per acre elsewhere.

But there are also big problems associated with the scheme. Most of the canal flows through unpopulated land. The Command Area Development Authority, set up to sponsor settlement in the canal area, has found its work heavy-going. Of 7,000 families allotted land in the first phase of the canal, 6,000 have yet to move in.

Newcomers are unwilling to move until the benefits are clear. Although the Authority offers a subsidy and farming support, the 1,000 families who have made the move complain about lack of facilities like power connections, markets and recreational centres.

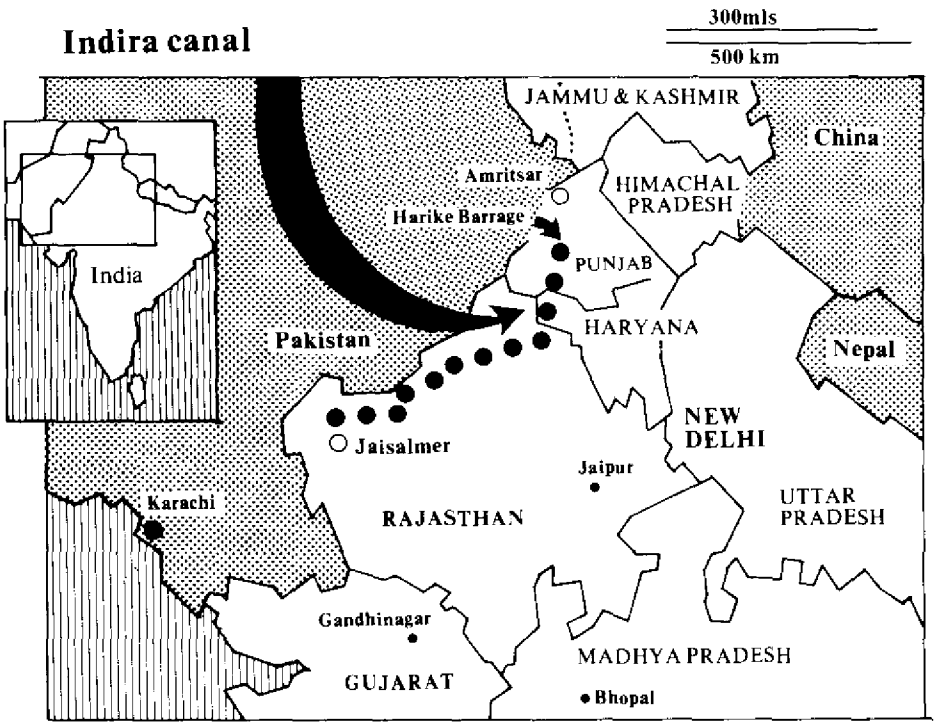
There is also considerable concern about potential ecological side-effects.

Irrigation engineers and politicians—both of whom often show scant concern for the environmental hazards of water control projects—were convinced that surplus water from the neighbouring Punjab could change the face of Thar in one quick sweep. It was assumed that additional water would easily percolate and reach the very depths of the terrain.

But the Thar lacks a drainage system and excess water left after irrigation has the potential to create waterlogging. Indeed, complaints of waterlogging in the canal area have been pouring into the office of the Central Water Commission.

To further complicate matters, the heavy calcareous cum gypsum content of the soil can seriously impede the flow of water. After intense evaporation, salt is left, making the soil unfit for farming.

An expert group headed by the Chairman of the Central Water Commission, M.G. Padhye, has



warned that waterlogging and subsequent soil salinity could take a grip within a few years of the start of intensive irrigation unless immediate remedial measures are taken.

Similarly, intensive agriculture might loosen and erode the precarious top soil. As it is, the canal is cut virtually in a straight line through the stable sand dunes. This might cause the sand to start shifting, allowing it to be blown into the canal.

There is also a fear that winds may blow the loose sand eastward to the more fertile lands on the desert fringe, thus encouraging the spread of the desert.

People's participation as a key to Himalayan Eco-system Development

By, M.L. Dewan Sudhirendar Sharma

Report of the Non-Governmental Organisations Meeting at the Centre for Policy Research, New Delhi India March 16-18, 1985

The degradation of land resources in the Himalayas, India, has been a matter of great concern in recent years. Due to the increasing pressures of human and animal populations, myriad environmental problems have developed.

