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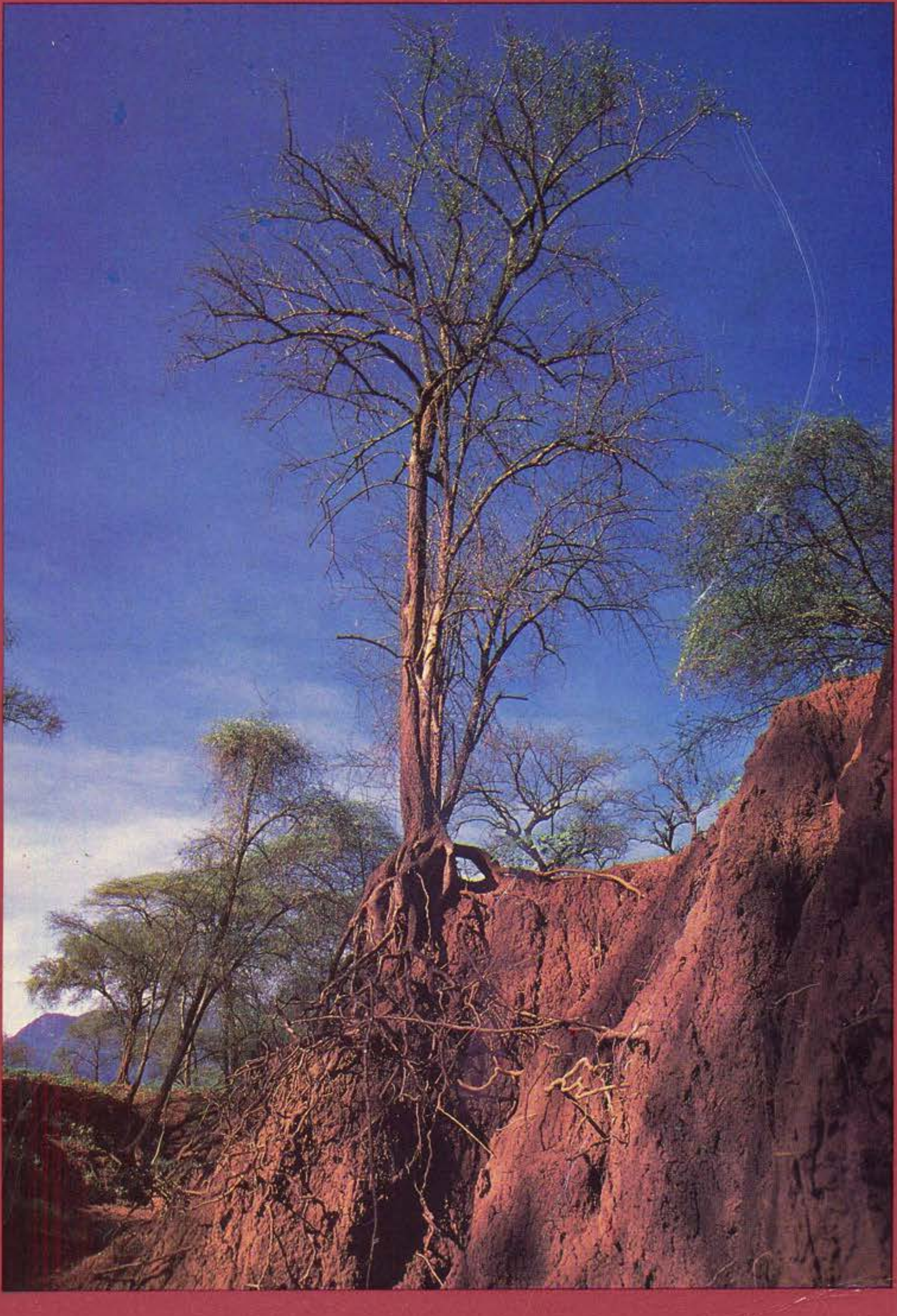
Desertification Control Bulletin

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

Number 19, 1991



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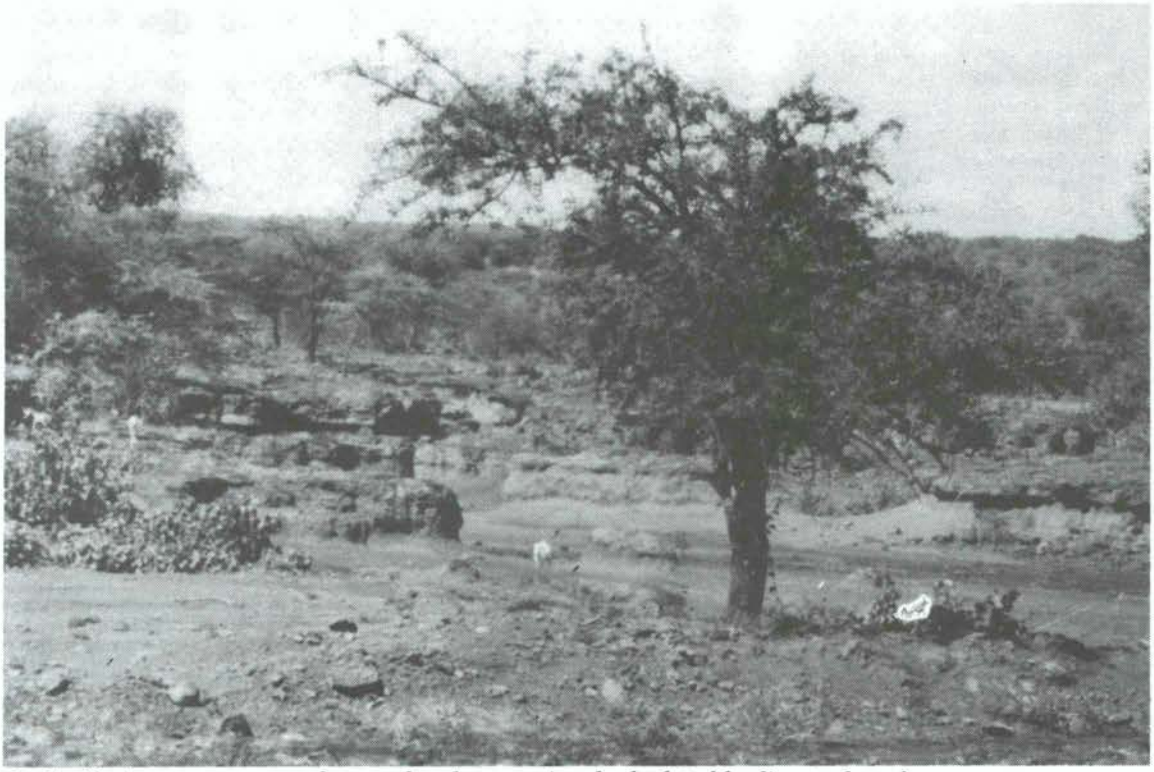

In the Baringo area ground cover has been seriously depleted by livestock and, as a consequence, gullies have developed along seasonal river beds. Photo: Y. Matsumoto

Cover: Gully Erosion in the Kerio Valley, Kenya. Photo: ICRAF/A. Njenga

The United Nations Conference on Desertification (UNCOD) was held in Nairobi from 29 August to 9 September 1977. This was the first worldwide effort initiated to consider the global problem and responsibilities posed by the spreading menace of desertification. 95 States, 50 United Nations offices and bodies, 8 intergovernmental organisations and 65 non-governmental organisations participated. The United Nations Conference on Desertification prepared and adopted a worldwide Plan of Action to Combat Desertification (PACD) with 28 specific recommendations. The Plan of Action was approved by the United Nations General Assembly at its 27th session on 19 December 1977.

Recommendation 23 of the Plan of Action invited all relevant United Nations Bodies to support, in their respective fields, international action to combat desertification and to make appropriate provisions and allocations in their programmes. Recommendation 27 gave the responsibility for following up and co-ordinating the implementation of the Plan of Action to the United Nations Environment Programme (UNEP) with its Governing Council (GC) and Administrative Committee on Co-ordination (ACC).

Immediately after approval of the Plan of Action, the Desertification Unit was established within the UNEP Office of the Environment Programme to assist the Executive Director and ACC in carrying out their tasks in the implementation of the Plan of Action. One of the main functions required by the Plan of Action from the Desertification Unit was to prepare, compile, edit and publish at six-monthly intervals a newsletter giving information on programmes, results and problems related to the combat against desertification around the world.

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

Desertification Control Bulletin is an international bulletin published at six-monthly intervals by 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. Articles published in *Desertification Control Bulletin* do not imply expression of any opinion on the part of UNEP concerning the legal status of any country, territory, city or area, or its authorities, or concerning the delimitation of its frontiers or boundaries.

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Cover photographs

The Editor of *Desertification Control Bulletin* is seeking photographs for consideration as bulletin covers. All submissions should be sent to the address above.

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 measuring 18 cm x 18 cm.

Captions

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

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Articles

Articles are invited from scientists and specialists interested in the problems arising from, or associated with, the spread of desertification.

Audience

Desertification Control 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

Desertification Control Bulletin is published in English. All manuscripts for publication must be in English.

Manuscript preparation

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

Metric system

All measurements should be in the metric system.

Tables

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

Illustrations and Photographs

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

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Floodwater Spreading for Desertification Control: An Integrated Approach

An Iranian Contribution to the Implementation of the Plan of Action to Combat Desertification

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May 1989

Abstract

Improper land use and drought are the principle agents of desertification. Reduced groundwater discharge, a variation of drought, is mainly due to over-exploitation of a limited resource — hence, it is partly man-made; therefore, man has the power to control desertification through proper utilization of land and water. This may be partially achieved by harnessing the flash floods common to most deserts. Floodwater spreading is the key to desertification control in many parts of the world. Artificial groundwater recharge, production of food, feed, fibre, fuelwood and flood abatement are some of the advantages of floodwater spreading. All of these have materialized in the Gareh Bygone Plain, 200 km to the south-east of Shiraz, Iran.

A 6,000 ha sand-covered debris cone was selected in January 1983 with the main objective of utilizing floodwaters to stabilize the moving sands by sedimentation of the suspended load while recharging an empty aquifer with a potential volume of 100 million m^3. Eight floodwater spreading systems, covering an area of 1,365 ha were designed and constructed in the 1983-1986 period. Nine month old seedlings of Eucalyptus camaldulensis *(Dehnh.),* E. microtheca *(F. Muell.),* Acacia cyanophylla *(Lindl.),* A. salicina *(Lindl.) and* A. victoriae *(Benth.) were planted in the first system in February and March 1983, and in the newly constructed systems during the succeeding winters. Nine month old seedlings of* Atriplex lentiformis *(Torr. Wats.) were planted in February and March 1984 in five systems.*

The number of flood events range from 3 to 7 per year during the 1983-88 period, with the diverted volume ranging from 0.07 to 14.7 million m^3 per year. The cumulative volume of the utilized floodwater for the same period amounted to about 38.1 million m^3.

Floodwater spreading and tree and shrub planting have transformed a wasteland into a verdant pasture; the carrying capacity of the stabilized drifting sand has increased 10-fold. The height and diameter breast height of many eucalyptus have exceeded 16 m and 25 cm, respectively. The return of a few hubara bustards and gazelles to their former haunts is an auspicious sign for the total recovery of the Gareh Bygone Plain.

Provision of irrigation water for 1,000 ha of cropland through 40 "new" and 16 "old" wells has substantially raised the income of the 4 farming communities in the Plain. Moreover, the yield of 650 ha of flood-irrigated barley has doubled.

Flood mitigation, a casual dividend of floodwater spreading, was demonstrated during the deluge of 1986, and may affect flood control strategies in the future.

All these results, although preliminary, are logical and could be utilized with confidence in many deserts in Iran and other places with similar environments. Given the will, the destructive flash floods make wastelands bear fruit. "... and we made from water every living thing," (Koran, Prophets:30).

Scope of the Problem

Hunger, ignorance and short-sightedness have wreaked havoc on the environment, particularly in the deserts. Overgrazing and fuelwood collection have denuded vast expanses of rangelands, depriving their soils of the vegetative cover which protected them against erosive rains, running waters and destructive winds. To meet the urgent need to produce food and fibre for a growing population, timber and pasture land has been cultivated, exposing it to the ravage of erosion. To satisfy the water requirements of the crops growing on these marginal lands, as well as on the more fertile fields, groundwater has been exploited in many parts of the world where, apart from the meagre rainfall, it is the sole source of this life-giving substance. These improper land and water uses, and the recurrent droughts, have transformed productive soils into wastelands. Occurrence of devastating floods which are, directly or indirectly, related to the misuse of land and water, closes this vicious circle. Floodwater spreading, where it is technically possible and economically feasible, is a simple and inexpensive method of breaking this vicious circle by reclaiming the eroded land, producing food, feed, fibre and fuel, mitigating floods and, in certain places, recharging the depleted aquifers.

Water shortage is one of the main limiting factors in the economic development of Iran, particularly in the agricultural sector. Although no official data is available, reduced groundwater discharge has been singled out as the most important reason for the presence of hundreds of ghost villages in central, southern and eastern Iran. Overpumping and uncontrolled sinking of wells in a country where the mean annual precipitation over 47% of the area is only 115 mm (Anon. 1984), have dried up most of the existing wells and *qanats* (underground water collection and conveyance galleries). Deepening of the hand-dug wells and boreholes, or extension of the galleries into water bearing strata, have gone as far as technically practicable and/or economically feasible. Most alarming of all, the annual overdraft of groundwater resources in Iran is estimated between 5 and 8 billion m^3.

The falling water table is accepted as the rule, the exception being the low sectors of a few metropolitan areas (e.g. Tehran and Shiraz) where large percentages of their water requirements are supplied through the inter-basin transport. Granted that reduced groundwater discharge is a variation of drought (Kassas, 1987), then the falling water table may be perceived as a very important agent of desertification in arid areas where most water needs are supplied through underground resources. Since this phenomenon is mainly due to overpumping, it is appropriate to designate this particular kind of drought as man-made, as promoted by current desertification beliefs (Tolba, 1987); therefore, man has the power to reverse the processes leading to groundwater shortage. As Mabbutt (1987) has aptly summarized: "... water management is often the key to many aspects of desertification control". Groundwater management through artificial recharge and controlled withdrawal appears to be the most rational method of replenishing the empty aquifers, ensuring the sustainable yield of wells and *qanats*, and preventing saltwater intrusion into numerous coastal and inland aquifers. These objectives may be achieved by the application of floodwater spreading methods at a reasonable cost while enhancing the environmental quality and economic well-being of the inhabitants of the areas inflicted with water shortage.

Introduction

The meagre amount and uneven distribution of precipitation means that more than 90% of Iran is designated as arid or semi-arid. The mean annual precipitation of the 870,000 km^2 of mountainous regions and 773,000 km^2 of plains area is estimated to be 365 and 115 mm respectively (Anon. 1984). It is further estimated that of the 400 billion m^3 of annual precipitation, and 5 billion m^3 of surface runoff received from neighbouring countries, 35 billion m^3 recharge the aquifers which supply about 55% of Iran's annual water needs, while 33 billion m^3 of surface waters provide the rest. The volume of surface runoff which annually drains into the Caspian Sea, the Persian Gulf, the Oman Sea and into numerous inland lakes and swamps adds up to 53 billion m^3. If a substantial amount of this flow could be saved, a major portion of our water demands would be satisfied. Furthermore, undoubtedly, a significant volume of the 284 billion m^3 of mean annual precipitation which, for the lack of a better term, is reported as mean annual evapo-transpiration, is directly evaporated from the saline soil and salt marshes, or transpired by a few non-economical plants.

Iran: A Land of Floods, Droughts and *Qanats*

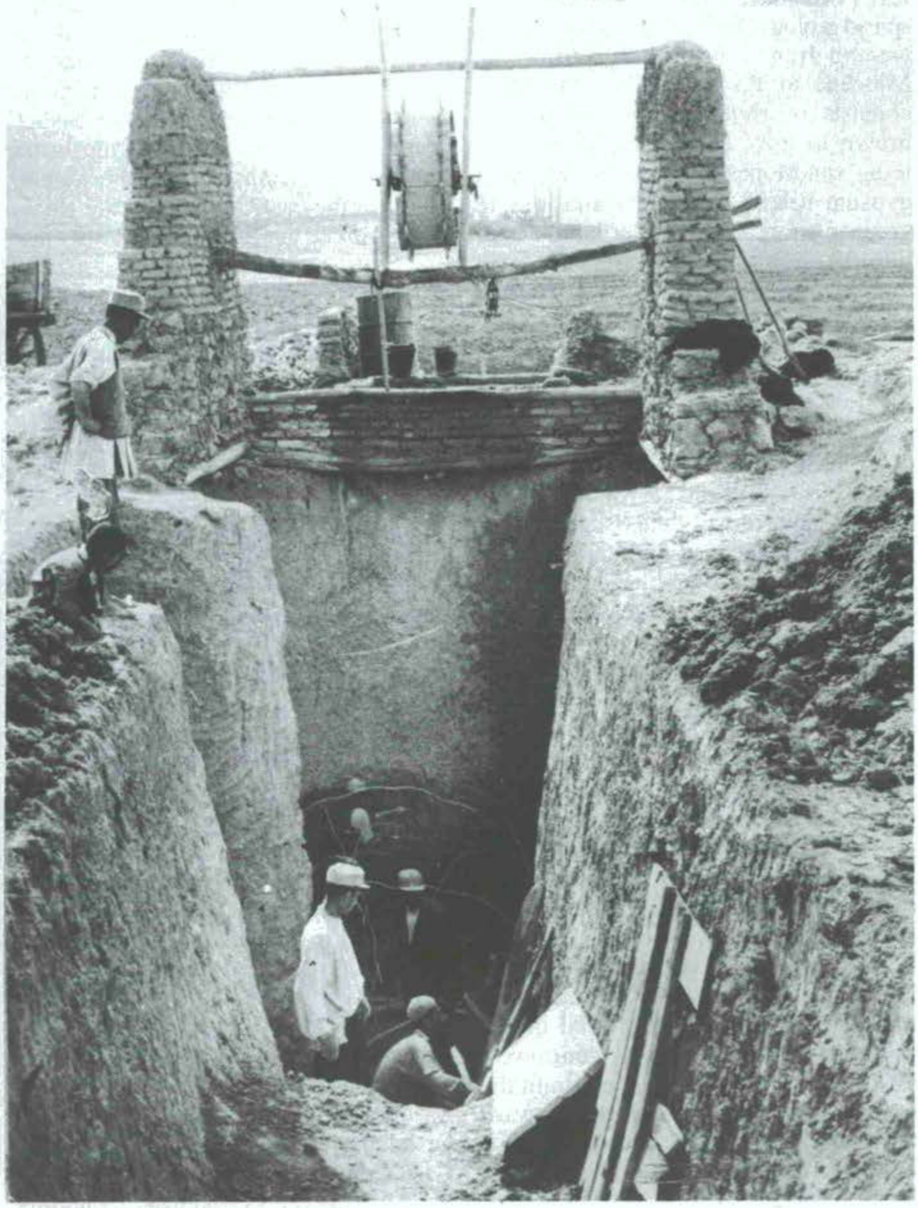
Droughts due to low rainfall recur sometimes for a few years in succession. This, in a country which produces a substantial amount of its food and feed on 6 million ha of dry-farms and 90 million ha of rangelands, could mean distress and, in extreme cases, disaster. It is ironic that these rainless periods are usually interrupted by flood-producing downpours which devastate the drought-stricken people and their starving herds of sheep and goats. Furthermore, convective storms, which usually occur in the summer afternoons, cause flash floods that rob the farmers on the fringes of deserts of their harvests. It is also observed that the monsoon activity, which provides about 10% of the annual precipitation in the southeastern province of Baluchistan (Ganji, 1965), brings in the vital rains to southern Iran as far west as Longitude 52°E and produces destructive and, at the same time, benevolent surface runoffs that replenish numerous cisterns. These ingeniously constructed and strategically located tanks provide the only source of fresh, although by no means hygienic water for a large number of communities across southern Iran. Were it not for these events, there would be far fewer people in the region due to the total lack of perennial streams and groundwaters of good quality which could satisfy their water needs. It is, therefore, absolutely essential to accept the twin and alternative curses of drought and flood as the rule of nature, and utilize floodwaters to mitigate both.

It is postulated that, about 3,000 years ago, the ancient Persians transformed a man-made, uninhabitable desert into a garden through the invention of the *qanat* (Wulff, 1968). This ingenious system supplied them with water not only during the years of average precipitation, but also guaranteed a reasonable flow during the long-term droughts which could have otherwise devastated the Persians. Presence of seemingly prehistoric flood-irrigated farms on the recharge area of many of the *qanats* in the northeastern province of Khorasan lends support to the contention that our ancestors replenished their aquifers, albeit unknowingly. It is therefore apparent that these two systems worked in harmony: while an upstream farm recharged a *qanat*, the discharged water from the same *qanat* irrigated a downstream farm, ad infinitum.

It is estimated that about one half of all the *qanats* of Iran have dried up; the total annual discharge of the remaining 21,500 *qanats* amounts to 8 billion m^3. Should these life-giving vessels stop flowing, the re-desertification of many reclaimed wastelands is imminent.

Floodwater Spreading: A Panacea

Floodwater spreading is a method of flood irrigation that has been practised since time immemorial. Not only floodwaters, but any water of good quality may be utilized in applying this method.



The "qanat" —an ancient irrigation system used in certain arid regions of Iran. It is a horizontal well with canals dug deep into the slope, leading from one qanat to another in order to avoid evaporation. They are fed both by rain and ground water. Photo: Paul Almasy

However, since floodwaters constitute a major portion of the wasted surface waters in Iran, the terms floodwater spreading and flood irrigation are employed interchangeably in this report implying the beneficial application of the ordinarily wasted surface flows to the soil for any number of the following purposes:

1. To satisfy the water requirements of annual and perennial crops, range plants, shrubs and trees;
2. To remove sediment carried by floodwaters for later storage in surface reservoirs or aquifers;
3. To recharge aquifers artificially for later withdrawal and/or to prevent saltwater intrusion into the water bearing strata; and/or to prevent subsidence of well fields;
4. To stabilize the drifting sand by silts, clays and organic matter carried as suspended load by floodwaters;
5. To grade land on sloping and eroded surfaces by construction of contour or level crested banks and/or walls, to fill the empty spaces behind them (dead storage) with sediment, and to transform them into productive farms;
6. To reduce gully erosion and to control downstream flooding;
7. To leach saline soils; and
8. To prevent waterlogging of agricultural lands and population centres which are located downstream of the floodwater spreading areas.

Of the above eight items the first six have been successfully practised in reclaiming parts of the Gareh Bygone Plain, a small sand-covered desert in southern Iran; item 7 will be put into practice later; item 8 will take many years to accomplish.

Reclamation of the Gareh Bygone Plain: A Case Study

Of the 12 million ha of drifting sands and moving dunes in Iran, a very small "island" of sandy desert lies between Latitudes 28°35' and 28°41'N and Longitudes 53°53' and 53°57' E on a debris cone in the Gareh Bygone Plain, 50 km to the south-east of Fasa. Elevation of the study site varies from 1,120 to 1,160 m. It was about 5,400 ha in extent in 1963 (Ganjini and Farman Ara, 1965), and covered over 6,000 ha in 1989. Illegal conversion of marginal lands to dry-farms, which produce low yields in growing seasons with above average rainfall, has denuded the area covered with drifting sands. Where ploughs disrupt the protective, 10-cm thick mat of the fibrous roots of *Carex stenophylla (*Wahl.*)* sand grains are carried away by the southwesterly winds which blow mostly in April through September. Tilling the land for dry-farming has been judged as the most obvious means of destroying the precarious ecological balance which existed in the Gareh Bygone Plain prior to the advent of farm machinery. Overgrazing is another menace which has degraded the environmental quality of the Plain. The annual production of forages of fair to poor palatability ranges between 20 to 50 kg ha^{-1} and this, in an area inhabited by nomads-turned farmers, who still prefer sheep and goat herding to tilling the land, is another cause for concern.

There are 4 villages in the Gareh Bygone Plain: Ahmad Abad, Rahim Agad, Bisheh Zard (Yellow Marsh) and Tchah Dowlat (Government Well). The water needs of each of the first three villages used to be supplied by its own *qanats* before the advent of diesel powered pumps. The fourth village came into existence because of a well which was dug by the Government to persuade a small tribe of nomads to settle down. Judging by the ruined and deserted hand-dug wells, the depth to the water-table had been about 10m when the first pumps were installed in the area. When the water-table receded to about 20 m, the owners of the wells removed the pumping installations and left.

It was in November 1982 when flood irrigation of wheat and barley farms in the Gareh Bygone Plain was proposed to the floodwater spreading group of the Research Institute of Forests and Rangelands. The reconnaissance soil survey had indicated the futility of dry or flood-irrigated farming on sands, and because the debris cone presented a suitable place for artificial recharge along with accruing some incidental benefits, it was decided to draw a general plan for reclamation of the Gareh Bygone Plain. This would apply the existing knowledge and expertise, and refine procedures as the results of ongoing experiments were obtained, or observations made.

The site of the applied research projects is unofficially designated as the Gareh Bygone Experiment Station and works are in progress to upgrade its scientific status to that of the established research centres.

Description of the Study Area

Geology and Geomorphology

The experiment is being conducted on a debris cone deposited by the Bisheh Zard (Yellow Marsh) River, an ephemeral stream that is a tributary to the Shur (Salty) River of Jahrom and that drains a sub-basin of the Mand River Basin. The Bisheh Zard Basin which is 192 km^2 in extent, comprises 3% of the Shur River of Johrom contributing area of about 6,400 km^2, or only 0.4% of the 48,400 km^2 of the Mand River Basin.

The Bisheh Zard Basin is a northwest to southeast syncline formed by the tectonic movements of the Zagros Mountain Ranges during the Mio-Pliocene time in the Agha Jari Formation (James and Wynd, 1965; Prof. Gh. Farhoudi, Dept. of Geolo., Shiraz Univ., personal communication). The Agha Jari Formation, one of the most widespread geologic formations in south-southwestern Iran, ranges in age from late Miocene to Pliocene. This formation consists of rhythmically interbedded brown to grey, calcareous, feature-forming sandstones and low weathering, gypsum-veined, red marls and grey to green siltstones. The Agha Jari Formation lies conformably over the grey marls and limestones of the Mishan Formation, which is of early to middle Miocene in age. Although the Agha Jari Formation is usually capped unconformably by the Plio-Pleistocene Bakhtyari Formation, severe erosion during the Quaternary period has left only small, scattered patches of the Bakhtyari Formation on the Bisheh Zard Basin. The Bakhtyari Formation, which mainly consists of pebbles and cobbles of Cretaceous, Eocene, and Oligocene limestones and dark brown, ferruginous cherts (James and Wynd, 1965), has provided the bulk of the alluvium in the debris cone; the Agha Jari Formation has contributed the rest. The Agha Jari Formation forms the major bedrock on which the alluvium has been deposited.

The westward flowing Bisheh Zard River has deposited the debris cone in such a way that it slopes from east to southwest/northwest. This direction of flow is consistent with the findings of Oberlander who, in 1965, established that although the folding trend of the Zagros Mountain Ranges is northwest to southeast, the rivers which drain the basins in those ranges flow westward through the gorges cut across the anticlines. The debris cone is terminated on its western extremity by the Shur River of Jahrom, an effluent, perennial stream which flows southward in the thalweg of the Gareh Bygone Plain. The baseflow of this river, which drains the Fasa watershed covering an area of 4,530 km^2, is quite saline; the electrical conductivity ranges from 6 to 15 mmhos cm^{-1} during the year. Since the general direction of the groundwater flow in the debris cone is toward the west, a substantial volume of water which is not extracted from the aquifer eventually turns saline and seeps into the Shur River of Jahrom. Although the salinity source has not been pinpointed as of now, it is postulated that the dissolution of a hidden salt dome by the karstic waters, which probably discharge through a thrust fault on the western margin of the Gareh Bygone Plain, pollutes the groundwater in the area.

The known thickness of the alluvium ranges from practically none on the eastern margin of the debris cone, to 43 m, 4 km downstream from the gorge which forms the outlet of the Bisheh Zard Basin. The depth to the water table ranges from 17 m in the west to 26 m in the east. Assuming the extent of the area, the average thickness and the coefficient of storage of the aquifer to be 50 km^2, 20 m and 10% respectively, it is possible to store 100 million m^3 of water in the debris cone and manage it properly.

Soil

The debris cone is covered with a layer of drifting fine sand ranging in thickness from a few mm to several cm. A structureless coarse sandy loam with average sand, silt and clay contents of 70, 18 and 12% respectively, forms the A horizon, 10-20 cm thick. The stony C horizon lies directly under the A horizon. A description of a typical profile, characterized according to Soil Survey Staff (1951, 1975), is given in Table 1; the results of particle size, distribution and some chemical analyses, which were determined by established methods (Black *et al.*, 1965), are presented in Table 2.

Climate

The Gareh Bygone Plain climate is characterized by a very low and highly variable winter rainfall which is brought in by the clouds originating over the Mediterranean Sea, and summer dryness. However, occasional downpours on the Bisheh Zard Basin produce major floods during August and September. Whether these torrential rains are convective or are the tail ends of the Indian monsoon is not known with certainty. However, the circumstantial evidence gives support to the convective nature of the events; on at least three occassions the recording rain gauge installed at the Gareh Bygone Experiment Station, 4 km downstream from the Bisheh Zard Basin outlet, has registered only 0.2 to 2 mm for the flood-producing rains which occurred on the watershed. Since it has been observed that a minimum of 5 mm of precipitation, with an intensity of 5 mm hr^{-1} is required to initiate any measureable runoff, the depth of rainfall on the Bisheh Zard Basin should have been

Classification: Typic Calciorthids, coarse-loamy over loamy skeletal, carbonatic, (hyper) thermic.
Location: Gareh Bygone Plain Experiment Station.
Physiographic position: Plateau and upper terraces (old alluvial fan): 1,140 m elevation.
Topography: Gentle, west-facing, 0.6% slope.
Drainage: Somewhat excessively drained.
Vegetation: *Zizyphus nummularia, Pteropyrum aucheri, Artemisia sieberi, Astragalus glaucacanthos, Carex stenophylla.*
Parent material: Calcareous alluvium.
Sampled by: Kh. Rameshni, S.Kh. Mirnia and A.A. Naderi, 3 November 1987.
Remarks: The water table is below 20 m.

Ap	0-15 cm (0-6 in). Light yellowish brown (10YR 6/4, dry); yellowish brown to dark brown (10YR 4.5/4, moist); sandy loam;massive structure, soft (dry), very friable (moist); nonsticky (wet); few fine roots; strongly effervescent; clear smooth boundary.
C_1Ca	15-50 cm (6-20 in). Yellowish brown (10YR 5/4, dry); sandy loam; massive structure; common carbonate powdery pockets; very friable (moist); nonsticky (wet); few fine roots; violently effervescent; clear smooth boundary.
IIC_2Ca	50-100 cm (20-40 in). Brown (7.5YR 5/4, dry); loamy sand to sandy loam; massive structure; carbonate coating on gravels and pebbles; very friable (moist); nonsticky (wet); 50-60% fine and coarse gravels by volume; strongly effervescent; gradual smooth boundary.
IIC_3Ca	100-150 cm (40-60 in). Brown (7.5YR 5/4, dry); loamy sand; massive structure, loose (moist); nonsticky (wet); 60-70% gravel by volume; thin discontinuous carbonate coating on gravels and pebbles; effervesces strongly.

Table 1: *Description of a typical soil profile in the Gareh Bygone Plain*

more than 5 mm on these occassions. Therefore, this spottiness of the storms suggests that they may be convective.

The mean annual precipitation and mean annual evapo-transpiration of the Gareh Bygone Plain are estimated to be 150 and 2,860 mm respectively (Anon. 1976). The mean annual temperature is 19°C, and the absolute minimum and maximum temperatures are -7°C (January) and 43°C (July). During the summer (July), the mean minimum and maximum temperatures are 22°C and 38°C(1). There are on average 26 frosty nights per month in the Fasa area. It is essential to note that the climate of the Gareh Bygone Plain is harsher than that of Fasa: hotter in the summer, colder in the winter and drier all the year round (150 *versus* 254 mm). There are very few dewy nights in the area and they usually occur after rainy days in the fall and winter.

Hot, dry winds which usually blow from the southwest during late spring and summer raise the temperature to around 50°C in the shade. Moist winds sometimes blow from the south in the fall and winter. The nomads, who call these anomalous events "Left winds", are of the opinion that the occurrence of rain on cloudy days is assured only if the Left Winds blow; our limited observations have proved them right. Apparently, these winds act as an opposing force retarding the advancement of the north-westerlies, piling the clouds while impregnating them with water droplets.

Native Vegetation

The original vegetation of the area appears to have been a Mediterranean type dominated by *Amygdalus scoparia* (Spach.) and *Pistacia atlantica* (Desf.), of which a very few single stems have survived the ravage of man by being located in inaccessible places on the Bisheh Zard Basin. A few trees of Euphrates poplar (*Populus euphratica* (Oliv.), Athel tamarisk (Tamarix aphylla (L.) (Karsten)) and many shrubs of willow leaved boxthorn (*Lycium depressum* (Stocks)) live by the stream banks on the Basin.

Zizyphus nummularia (Burn. F., Wight. and Walk.) and *Pteropyrum aucheri* (Jaub & Spach.), which attain a height of 3 and 1.5 m respectively, and are the tallest native bushes on the debris cone, are found by the stream bank and in rivulets and depressions. The grey-leaved sagebrush (*Artemisia sieberi* (Besser)), *Atriplex leucoclada* (Boiss.) and *Astragalus glaucacanthos* (Fisch.) occupy the somewhat eroded, silty-clay soils of the Plain on the eastern margin of the debris cone.

The most ubiquitous perennial on the debris cone is "the forty day grass"(*Carex stenophylla* (Wahl)), a rhizomatous plant which forms a 10 cm mat of fibrous roots immediately below the soil surface holding the sands in place. This grass, which sprouts in early February and sets seed in late March - hence its local name - as well as *Helianthemum salicifolium* (L., Miller), are speculated to be hosts of black truffle (*Terfezia spp.*), an expensive delicacy. *Stipagrostis plumosa* (L., Munro ex T. Anders.), Bermuda grass (*Cynodon dactylon* (L., Pers.)), a few annual medics (*Medicago spp.*), camel thorn (*Alhagi camelorum* (Fisch.)) and *Peganum harmala* (L.) are also prevalent on the debris cone. A more exhaustive list of plant species for the Gareh Bygone Plain will be published later.

Water Resources

Water is one of the most scarce natural resources in the Gareh Bygone Plain; therefore, it should be considered as a highly precious commodity. Deficiency of surface waters in the Fasa Basin and the accelerating rate of recession of water tables in that region, which in some localities is followed by salinization of the groundwater, have prompted the water-related authorities to proclaim the Fasa Basin as a prohibited area, implying that the permits required for digging or drilling of new wells would not be issued, and deepening of the existing wells, or extension of the *qanats* are allowed only under special circumstances. Although the presence of high yielding, calcareous aquifers in the Jahrom and Asmari formations of the Eocene and Oligo-Miocene age in the Fasa Basin has been confirmed, the unpleasant consequences which result from the overuse of these resources have made the Government impose a

	Horizon and Depth (cm)			
	Ap (0-15)	C1Ca (15-50)	IIC2Ca (50-100)	IIC3Ca (100-150)
Particle Size Distribution				
Sand (%)	70.0	72.0	77.0	84.0
Silt (%)	18.0	16.0	13.0	8.0
Clay (%)	12.0	12.0	10.0	8.0
Total N (%)	0.042	0.032	0.029	0.02
Organic C (%)	0.27	0.15	0.15	0.10
$CaCO_3$ (%)	36.0	44.0	41.0	40.0
Saturation (%)	28.0	27.0	23.0	22.0
ph mmhos/cm	8.0	8.1	8.0	8.0
Electrical Conductivity (mmhos/cm)	0.54	0.74	0.78	0.84
Available K parts per million	180.0	100.0	100.0	80.0
Available P Parts per million	3.7	1.4	1.0	0.6
Sodium absorption rate milliequivalents/100g	0.63	1.41	1.34	1.01
Exchangeable sodium % milliequivalents/100g	1.89	4.52	7.07	4.32
Exchangeable sodium milliequivalents/100g	0.14	0.19	0.29	0.16
Cation exchange capacity milliequivalents/100g	7.4	4.2	4.1	3.7
Water soluble cations				
$Ca^{+2}+Mg^{+2}$ milliequivalents/litre	3.6	4.0	6.0	6.0
Na^{+} milliequivalents/litre	0.85	2.0	2.31	1.75
K^{+} milliequivalents/litre	0.19	0.19	0.21	0.22

Table 2: *General Characteristics of the Gareh Bygone Plain Soil*

ban on further drilling in these deposits. Furthermore, the possibility of conveying water to the Fasa Basin from adjacent watersheds in the foreseeable future is quite remote; they are experiencing water shortage at present, and are facing the same grave situation as the Gareh Bygone Plain. It is, therefore, obvious that the inhabitants of the Gareh Bygone Plain must rely on their very limited water resources and manage them properly.

In addition to the Bisheh Zard River discussed earlier, there are two ephemeral streams which flow through the Gareh Bygone Plain before joining the Shur River of Jahrom; Tchah Qootch River (the Well of the Ram), and Gehr Ab River enter the Plain through its eastern and southern corners, respectively (Fig. 1). The base flow of these rivers, which originate from many seepage springs, ranges from less than one litre per second (l s^{-1}) in the Gehr Ab River to about 3 l s^{-1} in the Bisheh Zard River. These saline and gypsiferous seepages are not fit for human consumption but are readily drunk by the livestock animals. Irrigation and domestic waters were supplied up to the sixties from the three *qanats* mentioned earlier. Furthermore, potable water used to be extracted manually from a few hand-dug, alluvial wells utilizing ropes and buckets; pullies or foot-operated windlasses were seldom used in the area.

From the sixties onwards, provision of more water at a cheaper price through utilization of diesel powered pumps put the *qanats* in disfavour. Pumping water out of the aquifers at a rate substantially more than the annual rate of replenishment lowered the water table about 10 m in less than 20 years, drying three *qanats* and forcing the abandonment of many wells prior to 1982, when there were only 16 low yielding wells which could be operated from 1 to 20 a hours day. The quality of the groundwater in 1982 was from fair to saline; the electric conductivity ranged from 1.6 to 4.3 mm hos cm^{-1}.

There are at least two floods in the Gareh Bygone Plain per year; one in the summer and one in the winter. Although the spottiness of the summer storms substantially decreases the probability of occurrence of the flow in all of the three rivers, the chance of receiving the runoff from one of the three is close to unity. It should be emphasized that this statement is based on very limited observations made during the period 1983-1988; there were two floods in the summer of 1986 and one in each of the remaining years. Data acquisition and analysis in the future may validate this claim.

Water Economy: The Key to the Integrated Approach

It is realized that shifting cultivation and excessive exploitation of rangelands and scrublands in arid and semiarid areas set the stage for accelerated ecological degradation, particularly during prolonged droughts. Depriving the soil surface of its vegetative cover exposes it to the hazards of erosion by water and/or wind, with the resultant removal of the fertile topsoil. Formation of scalds in localities where clays are the main soil constituent, or drifting sands and mobile dunes in regions where major geological formations are arenaceous, is the consequence of this chain of events. Since all of these processes are water-related, it is obvious that water management plays a major role in combating desertification.

Groundwater management in areas underlain by nonindurated sediments, especially calcareous, coarse grained alluvium, with due regards to ecological aggradation is a logical first step in reversing the trend of desertification. Artificial recharge of groundwater utilizing floodwaters is the principle action taken in this management plan, thus providing the much-needed water for sustainable use; stabilization of drifting sands with suspended load, irrigation of denuded rangelands and dry-farms, establishment of shelterbelts and fuelwood lots, and flood abatement are some of the incidental benefits accruing from the application of floodwater spreading methods in desertification control. Return of prosperity to the deserted farmlands and inward migration are the immediate outcome of such projects.

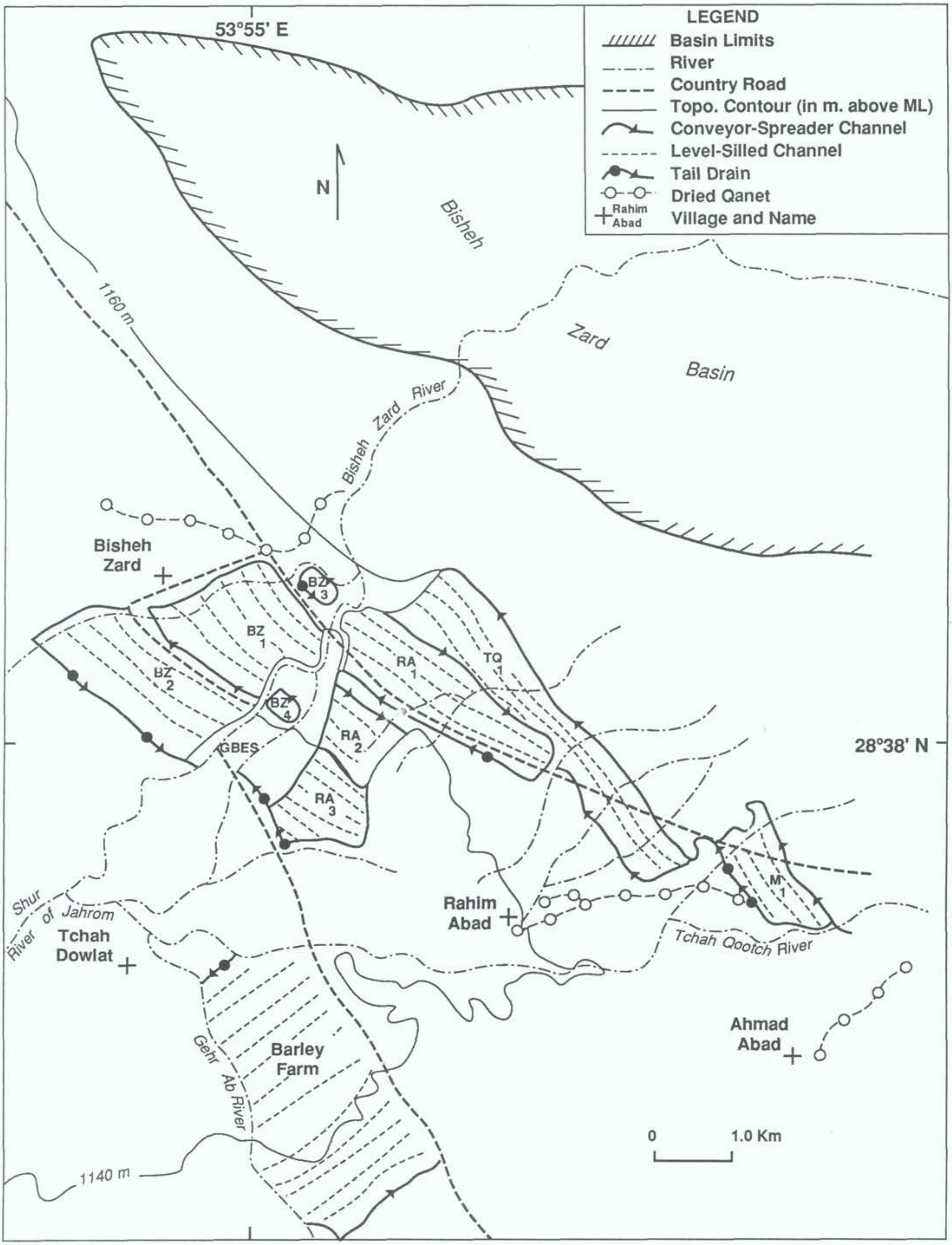


***Figure 1:** Sketch map of the Gareh Bygone Plain floodwater spreading system*

Production of forage on the floodwater spreading areas eases the pressure of livestock on grazing lands, thus rehabilitation of degraded watersheds is the long term dividend of such endeavours.

The General Plan

The complete lack of data on the flow of the three ephemeral rivers in the Gareh Bygone Plain necessitated a cautious start. It was decided to begin work on the Bisheh Zard River on a very small scale and to expand it commensurate with the rate and volume of flow of the rivers, the availability of funds and the acceptance of the nomad-farmers whose grazing ground and dry-farms would have been encroached on by the floodwater spreading project. Diversion of 5-10 m^3s^{-1} of runoff through a simple, trapezoidal intake structure, with or without an apron and/or a groyne and, in rare cases, with a diversion dam, and via an inundation canal to a 200-300 ha flood irrigation system was accepted as the main theme, with appropriate variations as the needs arose.

Although artificial recharge of the Gareh Bygone Plain water-bearing strata has been the main objective of the experiment, and the best way to achieve optimum results in this class of projects entails using the least amount of land to replenish an acquifer with the maximum volume of water at the lowest cost, in this particular case expediency dictated that provision of fodder and stabilization of drifting sands over the largest possible area were more essential goals. Further planning and execution of floodwater spreading and groundwater recharge and flood mitigation on very large scales are essential to replenish the depleted aquifers in a very short time, thereby restoring prosperity to many deserted farms and safeguarding numerous communities from such deluges as those that occurred in December 1986.

Background

The irrigation of basins by utilizing floodwaters was introduced into Egypt more than 5,000 years ago (Gulhati and Smith, 1967). Since floodwaters are a rather dependable source of water, the ancient Egyptians constructed elaborate water distribution systems which irrigated 1.2 million ha in the 13th century A.D. Other fluvial civilizations which based their livelihood on hydraulic economy abound in history; however, not many documents are available concerning the people whose existence depended entirely on the ephemeral flood regimes. Were it not fo:.-;e scholarly endeavours of the likes of Wilkinson (1978), very few inhabitants of the modern world would have known of the flood-based civilization of the Ibadis of North Africa in the 11th century A.D., or that of the Algerians living in Ghardaia nowadays. Recharging the groundwater through benefiting from occassional floods has been one of the most intelligent mechanisms by which the human race has accommodated itself to life in the desert.

Groundwater recharge in Iran could date back more than 3,000 years to the time when the Aryans invented the *qanats*. Although no written document is available to substantiate this claim, and even Alkaraji, the great Iranian hydrogeologist and hydraulic engineer of the 11th century A.D., has made no mention of this subject in his monumental book, *Exploitation of the Hidden Waters*, the inhabitants of north-east Iran could have been recharging the groundwater through flood irrigation on the alluvial cones and fans much earlier than the development of the technically more advanced *qanats*. In the process of flood irrigation the fields functioned dually as infiltration ponds and sedimentation basins, accumulating the precious and highly fertile eroded soil on stony and gravelly foothills and valleys thus building productive farms in places where rainfed agriculture was, and still is, impracticable. Construction of new basins further down-slope usually followed the near complete siltation of the upper ones, thus while the upstream farms were being irrigated with the sediment laden runoff, the less turbid surcharges of these farms were directed into the newly prepared infiltration ponds. Although this time proven and labour-intensive method is very effective and has a great merit in employing large masses, the prohibitive cost prevents its application today. Furthermore, such systems cannot accommodate large flows; therefore, design and construction of inexpensive floodwater spreading systems of large capacity is desired.

Of the different systems of floodwater spreading studied, application of the methods developed and tested by three Australian workers (Phillips, 1957; Newman, 1963; Quilty, 1972 a,b) was found most desirable for design, layout and construction of sedimentation basins and their water conveyance systems. Annexation of an infiltration pond to the downstream end of a string of sedimentation units completes a recharge system.

The most important element in any floodwater spreading system which receives large flows from an ephemeral river is a dual purpose conveyor-spreader channel which transfers water to the head of the spreading area and, ideally, distributes it evenly on to the land. This channel is actually a long, shallow stilling basin which converts some of the kinetic energy of the flowing water into potential energy, thus elevating the level of the water surface a few cm above that of the lower sill of the channel, with the resultant flow of a shallow sheet of water on a very long front. The excavated soil forms a bank on the upslope side of the channel.

Openings or gaps are provided in the bank to facilitate entrance of water into the channel during major floods when flows, larger than the capacity of the conveyor-spreader channel, bypass the junction of the diversion canal and the channel and flow along the topside of the bank. Water is supplied to the conveyor-spreader channel by a diversion, or an inundation canal. It is imperative to realize that the conveyor-spreader channel is the only structure in the system which is connected to the river.

The spillage from the conveyor-spreader channel flows over the land in a sheet whose depth and velocity depends on the flow rate, slope, infiltration capacity, sediment concentration, soil and water temperature, ground cover, etc. The depth of water on the sill of the conveyor-spreader channel, which also depends on the foregoing factors, is usually 3-5 cm, rarely exceeding 10 cm. The terminal velocity of a 10 cm deep sheet of water on a 2% slope on denuded land seldom exceeds 60 cm s^{-1}. At this depth and velocity the flow is non-erosive for all practical purposes.

The flow of water on the land is regulated by the level-silled channels which are closed at both ends. These channels, which are located at 140-250 m spacing downstream of the conveyor-spreader channel, function as described for the conveyor-spreader channel with two exceptions.

a. They receive water only through the gaps provided in their banks at 100-400 m intervals; thus in low flows or short duration floods they may receive no water to spread.
b. They are level along their entire lengths so they spread the water more evenly.

When floodwater reaches the end of a floodwater spreading system it has lost most of its sediment load and is suitable for artificial recharge, or filling up surface reservoirs. Construction of recharge ponds, returning the rather clear water to alluvial streambeds or, in rare cases, injecting the water into aquifers through recharge wells are 3 methods of replenishment of groundwater of which the first two are employed in the Gareh Bygone Plain.

Materials and Methods

System Design and Construction

The floodwater spreading systems in the Gareh Bygone Plain were designed, laid out and constructed according to the procedure suggested by Phillips (1957), Newman (1963) and Quilty (1972 a,b), with the following modifications:

a. The slope of the conveyor-spreader channels was set at 0.0003 in the direction of flow for about 85% of their lengths; the slope of the final 15% was decreased gradually from 0.0003 to zero. These modifications ensured a more uniform spreading along the entire length of each channel during high flows, and indundation of a small tract of land at the upper far end of the floodwater spreading systems in low flows.
b. Vertical intervals of 1.10 and 0.75 m were adopted on slopes of 0.5-0.7% and 0.3-0.5% respectively, resulting in the spacing of 140-250 m for the channels.
c. Construction of level crested end banks parallel to the major slope confined floodwaters to the spreading areas, thus preventing both uncontrolled flooding of the adjacent lands and return of the water to the river in unsuitable places.
d. Construction of tail drains ensured safe return of the surcharges to the Bisheh Zard River.
e. Larger and more powerful bulldozers than the machines used by the Australians were employed in constructing the water conveyance and spreading systems. Furthermore, a rubber-tyred loader was used to construct the level-silled channels in the dry, drifting sands because the bulldozer tracks would have peeled the protective mat of *Carex stenophylla* (Wahl.) off the soil surface, thus exposing the sand substratum to the hazards of wind and water erosion.
f. The very severe erosion which occurred during the first floodwater spreading event in the gaps, and the head-water erosion on their upstream side and along the top toe of the banks immediately in the neighbourhood of the gaps, necessitated construction of specially designed chutes and drops in the gaps. The level of the sills of these structures should be raised as the depth of sediment increases in the basins.

The floodwater spreading project in the Gareh Bygone Plain consists of 8 systems (Table 3; Fig. 1). The Bisheh Zard River supplies floodwater to 7 systems; the Tchah Qootch River supplies only one. Since each system is designed to fit the lay of the land, the length of the conveyor spreader channels and the level-silled channels, as well as the number of the latter, differ considerably among the systems. Except for the systems Rahim Abad$_2$ and Rahim Abad$_3$ which are fed by a single diversion canal, each system is supplied by an individually designed diversion canal. Furthermore, the possibility of supplying the lower lying systems with the surcharge of the upper ones has eliminated five of the tail drains. Only one tail drain on each side of the Bisheh Zard River returns the surcharge to the river. The return flow of the Tchah Qootch River system is discharged into the Bisheh Zard River through its left bank tail drain.

Tree Planting

Establishment of shelterbelts is an acknowledged method of stabilizing the drifting sands and the shifting dunes. Provision of fuelwood, fence posts, utility poles and roofing timbers for a

Name of the FWS* system	Duration of Construction	Area in ha	Diversion canal length	CSC* length	Level-Silled channel length	Tail Drain length
Bisheh Zard$_1$	Jan-Feb 1983	200	500	1340	9940	-
Bisheh Zard$_2$	Mar-June 1983	250	340	1800	6740	2500
Bisheh Zard$_3$	Dec 1983-Mar 1984	25	330	400	1000	1000
Bisheh Zard$_4$	Jan-Mar 1984	25	300	200	920	-
Rahim Abad$_1$	Jan-June 1984	200	200	2500	7900	2600
Rahim Abad$_2$*	May 1984-Feb 1987	300	1540	540/1950	4340/6450	1780
Tchah Qootch$_1$	Nov 1985-Feb 1987	365	500	7000	14350	-
Totals		1365	3710	15730	51640	7880

*The RA2 diversion canal supplies two systems through specially designed weirs and drops
*FWS - Floodwater spreading system
*CSC - Conveyor-spreader channel

Table 3: *Name, Code, Duration of Construction, Area and Length of Diversion Canals, Conveyor-Spreaders and Level-Silled Channels and Tail Drains of the Gareh Bygone Plain Floodwater Spreading System*

fast-growing population necessitates tree-planting on very large scales. This has been achieved by the introduction of some fast-growing Australian species into the Gareh Bygone Plain. Nine month old, perforated polyethylene bag-grown seedlings of *Eucalyptus camaldulensis* (Dehnh.), *E. microtheca* (F. Muell.), *Acacia cyanophylla* (Lindl.), *A. salicina* (Lindl.) and *A. victoriae* (Benth.) which had been successfully tried in the more clement environment of southwestern Iran (i.e. Noor Abad, Kazerun), were planted in the Bisheh $Zard_1$ in February and March 1983, adjacent to the upslope toe of the banks of the channels, along the waterline of the diversion canal, and by the inside toe of the end banks. The planting lines were ripped to a depth of 35 cm, using bulldozer mounted rippers. The seedlings were planted at 3 m spacing, usually in one row, in the hope that a 50% survival rate would result in an average spacing of 6 m. A second row of *Eucalyptus camaldulensis* (Dehnh.) was also planted at the same spacing, 4 m upstream of the conveyor-spreader channel of the Bisheh $Zard_1$, and another row about 70 m downstream of the same channel.

Floodwater irrigation of most of the planting sites on 18 and 19 January and 6 March 1983 eliminated the need for watering the seedlings immediately following transplantation. The seedlings were protected from browsing for 9 months. Fertilization, pest management, or any kind of aftercare has not been practised for these plants.

The unexpectedly high rate of survival and growth of *Eucalyptus camaldulensis* (Dehnh.) during the first growing season encouraged its planting every year, not only by the banks, but in 3 x 3 m spacing between them. To date upwards of 30,000 seedlings of this species have been planted in the floodwater spreading systems.

Plantation of the acacias has not kept pace with that of the eucalypts; lack of resistance to temperatures as low as -7°C has actually eliminated *Acacia cyanophylla* (Lindl.); survival rate of this species has been only 37%.

Two separate tree species trials have been executed on the project site; the tried species will be briefly mentioned under the heading "Research".

Shrub Transplanting

Although a limited trial of quailbush (*Atriplex lentiformis* (Torr.), (Wats)) in 1983 was very discouraging, the experiment was repeated in 1984. Nine month old perforated polyethylene bag-raised seedlings of quailbush were planted at 3 m spacing in contour furrows in February and March 1984. The distance between the furrows was 4 m. Each seedling was irrigated with 2 litres of water immediately following transplanting. Flood irrigation of the systems during the period 20-30 March 1984 made further watering unnecessary.

Transplanting for 1985 was extended to the outside of the floodwater spreading systems on the eastern margin of the Plain, which has a heavier soil derived mostly from a red marl.

Observation Well Installation

Lack of funds impeded installation of observation wells until September 1987 when a network of seven 4-inch wells was drilled and cased in the project area. The locations of these wells were selected by a geohydrologist. The eighth well was added to the network when a low yielding, 43 m-deep domestic well was abandoned close to the centre of the study area. Water level in these wells is measured monthly by a technician from the Fasa District Groundwater Authority.

The water level in 4 irrigation wells has been measured periodically since June 1983 when the first high yielding, 26 m-deep well touched water at 19 m. Measurements were made early in the morning, usually 2-3 days after the pump shutoff time.

Results and Discussion

Floodwater spreading has dramatically changed the appearance of the study area. Transformation of a desolate, sandy expanse to verdant scenery is the most obvious result of flood irrigation of the native vegetation and the transplanted tree, bush and shrub seedlings. A clear space in a dust bowl is a proof to the effectiveness of stabilization of the drifting sands by sedimentation of the suspended load carried in floodwaters. Mushrooming of irrigated fields in an area previously short of water is convincing evidence of the effectiveness of artificial recharge of groundwater. Gradual return of wildlife and the constant raiding by sheep and goat flocks of the spreading areas bear witness to the presence of feed and shelter for hungry animals. Above all, the inward migration by those inhabitants who had left the Gareh Bygone Plain due to economic hardship refutes the often-heard argument that amenities and "easy money" attract rural people to the cities.

A brief account of some of the observations will follow; more rigorous treatments of each subject matter will be reported later.

Floods

Definitions: A flood is defined in this report as any flow of the Bisheh Zard River if the stream enters at least one of the intake structures; therefore, those minor flows which infiltrate the stream bed but do not enter any one of the floodwater spreading systems are not counted as floods. The elapsed time during which water flows from the Bisheh Zard River into the Bisheh $Zard_2$ and Bisheh $Zard_1$ intake structures in minor and major floods, respectively, is defined as flood duration. A weir installed on the Bisheh Zard River by the Bisheh $Zard_2$ intake structure diverts all of the minor flows towards the lowermost floodwater spreading system; therefore, the actual duration may be timed there. Location of the Bisheh $Zard_1$ intake structure, which is midway between the uppermost and lowermost diversion points (Fig. 1) offers a practical choice for measuring flood duration for all the floodwater spreading systems which are supplied by the Bisheh Zard River in major floods. The duration is rounded to the next lower full hour; e.g., 25 hrs and 45 mins is taken as 25 hrs. This is done to be on the safe side when reporting the recharge volume. A flood peak is defined as the rate of flow at the highest stage of the Bisheh Zard River, about 300 m upstream of the Bisheh $Zard_3$ intake structure, before any diversion from the river takes place. Although this reach of the river has semi-solid banks with no apparent signs of erosion, the instability of the alluvial streambed makes it difficult to determine the exact flow along this section. This uncertainty, along with the estimated flow velocity figures obtained by the floating object method, justfies rounding off the peak flow rates to the closest decimal number.

The data for the floods in which at least one floodwater spreading system has functioned are presented in Table 4. The diverted volume of floodwater is obtained by estimating the peak flow in each of the intake structures in $m^3 s^{-1}$, dividing it by 2, and multiplying it by the appropriate duration in seconds. As the number of systems and their intake structures have increased, so has the volume of diverted water for comparable floods. The volume of diverted water for major floods is rounded to the next lower 10th of a million m^3.

It is observed that the volume of diverted water ranges from 0.07 to 7.8 million m^3 in the floods reported in Table 4. It should be emphasised that on at least 5 occasions, particularly in the summer, water entered the Tchah Qootch1 and spread over a few hundred ha without being timed by a watchman; therefore, the volume of diversion is not known for those floods. Furthermore, floodwater entered the systems from the overflowing banks of the Bisheh Zard River and Tchah Qootch River during the catastrophic events of December 1986; therefore, the reported flows from which the estimated volumes have been given in Table 4 were more than the combined capacity of the intake structures.

Date Year	Month	(2)Estimated peak flow $m^3 s^{-1}$	Duration, hours	Volume of diversion million m^3
		Sampling for quality determination		
1982	November 10	40		
1983	January 19-20	48	24	0.07
	March 6	30	19	0.07
1984	February 27	70	20	1.10
	March 21	40	5	0.40
	March 22-23	50	34	1.80
	March 24-26	60	48	2.60
	March 28-31	60	40	2.10
1985	January 4	30	17	0.92
	January 20-24	40	20	1.20
	May 12	30	2	0.10
	December 19-20	70	26	3.10
	March 8	80	26	3.20
	July 26	100	13	1.00
	August 6	100	14	1.10
	November 30- December 1	200	24	3.90
	December 2-3	300	26	7.80
	December 4-6	130	34	2.40
	December 6-7	100	8	0.60
1987	August 18	20	2	0.07
1988	January 18	100	15	1.90
	February 23-25	30	50	2.70

1. For more details refer to the text under the heading "Floods"
2. The slope-area method has been used in estimating peak flows
3. Diversion from the Tchah Qootch River and 4 minor waterways which drain into the conveyor spreader channel of the Tchah Qootch[1] floodwater spreading system was started on December 19, 1985
4. Duration of these 2 floods were reported by a watchman; other floods were timed by the research personnel who were on location on these particular dates

Table 4: *Summary of flood events of the Bisheh Zard River from November 1982 to February 1988, and estimated volume of diversions to the floodwater spreading systems*

Augmentation of Groundwater Deposits and its Effect on Irrigated Agriculture

There were 16 medium to low yielding wells in the Gareh Bygone Plain prior to 1983 when the recharge project was initiated, of which 12 delivered 10-15$m^3 h^{-1}$ for 6 to 20 hours per day; the remaining 4 wells yielded at the same rate, but for less than 6 hours a day. According to the survey taken in January 1989, the number of wells has increased to 58. Of the 42 newly dug or bored wells 40 are utilized for irrigation and 2 for domestic consumption. Although these wells are usually operated less than 20 hours a day, some owners claim that water may be pumped out of them for longer times without any measureable decrease in their yields.

The substantial increase in groundwater deposit has had a pronounced effect on the agricultural and social outlooks of the Plain, the reverberations of which are subjects of other studies. Only a brief account of the increase in irrigated area is presented here. It should be realized that the areas of the "new" and "old" farms were reported by the farmers; therefore, considering the number of wells and their yields, it seems that the areas of the "new" and "old" farms have been under- and over-estimated, respectively.

A recent survey has put the total area of newly developed irrigated farms at 492 ha. These farms have gradually come into production since 1983, about 6 months after the recharge project commenced. Provision of irrigation water for these farms, in addition to supplying another 514 ha of "old" farms with water, appears to be the most important result of the groundwater recharge activities. This, in an area faced with a rapidly lowering water table, may be termed as a success.

Although accurate measurement of the recharge volume is difficult due to illegal sinking of wells and competition in pumping of water, a rough estimate is presented here. Assuming that 700 ha of land is under irrigation each year, and 10,000 $m^3 ha^{-1}$ of water is used in producing one crop a year, the annual extraction from the aquifer would amount to 7 million m^3. It is reasonable to further assume that the annual volume of water recharged naturally, as well as artificially, is more than 7 million m^3 since the seepage into the Shur River of Jahrom has remained constant (observation only). Whether this rate of extraction would hold for a long time is an open question.

It is postulated that the recharge flood of December 1986, when about 14 million m^3 of floodwater were diverted and substantial natural recharge took place, has stored enough water to last for about 3 years, assuming the annual pumping rate does not exceed 7 million m^3. However, the demand for water is so great and the competition for water extraction and making "quick money" is so intense, that the sustainable yield of the aquifer would soon be exceeded.

Although the real potential for artificial recharge in the Gareh Bygone Plain has barely been exploited, the trend points to an urgent need for educating the farmers not to pump water at a greater rate than the recharge permits.

Survival and Growth of *Eucalyptus camaldulensis* (Dehnh.) Seedlings

Results of survival and growth of over 60,000 tree seedlings planted during 1983-1988 will be reported later. However, a few observations on the performance of the tree seedlings which were planted by the upslope toe of the channel banks in February and March 1983 in the first installed floodwater spreading system (Bisheh $Zard_1$) are presented here for the benefit of desertification control planners and practitioners.

The performance of *Eucalyptus camaldulensis* (Dehnh.), planted in the harsh environment of the Gareh Bygone Plain, has been outstanding. This, for a tree known as the river red gum in its land of origin, is unexpected since this species is usually utilized for reclamation of inundated areas. Of the 820 seedlings planted by channel No. 6 Bisheh $Zard_1$, whose sites had not been irrigated at all before planting and for 11 months thereafter, only 34% succumbed to drought (Table 5). Although these seedlings had grown very little during the first year, they have been competing successfully ever since with those trees which were flood irrigated only once (channel No. 5) or twice (channels No. 1-4) during January and March 1983 (Table 5). Apparently, the estimated 150 mm of precipitation which had occurred in the fall of 1982 and winter of 1983 had provided enough reserve to satisfy the water requirements of the non-irrigated seedlings for survival and insignificant growth.

Cumulative 6 year height for the gums ranges 8-16 m, with the tallest and shortest trees being located by channels No. 1 and 6 respectively. Channel No. 1, being a conveyor spreader channel, receives floodwater in all floods; channel No. 6 is inundated only during major floods, about once a year. The diameter breast height ranges from 12 to 25 cm for the 6 year old trees.

Stabilization of the Drifting Sands

Deposition of the suspended sediment load on the spreading areas has stabilized the drifting sands. Sedimentation of silts, clays and organic matter on sands has transformed the surface soil into a cohesive, wind resistant material. Provision of a better growth medium, containing more nutrients and having a higher water holding capacity, has helped proliferation of the existing vegetation and invasion of new plant species. The combined effects of physical, chemical and biological stabilization of the drifting sands have been phenomenal. Although the importance of eucalypt shelterbelts in reducing wind erosion should not be slighted, the moving sands from the bands between tree rows, which had not been covered with the water-borne load, point to a very significant role played by floodwaters in stabilization of drifting sands.

Sedimentation, which is the menace of water-related projects, particularly of surface reservoirs, is a blessing in disguise for the debris cone. Apart from its role in stabilization, sedimentation increases the soil depth, levels the spreading basins, and finally creates potentially productive fields which may be put under irrigation requiring the least amount of land grading.

Improvement of Forage Production

Flood irrigation of the depleted rangelands, as well as the concomitant soil-building processes materialized through sedimentation, have provided a better environment for plant growth on the spreading areas. Introduction of quailbush *(Atriplex lentiformis* (Torr. Wats.)), and invasion of *Atr. leucoclada* (Boiss.), grey-leaved sagebrush *(Artemisia sieberi* (Besser)) and many other forage species have added more palatable fodder to a very poor grazing ground. Growth of quailbush, which performs poorly on sands, has been spectacular in sedimentation basins; 3 year old bushes have grown to a height of 2 m and crown diameter of 2.5 m. The dry weight of leaves and shoots of a single, 3 year old bush were 2.5 and 10.7 kg respectively. It is estimated that at 4 x 4 m spacing this species may produce upwards of one ton/ha/year.

Vegetative dry matter production, regardless of its palatability, ranged from 20 to 50 kg ha^{-1} prior to the implementation of the floodwater spreading project in the Gareh Bygone Plain. The annual forage production on 500 ha of the spreading areas (Bisheh $Zard_1$, Bisheh $Zard_2$, Bisheh $Zard_3$), estimated by sampling 17 one m^2 plots, ranged from 240 to 1,950 kg ha^{-1}, with an average of 515 kg ha^{-1}, again regardless of its palatability. Although the removal of only 100 kg ha^{-1} of the forage had been approved by the province's range specialist, the local herds grazed many times that figure: the area supported 1,877 sheep and 1,760 goats for a period of 45 days in November and December 1987. Assuming that the

Channel No.	Number of Seedlings Planted	Number of Living trees	Success %
1	333	298	89
2	573	473	83
3	637	537	85
4	560	477	87
5	627	482	79
6	820	538	66
Total	3550	2805	Ø 81

Table 5: *Survival of the* Eucalyptus camaldulensis *(Dehnh.) seedlings planted adjacent to the upslope toe of the channel on the Bisheh* $Zard_1$ *floodwater spreading system, 5 years after planting.*

average daily consumption of each animal was 1.5 kg, 245 tons of forage were removed from the waterspreading areas. This amounted to 490 kg ha^{-1}. Although it is easy to assign precise monetary values to the feed, and the double lambing and kidding experienced by the ewes and does that grazed the floodwater spreading areas, the real advantage of flood irrigation for feed production is hard to envisage by non-nomads. The most important concern of the nomads in Iran, who consider animal husbandry as the mainstay of their lives and the size of the flock as a status symbol, is provision of feed for fall and winter, particularly in drought years. Thus, some 60 stockmen from the village of Bisheh Zard, and about twice as many from Rahim-Abad and Tchah Dowlat, constitute the direct beneficiaries of the floodwater spreading project.

Provision of shade and drinking water for livestock has been an incidental benefit of the floodwater spreading and shelterbelt establishment in the Gareh Bygone Plain. Water usually stays in the channels for about 3 weeks in the summer and for 2 months in the winter following flood termination. Many herders, who prefer the quality of floodwater to that of the well water (electrical conductivity of 0.25 *versus* 1.60+ mmhos cm^{-1}) frequent the channels as long as the water lasts, carrying it inside goatskin bags and on donkey-backs.

A strange observation is worth mentioning here: sheep and goats severely browsed *Eucalyptus camaldulensis* (Dehnh.) leaves and young shoots with no apparent ill effects. Since these trees leaf profusely, and feed production is vital in the region, effects of inclusion of eucalyptus leaves in the livestock ration should be thoroughly investigated.

Aggradation of Environment Quality

The climate of an oasis which has emerged out of the Gareh Bygone Plain is milder than the surrounding desert. Near complete elimination of dust storms in the spreading areas, which cover about one quarter of the sandy expanse, has made life more pleasant for the inhabitants of the Plain. Apart from the people who use the project grounds as a picnic area and camping site, many birds and mammals have found refuge there: rock doves (*Columba liva* (Gm.)), turtle doves (*Streptopelia turtur* (L.)), common babblers (*Turdoides caudatus* (Drapiez.)), white-eared bulbuls (*Pycnonotus leucotis* (Gould.)), blue-cheeked bee-eaters (*Merops superciliosus* (L.)), Indian rollers (*Coracias benghalensis* (L.)), rollers (*Coracias garrulus* (L.)), hoopoes (*Upupa epops* (L.)), black-bellied sand grouses (*Pterocles orientalis* (L.)), see-see partridges (*Ammoperdix griseogularis* (Brandt.)), house sparrows (*Passer domesticus* (L.)) and sparrow hawks (*Accipiter nisus* (L.)) are some of the most frequently seen birds in the floodwater spreading systems. Mallards (*Anas platyrhynchos* (L.)) invade the project site in the fall and winter as long as water remains in the channels and infiltration ponds. Of the mammals, rabbits (*Lepus capensis* (L.)), foxes (*Vulpes vulpes* (L.)), jackals (*Canis aureus* (L.)), wolves (*Canis lupus* (L.)) and numerous mice and rats have literally occupied the spreaders. The main cause of bank-breaching during floods is the flow of water through the burrows of these animals. Return of houbara bustards (*Chlamidotis undulata* (Jaqu.)) and gazelles (Gazella subgutturosa subgutturosa (Guldenstaedt.)) to their previous haunt may be interpreted as an indication of the recovery of a degraded habitat.

The introduction of *Acacia salicina* (Lindl.) in the Gareh Bygone Plain appears to be a right move; not only the livestock enjoy the fodder produced by this leguminous tree but honey-bees swarm it from October through March. This flowering habit is of great significance for the beekeeping industry since very few plants which are frequented by honeybees flower during fall and winter. Considering that eucalyptus, other acacias and most native vegetation provide pollen and nectar sources for the bees from March to September, establishment of large stands of *Acacia salicina* (Lindl.) may provide a yearlong habitat for the bees, thus increasing the income of many people in the area.

Barley Production

As was previously mentioned, although dry-farming for wheat and barley is a total failure on sandy soils of the Gareh Bygone Plain, almost all farmers practise it against professional advice. However, sedimentation of very fine grained minerals and organic matter has gradually prepared a better medium for plant growth.

Sixty kg of barley of local stock was seeded in a one ha area in Rahim $Abad_2$ in January 1986 following the flood of December 1985 (Table 4). This crop was flood irrigated on 8 March 1986. Although the total depth of precipitation for the entire growing season (October to April) was only 153 mm, one ton of grain was produced on that field. Moreover, barley production of up to 2 tons ha^{-1} on a limited scale, and 1,400 kg ha^{-1} on a 650 ha floodwater spreading system, has been observed on a loamy soil about 5 km to the southwest of the debris cone. The increased income from the extra production of 700 kg ha^{-1} of barley and of 1,050 kg ha^{-1} of stubble, as compared to the rainfed counterparts, was 2.3 times the cost per ha of floodwater spreading system construction. Thus, if the market value of barley and straw, as well as the bulldozer rental remain relatively constant, theoretically, the yearly reconstruction of the floodwater spreading systems for barley production is still economically feasible. However, if other profits are taken into account, the benefit to cost ratio would exceed 2:3.

Flood Damage Mitigation

Although absolute control over floods seems impossible, mitigation of their damage through flood plain management is practicable. Waterspreading systems usually function as flood retarding structures which, by virtue of absorbing some water, decrease the flow rate. Moreover, if they are specifically designed to come into operation as the flood stage rises, the string of waterspreaders dampen the peaks without jeopardizing any of the functioning systems.

The eight floodwater spreading systems accomodated about 100 $m^3 s^{-1}$ in the deluge of 1986[3], 75 $m^3 s^{-1}$ from the Bisheh Zard River and 25$m^3 s^{-1}$ from the Tchah Qootch River and 4 minor waterways. The average infiltration rate of the spreaders during this event was 74 $ls^{-1} ha^{-1}$, or 26.4 mm hr^{-1}. Apparently, this was a rather low rate for a sandy soil and higher flows might have been diverted to the existing systems if larger water distribution networks had been constructed.

Although no feasibility study has been done on this aspect of floodwater spreading in the Gareh Bygone Plain, some preliminary estimates may be made on the basis of some of the financial damage suffered by the Fasa District in the deluge of 1986: assuming that the flood stage capacity of the Shur River of Jahrom as it leaves the Fasa Basin is 500 m^3 s^{-1}, the 6 billion rials-worth of damage incurred by the basin in the deluge was due to 1500 m^3 s^{-1} of flow rate above that of the flood stage. This damage, on average, amounted to 4 million rials per m^3 of the flow rate. If this figure is taken as the first approximation of flood damage mitigation benefits, the floodwater spreading systems in the Gareh Bygone Plain have saved upwards of 400 million rials in that catastrophic event, about 10 times their original cost. However, since no monetary value can be placed on intangible benefits of flood control, not all of the advantages may be so simply evaluated; e.g., how could the surviving relatives of the 424 people who were drowned in the deluge be compensated?

Migration Reversal

Irrigation water availability on the one hand, and a substantial rise in the price of agricultural commodities on the other, has encouraged many absentee farmers to return to the Gareh Bygone Plain. Moreover, seasonal farm labourers have found well-paying jobs as irrigators, farm machinery operators and the like in the Plain. Although no data on outward migration are available, over-population of cities and towns, and the difficulty of providing the necessary services for the added inhabitants, are of major concern for municipalities. The favourable results of floodwater spreading in the Gareh Bygone Plain, and its varied effects on the lives of the inhabitants, made the ex-mayor of Fasa an ardent supporter of the project.

It is estimated that the funds required by the City of Fasa to accommodate one rural family of 7 may be used in construction of 25 ha of floodwater spreading system which would nicely support the same family in the Gareh Bygone Plain. Furthermore, extra funds should be appropriated for the police and judiciary systems to keep the city safe and secure. These difficulties, along with turning consumers into producers, have been instrumental in gaining the support of Government authorities and private citizens for continuation of the floodwater spreading project in the Gareh Bygone Plain.

Economic Feasibility

Discussion of economic justification of a floodwater spreading project, particularly for the purpose of groundwater recharge and its casual benefits, might appear irrelevant, especially when social dividends far outweigh monetary gains. However, a very simple analysis, made below, may help to facilitate the task of decision makers:

The following assumptions are made in performing this analysis:

1. The economic life of the project is 10 years;
2. The total cost of maintenance is 52% of the original outlay for the earth-moving and masonary works;
3. The expenditure of 5% of the cost of flood damage restoration is justified for its mitigation;
4. The value of the diverted water is one rial m^{-3}; and
5. The stabilization of the drifting sands, the building of soil, and the aggradation of environmental quality are tangible benefits.

Based on January 1989 market prices, bulldozer rental, which amounts to 3,500 rials hr^{-1} (1 US dollar = 70 rials) for a 125 horse power unit with a 4 m wide blade and 60 cm long rippers, comprises about 80% of the expenses; surveying, designing and supervision make up the rest. The total expense of preparing one ha of floodwater spreading system is about 11,000 rials on slightly erodible soils. However, the need for construction of small concrete or masonary conservation structures may double the costs on sands, loamy sands and sandy loams. Other expenses, such as tree and shrub planting, seeding etc are extra.

The financial losses incurred in the deluge of 1986 were estimated at 4,000,000 rials per m^3 s^{-1} over the flood stage of the Shur River of Jahrom. Since the lowest infiltration capacity of the floodwater spreading systems in the Gareh Bygone Plain was 0.05 m^3 ha^{-1} during that event, the flood mitigation costs at 5% and on a per ha basis amount to 10,000 rials.

The average construction and planning costs for a floodwater spreading system in the Gareh Bygone Plain on a per ha basis are itemized below:

		Rials
Bulldozer rental	@ 3,500 rials hr^{-1}	5,600
Masonary structures	@10,000 rials m^{-3}	10,650
Surveying	@ 2,000 rials hr^{-1}	1,000
Design and Supervision	@ 5,000 rials hr^{-1}	2,000
Tree planting (all costs included)	@ 150 rials/tree	4,200
	Total	**23,450**
Deducted for flood mitigation		-10,000
The original outlay for floodwater spreading and groundwater recharge		13,450
Compounded yearly at 15% for 10 years		54,418
Maintenance for 10 years		10,000
	Total	**64,418**
The average benefits for a 10 year period are:		
Forage	@ 25 rials kg^{-1}	90,000
Wood	@ 10 rials kg^{-1}	32,440
Water	@ 1 rial m^{-3}	25,000
	Total	**147,440**

Ratio of benefits to costs 147,440:64,418 = 2:0.28

Research

Apparent simplicity of floodwater spreading for groundwater recharge, along with the lack of funds and research staff where the problems exist, has resulted in a dearth of data on desertification control utilizing floodwaters. One of the main objectives of the Research Institute of Forests and Rangelands has been the initiation of studies which reveal the long term effects of floodwater spreading on soil building in, and gradual impermeability of recharge ponds. To this end, establishment of a baseline is therefore required. *Effects of waterspreading on* *some physical and chemical properties of a sandy soil of the Gareh Bygone Plain* is the title of an MSc thesis by Mr A.A. Naderi of the University Faculty Educational Centre. Seyyed Kh. Mirnia of the same university has written his MSc thesis on *Application of clay mineralogy in detection of sediment sources on the Gareh Bygone Watershed*. Since clay particles play a major role in decreasing permeability of sedimentation basins and recharge ponds, determination of clay species is essential in designing floodwater spreading systems and in outlining the chemical treatments for coagulation and flocculation of suspended clays. Close cooperation among the Research Institute of Forests and Rangeland, UFEC, and universities of Shiraz and Mashhad has made these studies possible.

Adaptability trials on 6 species of eucalyptus, namely: *Eucalyptus camaldulensis* (Dehnh.), *E. fruticetorum* (F. Muell. ex Mig.), *E. gilli* (Maiden), *E. intertexta* (R.T. Bak.), *E. microtheca* (F. Muell.) and *E. oleosa* (F. Muell.); 6 species of acacia, namely: *Acacia cyanophylla* (Lindl.) *A. farnesiana* (L.); (Willd.), *A. notabilis* (F. Muell.), *A. salicina* (Lindl.), *A. victoriae* (Benth.) and also *Parkinsonia aculeata* (L.), *Prosopis juliflora* (Swartz); (DC) and *Zyziphus spina-christi* (L.); (Desf.) were started in March 1985. Investigation to identify the hosts of a truffle species (*Terfezia spp.*), which has fortunately invaded the spreaders, is underway.

Water consumption studies of the native and introduced plant species will be initiated in the summer of 1989. The ultimate objective of these research projects is the development of a computer programme which would predict the elevation of the water table at specific times and locations, and assign the withdrawal rate for each single well so that while preventing salt water intrusion into the debris cone, and salt water seepage from the debris cone into the Shur River of Jahrom, enough reserve may be maintained for probable droughts. Moreover, optimization of water recharge and consumption in accordance with Government policy on strategic agricultural products necessitates allotment of water to different farms on the debris cone or around it. This may be better achieved if such computer programmes were available.

Although salt water utilization has not been contemplated as of now, possibilities exist to plant crop and tree species according to their salt tolerance on the debris cone and beyond, i.e. the most salt tolerant species, such as date-palm (*Phoenix dactylifera* (L.)) and Athel tamarisk (*Tamarisk aphylla* (L.); (Karsten)) shall be planted close to the Shur River of Jahrom. Fish ponds will be constructed by the Shur River of Jahrom; thus, even the saline water will help people raise food and fibre.

It is hoped that through such studies this degraded land shall eventually achieve its ecological balance.

Summary and Conclusion

Floodwaters and deep, coarse alluvial deposits are two of the most abundant and least known natural resources in Iran, as well as in many other so called third world countries. To most people floods are a curse, not a source of water. If it was realized that a flood can be a blessing in disguise which may be put to beneficial use, people would respect and love it. Alluvial aquifers provide very large reservoirs, usually at no cost, for impounding and transporting clean water with a minimum loss due to evaporation. These facts have to be taught to people through the establishment of floodwater spreading experiment stations on debris cones in the deserts. The basic objective of the researchers at these institutions should be exploring ways and designing means to harness the optimum volume of floodwater at the minimum cost while optimizing the systems to gain the maximum sustainable benefits from the inputs. These could be achieved only if due regard is paid to the ecological balance.

The main framework of desertification control in the Gareh Bygone Plain has been floodwater spreading to augment the groundwater deposits. Deposition of the suspended load in sedimentation basins has stabilized the drifting sands and has provided a better growth medium for the native vegetation and exotic plant species. Establishment of shelterbelts and woodlots has favourably modified the climate, as well as providing the much-needed industrial wood and fuel for the populace.

The 38.1 million m^3 of floodwater which were diverted during the period 1983-88 have changed the face of the Gareh Bygone Plain and the lives of its nomad-farmer inhabitants. The 42 shallow wells, which have been hand-dug or bored during the same period, and the 16 previously dug wells, irrigate about 1,000 ha of land in the Plain. The income from these irrigated farms has made many owners relatively rich in a very short time. Moreover, the flood irrigated barley fields produce 600-800 kg of grain and 900-1,200 kg of stubble more than those of their rainfed counterparts. Therefore, not only the owners of the irrigated fields, but the dry-farmers have benefited from the floodwater spreading project in the Plain.

The carrying capacity of the floodwater spreading systems has increased at least 10-fold; the potential for extraction of fuelwood from the fast-growing species is about 10 tons ha^{-1} $year^{-1}$. The incidental benefit of floodwater spreading/flood damage mitigation could have a profound effect on the lives of the people downstream of the Gareh Bygone Plain as far as the Persian Gulf.

Application of floodwater spreading methods for desertification control is a step in the right direction towards achieving self-sufficiency in water, food and fuelwood for the desert communities. These methods, as applied in the Gareh Bygone Plain, are "economically feasible, environmentally sound and socially acceptable;" thus, what had been envisaged by the Cairo Plan (Tolba, 1987) has materialized in the Gareh Bygone Plain, Iran.

Epilogue

Floodwater management is the key to charting an integrated approach to desertification control. Harnessing large instantaneous flows and impounding significant volumes of water through provision of very simple and inexpensive structures necessitates the collaboration of many specialists; hydrogeologists; geohydrologists; soil, range, and forest scientists; agronomists; irrigation engineers; economists; sociologists; and practitioners of all of the related disciplines should carefully plan water distribution and utilization in desert watersheds. To this end, every activity is planned and implemented according to the best use of each unit of water, i.e., optimization of water consumption. Although models should eventually be developed to analyse systematically the conjunctive use of floodwaters for different purposes, the lack of trained personnel and accurate data should not discourage responsible authorities from planning and implementing floodwater spreading for artificial recharge of aquifers. Application of the existing knowledge would suffice under many circumstances; all that is needed are courageous persons who are not afraid of trying.

Replenishing empty aquifers in the deserts with as much floodwater as possible should be the main goal of desertification control. Most of the water which was deposited in the desert aquifers during the glacial period and thereafter has been seriously depleted in a matter of decades. If the current inhabitants of water-short regions of the world are to survive, and if they feel any obligations towards future generations, they must redeem themselves by aiming to return water levels in the aquifers to their previous stage. Furthermore, it is worth repeating that the economy has to be matched to the available water. To this end, development and implementation of the hydro-agro-silvo-pastoral economic plan for dry areas is suggested. In such a system water shall acquire a status on a par with oil in petroleum-producing countries, or with other tangible finite resources in other lands. Water is allocated to each sector of the economy with the objective of achieving an ecological balance while optimizing its utilization.

It will be thirst, not starvation, that will imperil desert inhabitants who let floodwaters go to waste. It is then logical to use flood and drought relief funds to execute flood irrigation and artifical recharge projects.

Tens of millions of unemployed manual labourers subsist in the deserts; they have to be fed and housed. It is more dignified that alms be given to them as wages to make wastelands bear fruit than if they were to perish through the waste of flood water.

References

Anon. 1976. Rainfall and evaporation maps of Iran. Surface Waters Authority, Ministry of Power, Tehran (in Farsi).

Anon. 1984. Tentative water balance in Iran. Ab 3:Back Cover.

Black, C.A. (ed). 1965. Methods of soil analysis. Parts 1 and 2. *Agronomy 9.* ASA, Madison, WI. p. 1,572.

Ganji, M.H. 1965. Climate. p. 212-249. In W.B. Fisher (ed). *The Cambridge history of Iran. Vol. I. The land of Iran.* Cambridge University Press, London.

Ganjini, A., and M. Farman Ara. 1967. Semi-detailed soil survey report of Jahrom. Soil Institute, Tehran, Iran. *Tech. Rep. No. 97.* p. 78 +2 maps (in Farsi).

Gulhati, N.D. and W.Ch. Smith. 1967. Irrigated agriculture: An historical review. p. 3-11. In R.M. Hagan, H.R. Haise, and T.W. Edminister (eds.) Irrigation of agricultural lands. *Agronomy 11*, Madison, WI.

James. G.A., and J.G. Wynd. 1965. Stratigraphic nomenclature of Iranian Oil Consortium Agreement Area. Amer. Assoc. Petrol. *Geol. Bull. 449*, pp. 2, 182-2, 245.

Kassas, M. 1987. Drought and desertification. *Land Use Policy 4*, pp. 389-400.

Mabbutt, J.A. 1987. Implementation of the Plan of Action to Combat Desertification: Progress since UNCOD. *Land Use Policy 4*, pp. 371-388.

Newman, J.C. 1963. Waterspreading on marginal arable areas. *J. Soil Cons. N.S.W. 19*, pp. 49-58.

Oberlander, Th. 1965. The Zagros streams. The new interpretation of transverse drainage in the orogenic zone. *Syracuse Geographical Series No. 1.* Syracuse University Press. Syracuse, N.Y., p. 168.

Phillips, J.R.H. 1957. Level-sill bank outlets. J. Soil Cons. N.S.W. 13(2), p. 15.

Quilty, J.A. 1972a. Soil conservation structures for marginal arable areas - Gap absorption and gap spreader banks. *J. Soil Cons. N.S.W. 28*, pp. 116-130.

Quilty, J.A. 1972b. Soil conservation structures for marginal arable areas - Diversion spreader banks and tank drains. *J. Soil Cons. N.S.W. 28*, pp. 157-168.

Soil Survey Staff. 1951. *Soil survey manual.* USDA Agric. Handbook No. 18. USG PO, Washington, D.C. p. 503.

Soil Survey Staff. 1975. *Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys.* USDA Agric. Handbook No. 436. USG., Washington D.C., p. 754.

Tolba, M.K. 1987. Ten years after UNCOD. Land Use Policy 4, pp. 363-370.

Wilkinson, J.C. 1978. Islamic Water Law with special reference to oasis settlement. J. Arid Environ. 1, pp. 87-96.

Wulff, H.E. 1968. The qanats of Iran. Sci. Am. 218*(4)*, pp: 94-105.

Footnotes

(1) The closest meteorological station to the Gareh Bygone Plain is located at Fasa Airport, 50 km to the north-west of the newly established Gareh Bygone Experiment Station; the closest rain-gauging station is located at Bukhan, Baba Arab, 20 km to the west of the Gareh Bygone Experiment Station.

(2) The Gareh Bygone Plain is part of the Fasa Basin with a total area of 4,532 km^2.

(3) Reported deaths and financial damage due to the deluge are 424 people and 120 billion rials (70 rials = 1 US dollar), respectively).

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Kenya Pilot Study to Evaluate FAO/UNEP Provisional Methodology for Assessment and Mapping of Desertification

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Introduction

The purpose of the Kenya Pilot Study was to evaluate the FAO/UNEP Provisional Methodology for Assessment and Mapping of Desertification, and to recommend an effective, simple methodology for desertification assessment within Kenya.

The FAO/UNEP Provisional Methodology (1984) proposes seven processes for consideration in desertification assessment: degradation of vegetation, water erosion, wind erosion, salinization, reduction of organic content, soil crusting and compaction, and accumulation of toxic substances. Of these, the first four were felt to be most determinative of desertification. In addition four aspects of desertification were proposed: status, rate, risk and hazard. A variety of criteria were suggested for the evaluation of desertification processes according to the proposed aspects.

The Provisional Methodology was field tested and evaluations were carried out at the Third Expert Consultation in 1984. While the provisional methodology was found to provide a useful context for desertification assessment, a variety of observations were made. Among these were:

- Data is frequently lacking.
- Mapping of some desertification processes can be difficult particularly for broad regional assessment.
- Some evaluations require a considerable element of personal judgement.
- Desertification assessment models, although useful, are limited in their application due to data availability.
- Among the broad range of criteria suggested for desertification assessment, some subset is generally most useful.
- Some confusion exists as to definitions used in evaluations.

In late 1985, a pilot project for the assessment of the FAO/UNEP Methodology within Kenya was proposed and, in 1987, a memorandum of understanding between the Government of Kenya and UNEP for the implementation of that study was signed. Study areas within Baringo and Marsabit Districts were identified and a review of existing data for these areas was conducted. A preliminary assessment based on a selected subset of desertification criteria was performed for the Marsabit study area (Bake, 1988). The results of this initial assessment suggested that computer assisted evaluation of desertification could be very useful. However in reviewing this study, and in light of the conclusions found in the evaluation of the Provisional Methodology, several recommendations can be made:

- Models can be useful to assist in desertification assessment.
- Models can be developed from FAO/UNEP Methodology.
- Any modeling output requires verification.
- Ground survey and remote sensing can be important sources of data.
- An evaluation of data and methodologies necessary to allow verification of desertification assessment modeling is required.
- The human implications should be incorporated into desertification assessment in terms of management and socio/economic context.
- Computer implementation of desertification assessment can be effective; however procedures should be well defined.

This study within the Baringo Study Area was designed to address these concerns.

Study Approach

For the purposes of this study, desertification was considered as a form of land degradation found in arid, semi-arid and sub-humid environments. Consequently the diminution of biological productivity, particularly with regard to human use, was of central interest.

Simple Models

Desertification assessment can be viewed as assessment of a problem of landscape ecology, and therefore as assessment of holistic processes involving physical, biological, climatic and human influences that alter landscape patterns (Naveh, 1989). Although such processes are very complex, it was felt that simple models could be constructed that approximate the processes of interest. In addition, it was felt that only simple models could be practically applied and be broadly applicable.

In this study, factors were identified as particular data elements that describe some aspect of the landscape. Indicators were considered as something that provides information about the condition being investigated (desertification). Although factors can sometimes be used directly as an indicator, they can also be integrated through processes to produce an indicator. The models developed in this study were attempts to approximate such processes. The FAO/UNEP Methodology served as a starting point for the definition of indicators. In addition, an effort was made to consider indicators that were relevant to management intervention.