This report first makes a short assessment about the state of the environment in the Himalayas and of the efforts that have been made thus far, mostly by the Government, to conquer such problems as overgrazing, deforestation, soil loss, siltation, flooding and droughts. The conclusions of the assessment were: efforts thus far have been unsuccessful, the Government alone cannot undertake this mammoth task, and a new approach must be adopted. The new approach calls for a greater involvement of the people, who would be organized through the machineries of non-governmental organisations (NGO's).

Against this backdrop, the Programme for Himalayan Eco-System Development (HESD) was initiated in New Delhi at the Centre for Policy Research which hosted the Programme and facilitated contacts with NGO'S. They also organized a meeting which took place in March 1985, (meeting notes included in the book) whereby a number of NGO's and representatives of various governmental departments and donor agencies exchanged views and worked out a strategy for preparing an action plan and projects, to assist in saving the Himalayas.

Developed at this meeting was an Action Plan, proposing an integrated policy programme based on the realisation that it is necessary to mobilise people and groups locally, regionally and nationally, to attempt to deal with large environmental problems. The Action Plan is intended to establish contact between the Government and NGO's, and amongst NGO's themselves, and embark on a large-scale programme with coordination both from the Central HESD cell, as well as some Regional Coordination Centres in various Himalayan States. If the integrated mechanism enlarges successfully over time as planned, goals to save and rehabilitate the Himalayas may be achieved.

By applying the decentralized community labour mobilising concept, social, cultural, and economic considerations can be acknowledged to a much greater degree because people affected are helping to make decisions. It promises a greater degree of success and sustainability with projects and also heightens individual motivation when the people involved realise that there are gains to be made by changing their techniques or lifestyle.

The HESD Action Plan will be an interesting programme to watch over time, and will hopefully provide fruitful case studies for future use in global environmental management.

This report is worthwhile reading for environmental policy makers and administrators interested in an innovative approach to land resource management, or those interested in the environmental state of affairs in the Himalayas.

"Seeds of Hope"

Six-part Documentary Film Series, made by Central Independent Television of Great Britain, in association with the Television Trust for the Environment

"Seeds of Hope", a six-part documentary serial, opens the door for a look into the everyday lives of Central Highland villagers in Ethiopia during the days which preceded the devastating famine that has received world-wide attention.

It was filmed by director Charles Stewart and his crew, the same people responsible for "Seeds of Despair", the documentary which was the catalyst for massive emergency food relief to Africa.

The film crew originally intended to document, beginning in 1983, the problem of soil erosion and its impact on agriculture and the economy in a small village and surrounding communities. What they eventually came upon was a mounting crisis situation that alerted the international community to some of Africa's major problems: a tenuous food supply, droughts and land degradation.

In this unique and moving record, one sees how a proud, hard-working, traditional farming family loses their livlihood in a matter of months, because of their inability to sustain themselves through successive droughts on degraded marginal lands.

Unlike "Seeds of Despair", which focuses on the suffering that resulted from a lack of access to food, "Seeds of Hope" reveals *how* the situation evolved and *why* it wasn't averted.

As the camera scans across seemingly green and fertile, rolling hills, the narrator informs you that these used to be forests—but now there's not a tree in sight. In a sudden downpour, the viewer sees massive quantities of topsoil being washed down steep hillsides, via large gullies, due to the lack of trees and vegetation to bind the soil. When hearing the dialogue of the villagers, we learn that these problems are not new, but have only been exacerbated by recent erratic weather patterns. The viewer is taken in and out of governmental and various United Nations meetings, where lip-service is paid to the problems in Africa while the crisis is gaining full momentum. They also scrutinize a UNICEF project going on in the village, "Cash for Work", which ironically gets discontinued at the point when the villagers most need it.

The tragic Ethiopian situation involves many complex environmental, social, economic and political factors. But one point is made clear—that the land is so deteriorated that it can no longer sustain its human and animal populations, and that without proper land rehabilitation and management, it never will again. This is what brought on the great famine, and this is what must be remedied to prevent similar situations in the future.

By the end of this series, everyone is hungry, the village is disbanding, people are dependent on food handouts and some have chosen resettlement in other regions. One can't help but wonder why it's entitled "Seeds of Hope"? But what comes across in this human drama is the courage and strength of spirit that these people possess, and therein lies the "Hope".

In this light, it seems feasible that with the right kind of help and advice in time, self-suffiency for the villagers is realistic.

The film does not, for whatever reasons, take a look inside the resettlement camps that are an important factor in the village peoples' fate. Unfortunately, the director had to edit this series in a hurry for broadcasting and it is at times evident.

"Seeds of Hope" should be required viewing for anyone who believes that famines are the direct result of droughts, and have yet to realize the environmental factors. It also enables one to learn about the perspective of those on the receiving end of aid.

Expert consultation on the role of forestry in combating desertification

Venue: Saltilo-Coahuila, Mexico, from 27-28 June, 1985

The Expert Consultation was organized as a satellite meeting of the 9th World Forestry Congress by FAO in co-operation with the Ministry of Agriculture and Water Resources of Mexico. The meeting was preceded by a study tour which visited two sites in Arizona, USA, and Saltilo-Coahuila, Mexico, from 17-22 June, 1985. The study tour was organized to enable the participants to observe the achievements of the role of forestry in combating desertification.

The Expert Consultation was attended by some 30 selected scientists and specialists from 21 countries in the field of forestry and related disciplines who are involved in work concerning arid zone environments. Representatives from UNEP, UNESCO, ESCAP, ICRAF, USAID, GTZ, ALECSO, IUFRO and observers from five countries were also present.

The purpose of the consultation was to: review and assess the present state of knowledge in the field of forestry in arid zones as it relates to rural development and the control of desertification; discuss research and application of existing knowledge; exchange ideas and experiences; and outline actions needed and define a framework which would orient future development programmes at the national, regional and international levels.

Topics discussed at the meeting included:

a) National and international arid zone forestry programmes, including a paper: *Forestry in UNEP's Integrated Programme to Combat Desertification*, written by the Desertification Control PAC of UNEP;

b) Potentials and constraints of the forestry contribution for development; and

c) Identification of key elements to mobilize forestry to combat desertification and contribute to the development of arid lands.

The FAO Secretariat prepared five background documents which guided an in-depth analysis of the problems and prospects and helped to produce specific proposals for action.

The Expert Consultation divided into Working Groups to discuss the three main areas where proposals would have to be made to check and reverse deforestation:

- production, utilization and processing;
- conservation and restoration; and
- policy, institutions and socio-economic aspects.

The following principles will constitute the conceptual framework within which the action proposals are conceived:

- integration of forestry in sectorial and multi-sectorial programmes;
- broad-based rural development with emphasis on diversification of rural economic activities;
- vital role of trees and forests in providing congenial conditions for agricultural and animal production through shelterbelts, conservation of the water resources, erosion control, and fuelwood and timber production, etc.;
- direct economic benefits for the local communities from forests and forest products, and by generation of employment, thus promoting rural development; and
- contribution of forestry to conservation and prevention of desertification processes.

The above principles are also in line with those elaborated by the World Conference on Agrarian Reform and Rural Development (WCARRD) and the Jakarta Declaration which emanated from the 8th World Forestry Congress.

Keeping the above principles in view, *the main objectives* of the action proposals will be:

i) to enhance the place of forestry and woody vegetation within sound land husbandry, so as to ensure that the whole system will contribute effectively to the production of goods and services and to the wider aim of food security;

ii) to enhance benefits to the community from appropriate use of forest resources and to involve the community in their expansion, diversificaton, management, conservation and rehabilitation;

iii) to create awareness among politicians and the public of: the contribution of forestry to sustained use of the resource base; minimizing damage and degradation caused by desertification, salinity, droughts and torrential phenomena; the need for food security and rural development; and

iv) to ensure that forestry is made a vital part of national plans regarding food security, conservation and prevention of desertification.

These general objectives should lead to specific results, such as:

- improvement of agricultural production by a combination of dry farming practices, as well as protective measures, such as: shelterbelts, windbreaks, watershed protection and management, and water resource development;
- improvement of animal production through the inclusion of drought resistant fodder trees and shrubs in afforestation and range management schemes;
- appropriate location of watering points and management of water resources;

- alleviating the energy deficit by improving the productivity of the existing woody resources, creating plantations and woodlots, and improving the conversion and utilization of wood based fuels; and
- providing alternative sources of employment and diversification of income of rural people through better forest management within the multi-purpose concept.

Book Reviews

Land Food and People

Prepared for FAO by Paul Harrison. Based on the FAO/UNFPA/IIASA report *Potential population-supporting capacities of lands in the developing world*, Rome, FAO 1984, 96 pp+illustr.