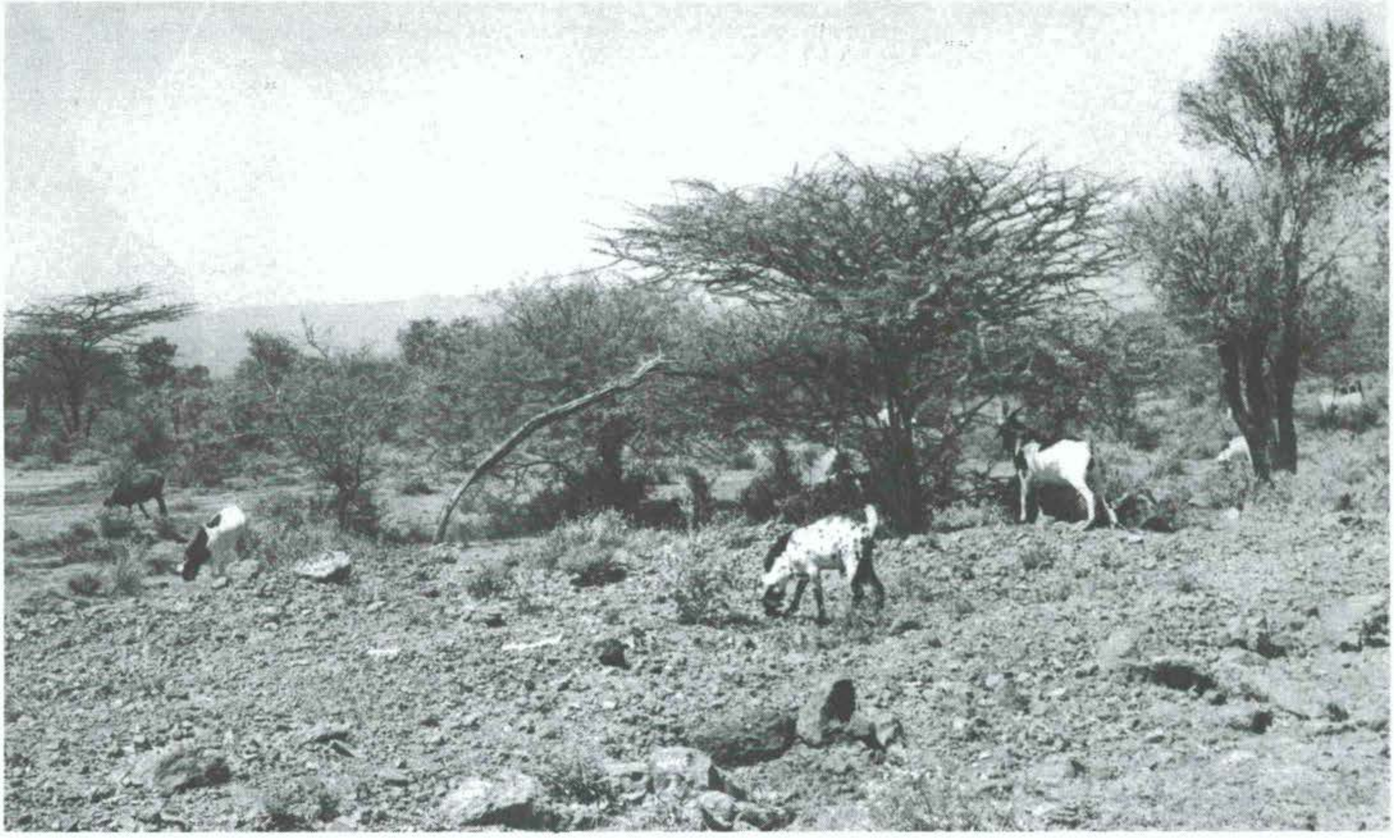
Models can serve as a tool to facilitate an integrated assessment of resources and human use. Resource demand models can be developed that allow insight into the impacts of human use of resources and the implications of management alternatives.

The models presented in this study are intended to be illustrative of a general approach to computer-aided assessment of desertification. Many additional models could be formulated to expand and refine evaluations. Central to this approach was the development of methods to allow iterative refinement and verification of model output.

Iterative Refinement

In developing models it was necessary to generate criteria against which the results of the modeling could be evaluated. It was assumed that many of the desertification indicators were related as each was describing another aspect of the same overall phenomenon. For example, a desirable species indicator determined from ground observations of plant species occurrence should be correlated with a vegetation degradation indicator calculated from actual and predicted biomass. Similarly vegetation degradation might be reflected in soil erosion mapping. Such phenomenon can be measured, modeled, mapped and compared.

It is recognized that such relationships are not necessarily continuous, particularly in extreme cases. Severe soil erosion areas may no longer be areas of high human/livestock use. In addition, such areas might have different vegetation communities producing discontinuity in a vegetation degradation or desirable species indicator. Also when comparing modeled indicators, sufficient bias due to similarity of factors might arbitrarily produce



The main land use within the Baringo study area is livestock and limited dryland agriculture correlation. However careful comparison of indicators can prove extremely useful.

Training Areas

Within a large study area, small training areas can be defined that are representative of the diversity of the larger area. Such areas can be used for more detailed data gathering and provide a basis for model development. Derived models can then be applied over the study area. Similarly verification areas can be identified to validate model performance and facilitate required modifications.

The Baringo Study Area identified in this study would be typical of such a training area. The models developed during this study could be applied to the general region and be further evaluated using verification areas.

GIS Environment

A computer geographic information system (GIS) can be especially useful in desertification assessment. Desertification is a spatial phenomenon and the GIS is specifically designed for handling spatial data. The analysis tools of a GIS provide a capability for the evaluation of spatial correlation, as well as process oriented modeling. In particular, where spatial relationships such as proximity to population centers, watering points etc. are required, the GIS provides invaluable analytic resources.

Use of a GIS stimulates a view toward the overall integration of data, and consequently encourages the establishing of a systematic database. Beyond the immediate need of assessment, such a database can provide important baseline data for future work such as the determination of desertification rate or the evaluation of mitigation efforts.

The cartographic production capabilities of a GIS are attractive since frequently simple maps and graphics can be more effective in communication than an assemblage of tables and text.

Hierarchical Assessment

The approach adopted in this study stresses a hierarchical view toward desertification assessment. Hierarchical systems are composed of components that operate at different spatial/ temporal scales (Urban *et al*, 1987). Implied in such an approach is that different modes of assessment are relevant and different questions can be answered at different levels within the hierarchy. Three levels of hierarchy for desertification assessment might be considered:

- A local level assessment implies specific detailed data and analysis that should be expected to guide specific management intervention. Such an assessment must carefully consider the socio/economic, political as well as ecological context.
- In a broader geographical analysis, less detailed data can be collected. Consequently a more general assessment of desertification is expected. However models can be developed to help extend an initial assessment over broad areas. Modeled indicators may be suitable provided the results can be evaluated for accuracy. Models can be developed that consider general socio/ economic data to provide general management recommendations.
- At a more general level of desertification assessment such as continental or global evaluations, much data may no longer be available and consequently certain indicators may no longer be practical. General policy oriented descriptions of desertification however can be generated.

The analysis described in this study is appropriate to Level 2 type desertification assessment.

Desertification Status and Hazard

Status can be considered to be the state or condition of an indicator (FAO/UNEP, 1984). In this study hazard was considered to be an integration of the status of various indicators, to provide a cumulative assessment of desertification.

Baringo Study Area

The study area lies between 0°15'-1° N and 35°30'-36°30' E. It is located between the Laikipia escarpment to the East and the Tugen Hills to the West. Topographic elevations vary from 900 m on the Njemps flats to 2,000 m in the Puka, Tangulbei and Pokot highlands. The size of the study area is approximately 1,500 km^2.

The Perkerra and Molo Rivers are permanent rivers which drain into Lake Baringo via the Njemps Flats. Impoundment of these rivers in the highlands provides water for irrigated agriculture.

The average rainfall within the project area is 600 mm; however rainfall increases with increasing elevation. Rainfall of up to 1,900 mm can be found in the surrounding mountains. Rains occur in the periods April-May and July-August. Rainfall variability is high.

The main land use within the study area is livestock and limited dryland agriculture. Some irrigated agriculture is also found.

Data Collection

A wide variety of data was collected (Table 1). Detailed data was required to provide a basis for evaluating more general cost effective data gathering techniques and to provide a basis for model verification. Such detailed data, particularly the socio/economic data, is necessary for local desertification assessment (level 1), while the more general data is relevant to a level 2 assessment. Data collection methods included field sampling, laboratory analysis, use of satellite imagery and systematic reconnaissance flights (SRF). After data collection, the data required for GIS modeling were automated through digitizing and tabular data entry (Table 2).

Model Development and Results

On the basis of an initial review of the FAO/UNEP Methodology, the Marsabit Case Study and available data, five desertification indicators were selected for investigation. These were water erosion, wind erosion, vegetation degradation, range utilization, and human settlement. Models for the first four indicators were developed and evaluated on the basis of relevant field data and through correlation with related indicators. The human settlement indicator was taken directly from the field data. Desertification hazard was calculated through the integration of the individual indicators and was evaluated in conjunction with each of the indicators and the available verification data.

The water erosion model is based on a modification of the USLE (Wischmeier and Smith, 1978). Because of the general nature of data used, this model was used to predict areas of surface deformation (Table 3) rather than actual soil loss (ton/hectare/year). Vegetation degradation was calculated using field measurements of actual herbaceous biomass and potential herbaceous biomass production calculated using Rain Use Efficiency (Le Houerou, 1984; Pratt and Gwynne, 1977). Range utilization was determined by subtracting predicted annual herbaceous biomass consumption from the measured available herbaceous biomass. Herbaceous biomass consumption was calculated by summing the herbaceous biomass requirements of the livestock species in the study area (Pratt and Gwynne, 1977; Lusigi, 1984). Livestock populations were estimated using systematic reconnaissance flight census methods (Norton-Griffiths, 1978). Wind erosion potential was modeled by multiplying wind erosion potential by the measured percent bare ground.

Using the spatial correlation capabilities of the GIS, the model results were compared with relevant field data and other model output. The modeled water erosion results were compared with actual field mapped water erosion features. Similarly vegetation degradation was evaluated with desirable/undesirable species data (Table 4). Through such evaluations, model performance could be refined and validated.

Soil water surface deformation classes were mapped and used as ground verification data. Data on the number of desirable and undesirable species for livestock grazing were used to calculate a desirable/undesirable species ratio that was also used for verification purposes.

In general the modeled water erosion (MWE) performance conforms well to the actual water erosion (AWE) classes. Also the vegetation degradation model (VDS) appears to perform well in comparison with the desirable/undesirable species ratio (DUS). Correlation of the range utilization (RUM) with AWE and DUS is not as strong, however a general trend of increasing RUM and increasing DUS and AWE is noted. Actual wind erosion (ADE) and modeled wind erosion (MDE) show good correlation. Table 5 describes the relative contribution of

I) PHYSICAL

Climate
a. Rainfall
b. Temperature
c. Windspeed, Direction, Frequency
d. Rainfall erosivity (calculated)
e. Sunlight duration
f. Potential Evapotranspiration (calculated)
g. Vorticity
h. Sandstorm/duststorm frequency

Soils
a. Surface rockiness
b. Texture
c. Organic Matter
d. Structure
e. Permeability
f. Erodibility
g. Alkalinity
h. Soil type units
i. Water erosion
j. Wind erosion

Surface Terrain
a. Elevation
b. Slope

II) BIOLOGICAL

Vegetation
a. Herbaceous canopy cover
b. Herbaceous biomass
c. Percent bare ground
d. Species composition (desirable/undesirable species)
e. Vegetation type units

Livestock
a. Distribution
b. Abundance

III) SOCIO/ECONOMIC

Human Population
a. Density of permanent structures
b. Transhumance
c. Environmental perception

Table 1: *Data Collected for Desertification Assessment*

I) PHYSICAL

Climate
a. Rainfall and Erosivity Map
b. Wind erosion potential

Soils
a. Soil Units Map (soil type, erodibility, coarse fragments)
b. Water Erosion Map
c. Wind Erosion Map

Surface Terrain
a. Terrain Model (elevation, slope, aspect)

II) BIOLOGICAL

Vegetation
a. Vegetation Unit Map (vegetation type, herbaceous biomass, herbaceous canopy, desirable herbaceous species, undesirable herbaceous species, percent bare ground)
b. Livestock Density Map

III) SOCIO/ECONOMIC

Human Population
a. Density of Permanent Structures Map

Table 2: *Required Computerized Desertification Data Sets*

Erosion Category	Description
None	No visible erosional features
Slight	Sheet erosion
Moderate	Rill erosion
Severe	Gully erosion
Very severe	Badlands

Table 3: *Water Erosion Mapping Categories*

Water Erosion Potential =	Soil Erodibility * Slope * % Bare Ground * % Surface Coarse Fragments
Vegetation Degradation =	Potential Herbaceous Biomass Production - Actual Herbaceous Biomroduction
Range =	Actual Herbaceous Biomass Production - Predicted Herbaceous Biomass Consumption
Wind Erosion Potential =	Wind Erosivity * % Bare Ground
Human Settlement =	Density of Permanent Structures
Potential Desertification Hazard =	Potential Water Erosion + Vegetation Degradation + Potential Range Utilization + Potential Wind Erosion + Human Settlement

Table 4: *GIS Models*

individual desertification indicators to the overall desertification hazard summation. The general trend in the individual indicators is maintained in the desertification hazard summation.

From these evaluations 979 km^2 (66%) of the area was found to have no significant level of desertification; 275 km^2 (18%) was found to be slightly desertified; 74 km^2 (5%) was found to be moderately desertified and 162 km^2 (11%) was found to be severely desertified.

The Baringo Study area served as a training area for model development. Detailed data was collected to provide a basis for the model development. These derived models can now be applied over a broader study area. Similarly verification areas can be identified to validate model performance and facilitate any required modifications.

Field Data Collection Methods Evaluation

By emphasizing a hierarchical approach to desertification assessment, this study hopes to underline the need for different data at different levels of assessment. The type and costs required for each level of assessment should be appropriate to the analysis required. Local assessment, calls for intensive field investigations. Level 2 assessment, as illustrated in this study, requires data that can be gathered cost effectively using appropriate techniques. Level 3 assessment can be categorized as being limited to available data and is intended to provide a broad overview of the problem. It is the purpose of this section to review data collection procedures appropriate to level 2 analysis as used in this study.

Physical Data

Topographic Data

Topographic data is required for water erosion modeling. There is a tendency to overemphasize the need for detail in topographic data when using USLE since it was developed for precise application to individual drainage systems (Wishmeier and Smith, 1978). It is unrealistic to attempt to provide micro-relief data over a broad area. For broad qualitative description of soil deformation classes such as used in this study, general topographic data available on 1:100,000 and 1:250,000 maps is quite sufficient. Interpolation of this data to eliminate discrete surface elements which are artifacts of digitizing is required. A simple low pass filter can provide satisfactory interpolation.

Soils Data

An accurate soils map is required for level 2 assessment. Associated with each soil type should be soil erodibility and surface rockiness. Erodibility requires detailed evaluation of soil organic matter, texture, structure and permeability that can only be acquired through field survey and laboratory analysis. Generally such data is available if reconnaissance soil surveys have been performed. Surface rockiness data is less likely to be found; however it can easily be determined through field investigations. It was found that a trained observer can visually estimate surface rockiness classes much faster than by using quadrat sampling and with suitable accuracy.

Mapping of soil water erosion can be done effectively through manual interpretation of SPOT imagery in conjunction with field investigation for the five deformation classes. It is not recommended that digital classification of soil erosion be used since simple digital classification of spectral data is insufficient to allow reliable classification. Significant ancillary data and a highly skilled analyst is required. An individual familiar with an area and photo-interpretation can generally more accurately classify soil erosion features through manual interpretation and field visits.

General wind erosion deposition areas can be mapped. They are recognized in the field as an area of hummocks and sand dunes. Deflation areas cannot be adequately recognized in the field; however they can be inferred by evaluating wind erosion potential and land cover.

Climate Data

Estimation of rainfall erosivity using Fourier index appears appropriate. A linear regression between rainfall and erosivity can be calculated and, provided rainfall isohyets exist for the study area, an erosivity map can be generated.

Wind erosion requires the availability of windspeed, rainfall, and the calculation of PET. While the Penman equation is generally felt to be more accurate, Thornthwite is sufficient for general use.

Table 5a: Actual Water Erosion vs Modeled Water Erosion

		Model Water Erosion		
		0	1	2
	2	.950	.034	.015
Actual	3	.136	.179	.685
Water	4	.038	.563	.399
Erosion	5	.085	.104	.812

Table 5b: Actual Water Erosion vs Desirable Species Status

		Desirable Species Status			
		0	1	2	3
	2	.621	.300	.065	.014
Actual	3	.198	.016	.358	.427
Water	4	.010	.022	.969	.000
Erosion	5	.201	.105	.356	.338

Table 5c: Desirable Species Status vs Actual Water Erosion

		Actual Water Erosion			
		2	3	4	5
	0	.956	.016	.000	.027
Desirable	1	.965	.003	.002	.030
Species	2	.447	.127	.212	.214
Status	3	.209	.338	.000	.453

Table 5d: Desirable Species Indicator vs Vegetation Degradation Status

		Vegetation Degradation Status		
		0	1	2
	0	.810	.147	.043
Desirable	1	.516	.434	.049
Species	2	.140	.241	.619
Indicator	3	.047	.052	.901

Table 5e: Actual Water Erosion vs Vegetation Degradation Status

		Vegetation Degradation Status		
		0	1	2
	2	.666	.274	.060
Actual	3	.027	.234	.739
Water	4	.010	.023	.966
Erosion	5	.193	.009	.789

Table 5f: Actual Water Erosion vs Range Utilization Model Status

		Range Utilisation Model		
		0	1	2
	2	.477	.197	.326
Actual	3	.139	.334	.527
Water	4	.004	.437	.559
Erosion	5	.174	.211	.615

Table 5g: Desirable Species Indicator vs Range Utilization Model Status

		Range Utilisation Model		
		0	1	2
	0	.654	.128	.218
Desirable	1	.307	.298	.395
Species	2	.151	.177	.671
Indicator	3	.064	.426	.570

Table 5h: Actual Wind Erosion vs Modeled Wind Erosion

		Modeled Wind Erosion	
		0	1
Actual Wind	0	.100	.000
Erosion	1	.270	.730

Biological Data

Vegetation Data

Mapping of vegetation types can be done using manual interpretation of SPOT imagery and limited field work. Digital processing is not recommended. During field investigations in the training areas, measurement of herbaceous primary production should be made through clipping. Percentage cover of herbaceous, shrub and tree species can be accurately estimated by a trained technician using releve methods rather than quadrat or line transect sampling. Within training areas, the number of desirable and undesirable species should be determined. From this a desirable/undesirable ratio can be calculated.

Livestock Data

The systematic reconnaissance flight (SRF) provides an effective low cost method of estimating livestock populations within broad areas. The exact parameters of the SRF must be carefully considered relative to particular survey constraints and requirements.

Socio/economic Data

Data on permanent structures can be collected by SRF. More detailed data on populations is relevant to level 1 type desertification assessment.

Conclusions

Hierarchical assessment underlines the need for careful definition of data availability and expected results. It recognizes that certain decisions are appropriate within particular levels of a hierarchy. Three levels of hierarchy are suggested for desertification assessment:

Level 1

This most detailed level assumes specific data and analysis intended to guide management intervention. In particular, such an evaluation assumes consideration of the socio/economic and political context.

Level 2

Most appropriate for general planning. Specific data is needed and limited field work may be required. Verifiable models are useful for extrapolation of the analysis from training areas throughout the study area.

Level 3
General policy formulation and problem definition based on available data.

For Level 2 type assessment, systematic reconnaissance flight sampling, manual interpretation of satellite imagery, and efficient field assessment are effective data sources. Such data can be gathered for representative training and verification areas within a study area.

Simple models can provide a useful context for desertification assessment provided model results can be verified. Iterative methods using training areas allow refinement and verification of models. Models can be evaluated through spatial correlation analysis and inspection of results in map form. The FAO/UNEP Methodology provides a useful basis for model development.

The models presented in this study are intended to illustrate a general approach to desertification assessment. Many additional models could be developed or different model parameters might be more appropriate in different circumstances.

GIS technology facilitates model development. The analysis tools of a GIS provide a capability for the evaluation of spatial correlation, process oriented modeling and map production. It should be emphasized that the GIS and its derivative products can only be as good as the data used. Careful attention to data quality and database development is crucial to GIS implementation. Beyond the immediate needs of desertification assessment, a well implemented database can be an invaluable resource for future evaluations. Given simple process oriented models, clear definition of data types, methods of data collection and a methodology for iterative refinement and verification of models, GIS methods can be expected to prove broadly useful in desertification assessment.

Resource demand or utilisation models can help integrate socio/economic and natural resource data. With such models, simple management strategies can be explored. Such models provide another view on desertification status, beyond strict resource oriented evaluations. Indeed resource oriented assessments dominate the literature. For over forty years the environmental condition of the Baringo Study Area has been lamented (Little, 1989). It has been described as "the agricultural slums of Kenya" (Maher, 1937) and "an ecological emergency area" (Republic of Kenya, 1974). However despite such dire evaluations the resident populations continue to survive, evolve and grow. Desertification assessment needs to address itself not only to the cataloguing of resource decline but to begin to confront the issues of adaptation and social change with which human populations confront their environment. Integration of resource oriented and socio/economic analysis should be encouraged. Resource demand models are one such approach.

To a certain degree, desertification is associated with human activity (Spooner and Mann, 1984). Indeed it could be argued that one force behind desertification may be the social transformations produced by development. What is particularly relevant to desertification assessment is how change causes deviation from normal mechanisms of resource utilisation and the resulting impacts such changes have on the environment. Resource demand models can facilitate evaluation of management alternatives and development intervention.

Acknowledgment

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References

Bake, G., 1988. *Geographic Information Systems: An Application*, an appraisal of the FAO/UNEP Methodology for the Assessment and Mapping of Desertification, S.W. Marsabit District, Northern Kenya, unpublished.

Le Houerou, H.N., 1984. *Rain Use Efficiency: a unifying concept in arid land ecology* in *Journal of Arid Environments 7*, pp. 213-247.

Little, P.D., 1985. *Absentee Herd Owners and Part-Time Pastoralists: The Political Economy of Resource use in Northern Kenya* in *Human Ecology, Vol. 13, No. 2,* pp. 131-151.

Lusigi, Walter J., 1984. *Integrated Resource Assessment*, UNESCO-FRG-MAB Integrated Project in Arid Lands, IPAL Technical Reports.

Norton-Griffiths, M., 1979. *Counting Animals, Handbook 1*, second edition, African Wildlife Foundation, Nairobi, Kenya.

Pratt, D.J. and M.D. Gwynne, 1977. *Rangeland Management and Ecology in East Africa*, Hodder and Stoughton, London, p. 310.

Republic of Kenya, 1974. *National Development Plan 1974-1978*, Government Printer, Nairobi.

Spooner, R. and H.S. Mann, 1982. *Desertification and Development. Dryland Ecology in a Social Perspective,* Academic Press, New York.

Urban, D.L., R.V. O'Neill and H.H. Shugart Jr., 1987. *Landscape Ecology. A hierarchical perspective can help scientists understand spatial patterns* in *Bioscience Vol. 37*, No. 2, pp. 131-151.

Wischmeier, W.H. and D.D. Smith, 1978. *Predicting Rainfall Erosion Losses* in *Agricultural Handbook 537,* United States Department of Agriculture.

By the Bootstraps - A Contribution to the Problem of Enhanced Food Production in the Sudano-Sahel

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Mr Orev worked in Niger in the mid 1960s and has continued to follow with interest what has been published on the region. Here he proposes a means for improving food production in the Sudano-Sahelian region, based on Australian ley-farming methods.

Europe

In the 12th and 13th centuries there was a relatively rapid population growth in western Europe which led to pressure on existing land resources. The need to increase yields to support the growing number of people led to an important innovation: the three-field system of farming. This left one third of a village's lands in fallow after two crops of food grains. The fallow field was used for grazing and the manure, together with the nitrogen added by the electrical discharges from the atmosphere, restored the fertility for two more crops. (A modern example of this is in the Negev where in a 250 mm belt, after a fallow, even in a drought, the level of nitrates absorbed from the atmosphere is enough for a 2 tonnes/ha yield of grains, without artificial fertilizer, provided that other cultural practices are up to standard.) Legumes were not an important part of the system, except for broadbeans which had already been introduced by the Romans.

Another important innovation was the invention of the mouldboard plough which enabled the turning over of permanent grassland.

The population increase was set back in the 14th century by the Black Death which reduced the population by one third or more. The 3-field system served its purpose well into the 16th century. Then farming was improved still further by the introduction of white clover and turnips in the Low Countries. However, the Agricultural Revolution really took off in the 18th century in England when all these developments were incorporated into the 4-course Norfolk rotation: grain/grain/root-crops/clover.

This rotation raised fertility and yields, and maintained them at a high level for more than 100 years; the increased fodder production added more manure, did away with the fallow, and made possible the improvement of animal breeds.

Only in the late 19th century were chemical fertilizers introduced. It is not clear whether this originated from the farmers' needs or from the chemical industry looking for outlets for their byproducts - such as basic slag as a phosphatic fertilizer, increased ammonia production from the Haber process in Germany, etc. The result was a further increase in yields, well into the 20th century.

Africa

African agriculture developed in conditions of abundant available land. When a field became exhausted by continuous cropping a new piece of bush or forest was cleared and cropped to exhaustion, a process known as "shifting cultivation". A bush or forest fallow of 15-20 years was enough to restore the land's fertility. There was no need to invent anything new.

This began to change in the 19th century when hygiene and modern medicine were introduced and brought about a rapid population increase. By the mid-20th century many areas did not possess land reserves for a fallow of 15-20 years; the fallows became shorter, fertility could not be restored and consequently decreased. Cultivation of new lands soon reduced their fertility too, and fertilizers could not be used by the farmers because they could not pay for them. Traditional agriculture is now in a fix since it is no longer capable of supplying the people's food needs.

In the wet tropics there are hardly any droughts. The colonial powers introduced some scientific agriculture for their own needs which also helped traditional farming. However, in the Sudan-Sahelian zone the recurrence of prolonged and severe droughts disrupted everything and loss of fertility combined with the lack of rainfall to destroy the food base.

The farmers are not blind to this and talk of the land being "tired" or even "dead". There is an urgent need for an agricultural revolution, to tackle the problem at the base - i.e. to improve soil fertility and consequently to raise the capacity of the soil to produce more and to maintain this capacity for an indefinite period.

Sustained agricultural yield in the dry tropics has been achieved by several agricultural systems. In Egypt, fertility of the soil has been maintained by the annual input of the Nile mud, but in the 19th century, when two or more crops a year began, this annual flooding was not enough and for a century now the fertility has been kept up by having one-fourth of the land in Barseem (Alexandrine clover), which produces milk and manure and adds nitrogen by itself.

In some of the dry zones of Australia there developed a system of ley farming, of 4-5 years of annual medics grazed by sheep which increased the fertility of the land and allowed for 1-2 cash-crops of wheat to be grown. Only phosphatic fertilizer is used in soils which were not inherently fertile. In tropical northern areas another legume, *Stylosanthes*, is used to add protein to the grazing.

The system I propose for the Sudano-Sahel is similar to Australian ley farming: 3-5 years of grass, *Andropogon gayanus*, perhaps strengthened by *Stylosanthes*, grazed by tethered cows, which will result in considerable inputs of manure, then followed by 2-3 crops of millet and perhaps cowpeas. Rows of *Acacia albida* along field boundaries will raise the soil nutrients from deep levels to the surface.

To show that this is more than "an article of faith" I would like to quote some research which was reported as far back as 1962.

"When it is possible to practice a short fallow period (four years at least) a cover of *Cajanus cajan* or *Andropogon gayanus* seems to be more efficacious than a volunteer natural cover ... It is probable that the fertility of the soil cannot be maintained by a fallow (ley) of less than three years... It has been shown that with an appropriate organic manuring... a continuous cultivation ... can give total yields superior to those obtained by a system of alternate ley husbandry."[3]

It should be added that there is no contradiction between ley and manure because, when the ley is grazed by tethered cows, 60% of the dry matter is returned as manure *in situ*.

Other authors have written of *Andropogon gayanus*: "A good cover of *Andropogon gayanus* can establish itself even in degraded regions by rapid and simple means."[4]

From my own observations near Niamey in 1965-66 I can add that an eroded bush-infested field was cleared of bush but left with some bunches of *Andropogon gayanus*. By the end of the second rainy season following the clearing it was completely covered with *Andropogon gayanus*. In this case the *Andropogon gayanus* easily colonized bear and badly eroded patches, of the kind that Australians call "scalds" and Texans "lizard lakes".

Another author reports on the use of *Andropogon gayanus* in agriculture, saying that it was tried in Queensland and Kimberley (Australia) and found superior to *Panicum maximum*. The same author claims that the regeneration of the fertility of the soil did not usually last beyond the first sown crop.[5]

The green matter yields reported by the aforementioned authors are all from more rainy areas. The field I observed was equivalent to 1,000 metric Fodder Units (FU) per ha. A trial in Nigeria showed a DM intake of 3.3 kg/day with 50 g protein. The protein content of this ley could perhaps be improved by the introduction of a native *Stylosanthes*, and the cows could also be fed cowpea hulls, a crop widely used for human consumption (cowpeas taste similar to European garden peas).

Such a farm would operate roughly as follows:-

The farm would be laid down in fields of 15 x 330 m, equal to 0.5 ha. Alternate fields would be laid down to grass by planting bunches of *Andropogon gayanus* collected in the wild and cropped fields. This means that there will always be fields of grass to supply the seeds for the ley leg of the rotation. Thus a 6 ha farm will possess 12 fields, for flexibility of cropping.

Planted bunches of Andropogon gayanus, *near Niamey, Niger. Photo: Y. Orev*

The 3 ha of grass ley will produce 3000 FU of fodder, enough for a milk cow and calf. The manure production will be some 2 tonnes annually, all of it dropped *in situ*. At all times there will be 3 ha of grass and 3 ha in grain.

A yield expected from a freshly cleared bush fallow is about 1 ton/ha. 1 ha of freshly cleared grass ley should produce the same, the next year say 750 kg, and the third year around 500 kg. The average yield for the rotation will be some 750 kg/ha, equivalent to the approximate annual consumption of two adults. The farm should yield enough for the annual consumption of six adults, therefore with an average family of two adults and three children, and considering the need for keeping a reserve of grain, there will still be some surplus to sell.

The millet straw and some of the cowpea hulls can be used to keep a donkey which can help with the weeding and sowing. A donkey with a simple chisel plough can do the weeding of 2-3 men, and quicker weeding means a better yield. There is no need to invent a new tool - such chisel ploughs exist in many countries and it may even be possible to adapt the traditional tools to donkey traction. Donkeys have already been successfully introduced to Gambia.[6]

A further refinement should be the planting of *Acacia albida*[7,8] at 15 m intervals along the boundaries of the fields. They will lift nutrients to the surface and produce leguminous pods for the animals. *Acacia albida* do not interfere with cropping because they shed their leaves before the rains and the pods are produced towards the end of the dry season and are consumed by the animals in the field.

It is also possible to consider using the goat as a traction animal. Goats have been widely used for this purpose in the past and there are millions of goats in the Sudano-Sahel. The bucks in particular are big and two adult bucks can almost do the work of one donkey.

To increase the food production of Sudano-Sahel, nothing short of a revolution will do. The revolution must result in higher fertility of the soil and thereby higher production potential, and it must be done in a way which will persuade the local farmer that the land is no longer tired but is alive.

On the face of it, given the present state of knowledge, it seems possible to raise the average yield of millet from 350-400 kg/ha[2] to 700-750 kg/ha, in a manner which will not demand of the local farmer to do much beyond what he already knows. The present cultivated area of Niger is 5.5 million ha (55,000 km^2) out of the 300,000 km^2 of "useful country" (the "pays utile" has between 800 and 350 mm rainfall) so it would appear that there exists great potential for further expansion.

References

1. **McIntire, J. and Fussell, L.K.,** *On-Farm Experiments With Millet in Niger: Crop Establishment Yield Loss Factors and Economic analysis* in *Expl. Agric.* (1989), vol. 25, pp. 217-233.
2. **Painter, Thomas M.,** *Bringing Land Back* In: *Changing Strategies to Improve Agricultural Production in the West African Sahel* in *Lands at Risk in the Third World: Local Level Perspectives*, Westview Press/ Boulder and London.
3. **Watts, K.A. and Goldsworthy, P.R.,** *Soil Fertility in the Middle Belt of Nigeria* in *Emp. Jl. of Expl. Agricu.* 32(128), October 1962, pp. 290-302.
4. **Ramsay, J.M. and Rose Innes, R.,** *Some Quantitative Observations on the Effects of Fire on the Guinea Savanna Vegetation of N. Ghana over a period of 11 years* in *African soils*, 8 (i), January and April 1963, pp. 41-85 and 87-120.
5. **Bowden, B.N.,** *Studies on Andropogon gayanus* (Kunt.)I - *The use of Andropogon gayanus in Agriculture* in *The Emp. Jl of Expl. Agric.*, July 1963, vol. XXXI, No. 123, pp. 267-273.
6. **Orev, Y. and Abu-Rabia, A.,** *Donkeys as Draught Animals* in *The Professional Handbook of the Donkey*, second edition, The Donkey Sanctuary 1989.
7. ***The Apple Ring*** in *Agroforestry Today*, April-June 1989.
8. **Rocheleau, D., Weber F. and Field-Juma A.,1988.** *Agroforestry in Dryland Africa*, International Council for Research in Agroforestry, PO Box 30677, Nairobi, Kenya.

Two adult goats could almost do the work of one donkey and could be put to productive use as traction animals throughout the Sudano-Sahel region

Environmental Degradation in a Semi-Arid Range Land in Northern Sudan

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Abstract

A typical range-land of Acacia tortilis-Mearua crassifolia *grassland is surveyed projecting the changes which have taken place over a number of years. Inhabited by nomadic and semi-nomadic tribes, the area is one of the traditional animal rearing grounds in Sudan.*

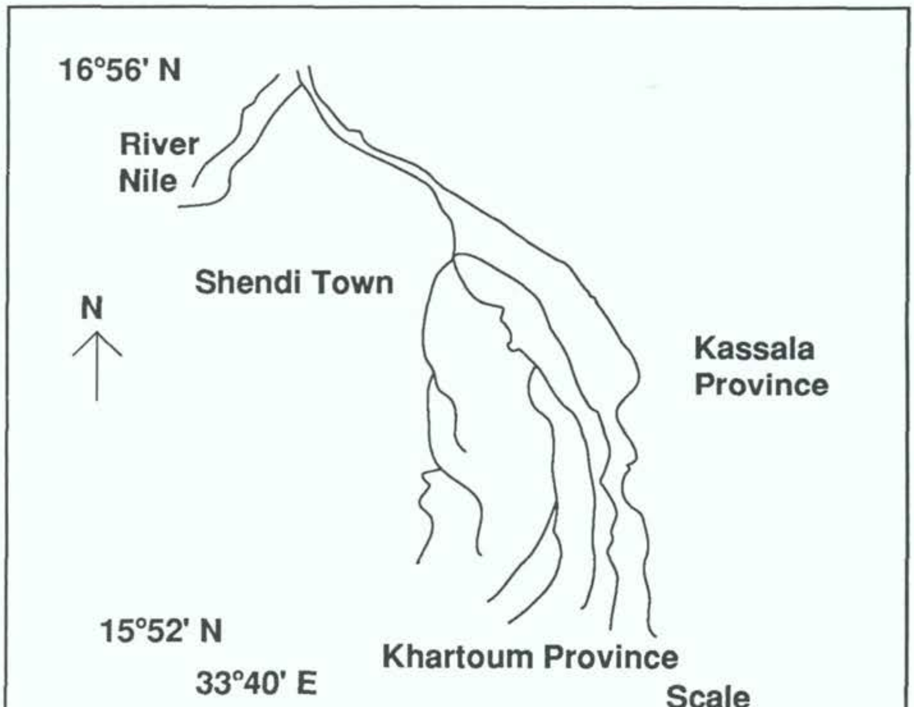
Vegetation was studied by the Parker loop method and trees were sampled in larger random samples. Soil profiles were dug and sand movement was monitored by collecting sand blown by wind on canvas sheets. Other data were obtained by questionnaire and from records.

Tree and ground vegetation species were recorded together with the frequency of palatable and unpalatable species.

The study showed a slight increase in the frequency of unpalatable species in the semi-nomadic sites because of heavy selective grazing. The dominant palatable and unpalatable species were listed. The forage production was higher inside the Wadi (depression) than outside. There was a drastic reduction in livestock due to the lack of adequate grazing land which resulted in animals dying or being sold away. Areas cultivated decreased sharply until 1985 when they increased again with increase in amounts of rainfall. However, productivity was much lower than in the past due to soil impoverishment as a result of degraded vegetation cover which is aggravated by tree cutting for fuel, especially in semi-nomadic areas.

It is evident that serious environmental degradation is taking place as indicated by low tree stocking, increasing rock and bare ground and active sand movement - early symptoms of desertification. This can be attributed to aridity and land misuse which may be the main cause of environmental degradation in such lands.

It is recommended that permanent settlements be discouraged in these range-lands which should be properly managed as natural pasture with minimum cultivation and adequate protection of trees and other vegetation cover.



Map 1: *Wadi Elhawad lies in North Butana between Khartoum and Shendi towns*

Introduction

Sudan is among the countries most seriously affected by desertification, especially during the drought period of 1981-84 which affected most areas in northern Sudan. It resulted in destruction of people's livelihood and land resources. Mass migration for food and shelter accentuated the degradation process. International organisations came to the rescue of the country which embarked on quick relief of the areas affected and study of the environmental degradation.

This paper deals with a typical area which is susceptible to desertification by monitoring the vegetation change taking place, projecting environmental degradation and suggesting ways of halting or at least slowing the process.

Locality and General Description of the Study Area

Wadi Elhawad lies in North Butana between Khartoum and Shendi towns at 15°52'-16°52' N, 33°40'-34°15' E (see Map l). It is the main *Wadi* (depression) in Northern Butana.

Ecologically, the area lies in *Acacia tortilis-Maerua crassifolia* grassland, according to Harrison and Jackson (1958). The climate is semi-arid with high temperatures (22.2-35°C) and 248 mm rainfall (daily during July-September) with a maximum relative humidity of 40% in August.

Geologically the area is basement complex of Cambrian era, according to Osman *et al* (1963) but the top soil deposited in the Quaternary consists of gravel, silt and clay. Topography is generally flat with gentle undulations, according to Abdel Ati (1984).

The area is inhabited by nomadic and semi-nomadic tribes. The nomads move along the region after grazing. The semi-nomads are settled in permanent villages. Most of these villages were settled after 1960 when water wells were dug by the government.

Methodology

Vegetation was studied by the Parker loop method (1959) using 1m^2 loops. Tree cover was recorded in larger samples of 20 x 20 m. Soil profiles were dug in five locations across the depression. Sand movement was monitored by collecting sand blown by the wind on to 50 x 50 cm sheets and weighing the quantities collected. Other data were obtained by questionnaire (answered by 33% of the population) and from records. The samples were taken in such a way as to cover nomadic and semi-nomadic sites both inside and outside the depression. The field work was completed over a year (1985/86).

Results

Table 1 gives tree and shrub cover in *Wadi* Elhawad. Trees averaged 6.5 m in height and 0.74 cm in girth at breast height. Shrubs were an average of 1.2 m in height. Tree species consisted of *Acacia tortilis*, *Maerua crassifolia*, *Capparis decidua*, *Acacia mellifera*, *Acacia ehrenbergiana*, *Acacia nilotica*, *Zizyphus spinachristi*, *Balanites aegyptiaca*, *Acacia albida* and *Calatropis procera*. *Acacia seyal* has disappeared while the frequency of other species has decreased, e.g. *Acacia albida* and *Acacia nilotica*. The shrub *Calatropis procera* has increased indicating site degradation. Around settlements and water points, trees have diminished. This explains the low frequency of trees in the semi-nomadic areas. The overall average frequency is very low.

The following grass and herb species were encountered: *Aristida mutabilis*, *Aristida funiculata*, *Brachiaria lecrisoides*, *Cenchrus ciliaris*, *Cenchrus turgidum*, *Digera alternifolia*, *Ipomea cardiospila*, *Euphorbia aegyptiaca*, *Echinochloa colonum*, *Sorghum spp.*, *Solanum dubium*, *Citrullus colocynthis*, *Chrozophora plicata*, *Tribulus terrestris*, *Tephorosa spp.* *Cassia senna*, *Ocimum basilicum*, *Thunbergia annua* and *Hygrophylla spinosa*. The corresponding frequencies of palatable and unpalatable species relative to other parameters are shown in Table 2.

There is a slight increase in frequency of unpalatable species in the semi-nomadic sites due to the heavy selective grazing by sedentary animals. Thus *Blepharis edulis* - once covering large areas of the Butana and cherished by camel and sheep - has been completely eliminated. Similarly *Andropogon gayanus* -consumed largely by camels - is no longer present in the area.

The dominant palatable species are: *Brachiaria lecricoides*, *Aristida spp.*, *Digera alternifolia*, *Ipomea cordofana*, *Cenchrus trilocularis* and *Euphorbia*

	Tree cover (No/ha)		Shrubs (No/ha)	
	Nomadic	Semi-nomadic	Nomadic	Semi-nomadic
Inside *Wadi*	11	4	80	12
Outside *Wadi*	8	2	10	5
Mean	10	3	45	9

Table 1: *Tree and shrub cover in* Wadi *Elhawad*
Source: Field survey 1986

%	Bare soil	Rocks	Litter	Unpalatable	Palatable
Nomadic	35	5	2	5	53
Semi-nomadic	35	4	3	8	51
Mean	35	5	2	6	52

Table 2: *Percentage frequencies of bare soil, rocks, litter, palatable and unpalatable species at* Wadi *Elhawad*
Source: Field survey 1986

aegyptiaca. *Panicum turgidum* is common in the nomadic area.

Among the unpalatable species, the following are dominant:
Citrullus colocynthis, *Cassia senna*, *Tribulus terrestris* and *Callatropis procera* which forms dense stands in the nomadic areas.

The forage production calculated for the region is as follows:-
Inside Wadi = 195 kg/ha
i.e. 19,500 kg/km^2
Outside Wadi = 141 kg/ha
i.e. 14,100 kg/km^2

The overall carrying capacity averaged five animal units per km^2 which is within the average animal units estimated. However, a lot of animals are brought in from outside the region for drinking and grazing - these are almost equal in numbers to the animals already present, hence the pressure on the range. Moreover, the animal population has seriously been reduced during the drought years as shown in Table 3.

The reduction in livestock is drastic, representing 87% between 1980 and 1985. This is attributed to lack of adequate grazing land which resulted in animals dying or being sold away by their owners. In addition, many owners migrated to better rangelands with their livestock. Mass migrations occured during the period 1980-1985 as indicated in Table 4. This exodus is reflected in the reduction of cultivated areas as given in Table 5.

After the sharp drop in 1980, cultivated areas have increased in 1985 because of a better rainy season. But yields per unit areas were much lower in 1985 than previously. In fact, yields have shown a gradual decrease from an average 1,140 kg in 1960 down to an average of 393 kg/ha in 1980 and then fell sharply to an average 117 kg/ha in 1985. This may be attributed to depletion of soil fertility in such a degraded environment coupled with low rainfalls. The low vegetation frequency shown earlier does not permit quick soil rejuvenation. The drought years of 1970 and 1980 show sharp drops in acreage compared to the wetter years of 1965, 1975 and 1985.

Cultivation is more in the semi-nomadic areas where farming is the main occupation, unlike the nomadic areas where animal rearing is the main activity; in addition, farmers from far away come during the rainy season, e.g. from the banks of the Nile. The main crops cultivated are sorghum, okra, water melons and fodder. Yields in semi-nomadic areas are higher than in the nomadic areas, probably because the semi-nomadic farmers are more attentive to their farms.

The present production is just enough to sustain the family according to 70% of the questionnaire respondents. The amount of sand blown by wind was calculated as 38 kg/ha/day for the whole area which is generally sandy soil (50-60%). The situation is aggravated by the fact that trees are still the main source of fuel wood, representing 55% of total fuel consumption as estimated by Farah (1986). Other sources of fuel are herbs, crop residue and dung. Fuel consumption is higher in semi-nomadic villages because of greater numbers of sedentary families. Therefore the distances to travel for fuel sources have increased enormously from 3 km in 1975 to 15 km in 1985 in semi-nomadic areas, while in nomadic areas, the distance is 5 km compared to 2 km in 1975.

Year	Cattle	Camel	Sheep	Goat	Total
1976:	14,902	36,226	176,509	100,465	328,102
1980:	7,738	6,208	39,972	22,644	76,562
1985:	1,570	1,660	4,077	2,676	9,983

Table 3: *Animal population in* Wadi *Elhawad*
Source: Field survey 1986

Year	Nomadic	Semi-nomadic	Total
1980:	4,135 (457)	4,726 (481)	8,861 (938)
1985:	1,066 (133)	3,181 (331)	4,247 (464)

(Figures in brackets refer to number of families)

Table 4: *Population of* Wadi *Elhawad*
Source: Field survey 1986

Year	Nomadic	Semi-nomadic	Total
1960:	187	252	439 ha
1965:	259	398	657 ha
1970:	103	104	207 ha
1975:	180	407	587 ha
1980:	n/a	120	120 ha
1985:	95	365	460 ha

Table 5: *Areas cultivated in* Wadi *Elhawad*
Source: Field survey 1986

Discussion

The results of this study have shown that a serious environmental degradation is taking place in a typical range land in Northern Sudan. *Wadi* Elhawad, once carrying dense forests of Acacia and other species, is now a degraded rangeland with scattered trees of very low stocking and increasing rock and bare ground. These are similar to symptoms of desertification seen elsewhere in Sudan and Africa as reported by several writers, e.g. Bovil (1921), Stepping (1935, 1938), Aid (1972), Elhag (1984) and Smith (1986).

The causes of desertification are complex and different conclusions were made by different investigators. Thus while Lamprey (1975) concluded that, in Sudan, the Sahara had advanced 90-100 km between 1958 and 1975, i.e. 5.5 km/year, Heldon (1984) casts doubt on this, stating that there did not seem to be evidence to substantiate the conclusion that the Sahara had advanced southwards. On the other hand Suliman (1988) reported that in 1985 (a wet year), the arid/semi-arid boundary shifted northwards about 200 km along the Sudan/Chad border and 150 km along the Sudan/Ethiopia border. Because of this north/south shift in vegetation boundaries, it is difficult to make conclusions about a permanent vegetation shift.

Aridity, together with land use pattern and influenced by the condition of settlements, is one of the main causes of desertification. Aridity alone may not cause desertification; over-grazing, especially around water points, is an over-riding factor bringing about environmental degradation.

The results of this study have rated the causes of degradation as follows:-

1. Low Rainfall	38%
2. Over-cutting	32%
3. Over-cultivation	15%
4. Over-grazing	13%
5. Other Factors	2%

Thus land misuse is the main cause of environmental degradation in such marginal range lands. It is therefore necessary to maintain the old practice of nomadism in which animal rearing is the primary occupation with people moving seasonally along the entire Butana. Water points should be provided at calculated distances, taking into consideration the carrying capacity of the range. Permanent settlements should be discouraged and, if absolutely necessary, supplementary feed and fuel must be provided. It is essential to preserve this nomadism on a modern basis with veterinary health services and new breeds of animals of high productivity which will allow maintenance of the ranges under smaller livestock populations. A fallow rotation should be incorporated most of the time with cultivation kept to the minimum required. Trees should be protected for regeneration and palatable fodder species should be enriched.