This is a very important book for anyone who wishes to understand the major world problems of development, land degradation and desertification, and the effects on all three of the rapid population growth taking place in the developing countries. It is also the first attempt at a scientific estimate of the number of people that the lands of the developing countries are capable of feeding on a sustained basis.

The Land Resources for Future Populations Project was based on some 20 years of preparatory work and two other major projects: the FAO/UNESCO soil Map of the World and the Agro-ecological Zones Project which combined data on soils and climate to assess the extent of lands in the developing countries suited to production of various major crops. The success of this project made it feasible to calculate the potential populations that the land resources of the developing countries could feed and to identify critical areas and countries that would be unable to support their present or projected populations from their own lands.

As the level of farming has a great influence on yields, the study was made for three levels of inputs:

> "low inputs, using no fertilizers, pesticides or improved seeds and no long-term conservation measures—equivalent to subsistence farming",
>
> "intermediate inputs, with some fertilizers, pesticides and improved seeds, conservation measures and improved cropping patterns on half the land", and
>
> "high inputs, with full use of all inputs, full conservation measures and the most productive crop mix on all land—equivalent to Western European levels of farming"

The findings have grave implications for many developing countries. Of the 117 countries studied, 64—twenty-nine of them in Africa—would be unable to feed their projected year 2000 populations from their own land resources at current levels of agricultural inputs. Of these, 14 are land-locked, 19 are islands, 20 figure among the least developed countries. Three-quarters are expected to face a decline in their rates of self-sufficiency in basic foods over the next two decades and 56 per cent already have average *per caput* daily calorie supplies below the recommended levels.

Nearly two-thirds of these "critical" countries are already cultivating over 70 percent of their potentially cultivable area, and 69 percent are getting cereal yields below the average for developing market economies. An even greater proportion, 89 percent face serious environmental problems as indicated by acute shortages or deficits of fuelwood, which, in turn often implies deforestation and probable soil erosion. Most of these countries face continuing high rates of population growth over the next 40 years, and over half of them are likely to face increasing problems in financing food imports.

The study assumed that all potentially cultivable land would be used for staple food crops or pasture for livestock with all produce equally divided among social groups to furnish a basic calorie requirement. In reality, at least one-third of the land would have to be used for other essentials such as forestry, vegetables, fibres, non-food cash crops, etc. For example, it was found that in 1975 there were already 54 countries that could not support their existing populations on a sustained basis using low inputs, but deducting one-third from the carrying capacity and allowing for land actually cultivated, this number rises to 99 out of 117 countries.

This implies the overloading of certain zones which poses a serious ecological threat. In 1975, around 2450 million hectares, nearly 40 percent of the land area, were carrying more people than they could sustain on a long-term basis with low inputs. These areas often coincided with areas noted for extensive deforestation, soil erosion and high risk of desertification.

The study points out that this land degradation could lead to a long-term drop in food production of about 19 percent if no long-term conservation measures are taken. As much as 544 million hectares of rainfed cropland could be lost, including 30 percent of Central America's rainfed croplands, and 36 percent of Southeast Asia's.

Rapid population growth in the developing countries means that by the year 2000 the situation will have deteriorated in most countries and 38 of them would be able to support less than half their projected populations.

The entire potentially-cultivable lands of the developing countries, some three times the present cultivated area, with deduction of one-third for non-staple food crops, would be able to support only seven percent more than their projected year 2000 population using low inputs, but much of this land is only theoretically available being separated by national borders or by vast distances within countries from the populations that need more land.

The FAO study indicates that all five regions would be in critical condition in 2000 if using low inputs on the land they are likely to be using by then. Southwest Asia, Central America, Africa and Latin America would be able to support about half their expected populations on a sustained basis, while South-east Asia would be able to support about 85 percent.

The environmental implications of this population expansion are considerable, particularly in those countries in Africa and elsewhere that are unlikely to be able to make substantial progress towards an intermediate level of farming over the next 15-20 years. The effects of the 50 to 75 percent increases in population projected for the year 2000 carry the threat of environmental disaster.

According to UN medium projections, the year 2025 populations of the 117 countries studied will total 5,100 million, or two and one half times the 1,975 figure of 1960 million. This will mean vastly intensified pressures on land resources in many developing countries.

The situation is particularly serious in Africa. The region has some 790 million hectares of potential rain-fed cropland, not including marginal land, of which only 168 million hectares were under cultivation in 1975. But these land reserves are very unevenly distributed with many countries in North Africa, the Sahel and East Africa already using most of their potentially cultivable land, and expanding into marginal lands.