References

Abdel Ati, H.A., (1984). *Lower River Atbara, Nile Province* I.E.S., University of Khartoum

Bovil, E. (1921). *The Encroachment of the Sahara on the Sudan* in *Journal of the Royal African Society* 20, pp. 175-185 and pp. 259-269

Elhag, M.M. (1984). *Study of Desertification based upon Landsat imagery-North Kordofan, Sudan*, Doctoral thesis - Rijksuniversiteit Gent, Belgium

Farrah, M.M. (1986). *Ecology, Land Use & Environmental Degradation in Wadi Elhawad Area in the Butana-Sudan*

Harrison, M.N. and J.K. Jackson (1958). *Ecological Classification of the Vegetation of the Sudan*, Sudan Government Mimograph

Heldon, U., (1984). *Drought Impact Monitoring* in Lunds Universitets *Naturgeografiska Institution Rapporter och Notiser* 61, Lund, Sweden, p. 61

Lamprey, H.F. (1975). *Report on the Desert Encroachment Reconnaissance in Northern Sudan*, UNESCO/UNEP, Paris/Nairobi, p. 168

Osman *et al*, **(1983).** *An Integrated Rural Development Project for the Nomads of Shendi Rural Council*, Ministry of Agriculture

Parker, K.W. and R.W. Harris (1959). *The 3-Step Method for Measuring Condition and Trend of Forest Ranges*, U.S. For. Serv. South and South East For. Exp. Sta. Proc. pp. 55-69

Smith, S.E., (1986). *Drought and Water Management: The Egyptian Response* in *J. of Soil and Water Conservation* 41 pp. 297-300

Stepping, E.P., (1935). *The encroaching Sahara; the threat to the West African colonies* in *The Geographical Journal* 85, pp. 506-524

Stepping, E.P., (1938). *The Advance of the Sahara* in *The Geographical Journal* 91, pp. 356-359

Suliman, M.M., (1988). *Dynamics of Range & Desertification Monitoring in the Sudan* in *Desertification Control Bulletin* 16, UNEP

Forestry - an Integrated Part of the United Nations Environment Programme

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Introduction

Forestry is an integral part of the United Nations Environment Programme. Since 1973 UNEP has developed several projects and activities on the forest ecosystems of the world. UNEP was able to increase the state of knowledge of tropical forest ecosystems, initiate research, develop preliminary guidelines and call public attention to the fate of tropical forests. At present UNEP is focusing on tropical forests.

Forests are threatened by different environmental hazards. The temperate-zone forests are afflicted by industrial air pollution, particularly from acid rain. The tropical forests are decreasing because deforestation - mainly as a result of shifting cultivation - is not compensated by reforestation (Gwynne, 1983).

The tropical rain forests in Latin America, Africa and Asia probably support at least 50 per cent of the planet's species, and many of these are little known to man. The value of these genetic resources is not in doubt: they must be preserved to sustain and improve agricultural, forestry and fisheries production, and to keep our options open for the future. Preserving genetic diversity cannot be left to individual nations but is an international responsibility.

There are sound ecological, commercial and moral reasons for preserving the tropical rain forests. In many parts of the world the loss of vegetation cover is causing wide-spread soil erosion, desertification and siltation of rivers, lakes, dams and oceans. It is also threatening the majority of third world populations with loss of their primary source of fuel for cooking and heating.

A study carried out jointly by FAO and UNEP revealed that 7.5 million hectares of closed forests and 3.8 million hectares of woodland are being cleared in the tropics every year. Replanting has been accelerated but ten hectares of forest are still being cleared for every hectare of plantation established. If this trend continues, nine countries will have destroyed all their closed forest within 30 years, and a further 13 nations within 55 years (Clarke and Palmer, 1982).

In recent years, die-back has affected large areas of forests in Europe and North America. By 1982, more than 8 per cent (560,000 hectares) of mainly coniferous forests in the Federal Republic of Germany were damaged; in 1983, a survey showed that damage affected 34 per cent of the forests (FDR report, 1984). Widespread damage has also been reported from Czechoslovakia (500,000 hectares) and Poland (500,000 hectares) (Pudis, 1983). Serious damage is also reported from Switzerland, France, the Netherlands, Denmark, Belgium, East Germany, Austria, Britain, Norway, Sweden, Finland and the Soviet Union.

The same type of forest destruction can be seen in the Appalachian Mountain range of the eastern United States. Red spruce on the high western slopes facing the industrial US heartland are dying. Forest decline has been reported as far south as Florida's eastern coastal plain and west into the heavily-polluted Ohio Valley. It is also found on the western and southern slopes of the Californian mountains, which are affected by air pollution from the Los Angeles area (Toronto Globe, 1986).

In Canada, green forests are turning grey. South of Québec City, the maple forests that make the area the world's maple syrup capital are dying in huge numbers. Damaged trees are in an area that is severely affected by acid rain from Ontario, Québec and US industries. Ontario has small but sometimes severe areas of tree decline from the east shore of Lake Superior to the Québec border. The other area of forest decline is a band along the Fundy shoreline of New Brunswick.

The impact of civilized man on forests in recent centuries has had drastic short-term effects and is likely to have far-reaching effects on the biosphere. Forest ecosystems are both stable and vulnerable: their survival through geological time shows that they possess a great capacity to withstand the climatic and other hazards of the natural environment but when faced with men and modern technology they prove very fragile.

The United Nations agencies concerned with the problems are FAO, UNESCO and UNEP, but their interests are not the same and the activities which they promote have different aims. FAO is primarily interested in the development and rational management of forest resources, while the aims of UNESCO are to promote scientific knowledge of forests and to make this knowledge available through education. The role of UNEP is to encourage, support and particularly coordinate action which is oriented towards an environmental approval to forest resources evaluation, assessment and management.

From the Stockholm Conference to UNEP

The United Nations Conference on the Human Environment held in Stockholm in 1972 reaffirmed its support for strengthening UNEP as the major coordinating body for global environmental co-operation, and called for increased resources to be made available to address the problems of the environment, in particular through the Environmental Fund. It urged governments collectively and individually to discharge their responsibility to ensure that our planet is bequeathed to future generations in a condition which fosters universal human dignity.

In January 1973, two of the tasks assigned to the Executive Director of UNEP by the General Assembly of the United Nations in its resolution 2997 (XXVII) by which it established UNEP were:

a. *To co-ordinate, under the guidance of the Governing Council, environmental programmes within the United Nations System, to keep their implementation under review and to assess their effectiveness; and to advise, as appropriate and under the guidance of the Governing Council, intergovernmental bodies of the United Nations system on the formulation and implementation of environmental programmes.*

b. *Keep under review the world environmental situation in order to ensure that emerging environmental problems of wide international significance receive appropriate and adequate consideration.*

The Role of UNEP in the Tropical Forestry Action Plan

In collaboration with UNESCO, FAO, IUCN, IIED, WRI and several other bodies, or through internal projects, UNEP was able to prepare a State of Knowledge Report on Tropical Forest Ecosystems (UNESCO-UNEP, 1978). This included a tropical forest resources assessment (FAO-UNEP, 1982) with regional reports for Africa, Asia and tropical America; guidelines for tropical forest management, ecological principles and methodologies for assessment.

Based on decisions of the Governing Council (GC. VII - 7/7 1979) the Executive Director proposed a meeting of experts and an integrated programme of activities for the conservation and use of tropical forests. The Council meeting recognized the need for an integrated international plan of action on tropical forest management.

Two meetings on tropical forests were held in Nairobi and Rome in 1980. These two meetings were the basis for the development of the Tropical Forestry Action Plan (1985) which was completed at the Committee on Forest Development in the Tropics at its Seventh Session at FAO headquarters in Rome in 1985. It has five priority areas which were endorsed by representatives of developing countries during the Ninth World Forestry Congress in Mexico City in the same year.

The priority programmes were:

1. Forestry in land use
2. Forest based industrial development

	Africa	Asia-Pacific	Latin America	Total
Global Level				
Agri-silvo-pastoral development	-	-	-	2.0
Integrated watershed management	-	-	-	6.9
Arid zone forestry and desertification control	-	-	-	5.7
Assessment of tropical forest lands	-	-	-	0.5
Regional level				
Agri-silvo-pastoral development	3.7	3.1	2.6	9.4
Integrated watershed management	3.5	5.5	4.3	13.3
Arid zone forestry and desertification control	7.2	1.5	1.5	10.2
Assessment of tropical forest lands	5.0	5.0	5.0	15.0
National level				
Agro-silvo-pastoral development	55.0	66.0	74.0	195.0
Integrated watershed management	72.0	68.0	76.0	216.0
Arid zone forestry and desertification control	144.0*	8.0	46.0	197.0
Assessment of tropical forest lands	24.0	42.0	33.0	99.0
Total	**314.4**	**199.1**	**242.4**	**770.0**

*Two countries of the Near East Region, Yemen Arab Republic and Yemen P.D.R. have been included with Africa.

Table 1: *Resources required for technical assistance over a period of 10 years (million US$)*
Source: Tropical Forestry Action Plan, 1985

3. Fuelwood and energy
4. Conservation of tropical forest ecosystems
5. Establishment of forest institutions.

These reflected the approach UNEP pioneered in tropical forests and together they form a comprehensive plan for tropical forest management.

The aim of forestry in land use is to reduce the pressure on tropical forest land by a number of techniques encouraging agroforestry, crop rotation, use of fertilizers, etc; to protect the river catchment areas; and to avoid desertification by avoiding over-stocking, over-cultivation, excessive burning or indiscriminate felling of trees for fuelwood. Table 1 summarizes the technical assistance required for the Forestry in Land Use Action Programme over a 10 year period.

The second priority programme - forest-based industrial development - is the promotion of forest conservation by demonstrating to governments and individuals that well-managed forests can be made commercially viable by establishing and managing appropriate forest industries, developing ways to harvest raw materials; and by reducing waste.

The fuelwood and energy programme (no. 3) is designed to meet the energy requirements of the 2000 million people in the tropics who rely upon fuelwood for domestic purposes. It promotes the development of wood-based energy systems for rural and industrial development, and also supports training and research. Table 2 shows the population and fuelwood deficit involved as well as the countries mainly threatened by such fuelwood situations.

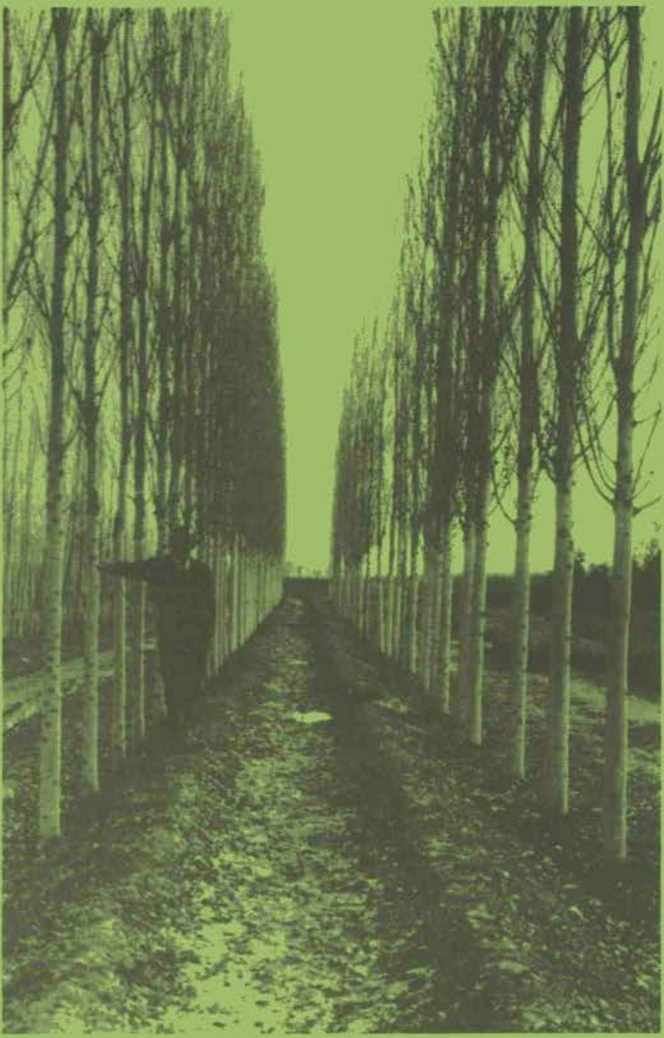
The fourth programme - conservation of tropical forest ecosystems - will encourage management of existing forests and the establishment of new, protected areas in all countries where rainforests remain. This will include the protection of endangered species and preservation of the forest's genetic diversity.

The final programme will concentrate on the establishment of new institutions and the support of existing programmes of training, education and research through which new projects can be started and on-going projects continued. Forestry has to be integrated into national development plans and forest administration improved with the help of networks set up by such institutions.

There are numerous tropical forests projects, one of the most important being the Man and the Biosphere projects run by UNESCO in collaboration with UNEP. Between 1973 and 1985, UNEP invested US$ 3.42 million in 18 projects to which the external partners contributed US$ 11.28 million. UNEP also supports IUCN's tropical forest programme and, in Central America and Mexico, is about to start its own sub-regional programme on the potential development of tropical and subtropical forests. This will be the Tropical Agronomical Centre for Research and Training (CATIE).

The Tropical Forestry Action Plan identified several areas in which UNEP will be directly involved at national and international level, e.g. forest in land use, fuelwood and energy, and conservation of tropical ecosystems. Forest-based industrial development and institutions are of less direct interest but should not be ignored in UNEP plans, whose coordinating role will include:

1. Setting achievable targets for slowing the rate of destruction;



An avenue of Populas nigra *"Spindar" at Nineveh, Iraq. These trees were planted in an early UN project aimed at increasing productivity of degraded land*

2. Helping to improve North-South cooperation to achieve better rates of return of tropical forest use in exchange for forest conservation;
3. Promotion of South-South cooperation and information exchange;
4. Assisting the activities of serious field-action oriented non government organizations (NGOs) in tropical forest nations by raising additional funding for sound projects and support through modest funds;
5. Planning joint action with relevant UN agencies and establishing common programmes with campaign organizations such as the IUCN and the World Wildlife Fund; and
6. Initiation of a major media campaign to elicit public support for the sustainable use of tropical forests.

A new plan to which UNEP, FAO, UNDP, the World Bank and the World Resources Institute have all contributed, looks like having greater success. It calls for US$ 8,000 million to be spent on tropical forests over the next five years, half to be mobilized by development agencies and international lending institutions, the other half to come from national governments and the private sector. Most

Region 1980	Populations Involved	Fuelwood Deficit	Countries Mainly Concerned
Acute Scarcity - Arid and Semi-Arid Areas			
Africa	13 million people	6 million m^3	Cape Verde, Chad, Djibouti, Mali, Mauritania, Niger, Sudan, Kenya, Ethiopia, Somalia, Botswana, Namibia
Asia	9.5 million people	3.6 million m^3	Afghanistan, Pakistan
Latin America	6.8 million people	3.5 million m^3	Chile, Peru
Acute Scarcity - Mountainous Areas			
Africa	36 million people	40 million m^3	Burundi, Rwanda, Lesotho, Swaziland
Asia	29 million people	34 million m^3	Nepal
Latin America	2 million people	2 million m^3	Bolivia, Peru
Deficit - Areas with rapidly increasing population and agriculture			
Africa	131 million people	66 million m^3	Cameroon, Congo, Zaire, Malawi, Kenya, Madagascar, Uganda, Tanzania, Gambia, Guinea, Benin, Togo, Senegal, Sierra Leone, Nigeria, Mozambique
Asia	288 million people	75 million m^3	India, Nepal, Pakistan
Latin America	143 million people	36 million m^3	Brazil, Colombia, Peru, Cuba, Dominican Rep., Guatemala, Mexico, Trinidad and Tobago
Deficit - Densely populated			
Asia	412 million people	120 million m^3	Bangladesh, India, Sri Lanka, Thailand, Indonesia (Java), Philippines, Vietnam
Latin America	9 million people	6 million m^3	El Salvador, Haiti, Jamaica
Prospective Deficit - Areas with rapidly increasing population and agriculture			
Africa	(in year 2000) 175 million people facing a 40 million m^3 deficit		Ghana, Ivory Coast, Central African Republic, Angola, Sudan, Zimbabwe, Guinea-Bissau
Asia	(in year 2000) 239 million people facing a 50 million m^3 deficit		Burma, India, Indonesia, Philippines, Vietnam
Latin America	(in year 2000) 50 million people facing substantial degradation of fuelwood supplies		Ecuador, Paraguay, Uruguay, Venezuela
Surplus Potential for Wood Based Energy - Low population tropical forest area			
Africa	Surplus potential 50 million m^3		Cameroon, Congo, Equatorial Guinea, Angola, Zaire, Central African Republic
Asia	Surplus potential 220 million m^3		Bhutan, Laos, Kampuchea, Indonesia (except Java)
Latin America	Surplus potential 200 million m^3		Amazon Basin

Table 2: *Main Categories of Fuelwood Situation*
Source: Tropical Forestry Action Plan, 1985

of the countries that should be involved spurned such global action a few years ago but have already agreed to participate in this scheme.

UNEP's Role

Most of the attention over the last twenty years has been given to tropical forests, particularly to moist tropical forests and forests in arid and semi-arid areas.

Governing Council decisions have further oriented UNEP's activities as follows:

a. development of guidelines for tropical woodlands and forest ecosystems for rational management;
b. assistance to governments in managing forest resources;
c. initiation of pilot projects for promotion of applied studies and research and for training in the rational use of tropical rain forests;
d. support for afforestation policies in developing countries including encouragement of the use of fast-growing species and promotion of improved efficiency and conservation methods; and
e. support of non-governmental and private organizations for rational management of resources of humid tropical ecosystems.

UNEP will collaborate with its traditional partners, for example the Ecosystem Conservation Group (UNESCO, IUCN, FAO) and will try to enlarge its partnership network to include an active role with governments and NGOs. The UNEP forestry ecosystem programme should focus on the following:

a. assessment and monitoring at global and regional scale of forest cover and quality of ecosystems and in selected cases at lower level. Monitoring at global scale will be continued under regular activities of the Global Environment Monitoring System (GEMS) in close collaboration with the forest programme;
b. promotion and support of research in the fields of integrated management of forest resources, biological diversity and processes, and forest genetic resources;
c. forest management as a tool for improvement of conservation of forest resources;
d. training; and
e. timely and scientifically sound information on forests is necessary worldwide for the creation of public awareness and political support and for the orientation of administrative and technical action.

Desertification affects mostly the arid and semi-arid areas of the Earth and is not primarily a natural process. Though it may be accelerated by drought, it is rarely caused by it. On the contrary, its causes are man-made. Typical causes of desertification include overgrazing, overcultivation and deforestation.

UNEP's policy in this respect is guided by several recommendations and principles in the Plan of Action to Combat Desertification (PACD), by General Assembly resolutions, and by UNEP Governing Council decisions.

In the PACD, specific recommendations provide direct instructions such as:

a. maintaining and protecting existing vegetation, and revegetating damaged areas;
b. monitoring climatic, hydrological or pedological and ecological conditions of plants;
c. improving and controlling the use of fuelwood and charcoal and pursuing alternative sources of energy.

The General Assembly resolution 39/208 paragraph 4 recommended that the international community, and above all the developed countries, should continue to provide coherent assistance to those countries affected by desertification in order to support the rehabilitation process, in particular through intensive afforestation.

UNEP Governing Council passed the following decisions, among others:

a. formulation and promotion of programme activities for sustainable management of tropical forests, development of environmentally-sound farming and forestry practices, including agroforestry;
b. approves recommendations of the Executive Director's report in respect of establishing networks for afforestation;
c. requests the Executive Director to accord high priority in the provision of assistance to African countries to deal with the most urgent environmental problems, among them, protection of forests, and afforestation;
d. requests the Executive Director to consult with FAO, UNESCO and other relevant agencies with a view to having the Committee on Forest Development in the Tropics assume the role of continuing review of international activity on tropical forestry.

From the above recommendations, resolutions and decisions, UNEP receives its guidance which is translated into its efforts and activities either alone or working through the United Nations Sudano-Sahelian Office (UNSO) or other UN agencies, support actions and projects to control desertification.

References

Gwynne, M.D. *et al*, **1983.** *Tropical Forest Extent and Changes*, Adv. Space Res. Vol. 2, pp. 81-89

Clarke, R. and Palmer, J., 1982. *The Human Environment - Action or Disaster?* An account of the Public Hearing held in London, published for UNEP by Tycooly International Publishing Ltd., Dublin

***New Scientist*,** 27 October 1983

Federal Republic of Germany Report to the Multilateral Conference on Causes and Prevention of Damage to Forests and Waters by Air Pollution in Europe, Munich, 24-27 June 1984

Pudis, E., 1983. *Poland's plight: Environment Damaged from Air Pollution and Acid Rain*. Ambio, Vol. XII (2), pp. 125-127

***Toronto Globe and Mail*,** *Pollution Hastens Greying of Northern Hemisphere*, 26 September 1986

Tolba, M.K., 1985. *Heading off Environmental Catastrophe*, Oral Statement by Dr M.K. Tolba, Executive Director of UNEP. Second Committee of the 40th General Assembly, New York

Skoupy, J. and Karrar G., 1985. *Forestry in UNEP Integrated Programme to Combat Desertification*. Paper presented in Expert Consultation on the Role of Forestry in Combating Desertification, Saltillo, Mexico, Satellite meeting of the 9th World Forestry Congress

The Role of Trees in Agroforestry

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Introduction

Agroforestry is a collective name for all land-use systems and practices in which trees, shrubs and other woody perennials are deliberately combined on the same land management unit in close association with crops and/or animals, either in some form of spatial arrangement or temporal sequence. This definition includes systems and practices that range from ancient so-called "primitive" shifting cultivation to complex, multi-storey homegardens where crops, shrubs and trees are grown to planned different heights, to "modern" intensive agroforestry such as alley farming, where crops are grown between lines of selected shrubs or trees.

The term agroforestry is not entirely new. Far from it, farmers, pastoralists and other land-users all over the world have always practiced different forms of what is now called agroforestry. Trees mixed into crop fields or pastures, either planted or selectively left over from the natural vegetation, are still a common sight in many land-use systems.

What is new, however, is the name agroforestry and the realisation that the systematic and scientific development of mixing trees, crops and/or animals holds great promise for improving land-use in many developing countries.

Benefit of Trees

Conventional approaches to land development, such as monocropping with improved crop varieties, using irrigation wherever possible and high levels of fertilizers, pesticides and energy inputs, should continue to play a significant role in the economic and agricultural development of poor countries, where such approaches are relevant and feasible.

However, these high-input alternatives are simply not available to a very large number of small-scale land-users in sub-tropical and tropical countries. This may be for reasons of marginal ecologies (infertile, erosive soils or insufficient and erratic rainfall), and/or marginal economies (no cash to buy inputs, no transport-marketing infrastructure to sell surplus production, etc).

Trees and shrubs, and the multitude of products and services they can provide, can help resource-poor farmers to increase productivity, improve sustainability and ensure wider diversity of the output of their land. This new approach to trees in which, contrary to forestry, other uses, products and services besides timber and pulpwood are valued and explored, obviously calls for a distinction between trees in general and trees for agroforestry.

In general, trees play two major roles in agroforestry systems: (a) production of goods and (b) protection/amelioration of the site.

The Productive Role of Forest Trees

Wood products such as fuel, timber and poles for building, fencing and for a wide variety of purposes in farm and home construction, are important components of the everyday life of rural people. It is obviously better if these can be produced on the farm rather than have to be purchased with limited cash resources or collected from communal land, which is both time - and energy - consuming.

Several plant species already established in the Sahel could make important contributions to. agriculture, medicine and industry. *Balanites aegyptiaca* is said to be lethal to the snails which are the intermediary host of schistosomiasis and to the water flea which carries dracunculiasis (guinea-worm disease): *Acacia seyal* and *Prosopis juliflora* produce gums of commercial quality; *Calatropis procera* and *Euphorbia spp.*, which can be grown in marginal lands, are promising sources of liquid hydrocarbons (*Environmental Changes in the West African Sahel*, 1984).

Some "minor" products such as fodder, resin, gum, fibre, rubber, honey and myriads of other food stuffs play a very important role in some communities. For example, in Sudan, gum arabic from *Acacia senegal* and other species produces an annual income of about US$ 4 million (H.M. Amin, 1973).

Among recent developments, the most important has been the realization of the importance of multi-purpose, woody, leguminous trees and shrubs in low-input farming systems (M.S. Swaminathan, 1987). The legumes *Prosopis* are capable of providing the food, fodder, fertilizer and fuel needs of rural populations. They serve as organic fertilizer, leaching or biomass harvest. Leaves of different tree species obtain varying degrees of the essential nutrients: Nitrogen, Phosphate and Potassium (Table 1). Trees maintain/increase the organic contents of the soil, improve the soil tilth and enhance the overall capacity to produce goods.

Alley Cropping

Many agri-silvi-pastoral systems have been proposed in recent years. Alley cropping is one of the most important systems. In this system, food crops are grown in alleys framed by hedgerows of trees or shrubs (B.T. Kang, 1984). The hedgerows are cut back at the time of planting crops and are kept pruned to prevent shading the crops. Pruned foliage is allowed to decompose in the alleys and the nutrients released increase grain yields (Table 2). The foliage is also used to feed livestock. Simultaneously, the trees provide many other by-products such as fuelwood and stems for staking viney crops.

Species	Age in years	N	P	K	Ca	Mg
		Nutrients added - kg/ha/year				
Leucaena (Philippines)	1	247	14	259	239	49
Leucaena (Hawaii)	1	104	5.4	98.2	79	14.3
Mixed forest (Ghana)	40	199	7	68	206	45
Mixed forest (Guatemala)	1	74	3	11	71	40
Mixed secondary forest	18	143	7.8	8.6	76.7	

Table 1: *Nutrients added by litterfall from various forest species. Source: MacDicken, 1981*

Homegardens and Multi-level Plantations

Multi-level plantations and homegarden systems, common in small landholdings and designed to increase food production, are fairly analogous to a rainforest with a multi-layered canopy (M.S. Swaminathan, 1987). The systems and its component crops vary with the location. In the humid tropics, plantations of coconut, oil palm and rubber have increased during the last few years due to greater demand for vegetable oils and rubber products. New opportunities have become available with the development of high yielding hybrids between tall and dwarf coconuts, which have a potential similar to that of oil palm.

Arid and Semi-arid Environments

In arid and semi-arid environments, agroforestry systems also help to provide greater insurance against weather abnormalities. Many multipurpose trees such as *Prosopis cineraria*, *Zizyphus rotundifolia*, *Casuarina*, *Tecomella undulata*, *Acacia tortilis*, *Dalbergia sissoo* and *Sesbania*, thrive in arid areas. Crops accompanying these trees may not show any significant reduction in grain yield. Perennial shrubs such as *Sesbania* and *Cajanus cajan* also show promise to produce food, fodder and fuelwood. Alley cropping can be successfully practiced in many areas.

N rate (kg/ha)	*Leucaena* prunings	1979	1980	1981*	1982	1983
		Yield by year (t/ha)				
0	removed		1.9	0.5	0.6	0.3
0	removed	2.1	1.9	1.2	2.1	0.9
80	retained	3.5	3.4	1.9	2.9	3.2
LSD	0.05	0.4	0.3	0.3	0.4	0.8

*Maize crop seriously affected by drought during early growth

Table 2: *Main season grain yield of maize alley cropped with* Leucaena leucocephala *as affected by application of* Leucaena *prunings and nitrogen. Source: Kang et al, 1984*

Windbreaks and live fences are other options available in agroforestry for dry areas. *Leucaena leucocephala*, when planted as a windbreak, increases the grain yield of agricultural crops and moisture availability in soil by reducing run-off and evaporation. In the Majjia Valley in Niger, a 1-year study of the effect of 2 rows of *Azadirachta indica* showed that milled yields in the protected fields were 123 per cent of the yields outside the protected areas. This takes into account the loss of production caused by the proximity of the planted tree. At distances of up to five times the height of the planted trees on the leeward side, yields were 156 per cent greater than in the unprotected fields.

In the Kazaure Emirate, farmers interviewed in 1980 claimed that in the severe drought years of 1973-1974, surrounding villages without shelterbelts experienced serious

Farm Forestry

In several countries, some very successful farm forestry projects have begun to increase the rate of reforestation and to augment the supply of timber, fodder, fruits, and fuelwood. In the Gujarat State of India, the Forestry Department started a project in the early 1970s. The system was gradually accepted by farmers because it was less labour-intensive and labour requirements were spread over the year. Tree farming with eucalyptus has now become so popular that irrigated, fertilized fields are also being used for this purpose (Centre for Science and Environment, 1985). Today, at least 10 per cent of Gujarat's farming families are involved in farm forestry. Similar success has been achieved in Haiti, Kenya, Senegal and Nepal (World Research Institute, 1985). Such tree monocultures on farmland may not, however, always represent a major ecological advantage. Trees such as eucalyptus do not provide fodder or mulch and may consume large quantities of water.

crop failures, whereas the protected fields which were block planted in 1965 had normal crops. As an additional benefit, these farmers reported that in normal years, only one sowing of the crops is required to the leeward side of the shelterbelts. In the unprotected areas it is frequently necessary to sow seed two or three times each season because of blown surface sand burying or damaging the germinating seed.

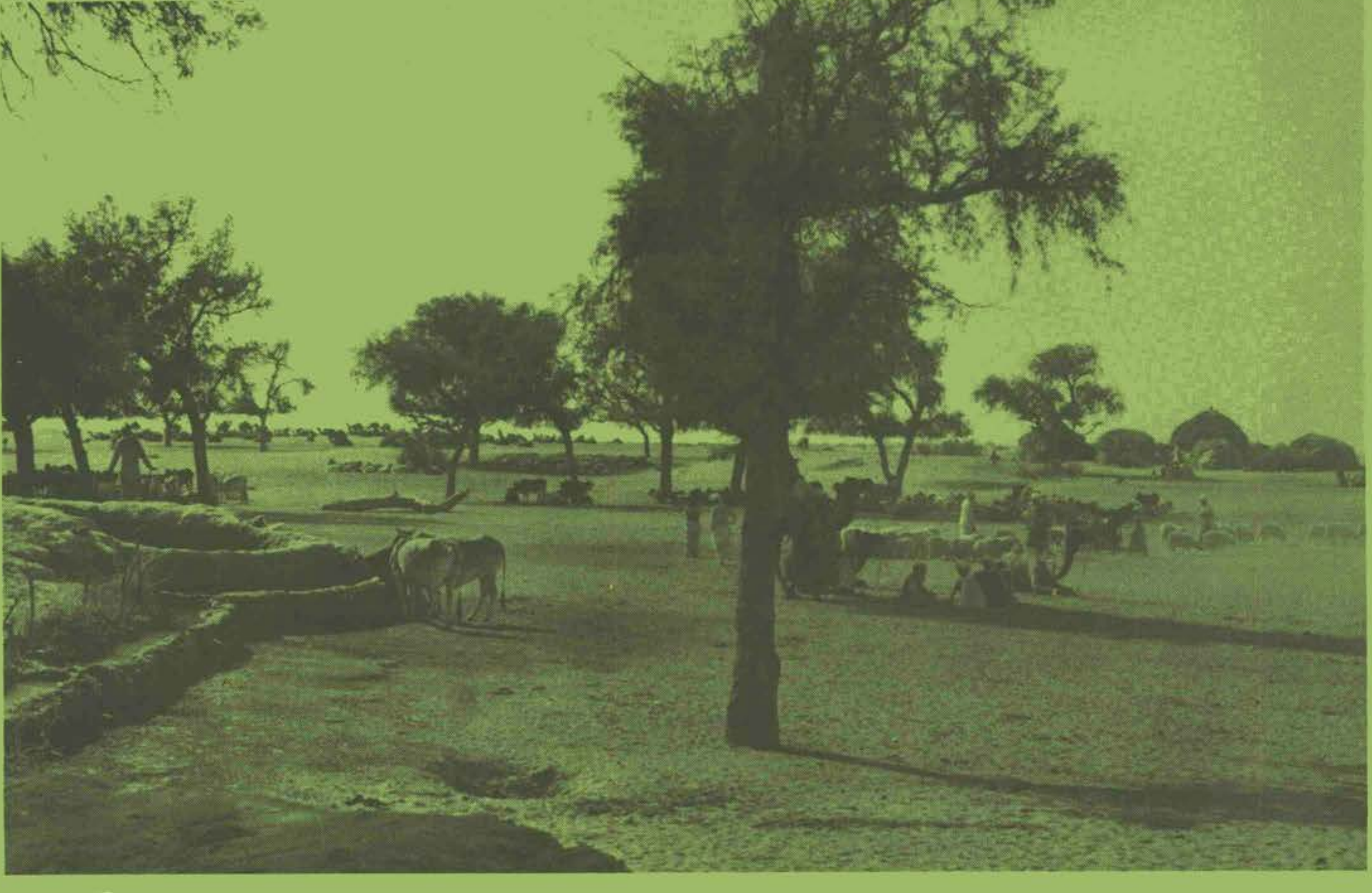
In the coastal areas of Gujarat, India, extensive areas have been planted with *Prosopis juliflora*. In West Bengal, India, the government has leased out marginal degraded forest wastelands to landless farmers. These farmers are provided with sufficient incentives and inputs to practice agroforestry, leading to increased tree plantations in the area. Large tracts of eroded wastelands in the Loess Plateau of China have been reclaimed by planting trees and using legumes as groundcover. Cheaper techniques such as planting tree seedlings in pits to which gypsum has been added can also be very useful in expanding agroforestry.

The protective Role of Forest Trees

The establishment of vegetative cover is one the most effective ways of conserving soil and water. As is well known, the magnitude of soil loss depends upon several factors, such as erodibility of the soil, erosivity of rain, slope, vegetation types, management practices, etc.

When the soil's protective vegetation cover is removed, the structurally unstable soils are exposed to the beating action of rains. Losses due to erosion immediately after land clearing are normally alarmingly high. Experiments at the International Institute of Tropical Agriculture, Ibadan, Nigeria indicate a soil loss of up to 120 t ha^{-1} in the first year after land clearing (R. Lal, 1974). R. Fourmier (1967) reported significant erosion losses even from soils with a 1.5 per cent slope. Through the anchorage and binding action by the trees' root system, slopes can be stabilized and protected from slides and slips. The double "armour" provided by the crown cover and the layer of litterfall protects the soil from splash erosion and surface or sheet erosion. A report from China (Xiaoliang Experimental Station, 1977) indicates that under a tropical monsoon climate, the establishment of forest on eroded slopes reduced annual soil erosion from about 15,000 to 3,000 m^3 km^{-2} over a period of 10 years.

The benefit of woody perennials to soil conservation is particularly important in highlands with rolling topography and steep slopes, which are increasingly being brought under cultivation. For example, in South East Asia, especially in Indonesia, there is a long tradition of planting *Leucaena leucocephala* in contour hedgerows for erosion control and soil improvement (P.K.R. Nazir, 1984). These contour rows of *Leucaena* survive through the long dry season because of their long taproots which can reach water deep underground. Loppings and prunings from the hedgerow species could also provide mulch aid in preventing sheet erosion between trees. A schematic representation of a typical planting pattern of hedgerows for soil conservation



*Tall trees (*Prosopis spicigera*) of the Cholistan desert in Pakistan provide shade for the inhabitants and their livestock during hot summer days* is given in Figure 1.

Water infiltration in the soil is enhanced by both the trees' root action and the accumulation of absorbent humus on the soil surface, thereby significantly reducing the volume, velocity, and erosive and leaching capacity of surface runoff. Tree crowns lessen solar radiation on the soil, reduce soil temperatures, and thereby reduce moisture loss through evaporation from the surface soil where most annual food crops draw their moisture and nutrient uptakes.

In undisturbed forest ecosystems, under saturated conditions, water movement takes place in soil through macropores that dominate the pore space and, therefore, surface

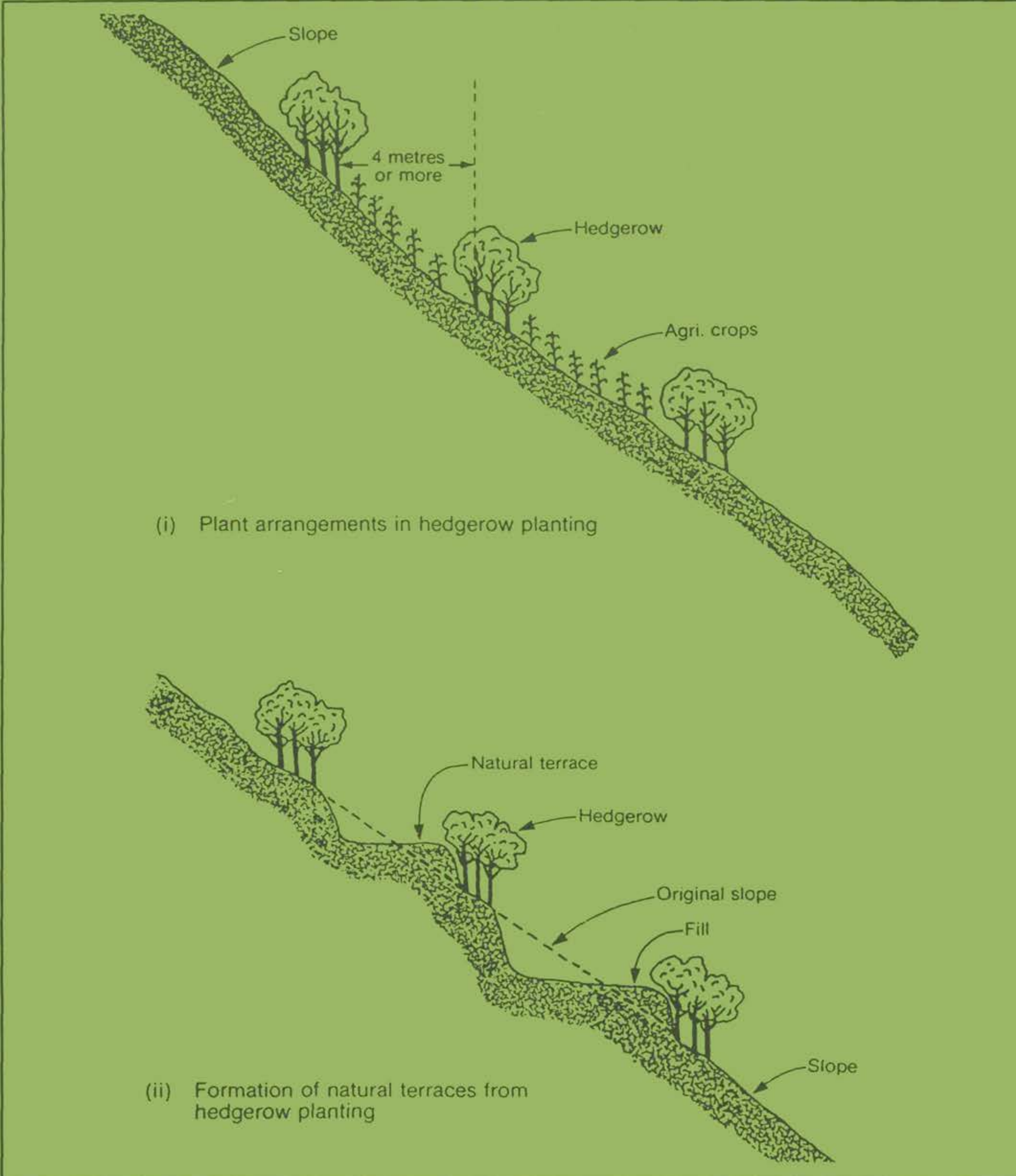


Figure 1: *Hedgerow planting for soil conservation. Source: N.T. Vergara, 1982*

runoff is generally low, even in regions of intense rains with a high drop-size distribution. The removal of the vegetative cover from the soil generally results both in an increase in density and a decrease in porosity, as well as a reduction in infiltration. The data of G.E. Wilkinson and P.O. Ania (1976) from Ife, Nigeria on the high rates of infiltration and water entry into the soil (sandy soil, 10 per cent clay) under tropical forest fallow, and the reduction of the rates after two subsequent years of maize cropping (Table 3) are quite illustrative. "Infiltration capacity" here refers to water entry into saturated soil when lateral flow is not restricted, and "infiltration rate" means the rate of entry when horizontal movement is prevented. In other words, subsoil permeability determines infiltration rate which is barely influenced by clearing and cultivating, but the infiltration capacity is reduced considerably by compaction of the well-structured topsoil by cultivation.

In addition to direct effects of trees on the physical properties of soils, there are also indirect advantages that could profitably be made use of in soil management in agroforestry. For example, one of the well-accepted effects of mulching (which is one of the most feasible soil management practices in agroforestry) is the improvement of soil physical properties.

The use of trees and other woody perennials to protect agricultural fields from adverse effects of wind is a widespread practice in many agricultural systems. The principle can be of considerable value in developing sound agro-forestry technologies for areas that are prone to wind damage. Here, again, it is important to select appropriate species of woody perennials and manage them accordingly with a view to obtaining multiple outputs from them, in addition to realising the expected windbreak/shelterbelt effects. In this regard, very encouraging results have, for example, been reported from studies conducted at the Pakistan Forestry Research Institute, Peshawar (M.I. Sheikh and A. Khalique, 1982). The physical, ecological and biological consideration involved in the design of agroforestry shelterbelts has to be site-specific and depends on a large number of factors, such as the major components of the farming system (crop/livestock), the desired pattern of windbreak (simple, multiple, successive) or network system (with or without secondary hedgerows) etc.

The protective role of trees in imparting stability to the whole ecosystem is also well known. The clearing of vegetation affects not only the farmlands in the immediate vicinity, but also destroys the water catchment areas, causing flooding of rivers and rapid silting of dams. For example, as population pressure throughout Nepal and Northern India has taken the tree line further north following the beds of the Ganges, Hooghly, Beas and many other rivers, the hard monsoon rains, once absorbed by the forest and released over time, now head straight for the river valley. The result is flooding, hundreds of miles down stream. On average, floods annually affect an area of about 8 million ha of cropped land (D.S. Sharma, 1985).

These attributes of trees and their favourable influence and effect on soil conservation, physical properties, the hydrological balance, microclimate and shelterbelt effect are sufficiently large to indicate the beneficial role of trees in conserving and stabilizing the ecosystem. In the light of available evidence of micro-site enrichment qualities of individual trees and tree communities, a generalized scheme can be conceptualized to project the advantages of agroforestry, as shown in Figure 2.

Soil Condition	Iwo Infiltration capacity ($cm\ hr^{-1}$)	Iwo Infiltration rate ($cm\ hr^{-1}$)	Oba Infiltration capacity ($cm\ hr^{-1}$)	Oba Infiltration rate ($cm\ hr^{-1}$)
Bush fallow	118.9	21.1	107.7	25.4
After first cropping year	44.7	20.5	48.8	25.1
After second cropping year	49.5	22.4	21.6	9.1

Table 3: *Equilibrium infiltration capacities and rates of water entry into crust-free Iwo and Oba (Ife, Nigeria) soils in bush, fallow and after subsequent years of annual crops (maize). Source: Wilkinson and Ania, 1976*

Choice of Tree Species for Agroforestry Systems

To reach a decision with regard to the species to be planted or favoured for agroforestry, it is necessary to consider the requirements of possible species in relation to any special features of the site within the general climate, soil and vegetation types of the region. It is also important to consider the mutual compatibility and non-competitiveness of the various agricultural and tree and/or shrub species to be introduced. Special regard should be given to avoiding species that pose problems of competition for water, nutrients and solar energy.

Considering the important and varied roles that trees can, and are expected to play in agroforestry, it becomes imperative that the trees be multi-purpose ones. An understanding of evolutionary history of the genetic "fitness" or flexibility of a multipurpose woody species in relation to its network ecological range is far from academic. It can help to establish whether sets of suitable morphological and physiological characteristics are likely to be present which will fulfill the objectives for choosing that particular species in the first place.

Any definition of multipurpose cannot be applied entirely to a completely circumscribed set of species. Virtually every species of tree or shrub can be used for more than one purpose. However, the term "multipurpose" appears to be used most commonly when a species is

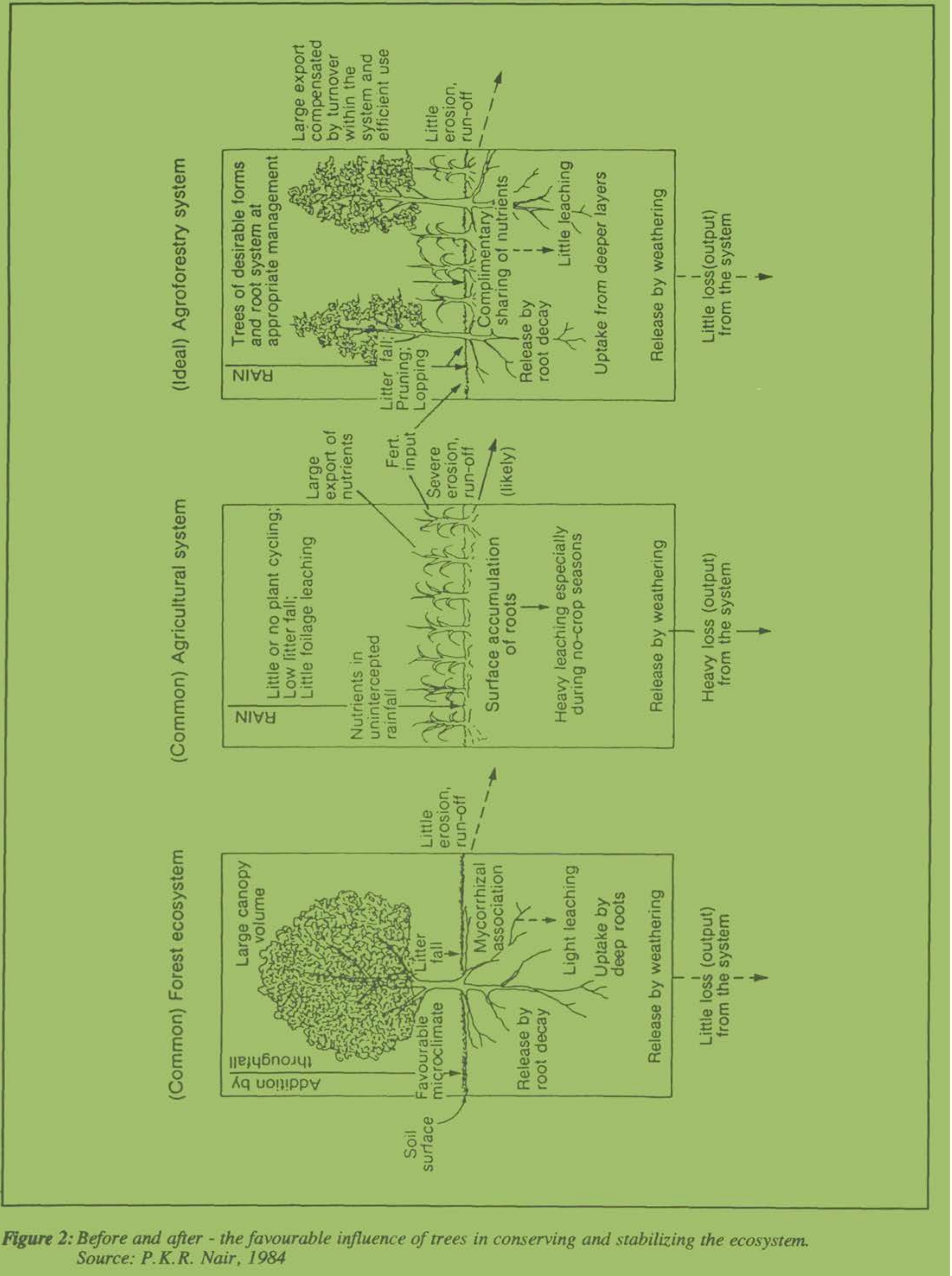


***Figure 2:** Before and after - the favourable influence of trees in conserving and stabilizing the ecosystem.*
Source: P.K.R. Nair, 1984

deliberately grown at one site and time to produce more than one product or benefit: these include timber, fuelwood and the so-called "minor forest products" such as extractives, medicines, human food and animal fodder (including flowers for bees and leaves for silkworms), and service attributes such as shade, shelter, soil conservation and improvement of soil fertility.