In 1975 some 184 million people or 48 percent of the regional population lived in zones capable of feeding 79 million people on a sustained basis with low inputs. These are often areas where the land is overexploited and the threat of land degradation is greater. By the year 2000 most of these countries are expected to at least double their 1975 population and double them again by 2025.

FAO points out that the land resources study only offers "a first approximation assessment of the numbers each country can support from its own lands", and stresses the need for national surveys to provide a more detailed picture. What is clear, however, is the need for every country to begin now to plan how to balance its population over the next 40 years with its possibilities of producing food from its own lands or earning foreign exchange on a stable basis with which to import food.

One solution is to raise the level of agriculture and this will be essential for most developing countries over the next few decades, though it is often a slow process and in some cases it may not be enough in the absence of effective measures to slow their rates of population growth.

S.L.M.

Arid Lands

Time-Life Books Inc., 1984, 176 p.

Arid Lands is a survey from past, present to future of the earth's classified desert areas, and is studded with spectacular photographs from all over the world. It is another in the series of Time-Life didactic books which focus on interesting subjects, and are written with creative flair.

The book begins with five double-spread coulour photo plates, and a historical summary of great explorers who have sought to plumb the world's great deserts, from the 13th century documented peregrinations of the Polo family, up unto the modern scientists of today. But even though a wealth of scientific and technological knowledge has unravelled previous mysteries about arid lands, scientists are always encountering new enigmas that challenge the most educated minds. As the author points out on page 79: "Pursuit of the complex secrets leads inevitably to even larger considerations—of the origins and eventual fate of the planet and its life forms."

This book offers resourceful explanations about how deserts were formed, the different types of deserts, and why they're located where they are. It also goes into detail about such phenomena as sand dunes and oases. To illustrate the changing faces of deserts, there are five colour map plates depicting the global geological migrations of arid lands from 65 million years ago up until today, and project how arid lands may appear 100 million years from now. Page 88 foretells: "A comparison of present continental configurations with those predicted for 100 millions years in the future shows a markedly different arrangement of land under the subtropical belts of high pressure. With far more land in the vicinity of lat. 30 ° N., the Northern Hemisphere will have a colder, drier climate and more extensive deserts. Conversely, less land and more water in the Southern Hemisphere will contribute to a warmer, wetter climate and fewer deserts."

The book does well in dispelling common misconceptions many people have about arid lands, for example, that deserts usually consist of only sand, and are extremely hot and desolate expanses devoid of life. Through a perusal of different deserts on earth, it becomes evident that a biological plethora of desert-adapted species of fauna and flora exist, and that deserts are truly multifarious ecosystems. While lauding the dromedary, or camel, as a desert creature perfectly adapted to its environment, the authors neglect to mention one of the camel's greatest attributes—their great potential to supply meat and milk to desert dwellers. (Evidence now exists that cites the camel as being the animal of the future in terms of desertification control in arid lands.)

The last chapter is devoted to the subject of desertification, but unfortunately gives an erroneous definition of the term. The author has confused desertization (the natural formation of deserts over time by climatic and ecological shifts) with desertification (the man-made phenomenon of land degradation through misuse of fragile ecosystems). Descriptions about human societies such as the Aborigines, Bushmen and Hopi Indians that have adapted well over time to desert environments is very interesting. But the authors didn't devote much time to explain the relationship between people who inhabit arid environments and desertification, and how they cause it through improper land management.

The book ends with a series of good photo plates that depict some of the ways in which deserts have been controlled or reclaimed around the world with appropriate technology, and offer hope for lands lost to sand.

Arid Lands would make an excellent coffee table book because of the high-quality photographs, and an enjoyable read for those interested in the subject of arid lands.

J.B.

Africa in crisis, the causes, the cures of environmental bankruptcy

By Lloyd Timberlake
An Earthscan Paperback, 1985, 232 pp.

The author of *Africa In Crisis* has spent a lot of time in Africa and discusses the famine situation from an informed insider's point of view. But more important, Timberlake constructs a convincing argument against the commonly held belief that famines are caused by drought, and cites the major cause as unsound economic, agricultural and environmental strategies.

The author happened to be in Ethiopia during the emerging famine crisis in May 1984, and it was there that this book was conceived. He believes Africa's plight to be unique because according to normally accepted indicators of progess, Africa is moving backwards while the rest of the developing world is moving forwards. This is

happening, he observes, in the midst of a thriving consulting business where "experts" regularly go to Africa from Europe and North America to solve problems. The author suggests that Africa is not getting the right advice because problems are not being understood and projects don't fit. That's why the famine disaster occurred.