The term "multipurpose" should also be used to cover species that may be grown for different purposes on different sites. Thus an accepted timber tree such as *Grevilea robusta* should be considered multipurpose if it is grown in different places for shade, mulch, honey, etc. (J. Burley and P. Von Carlowitz, 1983).

According to a 1983 questionnaire, which identified multipurpose trees, *Acacia albida* has 6 uses, *A. arabica* 11 uses, *Albizia falcataria* 5 uses, *Eucalyptus globulus* 7 uses, *Leucaena leucocephala* up to 13 uses, *Prosopis juliflora* up to 9 uses and so on (J. Burely and P. Von Carlowitz, 1983).

The desirable characteristics of an agroforestry tree are as follows:

a. multiplicity of uses for the leaves, fruits, flowers and woody parts of the tree so they can help satisfy the various needs of the farmers;
b. deep rooted so that it can effectively stabilize soil (especially on slopes), so its roots do not compete for moisture and nutrients with the shallow roots of annual food crops, and so it can reach lower water tables and survive during dry periods;
c. light-crowned so it does not totally shade intercropped food plants;
d. rapid rates of growth to reduce waiting period for tree products by farmer;
e. self-pruning properties, or if not self-pruning, it should be able to tolerate relatively high incidences of pruning;
f. its phenology, particularly with respect to leaf flushing and leaffall, should be advantageous to the growth of the annual crop;
g. it should be tolerant of side-shade;
h. its rate of litter fall and litter decomposition should have positive effects upon the soil;
i. it should be a nitrogen-fixer so that it can contribute much to the rehabilitation/improvement of the soil;
j. it should be good coppicer so that it can regrow after periodic cutting without requiring replanting.

Trees for Agroforestry in Dry Regions

In all continents, dry regions, extending over large areas, have long constituted difficult problems for foresters as far as artificial regeneration is concerned. A notable example of successful integration of trees on farmlands can be found in the semi-arid regions of West Africa where trees, such as *Acacia spp.* and *Prosopis spp.* form an essential part of the traditional farming systems.

In the peanut and millet areas of the Sahelian zone of West Africa, the following trees form an essential component of the farmland. *Acacia albida*, *Balanites aegyptiaca*, *Prosopis spp.*, *Borassus aethiopum*, *Parkia biglobosa*, *Ficus spp.*, *Acacia tortilis* and other species. In Burkina Faso, *Acacia albida* are intercropped with millets; crop growth is better nearer the tree than away from it, thus indicating the effect of microsite enrichment by the tree.

Acacia albida is a very important tree for the dry regions. The tree is completely leafless during the rainy season, thus allowing crops to flourish under its light shade. During the dry season, the leaves reappear providing shade for the crop against the sun, and a comfortable working environment for the farmer. Its pods ripen in the dry season too and provide livestock with nutritious high-protein fodder. Leaf litter and manure dropped by animals as they feed under the trees greatly improve soil fertility. The effects on the yields of millet in Senegal is documented in Table 4. P. Felter (1978) concluded that in the infertile sandy soils of the peanut basin of Senegal, crop yields of peanut and millet increased from 500 ± 200 kg ha^{-1} to 900 ± 200 kg ha^{-1} directly under *Acacia albida* foliage.

In addition to a 50 to 100 per cent increase in soil organic and nitrogen content, a marked increase in soil microbiological activity and water-holding capacity was also observed beneath the tree. *Acacia albida* could more quietly degrade leaf litter to release plant nutrients. The presence of *Acacia albida* on farms could increase land carrying capacity from 10-20 to 40-50 persons per square kilometre and enable the farmers to have more sedantery, permanent agricultural settlements by eliminating the need for fallow-period.

Prosopis spp. is another important leguminous tree for the dry regions. The main advantages of the tree are its deep root system and low requirements for water, nitrogen and plant management, and thus the ability to grow in semi-arid and arid marginal environments (250-500 mm annual rainfall) and yet produce pods rich in protein (13%) and carbohydrate (up to 30% sucrose) for human and animal consumption (P. Felter and R.S. Bandurski, 1977). It can also prevent soil erosion caused by wind and water, and yield high-quality fuelwood.

With regard to inter-cropping with food and fodder-crops

Parameter measured	Near trunk of *Acacia albida*	Edge of tree canopy	Outside tree canopy
Yield of millet protein (kg/ha)	180	84	52
Mean number of ears per plant	5.4	4.2	2.9
Weight of grain per ear (g)	29.8	23.3	22.6
Soil analysis: Total humus %	142	142	100
Available P_2O_5	234	127	100

Table 4: *The effects of* Acacia albida *on the yields of millet in Senegal. Source: Charreau and Vidal, 1965*

and soil fertility improvement, *Prosopis cinerarea* is a far more useful species than *P. juliflora*. This preference for *P. cinerarea* is attributed to the high amount of leaf litter it adds to the soil, as well as increasing soil organic matter and nitrogen content, and increasing the availability of micronutrients (zinc, manganese and copper) and moisture in the surface soil layer in comparison with the soil under *P. juliflora* or open field conditions (R.K. Aggarwal, 1980; A.N. Lahiri, 1980).

Another example is the system practiced in Sudan in the production of gum arabic (*Acacia senegal*). Gum arabic is combined with agricultural crops in a well defined rotational practice such that the gum is produced during the dry season when the farm labour requirement is at its lowest.

Shelterbelt establishment has emerged as a particularly promising component of environment rehabilitation programmes and more stable agricultural and livestock production. In addition to affording protection against wind and wind-blown sand, and the provision of fuel, fodder, building materials and various tertiary products such as gum and medicinals, the belts substantially increase wildlife habitat. The following are examples of trees used for shelterbelts established in the drylands of West Africa. In Cameroon, *Cassia siamea* was used because it is not eaten by animals and fencing was therefore not required. In Nigeria, planting consisted of *Acacia nilotica*, *A. albida*, *A. senegal*, *Azadirachta indica*, *Eucalyptus camaldulensis* and *Anacardium occidentale*. *Azadirachta indica*, *Acacia nilotica*, *A. senegal* and *A. tortilis* have been planted in Niger. In Senegal, *Casuarina equisetifolia*, *Anacardium occidentale*, *Balanites aegyptiaca* and *Acacia nilotica*, ssp. *adstringens* have been used for shelterbelt establishment.

There are several other multi-purpose species of trees and shrubs that are found in the dry-land regions of the world. For example, in India *Albizia lebbeck*, *Azadirachta indica*, *Acacia spp.*, *Balanites aegyptiaca*, *Cassia auriculata*, *Tecomella undulata* and *Zizyphus nummularia*: in Iran, *Haloxylon spp.*, *Tamarix stricta*, *Calligonum persicum*, *Zizyphus spinachristi*, *Acacia farnesiana* and *Prosopis juliflora* (J. Skoupy, 1982): and in Argentina, *Prosopis alba*, *P. nigra* and *P. chilensis*, etc.

References

Aggarwal, R.K., 1980. Physico-Chemical status of soils under Khejri (*Prosopis cinerea* Linn.). In: Mann, H.S. and S.K. Sakena (ed), *Khejri in the Indian Desert*, pp. 31-36. Monograph No. 11, Jodhupur, GAZRI.

***Daily Nation*, 1973.** *Agroforestry. Ancient practice with an active future,* Kenya

Amin, H.M. 1973. Sudan acacias. Forest Research Institute, Bull. No. 1. Information Department, Khartoum.

An account of the activities of the International Council for Research in Agroforestry. 1983, ICRAF, Nairobi.

Burley, J. and Von Carlowitz, P. 1983. *Multipurpose tree germplasm.* Proceedings of a planning workshop to discuss international co-operation. Washington DC, U.S.A.

Environmental change in the West African Sahel, 1984. National Academy Press, Washington D.C.

Ester Zulberti, 1985. Report on the third ICRAF/USAID agroforestry course, 1-19 October 1984, Serdang, Selangor, Malaysia.

FAO, 1963. *Tree planting practices for arid zones*, Rome.

Felker, P., 1978. *State of the art:* Acacia albida *as a complementary permanent intercrop with annual crops.* Univ. California.

Felker, P., Bandurski, R.S., 1977. Protein and amino-acid composition of tree legume seeds. *J. Sci. Fd. Agric. 28*, 791-1987.

Fournier, R., 1967. Research on soil erosion in Africa. *Afr. Soils* 12, pp. 53-96.

Huxley, P.A., 1987. Agroforestry experimentation: Separating the wood from the trees? In *Agroforestry Systems; An International Journal*, ICRAF 1987-88.

Kamweti, D., 1982. *Tree planting in Africa south of the Sahara.* The Environment Liaison Centre, Nairobi, Kenya.

Kang, B.T. *et al*, 1984. *Alley cropping. A stable alternative to shifting cultivation.* International Institute of Tropical Agriculture, Ibadan, Nigeria.

Lal, R., 1974. Soil erosion and shifting agriculture. In: *Shifting cultivation and soil conservation in Africa.* FAO Soils Bull. 24, Rome.

Lahiri, A.N., 1980. *Prosopis cinerea* in relation to soil water and other conditions of its habit. In: Mann, H.S. and S.K. Saxena (eds), *Khejri in the Indian Desert*, pp. 37-44. Monograph No. 11, Jodhupur, GAZRI.

Nair, P.K.R., 1984. Soil productivity aspects of agroforestry, ICRAF, *Science and Practice of Agroforestry 1.* Nairobi, Kenya.

National Academy of Sciences, 1979. *Tropical legumes: resource for future.* Washington DC.

Norman, H. et al, 1972. *The use of trees and shrubs in the dry country of Australia.* Australia Government Publishing Service, Canberra.

Sampler, A, 1987. *The present and potential role of agroforestry in the South and Central America.* ICRAF 10th Anniversary Celebration 7-11 September, 1987, Kenya.

Sheikh, M.I. and Khaligue, A., 1982. Effect of tree belts on the yield of agricultural crops. *Pakistan journal of Forestry 32*, pp. 21-23.

Sharma, D.S., 1985. Peoples' participation in Himalayan eco-system development. Centre for Policy Research, Dharma Marg, New Delhi.

Skoupy, J., 1982. Afforestation of extreme sites. In: *Silvaecultura Tropica et Subtropica*, 9, Prague, CSSR.

Swaminathan, M.S., 1987. *Agroforestry in Asia.* Paper presented at ICRAF 10th Anniversary Celebration, 7-11 September 1987, Nairobi, Kenya.

Von Carlowitz. P., 1983. *Multipurpose tree germplasm.* ICRAF, Nairobi.

Xiaoliang Experiment and Extension Station of Soil Conservation, 1977. *Effects of artificial vegetation on soil conservation of littoral hilly slopes.* Diambai county, Kwantung, China.

Weber, F.R., 1977. *Reforestation in arid lands.* Peace Corps. Vita publications. Mt. Rainier, USA.

Wilkinson, G.E. Ania, P.O. 1976. Infiltration of water into two Nigerian soils under secondary forest and subsequent arable cropping. *Geoderma*, 15, pp. 51-59.

World Research Institute, 1985. *Tropical forests: a call for action.*

People's Participation in Planting Trees

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For too long African development strategies have been influenced by colonial patterns which regarded local populations as passive entities to be acted upon rather than people to be empowered to solve their own problems. Rural people, in particular, have been wrongly assumed to be ignorant or wilfully destructive of their environment in their basic farming/herding activities.

However, in the past two decades or so, increasing emphasis has been placed on the notion of rural people themselves "participating" in rural development. Community participation in planting trees is a process of developing awareness, knowledge and responsibility for forestry among people for whom the presence of forest and trees in their neighbourhood is already or potentially beneficial. With regard to rural development, participation is considered a voluntary contribution by the people in one or another of the public programmes supposed to contribute to national development. In other words, participation is a way of using the economic and social resources of rural people to achieve predetermined targets.

Problems and Constraints of People's Participation

Many programmes and projects designed to encourage and support forestation for local community development are now in existence. Most are still in development - few have been in place long enough to complete a full cycle of production and use. The process of learning the requisites for success in community forestry including people's participation is therefore still at an early stage.

People's participation in planting trees encompasses a whole range of quite different situations and activities, in which the factors influencing success or failure can vary quite sharply. A variety of impediments limits people's willingness to participate. The most commonly cited constraint to tree growing faced by rural people is lack of available land. Competition for land is extreme and, in these cases, food rightly takes precedence over trees. However, trees do not necessarily compete with agriculture, nor are they always an inferior use of the land. Removal of the tree cover in the past does not necessarily imply that there is insufficient room for trees. In many situations trees can be added to agricultural production systems in ways which result in supplementary or complementary increases in yields or returns.

Physical and economic factors also prevent some people from growing trees and institutional restrictions exclude others from participation. Communal solutions have had only limited success in overcoming impediments.

Market opportunities are becoming increasingly important in widening the scope for farm-level tree growing. It has been widely argued that to be attractive to rural people tree growing must produce tangible short-term economic benefits. For the poor, the need to give priority to meeting present rather than future needs is very evident. Some form of government support is nearly always essential for all forms of participatory tree-planting and can be critical in removing or reducing impediments to participation.

The extent of people's interest in planting trees will vary greatly and depends in part on the scope and extent of a particular community forestry programme. Field visits and discussions with villagers on an *ad-hoc* basis may be sufficient for purposes of initial project design but a detailed random household survey in the project areas is highly desirable.

From a socio-economic perspective, a "community" usually consists of a mixed group of individuals with different resource endowments, unequal access to inputs and markets, and different production objectives. Thus individuals living in a "community" may have conflicting goals and will not necessarily readily agree on what should be included as community interests. So before the project can be designed, the specific targeted population must be identified.

It is not difficult to communicate with one or two leaders or a small group. However, involving the whole community and helping them to realize what can be achieved is more difficult. If the project satisfies only the goals of certain members of the community, planners should make sure that the project does no harm to those who are not participating. A project that satisfies the needs of several different groups within the community will be more sustainable. When community members participate in all phases of project planning, execution and evaluation they will be more committed to the project and have a sense of ownership.

Planners and community members may not always agree on the priority needs of a community. Each is looking at the problem from their own point of view. If planners begin a project that addresses needs which are not identified by the community, there will be insufficient support from the community. The world fuel crisis, for example, as identified by outside experts, does not seem to be perceived as such by local people, mostly because they have other priorities and perhaps much greater problems to worry about than fuelwood and planting trees. Understanding the social structure of the community is extremely important; failure to determine who makes the decisions, and what motivates them, can lead to the collapse of even the best-planned projects.

Most governments have a national policy on forestry and accompanying forestry legislation. In addition, national development plans reflect a government's priorities in the various sectors. An analysis of these documents will reveal the political and administrative commitments towards particular forestry components. If legislation facilitating community forestry activities is not available, it is doubtful whether extension programmes can be carried out effectively.

Integrating Tree Planting into Development Planning with the Active Involvement of the Local Community

In this century, Africa's forests have been halved - the result of continuing population pressure, agricultural encroachment, fuelwood gathering, keeping of excessive livestock, fires and commercial logging. About 50 million people in Africa face an acute shortage of fuelwood. Deforestation ultimately leads to soil erosion, siltation of rivers and reservoirs, increased use of valuable agricultural residues - including dung for cooking and heating - and an environment that each year yields less of life's basic essentials for a population whose living standards are steadily deteriorating.

Many national forestry departments are still predominantly concerned with traditional forestry plantations for supplying wood products to industry. Few resources are devoted to rural afforestation, agroforestry and indigenous woodlands. Agricultural services mostly ignore the important role of trees in peasant farming systems both from a biological and economic point of view.

Problems of environmental degradation, desertification and fuelwood supply cannot be solved by tree planting alone. What is required is a holistic approach to agriculture, livestock, land settlement, forestry and energy policies. Tree planting will contribute to the control of environmental degradation only if integrated with the rehabilitation of the entire ecology of denuded lands. Apart from trees, shrubs, grass, herbs, soil and water resources have to be considered.

Tree-planting projects therefore should not be regarded as ends in themselves, with success measured solely by the numerical targets achieved. Increasing the number of trees in an area may have little beneficial effects unless it is closely related to the needs and priorities of the people living there. Thus the integration of trees into the farming system should arise from the objective not only of growing trees but of improving the rural families' welfare which may involve, among other things, the introduction of some form of woody vegetation.

A prerequisite for a social forestry programme is a sound national forest policy backed by political support and a firm commitment on the part of the government to provide adequate resources on a sustained basis to meet the broad objectives set out in the policy statement. Social forestry schemes can assume a new dimension if they are considered as a means of rural uplift. Experience shows that forestry can neither develop nor survive without the active involvement of the local community, hence community participation is one of the most important ingredients of forest development. If we want to make substantial headway in social forestry, emphasis could be put on rural forestry, i.e. integrating forestry activities with wider rural development. Initiating any community forestry scheme with community participation involves grappling with all of the interlocking social, economic and political problems associated with rural society. The process of creative community action to create better life for their members is the crux of community forestry which would turn the potential income from wastelands into actual income for the community.

The scope of the national forest policy should accord special emphasis to the role of forests, woodlands and trees in providing support services to agriculture, contributing to appropriate agroforestry systems, specifically promoting the welfare of the rural poor, contributing to the fuel and energy needs of both rural and urban people and rehabilitating marginal lands.

Community participation in planting trees is a process of developing awareness, knowledge and responsibility for forestry among rural populations

The Forestry Department has to develop a programme in which the people, once they fully understand the importance of community forestry, can actually be aided in implementing it. Non Government Organisations (NGOs) could play a vital role in re-establishing communications between people and the forestry department. NGOs have the ability, resources, staff and credibility amongst the people and with the government to play their role of go-between effectively. The NGO's could foster liaison not only with the Forestry Department, but also with other government departments which have a role to play in promoting community forestry.

Special attention should be paid to the involvement of women. New perceptions of the role of women are crucial for re-evaluating the contribution of major groups who have been historically disadvantaged. Women's actual economic and social activities, including farming of food crops, collecting of forest products such as fuel, fodder, food and medicines, rather than preconceived ideas about their feminine role, should be targeted for particular assistance. With the increasing denudation of forests, they are suffering most since they have to manage all family needs. Our endeavour is to turn these working women into growers of trees, instead of mere collectors.

Economic Consideration and Environmentally Sound Tree Planting Programmes

Given the existing technological and economic conditions, people's participation in planting trees should be seen as an integral part of a larger complex of problems: ensuring more prudent and more productive management of natural resources, contributing to soil and water conservation, increasing energy, supplying food and fodder needs, improving environmental conditions, expanding productive employment, increasing income and achieving real improvements in the quality of life.

Trees and shrubs play a critically important conservation role. They can reduce soil surface temperatures, increase infiltration and retention of soil moisture, provide organic matter, pump nutrients, fix nitrogen, reduce erosion from water and wind, form live fences, shelterbelts and windbreaks, and provide shade, all of which create better growing conditions for crops and grasses.

Important though the increase in tree growing as a cash crop is, most forestation for local community development is presently primarily to meet subsistence needs. It is important to recognize in what form costs have to be borne by a small farmer, and that particular costs may weigh much more heavily in his economic calculation than in those of a forester or decision maker. Many of his costs and benefits take forms other than cash outlays and income. Poor farmers can seldom direct resources from producing to meet immediate needs for food and income to planting trees which will start producing returns at best a few years into the future. This underlies the priority given to choice of tree species which provide benefits quickly.

Tree planting, regardless of purpose or scale takes place within a complex system of physical, biological, technical, legal, institutional, economic and socio-political factors which comprise the environment. All of these factors should be taken into consideration when planning environmentally sound and economically valuable tree planting programmes. The success of such a project in terms of woody biomass and environmental effects depends upon the type of tree species selected and the site on which it is planted.

To reach a decision with regard to the species to be planted it is necessary to consider the requirements of possible species in relation to any special features of the site as regards the general climate, soil or vegetative type of the area. The planting site as a plant assemblage and ecosystem is an interface between life-supporting media and the techno-economic level of forestry activity. Indigenous trees are the best plants for village plantations. An indigenous tree will have already adapted to local climate, type of soil and other factors which contribute to the environment of a particular place, and as such is able to resist the resident pests and diseases and can support many organisms, such as fungi, lichens, algae, insects, birds, etc. Whenever possible, use species that local residents themselves have chosen and value.

When the native trees of a country are inadequate or the indigenous tree species appear, by reason of slow growth, lack of adaptability or low quality of produce, to be unlikely to satisfy the needs of villagers, a search has to be made for other, perhaps exotic tree species.

Given that there will be a need for large scale tree planting during the coming decades, the likely level of costs and economic rates of return from such investments will be a matter of some concern. The level of investment costs per hectare and economic rates of return appraised for 32 forestation projects funded by the World Bank since 1968 show that particularly noteworthy are the high levels of economic rates of return achieved for social forestry programmes involving establishment of multipurpose trees on farm lands and agricultural wastelands in situations where much of the work is carried out by the farmer or local community using fast growing short rotation species which begin to produce utilisable output within 2-5 years of establishment.

References

Arnold, J.E.M., 1983. *Forestation for local community development*, in *Strategies and designs for afforestation and tree planting*, p. 48-61, Wageningen.

Basu, N.G., 1983. *Community forestry and local community*, in *Strategies and designs for afforestation and tree planting*, p. 193-203, Wageningen.

Plinck, E., Manandhar, P.K. and Gecolea, R.H., 1983. *Training and extension for community forestry*, in *Strategies and designs for afforestation and tree planting*, p. 331-347, Wageningen.

Spears, J.S., 1983. *Role of forestation as a suitable land use and strategy option for tropical forest management and conservation and as a source of supply for developing country wood needs*, in *Strategies and designs for afforestation and tree planting*, p. 29-47, Wageningen.

Viersum K.F., 1983. *Strategies and designs for afforestation and tree planting*, Proceedings of an international symposium, Wageningen, 19-23 September 1983.

Kengo News, Vol. II, No. 2, July 1987.

Community Forestry as Ethiopia's Problem Solver: Soil Erosion, Fuelwood and Construction Material

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Introduction

Forestry for local community development has gained considerable momentum in Ethiopia's national forest and rural development policies. Legislation is indispensable in order to promote such policies. It should, in particular, offer a firm basis for assuring tangible benefits to local communities from forest areas and activities.[4]

For the last ten years the Ministry of Agriculture in Ethiopia has carried out a community forestry programme. Many community forest nurseries have been started in order to establish community forestry plantations. In the same period, more than one million hectares of land has been utilized for soil conservation activities. However, much more will have to be done in the future. As the existence of trees in the landscape contributes directly to the conservation of the soil, there is a clear desire to integrate community forestry into soil conservation practices. Every Ethiopian needs to take responsibility for conserving nature and natural resources by tree planting measures as well as by soil conservation measures.[3,5]

Trees play an important role in the life of people throughout Ethiopia. They provide essential contributions to day-to-day life, such as fuel for cooking and warmth, forage for livestock, construction material for housing, clean and permanent water, protection from erosion and habitats for wild life.

All these direct benefits have traditionally been taken for granted. But due to the increasing population pressure there is now an acute shortage of these products in all parts of the country.[3]

Attitude of People

The people of Ethiopia have a long tradition of protecting and cultivating trees, both in cultivated lands and in forested areas. Still the natural tree cover is believed to have gone down from around 40 per cent at the onset of agriculture to only 3-4 per cent today. This is mainly due to land clearance for agriculture, logging for valuable timber, cutting of fuelwood and overgrazing.[3]

Nowadays, planting trees in Ethiopia is becoming an increasingly cultural activity; each year during the rainy season more than a million tree seedlings are planted as community forests, fuelwood plantations, etc.

With the collaboration of the Ministry of Agriculture (MOA), the Ministry of Education (MOE) started to assist by teaching people about environmental degradation and methods of reclaiming land; this educational process is carried out with the help of the Swedish International Development Agency (SIDA). However, the problems of environmental degradation, poverty and famine which afflict Wollo in the North Eastern part of Ethiopia, as well as other parts of the highlands, cannot be tackled by soil conservation alone.[1]

Conservation must be combined with education to increase production and meet the demand for fuelwood in rural areas by developing community forestry.

The environmental education programme aims to change people's attitudes and behaviour and hence to contribute to the long-term objectives of the integrated plan of action. So far it has been operating as a pilot programme. Now it is proposed that the experience and inputs of the last two years should act as a foundation for the further development of soil conservation and community forestry.[1]

Most formal education institutions within the environmental education programme have carried out some construction of terraces within school compounds.[1]

Since the mid 1970s, conservation works such as construction of stone terraces and earth banks, together with tree planting, have been undertaken;[1] if this doesn't always succeed in bringing back already lost soil and recovering the degraded land, at least it prevents conditions getting any worse, conserves the soil, and keeps the environment favourable for crop production.

Definition of Community Forestry

Community forestry has been defined as a tree growing, production-oriented activity conducted with the purpose of providing forest-based products for the direct benefit of the local community that takes part in the activity.[3]

The basic framework of the community forestry programme is that any local community, through its active involvement and participation in a forest production activity, is able to benefit directly from the product that is made available.

Objectives of Community Forestry

The broad objectives of community forestry are to satisfy the basic needs for forest products of local communities and to introduce wide environmental benefits.[3]

The immediate objective is to meet existing demand for wood products such as construction poles and timber, fuelwood and other basic forest goods.[3]

The establishment of trial and demonstration plots cover as wide a range of ecological and social conditions as possible, including soil and water conservation, agroforestry and afforestation[2].

In addition community forestry also has a number of secondary objectives:

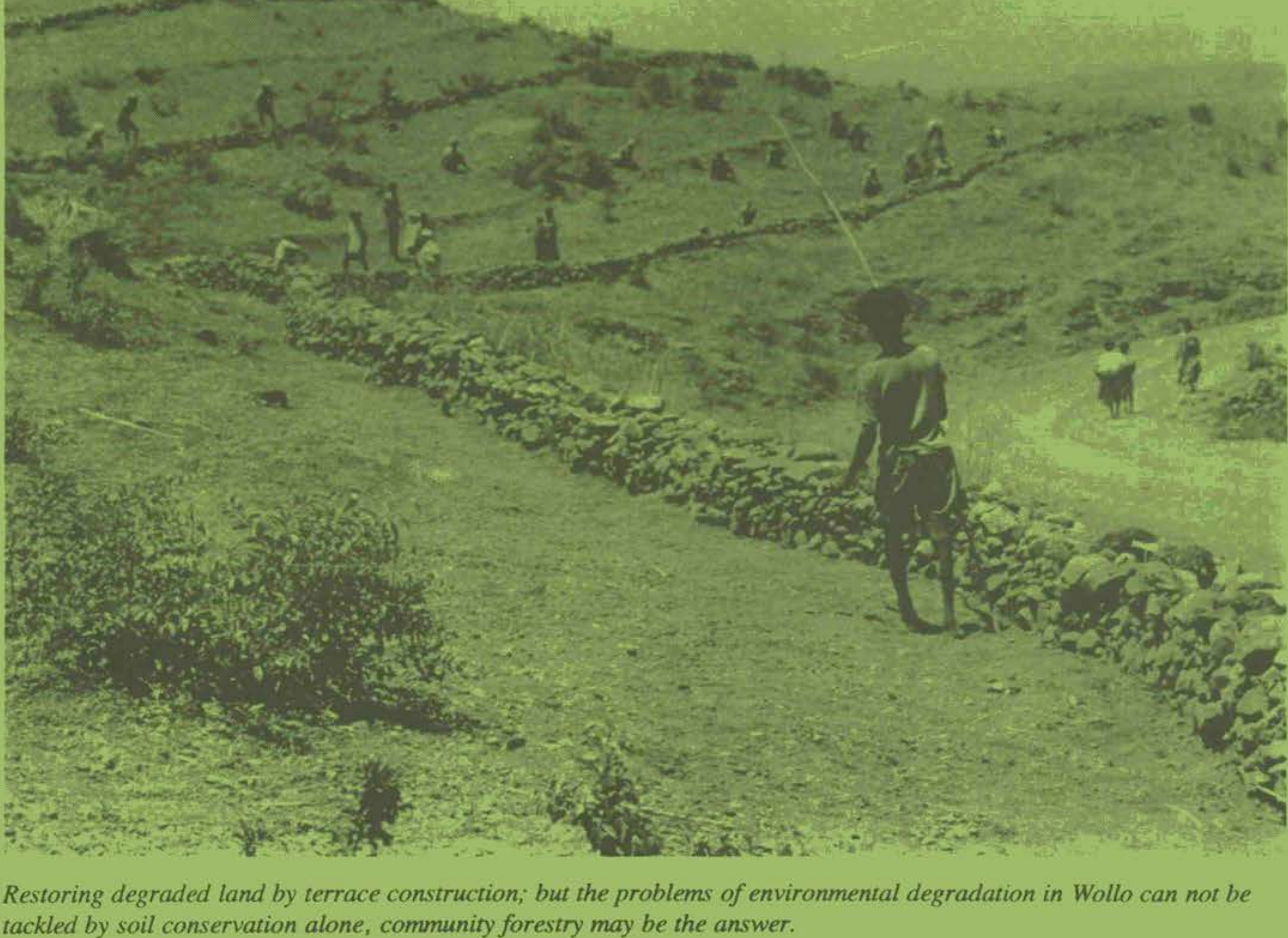
- To reduce environmental degradation and rehabilitate degraded land.
- To support and sustain agriculture production on cultivated land.
- To contribute to improved grazing conditions and increased animal production on grassland.
- To reduce the use of cow-dung as fuel by making fuelwood more easily and widely available, which will secure energy supplies and ensure that the cow-dung is used on cultivated land to improve soil conditions and contribute to increased agriculture production.
- To strengthen soil conservation efforts by growing trees and shrubs on soil conservation structures, along gullies etc.
- To improve people's standard of living by making certain forest products more easily available.
- To provide shelter and beautification around homesteads and public places.[3]

Community Forestry Measures on Different Types of Land

Since Ethiopia has a wide variety of climates, from dry to wet, and also many different altitudes, from lowland to highlands, one cannot apply the same method and community forestry measures on different types of land.

On Miscellaneous Land

Miscellaneous land is land that, although often of high



Restoring degraded land by terrace construction; but the problems of environmental degradation in Wollo can not be tackled by soil conservation alone, community forestry may be the answer.

potential, is not utilized for any planned production, be it agriculture, animal husbandry or forestry. Such land is therefore often found very close to cultivated land and grassland. Miscellaneous land usually consists of long strips or small pockets of land where trees can be cultivated without offering any competition to agriculture or animal husbandry, thus meeting the needs of the community without conflicting with other land uses.(3)

On miscellaneous land there are a number of plantation systems that can be implemented:

a. **Homestead plantation**:
This is a tree growing activity in the vicinity of people's homes and work places, i.e., around individual homes, in and around villages, around schools and factories as well as in public parks. Trees cultivated in this way provide the local people with easy access to various tree products. As the trees are grown close to where people live they can be well looked after.(3)

b. **Plantation along paths and roads**:
This is a tree growing activity on strips of land parallel to existing paths and roads. This is a good way of utilizing otherwise unproductive land. The trees will also stabilize the embankment of the path or track and provide shade to travellers as well as contributing to a better environment. Overall production of trees that are grown in small strips is higher than trees growing in closed stands. By appropriately managing and harvesting the trees, this system offers potential for producing forestry products which will benefit local communities.(3)

c. **Stream bank plantation**:
This is a tree growing activity on strips of land situated along water courses, which can be both natural waterways and streams as well as artificial channels. Due to the water seepage that always occurs from waterways, quite high tree growth can be expected. At the same time the trees shade the water surface, thus reducing evaporation. In this way, water is conserved and there is less water seepage; and this system also provides protection from the wind for neighbouring fields.(3)

d. **Farm boundary plantation**:
This is a tree growing activity along farm boundaries. The trees should not be allowed to interfere and compete with the food crops for moisture, nutrients or shade, but are to be grown "alongside" agriculture. Trees in boundary plantations also have the additional function of reducing wind velocity, thereby acting as shelterbelts.(3)

e. **Plantation around water bodies**:
This is a tree growing activity around ponds and small lakes, natural as well as artificial ones. By planting trees around a water body, its sides will become productive. The presence of trees around a collection of water can also help to limit dust and other foreign materials from blowing into the water. Similarly, a good vegetation cover on the ground above the water body will prevent soil and silt from being washed into the water. The trees reduce wind velocities over the water surface, thus reducing evaporation and, when a large area is planted, a woodlot is created.(3)

On Forest Land

Forest land is where the dominant species of vegetation is trees. Here it also means land that has been or will be selected for reforestation.

The woodlot plantation system is a traditional method in which trees are grown densely together in blocks, forming a forest stand. This is an effective way of producing wood for construction purposes and fuel and in addition creates shelter around settlements. The selection of a multipurpose species can lead to other benefits and products as well. The trees also contribute to soil conservation. Grass that grows between the trees can be cut and fed to animals.(3)

On all Land Types

These measures apply to cultivated land, grassland, forest land as well as miscellaneous land. The requirements and considerations are similar for all(3) and, in some cases, these measures may occur on more than one land type at the same time, for instance a shelterbelt might be established on the border between grazing land and cultivated land, or it may be established on miscellaneous land only.

Under this measure we see many systems of plantations:

a. **Plantation on degraded land**:
Degraded land (land which due to overuse has eroded soils and degenerated vegetation) can be planted with trees in order to reclaim and return it to production - i.e., forestry. Usually tree planting on degraded lands is carried out for the immediate purpose of conserving the soil. However, protection is combined with production so that the community's needs in forestry products are satisfied. The first benefit would be production of grasses to feed livestock.(3)

b. **Shelterbelts**:
Shelterbelts or wind breaks are barriers of trees or shrubs planted into systematic belts to reduce the velocity of the wind in windy areas. In this way trees help to:

- Prevent erosion by wind
- Reduce evaporation so that moisture is conserved
- Give the crops physical protection

While the main intention of a shelterbelt is to retain moisture and reduce wind velocity, properly managed trees and shrubs used in shelterbelts can provide many products such as fuel wood, forage, fruit, poles, fencing material, etc. Shelterbelts are ideal in combination with irrigation undertakings and can also act as a live fence(3) (where trees or shrubs are planted and grown in two or more rows to form a fence in order to protect a given area from external interference) while at the same time providing useful forestry products and conserving the soil.

c. **Gully side plantation**:
Trees are planted alongside gullies, inside gullies and at the gully's head.(3) This activity is often carried out in combination with gully control measures and the construction of soil conservation structures, such as check-dams, inside the gully. This is a good measure to utilize and improve land that is usually degraded and at the

same time put it to productive use. The trees contribute in preventing the widening and deepening of the gully through reducing the amount of water entering it.[3]

On Cultivated Land

Cultivated land is land under cultivation or laying temporary fallow, or land that will be used for cultivation in the immediate future.

This measure involves planting trees on cropland, alley cropping and planting shrubs or small trees on soil conservation structures on cultivated land, i.e., banks, bench terraces and grass strips. The advantage here is that trees and shrubs provide mulch for recycling of nutrients, the structures are stabilized, pruning provides useful by-products such as fodder, nitrogen is fixed and benefits the production of crops.[3]

On Grassland

The dominant species in grassland are grasses. Grassland includes cultivated land on which cultivation was or will have to be abandoned.

Here manageable trees and shrubs are planted in grazing lands in the hope that, particularly in times of drought, they will act as a fodder reserve.[3] The trees here have multipurposes - as shade for cattle, for community use as fuelwood and construction material and also keeping the soil firm to help prevent erosion.

Conclusion

The national average of forest coverage in Ethiopia does not exceed 3-4% but there are regions in the western part of the country where the forest covers more than 21% of the total area. This shows that if the community is aware of the use of forest the potential for successful planting is there. However in order to succeed, environmental education is vital.

To improve the country's forest coverage requires the participation of the entire community. Rural populations can participate, as individuals, or in corporate activities or on government lands, and in any phase of forestry development, from planting through to the consumption or sale of forest produce[4].

Community forestry is not only carried out on large areas of land but also on small pockets of land and on land that is cultivated for food crops by alley cropping with trees.

When the area covered by forest is increased, soil that would otherwise be lost by wind and water erosion will be reduced. This helps to reduce the spread of dryland areas further afield which, if unarrested, can cause poverty and famine.

If other African countries that are similarly afflicted by poverty and famine caused by dryland encroachment also follow the community forestry programme, they can improve the living standards of their people and also reduce the encroachment of the desert.

References

1. Ministry of Education, 19 June 1987, Final reports of a joint evaluation team on the MOE's SIDA-supported soil conservation/community forestry programme.
2. ICRAF, orgut-swedforest consortium, December 1985, Design of trial and demonstration activities at the Ethiopian Centre for Community Forestry and Soil Conservation (Mertu-Lemanriam).
3. Ministry of Agriculture, Community Forestry and Soil Conservation Department, February 1988, Guidelines for development agents on community forestry in Ethiopia.
4. Food and Agriculture Organization, 1986, Forestry paper 65.
5. Grunder, M., January 1988, Paper presented for 6th International Soil Conservation Conference.

Notes on the Germinability of some Tree Species and Results of Reforestation Activities in Wollo Region, Ethiopia

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Abstract

The germinative energy of different tree species used in reforestation activities in Wollo region, Ethiopia, was tested. Germinative energy at 21 days ranged from 100% for Eucalyptus globulus *to 22% for* Cassia simea. *Survival of seedlings on over 390 hectares of reforestation sites with a variety of species ranged from 100% for* Acacia albida *to 40% for* Sesbania.

Wollo Region in Ethiopia

Introduction

Wollo is one of the regions of Ethiopia which was heavily struck by the drought in the 1984-1985 period. The region and its environment is quite variable, consisting of high plateaux reaching over 3,000 metres above sea level and deep valleys with bottom land in some cases at less than 1,500 metres above sea level.

Erosion is serious and soil conservation measures are fragmentary.

The arboreal vegetation is scarce and the indigenous trees have been almost completely replaced by other species, especially eucalyptuses.

The main species still present in the region are: *Acacia abyssinica, A. seyal, A. lahai, A. asak, Cordia africana, Opuntia indica, Euphorbia spp., Ficus spp., Rumex nervosa, Dodonea viscosa, Chroton machrostachis, Olea africana and Juniperus procera.*

The climate experiences a bimodal rainfall pattern: the big rains or *Kremt* from June to September and the small rainy season or *Belg* somewhere from February to April. The objective of the investigation was to examine the germination at 21 days under standard laboratory conditions of several indigenous and locally adapted species, using germinative material from local sites and to assess the survival rate at 10 months of reforestation sites. Reforestation was carried out with seedlings prepared at Kundi nursery situated at 1,800 metres above sea level.

Materials and Methods

Seeds for the germination trials were collected along the Kes Kes river basin and in the highlands of Wollo, in the provinces of Desie Zuria, Where Himeno and Wadla Delanta. Mature material was collected, cleaned and dried in a ventilated and shaded area and packed in cotton bags. Sufficient material was sent to Shola Forestry Center, Addis Ababa, for standard germination trials.

The following species were collected and/or tested:

Calpurnia aurea, Acacia dicurrens, Olea africana, Cassia simea, Pterolobium stellatum, Croton, Cordia africana, Juniperus procera, Schinus molle, Eucalyptus globulus, Acacia saligna.

For reforestation purposes, instead, the following seedlings were tested for growth at the nursery:

1 *Acacia albida*; 2 *Acacia dicurrens*; 3 *Acacia saligna*; 4 *Albizia lebbeck*; 5 *Acacia tortilis*; 6 *Casuarina equisetifolia*; 7 *Cordia africana*; 8 *Cupressus lusitanica*; 9 *Cupressus pyramidalis*; 10 *Eucalyptus citriodora*; 11 *Eucalyptus globulus*; 12 *Olea africana*; 13 *Pinus patula*; 14 *Schinus molle*; 15 *Sesbania aculeata*; 16 *Juniperus procera*.

Seeds of species numbered 1, 2, 3, 4, 5, 15 were soaked in boiling water and let to stand for 24 hours before planting; species numbered 6, 7, 8, 9, 11, 13, 14, 16 had no pre-treatment while numbers 10 and 12 were soaked for 24 hours in cold water only. After treatment, seeds were sown in a germination bed and transplanted, when sufficiently grown, in polyethylene bags ten centimetres in diameter and 20 centimetres high, open at the end and pierced at the bottom.

A mixture of fine soil and sand was used to fill the pots. Both sown and transplanted material was kept shaded under elevated bamboo/grass shading mats.

The watering interval was variable and according to rainfall. The total amount was equivalent to 5 mm of water per day. Several sites were reforested ranging from 1,800 to 3,000 metres above sea level. More drought resistant species such as *Acacia* and *Schinus* were planted in lower and drier areas while *Olea*, *Eucalyptus* and *Cupressus* were planted in higher areas where more rainfall could be expected.

Seedlings were transported to the plantation sites either by donkey or on foot and were planted, eliminating the plastic pot, in 40 cm wide and 30 cm deep hand dug pits. Planting interspacing was variable and as specified in Tables 2, 3 and 4. Survival rate was recorded counting empty pits and vital plants approximately 10 months after reforestation.

Results and Discussion

The results of the germination tests at 21 days carried out on the collected seeds are summarized in Table 1.

For reforestation purposes only a few species among the sown seedlings were actually used, since *Albizia lebbeck, Casuarina equisetifolia, Cupressus pyramidalis, Eucalyptus citriodora and Pinus patula* germinated poorly at the nursery and not sufficient seedlings were available.

The survival rates at afforestation sites was quite variable but good altogether. Breakdown by species, altitude and province is reported in Tables 2, 3 and 4.

The germination laboratory tests were encouraging for some species such as *Eucalyptus* (100%) but not for other such as *Cassia simea* (22%). It is likely that some of the seeds were not at the proper maturation stage.

In the afforestation activities *Acacia dicurrens* was found at times to be slightly damaged by wild animals.

Altogether survival rates at reforestation sites are quite interesting. Data from another agency working in reforestation in the same area of Ethiopia (but in a different period) is reported in Table 5.

The outstanding results obtained in the current project may be explained by several factors, including the great manual inputs in planting and following the growth of the seedlings (all food for work activities), the difference in planting of species according to altitude and (likely) rainfall, and the exceptional favourable rains which occurred after plantation. In fact, the bimodal rainy season was almost uninterrupted with providential showers even during the dry periods. The reported findings could be of help for other operators since, when starting reforestation works in specific areas, little data is available and previous experience could be helpful to limit mistakes, to cut down time and perhaps to limit research just to essential, lengthy adaptability trials.

Species	Germinative energy (%) at 21 days
Calpurnia aurea	97
Acacia dicurrens	89
Olea africana	100
Cassia simea	22
Pterolobium stellatum	71
Croton	50
Cordia africana	47
Juniperus procera	43
Schinus molle	37
Eucalyptus globulus	100
Acacia saligna	82

Table 1: Germinative energy of different seeds

	Altitude					
Species	High	D	Medium	D	Low	D
Acacia saligna			45	2	90	2
Acacia dicurrens			65	2		
Eucalyptus globulus	90	2				
Sesbania					40	2
Schinus molle			50	2	60	2

Low: 1800m, Medium: 2000-2500m,
High: 2500m and above
D = distance in metres at which seedlings were planted

Table 2: Wadla Delanta province reforestation results on 87 hectares

Species	Altitude High	D	Medium	D	Low	D
Acacia saligna			85	2	95	2
Acacia dicurrens	75	2	85	2	70	2
Acacia tortilis					75	2
Acacia albida					100	10*
Eucalyptus globulus	95	2				
Cordia africana					65	4
Schinus molle			45	2	90	2
Olea africana	70	2	60	2		
Juniperus procera	50	2				

Low: 1800m, Medium: 2000-2500m,
High: 2500 and above
D = distance in metres at which seedlings were planted
* planted on farmland

***Table 3:** Desie Zuria province reforestation results on 203 hectares*

Species	Altitude High	D	Medium	D	Low	D
Acacia saligna			85	2		
Eucalyptus globulus	95	2				
Cupressus	85	2				

Low: 1800m, Medium: 2000-2500m,
High: 2500m and above
D = distance in metres at which seedlings were planted

***Table 4:** Where Himeno province reforestation results on 104 hectares*

Species	Survival rate in %
Acacia saligna	37
Acacia dicurrens	34
Acacia abyssinica	45
Eucalyptus globulus	53
Eucalyptus camaldulensis	65
Schinus molle	53
Juniperus procera	48
Cupressus lusitannica	54
Casuarina equisetifolia	30
Grevillea robusta	36

***Table 5:** Afforestation survival rates for 1988 planting season in Desie Zuria Region (Source: Mennonite Mission to Ethiopia Quarterly Report, 1989)*

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Bibliography and Supporting Material

International Seed Testing Association, 1976. *International rules for seed testing* in *Seed Science and Technology*, vol. 4, pp. 3-177

Weber, F.R., 1977. *Reforestation in Arid Lands*, VITA, Vita Publications, manual series no. 37E

Constable M., 1985. *Ethiopian Highland Reclamation Study*, Working Paper no. 24, Ministry of Agriculture/FAO, Addis Ababa, Ethiopia

International Livestock Center for Africa, 1986. *Potentials of forage legumes in farming systems in sub-Saharan Africa*, proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, ISBN 92-9053-080-4

FAO, 1983. *Guidelines: Land Evaluation for Rainfed Agriculture in FAO Soils Bulletin no. 52, ISBN 92-5-101455-8*

Composition of Plants - an Aid in Selection of Sand Dune Stabilization Species

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Abstract

Sand encroachment by winds over agricultural land, roads, pipelines and residential areas is a serious social and economic problem in Saudi Arabia. Research has proven that afforestation offers a permanent solution to the dune problem. Selection of a suitable plant species is crucial for successful afforestation. The objective of this paper is to discuss how plant ecology and chemical composition can aid in selecting plant species for afforestation of dunes.

A desert area northwest of Safwa was selected for this study. Plant communities and their ecological environments were investigated. Seven plant species were selected for further investigation. Samples of plant, soil and groundwater were collected and analyzed for several parameters using standard procedures. Correlation between the plant species and their environments was established. The results of this study are discussed in reference to the afforestation of sand dunes in Saudi Arabia.

Introduction

Wind blown sand is threatening agricultural lands, roads, pipelines, residential areas and other facilities. It is recognized as a serious social and economic problem in Saudi Arabia (Abdulwahid, 1979; Aziz and Abdulwahid, 1977; Abolkhair, 1981; El-Khatib, 1974).

Research conducted at the Research Institute of King Fahd University of Petroleum and Minerals, Dhahran, proves that afforestation offers a permanent solution to the dune problem (Armst, 1942; El-Khatib 1974; Kerr and Nigra, 1951). Vegetation provides the most desirable and permanent solution relative to other sand control methods which are often temporary, relatively more expensive and unsightly. Moreover, plants are ecologically beneficial to destabilized areas and add organic matter to the soil. Addition of organic matter to the soil improves the plants' micro-environment and exerts a binding effect on the soil. Vegetation is also the most aesthetically pleasing of sand control methods.

Afforestation of dunes is difficult and its successful implementation depends on several factors. Probably the most important and crucial for successful afforestation is the selection of a suitable plant species. The objective of this paper is to discuss how plant ecology and chemical composition could aid in the selection of plant species for afforestation of dunes.

Materials and Methods

Study Area

A desert area, northwest of Safwa in the Eastern Province of Saudi Arabia, was selected for this study. In order to identify plant communities, plant species and population density, 21 quadrats were randomly selected in the study area. The size of each quadrat was 5m x 5m ($25m^2$). These quadrats were fixed in different geomorphological settings. Each plant community was named after the dominant species in the quadrat. In naming a community, the dimensions of aerial and underground organs of plant species and its vegetative, social and reproductive behaviour were also considered.

Ecology of the Study Area

Natural vegetation of the study area comprised trees, shrubs and perennial and annual grasses. The density of vegetation was primarily controlled by climatic and edaphic factors. Relief characteristics, depth of groundwater table, wind action and salinity of soil and groundwater play an important role in determining plant density. The mean temperature in the study area exceeded 35°C for the month of July but dropped below 16°C in January. Maximum air temperature during summer reached 50°C and nearly 70°C on the upper surface of sand. Winds blow predominantly from north-northwest. During "Shamal" - the winds that blow in June and July - wind speeds increased to reach speeds of 40-50 km/hr, creating blowing dust and low visibility. Precipitation in the study area is low, approximately 77 mm/year. The rainy season extends from December to March: during summer the rainfall is almost nil. Relative humidity ranged from 30 to 60% during most of the year; however, between July and September relative humidity may reach 80 to 100% while in winter, from November to January, values between 60 to 100% are quite common. There is a shallow groundwater aquifer which ranges between 0 and 18 m from the surface. Salt concentrations of the shallow water varied between 10,000 and 50,000 mg/kg. The study area is underlain by shallow dipping late tertiary sediments of the hard rock formation which includes silty sandstones, sandy limestones and sandy marls.

Soil and Plant Analysis

Soil samples from the upper layer (0-50 cm) depth were taken from each quadrat for physical and chemical analyses. All the determinations were conducted using a 1:1 soil:water extract.

Samples of aerial parts of the dominant plant species were taken, dried at 110°C and ground to pass through 20 mesh sieve. Plant material was wet digested using nitric-perchloric acid mixture. The digestates were filtered and volume was increased to 50 ml using distilled water. The filtrates were used for chemical analysis. Concentrations of sodium, magnesium, potassium, chloride and sulfate in soil extracts and plant digestates were determined using standard methods of soil and plant analyses (Black *et al*, 1965).

Results and Discussion

Plant Communities

A plant community has been defined as "the integrated mixed population stands that occur as closed groupings" (Alechin, 1926). Desert plant communities have a number of features in common such as:

- dominance by one species which gives the community visual uniformity;
- common existence of associated plant species;
- high frequency or density of one or more species; and
- association with specific habitats.

The plant communities studied were:

- *Panicum* Community
- *Pennisetum* Community
- *Hammada* Community
- *Zygophyllum* Community and
- *Leptadenia* Community.

The following is a brief discussion of the main plant species in each community.

Panicum Community

Panicum turgidum was the main plant species in this community. This species belongs to the family *Gramineae*.

Experiments at the ICRAF Research Station in Machakos, Kenya have shown that Prosopis juliflora *is particularly resistent to drought conditions. Photo: T. Maukonnen*

It is woody, densely branched with thick roots and reaches a height up to 1.5 m.

This community was found on the vegetated sandsheets, parabolic dunes and quaternary beach rocks. The existence of the community is a good indication of stable soil conditions. The associated plant species included *Calligonum comosum*, *Cyperus conglomeratus*, *Hammada elegans*, *Pennisetum divisum*, *Moltkiopsis ciliata*, *Monsonia nivea* and *Convolvulus prostratus*.

Pennisetum Community

Pennisetum divisum was the most abundant plant species in this community. This plant belongs to the family *Gramineae*. It grows densely and puts out woody clubs up to 150 cm high from a strong woody root stock. Persistent empty yellow leaf sheathes were present at the swollen nodes.

This community was usually found on the fine texture soil occurring in depressions, wide runnels and *wadis*. Such soil shows low salt contents. The common associated plant species are *Cyperus conglomeratus*, *Moltkiopsis ciliata*, *Panicum turgidum and Stipagrostis plumosa*.

Hammada Community

The most important plant was *Hammada elegans* which belongs to the family *Chenopodiaceae*. *Hammada elegans* is a branched, erect, leafless plant of 30-70 cm height. This community was usually found on parabolic dunes, vegetated sand sheets and rock outcrops associated with sandsheets.

The other plant species included *Astenatherium fragilis*, *Calligonum comosum*, *Cyperus conglomeratus*, *Moltkiopsis ciliata*, *Monsonia nivea* and *Stipagrostis plumosa*.

Zygophyllum Community

Zygophyllum coccineum was the most abundant plant in this community. *Zygophyllum coccineum* belongs to the family *Zygophyllaceae*. It grows up to 75 cm high and has succulent, fleshy leaves. It is common on saline sandsheet and sabkha borders. It was most often associated with *Aeluropus massauensis*, *Zygophyllum album* and *Zygophyllum quatarense*.

Leptadenia Community

Leptadenia pyrotechnica was the most abundant plant species in this community. It belongs to the family *Chenopodiaceae*. It is usually an erect shrub or small tree reaching a height up to 3 m. Its stem is green and has numerous spinescent branches. Leaves are usually absent. This community is usually found on the top and wind exposed areas of mobile and semi-fixed dunes and in depressions in which blown sand is accumulating.

The associated species were *Cyperus conglomeratus*, *Moltkiopsis ciliata*, *Monsonia nivea*, *Panicum turgidum* and *Stipagrostis plumosa*.

*Beans/grass strips/*Grevilla robusta *are used in an experiment to stabilize soils on slopes at the ICRAF Research station in Machakos. Photo: T. Maukonnen*

Sample Type		Mean concentration in mg/kg or l					
Panicum turgidum							
	pH	Sodium	Calcium	Magnesium	Potassium	Chloride	Sulphate
Plant	nd	953	10,486	1,936	5,250	3,844	9,577
Sand	7.9	nd	209	9	9	54	765
Ground Water	7.3	13,262	1,075	1,037	357	23,859	3,126
Pennisetum divisum							
	pH	Sodium	Calcium	Magnesium	Potassium	Chloride	Sulphate
Plant	nd	986	8,264	2,204	4,755	4,715	7,466
Sand	7.5	nd	230	24	10	149	972
Ground Water	7.5	6,240	672	535	188	9,904	1,956
Hammada elegans							
	pH	Sodium	Calcium	Magnesium	Potassium	Chloride	Sulphate
Plant	nd	12,070	40,668	10,750	13,874	7,603	8,300
Sand	7.7	nd	296	21	14	388	1,340
Ground Water	7.5	7,797	783	621	215	12,349	3,107
Zygophyllum coccineum							
	pH	Sodium	Calcium	Magnesium	Potassium	Chloride	Sulphate
Plant	nd	8,532	22,963	29,321	3,109	26,096	169,400
Sand	nd	nd	483	45	9	1,228	1,745
Ground Water	7.5	11,541	1,129	905	322	23,557	2,517
Leptadenia pyrotechnica							
	pH	Sodium	Calcium	Magnesium	Potassium	Chloride	Sulphate
Plant	nd	900	6,388	1,688	9,396	4,074	6,590
Sand	8.2	nd	11	2	2	0.5	9
Ground Water	7.3	15,950	1,200	2,000	325	30,347	3,520

nd = not determined

Table 1: *Chemical analysis of desert plants, soil and water samples*

Chemical Composition and Afforestation

Chemical composition of vegetative parts of the selected plants, upper zone of the soil (0-50 cm) and shallow water table are given in Table 1. Results show that all five plant species have different abilities to assimilate and store different types of salts in their vegetative parts. There are some plants having greater capability of storing salts in their vegetative parts especially in the cell sap but, when grown on normal soil, they take up all available salts quickly and thus maintain a high salt content in their cell sap. The stimulating effect is primarily due to the chloride ions which cause a swelling of the proteins leading to a succulence of the organs. This is true in the case of *Zygophyllum coccineum* where the highest mean concentration of chloride ions (26,096 mg/kg) was observed in its vegetative parts and which has succulent fleshy leaves. It was found growing on saline soils near sabkha borders having high chloride concentrations (23,557 mg/kg). Chloride concentrations of the vegetative parts in the other four plant species were between 3,844 and 7,603 mg/kg.

The highest mean sulfate concentration (169,400 mg/kg) was found in the vegetative parts of *Zygophyllum coccineum;* in the other four plant species it ranged between 6,590 and 9,577 mg/kg. This indicates that *Zygophyllum coccineum* has the strongest affinity for sulfate assimilation, followed by *Panicum turgidum*.

The highest calcium concentration (40,668 mg/kg) was found in *Hammada elegans* followed by *Zygophyllum coccineum* with 22,063 mg/kg. It can therefore be concluded that *Hammada elegans* has a special preference for calcium assimilation and storage even when the soil and shallow water table contain little calcium. The least calcium was found in plant tissues of *Leptadenia pyrotechnica*. The calcium content of *Panicum turgidum* and *Pennisetum divisum* ranged between 8,264 and 10,486 mg/kg.

Potassium is a major element needed by the plant mainly for activation of various enzymes and regulation and control of different activities of various essential mineral elements. The highest mean concentration of potassium (13,874 mg/kg) was found in *Hammada elegans* and the lowest, 3,109 mg/kg, in *Zygophyllum coccineum*. High concentrations of potassium in *Hammada elegans* tissues may indicate some restrictions of growing under hypersaline conditions. For example, this plant may not grow well in soils where adequate amounts of plant available potassium are not present.

Magnesium is taken up by the plants in ionic (Mg^{++}) form. It is the only mineral constituent present in chlorophyll. It is also responsible for activation of different enzyme systems. The highest mean concentration of magnesium (29,321 mg/kg) was found in *Zygophyllum coccineum* tissues and the lowest (1,936 mg/kg) in *Panicum turgidum* although there was no great variation of this element in underground water in either case.

Different plant species have different abilities to accumulate sodium. Some species excrete sodium from their leaf surface. Large amounts of sodium in soil may have some negative effects on plant growth by exerting adverse structural modification (i.e. poor aeration and low water availability) of the soil. The highest mean sodium concentration (12,070 mg/kg) was detected in *Hammada elegans* and the lowest (953 mg/kg) in *Panicum turgidum*. The effect of increase in sodium in soil is more related to inherent specificity of the species in accumulating several other cations. It seems that *Hammada elegans* and *Zygophyllum coccineum* can tolerate reasonably high amounts of sodium relative to the other three plant species.

It is not possible to modify the desert environment on a large scale to suit the growth and establishment of different plant species. But suitable plant species can be selected that can survive under required ecological conditions. The ecological system of the study area has dunes, sandsheets and sabkhas. This means that the selection of plants for this area should be based on those with high saline and temperature tolerance, that can resist wind and that require little water, etc.

The results of this study suggest that *Zygophyllum coccineum* is ideal for afforestation on saline sandsheets, followed by *Hammada elegans*. Chemical composition of the other three plant species indicate their low salt tolerance. These, therefore, can be grown under less saline conditions. Moreover, their growing behaviour in the field also indicate that they could be grown in thick sandy areas having lower salt concentrations.

Due to the lack of adequate data it was not possible to study the correlation between soil and plant composition by applying any statistical method. More research work is needed before a definite correlation between soil characteristics and plant growth can be established.

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References

Abdulwahid, Y., 1979. *Sand stabilization project in Al-Hassa*, Forest Department, Ministry of Agriculture and Water, Saudi Arabia.

Abolkhair, Y.A.S., 1981. *Sand encroachment by winds in Al-Hassa of Saudi Arabia*, Ph.D. Dissertation, Department of Geography, Indiana University, U.S.A.

Alechin, W.W., 1926. *Was ist eine Pflanzengesellschaft?* Ihr Wesen und ihr Wert als Ausdruck des sozialen Lebens der Pflanzen, Repert. Spec., Nov. 37, pp. 1-50.

Arnst, W., 1942. *Trees against the winds*, American Forest 48, pp. 543-545.

Aziz, M. & Abdulwahid, Y., 1977. *The final report on the Second Agriculture Defence Line in Al-Hassa*, Sand Stabilization Project, Ministry of Agriculture and Water, Saudi Arabia.

Batanouny, K.H., 1981. *Ecology and Flora of Qatar*.

Black, C.A., Evans, D.D., White, J.L., Ensminger, L.E. and Clark, F.E. (Eds), 1965. *Methods of Soil Analysis*, 1st edition, volume 1, Soil Science Society of America Inc., Madison, Wisconsin, USA.

CSTPA, 1974. *Handbook on reference methods for soil testing*, Athens, Georgia, USA, Council for Soil Testing and Plant Analysis.

Doll, E.D. & Lucas, R.D., 1973. *Testing of soils for potassium, calcium and magnesium*, pp. 133-151, in Walsh, L.M. & Beaton, J.D. (Ed.) *Soil Testing and Plant Analysis*, Soil Science Society of America Inc., Madison, Wisconsin, USA.

Fagotto, F., 1987. *Sand Dune Fixation in Somalia*. Environmental Conservation, 14(4), pp. 157-163.

Kerr, R.C. & Nigra, J.O., 1951. *Analysis of aeolian sand control*, Saudi Arabia, Arabian American Oil Co.

El-Khatib, A.B., 1974. *Seven Green Spikes*, Ministry of Agriculture and Water, Saudi Arabia.

McLaren, 1979. *Environmental Study of Jubail Area*, Report prepared for the Royal Commission.

Mijahid, A.M., 1978. *Flora of Saudi Arabia*.

Al-Muhandis, N. Kurdi, 1977. *Surface Exploration and Testing Program*, Vol II, Unpublished report.

Sen-dou chang, 1977. *Desert Development and Management*, Volume 4, 1982, Proceedings of an International Conference held in Sacramento, CA, May 31-June 10.

Land Degradation and Resource Management in Kenya

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This paper was originally presented at the Regional Training Course on Land Use Management and Extension, organised by KENGO in Nairobi, Kenya, August 1990.

Introduction

According to the National Environmental Secretariat of Kenya (NES) some 483,830 km^2 of Kenya's land area of 569,137 km^2 is already experiencing some form of desertification, that intricate process of land degradation whereby the biological potential of the land and its ability to support populations is severely diminished or destroyed. What this means is that in about 85% of Kenya today, there is widespread deterioration of ecosystems and diminution or destruction of the land's potential for plant and animal production. The precise extent of the destruction of Kenya's land potential is not known. According to NES however, some 110,500 km^2 or 19.3% of Kenya can be considered to be already severely affected and some 53,500 km^2 or 9.4% of Kenya shows latent to moderate signs of deterioration. In other words, the productivity of about 30% of the country has been moderately to seriously affected, with about 55% in imminent danger of declining productivity and only some 15% of the land in good condition. For a nation so heavily dependent on agriculture as its major source of livelihood, this is a very serious state of affairs.

Land Use and the State of the Environment in Kenya

The Department of Resource Surveys and Remote Sensing (DRSRS), formerly the Kenya Rangeland and Ecological Monitoring Unit (KREMU) has been using satellite, aerial and ground observation to establish the basis for a continuous flow of reliable information techniques on land use and land cover in Kenya. The land use and land cover mapping recently undertaken by DRSRS was based on 1.1 million scale Landsat imagery and covers the whole country. A preliminary map was produced by projecting 1972-80 Landsat colour composite transparencies on to 1:250,000 scale base maps. The delineation of homogeneous land use categories was based on the various colours, textures and patterns found on imagery and subsequently checked from light aircraft and the ground.

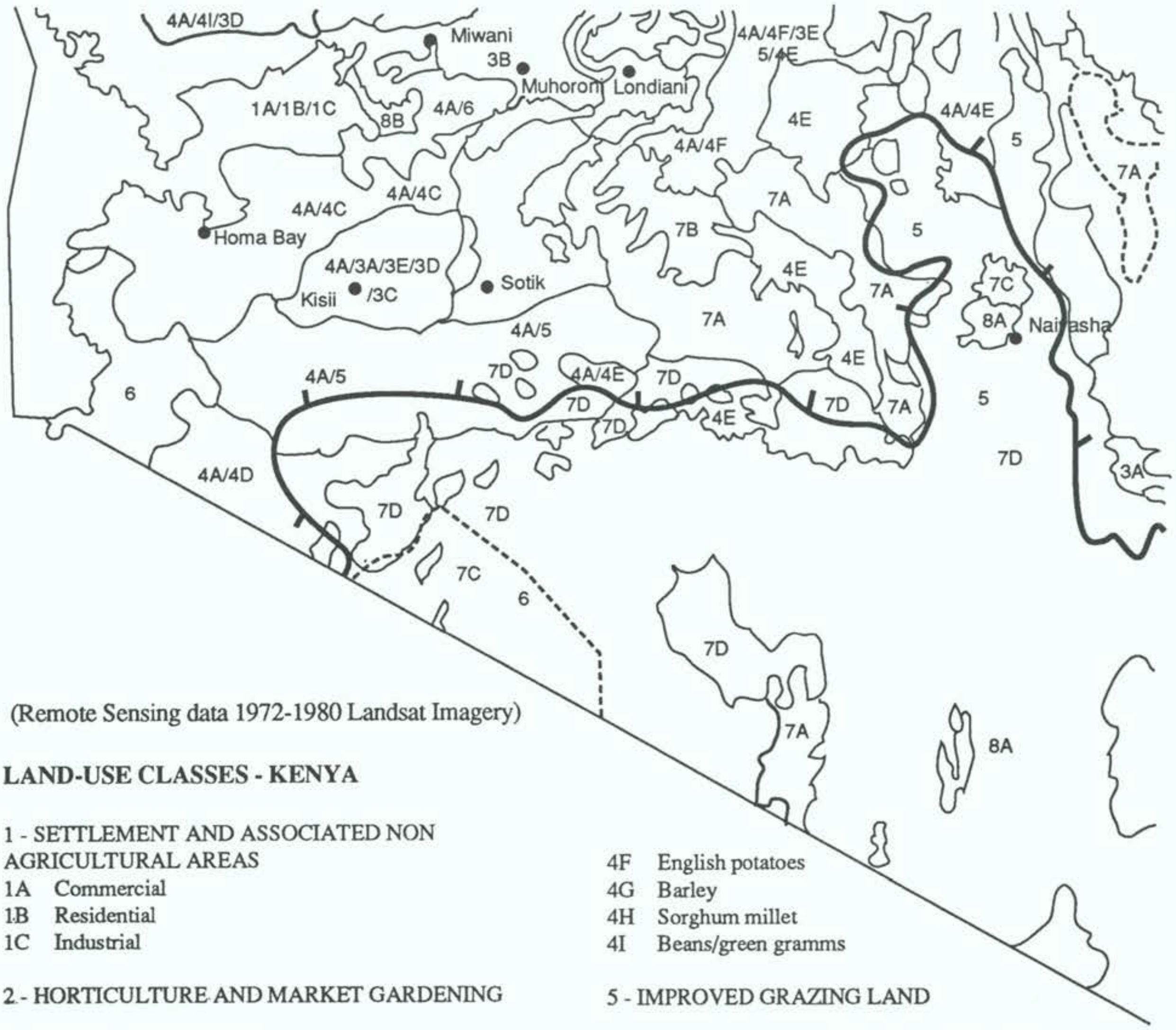
The result is Figure 1 which shows the land use classes of a part of Kenya. According to DRSRS, the actual area under cultivation in Kenya covers 91.238 km^2 which is 17.2% of the whole country (Epp, H. *et al* 1982, p. 120). Figure 2 shows differences in land use intensity from province to province. The results of this nationwide survey show that all the land area suitable for rainfed cultivation in Kenya is already being used and there has been a shift in the agricultural boundary from the high potential areas in to the semi-arid areas.

According to an FAO/UNFPA survey of food producing potential, the population of Kenya's high potential areas has already exceeded the land's carrying capacity, that is, the number of people or animals that a given area of land can support on a sustained basis at a given level of inputs and technology. Carrying capacity can be increased by raising the level of technology and inputs applied by using fertilizers, pesticides, improved crop mixes and conservation measures - and many commercial farmers in Kenya's highlands have done so. But that requires capital and for the average subsistence farmer, it is often not readily available.

Arable land for subsistence farming in the high potential areas of Kenya is also in short supply. Projections in 1977 and 1981 show that Nyanza region, the country's largest high-potential farming area, is expected to run out of additional land for subsistence farming by 1995 (Kisumu district 1983; Kisii 1983, South Nyanza 1987; Siaya 1995) (Kinyanjui and Baker 1980, p. 3, Milas and Asrat 1985, p. 36). In most of the province it has already happened as it has in Central province, one of the two main high potential farming areas.

Now Kenya's severe shortage of arable land is resulting in the inevitable expansion of the cultivation boundary into the arid, drought-prone marginal range areas of the east and north. Figures 3 and 4 and Table 1 which show the results of detailed land use mapping by remote sensing at 1:250,000 scale on a district basis by DRSRS, bear clear testimony to the shift in the agricultural boundary from the high potential areas into the semi-arid areas of Kitui, Narok and Kibwezi.

As a result of rapid population growth and its spill-over effects from lands of high potential to those of marginal productivity, some semi-arid districts such as Machakos, Kitui, Embu and Baringo are among the



(Remote Sensing data 1972-1980 Landsat Imagery)

LAND-USE CLASSES - KENYA

1 - SETTLEMENT AND ASSOCIATED NON AGRICULTURAL AREAS
1A Commercial
1B Residential
1C Industrial

2 - HORTICULTURE AND MARKET GARDENING

3 - PERENIAL CROPLAND
3A Tea
3B Sugarcane
3C Coffee
3D Bananas
3E Pyrethrum
3F Cassava
3G Sisal
3H Pineapples
3I Coconuts
3J Cashewnuts

4 - ARABLE CROPLAND

4A Maize
4B Rice
4C Cotton
4D Tobacco
4E Wheat
4F English potatoes
4G Barley
4H Sorghum millet
4I Beans/green gramms

5 - IMPROVED GRAZING LAND

6 - UNIMPROVED GRAZING LAND (RANGELAND)

7 - WOODLAND FOREST
7A Dense forest (natural)
7B Plantation forest or open woodland
7C Riverine forest
7D Mixture of bushes and woodland

8 - WATERBODIES
8A Lakes and ponds
8B Swamps and marshes

9 - BADLAND OR BARREN (AGRICULTURALLY UNPRODUCTIVE)

HIGH POTENTIAL AGRICULTURAL AREA

0 20 40 60 80 100 K.M.

Source: Agatsiva and Mwendwa (1982)

***Figure 1:** Land use map of a part of Kenya*

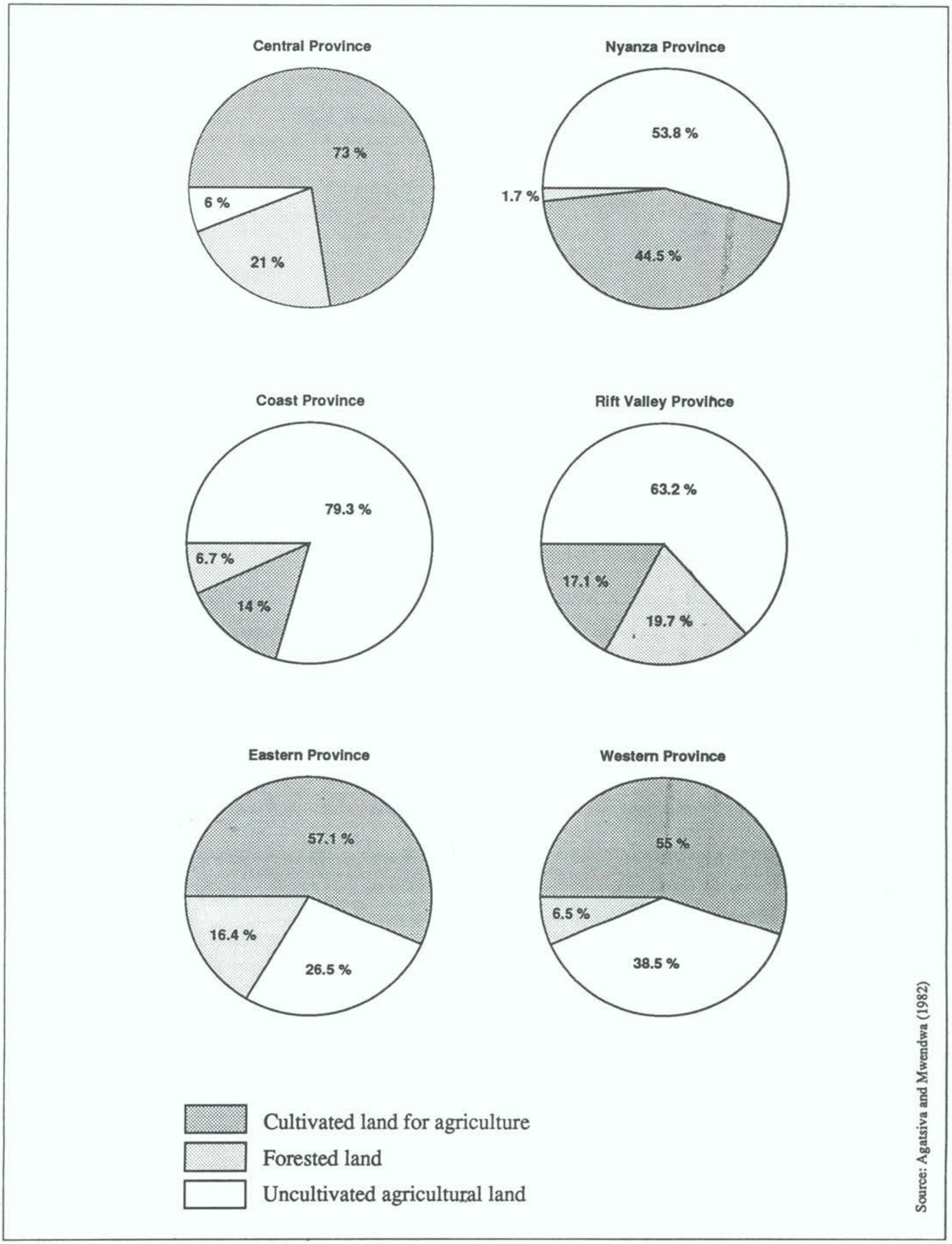
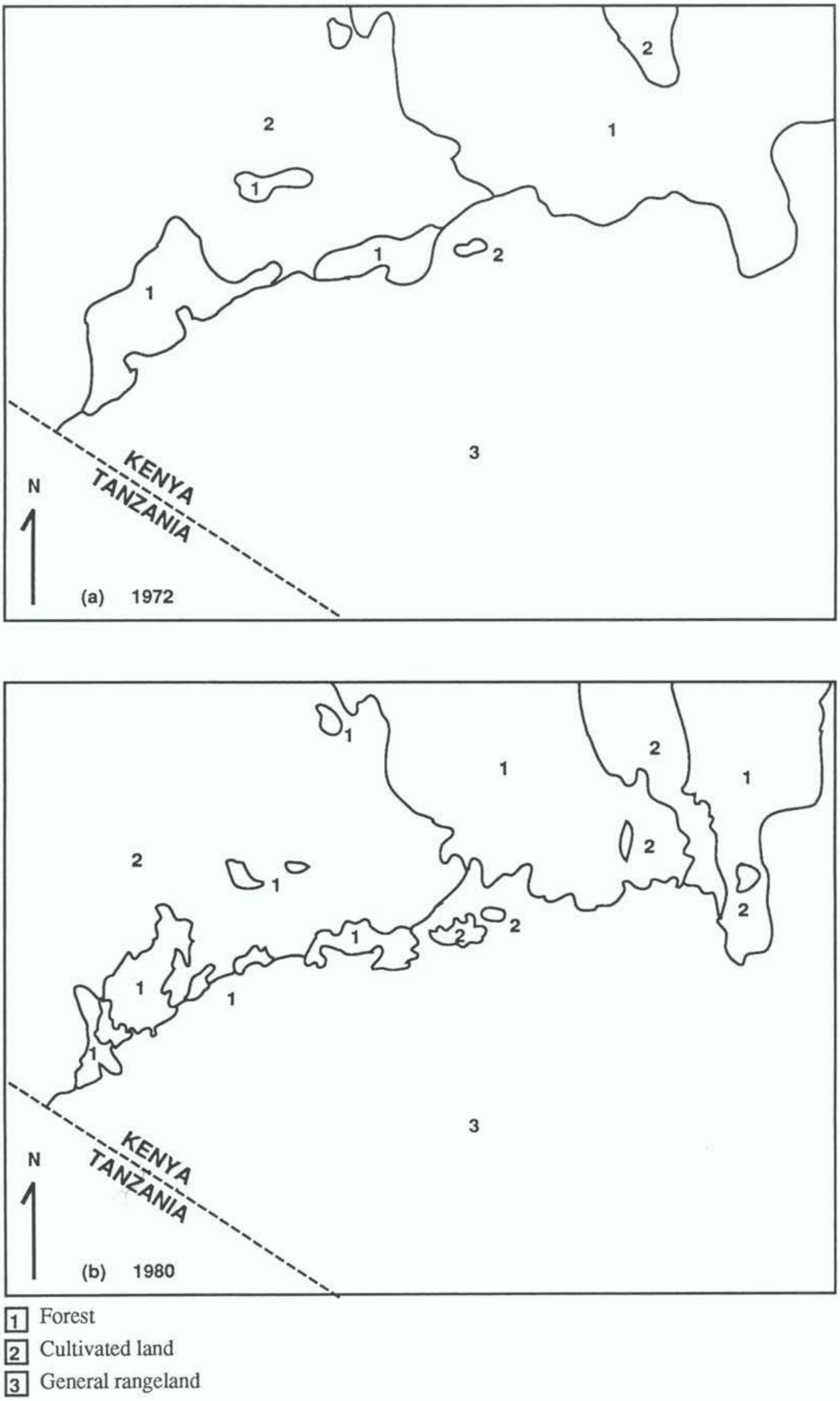


***Figure 2:** Differences in Land use Intensity*



Source: Agatsiva and Mwendwa (1982)

Figure 3: Agricultural Encroachment in Narok District

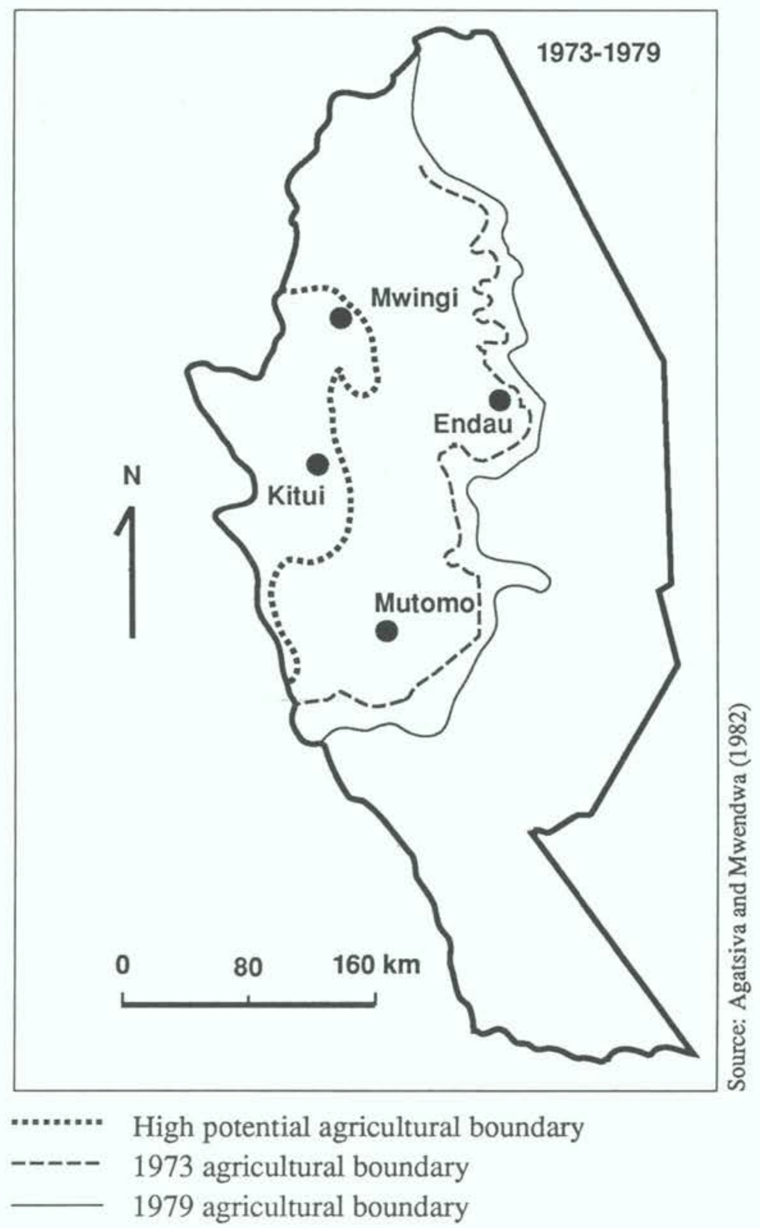


Figure 4: *Agricultural Encroachment in Kitui District*

most threatened marginal lands in Kenya. All these lands are experiencing rapid population growth - through natural increase and by migration; their rangelands are overgrazed, topsoils are eroding and food shortages are common.

Cultivation in the marginal lands of Kenya is a relatively recent phenomenon. Before colonial rule there was little cultivation in the arid and semi-arid lands of Kenya. Traditionally, the arid and semi-arid lands have been the home of pastoral peoples (e.g. Masai, Pokot, Samburu, Turkana, Galla, Rendille, Gabbra and Boran) and of abundant wildlife. Pastoralists maintained a variety of social and economic relationships within their own society and between themselves and neighbouring communities. There was little competition between livestock and wildlife and little pressure from neighbouring agricultural communities to move into the semi-arid areas. The movement of farmers into these lands, man-made famine and problems of overstocking originated from the imposition of colonial rule and was a direct consequence of European land alienation in the more humid areas which created a situation of land scarcity relative to requirements among those people whose lands were alienated (Wisner, 1977). Most of the land alienation occurred between 1908 and 1920. It has been estimated that by 1935 at least 3.5 million ha of high potential land in the Kenya Highlands had been alienated by the British

A: Narok District		
Land Category - Wheat farming		
1967	1973	1976
112	1176	2160
B: Kitui District		
Land Category - Shifting Cultivation		
	1973	1980
	900,000	1,080,000

Table 1: *Land Category Changes - Narok and Kitui Districts in Hectares Source: Agatsiva and Mwendwa (1982, p. 12)*

Colonial Government (Ogot, 1978). One of the well-documented migrations into pastoral areas took place from Kiambu to Ngong Hills in the 1920s (HMSO, 1934). As the pressure on land continued to grow in the humid areas so farmers spontaneously began to search for alternative locations where agriculture could be practiced. As a consequence, they moved into less favourable areas of the wetter margins of the rangelands.

More recently, movement into the arid and semi-arid lands has not only been due to spontaneous migration, but also to government policy which has been trying to solve the problem of lack of land in the higher potential areas by encouraging planned settlement and cultivation of the wetter margins of the arid and semi-arid lands. Among the planned migrations are those to the Government-sponsored irrigation schemes, e.g. Bura and Hola Schemes on the Tana River. According to Campbell (1981), the areas in which settlement is taking place, e.g. Ngong Hills, Mau, Narok, Cherangani Hills, Tugen Hills, Meru, Kitui, Chyulu Hills, Kilimanjaro foot hills and Soit Ololol Escarpment represent an interface between the sedentary farming economies of the higher potential lands and the pastoral and wildlife economies of the semi-arid rangelands.

In this interface conflicts have arisen as a result of intrusion of agriculture into lands traditionally used for domestic stock. There is competition for resource use between the various production sectors. The major contenders are agriculture, livestock, wildlife and settlements.

One of the semi-arid areas of Kenya which has been the focus of recent migrations of farmers from the higher potential areas is the Loitokitok area of Kajiado District (Campbell, 1986). The farmers have moved primarily to the foothills of Mount Kilimanjaro and also to land adjoining the perennial streams and swamps of the area. The experience of the pastoralists in the most recent drought, according to Campbell, indicates that they have become less capable of adapting to the drought conditions due to the reduction in range of resources available to them as a consequence of the gazetting of national parks and of the expansion of cultivation into the better-watered areas. Cultivation and the creation of national parks have reduced their access to dry-season pastures. If current trends continue, with no alternative sources of support being available in the arid and semi-arid lands, the probability is that drought hazards would worsen; the region would continue to experience poverty, famine, and range and crop deterioration (Bernard, 1985). Already in some of these areas, notably Machakos, Kitui and Baringo districts, population has exceeded carrying capacities (Bernard and Thom, 1981, Thom and Martin, 1983, Anzagi and Bernard, 1977).

Land use conflicts have also arisen in the key production areas within the arid and semi-arid lands proper. These are the riverine forests along the main water courses (such as the Tana, Turkwell, Ewaso Nyiro and Sabaki), the natural forests (e.g. Marsabit and Maralal), the swamps and hilly areas. As in the interface described above, the conflicts are between the various production sectors. The agricultural sector prefers these areas as the soils are better and the water regime is suitable for production; the pastoralists use these key production areas as fall-back areas for dry season grazing; wildlife converges on these areas in the dry season for similar reasons. Settlements prefer these areas because of water availability and the cooler climate. Many of these key production areas have already been gazetted as National Parks or Forest Reserves, resolving the conflict in favour of wildlife or forest preservation. This has caused the marginalisation of the weakest sector - pastoralism.

It is estimated that by the year 2000, Kenya will be able to feed only 17% of its population from its own land, using low inputs, and will not be able to produce adequate food for its entire population, even at an intermediate level of inputs (Milas and Asrat, 1985, p. 37). What this implies is that there will be drastic increases in pressure on the land with inexorable consequences. In the short run crop production could be increased by expanding the cultivated areas, overcultivating arable lands, reducing or eliminating fallow periods and cultivating "marginal" land unsuitable for agriculture, as is being done in the arid and semi-arid lands at present. In the medium and long term, however, as Milas and Asrat point out, the result is often less of productivity, and more of land degradation and accelerating desertification.

Population pressure on rainfed croplands and increasing encroachment of cultivators on adjacent dry-season grazing areas and the alienation of lands for national parks are rapidly diminishing the areas of available grazing lands and intensifying overstocking and overgrazing in the marginal lands of Kenya. The pastoral populations are also increasing (Ayiemba, 1983). In some areas such as northern Kenya they are increasing at unprecedented rates - along with the numbers of their livestock - cattle, camels, sheep and goats - as they require more animals to support their growing numbers (Stiles, 1983). As a result, overgrazing is intensifying and desertification is reaching critical dimensions in parts of Kenya's northern and eastern rangelands (Lusigi and Glasner, 1984).

Development Intervention in Traditional Pastoralist Societies

Pastoralist societies in Kenya's arid and semi-arid lands have been subject to considerable change in recent years. The Government has been keen to incorporate the arid and semi-arid lands more fully into Kenya. This emphasis on the rapid development of the arid and semi-arid lands has meant the development in these districts of an infrastructure, such as roads, hospitals and schools. Destitutes have been settled on irrigation schemes along the major rivers and the shores of the major lakes such as Lake Turkana. The general effect of such policies, which have been greatly facilitated by development agencies, has been firstly to restrict the movements of people and animals in the arid and semi-arid lands. This has had the effect of increasing the population pressure and pushing the pastoralists to utilize the harsher areas causing environmental imbalances previously unknown in the arid and semi-arid lands. Secondly, the general effect of such development interventions has been not only to concentrate development resources in agriculture and fisheries rather than livestock, but also to concentrate population in villages and towns. This has further exacerbated the more general shift of population in recent years towards the heartland of some of the districts because of livestock raiding in border areas and towards permanent settlement because of food relief. In Turkana, for example, according to Sorbo *et al* (1988), such is the concentration of people and livestock in the district that large areas, including some of the best grazing lands, are deserted and ungrazed, whereas in areas of population concentration, there is deforestation and overgrazing. In addition, the irrigation schemes in the arid and semi-arid lands have impeded access to river fronts and watering points and have removed valuable browsing and grazing resources from pastoral use. Some researchers and consultants, who have in one capacity or the other visited the arid and semi-arid lands districts, have been very critical of past and present development efforts. They have noted that quite apart from the lack of positive attention paid to the pastoral sector, the well-meaning government and foreign donor schemes have generally increased the people's dependence on outsiders, exacerbated their vulnerability to drought and helped create a natural environment under increasing pressure (Helland, 1987).

Soil Erosion and Desertification

A study by Rapp and Hellden (1979) on land degradation and desertification problems and the need for environmental monitoring in African drylands concluded that present knowledge about types, extent, causes and rates of desertification processes in Kenya is limited. It identified the following types of overexploitation leading to soil erosion and desertification in Kenya's drylands:

a. Overcultivation including bad management not adapted to the actual environment
b. Overgrazing and trampling
c. Excessive collection of wood for charcoal and firewood
d. Clearing of new land in areas susceptible to soil erosion (deforestation, excessive burning of grassland and woodland).

Kenya's National Environmental Secretariat (NES) in its position paper prepared for the United Nations Conference on Desertification (UNCOD) in 1977, cites the following causes of desertification in Kenya:

a. Excessive pressure of human population
b. Overgrazing
c. Destruction of vegetation
d. Collection of organic matter including plant material and manure for fuel
e. Arable farming in marginal lands

People are obliged to go further for the wood they need for fuel and fencing for their livestock.
Photo: UNEP/ Sarah Eddington

f. Irrigated agriculture leading to widespread processes of secondary soil salinization, alkalization and waterlogging in and around irrigation systems
g. Lack of water and adequate rainfall
h. Improper revegetation
i. Lack of education and environmental awareness.

Similar causal factors were cited to explain soil erosion which, according to NES, is "highly alarming" in Kenya (Government of Kenya, 1982, p. 5, UNEP, 1987, pp. 29-32).

Locally severe erosion occurs in several districts, including West Pokot, Baringo and Samburu. Erosion is particularly severe in hilly grazing areas such as Machakos and Kitui. At Marafa in Kilifi District, the erosive top soil of an area of 2-5 km^2 has been washed away leaving spectacular sandstone formations, nicknamed the "Devil's Kitchen" by the local people.

In a paper on patterns of soil erosion in Kenya, Dunne (1976) concludes that land use is the dominant variable which confounds the establishment of general relations of erosion (sediment yield) and climate. The general trend presented indicates increasing soil erosion for catchment areas dominated by the following broad land cover classes, in the order mentioned: (1) forest, (2) forest dominating over agriculture, (3) agriculture dominating forest, (4) grazing dominant. Observations by Ongweny (1978) confirm similar trends. According to Dunne *et al* (1978) erosion rates have increased three or fourfold in the last 10 to 15 years in Kenya's rangelands. Results from test sites indicate that erosion rates on gentle to medium/steep rangelands vary from 2,500 tons/km^2 a year to almost 18,000 tons/km^2 a year. The most important variable affecting erosion rates was found to be vegetation cover density.

Soil degradation typically occurs where the vegetal cover has been reduced. Kenya's forest cover is decreasing rapidly due mainly to clearing for settlement and crops, extraction of timber for commercial and domestic use and removal for fuel and charcoal production, particularly around settlements and urban areas. At the turn of the century perhaps about 20% of Kenya was forested. Today, only about 2.3% of the total land area of Kenya is under forest (Doute *et al*, 1981, p. 12). Forests cover a total area of 1,327,180 ha with mangroves covering an additional area of 52,980 ha. If plantations are estimated at around 150,000 ha, then the indigenous forests, not including mangroves, according to Doute *et al*, cover only 1,167,180 ha which is less than 2% of the country's total area. Using two scenarios, a demand of 1 m^3 and 2 m^3 per head annually, DRSRS (1981) has calculated that wood contributes between 73 and 84% of Kenya's energy. According to projections by DRSRS, the demand for wood has exceeded supply or will do so by 1990.

Earlier DRSRS' projections suggest tree cover in Kenya would be reduced by half within the next ten to thirty years. According to DRSRS, which analysed recent SPOT satellite scenes and aerial photographs, the general trend over many forests is an average rate of about 1% depletion per annum. Estimates of fuel consumption by the Central Bureau of Statistics and the National Council for Science and Technology, both based on household surveys, are 2.4m^3 and 1.4m^3 *per capita* annually (Hosier, 1981). In much of Kenya actual population density already exceeds sustainable density in terms of fuelwood supply. Fuelwood is being cut much faster than it is being replaced and the supply - and forest cover - are rapidly diminishing.

Natural forests covering a total area of 61,166 ha were monitored at intervals of 4 years over a 20-year period by DRSRS to determine the rates at which their physical boundaries are being altered by human activities (Ochanda *et al*, 1981). According to the results (Table 2), changes of area under forest cover occurred at rates ranging from 13 ha per year in arid areas to 420 ha per year in high potential areas. Depletion rates have risen steadily up to a peak period of 1972/1976 where forest cover was being removed rapidly. The trend shows that in the later years the rates appear to have slowed down for some forest areas while it remained steady in other natural forests. South Nandi forest had the highest annual rate of depletion (490 ha). Kakamega forest had a loss of 245 ha per year while North Nandi lost 295 ha per year. As a result of rapid depletion, only about 100 km^2 of the Kakamega forest is left. On the Mau escarpment, more than 30% of the forest has been excised in the last 12 years and in Ngong Hills in the Central Highlands the forests have been reduced from about 4 km^2 in 1967 to 1.5 km^2 in 1980. It is estimated that in 30 years this water catchment area for the Upper Athi river will be entirely lost. Taita hills forests have less than 5 km^2 remaining.

Destruction of vegetation is a widespread phenomenon throughout Kenya.

Forest	Forest Cover (ha) 1967	1972	1976	1980	Annual rate of Change (ha/yr)	Actual Area lost (ha) 1972-80	1976-80	% loss	Period (yrs)
Endani	720	-	-	455	13	-	265	37	13
Kakemega	-	14,268	13,088	12,308	245	1,180	780	14	8
Marsabit	13,675	13,675	13,675	13,675	0	0	0	0	13
Ngong Hills	394	184	-	156	-	8	238	60	13
North Nandi	11,460	11,460	9,831	9,100	295	1,630	730	20	8
South Nandi	18,222	18,222	15,000	14,300	420	3,222	700	21	8
Ururu	233	233	0	0	-	233	-	100	4
Bunyala	825	825	0	0	-	825	-	100	4

Table 2: *Depletion Rates and Trend in Indigenous Forest Cover; Source: Ochanda and Epp (1982)*

It affects a wide range of ecosystems stretching from high forest or climax forests to rangelands. In the latter the felling of trees and shrubs by nomads for the construction of livestock enclosures (*bomas*) is one of the most important causes of desertification. According to Lusigi and Glasner (1984), each of the human and livestock concentrations which have arisen as a result of sedentarization of nomads in Northern Kenya have become a nucleus of denuded land, which spreads in widening circles as the people are obliged to go further not only for grazing but for the wood they need for fuel and for fences for their livestock night enclosures.