Timberlake stresses that the main problems in Africa stem from environmental bankruptcy - Africans have overdrawn their environmental accounts by overcultivating, overgrazing and deforesting the soil. He relates bankrupt environments to bankrupt nations, and ultimately a bankrupt continent.

He acknowledges that for the developed West, the environment is a luxury issue pursued to enhance already high standards of living. In Africa, the degraded environment is a major factor as to why living standards remain low and development has gone into recession. Africa cannot even sustain sufficient food production, let alone attain the trappings of a modern, sophisticated society. Timberlake promotes grassroots rural development as the answer. Development based on the under-used skills and ambitions of small farmers will help Africa build a more stable, famine-free future, he claims.

In this book, he also discusses: "how famine is not necessarily the result of drought, how people and policies cause drought, and how drought reveals the misuse of natural resources and the vulnerability of the rural poor". It examines the causes and cures of environmental degradation, and the background against which this degradation has occurred: debts, falling commodity prices, high interest rates, extreme population pressures, and inappropriate aid. It examines the fuelwood crisis and the misuse of water resources, and explains how Africa's environmental diseases and loss of wildlife are both a cause of and a symptom of the continent's decline. In each instance, it offers examples of places where Africans are setting things right, proving that the problems are not insoluble. The book also shows the relationship between Africa's environmental bankruptcy, its millions of environmental refugees, and the continent's political and social instability.

Timberlake believes that there is hope for Africa—that environmental bankruptcy is man-made, and therefore it can be reversed by man. The key is the link between donors, governments and development policies in relation to the African peasant. He adds that common sense would be a good place to start.

This book includes several black and white photoplates depicting environmental degradation across the continent.

Africa in Crisis is an interesting, well-thought out book. It is recommended reading for anyone interested in Africa and its future in terms of environment and development.

J.B.

Soil at risk, Canada's Eroding Future

A Report on Soil Conservation by the Standing Committee on Agriculture, Fisheries and Forestry, to the Senate of Canada.
Hon. H.O. Sparrow, Chairman.
June, 1984, 129 pp. (Half English/Half French)

The purpose of this report is to take the reader on the equivalent of an "airplane ride" over Canada to make clear what soil degradation is and prove that it is serious in all regions of the country. They hope to make soil conservation a national issue by making people realize that Canadian soils are truly at risk, and that now is the time for national action.

The Standing Committee on Agriculture, Fisheries, and Forestry travelled extensively in Canada and based on the evidence presented to it, made a number of recommendations designed to raise public awareness of the problem and to improve the dialogue between the public, farmers, governments and environmental experts.

They determined that much of the problem lies with the great pressures being placed on the agricultural sector to demand as much productivity from the soil as possible due to economic necessity, international prices and technological progress. The answer, they claim, lies in conservation and the initiative of individual farmers, organizations, scientists and by Government playing an active role.

The report states that: "There is no substitute for the agricultural land which Cananda possesses, and indeed, the margin for error in trying to save the soil becomes smaller and smaller every year. We cannot ignore the limits of this vital resource."

Soil At Risk is a head-on examination of a critical problem and encourages individuals to take an active role in conquering it through a concerted effort. If all nations encountering this threat followed this prescription, global soil erosion might well be a problem of a shrinking nature, rather than a growing one.

The book contains many black and white photoplates depicting the extent of the soil erosion problem in Canada. There are also case studies of farmers who have developed or implemented successful land management techniques to deal with the problem.

This book is recommended reading for everyone interested in the soil erosion problem, agriculturalists and global policy makers who are involved with or have yet to tackle the problem of the loss of productive soil in their countries.

J.B.

Famine: *A Man-made Disaster?*

A Report for the Independent Commission on International Humanitarian Issues
Pan Books Ltd, London, 1985.
160 pp.

Famine: A Man-made Disaster is a report compiled and written from research reports and intended for the general public. The subject is famine and the focus is Africa, stressing the humanitarian dimension of the problem.

The report was written for the Independent Commission on International Humanitarian Issues (ICIHI), a group of eminent persons whose work is intended "to be a part of the continuing search of the world community for a more adequate international framework to uphold human dignity and rise to the challenge of colossal humanitarian problems arising with increasing frequency in all continents".

The report poses the question: "Is famine a man-made disaster?" They go on to examine Africa's famine situation in an economic, political, social and environmental overview. They come up with several conclusions as to why it occurred, comparing both natural and man-made causes, and offer their recommendations on how to avoid further crises.

They recognize that the African situation is complex and that root causes of famine are intertwined. The sad point is made that there is a massive in-flow of development assistance to the continent, but because it is usually misdirected for a number of reasons the famine was allowed to occur. One of the biggest problems cited in terms of development aid is the failure of governments and donors to target resources for the areas most in need of help — the rural poor in the agricultural sector.

Yet, amidst the seemingly grim outline that is drawn, the ICIHI insists that there is hope. They espouse that if donors as well as recipients governments can review their priorities, policies and practices and devote more energy to the rural sector, Africa has a chance to become self-sufficient in food supplies and will be able to prevent future famines.

The report emphasizes that environmental degradation is an important aspect in the famine drama and it is caused by man. The poverty stricken rural sector needs help to acquire technology and development resources along with intensive reform to break the vicious cycle of land overuse and abuse.

They offer short- and long-term measures that should be taken to correct a deteriorating situation in which the rural sector and the environment are priority development areas.

The report offers a lot of recent information and statistics on the state of Africa's development, and for those wishing to gain a better understanding of the underlying currents of the African famine, this is an informative report.

J.B

Drought impact monitoring

A Remote Sensing Study of Desertification in Kordofan, Sudan
By, Ulf Hellden
Lund, Sweden, November 1984.
61 pp.

This study is based on aerial photography from 1962 and satellite data from later periods when major land changes were analysed and related to precipitation and agricultural statistics covering the Sahelian pre-drought, drought and post-drought period of 1961-1979.
Seventy-seven villages were analysed in detail concerning changes in village "desert patch" conditions with time and possible relations to a number of environmental variables.

The results achieved contradict some important concepts regarding the course of desertification in Kordofan that have been presented by some authors. No evidence was found for a continuous Sahara desert movement southwards, large shifts in ecotype borders, southward sand and dune complex encroachment, or systematic growth of village "desert patches". Verification of reported expansion or recovery of areas classified by others as desert patches or overexploited areas was not possible.

The report also indicates an explosive expansion of the cultivated areas during the end of the Sahelian drought as a possible response by man to drastically declining crop productivity. He also finds, following the drought, a fast decrease of the area cultivated and a clear trend of crop productivity recovery.

A study of the potential of a Landsat data based transformed normalized difference green leaf density vegetation indicator for drought impact and green biomass monitoring was carried out. Achieved results indicate possible relationships with precipitation and crop yields.

The study is recommended for scientists involved in drought impact monitoring.

J.B.

Remote sensing manual of Tanzania

by, R.B.King
Land Resources Development Centre, UK Overseas Development Administration, in association with the Institute of Resource Assessment, University of Dar es Salaam, Tanzania, 1984.
206 pp.

Remote sensing is the science of detecting and interpreting objects from a distance. It involves the gathering of data from a sensor positioned on a platform which detects and records data from one or more bands within the electromagnetic spectrum. The data is later analysed and can be used to assist in mapping, investigating and assessing land resources, and to make recommendations of the use of these resources. Most remote sensing is done of the earth. Remote sensing is a fast-moving technology, of which most of the literature is primarily about and

originates from America and Europe. It can be expected that, being a rapidly changing technology, some of the information presented in this manual has already been outdated.

At a remote sensing teaching workshop at the Bureau of Resource Assessment and Land Use Planning (BRALUP) of the University of Dar es Salaam in 1979, delegates decided that Tanzania needed a manual specifically related to local conditions. It would concentrate on the Tanzanian environment but would have a much wider value than for Tanzania alone. For example, environmental scientists in other parts of the tropics, particularly in African countries, may find the examples and discussion more relevant to their physical and socioeconomic environment than many current textbooks.

This is the final draft of the manual, and the main part of the manual concentrate on aerial photography and satellite imagery.

This *Remote Sensing Manual of Tanzania* is recommended for any environmental scientists working in Africa or the tropics.

Photographs for
Desertification Control Bulletin
Covers

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

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

Technical requirements

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

Captions

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

Copyright

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

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

Audience

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

Language

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

Manuscript preparation

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

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.

Illutrations

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

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

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

Footnotes and references

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

Other requirements

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

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