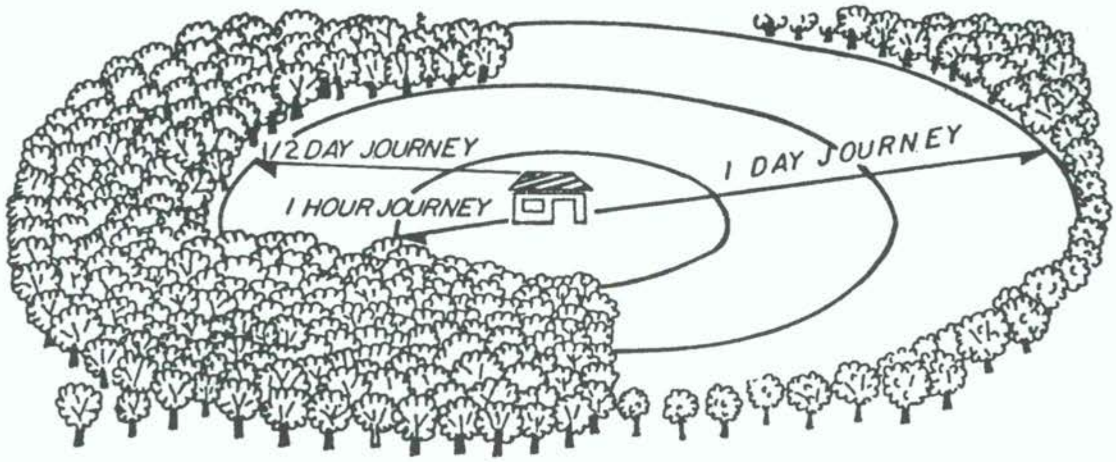
As wood becomes increasingly scarce in parts of the arid and semi-arid lands, the provision of wood for households becomes an arduous burden which usually falls upon rural women. Firewood that could be collected in the immediate vicinity of most households a few years ago now has to be gathered and carried half a day's walk. In the drier areas like Mandera, Wajir and Garissa, the job of collecting firewood has changed from a task which once took an hour to a chore which now takes a whole day (Figure 5).

Little evidence exists to suggest, however, that rural household energy consumption is responsible for large scale deforestation. As evidence in Kilifi District shows, it is rather the urban demand (Mombasa and Malindi), usually for charcoal, that leads to the wholesale cutting down of forests. The commodity status of charcoal makes it an attractive choice for entrepreneurs who can derive incomes from its production and distribution. The high demand for charcoal in Mombasa and Malindi has led to large scale felling of trees in the Margarini and Ganze Divisions of Kilifi District, while in Kaloleni Division the profitable woodfuel and charcoal trade has spurred encroachment on to the traditionally reserved areas such as the Kaya forests. Much of the indigenous trees in the Kayas have been depleted because of the needs of the charcoal, firewood and building trades. Tree felling for fuelwood to supply the needs of the urban population in Mombasa is currently also posing a serious threat around Mzima Springs, Mombasa's major source of water supply.

Charcoal transport has been banned in some of the districts in Kenya but the District Forest Officers and the District Environmental Officers are not equipped to combat the extensive charcoal burning and charcoal transported to the major and minor urban centres of Kenya. The afforestation programmes are too limited in scope to make up for the trees cut down. In Kilifi District, for example, only 60,000 seedlings are produced per year and proposals have been made for planting of 20 ha per year of fuelwood trees. This is only a fraction of what is cut down and exported to Mombasa.

According to the current *Development Plan for Kenya* (p. 178) total standing woodstocks in the country amount to about 950 million tons, with an estimated rate of decline of about 1% per annum. About 75% of these are found in the arid and semi-arid lands. Total yields are estimated at 20 million tons annually with just under half of these in the arid and semi-arid lands. Natural forests account for 10% of the total yields.

Table 3 is a forecast of wood and charcoal demand in Kenya. Wood energy is estimated to supply about 70% of total energy used in Kenya. The



FIREWOOD - The increasing trek to provide a family's fuel

In the North Eastern Province, the job of collecting firewood has changed from a task which once took an hour to a chore which now takes a whole day.

Figure 5: *Distance to walk to obtain fuelwood*

Sector	1985			1990			2000		
	Woodfuel	Charcoal	Total	Woodfuel	Charcoal	Total	Woodfuel	Charcoal	Total
Urban Households	4.4	11.7	16.1	6.0	16.6	22.6	13.9	34.4	48.2
Rural Households	194.9	7.8	202.7	220.2	8.6	228.8	283.8	10.7	294.5
Subtotals Households	199.3	19.5	218.8	226.2	25.1	251.3	297.7	45.0	342.7
Industry									
Large	22.8		22.8	29.8		29.8	50.8		20.8
Rural	35.0	2.3	37.3	40.3	2.5	42.8	50.7	2.8	53.4
Urban	0.6	1.3	1.9	0.8	1.9	2.7	1.5	2.9	4.4
Commercial	1.9	0.456	2.4	2.3	0.52	2.8	3.2	0.62	3.8
Non-energy	8.2		8.2	10.8		10.8	18.4		18.4
Subtotal Others	68.5	4.1	72.6	84.0	4.9	88.9	124.5	6.3	130.8
Total Wood and Charcoal End-Use Demand	267.8	23.6	291.4	310.2	30.1	340.2	422.2	51.3	473.0

Wood requirement including charcoal conversion losses

	1985			1990			2000		
	Woodfuel	Charcoal	Total	Woodfuel	Charcoal	Total	Woodfuel	Charcoal	Total
Million tonnes	16.7	6.1	22.9	19.4	7.5	26.9	26.4	12.2	38.6
Per Cent	73%	27%	100%	72%	28%	100%	68%	32%	100%

*Units = Million Gigajoules (1 million gigajoules = 23,900 tonnes of oil equivalent)
Charcoal figures are adjusted for error in Beiner Institute average national use, i.e., the proper figures of 473 kg/average household used here in 1985 base case, rather than the figure of 673 kg/household which properly applies only to urban families using charcoal.

Table 3: *Forecast of Wood and Charcoal Demand in Kenya 1985-2000*
Source: Oak Ridge Associated Universities (1989), Energy Efficient Stoves for East Africa, *Renewable Energy Applications Project Report No. 89-01, p. 10*

quantities of woodfuel required are very large, estimated at about 22.9 million tonnes in 1985. Urban requirements for wood-based energy consist primarily of domestic demand for charcoal which required about 3.0 million tonnes of wood input in 1985 and was roughly 90% of total urban wood energy demand. Due to a continuation of extremely high overall population growth rates (4% per year) and even faster urban growth, urban charcoal demand is projected to grow to over 7.0% per year over the next 10-15 year period. After taking into consideration conversion losses in the production of charcoal from wood, total urban and rural charcoal consumption is shown to account for about 27% of all wood required for energy and non-energy uses (Table 3). While it is recognized that there is a tendency for the urban population to gradually shift more to modern fuels in urban areas due to availability and income growths, this pattern is poorly understood and, therefore, not explicitly included in the forecasts in Table 3. Rural household demand for wood is the single largest wood energy requirement estimated at about 12.6 million tonnes in 1985, but growing at a much slower pace than charcoal demand, about 2.5% per year.

There is currently insufficient wood available on a sustained yield basis to meet all of the wood demand in the regions, with woodstocks on a national basis being depleted at almost 10 million tons a year.

One obvious effect of vegetation destruction is the simplification of ecosystem structure by eliminating some of the plants which play a vital role in the ecological food chain. Another effect is the destruction of catchment areas which have a natural water-retaining and conservation capability. Degradation of the remaining forests, grasslands and soils in Kenya is not only bound to increase run off and soil erosion but could diminish soil moisture, which in turn could reduce evapotranspiration and hence rainfall and so lead to the extension of desert conditions.

Meteorologists J.G. Charney and his colleagues proposed a mechanism by which desert conditions might spread beyond their normal boundaries. Clearing woodlands and degrading grasslands by overgrazing increases the land's albedo (surface reflectivity). The decline of absorbed sunlight, combined with reduced evapotranspiration expected when the vegetation is disturbed, counteracts cloud formation and rainfall. The diminished rainfall in turn dries out the landscape and further reinforces desertification. Although this 'biometeorological feedback' has not been confirmed to be the cause of drought in Africa, theoretical models of the dynamics of the atmosphere have tended to validate Charney's hypothesis as a mechanism for perpetuating drought (Brown and Wolf, 1985, p. 24). The persistence of drought in certain parts of the drylands of Kenya could be due in part to this kind of self-reinforcing action.

Environmental Management in Kenya

Since the 1972 UN Conference on Human Environment and particularly since the United Nations Conference on Desertification organised in Nairobi in 1977, many countries have been reviewing their environmental situation and trying to improve it. Kenya has been no exception. The combination of unprecedented population growth and accelerating loss of land productivity to soil erosion and desertification is increasingly a threat to the long-term stability of Kenya.

To contain the problem, the Government and people of Kenya are encouraging tree planting and soil conservation in the rural areas where forests and soils are quickly being depleted. The Government has established rural extension services which, with assistance from NGOs, are engaged in advising farmers on tree planting and better land use aimed at preventing soil erosion (Chavangi and Gathaara, 1982). Considerable attention has been given to research and an attempt is also being made to slow down the rate of population growth through family planning. Success in the creation of awareness on the value of trees and the need to plant more has been realised in most parts of the country. But success in afforestation has been recorded only in the high potential districts which constitute less than 20% of the total area of the country. In the rest of the country constituting the arid and semi-arid lands, the afforestation programme has not yet made much impact. Although the Government of Kenya has given special attention to rural development in these lands for nearly two decades now, the environmental situation there has not improved. Instead, conditions have worsened (Darkoh 1990). Population increases and shortage of land in the adjacent high potential areas has led to the extension of farming into these fragile marginal lands with little consideration of environmental impacts. Consequently, desertification is rife in the arid and semi-arid lands today.

Although the Kenya Government's policies with respect to the preservation and improvement of the environment are based on the premise that prevention of harmful effects is less costly than their subsequent correction, and although these policies emphasise that environmental considerations must be incorporated at the planning stage of development projects (Government of Kenya, 1981, p. 34), either through lack of political clout or because of lack of necessary machinery for monitoring and surveillance, there is often no follow-up observation of the impact of rural development schemes or projects. In a recent study which tried to evaluate the degree to which the Government has achieved its goal of reducing the risks in the semi-arid lands and improving the environment and human condition, the conclusion was reached that hazards have not been reduced or ameliorated (Bernard, 1985). Traditional hazard responses have rather been weakened for both farmers and pastoralists in the arid and semi-arid lands as a result of Governmental intervention. Well-meant development action on the part of the Government and donor agencies is contributing to the worsening environmental and human conditions. Halting the process of environmental deterioration in Kenya calls for effective management of natural resources as well as close surveillance and monitoring to check the efficiency of the remedial actions, to provide early warning of trends, and to identify and correct any negative effects. I have emphasised elsewhere that any serious approach to the man/environmental problems such as desertification should involve a three-step process: diagnosis of the actual situation; planning and implementation of counter measures (cures); and observation and follow-up of the effects of the measures (Darkoh, 1980, p. 40). Environmental management and resource development in Kenya must try to abide by this. Development and management of resources should also be sustainable on a long-term basis for there is a real danger that in our efforts to develop areas on a crisis basis or by fits and starts, we may adopt strategies that could be self-defeating.

References

Agatsiva J.L. and Mwendwa, H. (1982). *Land Use Mapping, Using Remote Sensing Techniques*, Paper presented at the 4th International Seminar on the Potential Influence on Remote Sensing Survey and Decision-Making, Nairobi, Kenya, 8-19 November 1982.

Ayiemba, H.O. (1983). *Population Growth in the Dry Lands, Kenya Geographer*, Vol. 5, pp. 110-115.

Anzagi, S.K. and Bernard, F.E. (1977). *Population Pressure in Rural Kenya, Geoforum* Vol. 63, p. 68.

Bernard, F.E. (1985). *Planning and Environment Risk in Kenya Dry Lands, Geographical Review*, vol. 75, No. 1. pp. 58-70.

Bernard, F.E. and Thom, D.J. (1981). *Population Pressure and Human Capacity in Selected Locations of Machakos and Kitui Districts, Journal of Developing Areas*, Vol. 15, pp. 381-406.

Brown, L.R. and Wolf, E.C. (1985). Reversing Africa's Decline, *Worldwatch Paper* No. 65, Worldwatch Institute, Washington.

Campbell, D.J. (1981). *Land Use Competition at the Margins of the Rangelands: An Issue in Development Strategies for Semi-Arid Areas*, in Norcliffe, G. and Pinfold, T. (ed.) (1981) *Planning African Development*, Westview Press, Boulder, Colorado.

Campbell, D.J. (1986). *The Prospect for Desertification in Kajiado District, Kenya, Geographical Journal*, Vol. 152, No. 1, pp. 44-55.

Central Bureau of Statistics (1989). *Economic Survey 1989*, Nairobi.

Chavangi, A.H. and Gathaara, G.N. (1982). *Afforestation in Kenya*, Paper Presented at the Seminar on Afforestation and Rural Development in East Africa, Organized by REECA, Nairobi, November 1982.

Charney, J. *et al* (1977). *A Comparative Study of the Effects of Albedo Change on Drought in Semi-Arid Regions, Journal of the Atmospheric Sciences*, Vol. 34, pp. 1,366-1,385.

DANIDA (1989). *Environmental Profile: Kenya*, Danida Ministry of Foreign Affairs.

Dangana, L. (1983). *Research in Environmental Management and Integrated Rural Development: Some Activities with MAB* in *Environmental Management and Integrated Rural Development: Eastern and Southern Africa Sub Region*, UNESCO; pp. 80-86.

***Daily Nation* (1985).** *Arid and Semi-arid lands: Aims to Improve Peoples Lives in Dry Areas, Daily Nation*, April 30 1985, p. 11.

Darkoh, M.B.K. (1980). *Man and Desertification in Tropical Africa*, Dar-es-Salaam University Press.

Darkoh, M.B.K. (1990). *Towards Sustainable Development of Kenya's Arid and Semi-Arid Lands*, Public Lecture 1, Kenyatta University, Nairobi.

Doute, R., Ochanda, N. and Epp., H. (1981). *Forest Cover Mapping in Kenya Using Remote Sensing Techniques*, KREMU, Nairobi.

Dunne, T. (1973). *Studies of Soil Erosion and Soil Degradation in Kenya*, University of Washington, Seattle (Mimeo).

Dunne, T. (1976). *Studying Patterns of Soil Erosion in Kenya* in *Soil Conservation and Management in Developing Countries. Report of an Expert Consultation Held in Rome, 21-22 November 1976, FAO Soils Bulletin* No. 33, pp. 109-122.

Dunne, T., Dietrich, Die W.E. and Brunengo, M.J. (1978). *Recent and Past Erosion Rates in Semi-Arid Kenya*. Z. Geomorph, N.F. Suppl. Bd. 29, pp. 130-140.

Epp., H., Agatsiva, J., Ochanda. and Lantier D. (1982). *Application of Remote Sensing in Earth Resources Monitoring*, in *Potential Influences of Remote Sensing Surveying on Decision-Making*, Proceedings of the 4th International Seminar, Remote Sensing Decision Making, Nairobi, Kenya, ITC. pp. 118-127.

IFAD (1987). *Arid and Semi-Arid Lands (ASAL) Development Issues and Options*, 2 Vols. and Annexes.

Government of Kenya (1979). *Development Plan 1979-1983*, Government Printer, Nairobi.

Government of Kenya (1981). *Economic Survey 1981*, Central Bureau of Statistics, Ministry of Economic Planning and Development, Nairobi.

Government of Kenya (1982). *Environment Management Report*, the National Environment Secretariat, Nairobi.

Government of Kenya (1989). *Development Plan 1989-1993*, Government Printer, Nairobi.

Helland, J. (1987). *Turkana Briefing Notes*, Chr. Michelsen Institute, Development Research and Action Programme.

Hosier, R.H. (1981). *Surveys of Domestic Energy Consumption in Kenya: A Summary*. Beijer Institute/Ministry of Energy, Nairobi, Kenya.

HMSO (1934). *Report of the Kenya Land Commission*, London.

Kinyanjui, D.N. and Baker, P.R. (1980). *Report on the Institutional Framework for Environmental Management and Resource Use in Kenya*, National Environment Secretariat, Nairobi, Kenya.

KREMU (1981). *A Survey of Natural Wood Supplies in Kenya and an Assessment of the Ecological Impact of Its Usage*, Ministry of Tourism and Wildlife, Nairobi.

Lusigi, W. and Glasner, G. (1984). *Combating Desertification and Rehabilitating degraded production systems in Northern Kenya: the IPAL Project, Desertification Control Bulletin*, No. 10, pp. 29-36.

Milas, S. and Asrat, M. (1985). *Eastern Africa's Spreading Wastelands, Desertification Control Bulletin*, No. 12, pp. 34-40.

National Environmental Secretariat (1977). *Kenya's Experience in Combating Desertification, Kenya's Country Position Paper*, United Nations Conference on Desertification (UNCOD), Nairobi (mimeo).

Ochanda, N., Doute, R. and Epp., H. (1981). Monitoring Forest Cover Changes of Selected National Forests in Kenya Using Remote Sensing Techniques, *KREMU Technical Report No. 46.*

Ochanda, N. and Epp., H. (1981). *Monitoring Recent Changes in Extent Natural Forests in Kenya Using Remote Sensing Techniques*, KREMU (mimeo).

Ogot, B.A. (ed.) (1979). *Ecology and History in East Africa*, Hadith 7, Kenya Literature Bureau, Nairobi.

Ongweny, G.S. (1988). *Erosion and Sediment Transport in the Upper Tana Catchment with Special Reference to Thiba Basin*, Ph.D. thesis, Department of Geography, University of Nairobi.

Rapp, A. and Hellden, U. (1979). *Research on Environmental Monitoring Methods for Land Use Planning in African Drylands*, Department of Physical Geography, University of Lund, Sweden.

Sorbo, G.M. (1988). *NORAD in Turkana, A Review of the Turkana Rural Development Programme*, Nairobi.

Stiles, D.N. (1983). *Camel Pastoralism and Desertification in Northern Kenya, Desertification Control Bulletin*, No. 8, pp. 2-8.

Thom, D.J. and Bernard, F.E. (1981). *Population Pressure and Human Carrying Capacity in Selected Locations of Machakos and Kitui Districts, Journal of Developing Areas*, No. 15, pp. 381-406.

UNEP (1987). *Kenya, National State of the Environment Report*, Nairobi.

Thom and Martin N.L. (1983). *Ecology and Production in Baringo-Kerio Valley, Kenya, Geographical Review*, vol. 73, pp. 15-29.

Werner, C.G. (1985). *Soil Conservation in Kenya, an Interview with Carl-Gosta Warner, AMBIO*, Vol. 12, No. 6, pp. 305-307.

Wisner, B. (1977). *Man-Made Famine in Eastern Kenya: The Interrelationship of Environment and Development*, in *Land Use and Development* ed. by O'Keefe, P. and Wisner, B., African Environment Special Report, pp. 216-228.

Desertification Control in Semi-Arid parts of Tanzania: What Is and What Ought to Be

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Introduction

Anything between 25 and 75 per cent of Tanzania may be classified as semi-arid (Anon, 1977). These areas get less than 700 mm of rain per annum, usually in a single rainy season. Animal husbandry and peasant agriculture are major land uses. Overstocking leads to a conflict between the livestock and arable sectors and, where pressure is great, each suffer and desertification is inevitable.

Desertification control measures have been proposed in a number of development projects such as the Shinyanga Regional Integrated Development Project. But most of the control measures offer vague distinction between "what is" and "what ought to be" in the control process. In this paper, an attempt is made to indicate that a clear distinction between the two may lead to the formulation of effective desertification control measures.

Desertification Control

Desertification is defined by some scientists as the creation of desert-like conditions where none had existed before. It is viewed as the result of either the vagaries of weather and climate or the mismanagement of land or, as in most cases, some combination of both (Glantz and Katz, 1977). The "desert-like conditions" which remain undefined render part of this definition circular. Rozanov (1977) gets over these shortcomings by explaining that "desert-like conditions" are the result of human or natural processes which lead to sustained decreases in the capacity of an ecosystem to carry flora and fauna.

Desertification control can therefore be viewed as a package of strategies geared to offsetting sustained decreases in the carrying capacity of an ecosystem.

What Is and What Ought to Be

Almost 50 years ago, Carr wrote about international politics in the interwar years and called attention to the need to distinguish between "What is" and "What ought to be", namely:

> *The antithesis of utopia and reality - a balance always swinging towards and away from equilibrium and never completely attaining it - is a fundamental antithesis revealing itself in many forms of thought. The two methods of approach - the inclination to ignore what was and what is - determine opposite attitudes towards every political problem. "It is the eternal dispute" as Albert Sorel puts it, between those who imagine the world to suit their policy, and those who arrange their policy to suit the realities of the world.*

In applying this distinction to development programmes, one could divide development specialists into two categories: those who emphasize "the need of integrated development" and advocate "the involvement of local rural populations in problem definition and solution" and those who suggest that the traditional system be taken as the basis of development and that projects be built upon the existing cultural, political, economic and environmental subsystems (Glantz, 1976).

Awareness of the gap between the two antithetical views is neither new, nor has it been confined only to development programmes. Yet this device could prove valuable in the search for an understanding of real as opposed to imagined desertification control measures in a country such as Tanzania. The "what is" discussion outlines conditions and attitudes of the people living in the semi-arid parts of Tanzania. The "what ought to be" argument considers those conditions and attitudes in the light of existing social, technological and institutional factors.

What is: Carrying Capacity

It is widely held that an assessment of carrying capacity is a necessary but insufficient step in any attempt to retard the continual deterioration of rangeland. However, there appears to be little agreement as to how such an assessment should be made. Suggestions have included: use of indictor plants (Ayuko, 1975), assessment on the sole basis of forage production of pastures (Boudet, 1975), consideration of the quality and quantity of the forage (Rivière, 1975).

Such a variation within a scientific community is likely to influence decision makers to make no decision at all or to consider all scientific recommendations to be of equal value and choose any of those suggested. But results of scientific research show enourmous variance: for example, the mean annual rainfall for semi-arid regions as recorded at Dodoma Airport, Kondoa Mission and Manyoni District Office is given as 581±189, 581±183 (Nshubemuki *et al.*, 1978). It is perhaps this inherent rainfall variability which leads Glantz and Katz (1977) to observe that: no single number can adequately describe the climate regime of an arid or semi-arid region. Decision-makers must supplement the "mean" with more statistical information in order to characterise adequately climate variability. The questions which arise are: should the carrying capacity be geared to the best, the average or poorest years? Which combination of statistical measures would be most meaningful for the planning of long term development of rangelands? On which variables should such an assessment be based - vegetation, rainfall, soil, ground or surface water or managerial capabilities?

Given the downward spiral of land deterioration it is essential that an ecologically acceptable carrying capacity be established and enforced. However, this requires other inputs in the form of transport, and cattle holding facilities, should it be necessary to destock.

Destocking

It has been widely advocated that destocking is the answer to the problems of environmental degradation in Tanzania. Destocking suggestions have ranged from increasing livestock prices to reintroducing livestock taxes.

A study conducted by the Nairobi based Ecosystems team in Shinyanga Region concluded that there are more than twice the number of cattle in the area than administrators and planners believe (Stocking, 1982). As the official figures are based on village censuses and conducted by people who ought to know their own local area, the implications for conservation programmes such as destocking are grave. Destocking relies on knowing the herd sizes and apportioning a fixed percentage reduction to each farmer. If farmers are lying about their herd sizes, then destocking cannot even be started (Stocking, 1982). A similar experience is given by the Canadian International Development Agency (CIDA, 1975), where it is observed that under Dodoma District conditions the optimum offtake for cattle and goats is an average of 10 per cent.

It is also worth noting that a rise in cattle prices tends to emphasize a return to what Khalifa and Simpson (1972) termed, from the western view, a perverse supply/demand relationship. In non-market oriented communities the money needs of the people are so limited that any rise of the price of their products inevitably leads to the curtailment of supply. A compromise should therefore be a balance between the experts' view of optimum livestock production and the herders' traditional desire to maintain as large a herd as possible (Ware, 1975).

Wood Consumption and Production

Wood consumption, particularly in the form of fuel, coupled with its inefficient use, also leads to problems of environmental degradation.

Working in Dodoma, Nshubemuki (1974) found that charcoal burning requires about 0.8m^3 stacked volume of wood to produce one bag of charcoal (Loose volume 0.1m^3). This is because recovery in most earth kilns is between 10 and 15 per cent (on dry weight basis). When wood is carefully stacked, a 25 per cent recovery is possible. These rough calculations seem to suggest that about 50 per cent of the wood used for charcoal production is lost when traditional earth kilns are used.

Fuelwood plantations give an annual increment in volume of between 15 and 25m^3 per hectare, depending on the species grown and the local environment. Given suitable species and treatments, increments of 15m^3 or more, per hectare per year are possible. However, increments recorded in Central Tanzania for 7.5 year-old *Eucalyptus tereticornia* plots was about 5m^3 per hectare per year (Malimbwi 1978) and about 9m^3 per year for the best performing species on the black cracking clays and the red sand clay loam at Malya (Anon. 1964). These growth rates are considerably lower than those which are generally quoted for the Eucalypts under humid conditions, i.e. 20-30m^3 per hectare per year (King, 1975). This implies that extra extensive fuelwood plantations are needed in the arid areas and consequently that in establishing such plantations a considerable amount of capital has to be injected in order to ensure that tending, protection and logging costs are adequately met, particularly for projects tailored for semi-arid areas.

Other Land Use Practices

In Shinyanga Region, the Ecosystems field survey revealed that, apart from a few special cases, the severest erosion and the greatest quantities of sediment were associated with grazing lands (Stocking, 1982). Rapp *et al* (1972) found a similar situation in Dodoma. Arable lands are also eroding, especially where they are flat cultivated and/or annually burnt, but they are of less significance than the pastures from the erosion or desertification point of view.

What Ought to Be: Improving the Nutritive Value of Herbage

Normally range management specialists quote carrying capacities as one livestock unit (1 Lu = 1 cattle or 5 sheep/goats) to every four hectares in this seasonal environment (Stocking, 1982), with possibilities of halving it to 1 Lu per 2 hectares. But stocking rates of up to 9.5 Lu per hectare have been recorded in Shinyanga Region where the worst erosion starts when there are 2 Lu per hectare. As destocking is resisted, improvement of the nutritional value of the rangelands seems the most acceptable compromise.

In this regard, consideration of the quality and quantity as well as improvement of forage (Rivière, 1975) is a convincing approach. The performance of natural and sown pastures at Kongwa, with the latter giving 50 to 60 per cent improved carrying capacity as well as more stable ground cover and freer weed and bush incursion (Wigg, 1973), suggests that the present range potential is not fully tapped. Estimation of carrying capacity based on range potential which is neither fully tapped nor improved can therefore be contested. There are also exotic grass species such

A gully in the process of rehabilitation in Tanzania. Photo: T. Maukonen.

as *Kochia prostrata* which may improve this potential even more.

The Role of Trees

Efficient uses of wood will check desertification. Many groups are now promoting improved wood stoves as a way to save scarce wood supplies, but a single, all-purpose stove design is unlikely. Charcoal kilns give higher yields of charcoal - from 25-30 per cent (on dry weight basis) compared with 10-15 per cent using conventional methods. As charcoal kilns are about 85 per cent more efficient in time-saving, full scale introduction of charcoal kilns in semi-arid areas of Tanzania may mean an increased capacity in devastating the forests. A careful study of introducing this technology is imperative because although technology is basically neutral, its results depend on where, when and how it is applied.

Extensive afforestation schemes alone will most likely contribute little in desertification control. This is principally because the deterioration of carrying capacity normally occurs as isolated pockets in areas which are otherwise not threatened. These pockets later coalesce to form desertification conditions proper. In order to check such developments, a combination of agroforestry and extensive afforestation schemes which bear in mind afforestation objectives and best suited species are called for.

The many varieties of *Leucaena leucacephala* have long been recognized as a soil erosion control plant (Dijkman, 1960; Buenaventura, 1961), a nitrogen fixer and therefore a soil improver, a firewood and timber producer, a fodder plant (Oakes and Skov, 1962; Ince, 1981), and a high quality charcoal producer (Fenega and Laxamana, 1968; Villaneuva and Banaag, 1968). Therefore it seems to have a potential for use in the semi-arid areas of Tanzania (Sabas *et al*; 1982).

Protein deficiencies which reduce the nutritive value of several grass species frequently found in the semi-arid areas (Karue, 1974) may be overcome by *Leucaena*. Oakes and Skov (1962) report yields of about 15 tons of dry matter per hectare per year with 18 per cent protein content, and cutting frequencies of 3 to 4 times a year. Furthermore, the absence of toxicity in Mawaii, where naturalized stands of *Leucaena* are used for cattle and it has been fed experimentally at levels of about 50 per cent (and up to 90 per cent for goats) of total dry matter intakes, suggest a solution to the problem of *Leucaena* toxicity in domestic animals grazing in extensively managed *Leucaena* pastures elsewhere (Jones, 1982; Jones and Bray, 1982; Chater, 1986).

Organisation

It is evident that lasting advances in desertification control require the organisation of all relevant departments and institutions into a joint force for scientific research through rational division of assignments and co-operation. This can be conceived at international, national and village levels.

At international level, and to a certain extent at national level, there is a tendency to think "too big". Since the deterioration of carrying capacity occurs first on the outskirts of villages, it is reasonable to suggest that control measures should begin there. Village development plans are therefore the best methods of tackling desertification. As Stocking (1982) observes, conservation should be treated as an integral part of farming and be related to village needs, constraints and opportunities in leadership, education and dissemination of better farming practice. Only through the village structure will people feel a part of the development process while at the same time taking on sound methods of soil conservation.

This does not mean that desertification control at village level has no limitations. It stresses that national and international efforts should supplement, rather than replace, village efforts. Successful control measures which were achieved by North West Nindo, a village in Shinyanga Region (Stocking, 1982), and the Kondoa Soil Conservation Project (NADO) (Mbegu and Mlengo, 1983), underline this interrelationship and stress the importance of village afforestation programmes.

References

Anon, 1984. *The arboretum of Igwata-Malya*, Tanzania Silviculture Technical Note No. 72, Mimeogr.

Anon, 1977. *The threat of desertification in Central Tanzania*. Technical Paper, UN Conference of Desertification, Nairobi, Kenya, September 1977.

Ayuke, L.J., 1977. *Ecological Status - Range Condition and trend recognition and value of indicator species*, pp. 175-176, Proceedings of the Seminar on Evaluation and Mapping of Tropical African Rangelands, Bamake, Mali, March, 1975; International Livestock Centre for Africa, (ILCA), Addis Ababa, Ethiopia.

Boudet, G., 1975. *Problems encountered in estimating the rate of stocking on natural pastureland in Tropical Zone*, pp. 265-267, Proceedings of the Seminar on Evaluation and Mapping of Tropical African Rangelands, Bamake, Mali, March 1975; International Livestock Centre for Africa, (ILCA), Addis Ababa, Ethiopia.

Buenaventura, S.P, 1961. *Reforestation of Imperata waste lands in the Philippines* in *Philippine Journal of Forestry* no. 14, pp. 67-76.

Carr, E.M., 1939. *Twenty years crisis*, (3rd edition 1964), Marper and Two, New York, pp. 4-21.

Chater, S., 1966. *Leucaena: An end of toxicity in ruminants*, ILCA Newsletter 5(2), pp. 1-3.

Canadian International Development Agency (CIDA), 1975. Dodoma Region Integrated Development Plan, Regional Development Director's Office, Dodoma.

Dijkman, M.J., 1950. *Leucaena - a promising soil erosion control plant* in *Economic Botany no. 4*, pp. 337-349.

Fenega, S.M. and Laxamama, N.B., 1968. *Activated charcoal from Philippine Woods* in *Philippine Forester* no. 2, pp. 8-9 and 49-50.

Glantz, M.N., 1976. *The value of long range weather forecast for the West African Sahel* in *Bulletin of American Meteorological Society* no. 58 (Reprint).

Glantz, M.M. and Katz, R.W., 1977. *When is a drought a drought?* in *Nature* no. 267, pp. 192-193.

Ince, R.J., 1982. *Legumes to end timber fix* in *International Agricultural Development* 1(6), pp. 18-19.

Jones, R.J., 1982. *Agronomic Research in the Development of Leucaena as a pasture legume in Australia* in *Leucaena Research in the Asian Pacific Region*, Proceedings of a Workshop held in Singapore on 26 November 1982, IDRC, 211e, pp. 44-48, IDRC, Ottawa.

Karue, C.N., 1974. *The nutritive value of herbage in semi arid lands of East Africa: I: Chemical Composition* in *East African Agricultural and Forestry Journal no. 4, pp. 89-95.*

Khalifa, A.M. and Simpson, M.C., 1972. *Perverse Supply in Nomadic societies* in *Oxford Agrarian Studies* 1(1), pp. 46.

King, K.F.S., 1975. *It's time to make paper in the tropics*, Unasylva 27, pp. 2-5.

Malibwi, R.E., 1978. *Performance of Eucalyptus species and provenance trials at Mtipa, Singida Region, Tanzania*, Tanzania Silviculture Research Note No. 31, Mimeogr.

Mbegu, A.M and Mlenge W.C., 1983. *Ten years of MADO*, Ministry of Natural Resources and Tourism, Dar es Salaam.

Nshubemuki L., 1974. *Mawazo Kihusu Mazao ya Misitu Mkoani Dodoma, Pamoja na marejeo kwa mji Mkuu*, (English translation: *Some random thoughts on the forest products question in Dodoma region with some reference to the Capital City*), Regional Natural Resources Office, Dodoma.

Nshubemuki, L., Semi, F.G.R., and Olotu, C.A., 1978. *A Forester's view on average monthly and annual rainfall and number of raindays over Tanzania. I: Regional Comparisons, Tanzania Silviculture Technical Note* (New series), No. 41, Mimeogr.

Oakes, A.J. and Skov. O., 1962. *Some woody legumes as forage crops for the dry tropics* in *Tropical Agriculture (Trinidad)* no. 39, pp. 281-287.

Rapp, A., Murray Rust, M.D., Christianson, C. and Berry, L., 1972. *Soil erosion and sedimentation in four Catchments near Dodoma, Tanzania* in *Geografiska Annaler* no. 54(A), pp. 255-318.

Rivière, R., 1975. *Problems in the evaluation of the nutritional value of natural tropical rangeland*, pp. 269-276, Proceedings of the Seminar on Evaluation and Mapping of Tropical African Rangelands, Bamake, Mali, March 1975; International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia.

Rozanov, B.G., 1977. *The fight against desertification must be waged with the full participation of the people concerned*, Ceres 56, pp. 23-28.

Sabas, E., Maphole, J.E.N. and Nshubemuki, L., 1982. *Some preliminary observations on the initial performance of Leucaena Leucocephala in some of the semi-arid parts of Tanzania.*

Stocking, M., 1982. *Reasons to be bullish about Tanzania's erosion* in *International Agriculture Development* no. 2(6), pp. 8-9.

Villaneuva, E.P. and Baang, N.F., 1968. *A study on the destructive distillation characteristics of Ipil-ipil (Leucaena Leucocephala (Lam) (de Wit)) wood* in *Philippine Journal of Forestry* no. 20, pp. 163-179.

Ware, M., 1975. *The Sahelian drought: Some thoughts on the future*, UN Sahelian Office, New York.

Wigg P.M., 1973. *The role of sown pastures in semi-arid Central Tanzania* in *East African Agricultural and Forestry Journal* no. 38, pp. 375-382.

NEWS FROM UNEP

New Collaborators in DC/PAC

Prof. Boris Rosanov

from Kazan, USSR, returned to DC/PAC in September 1990 as special advisor to the Executive Director, Dr Tolba. Professor Rosanov was previously with UNEP between 1976 and 1980 when he acted as principal officer and senior programme officer in the desertification unit.

Prior to joining UNEP Professor Rosanov was a lecturer and researcher at Moscow State University in the USSR where he obtained his DrSc in pedology in 1964. He has also worked in Rangoon, Burma, where he was responsible for setting up the Land-Use Bureau and training staff; and in Alexandria University, Egypt, where he was a visiting professor, expert with UNESCO and consultant on government projects.

Professor Rosanov is married with two children.

Mr Zewdie Gebeyehu

from Addis Ababa, Ethiopia, joined DC/PAC in December 1990 as computer systems analyst. He previously worked for the Economic Commission for Africa as regional advisor in data processing, associate statistician and data-base specialist. Prior to this he was chief of the computer section at the International Livestock Centre for Africa, based in Ethiopia.

Mr Gebeyehu has a BSc in Electrical Engineering from Haile Selssie I University (now the University of Addis Ababa), Ethiopia and has followed various courses in computer science in Amsterdam, Holland, and London, England.

Mr Gebeyehu is married with five children.

Ms Prema Murthi

from Monrovia, Liberia, joined DC/PAC in January 1991 as Information Officer. She spent the previous six years as Assistant Professor in the College of Business and Public Administration with the Department of Management at the University of Liberia. She has also worked as a consultant for the National Bank of Liberia and the National Social Security and Welfare Corporation of Liberia.

Ms Murthi obtained her Degrees in Law, Journalism and Social Sciences from the University of Madras, India.

She is married with two children.

Mr Michael N. Akello

from Nyanza Province, Kenya, joined DC/PAC as a junior research assistant in November 1990. He worked previously as a computer technician at the International Centre for Insect Physiology and Ecology and as a coding technician in the Department of Resource Surveys and Remote Sensing.

Mr Akello has a Diploma in Computer Studies from Kenya Polytechnic.

Global Assessment of Desertification: Status and Methodologies

The Proceedings of the *Ad-Hoc* Consultation Meeting on the Assessment of Global Desertification: Status and Methodologies, held in Nairobi from 15 to 17 February 1990, are now available.

One of the most substantial papers is written by Prof. Boris G. Rosanov, a senior advisor to the UNEP Executive Director for the second Global Assessment of Progress in Implementing the Plan of Action to Combat Desertification (GAP II). He attempts to provide a tentative statistical characterization of the global status of desertification in what is, in short, a preliminary statement of what GAP II is likely to produce. He takes a fairly comprehensive look at desertification globally and in particular takes interesting examples from the USSR and Middle Asia. The study leaves little doubt that desertification resulting from human activities is fast accelerating and it gives a new and more insidious picture of a problem which is still largely underrated in most countries but which is bound to have serious ecological and economic consequences for them all.

The Proceedings also contain case studies from various countries and regions, including Kenya (prepared by the Department of Resource Surveys and Remote Sensing in the semi-arid districts of Baringo and Marsabit), Sahelian West Africa (prepared by Soviet scientists who applied the FAO/UNEP Provisional Methodology for Desertification Assessment and Mapping) and Sudano-Sahelian regions (prepared by L. Guyot who elaborates a new method for monitoring desertification).

The Proceedings are mainly aimed at those who maintain a live interest in the problem of desertification and realise the need for a more realistic approach to its possible containment and for global investments towards its control. They will be made available to libraries and other institutions concerned with the assessment aspect of the desertification issue.

Global Assessment of Desertification and World Atlas

The second meeting of the Technical Advisory Group on desertification assessment and mapping was held in Nairobi, Kenya, in November 1990. The meeting was dedicated to reviewing the progress and status of preparations of various maps and other materials to be included in the World Atlas of Thematic Indicators of Desertification which is being produced as part of UNEP DC/PAC's Global Assessment of Desertification and is to be presented to the 1992 UN Conference on Environment and Development (see *Desertification Control Bulletin* No. 18).

Global Assessment

DC/PAC's Deputy Director, Dr T. Darnhofer and Mr M. Mendoza made a general report which was followed by detailed presentations by the various participants involved in the study. The meeting agreed that the Global Assessment will take into consideration only arid, semi-arid and dry sub-humid areas and that two sets of figures will be produced; the first will show the exact area actually affected by soil degradation within each polygon, as shown on the World Map of the Present Status of Human-Induced Soil Degradation (GLASOD) map (see *Desertification Control Bulletin*, No. 18); the other will consider the whole area of the polygons affected by desertification/land degradation since the GLASOD map mainly shows soil degradation and contains information on vegetation change and deterioration of rangelands which require complementary data.

World Atlas of Desertification

Different drafts of the maps were presented and discussed. There were also discussions on technical aspects and negotiations that are being carried out with the publisher, *Edward Arnold*, who has offered the participation of a specialist designer to support the project. It was recommended that these negotiations be formalised in a contract between UNEP and *Edward Arnold* in order to ensure that concrete decisions on technical aspects can be taken.

It was agreed to include the following in the Atlas:

Global Section

Present Status of Landscapes: One map to be prepared by Moscow State University, USSR.

Bioclimatic Zones: One map to be prepared by UNEP's Global Resources Monitoring System (GEMS)/Global Resources Information Database (GRID) using information provided by the Bioclimatic Research Unit of East Anglia University.

Soil Degradation Types: Four maps, reduced to 2 map pages, to be prepared by GEMS/GRID based on the GLASOD map.

Soil Degradation Severity Status: One map to be prepared by GEMS/GRID based on the GLASOD map.

Soil Degradation in Arid Zones: One map to be prepared by GEMS/GRID showing soil degradation based

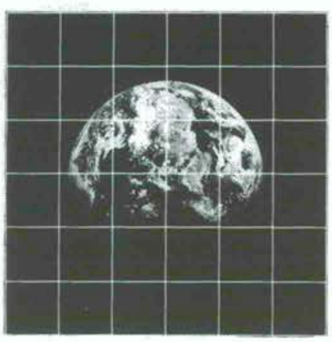
Technical Advisory Group meeting in Nairobi, November 1990: Selecting the maps for inclusion in the World Atlas of Thematic Indicators of Desertification. Photo: UNEP/ Y. Matsumoto on the GLASOD map, but in arid, semi-arid and dry sub-humid areas.

Soil Degradation and Vegetation Index: One map to be prepared by GEMS/GRID using the GLASOD severity variable and satellite derived vegetation index.

Continental Section (Africa)

Bioclimatic Zones: One map to be prepared by GEMS/GRID delineating bioclimatic zones.

Soil Degradation Types: Four maps on one map page to be prepared by GEMS/GRID using the GLASOD map.



Soil Degradation Causes: Four maps on one map page to be prepared by GEMS/GRID using the GLASOD map.

Soil Degradation Severity: Two maps to be prepared by GEMS/GRID using the GLASOD map.

Soil Degradation and Vegetation Index: Two maps to be prepared by GEMS/-GRID using GLASOD severity variable and satellite derived data and/or a vegetation map being prepared by ICIV, Toulouse, France.

Population Density: One map to be prepared by GEMS/GRID using data prepared by Birbeck College, England, on cities with populations greater that 10,000 inhabitants.

Overgrazing Status: One map may be prepared after consultations with experts in this field.

National/Local

Argentina: Three maps of desertification of the Centre-West of Argentina will be prepared by the Instituto Argentino de Investigaci6n de Recursos Naturales (IADIZA) showing the areas vulnerable to desertification, desertification hazards and areas prone to desertification in 1990.

China: Three maps at different scales will be prepared by the Lanzhou Institute of Desert Research, Academia Sinica, depicting the different methodological approaches according to the level of the assessment.

It was decided that DC-PAC should discuss with China/ IDRAS the technical aspects of their contribution and UNEP's financial support to this.

Kenya: Three maps of the Baringo area will be prepared by Kenya's Department of Resource Surveys and Remote Sensing (DRSRS), DC/PAC and GEMS/GRID showing the model and parameter used for the assessment.

Mali (1): Two maps will be prepared by the French Institut Géographique National (IGN) which, in a project partly funded by UNEP, is carrying out a case study of which the results are expected in 1991 (see *Desertification Control Bulletin* No. 18).

Mali (2): Four maps in three pages of the Western areas of Mali, prepared by the Desert Institute, Academy of Sciences of Turkmen SSR, USSR, showing the desertification status in 1980 and 1989, and the inherent risk and desertification rate and hazard.

Syria: Two maps will be prepared by the Syrian Ministry of Agriculture and ASCAD.

Tunisia: Two maps will be prepared by Moscow State University, USSR, following the same methodological approach of their "Global Map of Landscapes Status".

USSR/Middle Asian Republics: One map will be prepared by Moscow State University, USSR, following the same methodological approach of their "Global Map of Landscapes Status".

The contributions from Australia and India were not considered because official confirmation was not received in time. An FAO contribution was not accepted because its cost exceeded the UNEP/DC/PAC budget.

It was agreed that the third technical advisory group meeting will be held in Nairobi, Kenya, in May 1991 to review the final design and maps of the Atlas, and the results of the Global Assessment.

Global Wall Maps

The "Present Status of Landscape" map at the scale of 1.10 million, prepared by the Moscow State University, was accepted for use as the Global Wall Map which is to accompany the Atlas. This map was due to be ready in hardcopy format by December 1990.

The Global World Map of Desertification/Land Degradation, also on a scale of 1.10 million, based on the GLASOD map and bioclimatic zones, was not accepted because of the limited data on desertification processes contained in it. However, UNEP's GEMS/GRID will prepare a new draft proposal using a scale of 1:30 million, based on the GLASOD map but extracting the information on soil degradation causes.

Consultative Group for Desertification Control (DESCON)

History

The Consultative Group on Desertification (DESCON) was set up in 1977 following the United Nations Conference on Desertification (UNCOD). At this time there was great optimism that desertification would become a priority environmental concern and it was hoped that global efforts to combat land degradation would be adopted and would be able to halt or at least control the threat.

Thirteen years later, desertification is as much a problem for mankind as it was in 1977. Indeed the threat may have worsened - it is believed that the well-being of some eight hundred million people is directly affected by land degradation. Clearly the mechanisms established to counter the trends, institutionalised in DESCON and other forums, have not been as successful as was hoped.

One reason for this failure is the nature of desertification itself. Desertification is not simply a natural process but is a result of increasing populations (with no alternative for survival) and heavier exploitation stress on marginal land resources which are facing abuse through ill-suited farming techniques, unsustainable exploitation of vegetation, soil and water resources, etc. Moreover, desertification is global in scale and impact but local in origin and manifestation. The relationship between the local origin and global effects is not always fully understood and consequently has not received the attention it deserves or become a truly wide-scale political priority.

The lack of international attention given to the desertification issue is due, in part, to the administrative shortcomings of DESCON. The group's membership is open to governments, international bodies such as regional economic integration organisations, the United Nations agencies and the donor community, etc. DESCON's mandate is enshrined in General Assembly resolutions 36/168, 32/172 and 44/172. These provide for coordination, information exchange on participant policies and programmes, advise to the Executive Director of UNEP and mobilization of resources. However, DESCON's role has been perceived differently by its various members - for example, developing countries often regard DESCON as a funding mechanism whereas the donor community see it more as a forum for exchanging information. This confusion has led to a general lack of coordination between the various projects and programmes of donor countries, recipient countries and international agencies and meant that some projects were planned but never funded and follow-up coverage of those which took place was inadequate.

DESCON-7

Fully aware of this troubled history, representatives of 23 governments, 12 UN organisations, and 2 non-governmental organisations met in Rome, Italy, in December 1990 for the DESCON-7 meeting. Here, they examined the proposals contained in the Executive Director's report, *DESCON Past and Future* which attempted to redefine and clarify DESCON's role.

Although some concern was expressed that these proposals were not far-reaching enough and would not bring about any real improvement, members generally agreed that DESCON is a valuable instrument for considering desertification on a global level and must aim to help desertification achieve a more prominent place on the international environment agenda and to become an integral part of development and economic discussions. They also agreed that information exchange should continue to be one of DESCON's major roles and that this should be based on expert analysis of the various issues - such as the processes or the socio-economic aspects of desertification, etc., rather than on the various projects of different members.

Structure

In order to help coordination, the members approved the idea of establishing focal points in each member government, organisation or institution. However categorizing DESCON membership into groups of co-sponsors, core-members and observers was seen as no longer feasible and the group is to be kept open to all governments, organisations and institutions which can contribute or are affected by DESCON's work. The Executive Director's suggestion to establish a core group of members which would provide a firm basis of support and ensure needed continuity was rejected. In order to simplify the organisational structure still further the group proposed that the DESCON secretariat remain small and simple and the sole responsibility of UNEP. Consequently the suggestion that a group of cosponsors would support DESCON with seconded staff and funds did not materialize.

It was also suggested that in future the cosponsors' meeting, which precedes the DESCON meeting proper, should become part of the annual Inter-Agency Working Group on Desertification meeting since all the cosponsors are members of both mechanisms. The group also called on its secretariat to examine how other organisations in the same field, such as the Tropical Forestry Action Plan (TFAP) and the Consultative Group for International Agricultural Research (CGIAR) function with the aim of generating ideas of further ways to improve efficiency.

Fundraising

It was agreed that DESCON's role in fundraising should be understood to be indirect, through creating greater awareness among donors of the desertification issue, rather than directly mobilizing resources for specific projects. Members agreed that other approaches to funding should be examined - such as the Global Environment Facility (set up by the World Bank, UNDP and UNEP) which would also help to give desertification global prominence. It was also felt that DESCON should concentrate on assisting governments to prepare better project proposals since these automatically attract better funding. UNEP's study on financing of anti-desertification programmes, which is being carried out as part of UNEP's contribution to the forthcoming United Nations Conference on Environment and Development (UNCED) to be held in 1992, is to be reviewed at the DESCON-8 meeting in November 1991.

UNCED 1992

DESCON members expressed a strong desire to play an active role in, and to feed clear ideas into UNCED and called on their secretariat to consult with the UNCED preparatory committee to see how DESCON can best contribute. UNCED is expected to take emphatic action on desertification issues and may direct itself to the institutional question, which would affect DESCON. Consequently some members felt that DESCON is now in a transitional phase. It was proposed to hold the DESCON-8 meeting in Geneva where the UNCED preparatory committee is based. It is hoped that this meeting will attract widespread international attention.

The DESCON-7 meeting also heard reports on national and regional plans and programmes of action to combat desertification, including NPACDs of Tunisia, Mali, Somalia, Tanzania, Argentina, Yemen, Syria and Nigeria. The Southern Africa Development Coordination Conference (SADCC) representative presented the Kalahari-Namib Action Plan (see *Desertification Control Bulletin*, No. 18). In addition the following reports on the implementation of the Plan of Action to Combat Desertification (PACD) were submitted to the group:

- two African Ministers Conference on the Environment (AMCEN) pilot village and stock raising projects, one from Ghana and another from Zimbabwe;
- donor country reports from Belgium, Denmark, France, Japan and Sweden;
- a compiled report on UN agencies (FAO, IFAD, ILO, UNESCO, UNIDO, UNEP, UNSO and WMO).

Inter-Agency Working Group on Desertification

The 17th meeting of the Inter-Agency Working Group on Desertification (IAWGD) was held in Rome, Italy, in September 1990. The meeting was attended by representatives from the UN Economic Commission for Africa (ECA), UN Food and Agricultural Organisation (FAO), International Fund for Agricultural Development (IFAD), International Labour Organisation (ILO), UN Centre for Science and Technology for Development (UNCSTD), Office of the UN Disaster Relief Fund (UNDRO), UN Department of Technical Cooperation for Development (UNDTCD), UN Educational, Scientific and Cultural Organisation (UNESCO), UN Environment Programme (UNEP), UN Sudano-Sahelian Office (UNSO), UN Development Programme (UNDP), Southern African Development and Coordination Conference (SADCC), World Food Programme (WFP), World Food Council (WFC), and the World Meteorological Programme (WMP).

The meeting reviewed actions taken in response to UN General Assembly (GA) resolution 44/172 concerning the preparation of reports on the assessment of progress in implementing the Plan of Action to Combat Desertification which are to be submitted to the Preparatory Committee of the 1992 UN Conference on the Environment and Development (UNCED).

The meeting also heard detailed reports on the status of global assessment activities and the preparation the UNEP's Thematic Atlas of Desertification (see *Desertification Control Bulletin* No. 18). With regard to the evaluation of progress on implementation of the PACD, as required by GA resolution 44/172, UNEP informed the Working Group that it was intending to present a composite report comprising the following major chapters:

- Assessment of the Global Status of Desertification
- Evaluation of the PACD as required by Governing Council decision 15/23, paragraph 28.
- Progress in implementation of the PACD by governments, regional bodies, inter-agency organisations, etc.
- Financing the implementation of the PACD (including a review of the Consultative Group on Desertification).
- Recommendations for the future.

The report will be compiled from documents contributed by governments, inter-governmental organisations, regional bodies and inter-agency organisations, etc. A separate report containing expert studies on financing desertification is to be produced separately, in accordance with GA resolution 44/172, paragraph 7.

It was agreed that there is a need for close coordination with the UN system. A proposal was introduced for specific support reports and documents to be provided by the various bodies concerned with the desertification issue. This is intended to help coordinate efforts in the preparation of the different reports required both by the UNCED PrepCom and the GA in order to ensure that they can be prepared in a way that meets the respective requirements, and to avoid the risk of duplication and overlap. IAWGD noted that the UNCED Secretariat is to establish an *ad-hoc* Working Group where agencies most concerned with desertification will be represeted.

During discussion on UNEP's Thematic Atlas of Desertification it was suggested that the World Drought Hazard Map be included within additional experimental maps. UNDRO offered to follow-up this suggestion.

The IAWGD also discussed and amended the proposed agenda for the seventh and eighth meetings of the Consultative Group on Desertification (DESCON). The Working Group considered that the agenda was too broad to enable DESCON to have a meaningful output and suggested dividing items to be covered equally between DESCON-7 and -8 to allow each session to focus on specific aspects of the DESCON mandate.

The SADCC representative presented the Kalahari-Namib Action Plan which was prepared with the assistance of UNEP in response to a request by SADCC at the 16th IAWGD meeting, when it was agree to adopt SADCC as a test case for inter-agency action on mobilizing resources to assist selected member states to develop and implement national and regional programmes to combat desertification (see *Desertification Control Bulletin* No. 18). The first phase of the Action Plan is costed at US$ 1 mio. which covers technical and financial assistance for implementing the envisaged pilot components. The members of IAWGD complimented SADCC on its rapid progress and preparation of the Action Plan and suggested how they could support the pilot projects within their respective programmes. SADCC is to make copies of the Kalahari-Namib Action Plan available to members for their close study and comment. Members will deal directly with the Soil and Water Conservation and Land Utilization Unit of SADCC, which is authorized to coordinate all technical and financial support to the Action Plan for member states, concerning the assistance required under pilot project components.

UNSO presented a report on a meeting it organised in New York, USA, in August 1990 on Harmonization of Strategic Planning Frameworks for Environment and Natural Resources Management. The aim of the meeting was to exchange views on the problems encountered due to the large number of initiatives related to strategic planning for environment and resource management which, in the Sudano-Sahelian region, often overlap. Participants at the meeting agreed to convene an *ad-hoc* working group which will meet periodically in order, *inter-alia*, to review and harmonize interventions in specific countries.

Inter-Governmental Authority on Drought and Desertification

The Inter-Governmental Authority on Drought and Desertification (IGADD) is an autonomous regional body concerned with coordinating the efforts of its member states in food security and implementing programmes to combat desertification which maintain the ecological balance and sustain development.

The six member countries of IGADD (Djibouti, Ethiopia, Kenya, Somalia, Sudan and Uganda) cover an area of more than 5,000,000 square miles. More than 80% of the region is arid and semi-arid plains with an average annual rainfall of less than 400 mm. The Somali-Chalbi desert is located in this sub-region. No more than 7% of the entire sub-region is under cultivation and 28% of the land is used as permanent pasture. Almost half of the land is unproductive and this sub-region has one of the highest population growth rates in the world (3% per year).

In order to promote cooperation IGADD organised a Forum on Environmental Protection and Development of a Sub-Regional Strategy to Combat Desertification which was held in Nairobi, Kenya, in October 1990. The Forum attracted over 90 participants and provided an opportunity for policy makers to exchange information, compare experiences and formulate proposals for tackling the problem in a coordinated manner. It also gave government officials and donor agencies working in the field of environmental protection and desertification the opportunity to exchange views and experiences.

The Forum focused on the Environmental Protection and Development of Sub-Regional Strategy to Combat Desertification reports, volumes I (the main report) and II (country reports). The rationale of this strategy for environmental protection and desertification control is based on studies of the current and future economics of IGADD member states for whom wise use of land is essential. Arid and semi-arid lands are currently subjected to increased pressure and dangers of degradation and sub-regional efforts are needed to supplement national activities. This sub-regional strategy aims to:

- reduce pressure on arid and semi-arid land
- increase biomass resources and alternative energy sources
- maintain biodiversity
- manage water resources
- educate people in the region
- monitor the state of the environment and land degradation
- examine the problem of refugees.

The Forum drew up nine broad sectorial approaches which together address the environmental issues in a holistic way. Eight programmes have project proposals aimed at identifying activity areas and costs. These include: erosion control, biodiversity, rangeland management, water resources, oil pollution, environment assessment, research and education and refugees. The IGADD energy sector will be addressed separately.

After discussions in three committees the sub-regional strategy was adopted for follow-up and implementation by IGADD and its member states. This consolidates IGADD's mandate, given by the Regional Conference on Environment and Development, held in Kampala in June 1989, which states that IGADD will act as a focal point for co-ordination of sub-regional activities on environmental protection.

The IGADD secretariat is seeking closer cooperation with the African Deserts and Arid Lands Committee (ADALCO) and it has been proposed that an ADALCO mission be sent to the IGADD region to promote sub-regional cooperation.

African Deserts and Arid Lands Committee

The fourth meeting of the African Deserts and Arid Lands Committee (ADALCO) took place in Algiers, Algeria, from 3-5 December 1990. The meeting was attended by Committee members and Focal Points from Algeria, Angola, Botswana, Egypt, Ghana, Morocco, Senegal, Swaziland and Tanzania and by representatives from the UN Development Programme (UNDP), UNEP, UN Economic Commission for Africa and the World Association of Lawyers for Environment Protection.

Mr Jacques Baudin, the Senegalois Minister of Tourism and Protection for Nature, Vice-President of the African Ministerial Conference on the Environment (AMCEN) and Chairman of ADALCO made the opening speech in which he recalled the activities of the ADALCO Committee since its last meeting in Ouagadougou in February 1990. He reiterated the need to be more innovative in adopting inexpensive and unique strategies for combating drought and desertification and for closer cooperation between ADALCO and other intergovernmental organisations. Mr Baudin, who was elected President of ADALCO, said that the preparatory process for the 1992 United Nations Conference on Environment and Development (UNCED) presents an excellent opportunity for African countries to develop a common front and to formulate priority projects on drought and desertification to present to the conference.

The report on ADALCO activities was presented by the Secretariat.

North-East Africa

The Master Plan for the Development of the Nubian Sandstone Aquifer for Combating Desertification in North-East Africa (see *Desertification Control Bulletin*, No. 18) has been completed and is available in English.

Southern Africa

The ADALCO Focal Point for the Southern Africa sub-region reported on the workshop on the Plan of Action for the Kalahari-Namib region organised by the Southern African Development and Coordination Conference (SADCC) and held in Bulawayo, Zimbabwe in June-July 1990.

East Africa

The East Africa Focal Point reported on the Inter-Governmental Authority on Drought and Development (IGADD) Forum on Environmental Protection and Development of a Sub-Regional Strategy to Combat Desertification held in Nairobi in October 1990. A proposal was made to send an ADALCO mission to the IGADD sub-region in order to promote sub-regional cooperation.

West Africa

A report on the Control of Desertification and the Spread of the Desert in the South Sahara Zone and the Gum Belt through Programmes of Ecological Rehabilitation has been forwarded to the governments in the sub-region.

Pilot Villages and Pastoral Zones

To date, 11 pilot village and pastoral zone projects are in place in Djibouti, Egypt, Ghana, Senegal, Uganda, Zimbabwe, Zaire and Kenya.

The Algerian Minister for Agriculture, Dr Bachir Kadik, singled out the need to incorporate regional and international cooperation in strategies for combating desertification and said that Algeria was willing to share her experiences with her neighbours on the establishment of the North Sahara Green Belt.

The meeting also heard reports on the status of ADALCO activities in Ghana, Egypt, Senegal, Morocco and the SADCC region.

It was recommended that intergovernmental organisations submit their project proposals to the ADALCO secretariat in order to establish a project data bank for the region. It was also suggested that member states should take advantage of the UNDP fifth cycle to submit projects for funding and that the ADALCO secretariat, in conjunction with AMCEN, should take the necessary steps to contact other potential donors to fund the projects.

Follow-up Activities

The Plan of Action for the Kalahari-Namib Region and the Nubian Sandstone Aquifer projects are to be followed up. It was also suggested that ADALCO look into the possibility of establishing an environmental trust fund, taking into consideration the socio-economic problems of the region. Members endorsed the proposal to initiate a study tour/training workshop in Morocco to facilitate the exchange of experiences between ADALCO states.

UNEP's Mr J. Skoupy said that Africa's ecological debt problem was more severe than the fiscal debt but that UNEP was aware of the formidable economic problems facing African countries and is committed to providing, within available resources, continued support to AMCEN.

The Plan of Action for the Kalahari-Namib

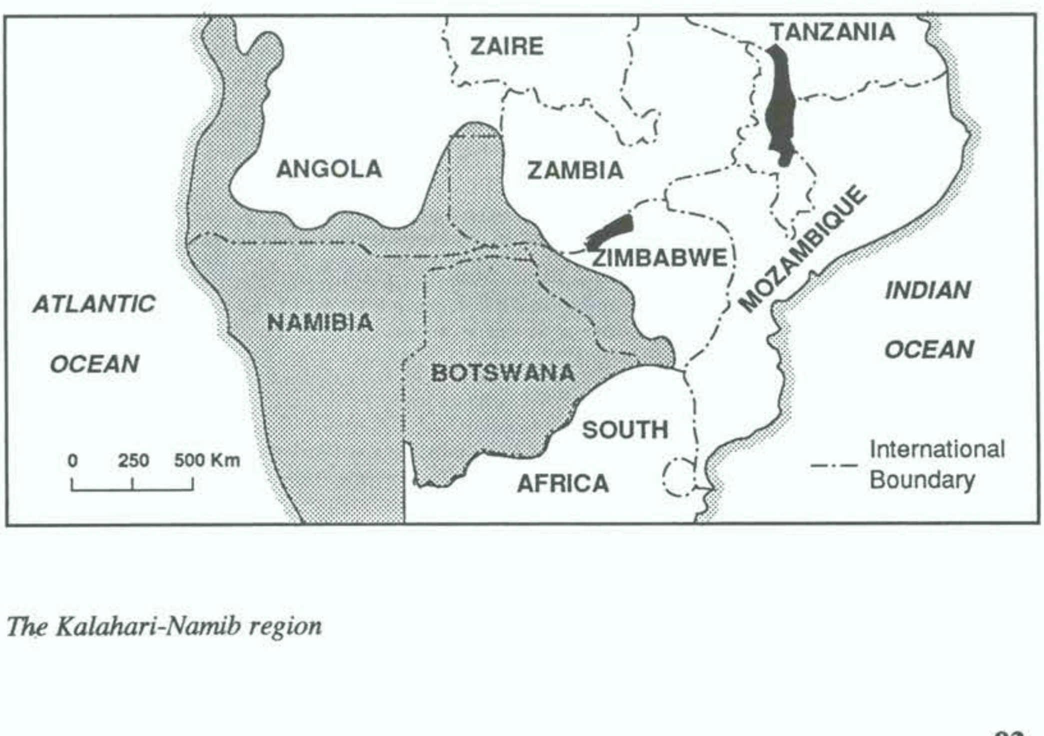
The Kalahari region includes most of Botswana, north-eastern and eastern Namibia, south eastern Angola, western and south western Zambia, western Zimbabwe and northern areas of the Republic of South Africa. The Namib covers a strip of land along the coastal area of Angola and Namibia.

Bioclimatically the Kalahari-Namib region is composed of semi-arid and arid areas with some sub-humid patches. The Namib is a true desert with clearly identified boundaries to the north and south; in the east it passes on to the Kalahari Desert through an arid transition area.

The vegetation is dry, shrubby or shrubby-arboreal savannah which is extremely sensitive to natural (e.g. drought) and anthropogenic (e.g. overgrazing, trampling, deforestation) factors, and rather fragile to fire and wildlife impact. The herbage is relatively dense, forming only during the rainy season.

With the introduction of livestock in the savannah eco-systems of the Kalahari-Namib region serious changes occurred in the natural vegetation, firstly in the balance of shrubby-arboreal species and grasses. Before the active development of livestock raising in the 1920-30s the Kalahari-Namib vegetation could be defined as huge grass populations with scattered trees. Since the 30s and especially after the early 60s the region's vegetation due to overgrazing has been subject to transformation with rapidly increasing shrubby vegetation, changing the balance of grass communities and reducing the number of grass species. Most trees and shrubs are very sensitive to water shortage; in dry periods the trees don't even flower.

In late 1989 the idea of a Plan of Action for the Kalahari-Namib region was approved by the SADCC Sectoral Technical Committee and endorsed by the SADCC Ministers of Agriculture and Natural Resources for further preparation.



The Kalahari-Namib region

A draft project document, prepared by a multidisciplinary expert team and discussed and improved in a regional consultation workshop by relevant experts from all involved SADCC countries was submitted to the SADCC Sectoral Technical Committee in June 1990. The Committee approved the Preparatory Phase and requested detailed proposals for the first phase of the project for each country to be elaborated for the next meeting, which is currently planned for May 1991. This decision was later endorsed by the Ministers of Agriculture and Natural Resources.

A further technical meeting, held in November 1990, harmonized and standardized the monitoring criteria and methods, and made specific guidelines for preparing workplans for the pilot area and final country project documents.

During the on-going Preparatory Phase, staff were trained on monitoring and management of range resources at a course held late in 1990 in Askhabad in the USSR. A second training course is to be held in June 1991 in Matopos and Bulawayo, Zimbabwe.

The main objective of the Action Plan is to enhance the measures needed to stop degradation of the natural resource base, deterioration of plant communities and the disappearance of species - in particular to stop man-induced land degradation and desertification processes and to achieve sustainable exploitation of natural resources in the region. In addition the Action Plan aims to improve the welfare of populations in the area and to break the vicious circle of poverty/ land degradation/increased poverty.

A project aimed at combating degradation of the land resources base will require improvements in management systems, development of appropriate techniques and practices and a holistic approach to both the natural environment and the communities obtaining their livelihood out of it, and interaction between all of these.

Research findings relating to species, inputs, techniques, practices, etc., have to be adapted to communities' requirements and to the various institutional and economic constraints affecting the SADCC countries.

The diversity of situations not only from country to country but even within a country renders universal solutions less useful; alternatives tailored to concrete sites and requirement are needed. Consequently, the Plan of Action envisages to try to promote environmentally and socio-economically sound management of natural resources at small scale, i.e. at local community level. This will facilitate the better understanding of existing practices and the evaluation of how recommended practices will be accepted by the local community. It will also allow for the evaluation of the environmental suitability of recommended practices and for the analysis of their replicability in areas with similar conditions. Moreover, it will permit the strengthening of the role of local institutions as managers of communal natural resources and assist the community in developing sustainable resource management systems.

For this purpose the Plan of Action envisages establishing 1-4 pilot areas in each of the participating countries where the local communities will be involved in the design, approval and implementation of both new and improved management practices and systems.

The first phase of implementation is due to start during the second half of 1991. The duration of this phase is four years, with an estimated cost of US$ 11.9 million, out of which about US$ 2.95 million will be funded by participating governments and for which US$ 8.95 million in donor/Global Environmental Facility (GEF) is needed.

The major groups of activities to be conducted during this phase are aimed at:

- developing improved land use systems, particularly in the rangelands
- promoting and developing environmentally sound resource management practices
- improving the living standard of involved populations
- establishing a monitoring system of the pilot areas
- the exchange and dissemination of information

The second phase will seek to expand the programme in the Kalahari-Namib region by replicating successful practices. Successful practices may also be tried in similar ecological areas of other SADCC countries. This phase, which has yet to be fully elaborated, is envisaged to last up to the year 2010 at an estimated cost of about US$ 12.5 million of which US$ 3.875 will come from local funds and US$ 8.625 from donor/GEF facilities.

The SADCC Coordination Unit for Soil and Water Conservation and Land Utilization Sector in Lesotho will be the overall coordinating body.

DC/PAC Training Programmes

The overall aims of DC/PAC Training Courses are:

- to facilitate the extensive use and application of proper anti-desertification techniques leading to a sustainable increase in food and agricultural production for the benefit of the indigenous population and to facilitate the spread of those techniques in the countries of the trainees
- to promote development on internationally acceptable methodologies and techniques of desertification control, assessment, mapping and monitoring
- to strengthen the capacity of national agencies in the various regions to apply such methodologies and techniques for desertification control, assessment, mapping and monitoring
- to promote regional and international cooperation in anti-desertification activities through exchange of information, experience and training
- to improve the capacity of countries concerned to deal with desertification issues by helping to increase the number of personnel in the area trained in desertification control, assessment, mapping and monitoring.

Training Programmes for Member Countries of the Arab Center for the Studies of Arid Zones and Dry Lands

A training course on "Diagnosis, Reclamation and conservation of Gypsiferous Soils" was held in Damascus, Syria in October 1990. It was attended by participants from the Republic of Yemen, Sudan, Somalia, Oman, Tunisia, Libya, Morocco, Egypt and Jordan who were addressed by five lecturers from Syrian Universities and Soil Research Institutes and six lecturers from the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) and one from ICARDA.

Lecture topics included engineering problems of irrigation channels and irrigation techniques, biological problems, genesis classification, field and laboratory testing technology and the Soviet experience on reclamation and conservation in Ukrainian semi-arid regions. Field trips were made to Deir El Zor and Euphrates projects.

The training course was organised by ACSAD in cooperation with the Center for International Projects (CIP), the All Union Academy of Agricultural Sciences (VASKHNIL) of the USSR and UNEP. This was the fourth training course held for ACSAD countries.

Training Course on the Assessment, Mapping and Monitoring of Desertification

An international training course on desertification assessment, mapping and monitoring was held in the Soviet Union in October 1989 in cooperation with the Institute of Deserts of the Academy of Sciences of the Turkmen Soviet Socialist Republic.

The course was attended by 17 specialists from Egypt, Iraq, Jordan, Kuwait, Libya, Morocco, Somalia, Syria, Tunisia, Yemen Arab Republic and two lecturers from ACSAD.

The training course was held in the Institute of Deserts of the Academy of Sciences of the Turkmen SSR, the Repetek biospheric reserve, laboratories of remote sensing techniques of the Geographical Department of the M.V. Lomonosov Moscow State University and of the State Committee for Hydrometeorology.

The main objective was to upgrade the expertise of the specialists from Arab countries and to exchange information in the field of methodology of assessment, mapping and monitoring of desertification on the basis of climatological assets, types of topography and soil and vegetation cover of arid areas, including the agricultural status of lands.

Practical studies and seminars were mainly related to the use of remote sensing and ground surveys' data for interpretation of desertification processes and compilation of synthesized thematic maps. Seminars and reports were provided with visual aids including maps, space images, slides, etc.

Field visits were organised to the Central Karakum Observation Station of the Institute of Deserts and to the Repetek Biospheric Reserve which is the branch laboratory of irrigation on oasis sands.

The participants endorsed the necessity for further training of experts from Arab countries in the framework of USSR/ACSAD/UNEP projects and support UNEP's efforts to expand these activities. They also recommend that more information on the practice and methodology of desertification control be elaborated and disseminated and that there should be better exchange of information and experts between the USSR and ACSAD member countries. They also called for ACSAD member countries to unite efforts in setting up a data bank on desertification processes in the region.

Training Programmes in Asia and the Pacific

DC/PAC's Mr Leonid Kroumkatchev met with representatives from the Economic and Social Commission for Asia and the Pacific (ESCAP)'s Division of Industry, Human Settlement and Environment and the UNEP Regional Office for Asia and the Pacific in November 1990. The aim of the meeting was to coordinate and develop detailed cooperative programmes within the DESCONAP Network Activity and to discuss future collaboration between DESCONAP and DC/PAC.

The meeting agreed that a training course on Desertification Monitoring Techniques will be organised in the USSR for Asia and the Pacific region countries in October-November 1991. DC/PAC has prepared a memorandum of understanding between UNEP and the Centre for International Projects (CIP) of the USSR State Committee for Environmental Protection. ESCAP will provide assistance to CIP in the selection of 25 participants from countries in the region. A training course programme is to be prepared by CIP in consultation with UNEP and ESCAP.

The meeting also discussed the DESCONAP Network Programme, in which DC/PAC cooperated with the USSR Commission for UNEP (UNEPCOM) and Mongolian national experts in organizing a multi-disciplinary expert mission to Mongolia in November-December 1990. The five Soviet experts, in cooperation with National experts, collected necessary background information for developing a National Plan of Action to Combat Desertification for Mongolia which is expected to be ready by early 1991.

It was agreed that the first Working Group meeting on elaboration of a unified Desertification Assessment and Mapping Methodology for Asia should be held either at the Regional Centre for Desertification Assessment and Mapping in Tehran in the Islamic Republic or Iran, or in Damascus, Syria, during the first half of 1992. ESCAP is to contact the Iranian authorities for their approval. Up to 15 participants from research institutions in the Asia/Pacific region and from ACSAD are to be invited, along with representatives from the UN Food and Agricultural Organisation (FAO), UN Educational, Scientific and Cultural Organisation (UNESCO), World Meteorological Organisation (WMO), UNEP and UNEPCOM.

The meeting agreed that part of the contribution from the Australian International Development Assistance Bureau of $ 70,000 Australian (US$ 53,293) will be used to support a regional seminar on promotion of desertification control technology. The seminar is to be organised by ESCAP for 35 participants from selected non-governmental organisations, women's groups and focal points of the DESCONAP Network in October-November 1991.

ESCAP is to be responsible for the preparation of the detailed seminar programme and its distribution to participants and will also organise the selection of, and travel and accommodation arrangements for participants and lecturers.

The other part of the Australian grant will be used to organise an evaluation of a multi-disciplinary expert mis sion to Afghanistan, India, Iran, Mongolia and Pakistan where assessment and mapping will be undertaken in 1992-3. The evaluation mis sion of 4-5 experts will aim to identify the present status of desertification in these countries and to find out their governments' interest in the field of mapping. UNEP has prepared a letter of agreement between the Division of Industry, Human Settlements and Environment of ESCAP and DC/PAC to transfer the Australian funds.

In accordance with the UNEP/ESCAP joint programming for 1991-1993, a new project document entitled "Support to DESCONAP activities through research and training" has been prepared in UNEP for implementation in 1992-1993.

Training Courses in Latin American Countries

The second training course in desertification assessment and control was held in Mendoza, Argentina for 25 participants from Mexico, Peru, Argentina, Bolivia, Chile, Ecuador, Colombia, Venezuela and Brazil in October 1990.

The course was organised by the Instituto Argentino De Investigaciones de las Zonas Aridas (IADIZA) in cooperation with UNEP.

The third training course on the Reclamation and Conservation of Saline Irrigated Soils will be held in the USSR in September-October 1991 for 20 participants from Latin American Countries. The course is being organised by the Centre for International Projects (CIP) in cooperation with IADIZA. A memorandum of understanding between CIP and UNEP was signed in January 1991.

Training Course for SADCC countries

As one of the activities of the preparatory phase of the Plan of Action for the Kalahari-Namib region a training course on "Rangeland Development and Desertification Control" was held in the cities of Ashkhabad, Samarkand and Chimkent in the USSR in September-October 1990. It was attended by 17 specialists from Angola, Botswana, Lesotho, Mozambique, Tanzania, Zambia and Zimbabwe and two lecturers from Egypt and the Southern African Development and Coordination Conference. These participants were identified at the Regional Consultation on the Plan of Action for the Kalahari-Namib Region held in Bulawayo, Zimbabwe in June 1990 (see *Desertification Control Bulletin* No. 18).

The scientific programme comprised lectures, seminars and discussions with field trips, including visits to experimental farms and stations and sessions in laboratories, etc.

All the participants were provided with training materials and methodological literature in the field of desertification control and rangeland management.

The training course was hosted by the Institute of Deserts, (Ashkhabad), the All-Union Research Institute of Astrakhan Breeding (Samarkand) and the Kazakh Institute of Astrakhan Breeding (Chimkent).

At the end of the course the participants expressed the opinion that they had considerably improved their scientific knowledge. However they felt that future training courses should be more closely connected with the specific natural conditions of the Kalahari-Namib region, taking into account that livestock (mainly cattle) productivity improvement and land degradation are the most important and urgent problems of the whole SADCC region.

Workshop on Chinese Eco-farming villages

The first training workshop on eco-farming villages for African countries was held in Nanjing, China, in October 1990. The workshop was organised by the National Environmental Protection Agency (NEPA) and the Nanjing Institute of Environmental Sciences of China and supported by UNEP (see *Desertification Control Bulletin* No. 18). It attracted 18 participants from 8 African countries.

The aim of the workshop was to train African villagers and technicians in Chinese eco-farming methods with a view to reinforcing the implementation of AMCEN pilot projects. Participants first toured various projects and villages, including Guquan Village of Nanjing, Jiangsu; Xihu Integrated Fishing Farm of Qixia District, Nanjing; Heheng Village of Tai County, Jiangsu; Shanyi Village of Xiaoshan, Zhejiang; Xiaozhangzhuang Village of Yingshang County, Anhui; Zhangliang Village of Linxia, Gansu and Shabianzi Village of Yanchi County, Ningxia to see how eco-farming works in the field. The participants were particularly interested in integrated production systems which encompass pig rearing, fishing, chicken raising and biogas projects, and believed that these are very suitable for adoption in Africa.

In the second half of the workshop the theoretical concepts of eco-farming were discussed in a series of seminars led by nine professors from the Chinese Academy of Sciences, Nanjing Agricultural University, Nanjing Forestry Industry University, Agricultural Techniques Extension Service of Jiangsu Province and the Nanjing Institute of Environmental Sciences. Participants also visited the Zhejiang Agricultural University and the Lanzhou Psammology Institute.

During the workshop, audio-visual materials and manuals on ecological farming that were developed for distribution outside China were tested and improved.

The seminars and field investigations provided participants with an overall knowledge of the basic concepts, theories, technologies, methods and practices of bio-agriculture in China. It opened their eyes to ways in which African countries can solve the problems of ecological crisis and food and energy shortages in rural areas and offered potential means of raising the living standards and income of African farmers.

Participants were keen that more training courses of this kind be held for officials from African countries to show them how eco-agriculture functions and to encourage them to mobilize and support similar projects in their own countries. They also asked that the video tapes and training manuals be widely distributed so that more people can be made aware of the functions and effects of bio-agriculture. UNEP was requested to invite regional officials to future workshops and to introduce Chinese-style biogas projects into UNEP-sponsored pilot village projects in Africa. Participants also suggested that bio-agriculture be introduced as an option in agricultural universities in Africa.

Participants in the Chinese training workshop on eco-farming villages were keen for bio-agricultural practices to be adopted in Africa. Photo: S. Sangweni.

News in Brief

The Impact of the War over Kuwait on Land Degradation and Desertification in the Middle East Region

All of the countries directly affected by the War over Kuwait are situated in the ecologically vulnerable arid, semi-arid or dry sub-humid zones of the Middle East Region which are prone to desertification processes.

In this region, as a direct result of hostilities, irrigation schemes may have been contaminated, drainage systems may have become waterlogged or salinized, and arable land, vegetation cover and anti-erosion networks may have been destroyed by tanks or explosives. Consequently, it is likely that anti-desertification/land degradation measures in the Middle East Region will require increased assistance. UNEP DC/PAC is proposing to assist in assessing the state of land degradation using a multi-disciplinary team of experts who will use data gathered through remote sensing and ground surveys. Based on this assessment, DC/PAC is proposing to prepare an operational plan of rehabilitation of land and to assist in mobilizing resources through existing international mechanisms to ensure that this rehabilitation plan is put into action.

DC/PAC will also assess the effects of the War on ongoing and planned anti-desertification/land degradation activities in the region, including the preparation of National Plans of Action to Combat Desertification in Yemen, Bahrain, Oman and the United Arab Emirates; proposals to combat shifting sand dunes in Iraq, Kuwait and Saudi Arabia; and the proposed project on pastoral nomadism in Saudi Arabia, among others.

NPACD in Unified Yemen

A team of consultants provided by the UNEP/ESCWA/FAO joint venture visited unified Yemen in November-December 1990 and assisted the government in drawing up a draft National Plan of Action to Combat Desertification which is to be discussed at a workshop in Yemen later this year. The workshop will later be followed by a Round Table meeting with donors (mini DESCON) to discuss ways of financing the NPACD once it has been approved by the government.

Syria to Contribute to World Atlas

The Syrian Government has agreed to contribute to UNEP's World Atlas of Thematic Indicators of Desertification with a series of maps on desertification in Syria. The Atlas is being prepared as part of UNEP's contribution to the forthcoming 1992 UN Conference on Environment and Development. A Memorandum of Understanding has been drawn up between UNEP and the Syrian Government.

Institute of the Sahel

The Institute of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS) invited UNEP to participate in research studies on the protection of vegetation. The meeting took place in Bamako, Mali in January 1991.

Mali

The Ministry of Environment of Mali has notified the African Ministerial Conference on the Environment (AMCEN) Secretariat of the selection of the Douékire Zone for the implementation of an AMCEN pastoral project (see *Desertification Control Bulletin* No. 18). In cooperation with a team of Soviet experts the government has already carried out feasibility studies and prepared the relevant project document. The documents have now been submitted to UNDP to enable it to mobilize the necessary funds.

Harmata

The drylands bulletin, *Harmata*, which is published by the International Institute for Environment and Development (IIED)/Earthscan, is to receive US$ 120,000 funding from UNEP as part of the IIED "Survival in the Drylands", Information Networks project. The 32-page Harmata, published in English and French, was established to promote the exchange of information among African non-governmental organisations on sustainable livelihoods and is an important medium for networking between practitioners, policy-makers and planners in the Sahel.

Farmers are forced into marginal areas, so that land which should never have been farmed is being stripped of its protective cover and, eventually, its topsoil.

NEWS OF INTEREST

Japan Agricultural Land Development Agency

JALDA

The Japan Agricultural Land Development Agency (JALDA) is a quasi-governmental agency which is under the jurisdiction of the Japanese Ministry of Agriculture, Forestry and Fisheries. It came into existence in 1974 when it was mandated by the government to guarantee a stable supply of agricultural products, especially of livestock products, to the nation. In the 15 years from 1974 to 1988 JALDA implemented various programmes such as land development, road construction, construction of agricultural facilities, water supply, etc.

Since 1988 JALDA has had the new role of establishing high productive agricultural structures in order to comply with the demands to restructure the agricultural production base and has consequently become a leading executing body specialized in integrated agricultural development projects.

In 1982 JALDA was institutionalised to act overseas and in 1985 began studying desert encroachment in the Niger River Basin (comprising Guinea, Mali, Niger, Benin, Nigeria, Chad, Côte d'Ivoire, Cameroon and Burkina Faso). The object of the study was to clarify the actual status of desert encroachment, to determine the causes of desertification and thereafter to establish a basic concept of desertification control.

The Niger River flows all year round and is the third largest river in Africa. However the discharge of the river fluctuates tremendously between the rainy season and the severe dry season. This makes water utilization difficult. Moreover the range of fluctuation has widened as a result of the worsening condition of the watershed area caused by improper land management and the amount of un-utilised discharge has been increasing. Therefore afforestation and reforestation in the watershed zone must be established.

JALDA also plans to establish a green defense zone and to promote coordinated land-use based on regional characteristics. Almost 13 million more hectares of arable land could be cultivated without destroying the forest in the Niger River Basin. The total arable land following that addition would be over 77 million ha.

There is also the possibility of 56 irrigated agricultural development projects being located along the Niger River and its tributaries which have abundant water resources. Approximately 1.5 million hectares of new paddy fields could be developed.

Other measures involve developing population control, education, and alternative energy and water resources. Soil conservation measures must also be taken to prevent further soil erosion in this area.

For more information on the JALDA project, please contact: JALDA, Shuwa Shiba Park Building B, 2-4-1 Shibakouen, Minato-Ku, Tokyo, Japan (105). Tel: 03-433-0171; Fax: 03-436-1029; Telex: J33129

Camels can survive and even breed in severe drought conditions when other animals are decimated. Photo: UNEP/ Daniel Stiles

ACSAD to Coordinate Camel Research Network

Camels have always played a major socio-economic role in pastoral societies in arid and semi-arid zones of Asia and Africa. This is largely due to their ability to survive and even to breed during severe drought conditions when other animals - such as cattle, sheep and goats - are decimated. Camel milk is still the sole nourishment for many families for long periods of the year when few other foods are available.

But as pastoralist societies become less nomadic, camels are increasingly produced less for subsistence and more for their market value. Small camel owners are finding that they must become more competitive in order to survive.

Various national, bilateral and international organisations have attempted to give focus and importance to camel research, but without satisfactory results. Resources are often not available to facilitate field work which is time consuming and expensive and, when it does take place, is carried out in small isolated pockets in camel-producing regions so that the results are not always well-publicised.

Because of the lack of information about and coordination between these various research projects, the International Fund for Agricultural Development (IFAD) and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) fielded a mission to evaluate the state of existing research and to assess how far it meets the needs of small camel owners.

The mission visited camel-producing areas in Algeria, Egypt, Libya, Mauritania, Somalia and Sudan and compiled a profile of the status of camel-related research programmes, plans and resources in these countries. Scientists working both in laboratories and in the field were consulted by the mission and expressed a need for coordinating research and collaborating on common problems affecting the camel sub-sector, such as high pre- and post-natal losses, low meat production, diseases, poor work efficiency, the erosion of the genetic base and reproductive physiology, etc.

The mission consequently recommended that a Camel Research Network be established to provide for the exchange of information between existing research institutions and programmes in the region which are directed at the small camel owner. They also recommended that a coordinating unit be set up under ACSAD with the responsibility of identifying priority areas for collaborative efforts under the guidance of a steering committee. The mission also recommended that arrangements be made for closer cooperation with other camel research institutions outside the region.

The major objective of the Network is to ensure that the results of camel research are widely applied and so benefit increased numbers of small camel owners.

(Extracted from the *Camel Newsletter* No. 6, September 1990, produced by the Arab Center for the Studies of Arid Zones and Dry Lands. Further enquiries should be directed to Dr Muhammad F. Wardeh, Editor in Chief, ACSAD, PO Box 2440, Damascus, Syria.)

Nomads in Sudan: their pastoralist way of life was discussed at the Aberdeen seminar. Photo: UNEP/P. Almasy

Pastoral Economies in Africa: Long-Term Responses to Drought

In April 1990 the African Studies Group of the University of Aberdeen organised a colloquium on long-term responses to drought in African pastoral societies. The intention was to draw together participants from different disciplines to consider some of the issues involved in understanding drought and its impact in pastoralist Africa and in devising long-term responses.

Aberdeen has long had a special interest in the problems of pastoral economies in Africa as a result of the work of animal scientists in the University and Rowett Research Institute and the African Studies Group was established in 1966 to further development of African Studies in the University. The Group fosters interdisciplinary cooperation in teaching and research concerning Africa, and organises an annual programme of seminars and short conferences on interdisciplinary themes every two or three years. These are open to members of staff, post-graduate students and members of the public.

The April 1990 colloquium was attended by 120 participants from Europe, USA, Scandinavia and Africa. Twenty-four papers were presented on disciplines including climatology, botany, soil science, animal physiology, anthropology, geography and sociology. The papers are now being revised in the light of the discussions at the colloquium and will shortly be published, together with a summary of the proceedings.

UNEP has agreed to finance the distribution of the proceedings to approximately 100 research institutions and universities in Africa.

SAREC Meeting on Desertification

A scientific round-table discussion on the status of desertification in Africa and the methodology for its assessment was organised from 5 to 7 December 1990 by the Department of Geography of the University of Lund, Sweden, at the request of the Swedish Agency for Research Coordination in Developing Countries (SAREC). Ten prominent scientists from Norway, Sweden, United Kingdom and USA as well as representatives from UNEP and UNITAR participated in the meeting.

Their discussions focused on the application of new satellite based remote sensing technology, including NDVI interpretation, for the assessment and monitoring of desertification, particularly in Africa. The participants agreed that this technology is rather promising but still not satisfactory and requires further development and refinement.

It was pointed out and generally agreed upon that the existing data on desertification is unreliable, inadequate, often controversial, derived from different methodologies employed by various agencies and is based more on estimates than measurements. The need was expressed for further development of the methodology to assess the dynamic process and to collect reliable data by actual measurements using a combination of remote sensing and ground surveys and employing a standardized set of desertification parameters.

Desertification in Western Madhya Pradesh

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Desertification in western Madhya Pradesh is being aggravated by the influx of migratory animals from neighbouring Rajasthan. Photo: UNEP/D. Stiles

In western Madhya Pradesh the combined pressure from increasing human and livestock populations has created a desert like situation within a period of four decades. Jhabua, Rajgarh, Ratlam, Dhar, Khargone and Khandwa are the worst affected areas. These districts were covered by thick, tropical forest of moist to dry deciduous trees in the not too distant past. However, these forests have disappeared in living memory and these districts have been converted into scrublands. The climate has changed from moist to dry and sub-humid and dry sub-humid to semi-arid type during this period. Variability in rainfall has increased by as much as 37 per cent and thus drought has become a common phenomenon. The hill tops and slopes have a bare look with no soil to sustain plant growth and cultivation of crops on such lands has further reduced its biological potential to almost zero level. Per unit land productivity has been measured to be less than that in the Thar Desert. So it seems justified to categorize the western tract of Madhya Pradesh as a desert.

The situation is being further aggravated by the massive influx of migratory animals from the neighbouring states of Rajasthan and Gujarat.

More than 1.5 million camels, sheep, goats and cattle migrate into Madhya Pradesh every year and travel towards the southern and central parts and even up to Bastar district in the far east. These animals consume, on average, 5,000 tons of dry matter per day as their fodder. Under the existing carrying capacity of the land these animals require 12,500 hectares of land per day for grazing purposes or in other words 3 million ha of land for the 10 months during which they stay in the state. Thus about 7.0 per cent of the total land area of the state is utilized by the migratory animal population alone.

The majority of the migratory animals are camel, sheep and goats whose grazing habits are devastating for the environmental conditions. Sheep and goats browse very close to the ground surface and uproot the rhizome of perennial grasses. Thus the root stock of better nutritive quality grasses is lost and the land is invaded by coarse, unpalatable grasses. Moreover, the removal of grass cover from the ground surface exposes the soil to the atmosphere and erosion takes place. Eventually land productivity is completely lost. Camels browse the leaves of trees and shrubs and thus remove the middle and upper storey of the vegetation.

Since the migratory routes of these animals are fixed, the land along which they move is subject to heavy grazing and the subsequent land and vegetation devastation can be easily seen on routes between Kota and Rajgarh; Chittaur, Jawad and Mandsaur and Dahod and Jhabua, which are the entry points to the state during the winter and summer seasons.

Such migration not only poses problems of land degradation and ecological imbalance but also brings the owners of animal herds into conflict with the forces of law and order. In the past there have been confrontations between the farmers and the forest guards and police. It is now reported that nomadic farmers enter into the state with offensive motives with political backing.

The question that is raised here is whether Madhya Pradesh should allow migratory animals to graze indiscriminately in the State, given that the majority of animals are unproductive and an economic burden on the ecological system. If not, then immediate steps should be taken to stop the migration and implement protective measures to check the process of desertification. Madhya Pradesh State Planning Board made a study in 1985-86 to work out the dynamics of desertification in Rajgarh district. The outcome of the study should be made public.

*NCHSE is a non-profit, non-governmental organization working for human welfare and environmentally sustainable development both in rural and urban areas.

International Meeting on the Physical Causes of Drought and Desertification

An international meeting on the physical causes of drought and desertification is being organised by the Australian Committee for the World Climate Research Programme and the Australian Meteorological and Oceanographic Society. The meeting is planned for December 1991 in Melbourne, Australia.

The topics to be covered include:

Drought:

- Observational aspects of drought
- Drought simulations
- Statistical and deterministic predictions
- Drought mechanisms and precursors (global and regional)
- Feedback mechanisms: atmosphere, ocean, land

Desertification:

- Causes and trends
- Feedback mechanisms
- Sensitivity studies
- Potential impact of climatic change

CSIRO Australia, Division of Atmospheric Research, Station Street, Aspendale, Victoria 3195, Australia.
Tel: 613-586-7666: Telex: AA34463: Fax: 613-586-7600

Do Broadbeds and Furrows really Increase Soil Erosion?

It is well known that broadbeds and furrows help boost crop yields on waterlogging-prone Vertisols. But they do this by improving surface drainage, or run-off, and this causes soil erosion.

So what effect do broadbeds and furrows have on soil erosion? Results of trials started by ILCA in 1986 indicate that they do indeed increase loss of soil. On land with a slight slope (0.65%) broadbeds and furrows increased run-off by 145% (282 vs 115 m^3/ha) and more than trebled the amount of soil lost (2.19 vs 0.71 t of soil/ha) compared with traditionally prepared flat seedbeds. On a moderate slope (2.7%) broadbeds and furrows increased run-off by 88% (1238 vs 659 m^3/ha) and soil loss by 92% (7.01 vs 3.65 t/ha).

"Obviously we are concerned about the increased loss of soil from plots with broadbeds and furrows," said Dr MA Mohamed-Saleem, leader of ILCA's highland research team. "But even on the moderated slope the amount of soil being lost is within the 'normal' range for African clay soils. The broadbed and furrow system allows a crop to be established earlier in the rainy season than is possible with traditional planting methods; early planting seems necessary to prevent soil erosion, especially on slopes that exceed 1%."

In light of these results, an ILCA project led by Abiye Astatke, an agricultural engineer, is looking at a number of ways in which the broadbed and furrow system might be modified to minimise soil losses. These include establishing early crop cover, selecting appropriate crop types to minimise run-off and erosion, planting crops or forages in the furrows to slow run-off, and adjusting cropping patterns to the topography.

For further information on this work, please write to: Abiye Astatke, ILCA, Addis Ababa, Ethiopia.

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